Faculté des Sciences
Université Ibn Zohr d'Agadir
Laboratoire Matériaux et Environnement
Association Ibn Zohr pour l'Environnement et les Sciences des Matériaux

# THE INTERNATIONAL CONGRESS: APPLIED MATERIALS FOR THE ENVIRONMENT

# LE CONGRÈS INTERNATIONAL : MATÉRIAUX APPLIQUÉSÀ L'ENVIRONNEMENT

# Proceeding


## 6-7 March 2024

**Faculty of Medicine and Pharmacy - Agadir**

# MOT DU COMITE D'ORGANISATION

Au début du 3ème millénaire, notre planète se trouve confrontée à de nombreux défis écologiques. D'une part, l'accroissement rapide de la population mondiale s'accompagne d'une augmentation de la consommation des ressources mais aussi de la détérioration de notre environnement qui menace la vie sur terre. D'autre part, le choix d'un matériau est généralement fondé sur des critères extra-environnementaux (performance, coût, disponibilité, fonctionnalité, esthétique,…) mais prend rarement en compte les impacts sur l'environnement et la santé humaine. L'utilisation de matériaux respectueux de l'environnement s'avère une nécessité incontournable pour résoudre ce fléau.

***C'est dans ce contexte que le Laboratoire Matériaux et Environnement (LME) et l'Association Ibn Zohr pour l'Environnement et les Sciences des Matériaux (AIZESMA) organisent, du 6 au 7 Mars 2024, le Congrès International : Matériaux Appliqués à l'Environnement CIMAE-2024 sous le slogan « S'engager et Agir ensemble pour protéger notre planète ».***

Cette manifestation scientifique est une opportunité de rencontres entre acteurs nationaux et internationaux spécialistes des domaines liés aux matériaux et à l'environnement. C'est une occasion de mettre en exergue les thématiques fortes, depuis l'étude des Surfaces et Interfaces passant par le Traitement et la Valorisation des déchets solides jusqu'aux applications innovantes des matériaux pour la détection et traitement de la pollution.

Nous témoignons notre gratitude à Monsieur le Président de l'Université Ibn Zohr et à Monsieur le Doyen de la Faculté des Sciences d'Agadir pour avoir cru en notre initiative et d'être engagés pour que ce congrès International soit une réussite.

Nous exprimons nos remerciements au Comité Scientifique pour son aide et sa collaboration dans l'expertise et la sélection des résumés. Les conférenciers nous ont honorés pour avoir accepté notre invitation, qu'ils en soient bien remerciés.

Nous saluons l'engagement des différents sponsors à nos côtés ; nous les remercions pour leur appui et soutien financier et pour l'intérêt qu'ils portent à cette manifestation.

Le Comité d'Organisation vous réitère ses sincères remerciements pour votre présence, marque de votre intérêt et de votre engagement pour notre initiative. Merci pour votre présence et votre soutien à cette manifestation.

**Ensemble pour la protection de notre planète ; faisons des éditions CIMAE une grande fête scientifique des matériaux et environnement.**

**Le comité d'organisation**

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## Pr. Nilgün Ünal

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# Role of nanomaterials in sensitive drug analysis

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**Abstract**

Nanotechnology has significantly transformed the drug analysis domain by enabling the creation of highly sensitive and precise detection methods. Nanomaterials are playing a pivotal role in augmenting the sensitivity of various drug analysis techniques, such as mass spectrometry, chromatography, immunoassays, and electrochemistry. These nanomaterials, which encompass nanoparticles, nanotubes, and nanowires, possess distinctive characteristics that render them well-suited for drug analysis applications. These features encompass high surface area-to-volume ratios, customizable surface chemistry, and unique optical, electrical, and magnetic properties. Nanomaterials can be imbued with specific ligands to amplify the selectivity of drug detection. The integration of nanomaterials into drug analysis has resulted in notable enhancements in sensitivity, detection thresholds, and throughput. Nevertheless, several challenges persist, including the necessity for standardized protocols, the potential for interference from matrix effects, and the requirement for further exploration into the environmental and health ramifications of nanomaterials. Overall, nanomaterials show great promise for the future of drug analysis, and continued research in this area is essential for the development of new and improved drug analysis techniques.

**Keywords:** Nanomaterials, analytical chemistry, electrochemistry, drug analysis, sensitivity

# Antimicrobial resistance issue in bacteria and antimicrobial properties of polymer coatings

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**Abstract**

Antimicrobials are agents that kill microorganisms or inhibit their growth. They are a crucial tool in our fight against infectious diseases. However, microorganisms can develop resistance to antimicrobials, rendering them ineffective. This phenomenon is known as antimicrobial resistance (AMR). Resistant bacteria can emerge, multiply, and spread through various mechanisms. The increasing prevalence of antibacterial resistant bacteria poses a global threat due to the health problems, deaths, and economic losses they cause. Addressing antimicrobial resistance (AMR) is a complex problem that requires a multisectoral approach. This includes adopting a One Health approach that takes into account human health, animal health, and environmental factors. It is essential for everyone in all sectors and disciplines to work together. The importance of discovering new antibiotics is increasing due to the difficulties involved. Scientists are exploring new approaches, such as nanotechnology and bacteriophages, to solve this problem. The interactions between bacterial cells and nanomaterials can alter the vital functions of bacteria through chemical and physical factors. Studies on the antimicrobial effectiveness of materials such as metals, metal oxides, and polymers, including nanomaterials, are increasing. These materials are being investigated for their potential use in biological materials important for public health, the food industry, and on surfaces.

**Keywords:** antimicrobial resistance bacteria, one health, nanomaterials, polymers coating

# Elaboration and characterization of $ABO_4$ type materials for photocatalytic and/or photoluminescent applications

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**Abstract:**

The work consists of developing materials based on rare earths or transition metals with the aim of studying the evolution of their photosensitive properties, either for photocatalysis or for photoluminescence.

These materials will be used as multifunctional materials dedicated to either photocatalytic devices for the photodegradation of pollutants in liquid environments (wastewater, seawater) or photoluminescent devices.

Thus mobybdates, tungstates and phosphates are particularly interesting for these subjects.

Specificities of these materials will be presented as well as a comparison.

Different effects inducing modifications of structural properties were thus discussed:

- effects of doping by a rare earth and/or presence of a two-phase system;
- chemical substitution effects in the case of solid solutions.

It should also be mentioned that the properties of these materials with a modified structure are very sensitive to the presence of point defects resulting either from synthesis conditions, thermal treatments or doping/chemical substitution. We focus all our attention on the role of lacunar defects in the properties.

**Keyword:** oxides, phosphate, photocatalysis, photoluminescence, détection, pollution

# Les digestats issus des déchets organiques comme ressources renouvelables pour la production de l'énergie et le traitement des eaux polluées

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**Abstract:**

Dans un contexte d'énergie renouvelable et de développement durable, la digestion anaérobie permet non seulement la réduction de la pollution de rejets organiques issus des effluents agroindustriels, des boues des stations d'épuration, des activités agricoles, et des déchets urbains (Figure 1), mais aussi la production d'un mélange de gaz (biogaz) composé principalement de méthane et de gaz carbonique et de digestats. Le méthane est une énergie verte et peut être utilisé sous diverses formes (électricité, chaleur, biocarburant, gaz naturel). Le digestat lorsqu'il est convenablement traité, peut être le précurseur dans la génération de plusieurs produits à valeurs ajoutées. Cette conférence mettra en lumière les rôles joués par les digestats de méthanisation, qui sont des ressources potentielles pour les éléments chimiques C, N et P et de l'énergie, dans plusieurs domaines, tels que l'amendement du sol, la production de carburants, la synthèse de nanoparticules, la conception des adsorbants ad hoc pour éliminer, les métaux, les produits toxiques, les colorants organiques, les antibiotiques, présents dans l'eau, pour capturer le CO2, et aussi leur rôle capital dans la production des supports catalyseurs, utilisés par la suite, dans les réactions d'élimination des polluants présents dans l'eau.

Figure 1. Différents types de rejets organiques

# Innovation dans les matériaux respectueux de l'environnement : Explorations des nanocomposites partiellement biosourcés à base de PP/PBS élaborés par extrusion bivis et leur application dans l'isolation électrique.

*Ahmed TARA, Maître de conférences HDR*

*Laboratoire Matériaux et Ingénierie Mécanique (MATIM)*

*Université de Reims Champagne-Ardenne*

**Abstract:**

Célébrant seconde édition en 2024 à Agadir au MAROC, cette conférence au Congrès International sur les Matériaux Appliqués à l'Environnement (CIMAE) offre une exploration des récents progrès dans le domaine des bio et nanocomposites, mettant particulièrement l'accent sur les avancées résultant de l'application de ces matériaux innovants dans l'isolation électrique. Les résultats de recherche présentésdécoulent d'une collaboration étroite entre le Laboratoire de des Matériaux et Ingénierie Mécanique et l'UMR-FARE A614 de l'INRA à Reims*. L'accent est mis sur le développement de nanocomposites par extrusion bivis. Ces nanocomposites partiellement biosourcés, issus de la judicieuse combinaison de polypropylène (PP) et de succinate de polybutylène (PBS) associés à des nanoparticules d'argile organiquement modifiées (Cloisite 20), révèlent des améliorations notables tant au niveau des propriétés mécaniques qu'électriques.

La discussion approfondie de cette recherche éclairera sur les défis environnementaux liés à l'utilisation de biopolymères, malgré leur biodégradabilité, et explorera les stratégies de compatibilisation déployées pour maximiser les performances des nanocomposites. En conclusion, l'accent sera mis sur des perspectives futures cruciales, notamment l'optimisation des processus de fabrication, l'approfondissement des efforts de caractérisation et des tests de biodégradation. Ces initiatives visent à catalyser **l'intégration de ces matériaux innovants dans des applications industrielles exigeantes, redéfinissant ainsi les normes d'isolation** électrique.

* Bencharki, M., Rondot, S., Tara, A., Jbara, O., Berzin, F. J. App. Polym. Sci. 2021, 138 (47), art. no. 51401.

# Innovation in Environmentally Friendly Materials: Advancements in Nanocomposites Featuring Partially Bio-Based PP/PBS Blends Elaborated through Twin-Screw Extrusion and Application in Electrical Insulation

*Ahmed TARA, Maître de conférences HDR*

*Materials and Mechanical Engineering Laboratory (MATIM)*

*University of Reims Champagne-Ardenne*

**Abstract:**

Celebrating its 2nd edition in 2024 in Agadir, Morocco, this conference at the International Congress on Materials Applied to the Environment (CIMAE) offers an exploration of recent advancements in the field of bio and nanocomposites, with a particular emphasis on progress resulting from the application of these innovative materials in electrical insulation. The research findings presented stem from a close collaboration between the Materials and Mechanical Engineering Laboratory and the UMR-FARE A614 at INRA in Reims*. The focus is on the development of nanocomposites through twin-screw extrusion. These partially bio-sourced nanocomposites, derived from the judicious combination of polypropylene (PP) and polybutylene succinate (PBS) coupled with organically modified clay nanoparticles (Cloisite 20), reveal notable improvements in both mechanical and electrical properties.

The in-depth discussion of this research will shed light on the environmental challenges associated with the use of biopolymers, despite their biodegradability, and will explore compatibilization strategies deployed to maximize nanocomposite performance. In conclusion, the spotlight will be on crucial future prospects, including the optimization of fabrication processes, deepening characterization efforts, and biodisintegration tests. These initiatives aim to catalyze the integration of these innovative materials into demanding industrial applications, thereby redefining electrical insulation standards.

* Bencharki, M., Rondot, S., Tara, A., Jbara, O., Berzin, F. J. App. Polym. Sci. 2021, 138 (47), art. no. 51401.

# PRESENTATIONS ORALES

## THEME 1 : SURFACES ET INTERFACES

# Using a novel adsorbent Amberlite TMIRC-200 extract resin polymeric to effectively remove CV dye from wastewater: Characterization, Insights from isotherm kinetic and modelling

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Novel adsorbent cationic Amberlite TMIRC-200 polymeric resin composite was studied as potential adsorbent for inhibitors of corrosion in HCl 1.0 M utilizing simulation and experimental, the cationic adsorbent resin can adsorb a much higher capacity of the CV dye [1-2]. The adsorbent resin polymeric was analyzed by several techniques such as Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM) [3]. The adsorption ability of the cationic resin for CV dye was investigated in relation to the following physicochemical parameters: adsorbent dose, contact time, starting pH imposed on the aqueous solution, and cobalt solution concentration. According to the results of the experiments, the solution is completely depleted when the adsorption occurs at a mass greater than 1g and 100%. After 120 minutes, the cationic resin reaches equilibrium [4]. Raising the temperature of the aqueous phase-adsorbate mixture from 25 to 55°C reduces the extraction yield and sorption capacity; an ideal pH for this adsorption is 5.5. Meanwhile, the Elovich model clarified that the process is proceeding rapidly according to the pseudo 2Sec order, while kinetic measurements made use of the pseudo 1St order and pseudo 2Sec orders, respectively[5]. Research on adsorption equilibrium utilizing various isothermal models, including Freundlich, Langmuir, and Temkin, has shown that cationic resin adsorbed cobalt CV dye most closely to the Langmuir model (R2 = 0.9999).

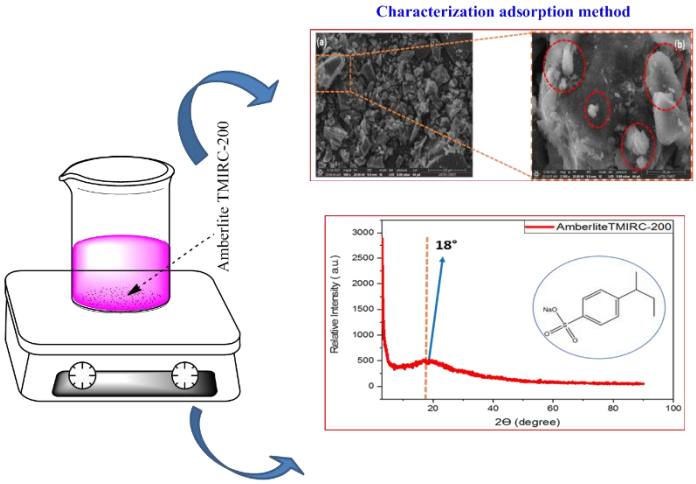


**Figure 1. Figure captions, bold, size 11 Times New Roman**

# Electrochemical degradation of orange G using a new anode based on $Bi_2O_3$ and $BaHPO_4$: study of the effect of current density, supporting electrolyte and pH

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## Abstract

In this study, we prepared a bilayer composed of $BaHPO_4$ (BHP) and $Bi_2O_3$ using the electrodeposition method. The synthesized anode was characterized using cyclic voltammetry (CV) to determine the underlying deposition reactions. Subsequently, structural, and morphological analyses were conducted through X-ray diffraction (XRD) and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy (SEM-EDX). Additionally, optical measurements were performed using UV-vis DRS to determine the bandgap energies of the two semiconductors.

The anode was evaluated for its electrochemical degradation performance on the anionic dye Orange G (OG). We discussed the influence of applied current density, the choice of supporting electrolyte, and the solution's pH on the degradation efficiency of the bilayer. Remarkably, the bilayer exhibited a high degradation efficiency of 98% within a 20 min timeframe at an OG concentration of 10 ppm. This efficacy was substantiated through electrochemical measurements such as linear sweep voltammetry (LSV) and electrochemical impedance spectroscopy (EIS). We proposed a degradation mechanism based on the results of Mott-Schottky measurements and trap studies. Furthermore, the anode demonstrated remarkable stability and reproducibility, enduring through 11 degradation cycles.

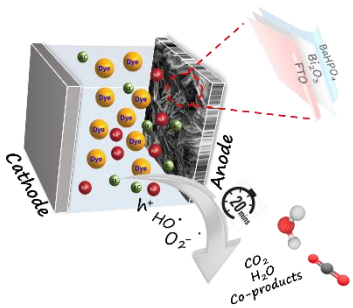


**Figure 1. Graphical abstract**

**Keywords:** Electrodeposition; BHP@$Bi_2O_3$; Thin films; Dyes removal; Electrocatalysis.

# Chemistry of the interaction between imidazole derivatives as corrosion inhibitors molecules and copper/brass/zinc surfaces: A DFT, reactive and classical molecular force fields study

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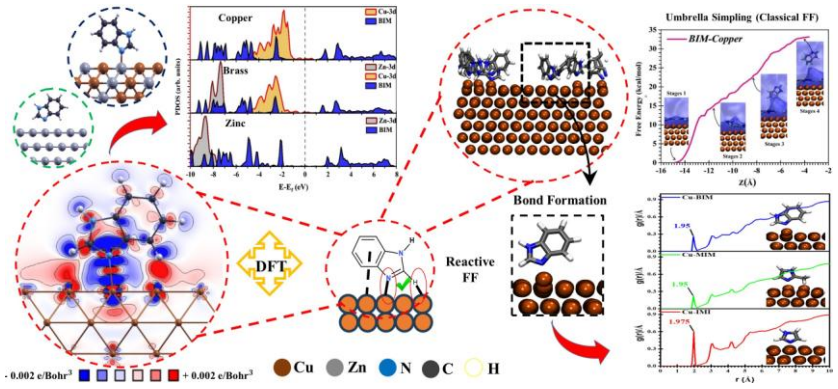
In the present research, we explored the corrosion inhibition mechanisms on metals and alloys by imidazole, methylimidazole, and benzimidazole applying density functional theory (DFT), reactive (ReaxFF), and classical force fields. Our investigation focused on the interaction of these molecules with different types of bare metal surfaces. The results of our studies have been compiled to compare the protection efficiency of the three organic molecules for copper, zinc, and copper-zinc alloys ($Cu_{63\%}$-$Zn_{37\%}$) exposed to the same corrosion conditions in an acid environment. The calculated interaction energy quantities are strongly correlated with the experimental corrosion inhibition efficiencies BIM > MIM > IM. The imidazole derivative studied, significantly better protect copper than zinc, which is attributed to the higher bond strength of Cu–N (formation of chemical bonds) than of Zn–N, confirms the increase in the protection effectiveness against corrosion of Zn < $Cu_{63\%}$-$Zn_{37\%}$ < Cu. This present study demonstrates the enormous potential of ReaxFF calculations to accurately simulate the adsorption of inhibitor molecules onto metal surfaces at a fraction of the computational cost of DFT, as well as the performance of the umbrella sampling method to assess the adsorption free energies.



# Polydopamines corrosion bio-inhibitors for mild steel in HCl solution: A DFT study and Molecular Dynamics simulations

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The inhibitory action of three polydopamine (PDA) monomers synthesized from dopamine (DA) and their adsorption on Fe (110) in 1M HCl aqueous solution was studied theoretically by DFT calculations combined with molecular dynamics (MD) simulations. The optimal geometry found for PDA on Fe (110) is similar for all three compounds. Protonation prediction revealed that the two inhibitors PDA1 and PDA3 are transformed under the action of the acidic medium to $PDA1H^+$ and $PDA3H^+$, while PDA2 is stable in its neutral form. Monte Carlo simulations were carried out to study the adsorption mechanism of PDAs on mild steel surfaces. Absolute adsorption energy values for the PDA2 inhibitor in interaction with the Fe surface, reaching 232.43 and 161.13 kcal/mol at the liquid-solid and gas-solid interfaces consecutively, make this inhibitor more effective for adsorption and corrosion inhibition. These Monte Carlo simulations thus produce an inhibition effect in the following order: PDA2>PDA3>PDA1, which agrees with experience regarding molecular orientation and adsorption site. Reduced density gradient (RDG) calculations based on the analysis of non-covalent interactions (NCI) existing in Fe@PDA systems were used to highlight the molecular interactions existing in PDA@Fe systems. This analysis shows that all inhibitors interact with the surface via electrostatic and van der Waals forces. Besides, the mean-square displacement (MSD) and self-diffusivity coefficient of water, hydronium, and chloride were estimated using Einstein's equations and velocity scale dynamic simulations, and results obtained show a lower migration of corrosive species in the PDA2@Fe system, which favors the formation of a more stable protective layer, compared to the $PDA1H^+$@Fe and $PDA3H^+$@Fe systems.

# Structural and optical study of ZnO thin films electrodeposited at different concentrations

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In the last two decades, wide band gap semiconductors such as zinc oxide (ZnO) have attracted great interest due to their potential applications in optoelectronic devices. In particular, they are widely used as: gas sensors, UV light emitting devices, etc. Zinc oxide (ZnO) thin films have been deposited on FTO substrates by the electrodeposition method.

On the basis of the best physico-chemical characteristics obtained from the different ZnO layers that were developed It was concluded that the best conditions for the electrodeposition of ZnO electrodes were determined. The X-ray diffraction spectrum shows that the chemical composition of the thin films is almost pure and the preferential orientation of the ZnO growth is (002) Wurtzite type structures and the UV-Visible Spectroscopy show that the Eg gap values obtained for the ZnO layers are between 3.12 and 3.24 eV.

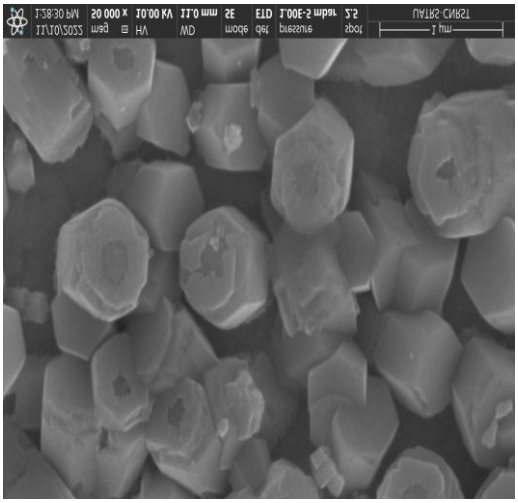

**Figure 1. SEM image of ZnO layer surface**.

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# Optical Properties of Transparent Thin Layers of Cobalt-Doped Zinc Oxide By electrodeposition process

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Zinc oxide (ZnO) is a semiconductor material in thin film form with interesting chemical and physical properties that place it among the most promising materials in various fields: such as photovoltaic energy recovery, optoelectronics, photoluminescence, and gas detectors.Cobalt-doped ZnO on FTO-coated glass substrates was synthesized electrochemically (electrodeposition method), and the results obtained from scanning electron microscopy (SEM), X-ray diffraction (XRD), and UV-Visible spectroscopy showed that the optical gap increases with the increase of the percentage of cobalt doping as well as the formation of a Wurtzite crystal structure of ZnO.

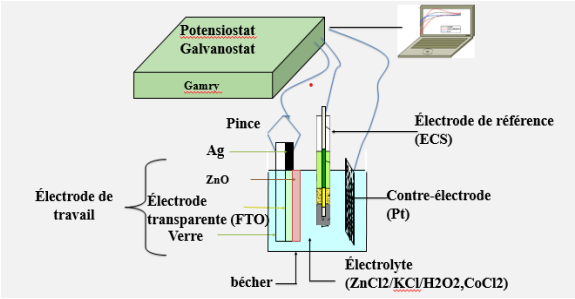


**Figure 1 . ZnO doped Cobalt thin films by electrodeposition**

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# Application of the process capability study on the adsorption of nitrates on Hematite-titaniferous sand, a new approach for a process based on a new performing natural material.

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Liquid discharges into the receiving environment (Rivers, ocean …) increasing, which imposes the protection of the environment by decreasing the amount of some chemical substances in wastewater. Among the pollutants that destabilize the environmental balance, we find the nitrates, which are indispensable to life. However, an excessive intake of these substances in ecosystems leads to eutrophication, it causes degradation of aquatic environments, a reduction of biodiversity and produces hazards on humans.

This work devoted to eliminating aggressive substance ($NO_3^-$) using a natural sand as a low-cost adsorbent. Also, highlight the purifying power of crushed Hematite–titaniferous sand; test its potentialities to purify wastewater by the adsorption process onto the solid support as well. The study of factors influencing the adsorption phenomenon was realized in static regime. The concentration of pollutants has been determined with spectrophotometric analysis in the visible range.

The pH solution has practically no effect on the adsorption process of the nitrates onto adsorbent surface in the pH range between 2 and 10. The adsorbent dose and initial concentration of pollutants have a positive influence on the retention capacity of the pollutant ($NO_3^-$). Modeling of adsorption kinetics shows that the pseudo second order model is best suited to describe the adsorption kinetics. Practically after 30 min of contact pollutant/support, we can eliminate more than 87% of $NO_3^-$. The thermodynamic parameters were determined; the negative value of $\Delta G°$ show that we are in front of a physisorption mechanism. The study of adsorption isotherms shows that Langmuir model correctly describes the adsorption process. The observed maximum uptake capacity was 1,91 mg-$NO_3^-$/g.

The process Capability Analysis has shown that the nitrate adsorption process on crushed Hematite–titaniferous sand is capable and satisfactory.

**Keywords:** Environment, Process capability study, eutrophication, nitrates, adsorption, low-cost material, natural material, Hematite–titaniferous sand.

# Advancing Sustainable Corrosion Protection: An In-Depth Investigation of a Hybrid Inhibitor for Mild Steel

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Keywords: Hybrid materials, Corrosion inhibition, Mild steel, electrochemical study

This study focuses on synthetizing and characterizing a hybrid corrosion inhibitor with the aim of providing robust protection for mild steel in environments containing hydrochloric acid. A simplified and efficient synthesis method is described, providing a thorough analysis of the hybrid's chemical structure using methodologies such as X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and nuclear magnetic resonance spectroscopy (NMR). To evaluate the corrosion inhibition efficacy, tests were conducted at varying concentrations of the hybrid in a 1 M hydrochloric acid solution for mild steel, employing techniques like potentiodynamic polarization and electrochemical measurements. The results indicated a correlation between inhibitor concentration and inhibition efficiency, leading to a simultaneous reduction in corrosion current density. Particularly, the inhibitor demonstrated its highest effectiveness at a concentration of 400 ppm, with an inhibition efficiency of 94% (Figure 1), This revealing that the prepared inhibitor acts as a mixed-type inhibitor. The influence of temperature on the inhibition efficiency was discussed over a range of 298 to 328 K. This methodology integrates efficient synthesis, in-depth characterization, and performance assessments, highlighting the potential of this hybrid inhibitor for effective corrosion protection of mild steel in corrosive environments.[1]

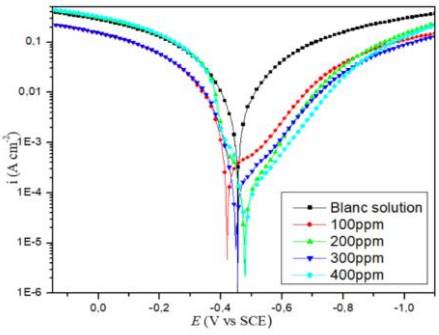


**Figure 1: Tafel polarization curves for mild steel obtained at 25°C in 1 M HCl solution for different concentrations of hybrid inhibitor**

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# Performances d'inhibition de la corrosion de l'extrait d'alcaloïde de graine de Citrullus Colocynthis en tant que nouvel inhibiteur vert pour la corrosion de l'acier doux dans 1,0 M HCl : Extraction, caractérisation, études électrochimiques.

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## Résumé

L'étude explore les capacités de prévention de la corrosion de l'extrait d'alcaloïde de Citrulus Colocynthis Seeds (CSEA) sur l'acier C38 dans un environnement 1M HCl, en utilisant des méthodes électrochimiques. L'extrait, à une concentration de 2,0 g/L à 298K, atteint une efficacité d'inhibition impressionnante de 94,3%. La polarisation potentiodynamique révèle que l'extrait agit comme un inhibiteur de type mixte. Les graphiques de Nyquist indiquent qu'à mesure que la concentration de CSEA augmente, il y a une augmentation de la résistance de transfert de charge et une diminution de la capacité à double couche, ce qui implique une efficacité d'inhibition accrue. L'adsorption des molécules inhibitrices s'aligne avec l'isotherme d'adsorption de Langmuir. Les effets du temps d'immersion et de la température ont été examinés en utilisant la spectroscopie d'impédance électrochimique (EIS) et la polarisation potentiodynamique. La microscopie électronique à balayage (MEB) et la spectroscopie des rayons X à dispersion d'énergie (EDX) ont été utilisées pour corroborer les résultats de l'adsorption. De plus, un test phytochimique et une spectrométrie de masse par chromatographie en phase gazeuse (GC-MS) ont été effectués pour déterminer la composition chimique de l'extrait d'alcaloïde de Citrullus Colocynthis Seeds (CSEA).

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# Effect of a green inhibitor on calcium carbonate precipitation in wastewater transport pipes

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Scaling is a phenomenon that occurs when a surface comes into contact with incrustating water, meaning water that is likely to cause the formation of an adherent deposit, primarily composed of calcium carbonate. This phenomenon is particularly visible and pronounced in pipes carrying purified water from the Agadir region. [1].

In general, approaches to reducing scale deposits are either physical or chemical in nature. The understanding of how physical methods work remains partially limited, thus restricting their applications. Because of their effectiveness and performance, chemical methods are the most commonly adopted. Inhibitors, generally preferred, act by establishing a threshold of effect. The aim of this study is to explore new, environmentally-friendly inhibitors derived from plants in the Greater Agadir region. These inhibitors must meet several criteria, such as a high capacity to prevent scale formation, low toxicity, high biodegradability, minimal impact on water quality, and good quality-price ratio.

The Agadir region is characterized by limited water resources. Therefore, the use of treated wastewater for watering green spaces can help preserve water resources. These green spaces cover hundreds of hectares, requiring a significant amount of water each year. The treated water from the L'Mzar wastewater treatment plant has the potential to meet this demand. However, the main obstacle to this project lies in the quality of the treated water, leading to the clogging of water transport pipes and the pores of sprinklers used to irrigate green spaces due to scale formation [2]. Our objective is to inhibit the formation of scale in these irrigation systems.

To contribute to reducing tartar formation, this study aims to examine the anti-tartar effectiveness of a plant extract. Firstly, measurements of total polyphenols and flavonoids are conducted. Subsequently, the LCGE technique is used to assess the anti-tartar efficiency of this extract.

Key words: green scale inhibitor-calcium carbonate-wastewater-plant extract.

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# Anticorrosion potential of a novel organic phosphonic acid on carbon steel in sulphuric acid

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One of the most cost-effective ways to slow down corrosion, protect metal surfaces from rust, and maintain industrial facilities, especially in acidic environments, is to use corrosion inhibitors[1-2-3-4]. In line with the advancement of organic phosphonic acids as agents that limit corrosion in acidic environments, we investigated how a new organic phosphonic acid namely Hexamethylenediamine-N,N,N′,N′-tetrakis (methylphosphonic acid) (HDMP) (see Figure) inhibited corrosion on carbon steel in a 1N H2SO4 solution.

The unique organic phosphonic acid (HDMP) was selected due to its molecular structure, which includes multiple phosphonic functional groups and heteroatoms (nitrogen) [1-2-3-4]. The compound's ability to suppress carbon steel corrosion in 1N H2SO4 at 303 K was assessed using electrochemical impedance spectroscopy (EIS) and Tafel polarization techniques.

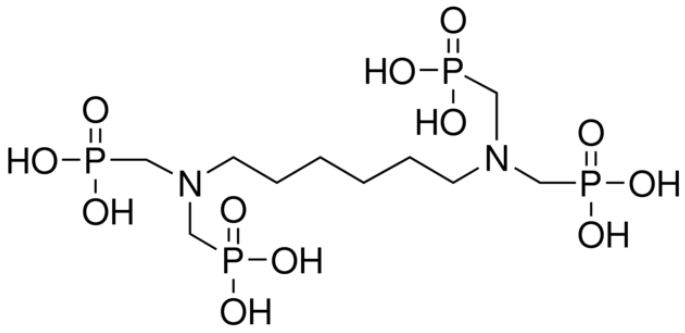

**Figure: HDMP**

The adsorption of HDMP on the metallic surface was also supported by scanning electron microscopy (SEM); while the elemental characterization of carbon steel was performed using energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FT-IR), and X-ray photoelectron spectroscopy (XPS). In addition, the effect of temperature on the corrosion rate was discussed. Both kinetic and standard thermodynamic parameters are calculated and discussed in detail.

The compound's effectiveness as an inhibitor of steel corrosion in 1N H2SO4 medium was demonstrated by the experimental findings, which also revealed that the inhibition efficiency of HDMP increased with inhibitor concentration. Using suitable equivalent circuit models, data from AC impedance measurements were examined to describe the corrosion inhibition process. The development of a protective inhibitor film on the carbon steel surface was confirmed by surface analysis.

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# Elaboration and characterization of new eco-friendly vitreous: Structural, chemical durability, morphologic, and thermal analysis.

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Bismuth-borate glasses are highly valuable as they find numerous applications across diverse domains including medicine, optics, electronics, radioactive waste management, biomaterials, semiconductors, solar panels, and laboratory equipment manufacture.
These glasses exhibit distinct physicochemical, thermal, and optical characteristics, such as high refractive indices, low glass transition and melting temperatures, great electrical conductivity, and favourable chemical stability.
The objective of this study is to create and analyse novel bismuth-borate oxide-based glasses and investigate the structural properties of the glass network resulting from the incorporation of barium oxide (BaO). The glasses were analysed and verified using Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, X-ray diffraction (XRD), and differential scanning calorimetry (DSC). To investigate the physical characteristics of the provided samples, the density, molar volume, and specific physical parameters were assessed. Additionally, the surface morphology and chemical composition of the glasses were examined using a scanning electron microscope (SEM) and energy dispersive spectroscopy (EDX), while the X-ray photoelectron spectroscopy analysis (XPS) determined the surface composition, chemical state, and binding energies of each glass element.

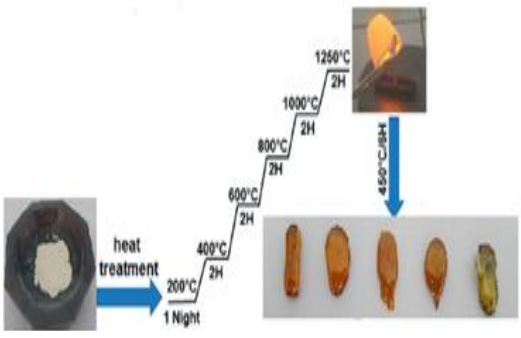


**Figure 1. Sample preparation steps**

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# Understanding the SEI layer formation at the electrolyte/electrode interface as a key solution to safer Li-ion batteries

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The urgent action to combat climate change is one of the Goals of the 2030 Agenda for Sustainable Development established by the UN organization. There is no doubt that the greenhouse gas emissions produced by the human activities are driving climate change. Turning to renewable sources of energy such as: sunlight and wind, is the best solution to fight the climate change. However, these sources are weather dependent which makes them intermittent. To overcome to this problem, the use of Energy Storage Systems (ESS) is capital. Among them, Li-ion batteries (LIBs) are the cornerstone for the usage of these sources of energy. They offer high capacity, energy and power and long cycle life. Nevertheless, this technology suffers some safety issues due to thermal runaway and mechanical abuse [1] leading to explosion and fire accidents [2-4]. The origins of thermal runaway are related to side reactions inside the battery.

For this reason, understanding the electrode/electrolyte interface is important to avoid such catastrophic results. Usually LIBs operate safely at ambient temperature; at low temperatures there is a risk of lithium plating and at high temperatures the breakdown of the Solid Electrolyte Interface (SEI) layer and the high reactivity of the electrolyte [5]. In fact, in our laboratory we try to understand the formation of the SEI layer at the surface of the electrode. This study is carried out by Electrochemical Impedance Spectroscopy (EIS). Figure 1 shows Nyquist plot before and after the 1$^{st}$ charge of the cell. After the 1$^{st}$ charge a new resistance due to the charge transfer appears, in addition to the increase of the SEI resistance.

During the CIMAE-2024, we will present a review about the formation of the SEI and how it affects the performances of the LIBs. In addition, we will expose and discuss in detail our results.

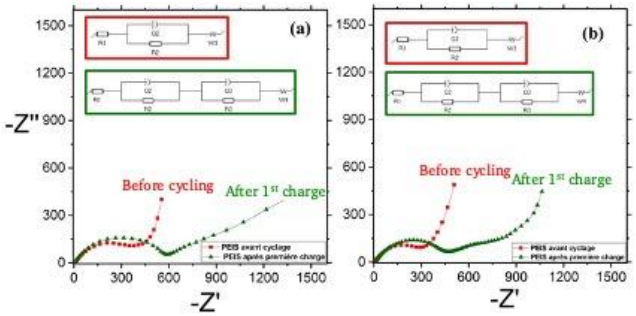


**Figure 1. Nyquist plot with the equivalent circuits of Li-metal cells before cycling and after the 1$^{st}$ charge, cathode materials: (a) $LiCo_{0.1}Ni_{0.45}Mn_{1.45}O_4$ and (b) $LiFe_{0.05}Ni_{0.475}Mn_{1.475}O_4$.**

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# Geochemical characterization and thermodynamic study of the scaling phenomenon in the hot spring water of Ain Skhouna in the Agadir region

Sara Darbal[*1], Mustapha Nassiri[1], Ilham Karmal[1], Mohamed El Housse[1], Said Ben-Aazza[1], M'barek Belaatar[1], Abdellah Hadfi[1] and Ali driouiche[1]

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The accumulation of scale in water transport pipes poses a significant problem with adverse economic consequences. This phenomenon occurs when surfaces come into contact with water considered as scaling, meaning it is capable of causing the formation of crystalline deposits, commonly known as scale. This phenomenon is more pronounced when it comes to hot water.

The hot spring Ain Skhouna is located approximately 7 kilometers north of Agadir, in the commune of Drarga, specifically in Douar Idoubella Tagadirt. This hot water is renowned for its therapeutic and healing properties. As part of diversifying tourist sites in the Agadir region, a project situated 10 km from the tourist zone of the city is currently underway. The project aims to harness the hot waters from the Ain Skhouna spring.

Currently, the pipes that transport hot water from the Ain Skhouna spring, either at the drilling site or towards a temporary basin, become clogged with scale after only a few weeks of operation.

Our study aims to find a solution to the scaling issue caused by the hot waters of the Ain Skhouna spring. This study involves the geochemical characterization and thermodynamic analysis of the scaling phenomenon in the hot waters of this spring, the subject of this presentation. The results of chemical analyses of the waters from the Ain Skhouna hot spring are represented on three types of diagrams: The Piper triangular diagram, the vertical logarithmic scale diagram by Schöeller-Berkaloff [1] and the stiff diagram. These representations indicate the presence of a calcic sulfate facies. The thermodynamic characterization of the scaling potential of the hot water from the Ain Skhouna spring was conducted using the Legrand-Poirier-Leroy (LPL) method [2] allowing us to determine the position of the hot water in relation to the calcareous-carbonic equilibrium, concluding that this water is of a calcifying type.

Keywords: Scaling, hot water, Ain Skhouna, geochemical characterization, thermodynamic characterization, scaling potential, calcifying potential.

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# Highly effective scale inhibition performance of green inhibitor on calcium carbonate

Ilham Karmal[1,2*], Jamila El Gaayda[2], Sara Darbal[1], Mustapha Nassiri[1], Said Ben Aazza[1], M'Barek Belattar[1], Rachid Ait Akbour[2] and Ali Driouiche[1]

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Water is one of the most vital substances for people and their activities and also a key element for ecosystems. In Morocco, water has become a concern for the southern regions due to repetitive droughts, the unequal distribution of rainfalls and the water resources they generate.
To overcome these problems, it is necessary to use other water resources and implement new production techniques to meet the needs of the growing population which implies the accelerated increase in water demand. Therefore, the use of brackish water demineralization is necessary to supply the TAN-TAN city by drinking water. This locality is endowed by the demineralization station of Khang Lahmam using reverse osmosis technology. This station is supplied with brackish water from boreholes located 80 km from the town. This demineralization unit produces drinking water with a flow rate of 1700 $m^3$/d. However, the problem of scaling of the filtration membranes used in this desalination unit is observed. Analysis of this tartar showed that it was mainly calcium carbonate ($CaCO_3$).
In this study, we examined the effectiveness of green inhibitor as a scale inhibitor for $CaCO_3$ as a function of pH and green inhibitor concentration. The relationship between pH and calcium carbonate formation parameters was evaluated by LCGE method, on pure Calco-carbonic water. We obtained the conclusion that the green inhibitor showed the exceptional performance of inhibiting the deposition of $CaCO_3$. The ability to prevent the formation of calcite at very low concentration, by deformed structures observed by Scanning Electron Microscopy images.

**Keywords:** Brackish water, Demineralization, Reverse osmosis, Green inhibitor, Calcium carbonate, LCGE method.

# Imidazole/pyridine-based derivative as a novel protectivity agent for mild steel corrosion in acidic solution: Comprehensive investigations

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## Abstract

Mild steel protection activity in hydrochloric acid poses an important industrial challenge. In this study, a new imidazole/pyridine derivative, i.e., 3-(imidazole[1,2-a]pyridine-2-yl)aniline (IPA), was synthesized, and its protectivity activity properties were evaluated using multifaceted comprehensive methods. Electrochemical measurements (PDP and EIS techniques) showed that IPA acted as a mixed-type protective agent with over 91% efficiency at a $10^{-3}$ M concentration. Thermodynamic analysis via activation parameters and adsorption modelling revealed the formation of an adherent protective layer on metal surface. SEM-EDX and UV–*Vis* spectroscopy validated protective film formation through adsorption and metal complexation. DFT calculations identified key functional groups actively donating electrons to steel surfaces. *Monte Carlo* simulations provided atomic-level insights into IPA's superior adsorption behavior. A combined approach established IPA as a promising green protective agent for acidized mild steel, with the potential applications in industrial areas utilizing hydrochloric acid, such as in acid pickling. By unveiling protection mechanisms at experimental and theoretical levels, this study facilitates protective agent design with optimized protective properties.

**Keywords**: Steel; Corrosion; Inhibitor; Acid; DFT; MCS; Protection.

# Insights into the [3+2] Cycloaddition Reaction: Unravelling Mechanism, Selectivity, Solvent, and Temperature Effects in the between N-Methyl-C-(2-furyl) Nitrone with Maleimide Derivatives through Molecular Electron Density Theor

Moulay Driss Mellaoui,[1] Khalid Abbiche,[1,2,*] Nivedita Acharjee,[3] Abdallah Imjjad,[1] Jamal Koubachi,[2] Abdellatif El Hammadi,[2] Hassan Bourzi,[1] Souad El Issami,[1] Majdi Hochlaf,[4,*] and Hanane Zejli,[1]

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In this study, the [3+2] cycloaddition (32CA) reactions of N-methyl-C-(2-furyl) nitrone with maleimide derivatives were systematically examined in the gas phase, ethanol, and acetonitrile using the Molecular Electron Density Theory (MEDT) framework at the B3LYP-D3/6-31G(d) level. Through topological analysis, the nitrone was identified as a zwitterionic (zw-) three-atom component (TAC) with a high-energy barrier. Remarkably, global electron density transfer (GEDT) analysis revealed a low polar character of forward electron density transfer (FEDF) with an electronic flux from the nitrone to the maleimides, resulting in reduced activation parameters compared to nitrone cycloadditions with simple alkenes. The reactions followed a one-step mechanism under kinetic control, featuring highly asynchronous bond formation with no new covalent bonds at the transition states. Predicted exo-selectivity aligned well with experimental observations. Solvent effects, especially along the endo pathway, increased activation energy. The study also explored temperature influences at 289.15 K, 298.15 K, and 393.15 K. Non-covalent interactions (NCIs) were identified at transition states using the atoms-in-molecules (AIM) method, and Independent Gradient Model (IGM) analysis characterized these interactions, offering comprehensive insights into the intricate details of the cycloaddition reactions and their environmental dependencies.

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# Development and Characterization of an Organic-Modified HDL-Type Synthetic Clay and Its Application for Rhodamine B Adsorption

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This research delves into the adsorption of Rhodamine B (RhB) from aqueous solutions using MgZnAl-layered double hydroxides (LDHs) that have been organically modified through a coprecipitation method. Initially synthesized using the coprecipitation method, these LDH materials underwent additional organic modification with dextrose. This dual modification highlights the potential enhancements in adsorption capabilities

The resulting modified LDH samples underwent detailed characterization using techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). These analyses offered valuable insights into the structural properties and surface modifications of the organically modified LDHs.

Moving forward, batch adsorption experiments were conducted to evaluate the adsorption performance of the dextrose-modified MgZnAl-LDHs with respect to RhB. The study systematically investigated various parameters, including initial dye concentration, pH, contact time, and temperature. The analysis of adsorption isotherms and kinetics aimed to comprehend the equilibrium and rate of RhB uptake by the organically modified LDHs.

The Langmuir isotherm model fitting well with the experimental data indicates monolayer adsorption on the organically modified LDH surfaces. The kinetics of the adsorption process, following a pseudo-second-order model, suggests chemisorption as the primary mechanism. Thermodynamic analysis reveals the spontaneous and exothermic nature of the adsorption process.

In summary, this study provides critical insights into the potential of dextrose-modified LDHs, synthesized through a coprecipitation method, as efficient adsorbents for RhB removal.

**Keywords:** Layered Double Hydroxides, Adsorption, Dextrose, Pollutants, Rhodamine B.

# Removal of Crystal violet dye from water using different algal-based adsorbents: A comparative study

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**Abstract**

The production and industrial use of dyes generate a large amount of colored effluents. The synthetic dyes are often non-biodegradable and toxic. Therefore, an intervention is necessary to treat the effluents loaded by synthetic dyes. Adsorption is the most important technology in addressing water pollution problems and protecting the environment by using absorbent materials. In this work, we perform a comparison between the untreated red (RS) and brown (BS) seaweed and their cirtic acid modified forms (RS-CA and BS-CA) as absorbent materials for removal of Crystal violet (CV) from aqueous solutions. For all studied adsorbent, the optimum CV removal was obtained at pH 6.5, CV concentration of 20 mg/l, adsorbent dose of 1g/l, equilibrium time of 60 min and 20 °C. The electrostatic interactions play an important role in the CV adsorption mechanism. The maximum adsorption capacities of BS, RS, BS@CA and RS@CA for CV dye removal reached 147, 150, 274, 224 mg/g, respectively. The functionalization of algal biomass by citric acid plays a critical role in the CV dye removal. Results also suggested that the CV adsorption was exothermic. In summary, BS, RS, BS@CA and RS@CA could be used as potential adsorbent materials to remove CV dye from wastewater.

# Study of the Adsorption of $Cu^{2+}$ and $Pb^{2+}$ using a bio-adsorbent based on functionalized porous carbon

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Background: To validate theoretically the experimental results of absorption efficiency of amine-functionalized porous carbon for the elimination of $Cu^{2+}$ ions and $Pb^{2+}$ and detail the reaction mechanism in the aqueous medium [1]. The current study was carried out by determining structural and energetic parameters. The Density Functional Theory calculations, molecular dynamics, and *Monte Carlo* simulations were used to investigate the absorption enhancement mechanism [2]. The calculations were performed using the Dmol3 module of the Materials Studio program (MatS) using the exchange-correlation function M-11L2. DFT calculations were determined for porous carbon (PC) and porous carbon functionalized by ethylene diamine (PC-ED). Indeed, this study aims to reveal the functionalization influence on improving the adsorption efficiency of $Cu^{2+}$ and $Pb^{2+}$ by porous carbon (PC). Overall, the study attempts to explain the experimental results of the improved interactivity of porous carbon functionalized by ethylene diamine concerning $Cu^{2+}$ and $Pb^{2+}$ ions, compared to the reactivity of these ions with the group carboxyl characterizes the porous carbon (PC). The Molecular dynamics and *Monte Carlo* simulations were used for more clarification of the interactions between $Cu^{2+}$ or $Pb^{2+}$ ions and porous carbon modelled in the presence or absence of ethylene diamine (PC–ED) function. The theoretical results obtained agree with the experimental results.

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# Polypyrrole as pretreatment for metal electroplating of acrylonitrile-butadiene-styrene (ABS)

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The present work concerns the development of a new metallization process of acrylonitrile butadiene styrene (ABS) plastics without any chromium or palladium pretreatment used in the conventional industrial metallization process. The process developed in our work consists to treat previously the ABS substrates by polypyrrole coatings to transform the plastic into a conductive state, followed by direct copper metallization. The adhesion of PPy coatings on the ABS substrates was improved using two groups of the ABS surface pretreatment (grinding process and chemical etching based on sulfuric acid, with hydrogen peroxide, replacing chromic acid, as oxidant) and estimated to 100%. Surface roughness, scanning electron microscopy (SEM), water contact angle measurements (WCA), and X-ray photoelectron spectroscopy (XPS) analysis were examined to characterize the ABS surface before and after treatment. The electric conductivity of polypyrrole coatings was enhanced by incorporation of silver particles into the PPy skeletons, and the electrodeposition of PPy doped with dodecyl sulphate anions on PPy/ABS using cyclic voltammetry. As a last step, a homogeneous and compact copper coatings were prepared on different coatings (PPy/ABS, Ag/PPy/ABS, and DS/PPy/ABS) by galvanostatic technique. Different coatings have been characterized to investigate their morphology, thickness, electric conductivity, surface roughness, wettability and chemical properties, using SEM, confocal microscopy, four point probe method, non-contact profilometer, contact angle measurement, energy dispersive X-ray spectroscopy, raman spectroscopy and XPS analysis, respectively.

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# Enhancement of three curcumin derivatives as E6co-friendlies corrosion inhibitors for carbon steel in HCl solution

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**Abstract**

Acid solutions are generally used for the removal of undesirable scale and rust in several industrial processes. Hydrochloric and sulphuric acids are widely used in the pickling processes of metals. The use of inhibitors is the most practical methods of protection against corrosion, especially in acidic solutions. Large numbers of organic compounds were studied and are being studied to investigate here corrosion inhibition potential. But, most of them are highly toxic to human beings and has the potential to degrade the environment. The known hazardous effects of most synthetic organic inhibitors and restrictive environmental regulations have compelled and motivated researchers to focus on the need to develop cheap, non-toxic and environmentally benign natural products as corrosion inhibitors.

Three Curcumin Derivatives: Chloride, Fluoride and Dichloride are investigated as corrosion inhibitors for carbon steel in HCl solution using impedance spectroscopy, polarization curves measurement, and SEM studies. Polarization curves showed that the three Curcumin derivatives behave as mixed-type inhibitors. EIS spectra exhibit one capacitive loop and confirm the inhibitive ability. The effect of concentration and temperature for Curcumin Dichloride on the corrosion behavior of carbon steel in 1M HCl was also studied and a Langmuir adsorption isotherm was found.

**Keywords:** Corrosion, Steel, Inhibitors, Curcumin derivatives, Langmuir.

# Biosorption of Cadmium (II) from Aqueous Solutions Using Green Algae Biomass

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This study explores the efficacy of green biomass algae as a biosorbent for the removal of cadmium (II) ions from aqueous solutions. A series of batch biosorption experiments were systematically conducted, manipulating key parameters including initial pH, biosorbent dose, initial cadmium (II) ions concentration, contact time, and temperature, in order to identify optimal conditions for the biosorption process. Cadmium (II) ion quantification was performed using Atomic Absorption Spectroscopy (AAS). Results reveal a significant biosorption capacity of green biomass algae for cadmium (II), achieving a maximum biosorption efficiency of 95.04% at solution pH of 4, biosorbent dose of 25 mg/L, contact time of 30 minutes, and a temperature of 20 °C. Equilibrium biosorption data were analyzed utilizing Langmuir and Freundlich isotherm models. Kinetic studies, employing pseudo-first-order and pseudo-second-order models, as well as intraparticle diffusion, were undertaken to describe adsorption kinetics. The findings of this study not only advance our understanding of the biosorption capabilities of raw green algae but also offer a promising and cost-effective strategy for cadmium (II) removal from aqueous solutions with potential applications in environmental remediation and wastewater treatment.

**Keywords:** Cadmium; Green biomass algae; Biosorption; Kinetics; Equilibrium

# Efficient removal of crystal violet dye from aqueous solutions using sodium hydroxide modified avocado shells: kinetics and isotherms modeling

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***Key words:*** *adsorption, avocado shells, crystal violet dye, isotherms, kinetics*

The presence of chemical compounds such as dyes in aquatic environments constitutes a serious environmental problem due to their harmful effects on human health and biodiversity [1]. Among various coloring pollutants, crystal violet (CV) dye, a synthetic basic cationic dye, imparts a purple color to an aqueous solution.
The aim of this work is to investigate the adsorption performance of crystal violet (CV) dye from aqueous solutions employing avocado shells (AS) and sodium hydroxide-modified avocado shells (NaOH-AS). The as-prepared adsorbents were characterized by scanning-electron-microscopy (SEM), X-ray energy dispersive spectroscopy (EDS) and Fourier transforms infrared (FT-IR) spectroscopy, and used to remove crystal violet dye from wastewater. Batch tests were performed as a function of adsorbent dosage, pH, contact time, interfering ions and initial CV dye concentration. Experimental results show that the kinetic model of pseudo-second-order and Freundlich isotherm provided a good fitting of the whole experimental data. The results revealed that the as-prepared avocado shells (AS) and sodium hydroxide-modified avocado shells (NaOH-AS), has the potential to be applied as a low-cost adsorbents for the adsorption of CV dye from aqueous media.

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# Application of Biopolymer (carboxymethyl starch CMS) as corrosion inhibitor of metallic materials

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**Abstract:**
The corrosion of metallic materials engenders irreversible damage that can cause the degradation of the environment quality, harm human health and lead to considerable economic losses. From an economic perspective, it is estimated (worldwide) that savings between 15% and 35% of the cost of corrosion could be achieved, or between 375 and 875 billion US dollars per year. Concerning just the steel material the numbers indicate that 158 million tons of steel are lost per year which is equivalent to five tons per second [1, 2] Controlling the corrosion phenomenon could reduce the cost by 20 to 25% by applying specific corrosion control processes and technologies [1, 3]. Natural polysaccharides are biopolymers that exist as biochemicals in living systems [4]. These are the most abundant renewable materials in natural resources. A wide variety of them have been used in various hardware applications [5]. The use of Biopolymers as organic corrosion inhibitors has recently attracted considerable attention, due to the presence of multiple adsorption sites along their macromolecule, the ability to form complexes with metal ions and their stability with metals in acidic media [6], these biopolymers being surfactants with a strong chelation capacity with metals [7]. They can donate electrons to the unoccupied orbital of the metal surface to form covalent bonds and can also accept free electrons from the metal surface using their antibacterial orbitals to form back bonds. For this, they form complexes with a metallic surface that occupy a large area and are excellent corrosion inhibitors. The objective of this work is to evaluate the inhibitory power of biopolymer (carboxymethyl starch) with respect to the metallic copper corrosion in an acidic medium; Experimental and theoretical study.

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**Keywords**: Biopolymer; Corrosion; Inhibition; metallic material; acid medium.

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# PRESENTATIONS ORALES

## THEME 2 : TRAITEMENT ET VALORISATION DES DECHETS SOLIDES

# Marine Biomass-Supported Zinc Oxide for anionic dye Removal: Synthesis Characterization and Adsorption Study

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The ability of Marine Biomass-supported Zinc Oxide (CT/ZnO) biocomposite has been tested for the removal of Congo Red (CR) from an aqueous solution. The biomaterial characteristics were analyzed, and X-ray diffraction (XRD) results confirmed the presence of peaks associated with zinc oxide and calcium carbonate. The optimum conditions for the effective removal of CR onto CT/ZnO are pH= 6, initial CR concentration= 50 mg/L, nanocomposite dosage= 20 mg, contact time= 90 min and temperature= 25°C. Adsorption isotherm studies and kinetic studies were done. Freundlich isotherm fits with the experimental data very well with high coefficient of determination ($R^2$ = 0.984) and the experimental maximum dye uptake was 69.43 mg/g. In kinetic studies, pseudo second-order model was obeyed ($R^2$ = 0.998). Thermodynamic properties were assessed, demonstrating the spontaneous and exothermic nature of the adsorption process, accompanied by an increase in randomness. Desorption studies illustrated the bioadsorbent effective reusability for up to four cycles. In conclusion, the CT/ZnO biocomposite proved to be a highly efficient, recyclable, and cost-effective adsorbent for treating dye-contaminated water.

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# Valorisation et recyclage de la saumure rejetée par les stations de dessalement.

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**Résumé:**

Les usines de dessalement ont connu une expansion considérable au cours de la dernière décennie, car les besoins en eau potable augmentent avec la croissance démographique. L'élimination ou la gestion de la saumure de dessalement (concentré) représente des défis environnementaux majeurs pour la plupart des usines, et elle devient de plus en plus coûteuse. Le rejet saumâtre a le pouvoir de déstabiliser les conditions locales de l'eau de mer, telles que la salinité constitue une menace importante pour la vie marine. Il est donc nécessaire de trouver un moyen de valoriser ces saumures avant leur élimination afin d'atténuer leur impact nocif sur l'environnement.

Le présent travail étudie deux approches, la première basée sur la production des produits chimiques utiles comme le carbonate de calcium ($CaCO_3$), bicarbonate de sodium $NaHCO_3$,… à partir des milliers des tonnes des saumures rejetées chaque jour par les stations de dessalement au Maroc. La deuxième approche consiste à la valorisation de ces produits chimiques par leur utilisation en post traitement au sein des stations de dessalement : application à la réutilisation de $CaCO_3$ récupéré en reminéralisation du perméat.

La première étude montre que l'ajout de la chaux $Ca(OH)_2$ et le gaz carbonique $CO_2$ aux saumures permet de la précipitation de $CaCO_3$, et la masse obtenue augmente au fur et à mesure avec l'augmentation des deux réactifs ajoutés. Les forts débits de $CO_2$ conduisent à une réduction remarquable de la salinité des saumures rejetées et par la suite favorise la protection de l'écosystème aquatique.

La deuxième étude est consacrée à la reminéralisation de l'eau osmosée (perméat) sur lit calcite pilote à l'échelle du laboratoire, rempli par une quantité de $CaCO_3$ récupérée. La reminéralisation est liée aux plusieurs paramètres tels que la vitesse et le débit de passage de perméat dans ce filtre et leur épaisseur. La reminéralisation par $CaCO_3$ récupérée permette de rendre l'eau à son équilibre calco-carbonique et la mettre sous la norme de potabilité.

**Points Forts :**

- La récupération de 17g de $CaCO_3$ à partir de 10g de la chaux et un débit de 1L/min de $CO_2$.
- La salinité de la saumure est diminuée de 42000 ppm à 35200 ppm (17% de réduction).
- La reminéralisation par $CaCO_3$ récupérée est plus efficace que la chaux.
- Cette valorisation des saumures permet de créer un bouclage de reminéralisation à l'intérieur de la station de dessalement.

**Mots Clés :**

- Reminéralisation, saumures, précipitation $CaCO_3$, la chaux, le gaz carbonique, équilibre calco-carbonique

# Creating a novel polyaniline@oak acorn biocomposite designed to eliminate Orange G dye from water-based solutions effectively.

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**Abstract:**

In this study, the aim was to develop a novel biocomposite by merging polyaniline (PANI) with oak acorn, enhancing the removal of Orange G dye from water-based solutions. The process was cost-effective and straightforward, involving detailed structural and chemical analysis using techniques like BET, TGA, FTIR, X-ray EDS, and SEM. Fine-tuning the adsorption process by exploring factors such as adsorbent amount, pH, contact time, initial dye concentration, and temperature revealed the PANI@oak acorn biocomposite's high adsorption capacity and swift dye removal, following a chemisorption-dominated pseudo-second-order kinetic model. The Langmuir isotherm model affirmed monolayer adsorption on the biocomposite surface, highlighting its efficacy in capturing dye molecules. Precisely quantified at 172.67 mg/g, the biocomposite's maximum adsorption capacity showcased its potential for dye removal. Its reusability across multiple cycles without efficiency loss added practical value. Overall, this research solidifies the PANI@oak acorn biocomposite as a potent adsorbent for Orange G dye removal, coupling easily available oak acorns with PANI for an eco-friendly water treatment approach. Thermodynamic calculations of $\Delta G^{o}$, $\Delta H^{o}$, and $\Delta S^{o}$ further elucidated the process's energetics and spontaneity, enhancing comprehension of biocomposite-dye interactions.

**Figure 1 . the use of PANI@OA to remove OG dye.**

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# Optimisation écologique du béton autoplaçant : des approches constructives pour un impact environnemental réduit

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Le béton autoplaçant (BAP) est un matériau de construction largement utilisé en raison de sa facilité de mise en œuvre et de sa résistance. Cependant, sa production et son utilisation peuvent avoir un impact significatif sur l'environnement et la santé humaine. Dans cet article, nous examinons différentes approches constructives soutenables pour optimiser le BAP, tout en minimisant son impact environnemental et en garantissant la sécurité des travailleurs.

Nous proposons d'utiliser des matériaux recyclés comme substitut partiel du ciment dans le BAP permettant ainsi une diminution des émissions de $CO_2$ liées à la production du ciment. Cette réduction peut être obtenue grâce à une conception appropriée du mélange et à l'utilisation d'adjuvants de haute performance. De plus, le béton autoplaçant écologique intègre souvent des granulats recyclables ou des déchets industriels comme remplissage, ce qui contribue à la réduction des déchets tout en préservant les ressources naturelles.

Ainsi, la compréhension des approches proposées sera fondée sur une caractérisation rhéologique et mécanique des BAP à base de granulats de caoutchouc.

# Exploring the Potential of Argan Shell-Derived Phosphorylated lignocellulose in the formulation of Wood Adhesive

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**Abstract:** The growing awareness of the environmental and health consequences associated with formaldehyde-based wood adhesives has prompted an urgent demand for alternative adhesive solutions. Lignocellulosic biomass, derived from renewable sources such as agricultural residues offers a promising and sustainable solution as an alternative to formaldehyde-based wood adhesives. The objective of our study is to explore the unexplored potential of the abundant Moroccan Argan Shell by-product (AS), with the specific aim of maximizing its value in the formulation of wood adhesive. For this purpose, chemical treatments, including hydrolysis and phosphorylation, were performed to AS in order to produce phosphorylated Argan Shell (P-AS). To investigate the success of phosphorylation, the prepared samples were characterized using Scanning Electron Microscopy and element mapping, Fourier Transform Infrared Spectroscopy, X-ray diffraction, Thermogravimetric Analysis, Conductometric Titration, Degree of Substitution and contact angle measurements. Afterword, the effect of different ratios of AS and P-AS on the ultimate particleboard's mechanical properties such as dry internal bond, modulus of rupture, modulus of elasticity and surface soundness was investigated and compared to the European Standards.

**Keywords:** Wood adhesives, Lignocellulose, Argan, Phosphorylation.

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# Analyzing the Adsorption of Methylene Blue Dye on Biochars Chemically Activated with KOH/HNO3 across Diverse Pyrolysis Temperatures: A Comparative Study

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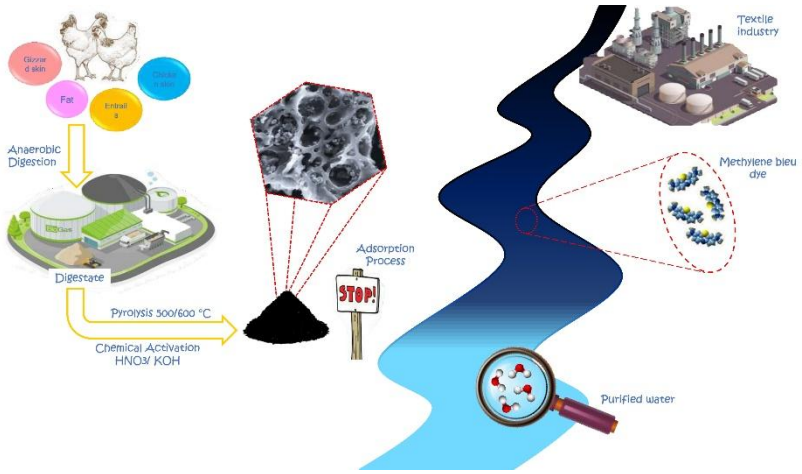
## ABSTRACT

This study sought to investigate the influence of activating activated carbon derived from digestate, obtained through the anaerobic digestion process of poultry by-product pyrolysis at temperatures of 500 and 600 °C, utilizing caustic potash and nitric acid. The primary objective was to evaluate the efficacy of the resulting activated carbon in the removal of methylene blue dye (MB) from water through the process of adsorption. Structural and chemical characteristics of the produced activated carbon adsorbents were scrutinized employing X-ray diffraction (XRD) spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, and scanning electron microscopy (SEM) in tandem with energy-dispersive X-ray spectroscopy (EDX). Optimal conditions for substantial MB dye removal from the aqueous solution were identified as a pH value of 10, an adsorbent dose of 0.6 g/L, a contact time of 20 minutes, and an initial dye concentration of 300 mg/L. Among the examined adsorbents, BC500@HNO3 demonstrated the highest adsorption capacity, reaching a maximum value of 101 mg/g. Kinetic analysis disclosed that the adsorption process adhered to the pseudo-second-order kinetic model. BC600@KOH exhibited the highest reaction rate constant of 0.058, coupled with a robust correlation coefficient value of 0.9997. The adsorption behavior of MB was well elucidated by the Freundlich isotherm model, indicating multilayer adsorption.




Keywords: Biochar, Activation, Adsorption, dyes, water treatment.

# Development of environmentally friendly fired clay materials: a comprehensive review of biomass waste incorporation

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The construction industry is an energy-consuming sector and an environmental polluter. To reduce associated greenhouse gas emissions, it is necessary to embrace environmentally friendly and sustainable building materials. Recent years have witnessed a growing interest among researchers in incorporating lignocellulosic biomass waste into clay bricks as a pore-forming agent during the production of fired clay bricks. Over the years, clay has been recognized as a powerful material for construction. The clays used as raw materials for manufacturing clay products are classified as non-renewable resources. In this perspective, the study of the impact of lignocellulosic biomass waste on the properties of clay materials holds promise for more sustainable management of clay quarries. Additionally, it represents a crucial initial step in assessing the influence of these materials not only on energy consumption but also on indoor comfort. This study examines the effect of lignocellulosic biomass waste as a pore-forming agent on the thermal properties of fired clay bricks used in construction. The bricks are produced by varying the percentages incorporated of lignocellulosic biomass waste and firing them at high temperatures. The pores appear in the clay bricks during the firing process, resulting in lightweight and sustainable building materials and enhancing thermal performance and promotes the use of energy-efficient materials. This innovative approach not only contributes to reducing environmental impact but also aligns with objectives aimed of producing more sustainable and efficient construction practices.

# Investigation of the Anti-Scaling Performance of Salvia Officinalis Extract as an Eco-Friendly and Sustainable Inhibitor for Water Distribution Systems: Experimental and Theoretical Approach

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The prevention or minimization of scale deposits in water distribution equipment, using environmentally friendly inhibitors, is an ongoing challenge [1,2]. With this in mind, the present work aims to investigate the performance of *Salvia Officinalis* extract as sustainable and highly effective green scale inhibitors. A chemical approach is employed to investigate the inhibition efficiency of Salvia Officinalis extract against calcium carbonate scale using the conductivity test and LCGE technique at a temperature of 25°C [3]. The calcium carbonate inhibition mechanism is then investigated via scanning electron microscopy (SEM) and X-ray diffraction (XRD). The experimental findings were further supported by density functional theory (DFT) calculations and Monte Carlo (MC) simulations. Experimental results showed that the tested inhibitor exhibited better anti-scaling performance, with an effective anti-scaling concentration of 62 $mg.L^{-1}$. Micrographic SEM and XRD diffractograms revealed that the addition of a scaling inhibitor resulted in an obvious change in the morphology and crystalline phases of scaling. Furthermore, the computational approach adopted supports the experimental results well. Thus, *Salvia Officinalis* extract could be valorized as a potentially valuable source of green and inexpensive scale inhibitors.

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# Development of new high-performance phosphogypsum-based cementitious materials for cementing in civil engineering applications

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**Abstract**
Research on the utilization of reclaimed phosphogypsum (PG) waste in cement industry applications worldwide due to increased efforts to promote environmental conservation and sustainable development [1-3]. New cement prepared from PG waste and clinker can still be considered as a rigid pavement material when its flexural and compressive strengths are improved adequately to support future traffic loads. In this study, waste (PG), a water-soluble calcium sulfate dihydrate, was used to improve the flexural and compressive strengths of the new cement. The influence of the types of gypsum on clinker (Gypsum type/C) and the water/cement ratios (w/c) on the compressive and flexural strengths of the new cement were studied by scanning electron microscopy (SEM). ) and X-ray diffraction (XRD). It was found that gypsum retards the hydration process, resulting in a delay in the initial process and final setting times of the cement paste, thereby reducing the compressive strength. For all w/c ratios tested, the flexural strength increased with decreasing w/c ratios up to an optimal w/c ratio that provided the highest flexural strength, followed by a subsequent decrease beyond of this maximum value. The optimal ratio w/c, being 0.35. The result of this research confirms the viability of using PG to improve the flexural and compressive strengths of the new cement in order to use it as a rigid and durable pavement material.

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# Obtaining nano calcium fluoride and ammonium sulfate from phosphogypsum

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Abstract: This study introduces an efficient and sustainable approach to convert phosphogypsum (PG) waste, in conjunction with hydrofluoric acid (HF) and ammonia ($NH_3$), into valuable materials. The results demonstrate the high efficacy of this proposed method, yielding relatively pure calcium fluoride ($CaF_2$) nanoparticles and ammonium sulfate ($(NH_4)_2SO_4$). The latter is recommended for agricultural use as a fertilizer, while the obtained $CaF_2$ can be applied in the metallurgical industry. Additionally, this procedure not only addresses the challenge of reducing fluorine gas emissions and managing PG waste but also plays a role in the responsible utilization of fluorite reserves.

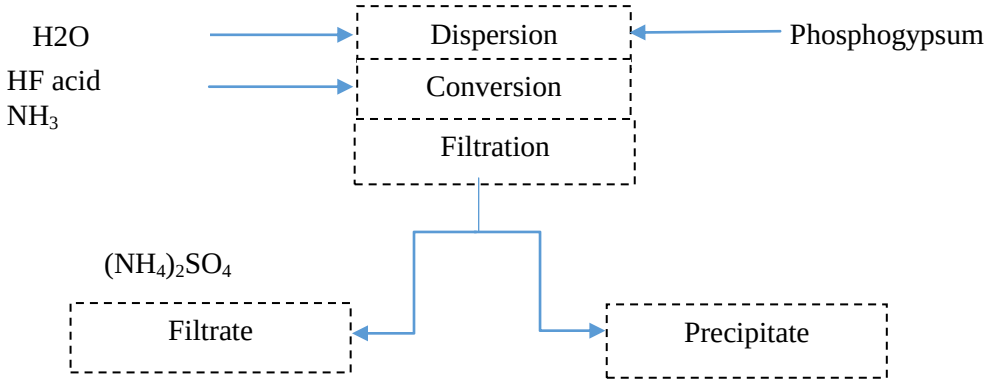


**Figure 1. Diagram of the procedure for converting PG**

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# Highly efficient bio-based nanoporous α-chitin-protein SE-CP macro-hierarchical nanofibers with significant stability and reusability for enhanced dye removal in aquatic environments

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**Abstract**

A shrimp shell-derived chitin complex was tested for its ability to biosorb two low-cost dyes: Acid Red 337 (AR) and the 1:2 chromic complex of Acid Blue 349 (AB). Among the factors taken into account were biosorbent characteristics, dye concentration, contact time and working pH. The SEM images of the biosorbent show different morphologies and pore structures. FTIR spectra of the biosorbent show the presence of chitin. Highest biosorption of the AR dye compared to the AB dye for all sorbents. Outstanding biosorption capacity for red and blue acids, with maximum adsorption capacities in excess of 160.99 mg/g. The kinetics of adsorption obey the pseudo-second-order model. The Freundlich model best matches the experimental sorption isotherms. Based on these processes, we have been able to clean up industrial wastewater and prove the value of chitin as an effective biopolymer in a number of fields of application. Both chemical preparation and functionalization methods, as well as characterization techniques, have enabled us to solve this problem successfully. The current study suggests that the sorbent derived from the wastes studied is effective in removing low-molecular-weight acid dyes from water.

**Keywords**: shrimp waste, biosorption, anionic dyes, biosorption, chitin, kinetic isotherm.

# New Process to prepare chloride-free KNS compound fertilizers from phosphogypsum waste using a $K^+$, $NH_4^+$ / $Cl^-$, $SO_4^{2-}$- $H_2O$ quaternary phase diagram

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It is well known that every year the phosphate industry plants produce a large quantity of phosphogypsum waste (PG) around the world (i.e., Currently, global production of this waste is estimated at 300 Mt/ year), but the valorization processes of this waste are limited and low valuable. In this study, we investigated the recycling of PG, which can be considered very promising sources of sulfate ions ($SO_4^{2-}$) for the manufacturing of chloride-free KNS compound fertilizers based on potassium-ammonium sulfate ($[K_{1-x}(NH_4)_x]_2SO_4$). The primary objective of this study was to develop a methodology for KNS synthesis and its separation process using the quaternary phase diagram $K^+$, $NH_4^+$ / $Cl^-$, $SO_4^{2-}$- $H_2O$ at 25 ◦C. The experiment results show that it is possible to recover relatively pure $(NH_4)_2SO_4$ from PG to re-synthesize in presence of KCl the KNS phase, whose high quality and purity were confirmed by the combined use of several analytical and characterization techniques such as XRD, SEM, EDS, and gamma spectrometry analysis. The main findings of this study may assist in developing methods for valorizing PG waste by converting it into valuable fertilizer products, which are particularly suitable for cultivating chloride-sensitive crops. Thus, total or partial substitution of non-renewable resources by PG not only helps to solve the environmental pollution caused by this waste, but also reduces production costs and improves farm economics.

**Keywords:** Chloride-sensitive crops, Fertilizer, KNS phase, Phase diagram, Phosphogypsum.

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# Harnessing carbon-based material from food waste digestate for dye adsorption: the role of hydrogel beads in enhancing stability and regenerative capacity

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This study focuses on both ecological and economic gains from food waste treatment. Accordingly, anaerobic digestion and adsorption have been combined to achieve these goals, resulting in synergistic effects that improve productivity. Firstly, a considerable amount of methane (energy source) was produced by the anaerobic digestion of food waste (FW) under mesophilic conditions (38 °C), resulting in a biologically activated digestate. Secondly, the residue of anaerobic digestion (digestate) was utilized as raw material to design two types of low-cost adsorbents for dye removal: a carbon-based material (CM-$HNO_3$) and an alginate encapsulated carbon-based material (CM-$HNO_3$@Alginate beads). We evaluated the adsorption capacity of the designed carbon materials to eliminate the target pollutant methylene blue (MB) from aqueous solutions. The results show that the CM-$HNO_3$ and CM-$HNO_3$@Alginate beads present maximum dye adsorption capacities of 303.03 mg $g^{-1}$ and 212.77 mg $g^{-1}$, respectively. Further, the adsorption process was found to fit best to the Langmuir and pseudo-second-order kinetic models for both the adsorbents. In addition, the CM-$HNO_3$@Alginate beads exhibited good long-term stability, regenerative ability, and high mass recovery, indicating that this absorbent is suitable for frequent usage.

**Keywords:** anaerobic digestion, food waste, digestate, adsorption, alginate beads, dye removal.

# Preparation and characterization of geopolymer based Fly Ash for adsorption of methylene blue from aqueous solution

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## ABSTRACT

Fly ash is waste product resulting from the combustion of coal or organic matter in thermal furnace. The use of fly ash (FA) as raw material to form fly ash geopolymer (FAGP) can be beneficial in mitigating its negative environment impact and contributing towards a circular economy. Due to its chemical composition rich in silica and aluminum, the investigation of the FA properties as precursor for the formation of geopolymers through alkali activation has been studied [1,2]. The objective was to apply it in the elimination of pollutants from aqueous solutions. In order to enhance the physicochemical properties of prepared geopolymer we added to raw FA the mass of natural kaolinite that known by their prefect reaction with the alkali activation solution.

The structure and morphology of both the initial fly ash and prepared geopolymer samples were determined using the following characterization methods: X-ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM) coupled with an Energy Dispersive X-rays Spectroscopy (EDXS) to obtain the elemental compositions.

Both the FA and the FAGP were tested for the elimination of methylene blue (MB) from aqueous solutions. The obtained results were: 9.1 mg/g for FA and 30.0 mg/g for FAGP meaning a significantly adsorption capacity for the prepared FAGP geopolymer compared to the raw fly ash.

Keys words: Geopolymer; Fly Ash; adsorption; methylene blue.

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# Etude de l'impact de la bentonite sur l'optimisation du procédé de solidification des déchets radioactifs organiques liquides par cimentation

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Les déchets radioactifs résultant d'activités nucléaires doivent être gérés de manière sûre et durable depuis leur production jusqu'à leur stockage définitif. Au Maroc, les déchets radioactifs produits sont principalement des déchets de faible et moyenne activité tels que les déchets organiques liquides. La solidification est la méthode de traitement la plus utilisée à l'échelle internationale. Elle consiste à transformer les déchets liquides en une forme solide, plus facile à stocker et à contrôler. Le ciment est le matériau le plus utilisé pour cette opération, car il présente de nombreux avantages, notamment une résistance mécanique élevée, une mise en œuvre facile et peu coûteuse. L'objectif principal de cette étude est de mettre en évidence une nouvelle technique d'immobilisation des déchets organiques liquides. En tenant compte des formulations et des processus déjà explorés dans des études antérieures- l'impact de l'introduction de la bentonite comme ajout dans le procédé de solidification des déchets radioactifs liquides dans un mortier à base de ciment avec ajout de poudres de bentonite a été étudiée dans le présent travail. Des composites ciment/huile ont été préparés avec différentes fractions d'huile (16, 18 et 20 %) et différentes quantités de bentonite. Les tests de résistance à la compression des éprouvettes de déchets cimentés ont été réalisés à 7, 14, 21 et 28 jours de durcissement. Les résultats ont montré l'utilisation de la bentonite comme ajout dans la formulation de cimentation des déchets organiques liquides permet de développer les propriétés mécaniques du déchet cimenté.

**Mots clés :** Solidification, ciment, résistance mécanique, déchets liquides, bentonite.

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# Innovative Approach for phosphogypsum and brine wastes transformation into valuable fertilizers

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Water pollution, intensified by industries such as phosphate production and seawater desalination, necessitates innovative solutions for sustainable water management. This study addresses the environmental challenges posed by phosphogypsum (PG), a by-product of the phosphate fertilizer industry, and the brine water (BW) from desalination plants. Focusing on a dual approach, we investigate the valorization of both phosphogypsum and desalination brine rejects water to produce $K_2Mg\ (SO_4)_2.6H_2O$ fertilizer, a high demanded fertilizer compound for agriculture application. In this work, we precipitated $K_2SO_4$, $MgSO_4$ from phosphogypsum and brine respectively. And then by applying the ternary phase diagram of the $K^+$- $Mg^{2+}$ // $SO_4^{2-}$ - $H_2O$ system at 0 °C and 25 °C fertilizer $K_2MgSO_4.6H_2O$ guided by. The solid phases obtained in this work were confirmed by various techniques such as: XRD, SEM/EDS, IR, ATD/ATG. The results of this study show that this process is highly recommended as an effective way of treating this waste while preserving our environment. Thus, total or partial substitution of non-renewable resources by PG and BW not only helps to solve the environmental pollution caused by this waste, but also reduces production costs and improves farm economics.

Keywords: Phosphogypsum, Brine, Fertilizer, Environment, Conversion.

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# Biomaterial Innovation: Aquatic Antibiotic Purification with Fish-Scale Hydroxyapatite

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## Abstract

The utilization of hydroxyapatite extracted from fish scales and a composite material derived from hydroxyapatite modified with polypyrrole presents a groundbreaking solution for efficient antibiotic removal in batch adsorption processes. This innovative application of fish-derived hydroxyapatite and its composite not only tackles concerns regarding antibiotic pollution but also underscores sustainable resource utilization, addressing a pressing concern in water quality management. Both the hydroxyapatite and its composite exhibit exceptional adsorption properties, displaying high efficiency in removing antibiotics even at trace concentrations. Furthermore, the optimization of dosage and contact time parameters enhances the efficacy of these materials in antibiotic removal, paving the way for practical implementation in water treatment processes.

**Keywords:** Fish scales, Bio-hydroxyapatite, Polypyrrole, Antibiotic, Adsorption

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# Green synthesis of metallic and metallic oxide nanoparticles from saffron by-products extract

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The production of nanomaterials using safe, biological, and environmental methods is attracting increasing attention as an alternative to environmentally damaging chemical methods. In the present study, aqueous extracts of Moroccan saffron (Crocus Sativus L.) by-products were used for the first time as a green stabilizer and reductant agent to synthesize metallic and metallic oxides nanoparticles. The synthesized nanoparticles (cerium oxide nanoparticles, silver nanoparticles and chromium oxide nanoparticles) were analyzed using high-resolution scanning electron microscopy, X-ray diffraction, and Fourier transform infrared spectroscopy analysis. As results, FTIR showed that the green synthesized nanoparticles were coated with saffron plant secondary metabolites. The crystalline nature, the spherical shape, and the small size of green synthesized had been confirmed by XRD and SEM analysis. Besides, antibacterial activity results showed that the biosynthesized green synthesized nanoparticles exhibited strong inhibition activity compared to aqueous solution of metallic salts and aqueous extract of saffron by-products.

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# Recycling agricultural waste for environmental purposes: investigation into dye removal

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**Abstract**

Rhodamine B (RhB) is a commonly used cationic dye that finds broad application in a wide range of sectors, such as food, paper, jute, leather, and textiles. Approximately 20% of the overall dye utilized is anticipated to persist in the effluent during production [1]. Consequently, a substantial portion of this dye finds its way into the environment by releasing untreated effluents from these industries.

To address this issue, the current investigation delved into the adsorption potential of pomegranate peel to eliminate RhB in a batch system. Rigorous studies were conducted on the reactional parameters' effects, kinetics, and isotherm adsorption. The adsorption of RhB exhibited rapid rates, reaching equilibrium around 120 minutes, with an adsorption capacity nearing 15.81 mg/g at an initial dye concentration of 50 mg/L. To model the kinetics of RhB adsorption, two well-known models—pseudo-first order and pseudo-second order—were employed. Evaluating the $R^2$, RMSE, ARE, and $\chi^2$ values indicated that the pseudo-second order model offered a superior fit to the kinetic data. Furthermore, the outcomes revealed that intraparticle diffusion is not the sole rate-limiting step in RhB adsorption onto pomegranate peel. Additionally, the isotherm analysis disclosed that the Langmuir model provided a better fit to equilibrium data, and the maximum removal capacity according to this model was estimated to be 47.17 mg/g. These findings suggest that pomegranate peel has potential as an eco-friendly and cost-effective solution for Rhodamine B removal from industrial effluents.

**Keywords:** pomegranate peel, adsorption, dye removal, kinetics study, isotherm modeling

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# A comparative adsorption study of a cationic dye on three agricultural waste biomasses

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**Abstract**

Water pollution caused by industrial wastewater is a major environmental issue in many countries. This type of pollution can have serious consequences. Several physicochemical methods are used to combat it, including adsorption on biomasses. This study aims to compare the isotherms, kinetics, and thermodynamics of methylene blue adsorption on three different substrates: sugarcane bagasse, almond shell, and walnut shell. Also, the effects of various parameters were examined, such as contact time, initial concentration of the adsorbent dose, pH, and temperature.

The results show that walnut shell is the most effective agricultural waste for removing methylene blue (MB) from water. The optimization approach shows that sugarcane bagasse adsorbed 49.26 mg/g, walnut shell adsorbed 106.83 mg/g, and almond shell adsorbed 107.53 mg/g under optimum conditions of 127 tr/min, 25 °C, 60 min, 100 mg/L, and 0.1 g for stirring speed, temperature, contact time, initial MB concentration, and adsorbent dosage, respectively. The adsorption kinetics followed the pseudo-second order ($R^2$ = 0.99). The adsorption isotherm data were well-fit by the Langmuir model. The outcomes indicate that the walnut shell adsorbs methylene blue better than the other substrates. Furthermore, the thermodynamic parameters of the methylene blue adsorption on the three substrates show the exothermicity and spontaneity of all studied systems.

**Keywords:** wastewater, adsorption, methylene blue, sugarcane bagasse, almond shell, walnut shell

# Le Biogaz issue des Déchets agricoles : Solution Durable et opportunité économique pour la balance énergétique au Maroc.

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**Résumé :**

Au Maroc, l'agriculture est un secteur socio-économique très important qui génère environ 15 à 20 % de produit intérieur brut national. Ce secteur reste le premier pourvoyeur d'emplois au pays par excellence, plus de 42 % de la population marocaine vivant de ce secteur. Parmi les activités agricoles, nous trouvons l'élevage d'animaux, qui est l'un des piliers de l'agriculture nationale, car il représente 25 à 30 % du chiffre d'affaires agricole. Notre pays occupe la première place dans le podium d'élevage des poulets et des bovins dans la région du Maghreb, avec une production d'environ 195 millions de têtes de poulets et 3 millions de têtes bovines. Par contre, il occupe la deuxième place dans l'élevage des ovins et caprins avec 25 millions de têtes. Ainsi, nous pouvons constater que l'élevage des animaux est l'une des activités agricoles génératrices des bénéfices économiques pour agriculteur marocain.

Actuellement, cette activité agricole est coincée entre deux contraintes majeures : La première est de type environnemental, la production journalière de la viande, laits, des œufs génère une quantité énorme de déchets organiques qui polluent les écosystèmes. La deuxième contrainte est énergétique, les activités d'élevage nécessitent de l'énergie électrique et thermique pour répondre à leurs besoins. Avec l'augmentation des prix des produits énergétiques, l'approvisionnement est devenu difficile. Donc, ces deux contraintes (environnementale & énergétique) agissent négativement sur le fonctionnement économique et durable des éleveurs marocains.

Nous avons senti que nous sommes devant la nécessité de développer une solution biotechnologique qui combine la gestion durable, le traitement, la valorisation énergétique et

la production d'énergie verte à partir des résidus de cette activité agricole. D'où nous avons l'élaborer ce travail. Ce dernier est constitué de trois axes :

Nous avons commencé par la détermination et la comparaison des caractéristiques physiques, chimiques et microbiologiques (humidité, solides totaux, solides volatils, carbone organique, azote, métaux lourds, staphylocoques, coliformes, levures et champignons et bactéries mésophiles aérobies totales) des déchets organiques produisent dans les unités d'élevage marocaines. Nous avons choisi quatre types de déchets (la bouse de vache, de cheval, les fientes de poulets de chair et les excréments de souris et des rats des laboratoires universitaires). Afin de construire une base de données nationale.

Après, Nous avons déterminé la qualité d'énergie produite au cours de la combustion de ces déchets organiques par deux méthodes : Incinération (le pouvoir calorifique inférieur) et par le diagramme ternaire de Tanner, qui est basé sur les trois paramètres constitutifs (quantité de matière organique, cendres et humidité). Enfin, nous avons évalué la capacité de ces déchets à les utiliser comme bioressources pour la méthanisation et l'application agricole. Donc, j'ai identifié et comparé leurs potentiels en production biogaz, afin d'estimer leur utilisation comme source d'énergie verte dans les exploitations agricoles et les élevages.

Dans ce travail, Nous avons montré que les quatre déchets agricoles étudiés ont un pouvoir calorifique inférieur plus près les uns des autres et que la valorisation de ces déchets organiques par incinération est sans intérêt énergétique et économique. Le contenu microbiologique reflète la présence d'un réservoir de bactéries pathogènes qui nécessite une gestion et un circuit de traitement. D'autre part, le potentiel de biogaz montre que les bouses de vache produisent la plus grande quantité de biogaz. La codigestion est processus nécessaire pour les bouses de cheval, les fientes de poulet et les excréments de souris de laboratoire afin d'augmenter leur potentiel en biogaz. La composition minérale montre la possibilité d'utiliser le digestat (résidus de la méthanisation) de ces déchets comme amendements organiques des végétaux.

Nous pouvons conclure que la détermination du potentiel biogaz et de la composition minérale de ces déchets montre la possibilité de les utiliser comme substrats bioénergétiques capables de produire de l'énergie verte sous forme de biogaz. Ce dernier sera converti en chaleur et en électricité pour les bâtiments d'élevage et les activités agricoles telles que l'irrigation. Ainsi, les déchets d'élevage ne sont pas des problèmes mais ils sont un gisement énergétique qui ne cessent de se régénérer. Donc, la digestion anaérobie des déchets des fermes marocaines est une solution efficace pour enlever les deux contraintes (environnementale & énergétique).

# PRESENTATIONS ORALES

## THEME 3 : MATERIAUX POUR LA DETECTION ET TRAITEMENT DE LA POLLUTION

# Strontium substitution effects on the crystal structure, microstructure, optical and electronic properties of $Ba_{2-x}Sr_xBB'O_6$ (B/B'= Ti, Mn, Zr) double perovskites

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Various studies carried out since the fifties to the present, have revealed that the materials with perovskite structure exhibited a wide variety of physical and structural properties [1, 2]. But probably the reason that determined the intensification of studies on these compounds, is the discovery in recent years, for some of them the colossal magnetoresistance effect [3], studies for understanding and improving these properties are conducted all over the world. In this context, considerable interest has focused in recent years on double perovskites type $A_2BB'O_6$ (A= Ba, Sr, Ca… ; B = Ni, Mg, Fe, Zn … ; B'= W, Mo, Te… ; or B/B' = Ti, Mn, Zr).

In this work, we report that the compositions in the system $Ba_{2-x}Sr_xBB'O_6$ (B/B'= Ti, Mn, Zr) with $0 \leq x \leq 0.25$, were synthesized by the solid state reaction in polycrystalline form by thermal treatment, in air. Crystallographic analysis was performed by Rietveld refinement of experimental X-ray diffraction patterns. Results show that the solid solution system $Ba_{2-x}Sr_xBB'O_6$ (B/B'= Ti, Mn, Zr), remains as cubic perovskite in the marge of $0 \leq x \leq 0.25$, with $Pm\bar{3}m$ (no. 221) or $Fm\bar{3}m$ (no. 225) space group at room temperature. The surface characteristics and microstructure of the samples were studied by SEM images, while micrography and composition were determined by EDS analysis. Vibrational properties of the compounds were studied by FTIR spectroscopy. Furthermore, UV-visible spectroscopy technique was employed to study the optical properties and band gap of the obtained double perovskites.

**Keywords:** Double perovskite, Synthesis, Crystal structure, Rietveld refinement, Optical properties, Electronic properties.

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# UV-Visible light-driven photocatalytic degradation of organic pollutants by bismuth/Zinc phosphate heterojunction photocatalysts: kinetics, mechanism and degradation pathways.

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To improve the photocatalytic and/or photoluminescent properties, various strategies have been developed, including the formation of crystal defects, the formation of heterojunctions, the broadening of the absorption range and modification of band gaps by doping with active elements and the change in synthesis method. Among these different strategies, the presence of heterojunctions materials is an important factor for designing photocatalysts and improving their properties. In this context the heterojunction synthesized between $BiPO_4$ and $Zn_3(PO_4)_2$ show that the best degradation performance is obtained when using the $(1\text{-}x)Zn_3(PO_4)_2/x$ $BiPO_4$ ($x = 0.7$) composite catalyst [1]. $BiPO_4$ powders himself exhibit strong heterojunction between its hexagonal and monoclinic polymorphic forms, which also ensures a great improvement in photocatalytic properties [2].

In the case of heterojunction formed between $Zn_3(PO_4)$ and ZnO, the high photocatalytic activities refer to the 20% molar proportion in ZnO which was prepared by solid-state reaction ($0.8Zn_3(PO_4)_2/0.2ZnO$), this catalyst exhibited superior photocatalytic performance to effectively degrade RhB after only 4 h rather than $Zn_3(PO_4)_2$ in more than 5 h [3].

**Keywords:** $BiPO_4$, heterojunctions materials, organic pollutants, photocatalytic and photoluminescent properties.

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# Utilizing Box-Behnken Design to Optimize Nanofiltration Process Parameters for Enhanced Fluoride Removal Efficiency

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**Abstract**

Over the past two decades, the Box-Behnken Design (BBD) has solidified its position as a potent statistical method, effectively optimizing experiments by accurately estimating coefficients in a second-degree polynomial equation. When integrated with models like Response Surface Methodology (RSM), this approach is emerging as a pragmatic solution for modeling, predicting, and optimizing chemical processes, leading to substantial time and cost savings. In this investigation, Nanofiltration (NF) was applied to eliminate fluorides from groundwater containing NaF, utilizing three distinct membrane types: TR60, NF270, and NF90. To delineate the operational range of each tested NF membrane, a RSM approach based on the BBD was employed. This method delved into the impact of operational parameters, including the initial fluoride concentration (A), transmembrane pressure (B), and conversion rate (C), on the permeate quality, permeate flux, and energy consumption. The findings underscored that the initial fluoride concentration wielded the most substantial influence on permeate concentration, while transmembrane pressure predominantly dictated permeate flux. The conversion rate exhibited a limited effect on both parameters. Concerning energy consumption, both conversion rate and transmembrane pressure wielded significant influence, whereas the initial fluoride concentration had a marginal impact. Moreover, among the three membrane types, NF270 demonstrated superior efficiency, characterized by high permeate flux and low energy consumption. The optimal conditions for NF270 involved a pressure of 15 bars, a conversion rate of 0.9, and an initial fluoride concentration of 5.31 mg/L. Additionally, a second-order regression model aptly described the relationships between operational parameters and measured results, boasting a high coefficient of determination ($R^2 > 0.97$) for all three membranes studied.

**Keywords:** Nanofiltration; Fluoride removal; Response surface methodology; Box-Behnken; Optimization.

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# Leachate treatment by ceramic ultrafiltration membranes: Fouling mechanisms identification.

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Abstract

The treatment of leachate is a complex process that involves the use of various treatment methods in order to achieve acceptable quality levels. The objective of this study is to investigate the impact of transmembrane pressure (TMP) at a constant flow velocity (V=2m/s) on the treatment of leachate from the controlled landfill of Oum Azza, Rabat, Morocco, as well as on the fouling mechanism of three UF ceramic membranes (UF20, UF50, and UF100) with varying porosities of 20, 50, and 100 nm. The experiments were conducted using a semi-industrial pilot plant provided by the French company TIA, which was equipped with a ceramic membrane. Two mathematical models, the Hermia model and the Bolton model, were used to identify the fouling mechanisms of the tested membranes. The Hermia model provides four equations that describe the four fouling modes, namely cake formation, intermediate blockage, pore constriction, and complete blockage. Furthermore, the Bolton model combines these fouling mechanisms to determine whether fouling is caused by adsorption, occlusion, or compression of the filter layer. The results indicate that the permeate and rejection of pollution indicators (chemical oxygen demand (COD), 5-day biochemical oxygen demand (BOD5), and total suspended solids (TSS)) for the three tested membranes are affected by the transmembrane pressure (TMP). The UF20 membrane showed the best rejection rates, followed by UF50 and finally UF100. For permeate flow, UF100>UF50>UF20. According to the Hermia model, the fouling of all three membranes was superficial, with the main fouling mechanisms being cake formation or intermediate blockage. Application of the Bolton model equations revealed that fouling of the UF20 and UF50 membranes was described by the combined equation of cake formation and complete blockage. For the UF100 membrane, fouling was described by the combined equation of cake formation and intermediate blockage.

Keywords: Ultrafiltration; Leachate; Ceramic membrane fouling; Modeling; Hermia model; Bolton model; Transmembrane pressure.

# Biodegradation of textile dyes by laccase from *Trametes versicolor* immobilized on layered doubled hydroxide-biopolymers composites beads

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Laccase is an oxido-reductase known having applications in biomass valorization (lignin depolymerization), in fine chemicals (building-blocks synthesis) or in environment (wastewater treatment). It works with molecular oxygen and produces water as its only by-product. However, its practical application is far from satisfactory due to the low stability and poor reuse of free laccase. To overcome these challenges, a laccase from *Trametes versicolor* was immobilized onto layered double hydroxide and biopolymer composite beads. The activity of the immobilized biocatalyst was measured with ABTS model substrate and pollutants dyes. The effects of laccase concentration, pH, storage stability and thermal resistance of the samples were also studied. Immobilized laccase showed high efficiency in removing diazo dyes. In conclusion, these results suggest the use of immobilized laccase on LDH-biopolymer composite beads as a promising and environmentally friendly tool for the degradation of environmental pollutants, in particular for the removal of diazo dyes from wastewater.

**Keywords :** Laccase, immobilization, LDH, biopolymer, environmental application, wastewater

# A Comparative Study of the Performance of Polyaluminum Chloride-Sodium Alginate and Polyaluminum Chloride-Chitosan Composite Coagulants in Dam Water Treatment

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## Abstract

Polyaluminium chloride (PAC) combined with natural polyelectrolytes has received considerable attention for its outstanding characteristics in drinking water treatment. Nevertheless, no well-defined criteria exist for selecting appropriate polyelectrolytes to incorporate into PAC to enhance coagulation. To overcome this, we conducted a comparative study of PAC-SA (sodium alginate, anionic polyelectrolyte) and PAC-CTS (chitosan, cationic polyelectrolyte) composite coagulants for dam water treatment. We evaluated the distribution of aluminum forms in the composite coagulant, taking into account the nature and ratio of the polyelectrolytes. Using FTIR analysis and density functional theory (DFT), we visualized the intramolecular interaction between PACs and polyelectrolytes. Coagulation efficiency demonstrated a notable impact of polyelectrolyte viscosity and aluminum forms distribution in the removal of turbidity and oxidizable matter. PAC-SA performed better than PAC-CTS in removing colloidal suspensions, due to the higher viscosity of alginate, which enhances coagulation through interparticle bridging and trapping mechanisms. This study underlines the importance of polyelectrolyte viscosity and aluminum speciation in improving PAC-CTS efficiency.

**Keywords** : Density functional theory (DFT) · Polyelectrolyte viscosity · Aluminum speciation · Basicity · Colloidal suspension removal

# Electrocatalytic Effect of Ultraviolet (UV) on the Oxidation of Amoxicillin on Carbon Paste Electrode Modified by (Sn-$SnO_2$)-NPh: Analytical Application in Tap Water and Wastewater.

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The carbon paste electrode, modified by (Sn-$SnO_2$)-NPh based on microparticles of tin and tin oxide scattered on natural phosphate were utilized for amoxicillin (AMX) oxidation. This oxidation was preceded by an activation phase using ultraviolet (UV) radiation as a catalytic step before electrochemical detection. The (Sn-$SnO_2$)-NPh modifier was prepared through a solid-state reaction process at a high temperature of 400 °C using natural phosphate and tin dichloride. The activation of AMX by UV radiation was studied using differential pulse voltammetry, chronoamperometry, and electrochemical impedance spectroscopy. Thus, the results confirm that the utilization of UV radiation catalyzed AMX oxidation. It has been found that the oxidation current of AMX increases with increasing exposure time of AMX solution to UV radiation. The results demonstrated that the activation of AMX by UV radiation before electrochemical oxidation is necessary for its trace level detection. The oxidation peak current was linear to the AMX concentration in the range of $2.0\times10^{-7}$ to $2.0\times10^{-6}$ mol $L^{-1}$ with a detection limit of $7.78\times10^{-8}$ mol $L^{-1}$. Furthermore, the designed sensing platform was successfully used to determine AMX in tap water and wastewater samples [1].

**Keywords:** Amoxicillin; Carbon Paste Electrode; Microparticles of tin and tin oxide; Natural Phosphate; Ultraviolet.

## References

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# Ultrafiltration for treatment of secondary effluents from domestic wastewater: Optimization using response surface methodology

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**Abstract**

The present work examines the effectiveness of three ultrafiltration membranes of different pore sizes UF1 (20nm), UF2 (50nm) and UF3 (100nm) for the treatment of secondary effluents domestic wastewater from a wastewater treatment plant Kenitra. Response Surface Methodology (RSM) by Box-behnken design is used to carry out the experiment based on the operating conditions in particular: Transmembrane pressure TMP and circulation velocity CV taking into account COD, $BOD_5$ and TSS as dependent variables. Analysis variance (ANOVA) showed relevance of the developed model with probability values (P value) < 0.0001 and Fisher (F value) high. The second-degree quadratic model was $(R^2) \geq 0.8$. The maximum permeates fluxes for the three membranes UF1, UF2 and UF3 are identified at 32 $L/m^2h$, 45 $L/m^2h$ and 90 $L/m^2h$ respectively by RSM at 3bar and 2m/S. The results show that UF1 membrane is more effective for the recovery of these secondary effluents, so that organic matters and suspended matters are retained up to COD (75%), $BOD_5$ (70%) and TSS (95%) compared to the two other membranes which showed retention of COD (69.5%), $BOD_5$ (68%) and TSS (92%) for UF2 and COD (63%), $BOD_5$ (62%) and TSS (88%) for UF3. The optimal operating conditions are at 1 bar and 1 m/S for UF1 and UF2 and for UF3 at 2 bar and 1 m/S.

**Keywords:** Ultrafiltration; Ceramic membranes; Domestic wastewater; Tertiary treatment; Response surface methodology; Optimization.

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# Enhancing of ofloxacin oxidation current through the overvoltage position displacement using carbon paste electrode modified by silver particles: Analytical application in water.

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In this study, a modified carbon paste electrode with silver particles (Ag–CPE) was used for ofloxacin (OFL) detection with enhanced over-potential for low concentrations. The incorporation of silver particles on carbon paste was confirmed by scanning electron microscopy. Electrochemical behaviour of ofloxacin at carbon paste electrode (CPE) and Ag–CPE was studied using cyclic voltammetry, chronoamperometry and electrochemical impedance spectroscopy. The OFL interaction with Ag+ was derived from the oxidation of silver during anodic scan has been investigated under different conditions. The strong binding affinity of Ag+ with 1.0×10−5 M OFL resulted in the upward shift of the OFL potential, which shifted potential from 0.85 to 0.95 V. The modification of carbon paste electrode by silver microparticles has enhanced the oxidation current with over-potential of OFL at low concentrations without a decrease of the current. The influence of the sweeping potential range on OFL oxidation was optimized. The calibration curve for ofloxacin at Ag–CPE is linear in the range from 4.0×10–6 to 1.0×10–3 M, and the detection limit was 9.47×10–7 M. The proposed method was successfully applied to OFL determination in tap water samples [1].

**Keywords:** Carbon paste electrode; Increase the over-voltage; Ofloxacin; Silver microparticles; water.

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# $C_3N_4$-based Photocatalysts Boosting Antibiotic Photodegradation Efficiency

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With a substantial rise in antibiotic consumption among both human and livestock populations in recent decades, the discharge of antibiotic residues into the environment has become a significant focus of scientific inquiry.[1,2] This heightened interest stems from the emerging risks posed to the aquatic ecosystem. Antibiotics, widely used for various infections, including those affecting the respiratory, urinary, and intestinal systems, have garnered attention due to their potential environmental impact.[3]

Within this framework, our investigation delved into a thorough analysis of C3N4-based photocatalysts with the aim of exploring their applicability in degrading antibiotics, specifically SMX. The study involved a comprehensive examination of the morphological, structural, vibrational, and optical properties of the prepared photocatalysts through systematic characterization. Prior to initiating photocatalytic assessments, the adsorption capacities of the synthesized materials for antibiotic adsorption were evaluated under dark conditions. Additionally, the impact of the heterojunction ratio was scrutinized to identify the most effective photocatalyst, followed by an exploration of their stability.

**Keywords**: Photodegradation; Antibiotics; $C_3N_4$-based photocatalysts

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# Detailed exploration of a phosphate-based glass and its use as a promising adsorbent for eliminating cationic dyes.

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**Abstract:**

This investigation centers on exploiting glass as standalone adsorbents to augment their adsorption capabilities for eliminating cationic dye from aqueous solutions. A novel phosphate-based glass was created using the conventional melt quenching technique. Various analytical methods, including Fourier transform infrared spectroscopy (FTIR), X-ray energy dispersive spectroscopy (EDS), scanning electron microscopy (SEM), Brunauer-Emmett-Teller (BET), and X-ray analysis (XRD), were employed to characterize the synthesized adsorbent. The phosphate glass demonstrated efficacy as an adsorbent for removing crystal violet (CV) dye from water. Results indicate that the adsorption process was significantly influenced by diverse physicochemical parameters. The Freundlich isotherm and pseudo-second-order models exhibited a favorable fit in isothermal and kinetic adsorption modeling. The maximum observed adsorption capacity was 262,745 mg/g. Thermodynamic analysis indicated that the CV adsorption process was spontaneous and exothermic. These findings suggest the synthesized glass holds significant potential for treating wastewater containing CV.

**Table 1: The values of ΔG°, ΔH°, and ΔS° for CV adsorption on the GP@VT.**

| Adsorbent | ΔH° (kJ.mol$^{-1}$) | ΔS° (J.mol$^{-1}$. K$^{-1}$) | ΔG° (kJ.mol$^{-1}$) | | |
|---|---|---|---|---|---|
| | | | 298K | 308K | 328K |
| **GP@VT** | -85157251,3 | -254,29508 | -26,01 | -24,23 | -19,09 |

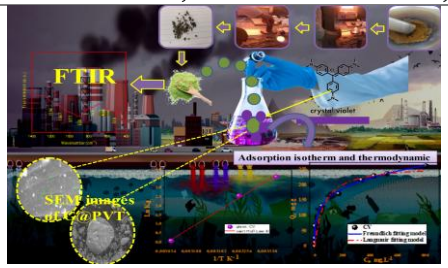


**Figure 1.Graphical abstract**

A. Hsini *et al.*, "Elaboration of novel polyaniline@Almond shell biocomposite for effective removal of hexavalent chromium ions and Orange G dye from aqueous solutions," *Environ. Sci. Pollut. Res.*, vol. 27, no. 13, pp. 15245–15258, 2020.

A. Shaim *et al.*, "Synthesis, characterization and photocatalytic activity of titanophosphate glasses," *Mediterr. J. Chem.*, vol. 8, no. 1, pp. 66–73, 2019, doi: 10.13171/mjc8119032221as.

# Elaboration of xBi3/(1-x)BiP for photodegradation of amoxicillin, sulfadiazine, rhodamine B, methylene blue and methyl orange

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In this study, a series of xBi3/(1-x)BiP were synthesized using a facile solid-state reaction. In this respect, nine samples of x = 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9 in Bi3 were prepared. Several characterization techniques were used to identify the structural, morphological, vibrational, optical, electronic and photoluminescent properties. The photocatalytic performance of the as-prepared catalysts was examined for the degradation of various persistent organic molecules such as amoxicillin, sulfadiazine, rhodamine B, methylene blue and methyl orange. The efficiency of degradation in several acid-base solutions was studied. In addition, the degradation mechanisms are examined on the basis of trapping and photoluminescence experiments. Based on the Raman results, the stability and reusability of the photocatalyst were investigated after five cycles of photodegradation under visible light ($\lambda$ = 420 nm) [1].

**Table 1. Kinetic parameters of rhodamine degradation in the presence of xBi3/(1-x)BiP - photocatalysts relative to gap energies.**

| **X** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** | **0.8** | **0.9** |
|---|---|---|---|---|---|---|---|---|---|
| **K ($min^{-1}$)** | **0.0023** | **0.0038** | **0.0025** | **0.0046** | **0.0027** | **0.0026** | **0.0304** | **0.0098** | **0.0179** |
| **$t_{1/2}$ (min)** | **301** | **182** | **277** | **151** | **257** | **267** | **23** | **71** | **39** |
| **$E_g$ (eV)** | **4.16** | **4.36** | **2.80** | **2.90** | **2.82** | **2.64** | **2.52** | **2.95** | **3.08** |

**References**

[1] B. Akhsassi, Y. Ettahiri, B. Bakiz, A. Taoufyq, S. Villain, C. Favotto, F. Guinneton, J..-R. Gavarri, A. Benlhachemi, Novel Z-scheme Bi3O4Cl/Bi24O31Cl10 2D/3D heterojunction for enhanced photocatalytic activity under visible light, Colloids Surfaces A Physicochem. Eng. Asp. **673**, 131762 (2023).

# Facile synthesis and characterization of a novel Arginine doped polyaniline@JS composite for highly efficient removal of Orange G dye from water

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## Abstract

A hybrid composite, named Arginine-doped polyaniline@JS (Arg-PANI@JS), was synthesized via interfacial polymerization by applying aniline to the surface of JS particles in the presence of arginine. The resulting composite underwent characterization through energy dispersive X-ray spectroscopy (EDS), field emission scanning electron microscopy (FE-SEM), and Fourier transform infrared (FT-IR) spectroscopy. Following this, the Arg-PANI@JS composite was utilized in adsorption experiments for OG dye in artificially contaminated solutions. Both the kinetics and equilibrium outcomes were aptly described by a pseudo-second-order model and the Freundlich isotherm. An experimental batch adsorption setup was employed to gauge the efficiency of the newly developed adsorbent in removing OG dye from aqueous solutions. Under optimized conditions (0.50 g·L-1 of Arg-PANI@JS, OG dye concentration of 20 mg·L-1, pH 6, and 298 K), the study demonstrated that the Arg-PANI@JS composite can be easily regenerated using a NaOH solution and reused effectively for OG dye removal from aqueous solutions. These findings emphasize the promising practical utility of the PANI@JS composite in wastewater treatment.

**References**

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[3] Hamid Zouggari et al, Carbon Letters, **33**, 1897–1908 (2023)

# Creating and analyzing arginine-doped polyaniline/$SiO_2$ for the purpose of adsorbing Orange G dye from water solutions.

Zitouni Ennajih[1]*, Taoufiq Bouzid[3], Amina Rguibi[1], Rida el-bardai[1] , Omar Doughmi[1], Mohamed Bouyghrissi[1], Issam Majid[4], Saïd Chakiri[4] , Abdelkrim Chahine[1], Abdelghani Hsini[1, 2] and Abdelillah Shaim[1].

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The objective of this study was to synthesize and characterize arginine-doped polyaniline/silicon dioxide (Arg-PANI@SiO2). The composite was created by polymerizing aniline monomer with SiO2 particles in the presence of arginine, utilizing sodium persulfate as an oxidizing agent. Various analytical techniques including X-ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FTIR), Brunauer–Emmett–Teller (BET), and PZC were employed to elucidate the properties of the developed composite material. Furthermore, the Arg-PANI@SiO2 composite was applied to remove OG (reactive orange G) from aqueous solutions. The adsorption of OG onto Arg-PANI@SiO2 was found to be influenced by factors such as the dosage of the adsorbent, pH levels, contact duration, pollutant concentration, and temperature. Experimental data exhibited excellent agreement with pseudo-second-order kinetics and the Freundlich isotherm. The maximum monolayer coverage capacity for OG onto Arg-PANI@SiO2 was determined to be 387.16 mg/g. The adsorption of OG onto the composite occurred spontaneously through an endothermic process. The findings from this study strongly suggest that the synthesized Arg-PANI@SiO2 hybrid composite has promising potential as an efficient filtration material for the effective removal of OG textile dye from aqueous solutions.

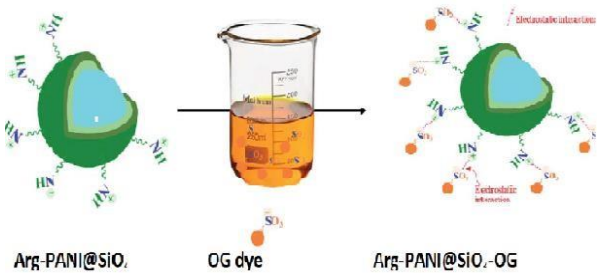


**Figure 1 . Illustration of the adsorption mechanism**

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# Efficient nanocomposites with sunlight responsiveness (gCN/SY/BiX) for the photocatalytic removal of dye compounds

Brahim Ennasraoui [1*], Hamza Ighnih [1], Mohamed Rhaya [1], Redouane Haounati [1], Hassan Ouachtak [1], Naima Hafid [2], Amane Jada [3] and Abdelaziz Ait Addi [1]

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In this work, we synthesize by coprecipitation[1] a recoverable photocatalyst gCN/SY/BiX nanocomposites, as a greatly effective visible-light-active photocatalyst, and they were characterized by XRD, EDX, SEM, UV–vis, and FT- IR analysis. Sun-light-convinced photocatalytic performances were studied by the degradation of MG dye as a pollutant. It was verified that the nanocomposites are effective in the reduction of $e^-$/ $h^+$ recombination via the matched relations between energy bands of gCN[2], SY, and BiX[3] semiconductors. The loftiest photocatalytic declination effectiveness was observed for the gCN/ SY/ BiX nanocomposite after 1h of radiation by more than 96% degradation of MG, more than each semiconductor used alone. In addition, a mechanism for photocatalytic performances was proposed using reactive species scavenging trials and characterization results.

**Keywords:** nanocomposite photocatalyst; coprecipitation; degradation; dye

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# Solar-light-driven photocatalytic degradation of orange G dye using a novel ternary photocatalyst

Mohamed Rhaya[1]*, Hicham Abou Oualid[2], Redouane Haounati[1], Hamza Ighnih[1], Brahim Ennasraoui[1], Hassan Ouachtak[3], Amane Jada[4,5] and Abdelaziz Ait Addi[1].

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**Abstract**

In recent times, there has been an increasing interest on the development of exceptionally efficient sunlight-driven photocatalysts for eliminate organic pollutants from aquatic environments. This study focuses on a ternary composite photocatalyst $M_x(PO_4)_y/CN/M_xO_y$ synthesized through the coprecipitation method, employing carbon and phosphate. The composition, morphological structure, and optical properties of the prepared samples were characterized using techniques such as X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), and UV–visible diffuse reflectance spectroscopy (UV–vis DRS). The ternary hybrid composite was employed in the degradation of orange G (20mg/L) under natural sunlight, achieving a 93.73% decolorization efficiency in 60 minutes at a pH=7, confirming its excellent photocatalytic activity. The study also investigated various parameters, including the photocatalyst amount, initial OG concentration, and solution pH, influencing the photocatalytic degradation process of OG. Quenching experiments highlighted holes (h+) and $\bullet O_2^-$ as the primary attacking species in OG decolorization. The increased photochemical reactivity of the ternary photocatalyst is attributed to the efficient separation of electron-hole pairs and the formation of a heterojunction structure in a double Z-scheme.

**Keywords**: Z-scheme, Solar light, Photocatalyst, Degradation, Orange G.

# Synthesis and study of the photocatalytic properties of a new $Bi_2Ti_2O_7/Bi_{12}TiO_{20}$ composite

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In recent years, significant focus has been directed toward bismuth-based compounds, driven by a growing interest in their diverse properties encompassing optical, electrical, and magnetic characteristics. This multifaceted nature underscores the widespread applicability of these materials across various domains, including photocatalysis, energy storage, and the advancement of supercapacitors[1,2].

In our study, we initially conducted the synthesis of a new bismuth-based composites by solid solid reaction. Subsequently, the materials elaborated are subject to structural, microstructural and physicochemical characterizations using different techniques: X-ray diffraction, scanning electron microscopy, UV-visible spectroscopy in diffuse reflection, Raman spectroscopy and Fourier transform infrared spectroscopy.

The X-ray diffraction analysis of the powders indicates that all composites exhibit well-crystallized structures, with two observed phases, both corresponding to a cubic structure. Infrared and Raman analysis revealed characteristic bands associated with the structures of sillenite and pyrochlore. Diffuse reflectance spectroscopy studies on the optical properties of the samples revealed band gaps ranging between 2.7 eV and 2.9 eV.

The photocatalytic activity of the composites was assessed through the photodegradation of Rhodamine B and Methyl orange under visible light irradiation. All the composites exhibited remarkably high photocatalytic activity.

**Keywords**: Bismuth-based, Solid solid reaction, X-ray diffraction, photocatalysis.

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# Efficient removal of eriochrome black T dye using CuAl LDH: Investigation of thermodynamic, kinetic, and equilibrium parameters

Wail El Mouhri[1]*, Iliass Nadif[1], Naoual Tajat[1], Widad El Hayaoui[1], Abderrahim Idlahcen[1], Jamal Talebi[1], Mohamed Badreddine[2], Idriss Bakas[1], Samir Qourzal[1], Ali Assabbane[1] and Malika Tamimi[1]

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This study focuses on the synthesis of CuAl LDH material through the coprecipitation method at constant pH and its subsequent application as an efficient adsorbent for the removal of Eriochrome Black T (EBT) dye from aqueous solutions. The synthesized LDH was systematically characterized using X-ray diffraction (XRD), scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM-EDX). The XRD analysis revealed a well-defined layered double hydroxide structure and SEM images further illustrated the nanolayered morphology of the LDH confirming the successful synthesis of the material. The EDX analysis confirmed the presence of the essential elements constituting the LDH, validating its elemental composition and the molar ratio 2 used during the synthesis. The adsorption efficiency of the LDH for EBT dye removal was investigated by studying the pH, initial concentration, contact time and adsorbent dose effects. Significant removal efficiencies were achieved (98.55% at the natural pH of the dye). This enhanced performance was attributed to the LDH's high ability to effectively adsorb dyes due to the electrostatic attraction between the positively charged surface of the material and the anionic dye. The results showed the promising potential of LDH for the environmentally friendly and efficient removal of dye pollutants from aqueous environments.

# Removal of agriculture herbicide 2.4 DP via adsorption process using magnetic LDH doped PPy

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**Abstract:**

2,4-DP is often present in the aquatic environment and is poorly biodegradable. The development of an effective method to reduce the amount of this toxic contaminant present in aqueous solutions has become an urgent issue. The synthesis of the ternary Mg-Ni/Al-$CO_3$ double lamellar hydroxide (LDH) was carried out by a coprecipitation procedure. This material was characterized by XRD (X-ray Diffraction), FT-IR (Fourier Transform Infrared Spectroscopy), SEM (Scanning Electron Microscopy), and EDS (Energy Dispersive X-ray Spectroscopy). The removal of 2.4 DP from water by adsorption onto the LDH magnetic doped PPy was investigated in this work. Contact time (0-360 min) of herbicide with adsorbent, pH (2-12), temperature (20, 30, 40, 50°C) and initial concentration (20 - 80 mg/l) of 2,4-DP all had an impact on material sorption capacity. The results confirmed that the Langmuir model was the most appropriate for describing the adsorption isotherms of 2,4-DP ($R^2$=0.9904). The adsorption kinetics of the herbicide on the synthesized nanocomposite were better suited to the pseudo-second-order model.

# In Situ Chemical Polymerization of Aniline on $NaPO_3$-$Fe_2O_3$ Particles for Adsorption of Cr(VI)

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In efforts to bolster environmental safety within water treatment, a novel composite, polyaniline@$NaPO_3$-$Fe_2O_3$, has been utilized as an effective adsorbent for eliminating hexavalent chromium ions. Synthesized via an in situ chemical polymerization technique, this composite underwent characterization through diverse analytical methods, including X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), BET analysis for nitrogen adsorption-desorption isotherms, and scanning electron microscopy (SEM). Experimental optimization of parameters such as pH, adsorbent dosage, contact time, initial Cr(VI) concentration, and coexisting ions corroborated the efficacy of polyaniline@$NaPO_3$-$Fe_2O_3$ as a proficient adsorbent for Cr(VI) in a synthetic solution. The heightened efficiency of Cr(VI) adsorption at lower pH levels underscores the predominant role of electrostatic interactions in governing the binding mechanism of Cr(VI) to the surface of polyaniline@NaPO3-Fe2O3.The Freundlich model and the pseudo-second order kinetic model display the strongest correlation with the experimental findings. Moreover, the adsorption capacity of Cr(VI) onto the @$NaPO_3$-$Fe_2O_3$ composite reached a maximum monolayer coverage of 467 mg g−1. This adsorption process onto polyaniline@$NaPO_3$-$Fe_2O_3$ is characterized by a spontaneous, endothermic reaction. Consequently, the utilization of the polyaniline@$NaPO_3$-$Fe_2O_3$ composite for Cr(VI) adsorption showcases its potential to effectively purify wastewater at a large scale

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# Synthesis and characterization of a triazole-derived compound: application to adsorption of the cationic dye crystal violet

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The heavy use of dyes by industrialists results in the pollution of a significant quantity of water, which must be treated before it is discharged into the environment [1,2]. The aim of this work is to treat industrial wastewater with a triazole-derived compound (PHT) as an adsorbent for the cationic dye Crystal Violet (CV). PHT was synthesized in our laboratory and characterized by various NMR and IR spectral techniques **[3]**. The study was carried out using the effects of mass, pH, time, concentration and temperature. The results obtained under optimum conditions (room temperature, 6 mg PHT, 10ppm CV in batch mode), show that the PHT adsorbent removes approximately 95,15% of the CV. Modulation of the adsorption isotherms shows that the model followed is that of Langmuir. The adsorption kinetics study according to $R^2$ values follows the pseudo second-order model ($R^2$ =0,9784) than the pseudo first-order one ($R^2$ =0,9529). The thermodynamic study of adsorption is exothermic ($\Delta H° < 0$) and spontaneous ($\Delta G° < 0$).

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# An electrochemical sensor based on Pt/α-$Fe_2O_3$@RGO nanocomposites for selective detection of the drug ornidazole (ORD) in environmental samples

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The widespread use of antibiotics for human and animal leads to the contamination of the water environments. Thus, several studies have been developed to monitor the contamination of environmental samples with pharmaceutical products. The electrochemical performance of the constructed sensor was examined by electrochemical impedance spectroscopy (EIS), cyclic voltammetry (CV) and square wave voltammetry (SWV). The obtained results indicate that the sensor achieves excellent electrocatalytic conductivity and rapid electron transfer for the detection of ORD, good reproducibility, storage stability and reliable selectivity. Additionally, the detection limit of the developed sensor was 15 nM with a sensitivity of 0.277 $\mu A\ \mu M^{-1}\ cm^{-2}$.

# Enhanced photocatalytic degradation of MB dye over $Ag_2CO_3/Ag_2O$@NiFe LDH under visible light irradiation

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The $Ag_2CO_3/Ag_2O$@NiFe LDH nanocomposite photocatalyst was successfully synthesized through a simple co-precipitation method followed by hydrothermal treatment. Employing various characterization techniques, the as-prepared photocatalyst exhibited remarkable physicochemical and optical properties. The incorporation of Ag was identified as a key factor in significantly enhancing the photodegradation performance of NiFe LDH for the removal of MB dye. The optimal composite, with a 0.75 Ag molar ratio, displayed superior degradation performance, achieving 99.5% removal of MB dye under visible light. This efficiency was three times higher compared to the pure NiFe LDH. Moreover, the apparent rate constant for the optimal composite (0.028 $min^{-1}$) was approximately 28 times greater than that of the pure LDH (0.001 $min^{-1}$). Even after five successive cycles, the composite maintained a high photostability with a degradation efficiency of 73%, highlighting its high performance throughout the regeneration process. The synthesized photocatalyst showed its promising potential for industrial applications in the treatment of dye wastewater.

# Development of new catalytic materials for liquid effluent disposal

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Titanium dioxide ($TiO_2$) is a well-known material due to its important applications in photocatalysis, and in various environmental fields [1-2], However, major drawbacks, such as low surface area and high band gap, have often limited $TiO_2$ materials for suitable applications. Self-assembled $TiO_2$ nanostructured materials with well-defined spherical morphologies have been synthesized using a biopolymer, sodium alginate, as a template, providing porous structures and controlling the morphology of $TiO_2$ nanoparticles under different synthesis conditions [3]. X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR) and energy dispersive X-ray spectroscopy (EDS) techniques were used to characterize $TiO_2$ nanoparticles. $N_2$ sorption analysis revealed moderately good surface area. The BET surface areas of pure $TiO_2$, $TiO_2$ with polymer (Tp=60°C) samples were (55.5851 m²/g), (65.0787 m²/g) respectively. Zero charge point (PZC) analysis revealed the zero charge point (PZC) of pure $TiO_2$ is at a pH of about 6 and the zero charge point (PZC) for modified $TiO_2$ nanoparticles is at a pH of about 10.

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# Title: Efficiency of an innovative polypyrrole-based composites for the removal of hexavalent chromium.

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**ABSTRACT**

Heavy metal ions have become an issue of extreme concern across the globe as a result of its harmful effects, Herein, we report the preparation of a polypyrrole-based composite for the hexavalent chromium Cr (VI) uptake from water. A batch experiment was conducted to evaluate the adsorption performance of adsorbent under variety experimental conditions, such as the adsorbent dosage, initial Cr (VI) concentration, contact time, pH of Cr (VI) solution and temperature. The pseudo-second-order model and Langmuir isotherm delivered satisfactory kinetics and equilibrium results. Optimum monolayer uptake of polypyrrole-based composite for Cr (VI) was 63.50 $mg.g^{-1}$. Thermodynamically, the adsorption process was found to be exothermic ($\Delta H<0$) and spontaneous ($\Delta G°<0$). After regeneration, it was found that polypyrrole-based composite could effectively be reused four times. Hence, we may assert that the polypyrrole-based composite has a potential application prospect as an efficient adsorbent for Cr (VI) detoxification.

**KEYWORDS:** Adsorption, polypyrrole-based composite, Cr(VI) detoxification, regeneration.

# Synthesis of novel porous geopolymer and its use for phosphate removal from aqueous media

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**Abstract**

Porous geopolymer monoliths were produced and investigated as an improved adsorbent for $PO_4^{3-}$ removal from contaminated seawater, brackish water, river water, and municipal wastewater. The porous monolith was produced by reacting metakaolin and fly ash with a Na-alkali activator and SCI as a natural foaming agent. The influence of SCI amount on water absorption, porosity, mechanical, and structural properties was examined. The developed monoliths exhibited the greatest porosity (2.3 - 86.2 % vol%), a significant ratio of open porosity to total porosity (64.7 – 96.1 %), and outstanding compression strength (5.2 - 16.4 MPa). The produced monolith structure has an adsorption capacity of 54.8 mg/g for $PO_4^{3-}$. The sequestration reaction of $PO_4^{3-}$ by porous GP is of pseudo-second-order kinetic behavior via Chi-squared ($\chi^2$), RMSE, and correlation coefficient ($R^2$) values. Regarding their agreement with Langmuir behavior, the $PO_4^{3-}$ adsorption uptakes occur in homogeneous and monolayer states. The reaction is exothermic, spontaneous, and favorable. The produced monolith exhibits significant affinity for $PO_4^{3-}$ co-existing with $Cl^-$, $Na^+$, $SO_4^{2-}$, $K^+$, $HCO_3^-$, and $Ca^{2+}$. The porous geopolymer shows high safety during the adsorption investigation, with a total cost of 0.55 $/kg-P.

**Keywords:** SCI, porous agent, geopolymer, monolith, phosphate removal, adsorption

# Synthesis and characterization of porous and photocatalytic geopolymers based on natural clay: Enhanced properties and efficient Rhodamine B decomposition

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**Abstract**

In this work, the incorporation of anatase $TiO_2$ semiconductor in the geopolymer matrix as catalytic materials has been studied. The most noteworthy results obtained from the synthesis of a novel $TiO_2$/geopolymer nanocomposite as an effective ecological catalyst with high thermal stability and significant porosity is presented. The porous and photocatalytic geopolymers based natural clay rich in pyrophyllite and kaolinite minerals were prepared by simple method, the geopolymerization reaction was able to successfully load $TiO_2$ nanoparticles into the geopolymer matrix. Furthermore, the results indicate that the prepared catalyst achieved the best performance to degrade Rhodamine B (RhB) molecules present in aqueous solution under UV light irradiation. The geopolymer matrix proved to be a reusable support for $TiO_2$ nanoparticles during the photocatalytic process, efficiently facilitating the separation of photogenerated charges. Finally, the physicochemical and morphological properties of the samples was characterized by several techniques, namely X-ray Fluorescence (XRF), X-ray diffraction (XRD), Fourier Transform Infrared spectroscopy (FTIR), Thermogravimetric and Differential Thermal Analysis (TGA/DTA), $N_2$ adsorption/desorption isotherm analysis (BET and BJH methods), UV–Vis Diffuse Reflectance Spectroscopy (DRS), Scanning Electron Microscopy (SEM) coupled to an Energy Dispersive X-ray Spectroscopy (EDS) analyzer and Transmission Electron Microscopy (TEM).

**Keywords:** Porous geopolymer; natural clay; photocatalysis; $TiO_2$; alkali activation solution.

# Soil fertility and agro-physiological responses of Basil (Ocimum basilicum L.) irrigated by treated domestic wastewater

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This work aimed to investigate the effect of treated sewage irrigation on the physiological and agronomic properties of basil. An experimental reuse study was performed using raw wastewater (RWW) and treated urban wastewater (TWW) by the Multi-Soil-Layering (MSL) process to irrigate Basil (Ocimum basilicum L.) in comparison to well water (WW) as a control over a period of 4 months. Based on the residual sodium carbonate (RSC), sodium percentage (Na%), and sodium adsorption ratio (SAR), the water quality was assessed for irrigation. These results showed that all treatments were suitable for irrigation. In this study, we also assessed the agro-physiological and biochemical proprieties of the crops. Hence, the highest productivity of basil and leaf area were achieved in reply to irrigation with RWW and TWW compared to WW; macro-elements (TP, TKN, and K) were also affected in basil irrigated with RWW in comparison with TWW and WW. However, the plants that receive well water accumulate higher Ca, Na, and Mg compared to those that receive RWW and TWW. All the crops irrigated with three water treatments showed a relatively similar concentration of micro-nutriments. The prevalence of total chlorophyll content in the plants has increased with WW irrigation. Nevertheless, RWW irrigation had a negative impact on biochemical parameters (protein and sugar content) compared to basil irrigated with TWW and WW. Additionally, the application of treated urban sewage increases crop productivity by improving soil fertility and physicochemical characteristics compared to WW.

**Keywords**: Basil; irrigation; TWW reuse; physiological proprieties; agronomic proprieties

# Photochemical stability of GO-$TiO_2$ prepared by two different methods under visible light

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The recent thrust in utilizing graphene oxide (GO) as a support for nanostructured catalyst particles has led to the claims of improved efficiency in solar cells, fuel cells, and photocatalytic degradation of pollutants. Specifically, the robust $TiO_2$ system is often coupled with GO to improve charge separation and facilitate redox reactions. The study of their photo-stability is of paramount importance. In this conference paper, we probe the stability of GO in the presence of visible excited $TiO_2$ in aqueous media and establish its reactivity toward $OH^{\bullet}$ radicals, a primary oxidant generated at the $TiO_2$ surface, by probing changes in absorption and morphology. The paper also discusses how the preparation method of $TiO_2$-GO can influence the photochemical stability.[1,2] We conclusively demonstrate the vulnerability of GO toward $OH^{\bullet}$ attack and raise concerns of its use in many applications where $OH^{\bullet}$ are likely to be formed. On the other hand, the $OH^{\bullet}$ radical-mediated mineralization could also enable new approaches in tackling environmental remediation of nanocarbons such as GO and RGO.

***Keywords:*** Graphene oxide, photocatalytic degradation, photochemical stability, $OH^{\bullet}$ radical

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# Singlet Oxygen-Powered Peroxymonosulfate Activation by Iron-rich Biochar from Sewage Sludge Digestate for Targeted Sulfamethoxazole Degradation—A Rigorous Examination of Performance and Mechanistic Insights

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## Abstract

The disposal of solid waste digestate generated from anaerobic digestion of sewage sludge poses a significant challenge. To address this issue, the present investigation focused on the synthesis of low-cost iron-rich biochar (Fe-BC) from sewage sludge digestate (SSD) via pyrolysis, with the aim of exploring its efficacy in activating Peroxymonosulfate (PMS) for the treatment of Sulfamethoxazole (SMX). The experimental outcomes exhibited that the introduction of biochar (BC) at a concentration of 0.4 g/L, along with PMS at a concentration of 3 mM, into the wastewater resulted in the removal of over 99% of a representative pharmaceutical compound (SMX, 30 ppm) within a time frame of 90 minutes, without necessitating any adjustments to the pH levels. The influencing factors, such as catalysts dosage, PMS dosage, solution pH, temperature, anions, scavengers, and SMX concentration were broadly discussed. This high removal efficiency was attributed to the presence of catalytic sites within the biochar, such as Iron-rich biochar, defective sites on biochar surface, graphitic carbon, and oxygen-containing groups. This, confirmed by several analysis techniques including, XRD, SEM, FTIR, and XPS which effectively activated PMS and facilitated the generation of reactive oxygen species ($O_2^{\bullet-}$, $^1O_2$, $OH^{\bullet}$, and $SO_4^{\bullet-}$). In a Fe-BC/PMS system, sulfamethoxazole (SMX) was degraded primarily by non-radicals rather than free radicals based on the contribution calculation. The present study provides scientific evidence that biochar produced from sewage sludge digestate (SSD) has the ability to activate peroxymonosulfate, thereby offering an alternative approach for the utilization of anaerobic SSD.

**Keywords**: Sewage sludge digestate, Peroxymonosulfate, Heterogeneous catalysis, Biochar, Pharmaceutical compounds.

# Polypyrrole Magnetic Functionalized Oxide-Graphene (FOPYGO) Nanocomposite for Effective Dye Pollutant Removal from Aqueous Effluents

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**Abstract :**

Water pollution caused by synthetic dyes and other organic contaminants is a significant contemporary concern for both society and researchers. Over recent years, extensive research has focused on the properties of graphene oxide nanocomposites, owing to their superior adsorption capabilities, degradation of the industrial pollutants and greater suitability to the environment. In the present research, A magnetic nanocomposite functionalized with graphene oxide and polypyrrole (FOPYGO) has been synthesized by the hydrothermal method. The crystallinity, morphology, functional groups, and thermal properties of these materials were characterized through various techniques including X-ray diffractometer (XRD), Scanning electron microscope (SEM), Fourier Transform Infrared (FTIR) and UV–visible spectrophotometer. In the present study, we present the adsorption properties of cationic methylene blue (MB) towards FOPYGO nanocomposite. The best-fitted kinetic model for dye was the pseudo-second-order model. The dye removal efficiency for MB was calculated to be 96.80% at a pH of 7. The Langmuir model, with a maximum adsorption capacity of 30.07 mg. g−1, was found to be the best-fitted isotherm model for MB. Thermodynamic analysis of FOPYGO indicates an exothermic adsorption process. Based on the aforementioned findings, the practical application of FOPYGO in wastewater treatment is highly recommended.

Keywords:

Polypyrrole - graphene oxide – adsorption – Wastewater – magnetic nanocomposite

# Towards the synthesis of a thermally stable clay with improved light absorption and reduced optical band gap energy

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Advanced photocatalytic depollution technology requires the search for adsorbents with high light absorption, low optical gap energy and thermal stability. Here, anionic clays of the type of nitrate intercalated Mg-Al-Fe layered double hydroxides (LDHs) (**Figure 1**) were synthesized with different iron doping using the coprecipitation at a constant pH method. The doping of aluminum with iron was carried out with different molar fractions of $Fe^{3+}$ (0, 0.25, 0.5, 0.75 and 1). The LDHs obtained were then characterized by X-ray diffraction, Fourier transform infrared and analyzed by diffuse reflectance spectroscopy. It was found that increasing the iron content allows to increase the light absorption, to increase the refractive index, to induce a redshift at the absorption edge. It was also found that the optical gap energy increases linearly with increasing iron content for ternary Mg-Al-Fe-LDHs, and that the 25 % iron doping simultaneously shows an improvement in thermal stability and light absorption behavior.

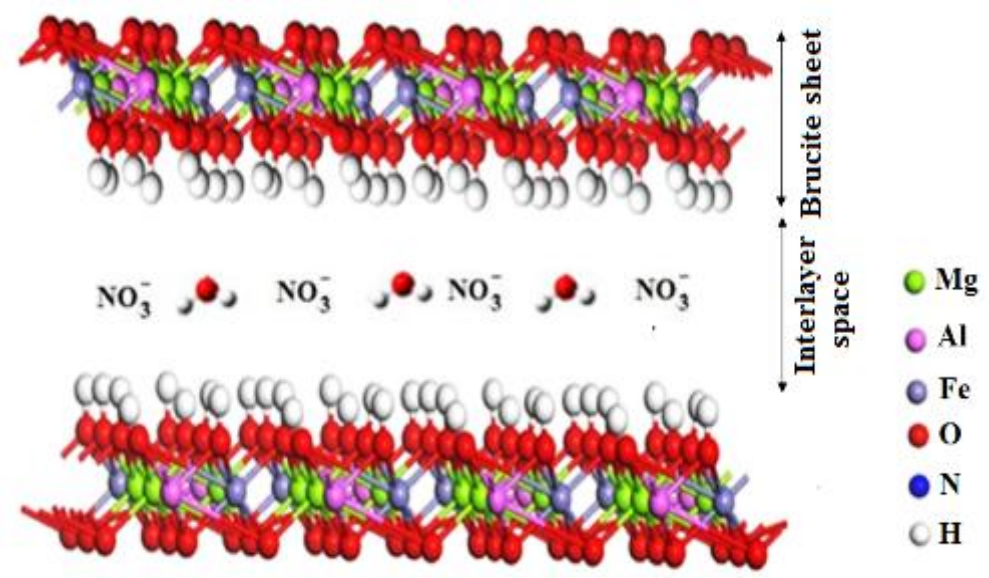


**Figure 1. Schematic representation of iron–doped Mg-Al LDH intercalated with nitrate ions**

# Maximizing the retention of methylene blue dye from contaminated water by grinding of natural sand

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The Sand is one of most abundant mineralogical material; it is the matrix of building materials. The sand used in this study taken from the Assa region south of Morocco (fine sand) and second one in Zagora region (wide sand), both of them are using before and after grinding for removal the methylene blue dye. The analysis of fine sand and wide sand by X-ray diffraction, the fine sand is made of Quartz ($SiO_2$), Muscovite ($K\ Al_2Si_3AlO_{10}(OH)_2$) and Albite, calcian ((Na, Ca)Al(Si, Al)$_3O_8$). The wide sand is composed of quartz, calcite (Ca Mg $(CO_3)_2$), albite ($NaAlSi_3O_8$) and dolomite (Ca Mg $(CO_3)_2$). The grinding carried out using a ring mill, installed at the Laboratory of hydrogeology at the Faculty of Sciences of Agadir. The size of the particles obtained after grinding and less than 10 µm. The grinding of the sand increases the specific surface the adsorbed quantities of methylene blue. For wide sand and fine sand, the quantities of methylene blue adsorbed are respectively 2.13 mg/g and 4.27 mg/g, after the grinding of these sands the quantities adsorbed increase. For wide sand powder, the value is equal to 4.267 mg/g and for fine sand powder, the value is 6.4 mg/g. We notice that the quantity adsorbed after the grinding of wide sand powder is twice as large and for fine sand powder, the quantity adsorbed is 1.5 times greater.

# Elaboration of a novel polyaniline-based composite for removal of orange G dye from water

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**Abstract**

This study aims to synthesis of a novel polyaniline@clay (PANi@Clay) composite as an effective adsorbent for removal of orange G (OG) dye from aqueous solutions. The PANi@Clay composite was successfully prepared via in situ chemical polymerization. The as-synthesized composite was thoroughly analyzed using various characterization techniques such as SEM-EDS, FTIR, XRD and point of zero charge. The OG dye adsorption process parameters including pH, PANi@Clay dose, contact time, temperature and OG dye concentration were systematically investigated and optimized. The adsorption experimental data were analyzed by kinetic (pseudo-first order, pseudo-second order and intraparticle diffusion) and isotherm (Langmuir and Freundlich) models. The thermodynamic parameters (ΔG, ΔH and ΔS) were also calculated. The experimental findings revealed that PANi@Clay composite displayed good removal efficiency for OG dye. Therefore, PANi@Clay composite can serve as an environmentally friendly and low-cost alternative adsorbent to remove synthetic dyes from textile effluents.

**Keywords:** Adsorption, Orange G dye, Polyaniline, Composite, Wastewater.

# A new hybrid nanocomposite BiOCl@Kaolinite for photocatalytic applications

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**Abstract**

The development of advanced photocatalytic materials for environmental purposes is among the high research topics. In the present work, a nanocomposite BiOCl@Kaol, made of kaolinite supported Bismuth Oxychloride "BiOCl" photocatalyst, was designed for Rhodamine B dye photodegradation in aqueous solution [1-3]. The obtained BiOCl@Kaol nanocomposite exhibited high photocatalytic activity in the removal of Rhodamine B dye (RhB) from water, with a degradation efficiency reaching 100 % within 35 min. Furthermore, it was observed that the nanocomposite photocatalyst, BiOCl@0.4Kaol, at optimal Clay/BiOCl ratio of 0.4, exhibited 4.37 times better photocatalytic performance, compared to bare BiOCl. Finally, to elucidate the photodegradation mechanisms, we determined various interactions occurring between BiOCl and kaolinite particles, as well as between RhB molecules and BiOCl@Kaol nanocomposites, using Monte Carlo calculations. It was concluded from Monte Carlo calculations that hydrogen bonds were established between oxygen atoms of BiOCl and H of kaolinite (001) hydroxyl groups upon the adsorption of BiOCl (003) particles on the kaolinite (001) surface, owing to its high negative interaction energy. Meanwhile, van der Waals attraction was also established between the RhB molecules and the BiOCl@Kaol (001) surface.

**Keywords**: BiOCl, Kaolinite, Co-precipitation, Photocatalysis, Rhodamine B, Sunlight.

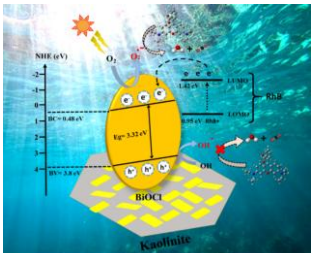


**Figure. 1. The schematic of proposal mechanism of the photocatalytic degradation of RhB dye oven BiOCl@0.4Kaol.**

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# Facile Synthesis of Magnetic $Fe_3O_4$@g-$C_3N_4$ Nanocomposite as a High Efficiency Heterogeneous Electro-Fenton Catalyst for Imidacloprid Degradation

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## Abstract

Ferro magnetic iron oxide ($Fe_3O_4$) nanoparticles (NPs) doped g-$C_3N_4$ were prepared through a facile and inexpensive chemical co-precipitation method. The synthesized magnetite nanoparticles were characterized using XRD, FTIR, Raman, BET, SEM, TEM, XPS, VSM and electrochemical methods. Selecting Imidacloprid Insecticide (IMD) as the target pollutant, using electrochemical system (BDD/Carbon felt) and enhancing the performance by the magnetite catalyst. Response Surface Methodology (RSM) coupled with Central Composite Design(CDD) was applied for analyzing and optimization of the experimental factors such as applied current, initial pH, catalyst load and electrolysis time. Analysis of variance (ANOVA) revealed that the quadratic model was adequately fitted to the experimental data with $R^2$ (0.9884) and adj-$R^2$ (0.9769). Under optimum conditions, the maximum removal efficiency was obtained to be 98.2%. Furthermore, the reusability test of $Fe_3O_4$@g-$C_3N_4$ after several cycles confirmed the high catalytic activities of adsorbent. The findings of present study revealed that heterogeneous electro-Fenton process without external aeration was a proper method for degradation of IMD from aqueous solutions.

**Keywords:** Heterogeneous Electro-Fenton, Nanomaterials, $Fe_3O_4$@g-$C_3N_4$, Imidacloprid, RSM, Wastewater treatment.

# Efficient orange G (OG) degradation via peroxymonosulfate (PMS) activation using quartz-sand@polythiophene (QS@PTh) composite.

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## Abstract

In this work, a composite material QS@PTh comprising quartz-sand (QS) and polythiophene (PTh) was used for the activation of peroxymonosulfate (PMS) to degrade Orange G dye (OG). The QS@PTh composite was synthesized through a polymerization process that resulted in the attachment of polythiophene onto quartz-sand surface. The formation of QS@PTh was demonstrated using X-ray diffraction (XRD), Scanning electron microscopy with energy-dispersive X-ray spectroscopy (SEM/EDX), and Fourier-transform infrared spectroscopy (FTIR). The activation of PMS by the QS@PTh composite was evaluated through degradation experiments using Orange G dye as a model pollutant. The results demonstrated the efficient degradation of Orange G dye by the QS@PTh/PMS system, achieving a degradation efficiency of 99.5% and a COD removal of 79.4% within 60 min. The mechanism of PMS activation for OG degradation was suggested, highlighting the role of electron transfer from the polythiophene component to PMS, leading to the production of highly reactive species such as hydroxyl radicals ($^{\bullet}OH$), sulfate radicals ($SO_4^{\bullet-}$), and singlet oxygen ($^1O_2$). Furthermore, the system exhibited remarkable efficacy in degrading other organic pollutants and real water samples, confirming its feasibility for decontaminating various pollutants. These promising results position QS@PTh/PMS as a versatile solution with potential applications in the industrial sector. Additionally, the QS@PTh composite's catalytic activity remained robust even after five cycles, indicating its potential for repeated use. These outcomes collectively underscore the utility of QS@PTh as a performant catalyst for PMS activation in the degradation of organic contaminants, showcasing its promise for environmental remediation applications.

**Keywords:** Quartz-sand, polythiophene, advanced oxidation process, PMS, heterogeneous catalysis, degradation.

# VOCs gas sensor based on 1D $SnO_2$ micro-tubes and its detection mechanism: experimental and theoretical studies

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Metal oxides are increasingly vital in cutting-edge technologies, with recent extensive research exploring their diverse applications in optics, electronics, batteries, and gas sensors. Semiconducting-based gas sensors, particularly those utilizing materials like $SnO_2$, have garnered immense attention from both users and researchers. $SnO_2$, with its outstanding morphological and electrical traits, excels as a semiconducting material uniquely capable of detecting harmful gases. Its detection mechanism relies on changes in sensor resistance provoked by gas molecules interacting with its surface. In this study, we produced $SnO_2$ micro-tubes using a homemade Forcespinning equipment. We examined the produced material properties through XRD and SEM methods. Additionally, we investigated the sensing capabilities of the synthesized material when exposed to various Organic Volatile Compounds (VOCs), such as Ethanol, Acetone and benzene, under thermo-activation mode. The mechanism of $SnO_2$ tube detection of the three gases was unveiled through calculations using Density Functional Theory (DFT) with the Ultra-Soft Pseudo-Potentials (USPP) method, conducted using the Quantum ESPRESSO code. Structural and morphological analysis confirmed the successful formation of $SnO_2$ micro-tubes composed of interconnected nanocrystalline grains (fig. a and b). The characterization results of our sensor under ethanol, acetone and benzene at 200°C show a higher sensitivity towards ethanol (fig. c and d). This was further confirmed by DFT calculations, which showed that $SnO_2$ tube (fig. e) has a higher adsorption energy in presence of ethanol gas molecule, than the other target gases (fig. f). Also, the density of states of $SnO_2$ tube changed after adsorption of the different gases, especially for Ethanol gas molecule (fig. g and h), which indicated the occurrence of the charge transfer from Ethanol gas molecule to the $SnO_2$ tube, in good consistence with our experimental findings and other results reported in literature.

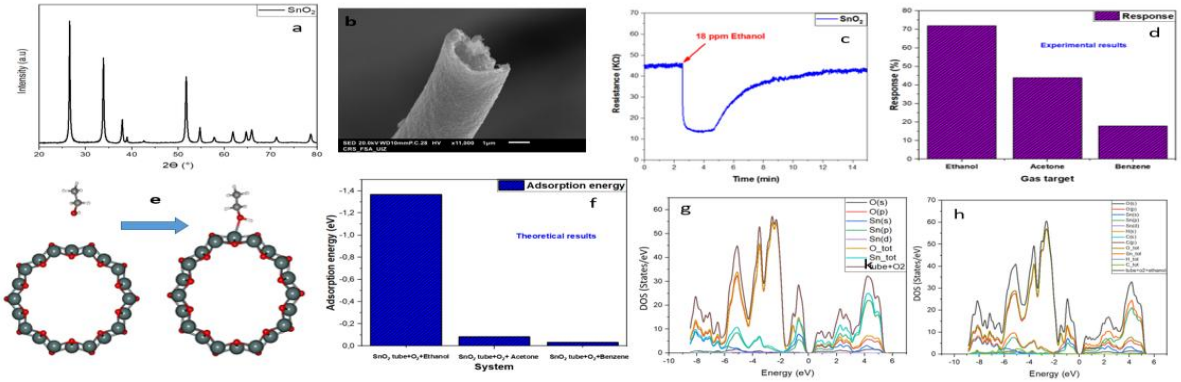


Figure 1: (a), (b): XRD and SEM analysis of $SnO_2$ micro-tubes respectively (c) and (d): sensor response towards gases. (e): $SnO_2$ tube before and after adsorption of ethanol gas molecule, (f): Theoretical calculations of the adsorption energy of different gas molecules on the $SnO_2$ tube, (g) and (h): Evolution of DOS of $SnO_2$ tube before and after adsorption of ethanol respectively.

# Electrochemical investigation and detection of verapamil HCl using poly methylene blue modified graphite electrode: Applications in tablets and serum samples

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**Abstract**

The electrooxidation behavior of Verapamil HCl, a class IV anti-arrhythmic agent, was studied on a Poly(methylene blue) modified Graphite electrode using cyclic voltammetry and differential pulse voltammetry. The investigation revealed its irreversible oxidation behavior across a pH range of 2 to 9 in Britton-Robinson buffer solution. The electrochemical detection of Verapamil HCl was further explored using both Differential Pulse Voltammetry and Adsorptive Differential Pulse Voltammetry. The analytical plot demonstrated linearity between 1 and 100 µM for Adsorptive DPV and between 5 and 100 µM for DPV in bulk solution. Additionally, the Adsorptive DPV methods were successfully employed for the determination of verapamil in tablets and extended to the in vitro determination of verapamil in spiked serum samples, yielding satisfactory recovery values in both tablet and serum.

# Activated carbon/$Fe_3O_4$ composite for dyes removal: optimisation of preparation conditions, kinetic and isothermal study

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Certainly, activated carbon is the most effective adsorbent for wastewater treatment, its adsorption capacity reaching its maximum when it is in powder form. However, one of the disadvantages of its use is the challenge of separation after treatment. For this reason, focus has been placed on the development of separable activated carbons. As a result, a growing number of researchers have turned their attention to the synthesis of magnetic activated carbon, aiming to overcome this problem [1–3].

In this approach, we have used an optimal activated carbon prepared in previous work [4] as precursor for a magnetic composite. The Doehlert design and the Desirability function were used to optimize three preparation conditions such as activated carbon mass $U_1$, impregnation time $U_2$ and temperature of contact $U_3$ and the experimental response analyzed was the adsorption capacity of methylene blue (MB). The optimization of preparation conditions of a magnetic activated carbon has led to prepare a magnetic composite which had a heterogeneous morphology with the presence of $Fe_3O_4$ micro-aggregates (figure 1), various surface functions and a $pH_{pzc}$ of 6.8 under the following conditions: AC mass 0.485 g, impregnation time 5.8h, and temperature 66.4 °C. The adsorption equilibrium of MB was well explained by the pseudo-second-order model and Freundlich isotherm. The maximum adsorption capacity of MB for the prepared material was found to be 379.32 mg/g.

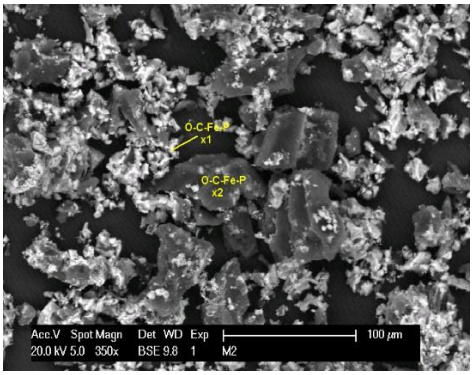


**Figure 1. SEM of the optimal composite.**

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# Nanostructured Electrochemical Platform for Sensitive Detection of Melatonin: Advancing Towards Clinical and Pharmaceutical Applications

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Our study is a focused on the synthesis of an electrochemical sensor for the detection of melatonin, a pivotal neurohormone implicated in various physiological processes, including circadian rhythm regulation, antioxidant activity, and sleep-wake cycles. The increasing recognition of melatonin significance in various physiological processes has motivated the demand for sensitive and selective detection methods. Electrochemical techniques, including voltammetry, amperometry, and impedance spectroscopy, have emerged as powerful tools for the quantification of melatonin due to their inherent advantages of high sensitivity, low detection limits, and potential for miniaturization. This work includes the use of nanomaterials, modified electrodes, and advanced sensing platforms. The discussed advancements highlight the potential for these electrochemical approaches to offer rapid, reliable, and cost-effective solutions for melatonin detection in biological and pharmaceutical samples, paving the way for improved understanding of the physiological roles of melatonin and its diagnostic and therapeutic applications. Additionally, challenges such as interference from other species, sensor stability are discussed.

# Effect Of synthesis route on the structural, morphological and photocatalytic properties of $Bi_{24}O_{31}Cl_{10}$ nanoparticles

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**Abstract**

In the present study, we report on the effect of the synthesis method in the photoactivity of $Bi_{24}O_{31}Cl_{10}$-NPs. The nanoparticles were prepared by solid-state and hydrothermal procedures using bismuth oxide and bismuth nitrate as $Bi_{24}O_{31}Cl_{10}$ precursors, respectively. The powders were calcined at 600°C and 500 °C respectively and further characterized by X-ray Powder Diffraction, Fourier Transform Infrared spectroscopy, Raman, Diffuse Reflectance UV-Vis spectroscopy, and Scanning Electron Microscopy. Both methods of synthesis lead to formation of pure $Bi_{24}O_{31}Cl_{10}$ with monoclinic crystalline structures with average crystallite sizes 71 nm for solid-state and 42nm for hydrothermal procedures. The gap energy was affected by the synthesis method, since $E_g$ values were 2.88 eV and 2.94 eV for solid-state and hydrothermal method, respectively. The electron microscopy revealed significant changes in morphology for the obtained nanoparticles. Photocatalytic activity was estimated by degrading Rhodamine B (5 ppm) under UV irradiation. The results demonstrated that $Bi_{24}O_{31}Cl_{10}$ hydrothermal reached 100 % of degradation after 60 min, whereas for $Bi_{24}O_{31}Cl_{10}$ solid-state, the result was 100% of

degradation after 90 min. These results support that even slight differences in physical, optical and chemical properties of $Bi_{24}O_{31}Cl_{10}$, have a significant impact on the photocatalytic performance of such nanoparticles.

# Removal of Various Contaminants From Water By ST@PANi Composite: A kinetic, Thermodynamic And Isotherms Modelling

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In this present study, an abundant, available lignocellulosic biomass, salsolat tetragona, ST, was used to prepare a composite with polyaniline as an effective eco-adsorbent for removing different types of organic pollutants, drug: Sodium salicylate, humic acid: pyromellitic acid and anionic dye: Orange G. After characterization of ST@PANi (MEB, EDX, IRTF and PZC), retention studies of the organic pollutants mentioned above are carried out by optimizing the physicochemical parameters influencing the adsorption process. SS, AP and OG adsorption kinetics follow the pseudo-second-order model. The experimental findings showed that the ST@PANi composite has considerable potential to remove different types of organic pollutants. Langmuir and Freundlich's models were used to analyze the equilibrium isotherms of SS, AP and OG adsorption on the ST@PANi composite. As a result, the best correlation of the experimental data was provided by the Langmuir model, and the maximum capacities of adsorption were SS 34.75 $mg.g^{-1}$, AP 45.40 $mg.g^{-1}$ and OG 85.77 $mg.g^{-1}$ thanks to the groups amines (–NH–) of the adsorbent. Examination of the thermodynamic parameters ($\Delta G°$, $\Delta H°$ and $\Delta S°$) suggests that the adsorption phenomena are spontaneous and exothermic. Importantly, ST@PANi still exhibited an excellent adsorption capability after five regeneration cycles, indicating the potential reusability of the ST@PANi composite. These results indicate that the prepared ST@PANi composite could be employed as an efficient adsorbent for the elimination of organic pollutants.

**Keywords:** Adsorption; Dyes; Kinetics; isothermal; biomass; aniline; composites; organic pollutants; polymers; Orange G, Pyromellitic Acid; Sodium salicylate; Pollutants.

# Experimental exploration of dye adsorption onto the chitosan matrix.

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The central motivation behind this research was the conversion of shrimp waste into a valuable resource: chitosan. This material was meticulously prepared and subsequently subjected to the adsorption process of methyl red dye. This step was rigorously examined using a spectrophotometric method over a specific time period. The results were significant, demonstrating a notable adsorption capacity of the dye onto the chitosan substrate. This discovery holds substantial implications in the realm of industrial waste treatment, especially within the textile industry. These findings offer a promising outlook regarding the utilization of chitosan as an effective agent in wastewater purification, highlighting its potential to address current environmental challenges associated with water pollution.

# Room temperature formation of {001} facet exposure plates Bismuth Oxybromide: visible-light photocatalytic and photoluminescence properties

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Abstract :

Recently, bismuth oxyhalides (BiOX, X = Cl, Br, and I) [1], [2], as a promising new family of photocatalysts, have demonstrated remarkable photocatalytic activities due to their single-layer structures with an internal static electric field, which can induce efficient separation of photogenerated electron-hole pairs. Among them, BiOBr has been recognized as a photocatalyst for visible light with excellent performances [3]. In addition, density functional theory (DFT) calculations show that the valence band (VB) of bismuth oxobromides is composed of hybrid orbitals of Br 4p, O 2p, and Bi 6s, while the conduction band (CB) is mainly composed of Bi 6p orbitals[4]. In this work, bismuth oxobromide photocatalyst was synthesized by coprecipitation, solid-state reaction, and hydrothermal methods using the bismuth nitrate {$Bi(NO_3)_3$, $5H_2O$} and potassium bromide {KBr} as a source of $Bi^{3+}$ and $Br^-$, respectively. To compare the structural, morphology, and optical properties, all phases were characterized by X-ray diffraction (XRD), scanning electron microscopies (SEM), FTIR, and Raman spectroscopies. The XRD patterns indicate well-crystallized BiOBr was formed at room temperature by coprecipitation and solid-state with high {001} facet exposure. The SEM indicate the formation of 2D nanoplates, which self-assembled to form the 3D structures. Based on the optical characterizations, BiOBr-Cop, BiOBr-SS, and BiOBr-HT possesses band gap energy (Eg) of 2.85 eV, 2.80 eV, and 2.67 eV, respectively. In addition, photocatalytic activity was analyzed by the ability to degrade the RhB pollutant. The as-prepared BiOBr exhibited excellent photoluminescence behavior and photocatalytic activity under visible light ($\lambda \geq 420$ nm).

Keywords:

Coprecipitation; Hydrothermal; Solid-State reaction; BiOBr; Photocatalysis; photoluminescence; RhB degradation

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# A comparative study of the elimination of an anionic dye by two composites based on formaldehyde-urea resin

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**Abstract**

Congo red is an anionic organic dye used to color textiles, paper, and plastic and is also used in biology and medicine. This dye is carcinogenic and mutagenic for humans and other living beings. The adsorption technique has been successful in the removal of organic species, especially dyes. The present study is part of this perspective by attempting to test composite materials based on urea-formaldehyde resin and natural clay (UF@AN) on the one hand and urea-formaldehyde resin and chitosan (UF@CH) to remove Congo red from an aqueous solution. The two composites are prepared and characterized by different analysis techniques (XRD, SEM, and IRTF). The different parameters (adsorbent dosage, contact time, initial concentration, and pH of the medium) influencing the adsorption of Congo red were studied. A comparative study of the elimination of said dye by the two composites was then carried out. We conclude that UF@CH has a greater capacity for eliminating Congo red from an aqueous solution than that of UF@AN.

**Keywords**: Adsorption, Composite, Congo red, Formaldehyde-Urea, Resin.

# Preparation and characterisation of a ceramic microfiltration membrane based on natural clay: Application to the pre-treatment of raw seawater for desalination by the reverse osmosis process.

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**Abstract:**
A low-cost porous ceramic membrane was developed by the spin coating method using raw clay. The corresponding support was prepared by the tape casting method using a mixture of raw clay and corn starch powder followed by sintering at 1050°C in a muffle furnace for 2 hours. The raw clay was characterised by a series of analytical and instrumental characterisation techniques (SEM-EDX, FTIR, DTA-TGA). In particular, the influence of the added starch content on support properties such as mass loss, shrinkage, porosity, mechanical strength, water absorption and density was examined. The ceramic membrane prepared has a homogeneous structure and improved pore distribution. The prepared membrane was applied to the pre-treatment of raw seawater for desalination, and demonstrated high retention of turbidity, suspended solids and total dissolved solids. The manufacturing cost of the developed membrane was estimated and analysed.
**Keywords:** Clay, Starch; Microfiltration membrane; Raw seawater; Pre-treatment; Desalination.

# Élaboration et caractérisation des supports membranaires planes de microfiltration et d'ultrafiltration à base d'une argile marocaine

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Résumé
L'objectif de ce travail est la valorisation d'une argile de la région Drâa-Tafilalet dans l'élaboration des supports membranaires planes macro-poreux, destinés à la microfiltration et l'ultrafiltration.
Dans un premier temps, la poudre argileuse est caractérisée par différentes techniques à savoir DRX, IR, ATD-ATG et MEB/EDX. Les supports membranaires sont élaborés avec différents pourcentages de la matière organique allant de 0 à10 % et traités à 1000°C/2h. Ces derniers sont caractérisés par différents tests à savoir la perte de masse, le retrait linéaire, la résistance chimique, et la perméabilité à l'eau. Les résultats obtenus montrent que cette argile est constituée principalement du quartz, de la calcite, de la dolomite, et de la kaolinite. Les supports de formulation 6% en matière organique ont les propriétés suivantes: une porosité de 41,87 %, une résistance chimique de 1,45 % pour l'attaque acide (HNO3/1M) et 0,3 % pour l'attaque basique (NaOH/1M) et une meilleure perméabilité à l'eau de 10541 L/h. m² à 2,5 bar.
***Mots clés :*** argile, membrane céramique, filtration membranaire, résistance chimique, perméabilité.

# Comparison of reverse osmosis and electrodialysis in the treatment of brassware effluents

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**Abstract**

The manufacture of the handcrafted items is carried out in a succession of deposit baths and rinses. However, this process gives rise to complex and highly loaded effluents, including a mixture of heavy metals (Cu (II), Ag (I) and Ni (II)). Therefore, to meet the Moroccan discharge limits, it is necessary to treat these effluents before discharging them into the natural environment. The objective of this study is the comparison of electrodialysis (ED) and reverse osmosis (RO) in the reduction of heavy metals in brassware wastewater of the city of Fez (Morocco). The first part is devoted to the study of the influence of the operating parameters of RO (transmembrane pressure (TMP) and recovery rate) on the quality of the permeate. The rejection (R) of metal ions (Cu (II), Ag (I) and Ni (II)) increases with TMP, but decreases with the increase in the recovery rate. The maximum values of 96%, 66.39% and 99.6% have been reached for Cu (II), Ag (I) and Ni (II) respectively. The second part of this work focuses on the feasibility of ED in the removal of heavy metals. The influence of the demineralization rate (DR) on the quality of the dilute is studied. Results show that the removal rate of cations (Cu (II), Ag (I) and Ni (II)) increases with the increase of DR and reaches respectively 98%, 95% and 97% for a DR of 90%. Finally, a comparison between RO and ED based on the water quality delivered and the energy consumed is performed under optimal operating conditions.

**Keywords:** Reverse osmosis; Electrodialysis; Brassware wastewater; Heavy metal removal; Copper ions, Silver ions and Nickel ions, Energy consumption.

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# Biosorption of a textile dye on a biosorbent derived from agricultural waste

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**Abstract:**

The pollution caused by the discharge of the textile industry is a serious environmental problem; these discharges are heavily loaded with organic pollutants and heavy metals. Organic pollution consists mainly of dyes, which have a harmful effect on the environment, particularly the contamination of aquatic environments. Hence, there is a need for the treatment of these industrial discharges before releasing them into the natural environment [1]. Among the techniques for treating water contaminated with dyes, adsorption is one method that researchers have considered effective and environmentally friendly [2]. Currently, activated carbon adsorption is widely used to remove dyes, but it is still considered a costly adsorbent [3].

Natural bio sorbents based on agricultural waste have attracted increasing attention for green production and environmental protection due to their biodegradability, economic viability, and ecological benefits.

This study focuses on the application of a natural adsorbent for the removal of a cationic dye known for its toxicity: Methylene Blue. The effect of various parameters such as contact time (180 minutes), initial concentration (10-300 ppm), and solution pH (4-10) was studied using the optimal mass with an efficiency of 98%. The maximum adsorption capacity was 232.55 mg/g at pH = 8. Results analysis revealed that adsorption follows the Langmuir model, and kinetic modeling showed a better fit to the pseudo-second-order model. The adsorbent was characterized using different techniques (Infrared, X-ray Diffraction, and Thermogravimetric Analysis) to better understand the interaction of the dye with the support.

Due to its adsorption capacity, the biosorbent can be considered an economical and environmentally friendly solution for the removal of methylene blue from aqueous solutions.

***Keywords:*** Adsorption, dye, isotherms, biosorbent, kinetics, agricultural waste.

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# Performance comparison of conventional method and ultrafiltration membrane in the pretreatment of landfill leachate

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**Abstract**
After biological and/or physico-chemical treatment of landfill leachates, COD and salinity content are often larger than reject requirements. In this case, reverse osmosis (RO) can be used to treat effectively these residual COD and salinity. However, reverse osmosis feasibility is limited by the membrane fouling.
The Oum Azza leachate treatment is performed in two stages: a biological pre-treatment which consists of an aeration basin and an anoxic basin followed by a pocket filter, and membrane treatment (reverse osmosis). The monitoring of the performances of the plant shows that the conversion rate of the RO is low, which leads to frequent stops for cleaning the fouling membranes due to the poor effluent quality after pretreatment. The pretreatment is the key of this operation, in terms of permeate fluxes and membranes lifetime. In this study, we will carry out and compare two pretreatment methods: coagulation-flocculation by ferric chloride and aluminium sulphate and ultrafiltration (UF) with ceramic membranes with different pore sizes (0.02, 0.05 and 0.1 μm). The performances of two pre-treatment processes must be analyzed in terms of reduction of pollution indicators SS, COD and $BOD_5$ suspended solids.

**Keywords:** Landfill leachate, Pollutant load, Ultrafiltration, Ceramic Membrane, Coagulation-flocculation.

# *Biodegradable block copolymers obtained by controlled polymerisation applied for wastewater treatment.*

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**Abstract:** This work was aiming at associating both expertises and thus combining to synthesize poly(ε-Caprolactone-block-poly(oligo(ethylene glycol)methyl ether methacrylate (OEGMA)) copolymers using a bifunctional initiator. Thanks to their POGEMA block, such copolymers may exhibit a lower critical solution temperature (LCST) in aqueous medium and self-assemble in aqueous aggregates with various morphologies, such as micelles or vesicles. This propriety is very promising for biomedical applications such as drug delivery or respect environment.

The two-step route for the synthesis of these copolymers is using either ATRP or ROP as first step and the other polymerisation secondly. Each polymerisation was studied carefully in order to control the macromolecular parameters of the copolymers. The ATRP of methacrylates bearing oligo(ethylene glycol) with different side-chains lengths was studied. Three different methacrylates were selected ($MEO_2MA$, $MEO_5MA$, $MEO_9MA$). Their ATRP was carried out in solution in toluene at 70 °C from two different intiators (Ethyl 2-bromoisobutyrate as model initiator or 2-hydroxyethyl-2-bromoisobutyrate as bifunctional initiator). Copper(I) bromide and *N*-propyl-pyridylmethanimine were used as catalytic system with or without initial addition of copper(II) bromide. ε-CL was polymerized in solution using tin octoate, tin of tetrakis(phenylethynyl) and bismuth triflate as non-toxic catalysts.

***Keywords:*** Biodegradable, thermo-sensitive, wastewater treatment.

# PRESENTATIONS PAR AFFICHE

## THEME 1 : SURFACES ET INTERFACES

# Insight on the corrosion inhibition efficiency on low carbon steel in phosphoric acid medium implementing a green inhibitor derived from Agro waste sources.

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**Abstract :**

Corrosion a pervasive and destructive phenomenon affecting various metal surfaces, leads to significant economic and industrials implications. One approach to protect metals involves employing natural sources as protective inhibitor.

This study aims to investigate the efficacy of a green inhibitor extracted from waste as inhibitor of corrosion in phosphoric medium (2M). Electrochemical techniques like potentiodynamic polarization (PDP), and electrochemical impedance spectroscopy (EIS) were used to evaluate the inhibitor's performance. The electrochemical results shows a notable enhancement in efficiency increase with increased the concentration of inhibitor and reduced temperature, additionally, the inclusion of a low concentration of KI demonstrated a considerable increase in inhibitor effectiveness. The MEB/EDX was used to confirm the corrosion resistance properties of the inhibitor.

*Key words: Corrosion; Phosphoric medium; steel; waste; green inhibitor*

# Préparation et étude électrochimique d'un matériau d'électrode destiné aux batteries lithium-ion en milieu aqueux.

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**Mots clés** : matériau- énergie - stockage d'énergie- les batteries lithium-ion -performances

La demande croissante en énergie due à l'augmentation de la population a engendré une crise énergétique. Afin de remédier à cette situation, des recherches sont en cours pour explorer des matériaux capables de stocker l'énergie de manière sécurisée. Les études se concentrent principalement sur les performances électrochimiques de ces matériaux dans un environnement aqueux, en raison de leurs avantages potentiels tels qu'une conductivité ionique élevée, une sécurité accrue et des coûts potentiellement réduits. Cependant, il est important de noter que les batteries utilisant un milieu aqueux peuvent présenter une limite de tension inférieure et une densité d'énergie plus faible par rapport aux batteries utilisant des milieux organiques.

Le matériau sélectionné présente plusieurs propriétés remarquables. Il possède une structure cristalline de type olivine, ce qui lui confère une stabilité chimique. De plus, sa densité élevée lui permet de stocker plus d'énergie par unité de volume. Il présente également une faible solubilité, garantissant ainsi sa stabilité et sa durabilité en tant qu'électrode. En ce qui concerne les performances électrochimiques, il est couramment utilisé comme matériau d'électrode positive dans les batteries lithium-ion en raison de sa tension de fonctionnement élevée, de sa stabilité cyclique et de sa faible toxicité. Toutefois, il présente une conductivité ionique limitée, qui peut constituer un inconvénient, mais des techniques de dopage ou de modification de la structure peuvent être employées pour améliorer cette conductivité.

En résumé, ces propriétés font de ce matériau une option prometteuse pour le stockage d'énergie, en particulier dans les batteries lithium-ion, grâce à sa stabilité chimique, sa densité énergétique et ses performances électrochimiques.

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# Performance-inhibitory action of the new imidazo pyridine compound on the corrosion of steel in 1 M HCl: Electrochemical and theoretical study

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**ABSTRACTS**

This study investigates the protection performance of a novel imidazole derivative, (E)-N-(7-methyl-2-phenylimidazo[1,2-a] pyridin-3-yl)-1-(3-nitrophenyl) methylamine (EMPPN), for mild steel in a 1 M HCl environment. Employing a multifaceted approach, the research integrates PDP, EIS, DFT and MC simulations to evaluate the efficacy of EMPPN. The results demonstrate an impressive protection performance of EMPPN, reaching up to 93.41% at a concentration of $10^{-3}$ M, highlighting its potential as a highly effective corrosion protective agent. Key aspects of the study include the synthesis of EMPPN through Schiff's base method, corroborated by spectral data analysis. Various experimental techniques, such as electrochemical studies, UV–visible spectroscopy, and surface examinations (SEM/EDX), were applied to assess the protective agent's performance. The electrochemical studies suggest that EMPPN functions as a mixed-type protective agent and adheres to the Langmuir adsorption isotherm, indicating a predominantly chemisorption-based protection mechanism. The protective agent's performance was observed to increase with rising temperatures, suggesting its applicability in diverse environmental conditions. Theoretical studies, including DFT and MC simulations, align with the experimental data, offering deeper insights into the molecular interactions and adsorption mechanisms at play. The defender layer was introduced with the addition of EMPPN, as shown by SEM and EDX analysis.

**KEYWORDS**: Protective agent; mild steel; acid medium; corrosion; DFT; MCS.

# Understanding the reactivity of N-methyl-C-(2-furyl) nitrone participating in [3+2] Cycloaddition reactions towards maleimide derivatives with a Molecular Electron Density Theory perspective

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## Abstract

This research systematically investigated the [3+2] cycloaddition (32CA) reactions between N-methyl-C-(2-furyl) nitrone and maleimide derivatives in various environments such as the gas phase, ethanol, and acetonitrile. The study employed the Molecular Electron Density Theory (MEDT) framework at the B3LYP-D3/6-31G(d) level. The nitrone was identified as a zwitterionic (*zw-type*) three-atom component (TAC) with a high-energy barrier through topological analysis. Notably, global electron density transfer (GEDT) analysis revealed a low polar nature of forward electron density transfer (FEDF) from the nitrone to the maleimides, resulting in reduced activation parameters compared to nitrone cycloadditions with simple alkenes. The reactions followed a one-step mechanism under kinetic control, exhibiting highly asynchronous bond formation at transition states without forming new covalent bonds. The predicted exo-selectivity was consistent with experimental observations. Solvent effects, particularly along the endo pathway, increased activation energy. The study also explored temperature influences at 289.15 K, 298.15 K, and 393.15 K. Non-covalent interactions (NCIs) at transition states were identified using the atoms-in-molecules (AIM) method, and Independent Gradient Model (IGM) analysis provided comprehensive insights into the detailed aspects of the cycloaddition reactions and their environmental dependencies.

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# Time effect on the electrochemical deposition of $Sb_2Se_3$ thin films

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**Abstract:**
Besides its suitable band gap, high absorption coefficient, benign grain boundaries, abundant constituent elements, and low manufacturing cost, antimony selenide ($Sb_2Se_3$) thin film solar cells have been the subject of intense research worldwide due to its unique quasi-1D crystal structure, playing a key role in the charge carrier transport mechanism. In this work, the $Sb_2Se_3$ thin film was synthesized by co-electrodeposition of Sb-Se precursors on ITO substrate, followed by high temperature (350 °C) selenization under a nitrogen atmosphere. The important effect of the electrodeposition time of Sb-Se precursors on the crystallographic structure, morphology, composition, and optical band gap of $Sb_2Se_3$ thin films has been investigated. Deposition time of 20-30 min allows the best structure with a significant increase of [hkl, $l \neq 0$]-oriented peaks, a compact morphology, and a respective band gap of 1.39 eV and 1.44 eV.

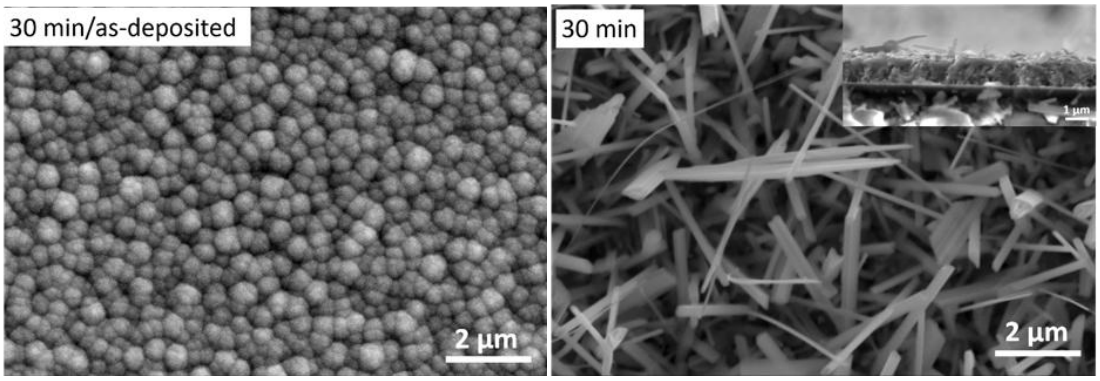


**Figure 1. SEM images of electrodeposited $Sb_2Se_3$ thin films at 30 min, before and after selenization**

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# New technique for polymethyl methacrylate (PMMA) metallization

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Copper electroplating of poly(methyl methacrylate) (PMMA) plastics has been achieved successfully using chemically synthesized polypyrrole as a precoat prior to metallization. The process is fast, economic, and ecofriendly to environment. To enhance the adhesion strength between the PMMA surface and PPy coatings, we have developed an environment-friendly pretreatment process, as an alternative of the dichromic acid etching process, composed by mechanical grinding, followed by chemical etching using $H_2O_2/H_2SO_4$ during 20 min at 70°C. As a result, many holes appeared on the PMMA surface, which increase significantly the porosity and the surface area. As well, the wettability has been enhanced due to the formation of polar groups on the PMMA surface. The scanning electron microscopy (SEM) and the contact angle measurements confirmed these results. X-ray photoelectron spectroscopy (XPS) results confirm the mechanism of chemical etching and formation of polar groups on the PMMA surface. Afterward, the adhesion of PPy coatings to the treated PMMA was determined using three different approaches including dipole-dipole interaction, mechanical anchoring, and wetting approach. The good economic yield and the non-toxicity of polypyrrole coatings confirmed the efficiency of the metallization process proposed in this work.

Copper coatings were deposited galvanostatically from plating baths. The metallic coatings were compact and homogeneous and the adherence was estimated at 100%. Different PPy and metallic coatings were characterized by Raman spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy (SEM). Moreover, surface roughness, electric conductivity, and wettability properties of different coatings were examined. The corrosion behavior of bare copper and Cu/PPy/PMMA was tested in 3.5% NaCl solution using scanning electrochemical microscopy, linear polarization, open circuit potential, and electrochemical impedance spectroscopy.

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# An exploratory investigation into the corrosion inhibition prowess of Isonicotinohydrazides on N80 steel in a 15% HCl environment: an experimental and theoretical focus.

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**Abstract:**
In this study, we aimed to evaluate the adsorption mechanism of two compounds from the isonicotinohydrazide family to determine their effectiveness as inhibitors for preventing the corrosion of N80 steel in a concentrated acidic medium (15% HCl) at a temperature of 303K. To accomplish this, we utilized the weight loss method (gravimetric) and various electrochemical techniques, including EIS, PDP, and SEM surface characterization. Our results demonstrate that both inhibitors exhibit high efficacy, particularly at relatively high concentrations of $5\times10^{-3}$M, with inhibition efficiencies surpassing 90%. This indicates that both inhibitors effectively resist corrosion when in the presence of this specific metal. Notably, our analysis unveiled that the adsorption process adheres to the Langmuir adsorption isotherm, and SEM imaging further illustrated that these compounds can form a protective layer against iron corrosion within an acidic environment [1]. Furthermore, through theoretical analysis, we were able to discern the physicochemical interactions involved in the adsorption mechanism [2, 3]. Specifically, it was revealed that charge transfer transpires between the S and P orbitals of the inhibitors and the d orbital of iron. These significant findings contribute to the continuous exploration of this compound family and their potential applications in addressing corrosion-related challenges [4].

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# Eco-friendly steel surface protection by electropolymerization of Natural Compounds from Origanum Vulgare L.

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**Abstract:**
Corrosion is a major challenge for steel structures, particularly in aggressive environments like salt water. Traditional corrosion inhibitors often have drawbacks like high cost and toxicity. This research explores the use of natural plant extracts, specifically Origanum vulgare L. (oregano), as a source of eco-friendly and efficient corrosion inhibitors for steel. Oregano is rich in phenolic compounds that can form protective films on the steel surface. Oregano extracts were obtained using a heat reflux extraction method with water-ethanol. Electropolymerized films of oregano were created on steel surfaces using cyclic voltammetry. The effectiveness of the films was evaluated through electrochemical measurements like impedance spectroscopy (EIS) and potentiodynamic polarization in a 0.1 M NaCl solution.
The electropolymerized oregano film formed a remarkable passive film on the steel, with an inhibition efficiency exceeding 99.9%. Tests on metal substrates with the films exposed to air also showed promising results. This research demonstrates the potential of using oregano extract as a green and highly effective corrosion inhibitor for steel in salty environments. Overall, this research shows great promise for the development of a sustainable and effective corrosion protection solution using natural plant extracts.

**Keywords:**
Electropolymerization, Origanum vulgare, Monomers, Electropolymerized, Films, Eco-friendly, Steel surfaces, Phenolic compounds

# Études cinétique, thermodynamique et mécanisme d'élimination du vert de malachite en solution aqueuse par les argiles brutes de la région du Drâa-Tafilalet

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Résumé
L'objectif de ce travail est l'étude de l'élimination du Vert de malachite en milieu aqueux par adsorption sur deux argiles (RCT) et (RCE) de la région Drâa-Tafilalet. Les deux adsorbants ont été caractérisés par plusieurs techniques d'analyses à savoir la fluorescence-X, infrarouge à transformée de Fourier (IRTF), diffraction des rayons (DRX), analyse thermogravimétrique (ATG), analyse thermique différentielle (ATD) et $pH_{PZC}$. Les essais d'adsorption du Vert de malachite ont montré que l'équilibre a été atteint après 40 minutes d'agitation pour les deux adsorbants à différentes températures. La quantité maximale d'adsorption est égale à 88 ,5 $mg.g^{-1}$ pour RCT et 89,6 $mg.g^{-1}$ pour RCE. La modélisation des cinétiques d'adsorption indique que l'adsorption de VM par RCT et RCE sont décrites par le modèle de pseudo second ordre forme non linéaire. Tandis que les isothermes d'adsorption correspondantes suivent le modèle de Redlich-Peterson et Freundlich. L'étude thermodynamique montre que l'adsorption du vert de malachite est physisorption et endothermique.

**Mots clés** : Adsorption, argile, le vert de malachite, isotherme, modèle de pseudo second ordre.

# Using natural polymer (starch) in a 3.0 wt% NaCl solution to monitor corrosion and inhibition corrosion of mild steel.

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## Abstract

Starch, a natural polymer, has been used as potential corrosion inhibitors for mild steel in NaCl 3% due to its ability to control corrosion. In this investigation, electrochemical frequency modulation, or EFM, served as a useful technique for determining corrosion rate in tests of corrosion inhibition. Without knowing the Tafel slopes beforehand, corrosion current density was calculated using EFM measurements. Corrosion rates discovered by EFM were contrasted with those discovered by other chemical and electrochemical methods. There was good agreement between the findings of the EFM, EIS, and potentiodynamic polarization (PDP) studies. Measurements of Tafel polarization reveal that starches are mixed-type inhibitors with anodic predominance. The results are substantially supported by SEM/EDX and X-ray diffraction analyses, which also reveals the presence of a barrier coating on the metal surface.

**Keywords:** Corrosion, NaCl, Corrosion inhibitor, Natural inhibitor polymer, EFM, EIS, PDP, SEM/EDX and X-ray diffraction.

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# Modeling and Simulation of Phosphoric Acid Production

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**Abstract:**
Phosphoric acid is an important chemical product with a wide range of applications, including fertilizers, industrial chemicals, food, and beverages. The processes for producing phosphoric acid are constantly evolving to meet the growing demand for this product [1]. There are two types of production processes: furnace processes and wet processes are the most common. They are based on the reaction of phosphate rock with sulfuric acid or hydrochloric acid [2]. This makes its valorization a crucial challenge for several reasons; on the one hand, to improve energy efficiency and valorize byproducts in order to minimize energy consumption and greenhouse gas emissions. On the other hand, to reduce the production of solid waste and highly acidic liquid effluents in order to protect the environment. In this aim, modeling and simulation play an important role in process valorization. They allow for understanding and optimizing industrial processes. The concept, in this case, is based on creating a mathematical model of the system and running it to get a vision of how changes in operating conditions will affect phosphoric acid production [3]. Or, to study the behavior of phosphogypsum over time, which can help to develop new valorization. The figure below describes the steps of the adopted phosphoric acid production process.

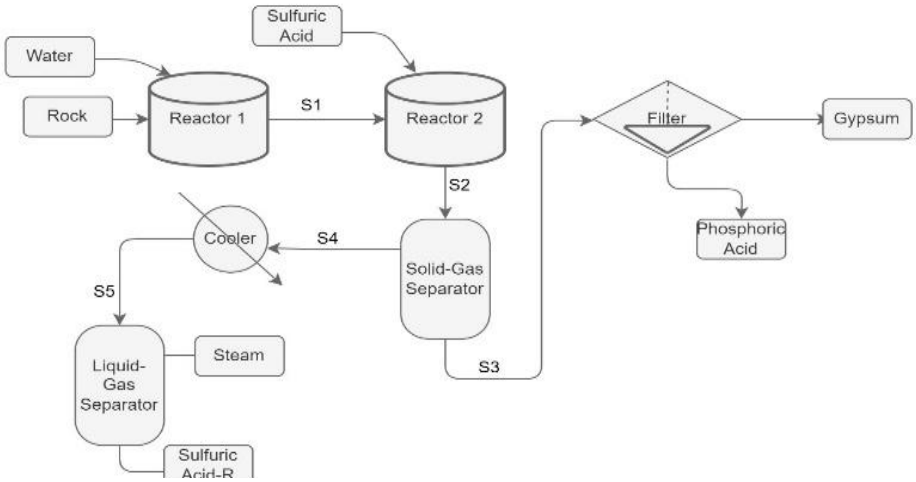


**Figure 1. Flowsheet of Wet Phosphoric Acid Production**

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# Polyaniline coated quartz sand (QS@PANI) as an adsorbent composite for Orange G dye removal from aqueous solution.

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## Abstract

In this study, a composite adsorbent QS@PANI was synthesized as an efficient, low cost, environmentally friendly adsorbent for Orange G dye removal from aqueous solution. The surface properties of materials were characterized using X-Ray diffraction analysis (XRD), Fourier Transform Infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM) - Energy Dispersive X-Ray Analysis (EDX), and the point of zero charge analysis. The influences of adsorbent dose, pH, adsorption kinetics, isotherm, and thermodynamics on OG removal were studied. The kinetic and isotherm studies indicate that OG adsorption on QS@PANI was well fitted by the pseudo-second-order, and Langmuir models. The adsorbent exhibit a high monolayer adsorption capacity of 85.49 mg/g for Orange G dye at 298K and pH 6. Thermodynamic investigations confirmed that OG adsorption was spontaneous and endothermic. Furthermore, the QS@PANI can be regenerated, and used more than six times, which demonstrate that it is qualified for practical applications.

**Keywords:** Quartz sand (QS), Polyaniline, Composite, Orange G, Adsorption.

# Exploring the Corrosion Inhibition Potential of Imidazole Derivatives on Copper, Brass, and Zinc Surfaces: Insights from DFT and Molecular Dynamic Investigations

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This study explores corrosion inhibition mechanisms on metal surfaces, focusing on interactions between imidazole derivatives and copper, zinc, and copper-zinc alloys. Experimental techniques such as polarization potentiodynamic and impedance spectroscopy are employed alongside theoretical calculations like density functional theory (DFT), reactive molecular dynamics (ReaxFF), and classical force fields to unravel the molecular intricacies of corrosion inhibition. The investigation reveals complex interactions between imidazole derivatives and metal surfaces, showcasing their protective abilities against corrosion in acidic environments. Benzimidazole emerges as the most effective inhibitor, followed by methylimidazole and imidazole. Importantly, imidazole derivatives demonstrate superior protection for copper over zinc due to the stronger Cu-N bonds compared to Zn-N bonds. Through the lens of computational chemistry, we unlock valuable insights into the intricate dance between inhibitor molecules and metal surfaces. This study underscores the remarkable potential of ReaxFF calculations in simulating inhibitor adsorption with remarkable accuracy, offering a cost-effective alternative to traditional DFT methods. Additionally, the application of umbrella sampling techniques illuminates the complex landscape of adsorption free energies, further enriching our understanding of corrosion inhibition mechanisms. In conclusion, our scientific investigation sheds new light on the potential of imidazole derivatives as corrosion inhibitors and underscores the promising role of ReaxFF in unveiling inhibition mechanisms. These findings pave the way for future advancements in materials science and corrosion protection strategies.

# PRESENTATIONS PAR AFFICHE

## THEME 2 : TRAITEMENT ET VALORISATION DES DECHETS SOLIDES

# Impact of Marine Aquaculture on the Environment

Congrès International Matériaux Appliqués à l'Environnement CIMAE-2024, Agadir 6 - 7 mars 2024

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**ABSTRACT**

The increase in the world's population, as well as the increase in average fish consumption per capita, as a result of the improvement in the quality of life of people in developing countries, has led to an explosion in request in fish.

To meet this need, and to preserve marine resources, global aquaculture has experienced a strong development over the last 30 years. This farming of carnivorous and omnivorous fish requires the distribution of fish to fish whose composition is in line with their nutritional needs, an ideal diet from a nutritional point of view would be composed of small wild fish from the sea fishing, because of their availability, plants have become the main source of protein and oil for farmed carnivorous fish, and help ensure the development of sustainable aquaculture.

The development of continental and marine fish farms raises a number of questions concerning the impact of this type of production on the aquatic environment. It is recognized that a significant portion of this impact is nutritional in origin. Discharges that consist essentially of uneaten food, faces (non-digestible part of the food and endogenous losses) and excretion products enrich the aquatic environment.

The negative environmental impacts of aquaculture are very numerous, but the most worrying is the eutrophication of watercourses receiving effluents from aquaculture farms. The main pollutants involved in this phenomenon are phosphorus (P), nitrogen (N) and suspended matter(SM), these pollutants are primarily food-borne and environmental concerns about aquaculture are not new. They have led researchers and producers to explore ways and means to make aquaculture a viable and sustainable activity.

To improve their tolerance, fish feed manufacturing has included plant processing processes by the extrusion system. This process makes it possible to concentrate the protein content of vegetable flours by eliminating the maximum amount of fibers, to reduce their content of antinutritional factors, to make their food compounds more digestible, especially carbohydrates in order to improve their palatability and to minimize the risk of deterioration of the environment.

**Keywords:** extrusion, fish feed, phosphorus, nitrogen, suspended matter, environment,

# Boues de Lavage des Phosphates et leur Impact sur l'Environnement

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Le processus d'enrichissement des phosphates naturels engendre des boues qui sont en général stockées dans des digues. Les grandes quantités de ces rejets altèrent le paysage et nuisent au développement naturel de la faune et de la flore [1] ; par la contamination de la nappe phréatique, stérilisation des sols et libération de poussière….

Pour minimiser l'impact de ces boues sur l'environnement, on pense à la valorisation de ces boues pour sa réutilisation dans d'autres industries. Parmi les initiatives visant à valoriser ces déchets, on retrouve leur utilisation dans le domaine de la céramique conventionnelle. Cette valorisation repose sur le fait que les boues de phosphates renferment des argiles, du quartz et des carbonates, qui rentrent bien dans la fabrication des produits céramiques. L'utilisation des boues de phosphates en céramique n'a pas fait l'objet d'un grand intérêt de la part de la communauté scientifique internationale. L'analyse et l'étude caractéristique des boues par DRX, FRX, ICP-MS, Microsonde électronique…, sont indispensables dans le but de les valoriser en se basant sur leurs compositions chimiques.

**Référence**

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# Optimizing Rubber Self-Compacting Concrete: A Taguchi TOPSIS Approach for Sustainable Waste Management

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Abstract:

The elimination of non-cement waste is an important issue for environmental protection. One of the proposed solutions is to consider the use of these products as aggregates in concrete.

The main objective of this study is to evaluate the properties of rubber self-compacting concrete (RSCC) through the substitution of a part of fine and coarse particles with rubber aggregates, considering both fresh and hardened phases of concrete. Various rheological tests were carried out on fresh concrete to determine its plastic viscosity, yield strength, slump flow, L-box flow time, and V-funnel flow time. Additionally, the curing parameters were evaluated using tests such as density, compressive strength, tensile strength, and modulus of elasticity.

This article explores the application of the Taguchi TOPSIS method to classify and optimize RSCC compositions, leveraging rheological and mechanical testing for a comprehensive understanding. The incorporation of rubber aggregates has demonstrated notable impacts on SCC but requires precise dosing for optimal performance. The optimization method used provides a systematic approach for optimal SCC formulations, highlighting the rubber effect on SCC quality.

# Recovery of mica minerals from granite waste

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Biotite mica, a common rock-forming mineral commonly found in metamorphic rocks but also in igneous rocks, has interesting dielectric properties that make it ideal for a number of applications. The aim of this paper is to investigate the possibility of biotite recovery from granite waste, as part of a circular economy, using a less polluting technique the high-intensity magnetic separation technique. Particle size analysis, inductively coupled plasma spectrometry and X-ray diffraction were used for physicochemical and structural characterization. The study shows promising results in terms of content and yield, underlining the effectiveness of this method for biotite beneficiation compared with other conventional techniques, and for getting rid of waste that represents a heavy environmental burden with no economic value.

**Keywords:** biotite, magnetic separation, granite waste, solid waste, circular economy.

# Review of the use of waste shells in the literature for the formulation of concretes and mortars

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Shell waste is one of the materials recently reused with construction materials by several researchers, in order to recycle them while minimising their impact on the environment and improving the energy efficiency of buildings, thereby reducing the high energy consumption of the construction and public works sector. This type of waste consists mainly of calcium carbonate, in percentages of over 90%. When calcined at high temperatures, the $CaCO_3$ is transformed into CaO, a chemical composition similar to that of limestone, which makes this type of waste very interesting for the construction sector. In this work, we have reviewed the different types of use previously studied in the literature for both concrete and mortar, comparing the results found of the different physical, mechanical and thermal properties and the formulations chosen by each author. We concluded that the size and shape of the shell aggregates directly affect the properties of the composites obtained, while the presence of organic matter has an effect on the porosity of the final materials.
Keywords: shell waste, recycling, concrete, mortar, mechanical properties, thermal properties

# Enhancing thermal insulation properties of clay bricks with Almond Waste Powder

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**Abstract:**

Almond waste powder (AWP) can be incorporated into clay-based materials to improve their thermal insulation properties. This study investigates the effect of incorporating AWP at different weight percentages (0, 5, 10, 15, and 20%) into the clay matrix. The results show a significant decrease in thermal conductivity with increasing AWP content. The thermal conductivity of the clay-AWP composites decreases by up to 30.77% compared to pure clay. Additionally, a comparison of the thermal conductivity of unfired and fired clay bricks is conducted. The results show that fired clay bricks have a lower thermal conductivity than unfired clay bricks by up to 19.27%, due to the densification of the clay matrix during the firing process. This densification increases the air pockets within the material, a poor conductor of heat. These findings suggest that AWP can be used as an effective and sustainable additive to improve the thermal insulation performance of clay-based building materials.

**Keywords*:*** clay bricks, thermal insulation, almond waste powder, thermal conductivity, fired clay bricks, unfired clay

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# Study of the properties of cellular concrete made from ecological waste

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**Abstract**

Cellular concrete is an ecological and sustainable building material with many advantages over conventional concrete, such as good thermal insulation, light weight and good acoustic insulation. The incorporation of ecological waste or plant fibers improves the properties of aerated concrete. In this context, we have attempted to study the different additives used by researchers and to make a comparative study, we have also studied the results of thermal, mechanical and durability tests obtained by other researchers. The present study demonstrates, on the basis of various recent publications, that adding fibers to aerated concrete improves its mechanical properties and durability.

**Keywords**: cellular concrete, construction, recycling, natural waste, durability, building materials

# A comparison of household and similar waste management systems in the provincial capitals of the Beni Mellal-Khenifra region, Morocco

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**Abstract**

The environmental and public health impacts of household and similar waste (HSW) remain a major concern for both developing and developed countries. The inefficiency of the solutions established for their management implies that they should be reviewed taking into account the technical and socio-economic aspects. The cities of the Beni Mellal - Khenifra region are not escaping this reality, where the need for local studies on the operation of the HSW management systems. A retrospective comparative analysis of their management systems in the main cities of the region was conducted (Beni Mellal (BM), Khenifra (KH), Azilal (AZ), Fkih Ben Saleh (FBS) and Khouribga (KHO)). The management methods used and some factors affecting waste management were compared, such as urban sprawl, demographic trends and the waste generated, physico-chemical characterisation, collection, disposal and recovery methods. This study reveals a sprawling urban expansion in the studied cities, marked by a clear proliferation of under-equipped urban fabrics. Also, the population has steadily grown, currently reaching 216344 inhabitants in BM, 130344 inhabitants in KH, 44204 inhabitants in AZ, 118237 inhabitants in FBS and 220161 inhabitants in KHO, with an average annual growth rate of 1.68%, 1.5%, 2.54%, 2.13% and 1.66% respectively. Today, the average annual amount of HSW produced is about 67534 tonnes in BM, 36157 tonnes in KH, 12100 tonnes in AZ, 28483 tonnes in FBS and 60269 tonnes in KHO. A close correlation was observed between the population trend and the change in HSW generation in these cities (Pearson's coef. ≈1). The cost of collection, transportation and landfill accounts for more than 12% of the overall budget of these cities. The moisture content and fermentable organic fraction are high in the analyzed HSWs, and are respectively 75% and 70% in KH, 73% and 65% in AZ, 72% and 63% in FBS and 75% and 65% in BM and KHO. These results are close to the national average of approximately 70%. Plastic, cardboard and glass account for a significant proportion of recyclable materials in the compared cities, around 22% of the overall total. The informal recovery of recyclable materials is the dominant activity, and only a very small quantity of these materials is exploited, estimated at 190t/year in BM, 102t/year in KH, 34t/year in AZ, 78t/year in FBS and 181t/year in KHO. This significant untapped potential for waste in these cities requires the establishment of an integrated and sustainable HSW management system taking into account the principles and good practice of the circular economy.

**Keywords**: Household and similar waste (HSW), management, comparison, Beni Mellal – Khenifra Region.

# Electrocoagulation treatment of paint wastewater and conversion of by-product sludge into nano-pigment

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**Abstract**

Paint manufacturing industries produce wastewater containing pollutants that cause enormous environmental damages. The treatability of this wastewater by electrocoagulation (EC) process using aluminum electrodes was investigated in this work. The influence of different parameters on the treatment performance was evaluated for optimum operating conditions. The experimental results showed that a current density of about 133.33 $A/m^2$, an initial pH of paint wastewater of the order of 7–8, an electrolysis time of 30 min and an inter-electrode distance of 2 cm are the optimal conditions. The specific metal consumption and the specific electrical energy consumption are about 0.168 $kg/m^3$ and 15 $kWh/m^3$, respectively. The EC treatment leads to a maximal COD reduction of about 92% and a removal of about 99.6% of the initial turbidity. The results show that the sludge generated by the EC process can be used as starting material for the synthesis of a blue inorganic nano-pigment. Its chromatic values, expressed as colour coordinates in the CIE L*a*b*, are: L*= 42.28, a*= -1.75 and b*= -9.77.

This study will have beneficial effects on the environment as well as on the economy because it makes it possible to transform the sludge from the paint wastewater treatment into value-added products. Treated wastewater can be reused for paint equipment cleaning and EC sludge can be completely transformed into pigment. The zero-waste principle can therefore be achieved.

**Keywords**: Paint wastewater; Electrocoagulation; Sludge; Synthesis; Inorganic nano-pigment.

# Amélioration du procédé de conditionnement de la résine radioactive usée par cimentation

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**Résumé :**
Le présent travail est entrepris dans le cadre général de la gestion des déchets radioactifs. Il a pour objectif l'amélioration de la qualité de procédé de conditionnement de ces déchets par cimentation. Ce procédé présente plusieurs avantages tels que la non-interaction de déchets avec le ciment, sa mise en œuvre facile et son faible coût. La résine échangeuse d'ions usée radioactive (REI), qui fait l'objet de cette étude, est considérée comme un déchet radioactif de faible et moyenne activité à vie longue. Elle est produite après son utilisation pour la purification des circuits d'eau du réacteur nucléaire TRIGA MARK 2 du Centre National de l'Énergie des Sciences et Technique Nucléaires marocain (CNESTEN). Dans ce travail, nous avons étudié l'impact de l'introduction de l'argile rouge sur le colis de la résine radioactive usée cimenté ainsi que sur l'augmentation de la quantité de la résine usée prise en charge par la formulation de cimentation.

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# Floating microplastics pollution in the Central Atlantic Ocean of Morocco: Insights into the occurrence, characterization, and fate

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## A B S T R A C T

This work presents preliminary results about abundance, distribution, characteristics, sources, and fate of microplastics (MPs) in the Central Atlantic Ocean (CAO) of Morocco. The investigation was conducted into three subsections, each characterized by different types of human activities and covering rural, village, and urban areas. MPs were detected in 100 % of the sampling sites. The abundances varied from 0.048 to 3.305 items/$m^3$, with a mean abundance of 0.987 ±1.081 items/$m^3$. MPs abundance was higher in surface seawater linked to urban areas compared to village and rural areas. The dominant polymer type was polyester (PET-53.8 %) followed by polypropylene (PP-24.36 %), polyamide (PA-7.56 %), polystyrene (PS-6.88 %), polyvinyl chloride (PVC-2.64 %), ethylene vinyl acetate (EVA-2.60 %), polyetherurethane (PUR-1.36 %), and acrylic (AC-0.8 %). Fibers were the most dominant shapes accounting for over 50 %. MPs were mainly smaller than 2 mm in size (71 %) and characterized by colorful aspects. These findings suggested that wastewater treatment plant (WWTP) effluents and anthropogenic activities (industry, tourism, sanitation, and fishing) are the major pollution sources of MPs in the study area. SEM/EDX micrographs showed different weathering degrees and chemical elements adhered to the MPs surface.

**Keywords**: Microplastics (MPs); Seawater; Toxicity; Ocean; Pollution; Morocco

# Vermicomposting of Agadir weekly souk wastes using *Eisenia fetida* and *Eisenia andrei*

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**Abstract**

This work is part of a study on the treatment and valorization of organic wastes. It presents a study on the laboratory-scale vermicomposting of organic wastes from the various weekly souks in the Agadir region, and explores the possibilities for recycling and incorporating the organic matter from the vermicompost produced as an organic amendment rich in nutrients easily assimilated by plants, improving their fertility and health.

The main objective of this study is to evaluate the efficiency of the vermicomposting process of this type of wastes and to compare the behavior of the two species of earthworms studied, namely *Eisenia fetida* and *Eisenia andrei*, during the degradation and transformation process of the studied wastes.

The initial substrates for vermicomposting were prepared by mixing different types of waste, namely weekly souk waste, cattle manure and sawdust, in order to balance the initial C/N ratio, moisture and ensure the optimum conditions required for earthworm growth and multiplication.

The various empirical, physicochemical, biochemical and biological tests carried out on the vermicompost produced by the two earthworm species (*Eisenia fetida* and *Eisenia andrei*) demonstrated their suitability for agricultural use in accordance with the requirements of French standard (NFU NF U44-051) relating to organic soil improvers and their agricultural applications.

**Key words:** waste management, organic amendment, vermicomposting, Eisenia

# Effect of materials mixture on the higher heating value: Case of biomass, biochar, and municipal solid waste.

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## Abstract

The valorization of biomass as an abundant, renewable and environmentally friendly energy resource and its co-combustion with other fuels of biomass, fossil or waste origins are attracting a lot of interest and making remarkable progress in the world.

In other words, the combined combustion of biomass, agro-industrial wastes and coal can be considered as a bridge between energy production systems based on fossil fuels and those based on renewable resources, which would contribute to reduce greenhouse gas emissions.

This work aims to characterize the selected fuel and then study the fuel mixture in order to determine the ideal mixture of fuels for co-combustion. The objective is the development of densified fuels with high energy power.

Indeed, the co-combustion of various abundant biomasses in Morocco (Wood chips, Kernel Olive, date seeds,…) with byproducts and waste (PVC, Synthetic rubber,…) has shown a synergy which is manifested by the improvement of higher calorific value. Significant results were observed. The calorific value is 13 to 20MJ/Kg for lignocellulosic materials and about municipal solid waste the calorific value is between 37,82 to 47,30MJ/Kg.

For the biomass/biochar mixtures, the average synergy was 0.31%, with a peak 12.38% for biochar/straw and a minimum -3.93% for biochar/coffee grounds.

**Keywords:** Thermochemical conversion, HHV, biomass, by-products, industrial wastes, energy value, mixture of materials.

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# Valorisation of Calcined Red Algae waste (CRA) as catalyst material in organic synthesis

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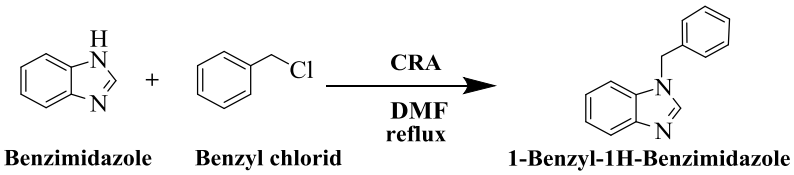
The heterocyclic compounds present-day a missions adopted in a varied number of ordinary bioactive crops [1], medical [2] and agrochemical [3].Although this, the traditional N-alkylation revolutions of benzimidazole by homogeneous catalysis [6] can show difficulties such as:(i) low yield (ii) the use of toxic reagents [7] (iii) the catalysts are: unrecoverable since they very frequently create jellies with the alkylation reagents or with alkylation products. To overcome these difficulties, it is also necessary to produce waste and require strict reaction conditions. It is therefore more economical to use these reactions by heterogeneous catalysis [8] using solid supports [9] which do not form stable gels with the products, which allows at the end of the reaction to be able to easily correct them and reuse. In addition, this would reduce equipment corrosion and reduce pollutant discharges [10].
The research of new uses of this layer appears in the perspective of her valorization in the synthesis of the molecules having biologic activities using calcined red algae (CRA) in the reaction of alkylation. (Scheme 1).




**Benzimidazole** **Benzyl chlorid** **1-Benzyl-1H-Benzimidazole**

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# Recycling Residues in the traditional Moroccan pottery Sector: Crafting Eco-Friendly Bricks Utilizing Indigenous Clay

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Clay is the oldest building material used by mankind, as demonstrated by the housing built in many parts of the world. But in recent decades, with urbanization and Westernization, they are increasingly built with cement materials, mainly imported. This has led to high construction costs and high energy consumption for thermal comfort in buildings.
Today, the energy challenges that accompany the global environmental crisis, which is of concern to more and more people, are helping to make more and more people aware of the ecological, but not only, advantages of eco-construction.
In Morocco, for example, in mountainous regions such as the village of "Tighmi", there are still craftsmen building with local materials. What's more, more and more people, generally the more affluent, are taking an interest in building with local materials such as clay, earth and wood.
Recycling waste in the construction industry also helps solve another environmental problem: waste management. One of the wastes we are studying is wood ash.
The aim of the study is to investigate the possibility of incorporating wood ash or shredded waste from traditional pottery into the formulation of environmentally-friendly bricks. Laboratory-scale experiments were carried out on different mixtures to determine the optimum dosage that would achieve optimal thermal characteristics for brick blocks. The percentage of wood ash and ground pottery waste varied from 0 to 50% of the total dry mix mass. Clay samples were used to create brick blocks and cylindrical specimens 5 cm in diameter and 10 cm high. The optimum dosage of wood ash was found to be 5% in combination with clay. The addition of ground pottery waste improved the absorption of these blocks, and the highest thermal resistance values were recorded with a dosage of 20% pottery waste. By replacing 5% of the clay with wood ash or 20% with crushed pottery waste, it was possible to produce ecological blocks with an increase in thermal resistance comparable to that of traditional building materials.
Keywords: Ecologic building material, Clay, Wood ash, Thermo-physical characterizations.
Figures, tables, and or schemes may be added as long as the one page limit is not exceeded.. Please remove any indent for captions and titles.

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# Evaluation de l'effet du digestat produit de la méthanisation des déchets organiques sur la germination des espèces végétales au Maroc

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## Résumé

La production de biogaz via le procédé de la digestion anaérobie présente un grand intérêt pour le traitement biologique et la gestion durable des déchets organiques. En plus de la génération du biogaz, le digestat est un sous-produit ayant des caractéristiques envisageable en tant qu'engrais agricole naturel. Nous considérons que la réutilisation du digestat dans l'agriculture est une solution durable car elle permet de réduire l'utilisation des engrais chimiques fabriqués à base de molécules synthétiques. Ces dernières constituent un danger permanant pour la santé humaine puisqu'ils sont cancérigènes et ils perturbent l'équilibre écologique à cause de leur effets toxiques sur la faune et la flore des écosystèmes.

Dans ce contexte, notre travail a pour objectif de déterminer la concentration optimale du digestat permettant une bonne germination des graines. À l'échelle du laboratoire, quatre digestats ont été récupérés après la méthanisation des fientes de poulets de chair, deux digestats (D1 et D2) issus de la digestion de notre substrat sans prétraitement (T1), tandis que deux digestats (D3 et D4) sont obtenus via la digestion du substrat traité préalablement (T2). Nos digestats ont été employés pour des tests de phytotoxicité sur les graines des deux espèces végétales, *Lepidium sativum* et *Sesamum indicum* sous des concentrations de 0%, 25%, 50% et 75% obtenues par des dilutions préparées à partir de

chaque digestat de méthanisation. Les paramètres évalués sont la cinétique de germination, le taux final de germination ainsi que l'indice de germination.

Par conséquent, les résultats ont montré que le taux de germination est inversement proportionnel à la concentration appliquée. Pour les graines de *Lepidium sativum*, la meilleure germination est enregistrée chez les graines sans aucun traitement (témoin), avec un taux maximal de germination qui est de 85%. D'autre part, le digestat concentré 25% a entrainé une cinétique améliorée chez les graines de *Sesamum indicum*, principalement en D4 par rapport aux autres concentrations qui ont provoqué une inhibition totale de la germination des graines. Suite aux résultats du test de phytotoxicité, nous avons passé à une application sur la germination d'une espèce végétale du Maroc, il s'agit des graines de *Pisum sativum* (petit pois). Cette fois-ci, des concentrations de 25 %, 20 %, 15 %, 5 % et 0 % ont été testées. Des effets phytotoxiques ont été observés à partir de 25% du digestat. Tandis que l'application de concentrations inférieures allant de 25% à 5% sur *P. sativum* n'a pas un effet positif sur la germination des graines testées. Dans ce travail, nous avons montré que le digestat issu de la méthanisation des déchets de poulet peut participer à la réduction de l'application des engrais chimiques dans les fermes marocaines.

# Maximizing Sustainability: Anaerobic Digestion of Poultry By-products for Biogas and Biochar Generation, Enabling Circular Green Energy Solutions

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## ABSTRACT

Efficiently managing organic waste from poultry by-products (PBP) to achieve zero waste is a significant ongoing challenge. A combined approach using anaerobic digestion (AD) and adsorption was adopted to address this challenge. AD activates biodegradable organic matter via microbial action, producing digestate. Chemical treatment and thermal activation of digestate yield activated carbon with a high surface area. This activated carbon effectively treats dye-containing wastewater, resolving solid-liquid separation issues. AD demonstrated substantial bio-methane potential, producing 15.04 L CH4 kg·SV−1 under optimal conditions. Adsorption experiments showed a maximum adsorbed amount of 101.74 mg g−1 for methylene blue onto activated carbon. The data fit pseudo-second order and Langmuir models, and thermodynamic analysis indicated an endothermic, spontaneous process. This integrated approach valorizes organic waste, generating bioenergy via AD while producing a valuable adsorbent for water treatment.

Keywords: Anaerobic digestion, Biogas, Biochar, Adsorption, dyes, water treatment.

# Distance learning-based higher education technology for a better sustainable development

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**Abstract**

Throughout the Covid-19 pandemic, teachers encountered various problems related to the development of teaching materials and post-production. Educational videos were the most common alternative. However, many teachers are still forced to produce educational videos, despite the difficulties associated with mastering audiovisual tools. The aim of this study is to propose an accessible, easy-to-use package for the creation of educational videos. Open Broadcaster Software (OBS) is a tool that offers several advantages for better distributing educational videos via different e-learning platforms. This free, open-source application offers simple editing tools that teachers can use to produce their own educational content. The lightboard is one of the innovative devices with which we were able to carry out several experiments to evaluate the usefulness of OBS. The results showed that the software adapts well to the lightboard. As a result, this tool will enable teachers to easily create educational videos and even broadcast them online. Thanks to its features, OBS will make it easier for teachers to produce educational videos that can be shared with learners.

Key words : Audiovisual - Pedagogic innovation - Platforms - Software - Techniques

# Activated carbon from tea waste digestate: An efficient adsorbent for methylene blue removal for a sustainable circular economy

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**Abstract**

Anaerobic digestion is a highly efficient and innovative method for treating organic waste while generating energy. However, it produces large quantities of solid waste digestate, often without proper disposal methods. In this study, and to address this issue, a biochar was prepared from tea waste digestate (TWD) through pyrolysis at a temperature of 600°C. Despite its potential, the use of untreated biochar is limited due to its insufficient adsorption capacity. Therefore, the prepared biochar was activated with nitric acid ($HNO_3$) to functionalize and increase the material's specific surface area for use as an adsorbent in the removal of methylene blue (MB) in aqueous media.

**Keywords:** anaerobic digestion, tea waste, digestate, adsorption, MB removal.

# PRESENTATIONS PAR AFFICHE

## THEME 3 : MATERIAUX POUR LA DETECTION ET TRAITEMENT DE LA POLLUTION

# Defect-related photoluminescence and photocatalytic properties of bismuth phosphate synthesized via a facile co-precipitation reaction

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During the past decades, various strategies have been developed to improve the photocatalytic performance and photoluminescence properties of photocatalysts. Among the different strategies, the defect is an important parameter for the design of photocatalysts and for the improvement of their properties [1].

In this work, the bismuth phosphate powder as photocatalyst has been successfully synthesized via a facile co-precipitation reaction at room temperature. The obtained hydrated sample was dried and then calcinated at different temperatures. Phases identification and structures of the powders were characterized by X-ray diffraction (**XRD**). The diffraction patterns showed a highly crystallized powder with an average crystallite size comprised between 35 and 77 nm calculated using Scherrer method. The functional groups and lattice modes were indicated by fourier transform infrared (**FTIR**) and Raman spectroscopy. The characterization of the powders by Scanning electron microscopy(**SEM**) coupled with energy dispersive X-Ray analysis (**EDS**) shows a homogeneous distribution of the phases. The thermal transformation of the as prepared samples was studied by using thermogravimetric analysis coupled with differential thermal analysis (**TGA/DTA**). The photocatalytic efficiency of these materials has been evaluated using rhodamine B as a pollutant model under UV light irradiation. Photoluminescence experiments performed under UV-laser light irradiation revealed unexpected emissions in the green-orange range, with optimal intensities for the mix systems. The positive roles of structural defects in enhancing photocatalytic and photoluminesence performance is discussed.

**Keywords:** bismuth phosphate; co-precipitation reaction; photocatalytic; photoluminescence; structural defects.

**Acknowledgments**
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# Adsorption of inorganic micropollutants (chrome) by a calcocarbonate material: kinetics and equilibrium isotherms

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## Abstract

Discharges of micropollutants from different sources (metallic or organic) into the environment are increasing. These toxic and poorly degradable pollutants are often responsible for numerous harmful effects on health. They also directly affect the balance of ecosystems as the quality of different environmental environments deteriorates. Hence the need to treat these effluents before their release into nature. For our part, we have chosen to synthesize and treat model liquid effluents in our laboratory. This treatment was carried out using a physicochemical process, namely adsorption. Based on the preparation of adsorbent material (shellfish) and their applications in the decontamination of water laden with chromium. The effect of several kinetic parameters such as temperature, initial chromium ion concentration and material dose during $Cr^{3+}$ adsorption was evaluated to determine the optimal conditions.

The results showed that the adsorption process is influenced by the parameters studied. On the other hand, the application of the mathematical models of Langmuir ($R^2$ = 0.92), Freundlich ($R^2$ = 0.97) and Temkin ($R^2$ = 0.94) better described the process of experimental isotherms. Then, the high affinity value for the metal studied ($K_F$> 1) indicates that the adsorption process is favorable, as much as the surface of the material is heterogeneous and can be written by the Freundlich model despite the coefficient value correlation which is close to unity for the adsorbent in the case of this micropollutant.

**Keywords:** Adsorption, Chromium, Isotherms, Kinetics, Material, Shell.

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**The Congress: Materials For The Environment, C I M A E 2 0 2 4, 6-7 March, 2024, Faculty of Sciences Agadir, Morocco**

# Using a novel adsorbent *Amberlite ™IRC-200* extract resin polymeric to effectively remove CV dye from wastewater: Characterization, Insights from isotherm kinetic and modelling

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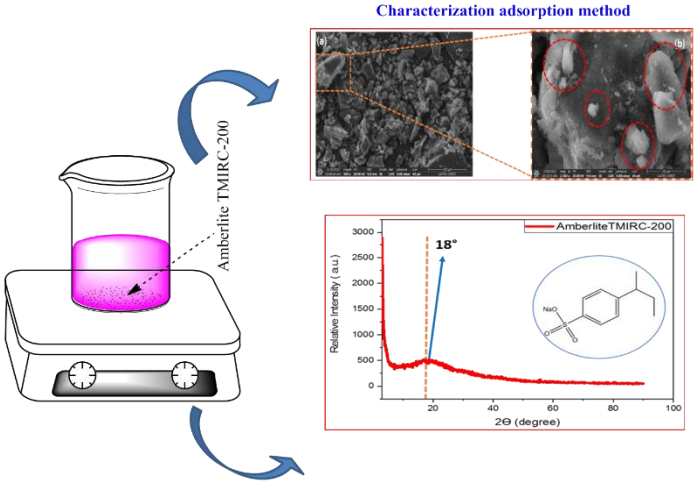
## Abstract

Novel adsorbent cationic Amberlite TMIRC-200 polymeric resin composite was studied as potential adsorbent for inhibitors of corrosion in HCl 1.0 M utilizing simulation and experimental, the cationic adsorbent resin can adsorb a much higher capacity of the CV dye [1-2]. The adsorbent resin polymeric was analyzed by several techniques such as Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscopy (SEM) [3]. The adsorption ability of the cationic resin for CV dye was investigated in relation to the following physicochemical parameters: adsorbent dose, contact time, starting pH imposed on the aqueous solution, and cobalt solution concentration. According to the results of the experiments, the solution is completely depleted when the adsorption occurs at a mass greater than 1g and 100%. After 120 minutes, the cationic resin reaches equilibrium [4]. Raising the temperature of the aqueous phase-adsorbate mixture from 25 to 55°C reduces the extraction yield and sorption capacity; an ideal pH for this adsorption is 5.5. Meanwhile, the Elovich model clarified that the process is proceeding rapidly according to the pseudo 2Sec order, while kinetic measurements made use of the pseudo 1St order and pseudo 2Sec orders, respectively[5]. Research on adsorption equilibrium utilizing various isothermal models, including Freundlich, Langmuir, and Temkin, has shown that cationic resin adsorbed cobalt CV dye most closely to the Langmuir model (R2 = 0.9999).

***Key words:*** Adsorption resin; Amberlite™IRC-200 polymeric; CV dye; SEM/IR/EDS/XRD.

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## Biography

Author he has expertise in study, characterization, evaluation and application of resins used in environment. He was awarded her PhD in 2019 from the University of Kenitra., Morocco. He published 28 papers.

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# Chromium accumulation in the roots of broad beans (*Vicia faba*)

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Heavy metals are trace elements whose proportion in the earth's crust is less than 0.1. According to the Geneva Convention, the term "heavy metals" refers to metals and their compounds with a density greater than 4.5 g/cm$^3$.

Some of these are trace elements (such as iron, magnesium, cobalt, copper, zinc, molybdenum and nickel) essential to biological processes, but toxic when present in excess in cells.

However, other non-essential trace elements are toxic in low concentrations (e.g. cadmium, chromium, lead and mercury).

These elements can cause pollution. If accumulated in large quantities, these elements may present a danger to living organisms or interfere with the normal use of the receiving environment.

The causes of heavy metal pollution can be man-made (atmospheric deposits, especially Zn and Pb, phosphate fertilisation with Cd, liquid manure and sludge with Zn and Cu) or natural (local geochemical background).

Chromium contamination of the environment has become a major problem in recent years. In its hexavalent form (Cr IV), it is highly toxic to animals and plants.

Roots are the organs of higher plants that specialise in exploring the soil and extracting water and mineral ions. Root growth and formation are closely linked to the environment in which they develop. The roots thus enable the plant to adapt, despite its immobility, to the heterogeneous and variable nature of the resources and constraints of its living environment.

In this work, we are interested in the accumulation of chromium in increasing concentration in the roots of broad beans. Initial results show that chromium accumulation in roots depends on their availability in the soil.

Keyword: Chromium, accumulation, broad bean.

# Study of the chemical forms of aluminum in the coagulant mixture of polyaluminum chloride and chitosan to optimize drinking water treatment

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## Abstract

Managing the aluminum chemical structure within coagulant blends proves effective in efficiently eliminating turbidity and natural organic matter from untreated water sources. This suspended matter in water affects its organoleptic quality and triggers problems by causing interference with the water treatment process. This study examined the behaviour of composite coagulants polyaluminium chloride-chitosan (PAC-CTS) with different aluminium speciation and polymer ratio to remove oxidizable matter and turbidity residing in surface waters. The fraction of basicity ratio (Al/OH) in the preparation of polyaluminium chloride (PAC) and chitosan (CTS) were simultaneously evaluated and optimized according to aluminium speciation by experimental design. The interaction between PAC and CTS was examined via Al-Ferron timed spectrophotometric approach, theoretical study and fourier transform infrared (FTIR) analysis. Ferron analyses reveal that basicity ratio and CTS fraction affect the distribution of aluminium forms (mononuclear Ala, medium polymeric Alb, colloidal, and high polymeric Alc) in PAC-CTS. The theoretical study showed that Al(OH)2+, Al13, and Al30 species are more reactive than aluminium hydroxide Al(OH)3 at different magnitudes and sites with chitosan. The FTIR analysis confirmed the existence of an interaction between PAC and CTS by revealing a new peak for Al-NH2 stretches. The coagulation performance study of composite coagulant PAC-CTS with different compositions showed that the increase of chitosan and the preponderance of Alb and Alc species compared to Ala are suitable for removing colloidal suspensions. Further, incorporation of PAC with high basicity (74.1%) in 16.3% of chitosan (PAC-CTS1) removed 99.51% of turbidity and 66.66% of oxidizable matter at AlCl3 concentration of 10 mg l−1. However, increasing the percentage of chitosan to 34.1% at the same basicity (74.1%) in the PAC-CTS4 compound was not beneficial for oxidizable matter removal. It was speculated that the improvement in coagulation performance could be achieved by considering the aluminum speciation and polymer content in the composite flocculant PAC-CTS. The present work could be a useful model for synthesizing and studying organometallic interactions in developing new composite coagulants to improve coagulation performance.

**Keywords** : Composite coagulant, Polyaluminium chloride (PAC), Chitosan (CTS), Basicity, Ferron method, Colloidal suspension removal.

# Étude approfondie des catalyseurs $TiO_2$ dopés au cuivre : synthèse, caractérisation et optimisation

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**Résumé**

Les catalyseurs à base de $TiO_2$ dopé au cuivre à des concentrations de 0,1%, 0,3%, 0,5%, 0,7%, 1%, et 2% ont été élaborés par la méthode de sol-gel- imprégnation. Ces catalyseurs ont été soumis à une caractérisation approfondie à travers diverses techniques, notamment la microscopie électronique à balayage avec analyse EDS, la diffraction des rayons X, la spectroscopie infrarouge à transformée de Fourier (FTIR), et la spectroscopie de réflectance diffuse (DRS).

Les images obtenues par microscopie électronique à balayage ont révélé une agglomération de nanoparticules de $TiO_2$ dopées au cuivre, suggérant un impact significatif du dopage. Les analyses EDS et IR ont confirmé la présence d'atomes de cuivre intégrés dans la matrice de $TiO_2$, avec une distribution homogène sur l'ensemble de la matrice.

Les études de diffraction des rayons X ont mis en évidence une structure tétragonale de la phase anatase pour les nanoparticules de $TiO_2$ dopé au cuivre, avec une taille variant de 19 nm à 32 nm.

La spectroscopie de réflectance diffuse a révélé que le dopage optimal a été atteint avec une concentration de 1% en cuivre, présentant ainsi la plus faible énergie de bande interdite.

**Mots clés :** Catalyseurs, $TiO_2$, Cuivre et dopage

**The International Congress: Applied Materials For The Environment, CIMAE 6-7 March 2024, Agadir, Morocco**

# Élimination des métaux lourds des solutions aqueuses à l'aide d'argile naturelle marocaine

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## Abstract

La pollution par les métaux lourds présente un risque important pour l'environnement et la santé humaine. Dans ce travail, nous étudions l'élimination de quatre ions métalliques bivalents ($Cr^{2+}$, $Cu^{2+}$, $Co^{2+}$ et $Zn^{2+}$) par adsorption sur l'argile naturelle collectée dans la région de Rabat au Maroc. La caractérisation de l'adsorbant a été réalisée par fluorescence X, spectroscopie infrarouge à transformée de Fourier et la diffraction des rayons X. L'influence des paramètres physicochimiques sur la capacité d'adsorption de l'argile pour les ions ($Cr^{2+}$, $Cu^{2+}$, $Co^{2+}$ et $Zn^{2+}$) à savoir la dose d'adsorbant, et le temps de contact ont été étudiée.

***Mots clés:*** Argile, adsorption, diffraction X, fluorescence, IR.

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**The International Congress: Applied Materials For The Environment, CIMAE 6-7 March 2024, Agadir, Morocco**

# Conception de nouveaux adsorbant à base d'argile brute et modifiée et leur utilisation dans le traitement des micropolluants organiques.

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## Abstract

L'argile naturelle a été utilisée comme adsorbant naturel pour éliminer les deux colorants cationiques, à savoir le Bleu de méthylène (BM) et la Rhodamine B des milieux aqueux. Le matériau naturel a été caractérisé et s'identifié à base des différentes techniques spectroscopiques et macroscopiques tels que la diffraction des rayons X (DRX), analyse par fluorescence des rayons X (XRF), microscopie électronique à balayage (MEB) avec spectromètre à rayons X à dispersion d'énergie (EDS) et le point de charge zéro, d'une part et de développer et de mettre en évidence un catalyseur à base d'argile modifiée ainsi mettre en évidence ses propriétés uniques. En plus nous avons effectué une comparaison entre l'argile brute et modifiée pour approfondir notre exploration en variant trois paramètres à savoir : la concentration initiale, la quantité de l'adsorbant et le pH de la solution….ect

***Mots clés:*** Argile, Argile pontée, catalyse, adsorption, diffraction X, fluorescence, IR.

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**The International Congress: Applied Materials For The Environment, CIMAE 6-7 March 2024, Agadir, Morocco**

# Theoretical and experimental studies of Indium-Doped $SnO_2$ Thin films fabricated using the SILAR technique

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Gas sensors utilizing metal oxide materials with chemoresistive properties are widely acknowledged as promising options for detecting a diverse range of gases and vapors. Their appeal stems from their cost-effectiveness, compact size, and intriguing physicochemical characteristics[1]. Seiyama and Taguchi pioneered the commercial development of gas sensors using metal oxide semiconductors in the 1960s, and these sensors continue to be a prominent presence in today's gas sensor market [2]. In the present study, the silar technique is employed to produce films of undoped and indium-doped $SnO_2$ semiconductor. The effects of the number of cycles, temperature, and indium doping have been investigated. The prepared materials undergo various structural and compositional characterizations, including SEM, XRD, and EDS analyses. The structural and optoelectronic characteristics have been explored employing first principle methods. Contrasting figure provide an example of an SEM image illustrating the formation of indium-doped $SnO_2$ films.

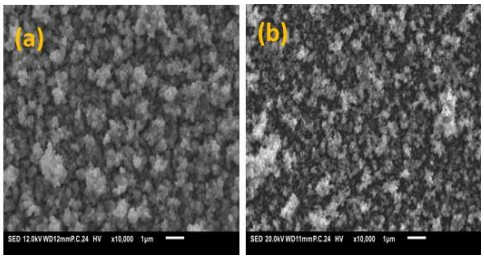


**Fig.1: SEM images: (a) Undoped $SnO_2$, (b) In 2wt%**

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# Tailored Electrochemical Monitoring of Ciprofloxacin Antibiotic using Electrochemically Exfoliated Reduced Graphene Oxide-Clay-Modified Graphite Electrode

Mouhcine Azriouil[1*], Fath-Ellah Laghrib[1,2], Abdelfattah Farahi [1], Mina Bakasse[3], Sara Lahrich[1] and Moulay Abderrahim EL Mhammedi[1]

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## Abstract

This research work covers the development of a green, sensitive, selective, and simple electrochemical strategy for the detection of ciprofloxacin (Cipro) in biological fluids, wastewater, and drug samples. Herein the carbon paste electrode was modified using reduced graphene oxide and clay composite based on the electrochemical reduction of GO (ErGO-Clay@CPE). The electrochemical impedance spectroscopy (EIS) and cyclic voltammetry were used for the electro-characterization of ErGO-Clay@CPE, and the results supported that the ErGO-Clay improved the electrode's conductivity and surface area. Moreover, the electrochemical performance was inspected by differential pulse voltammetry (DPV) and chronoamperometry in phosphate buffer (PB) with a pH of 6. The data demonstrated a magnificent sensitivity of ErGO-Clay@CPE regarding Cipro. Under the optimized operating conditions, the electro-analytical response was linearly related to the Cipro concentration in the range of 0.03-50.0 µM with a lower detection limit (DL = 3 nM). Furthermore, the ErGO-Clay@CPE was applied to identify the Cipro in drugs, wastewater, and urine samples, with satisfied recoveries [1].

**Keywords:** Reduced graphene oxide; Electrochemical sensor; Clay; Electrochemical reduction.

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# Optimisation des paramètres d'adsorption des polluants métalliques par l'argile lors du traitements des eaux.

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## Résume

Dans le cadre de ce travail, nous avons comparé l'adsorption des métaux lourds ($Cu^{2+}$, $Co^{2+}$, $Cr^{2+}$ et $Zn^{2+}$) en utilisant l'argile naturelle comme adsorbant potentiel dans le traitement des eaux usées. L'argile naturelle a été caractérisée et identifiée à l'aide d'une analyse par diffraction des rayons X (XRD), Fluorescence X, Infrarouge, Microscopie électronique à balayage Ensuite, nous avons entrepris une exploration approfondie en faisant varier trois paramètres clés : la quantité d'adsorbant, le pH de la solution et la concentration initiale des ions métalliques, pour ($Cu^{2+}$, $Co^{2+}$, $Cr^{2+}$ et $Zn^{2+}$) afin de savoir les paramètres optimaux pour favoriser l'efficacité d'adsorption.

***Mots clés :*** Argile naturelle, métaux lourds, pH, temps de contact, le rendement d'adsorption, traitement des eaux.

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Abstract

This study aims to characterize and identify natural clay and the alumina-based catalyst (Al-PILC) developed from it, in order to highlight its intrinsic properties. The analyses were performed using various techniques such as X-ray diffraction, X-ray fluorescence, infrared and scanning electron microscopy. We made a comparison between rough and decked clay to deepen our exploration by varying three parameters: the concentration, the mass of the adsorbent and the pH of the solution. This procedure was undertaken using two cationic dyes, methylene blue and Rhodamine B, in order to assess the effectiveness of adsorption.

Keywords: Clay, pillared clay, catalysis, adsorption, X-ray diffraction, fluorescence, IR.

# Producing and examining arginine-doped polyaniline/SiO2 with the aim of adsorbing Orange G dye from water solutions.

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This study aimed to produce and characterize arginine-doped polyaniline/SiO2 (Arg-PANI@SiO2) for the purpose of removing Orange G (OG) textile dye from water solutions. The Arg-PANI@SiO2 composites underwent comprehensive characterization using various analytical techniques, including X-ray diffraction, Fourier transform infrared spectroscopy, energy dispersive X-ray spectroscopy (EDS), and scanning electron microscopy (SEM). Experimental results indicate that the efficacy of OG removal is significantly impacted by several physicochemical factors, such as initial pH, contact duration, adsorbent quantity, initial OG concentration, and temperature. The adsorption process adheres to the Langmuir adsorption isotherm and follows the second-order kinetic model. Furthermore, thermodynamic parameters, including free energy (ΔG°), enthalpy (ΔH°), and entropy (ΔS°), were calculated.

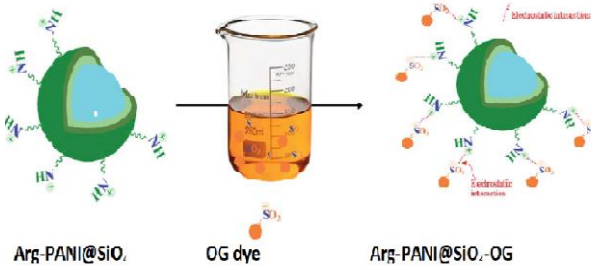


**Figure 1 . Illustration of the adsorption mechanism**

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# A molecule derived from triazoles: synthesis and characterisation and its use to the adsorption of the cationic dye crystal violet

Mohamed Bouyghrissi[1,2], Ahmed Dermaj[2], Zitouni Ennajih[1], Omar Doughmi[1], Aomar Biari[2], Saad Benmekki[2], Ouigua Rochdi[2], Abdelghani Hsini[1] and Abdelilah Shaim[1].

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Industrialists extensive use of dyes pollutes a large amount of water, which needs to be treated before being released into the environment [1,2]. The purpose of this work is to use a triazole-derived chemical (PHT) as an adsorbent for the cationic dye Crystal Violet (CV) in order to clean industrial effluent. PHT was created in our lab and examined using a range of NMR and IR spectroscopy methods [3]. The study was carried out using the effects of mass, pH, time, concentration and temperature. Results obtained in batch mode at room temperature with 6 mg PHT and 10 ppm CV reveal that the PHT adsorbent removes about 95.15% of the CV. The adsorption isotherms' modulation demonstrates that the Langmuir model was used. The pseudo second-order model (R2 = 0,9784) is more closely aligned with the adsorption kinetics study based on R2 values than with the pseudo first-order model (R2 = 0,9529). Adsorption is studied thermodynamically in a spontaneous ($\Delta G° < 0$) and exothermic ($\Delta H° < 0$) manner.

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# Formulation Innovante des Carreaux Céramiques : Optimisation du Broyage, Économie d'Énergie et Réduction des Émissions de CO2

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La production de carreaux, avec une optimisation du processus de broyage, est essentielle dans l'industrie céramique, visant à assurer la qualité supérieure des produits finaux. Une approche innovante adoptée consiste à substituer les matériaux fondants traditionnels, tels que le feldspath, par une argile A3 similaire. Cette substitution présente des avantages significatifs en termes de durabilité, de coût, et de disponibilité des matières premières.

L'utilisation de techniques de caractérisation avancées, telles que la diffraction X, la fluorescence X, l'infrarouge, et la microscopie, a permis d'observer que le remplacement du feldspath par l'argile A3 comporte plusieurs avantages notables. Il facilite le processus de broyage en améliorant les propriétés rhéologiques de la formulation, tout en apportant des bénéfices environnementaux en réduisant la dépendance à l'égard de matières premières potentiellement néfastes pour l'écosystème. De plus, cette substitution peut présenter des avantages économiques en réduisant les coûts de production.

**Mot clé :** Céramique, Argile, Feldspath, Broyage, Optimisation

**Tableau 1 : Caractéristiques technologiques des deux formulations Fs et Frectifié**

| | *Fs* | *F rectifié* |
|---|---|---|
| *retrait* | **6.3 %** | **5.6%** |
| *perte au feu* | **5.21%** | **4.89%** |
| *porosité* | **6.94%** | **5.32%** |

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# Innovative Bi-Ti materials with a high photocatalytic activity for degradation of pollutants present in industrial wastewater

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Various types of pollutants present in wastewater are supposed to decompose before evacuation into external systems. Photocatalysis plays a vital role in safeguarding the environment by breaking down pollutants [1], and employs materials illuminated by specific wavelengths, leading to the absorption of energy that transforms electrons from the conduction to valence bands (Figure 1) [2].

This mechanism enables the efficient degradation of contaminants, contributing to environmental protection. In the context of this research, the primary objective is the synthesis of Bi-Ti nanocomposite materials utilizing a solid-state method [2].

By employing XRD, SEM, and FTIR analyses, these materials undergo thorough characterization. The goal is to adapt their effective structure and properties to enhance their ability to degrade dangerous pollutants. This work seeks to contribute to the development of sustainable solutions for environmental challenges, aligning with the broader objective of mitigating the impact of pollutants on ecosystems and human health. The synthesized nanocomposite materials aim to play a crucial role in advancing effective and environmentally friendly strategies for pollutant removal and water treatment.

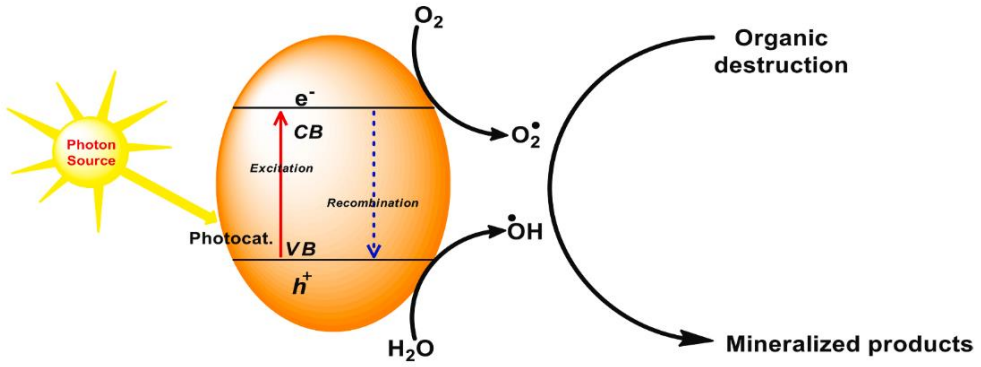


*Figure 1: Mechanism of photocatalysis process* [2].

**Keywords:** Photocatalytic activity; solid-state; Bi-Ti materials; XRD; pollutants.

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# $HNO_3$ Activation for improving the Pore Structure of Biochar-derived Sewage Sludge Digestate for dyes adsorption: Sustainable Closed-Loop Technology

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## Abstract

This study has been focused on both the ecologic and the economic gains resulting from the sewage sludge treatment. Accordingly, anaerobic digestion and adsorption were combined to solve these problems, resulting in synergistic effects to improve productivity. In the first, a considerable amount of methane (energy source) was produced by anaerobic digestion of sewage sludge (SS) under mesophilic conditions (38°C), resulting in a biologically activated digestate. Secondly, the residue of anaerobic digestion (digestate) was then utilized as a raw material to design a low-cost adsorbent for dye removal. The present work aims to evaluate the adsorption capacity of designed activated biochar with different concentration of nitric acid ($HNO_3$) to eliminate from aqueous solutions, methylene blue (MB) as targeted pollutant. The results showed that the BC-$HNO_3$ lead to maximum dye adsorption capacity of 83.09 mg/g. Further, the adsorption process was found to be best modelled by Langmuir and pseudo-second order kinetic models for the prepared activated biochar. In addition, the BC-HNO3 exhibited good stability and regenerative ability indicating that this absorbent is suitable for frequent uses.

**Keywords**: Sewage sludge, Anaerobic digestion, Activated Biochar, Adsorption, Dyes

# REMOVAL OF REACTIVE YELLOW 145 DYE BY AN ANIONIC CLAY

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A considerable quantity of reactive dyes finds extensive application across various sectors, including textile, printing, plastic, cosmetics, pharmaceuticals, and food industries. The resultant wastewater containing these dyes emerges as a significant environmental hazard. When these dyes are released into aquatic systems without proper treatment, they pose a substantial threat to both aquatic and terrestrial plants and organisms.

Thanks to its relevant properties, the application of anionic clays in the field of the environment has become a major concern for several laboratories, aiming to minimize the discharge of toxic substances (heavy metals, pesticides, dyes, etc.). In this context, we focused on the removal of Reactive Yellow 145 (RY145) dye through adsorption on an anionic clay of the CuAl- $SO_4$ type. The influence of various parameters such as the nature of the interlayer anion, contact time, initial dye concentration, adsorbent material mass, and solution pH on the adsorption process of the dye (RY145) was investigated.

The CuAl-$SO_4$ phase exhibits a high dye retention rate (RY145). In this case, the adsorption process follows the pseudo-second-order model, and the obtained isotherm is of the Freundlich type.

Keywords: Anionic dye, Reactive Yellow 145, Anionic clay, Adsorption.

# Efficacite photocatalytiques des photocatalyseurs $TiO_2$-CuO synthetises par micro-onde dans la degradation du carmin d'indigo

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**Résumé**

Les procédés d'oxydation avancés (POA) apparaissent comme des technologies innovantes de traitement de l'eau. La photocatalyse hétérogène en constitue une technologie stupéfiante basée sur le principe de la photo-excitation d'un semi-conducteur soumis au rayonnement UV artificiel ou solaire afin de dégrader la matière polluante en phase aqueuse[1].
S'inscrivant pleinement dans cette thématique de recherche, ce travail vise à améliorer l'activité photocatalytique de photocatalyseur sous rayonnements solaires, en se basant sur la photodégradation du colorant Carmin d'Indigo (CI). Les investigations développées ont porté sur le dopage de $TiO_2$ par l'oxyde de cuivre par la synthèse assistée sous micro-ondes à différents rapports molaires du CuO.
Les catalyseurs préparés ont été caractérisé par la microscopie électronique balayage couplée à la spectroscopie à rayon X (MEB/EDS) qui ont confirment la présence de particules d'oxyde de titane en forme de batonnet et particules d'oxydede cuivre en feuillede plus, la diffraction des rayons X (DRX) a été détectée deux phormes cristallines $TiO_2$ anatase CuO monoclinique.La spectroscopie infrarouge (IR)a indiqué la présence d'une hétérojonction entre $TiO_2$ et CuO. L'examen des résultats de test catalytique ont révélé que les deux rapports molaires de (90%)$TiO_2$-(10%)CuO et de (70%)$TiO_2$-(30%)CuO présentent une activité photocatalytique élevée par rapport aux semi-conducteur $TiO_2$ commerciale P25.

**Mots clés:** Photocatalyse hétérogène, Dopage $TiO_2$-CuO, Rayonnement solaire, Carmin d'Indigo.

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# The optical, Morphological, and structural properties of ZnSe thin film deposited at various potentials by the electrodeposition technique

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## Abstract

ZnSe thin films were deposited on the FTO substrate by the electrodeposition technique using aqueous solutions of $ZnSO_4.7H_2O$ and $SeO_2$. In this work, we study the effect of deposition potential on the properties of ZnSe thin films, all thin films are deposited at room temperature, and the deposition potential is varied from -0.7V to -0.9V for 30 minutes. The optical, morphological, and structural properties of our films were characterized by ultraviolet-visible-near infrared (UV-Vis-NIR) spectroscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDXS), and X-ray diffraction (XRD), respectively. The UV-Vis-NIR results indicate that ZnSe is an absorbing material in the visible range. SEM showed that all films are granular and homogeneous. The XRD patterns reveal that all the films are polycrystalline with the preferential (111) orientation corresponding to the cubic sphalerite structure of ZnSe.

***Keywords:*** ZnSe, gap energy, electrodeposition, thin film, optical properties, Direct gap semiconductor.

# Membrane technologies for heavy metals removal from aqueous solutions

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ABSTRACT

Clean water scarcity is an escalating global concern, requiring the elaboration of innovative membrane technologies. This communication explores the multifaceted realm of membrane technology, a field increasingly engaging academics and researchers.

The ceramic membrane is a porous fine ceramic filter which is sintered from Alumina, Titania or Zirconia under ultra-high temperature. Ceramic membrane normally has an asymmetrical structure with porous support active membrane layer. The macro porous support ensures the mechanical resistance while the active layer functions separation ranging from Microfiltration, Ultrafiltration and even Nanofiltration.

ceramic membranes are widely used in the wastewater and water treatment fields owing to their advantages, including higher chemical stability, stronger mechanical strength, longer service life, and better water filtration performance.

This work delves into the pivotal role of ceramic membranes in heavy metal water purification, emphasizing the evolving landscape of membrane technologies., this study outlines the future applications of ceramic membranes, delineating their indispensable role in nanofiltration, microfiltration, ultrafiltration. An insight into the hybrid processes combining ceramic membranes with other physical-chemical processes, shedding light on their diverse applications and their pivotal role in addressing the global water crisis has also been presented.

**Keywords :** membrane processes, heavy metals, water purification

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# Impact des eaux usées non traitées sur l'environnement

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**Mots-clés:** Eaux usées, Environnement, Pollution

La plupart des activités humaines qui utilisent de l'eau produisent des eaux usées. Etant donné que la demande en eau dans son ensemble augmente, la quantité des eaux usées produites, et leur charge polluante globale, sont en augmentation dans le monde entier. Elles sont rejetées dans la plus part des cas sans aucun traitement préalable dans le milieu récepteur. Cette pollution peut provoquer des effets nocifs sur l'environnement. L'évaluation des impacts sur ce dernier permet d'identifier les modifications anticipées sur le milieu récepteur par la réalisation des projets par la préservation de la nature. Pour réduire les effets néfastes de ces problèmes, plusieurs procédés de traitement sont mis en œuvre, en particulier l'infiltration-percolation. Cette dernière est une technique récente qui utilise différent type de sable comme massif filtrant, notamment le sable fin pour que l'infiltration se fasse d'une façon lente. La majorité des polluants sont retenues par cette méthode sauf les nitrates et les nitrites qui se forment dans les eaux épurées. Cependant, un apport excessif de ces substances dans les écosystèmes conduit à une eutrophisation et engendre des risques sanitaires pour l'homme.

# Heavy metal contents in soils and native flora of two major mining districts Touissit and Zaida in Morocco.

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**Abstract.**

Mining activities generate spoils and effluents with extremely high metal that might have adverse effects on ecosystems and human health. Therefore, information on soil and plant metal concentrations is needed to assess the severity of the pollution and develop a strategy for soil reclamation such as phytoremediation. We studied soils and vegetation in two heavily contaminated sites with potential toxic metals (Zn, Pb, Cd, Cu) in the mining districts of Touissit (eastern Morocco) and Zaida (middle atlas Morocco). The aim of this study aims to : i) inventory native flora of the the two mine sites and their taxonomy, ii) assess heavy metals contents in the soils and dominant plants growing on abandoned Pb/Zn mining sites. Vegetation inventory was carried in each of the two sites using the "field tower" technique, which consists of taking stock of all species in a defined area. The inventory of the vegetation of the Touissit mine site revealed the presence of 85 species belonging to 29 families. The most represented families are Poaceae and Aster-aceae, the biological spectrum indicates a predominance of therophytes (48%) and a high disturbance index of 51%. In Zaida mining district a total of 78 plant species belonging to 23 botanical families an mainly dicots with 74.49%, Asteraceae, Poaceae and Brassicaceae represent 62.82%, therophytes represent 48.72% of the listed flora. From both studied areas, metal content analysis (Zn, Pb, Cd, Cu) was investigated from rhizospheric soils and the corresponding plant species. The bioconcentration factor (BCF), translocation factor (TF), and biological accumulation coefficient (BAC) were determined for each element and each plant. Atractylis caepistosa showed the ability to translocate all analyzed metals with a TF >1 in both sites. Our study shows that several spontaneous and native plants growing on Pb/Zn contaminated sites have a good potential for developing heavy metals phytoremediation strategies.

**Keywords:** Phytoremediation, Mine site, Native plants, Heavy metal, Metal accumulation.

# Magnetic $Fe_3O_4$@g-$C_3N_4$ Nanocomposite as a High Efficiency Heterogeneous Electro-Fenton Catalyst for Imidacloprid Degradation : Optimization using RSM-CDD

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## Abstract

Ferro magnetic iron oxide ($Fe_3O_4$) nanoparticles (NPs) doped g-$C_3N_4$ were prepared through a facile and inexpensive chemical co-precipitation method. The synthesized magnetite nanoparticles were characterized using XRD, FTIR, Raman, BET, SEM, TEM, XPS, VSM and electrochemical methods. Selecting Imidacloprid Insecticide (IMD) as the target pollutant, using electrochemical system (BDD/Carbon felt) and enhancing the performance by the magnetite catalyst. Response Surface Methodology (RSM) coupled with Central Composite Design(CDD) was applied for analyzing and optimization of the experimental factors such as applied current, initial pH, catalyst load and electrolysis time. Analysis of variance (ANOVA) revealed that the quadratic model was adequately fitted to the experimental data with $R^2$ (0.9884) and adj-$R^2$ (0.9769). Under optimum conditions, the maximum removal efficiency was obtained to be 98.2%. Furthermore, the reusability test of $Fe_3O_4$@g-$C_3N_4$ after several cycles confirmed the high catalytic activities of adsorbent. The findings of present study revealed that heterogeneous electro-Fenton process without external aeration was a proper method for degradation of IMD from aqueous solutions.

**Keywords:** Heterogeneous Electro-Fenton, Nanomaterials, $Fe_3O_4$@g-$C_3N_4$, Imidacloprid, RSM, Wastewater treatment.

# Cu-Al and Mg-Al based anionic clays: preparation, characterization and investigation of optical properties

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Anionic clays, also known as lamellar double hydroxides (LDHs), are of growing interest in the environmental field [1]. Indeed, thanks to their two-dimensional (2D) structure, these materials can be used as photocatalysts for the degradation of organic pollutants, hydrogen production [2], water purification and carbon dioxide ($CO_2$) conversion [3]. The general chemical formula of anionic clays (LDHs) is given as: $[M^{II}_{1-x}M^{III}_{x}(OH)_2]^{+}\,[(A^{n-})_{x/n}.y\,H_2O]^{-}$, $M^{II}$ and $M^{III}$ are divalent and trivalent metal ions, respectively, $A^{n-}$ is the exchangeable hydrated anion located in the interlayer gallery for charge balance [4].

In this work, we have reported a comparative study of two anionic clays of the Mg-Al-$CO_3$ and Cu-Al-$CO_3$ type. These two materials were synthesized by the co-precipitation method at constant pH with M/Al =2 molar ratio (M=Cu, Mg).Subsequently, they were characterized by X–ray diffraction, Fourier transform infrared spectroscopy and thermogravimetric analysis.

Optical properties such as reflection light, absorption light and optical gap energy were investigated by diffuse reflectance spectroscopy. This study clearly showed a strong improvement in the light adsorption coefficient when magnesium is replaced by copper, which allows Cu-Al-based anionic clay to be of interest for its use in the field of photocatalysis.

**Keywords:** Cu-Al-$CO_3$ LDH, Mg-Al-$CO_3$ LDH, photocatalysts, water purification, absorption light, optical gap energy, diffuse reflectance spectroscopy

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# Poly(methylene blue) modified PLA-CB conductive 3D printer filament as a promising platform for electrochemical sensing of uric acid

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**Abstract**

The electropolymerization of phenothiazine dyes such as methylene blue (MB) known an interesting increase in last decades due to their interesting properties. In this work we describe the electropolymerization of phenothiazine methylene blue (MB) monomer on conductive 3D printer filaments made of polylactic acid doped carbon black (PLA-CB). Poly(methylene blue) (PMB) thin layers were successfully synthesized on PLA-CB electrodes using various electrochemical techniques, including cyclic voltammetry (CV), chronopotentiometry (CP), and chronoamperometry (CA). Thethreshold values required to initiatethe polymerization process were found to be 740 mV and 10 µAcm−2 for the potentiostatic and galvanostaticmodes respectively. Afterward, microscopic and spectroscopic characterization by scanning electronmicroscopy (SEM), Raman, electrochemical impedance spectroscopy (EIS) as well as, X-ray photoelectron spectroscopy (XPS) confirmed the successful modification of the PLA-CB surface with a thin layer of saccharin counter ions-doped PMB. The modified electrode PMB/PLA-CB was then tested for its ability as an electrochemical sensor for uric acid. The analysis conducted by cyclic voltammetry and differential pulse voltammetry (DPV) demonstrated a faster rate for electron transfer, consequently, uric acid can be electrochemically oxidized at a high number of active sites. The detection and quantification limits were determined as 22.63 µM and 75.46 µM for PLA-CB and 9.61 µM and 32.03 µM for PMB/PLA-CB, respectively. Indicating enhanced sensitivity of the modified electrode compared to the PLA-CB electrode. The modified conductive 3Dprinter filament tested in the present study can be considered a promising sensor, not only for uric acid but also for other analytes contained in pharmaceuticals and biological samples.

# Tailored Electrochemical Sensing with Molecularly Imprinted Polymers for Beta-Hydroxybutyrate Detection

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Ketosis, a metabolic state characterized by elevated levels of ketone bodies such as beta-hydroxybutyrate (BHB), has gained significance in clinical and dietary contexts.

Our study focusses on the development and application of molecularly imprinted polymer (MIP) electrodes for the sensitive and selective detection of BHB.

The design and fabrication of MIP electrodes involve the molecular imprinting technique, where specific binding sites for BHB are created within the polymer matrix. The molecularly imprinted polymers demonstrate high affinity and specificity for BHB, enabling enhanced electrochemical sensing capabilities.

This work discusses the synthesis methods of BHB-imprinted polymers, emphasizing the importance of template-monomer interactions and polymerization techniques.

The electrochemical properties of MIP-based electrodes for BHB detection are explored, highlighting their superior performance in terms of detection limits, response times, and stability compared to traditional sensing platforms.

# Activated Lignocellulose for Wastewater Treatment: Adsorption Studies of Crystal Violet Dye

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Organic compounds are widespread in aquatic environments. They have high toxicities and a long retention time [1]. Crystal violet as an organic pollutant is studied in this work. The retention of this pollutant is done using an ST plant in its raw state and activated by citric acid (ST-AC), sulfuric acid (ST-$H_2SO_4$) and sodium hydroxide (ST-OH). After characterization of these adsorbents (MEB, EDX, IRTF and PZC), retention studies of CV are carried out by optimizing the physicochemical parameters influencing the adsorption process: pH, contact time, ratio (mass/ volume), temperature and initial concentration of CV. The results show that crude and activated ST adsorbents effectively remove cationic dyes in aqueous solution. The effect of the functions grafted onto the surface of ST increases the affinity of CV towards the surfaces of the adsorbents. This is shown by the amount of adsorption of CV by ST (246.7 $mg.g^{-1}$), ST-AC (351.1 $mg.g^{-1}$), ST-$H_2SO_4$ (303.0 $mg.g^{-1}$) and ST-OH (327.9 $mg.g^{-1}$). CV adsorption kinetics follow the pseudo-second-order model Also, the results show that the Langmuir model better interprets the adsorption isotherm. Examination of the thermodynamic parameters ($\Delta G°$, $\Delta H°$ and $\Delta S°$) suggests that the adsorption phenomena are spontaneous and exothermic. In addition, the adsorption reactions involved are of the physisorption type which facilitates the desorption of pollutants from the adsorbents' surface, which is demonstrated by the adsorption-desorption cycles. Finally, the results can be considered a useful reference for wastewater treatment using modified biomasses.

**Keywords:** Adsorption; Citric acid; Dyes; Kinetics; isothermal; biomass; Chemical modification; organic pollutants; Pollutants; Crystal violet.

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# Preparation of CP@PANi Composite Adsorption Materials and Their Adsorption Studies for Orange G dye.

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Contaminants in water bodies cause potential health risks for humans and great environmental threats. Therefore, the development and exploration of low-cost, promising adsorbents to remove contaminants from water resources as a sustainable option is one focus of the scientific community. Here, we conducted a study regarding the application of a low-cost composite based on pistachio shell (CP) coated with a small amount of polyaniline (PANi). Various analytical techniques such as scanning electron microscopy (SEM-EDS) and Fourier transform infrared spectroscopy (FTIR) were used to characterize the prepared CP@PANi adsorbent, which confirmed that the CP particles were successfully coated by polyaniline polymer. Thereafter, the prepared composite material is evaluated to remove OG dye under batch adsorption study. The results demonstrated that the optimal removal efficacy was achieved at pH 3. Meanwhile, the pseudo-second-order kinetic and isotherm of the Langmuir model were fitted for OG adsorption. OG amount of 44,50 $mg \cdot g^{-1}$ was the maximum capacity of adsorption attained for CP@PANi. From a thermodynamic point of view, the OG adsorption process occurred spontaneously and endothermically. Importantly, CP@PANi still exhibited an excellent adsorption capability after five regeneration cycles, indicating the potential reusability of the CP@PANi composite.

**Keywords:** Adsorption; Dyes; Kinetics; isothermal; biomass; aniline; composites; organic pollutants; polymers; Orange G; Pollutants.

# Synthesis and characterization of a composite based on a formaldehyde-urea resin and natural clay. Application to the adsorption of anionic dyes

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**Abstract**

The reaction of urea and formaldehyde is an important synthetic chemical process used in the manufacture of various industrially produced resins, including wood adhesives and polymer powders. UF resins are the most important type of thermosetting aminoplastic resins and are made up of linear or branched oligomer and polymeric molecules. The aim of this work is to prepare a composite based on a formaldehyde-urea resin and natural clay UF@AN that is porous in nanometer size and has enhanced functionality. Also lacking are cross-linked structures that emit formaldehyde by tailoring certain reaction variables between urea and formaldehyde. Thus, UF@AN was prepared and characterized by various techniques (XRD, SEM-EDS, and FTIR). The various parameters (adsorbent dosage, contact time, initial concentration, and pH of the medium) influencing the adsorption of Congo red, taken as a model of the anionic dye, onto the prepared material were studied.

**Keywords**: Adsorption, Composite, clay, Formaldehyde-Urea, Red of Congo, Resin.

# Utilization of pomegranate peel for textile dye removal from aqueous environments

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**Abstract**

Methylene blue (MB) is a synthetic dye that is commonly used in various applications. However, its release into the environment has negative impacts on aquatic life and aesthetics.

The present study aimed to investigate the effectiveness of Moroccan pomegranate peel in reducing MB in aqueous environments. Several parameters were considered such as the dose of the adsorbent, initial concentration of MB, contact time, initial pH of the dye solution, ionic strength, and temperature. The experiments were conducted using a batch system to analyze the adsorption of MB. The results showed a rapid adsorption rate, with equilibrium being reached within 60 minutes. The adsorption of MB was significantly affected by the dose of the adsorbent, the initial pH of the solution, the presence of salt (NaCl) in the medium, and the initial concentration of the dye. The findings indicated that pomegranate peel has a maximum adsorption capacity of 67.78 mg/g when a dose of 2 g/L of pomegranate peel is used at a temperature of 25 °C. It was observed that an increase in water temperature led to a decrease in MB adsorption, indicating the exothermic nature of the process. The results strongly suggest that raw Moroccan pomegranate peel has promising potential as a biosorbent for treating dyestuff wastewater.

**Keywords:** pomegranate peel, textile dye, adsorption, reactional parameters, batch system

# Anionic dye removal by walnut shell

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**Abstract**
Water pollution by colored effluents is one of the most significant issues in many countries. The environment may suffer as a result of this pollution. Several wastewater treatment methods, particularly physico-chemical ones, have been implemented to reduce the harmful effects of these pollutants. Among others, the adsorption method was investigated in the present work. The study aimed to determine the capacity of a natural, biodegradable waste (walnut shell) to eliminate Erichrome T black dye. Batch kinetic and isotherm approaches were performed. The results showed that the adsorption process of Erichrome black T on the bio-adsorbent follows the second-order kinetic model. The adsorption isotherm results show that the Langmuir model is more appropriate than the Freundlich model to describe experimental data. The maximum adsorption quantity achieved is equal to 26.32 mg/L.

**Keywords:** wastewater; Erichrome T black; dye removal; walnut shell; adsorption capacity

# Competitive adsorption of Acid blue 113 and Congo red dyes from binary system with Moroccan Prickly Pear Cactus Peel (MPPCP) as natural adsorbent: Kinetic, isotherm, and thermodynamic studies.

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**Abstract**

Wastewater contaminated with organic pollutants must be carefully treated before being discharged into the environment in order to reduce its negative effects on public health. Currently, much attention has been paid to the removal of dyes from industrial wastewater. The aim of this study is to investigate the removal of Acid Blue 113 (AB113) and Congo Red (CR) dyes by using Moroccan Prickly Pear Cactus Peel (MPPCP) from the binary system in a batch reactor. All the parameters influencing the adsorption of the dye in the binary system were studied namely the effect of mixture composition, contact time (20-210 min), initial dye concentration (20-300 mg/L), temperature (25-40 °C), and pH of the dye solution (2-12). The results showed that the uptake of both AB113 and CR dyes highly depends on initial dye concentration, solution composition dyes, and temperature. The kinetic study was performed by applying two kinetic models, the pseudo-first-order and the pseudo-second-order. The pseudo-second-order model better describes the adsorption of the dyes onto MPPCP adsorbent. The analysis of the obtained results shows that the correlation coefficients of the Freundlich model are higher which shows that the adsorption of AB113 and CR dyes in the binary mixture takes a multilayer form. The thermodynamic study showed that the adsorption of dyes in a binary system is spontaneous, physical, and exothermic. The obtained results in this work show that MPPCP can be considered a good material for the removal of anionic AB113 and CR dyes in the binary mixture and therefore used this material on an industrial scale.

**Key-words**: Adsorption, Binary system, Anionic dyes, Moroccan prickly pear cactus peel.

# Exploring the crystal structure and photocatalytic properties of $A_2BB'(1-x)W_xO_6$ double perovskites

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**Keywords:** Double perovskite, Synthesis, Crystal structure, Rietveld refinement.

Double perovskites have recently attracted the interest of scientists [1,2] due of theirs interesting physical applications such as magneto-resistive devices [3] that are revolutionizing the computing world today. In previous studies, similar double perovskites showed a range of other properties including such as superconductivity [4], antiferromagnetic to ferri- and ferromagnetic [5], ferromagnetic and ferroelectric in the same phase [6], ionic conductivity [7], catalytic properties [8] and photocatalytic properties [9], among others etc. Indeed, because of their important applications cited above in diverse fields, oxides with the perovskites structure in modern materials continue to grow. Indeed, owing to their crucial applications across diverse fields as mentioned above, oxides structured as perovskites continue to advance in modern materials research. The crystallographic phase transitions as a function of composition are common in this type of perovskite. These structural changes are often intimately related to the physical properties of materials.

In this study, we present the synthesis of an eco-friendly material with double perovskite structure denoted $A_2BB'(1-x)B''(x)O_6$ (A= Ba, Sr; B= Cu, Mg, Ca, Ni; B' = Mo, Te, W) in its polycrystalline form by thermal treatment in air environment. This material crystallizes in the cubic system, with $Fm\bar{3}m$ space group at room temperature. The crystal structure was solved by the Rietveld refinement of X-ray powder diffraction pattern. The surface texture of the investigated sample was carried out through scanning electron microscope (SEM) micrograph and composition was determined through the EDS analysis. Vibrational properties of the compounds were investigated through FTIR spectroscopy. Furthermore, the optical properties of the material have been carried by UV–Vis spectroscopy.

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# Thin films for photoelectrochemical water splitting and wastewater treatment

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Keywords: Thin films, Photoelectrochemical, water splitting, wastewater treatment.

Utilizing renewable and clean energy sources is vital in mitigating greenhouse gas emissions and environmental degradation for achieving sustainability. Photoelectrochemical, among other sustainable energy techniques like solar power, is instrumental in addressing global challenges such as the energy crisis and pollution[1]. A critical component in the PEC technique is using a photoelectrode, such as thin films which should exhibit excellent visible-light response and charge-transport capacities to ensure efficient sunlight absorption and energy conversion[2]. This is why thin films play a crucial role in enhancing the efficiency of photoelectrochemical (PEC) water splitting and wastewater treatment. In this study we will present the mechanism of photoelectrochemical water splitting, wastewater treatment and some synthesis methods of thin films.

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# *solid-state fabrication of 3D $Bi_{24}O_{31}Br_{10}$ sheet-like with enhanced visible-light photocatalytic activity*

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***Abstract:***

The development of oxide catalysts has become an emerging trend for effective photocatalysts to eliminate environmental pollution (Xing, 2019). In this context, bismuth-rich oxyhalides ($Bi_xO_yX_z$)(X=Cl, Br…) are widely considered as one of the promising photocatalysts due to their strong oxidizing ability, nontoxicity, low cost, and wide band gap (Sharma, 2023). Recently, they have been tested for their enhanced photocatalytic potential in pollutant degradation (Li, 2020), clean energy conversion, etc. In this work, $Bi_{24}O_{31}Br_{10}$ photocatalyst was successfully prepared by a solid-state reaction method. Crystalline phases, optical absorption properties and morphologies were characterized by X-ray Diffraction (XRD), UV–visible Diffused Reflectance Spectra (DRS), Fourier Transform Infrared Spectroscopy (FT-IR) and Scanning Electron Microscope (SEM). Basing on optical characterizations, $Bi_{24}O_{31}Br_{10}$ owns a band gap energy (Eg) of 2.50 eV. Moreover, the photocatalytic activities of the as prepared catalysts were evaluated for the degradation of rhodamin B (RhB) dye under visible light using 250 W Xenon lamp. As a result, during 90 minutes of irradiation, the rate of degradation of RhB exceeds 98.9%. This work provides a method to experimentally prepare $Bi_{24}O_{31}Br_{10}$ and sheds a light on the significance of this bismuth-based semiconductor in photocatalysis application

***Keywords:***

Photocatalysis; $Bi_{24}O_{31}Br_{10}$; Solid-state reaction; RhB degradation

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# Synthesis and Characterization of a Novel BHP@ZnO Photoelectrode for Electrochemical and Photoelectrochemical Degradation of Rhodamine B

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**Abstract**

This study focuses on creating a new photoanode by combining $BAHPO_4$ (BHP) and ZnO to enhance the degradation of Rhodamine B dye (RhB). Characterization techniques including X-ray diffraction (XRD), SEM-EDX morphological analysis, FT-IR vibrational analysis, and UV-Vis DRS optical analysis were employed. Both semiconductors have band gaps in the UV region: ZnO at 3.1 eV and BHP at 3.9 eV. Electrochemical analyses such as Mott-Schottky (MS), open circuit potential (OCP), photocurrent (PT), and linear sweep voltammetry (LSV) were performed. Optimization of BHP@ZnO electrocatalytic activity was achieved using statistical CCD-RSM analysis, identifying key parameters for improved degradation efficiency. Remarkably, 100% degradation efficiency was achieved within 30 minutes, with a reduction to 8 minutes under UV light. Examination of trap states at the n-n junction of BHP@ZnO provided insights into the degradation mechanism, highlighting $^{\bullet}O_2^-$ as the primary radicals responsible. The photoanode demonstrated sustained stability and repeatability, underscoring its potential as an effective tool for RhB degradation. This study introduces a promising approach utilizing BHP and ZnO in a novel photoanode, showcasing their synergistic effect in RhB degradation and contributing to advanced photocatalytic materials research.