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В сборник включены материалы Международной конференции по полимерам, композитам, нанокомпозитам и биокомпозитам-2025 (ICPCNB-2025). Работы, представленные на ICPCNB-2025, отражают широкий спектр исследований — от фундаментальных аспектов синтеза и структуры до практических направлений, связанных с созданием энергоэффективных, биомедицинских и экологичных материалов. Сборник представляет интерес для научных и инженерно-технических работников, преподавателей, докторантов, магистрантов и студентов, занимающихся вопросами разработки, исследования и внедрения современных полимерных и композитных материалов. Представленные материалы могут служить ценным источником информации для дальнейших исследований и разработки инновационных решений, объединяющих научные достижения, технологический прогресс и задачи устойчивого развития.

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The present volume includes the materials of the International Conference on Polymers, Composites, Nanocomposites, and Biocomposites-2025 (ICPCNB-2025). The papers presented at ICPCNB-2025 cover a broad spectrum of research topics — from fundamental studies of synthesis and structure to practical aspects related to the development of energy-efficient, biomedical, and environmentally friendly materials.

This collection is intended for researchers, engineers, university faculty members, doctoral and master’s students engaged in the development, investigation, and implementation of advanced polymeric and composite materials. The presented works serve as a valuable source of information for further research and the development of innovative solutions that integrate scientific achievements, technological progress, and the goals of sustainable development.

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NEW OPPORTUNITIES IN SUSTAINABLE AND GREEN BIO-NANO MATERIALS AND THEIR POLYMER BIO-NANOCOMPOSITES: A CIRCULAR ECONOMY APPROACH

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Abstract

Green chemistry started the search for benign methods for the development of nanoparticles from nature and their use in the field of bio composite, antibacterial, antioxidant, and antitumor applications. Agro-wastes are eco-friendly starting materials to produce typical nanoparticles with well-defined chemical composition, size, and morphology. Cellulose, starch, chitin and chitosan are the most abundant biopolymers around the world. All are under the polysaccharides family in which cellulose is one of the important structural components of the primary cell wall of plants. Cellulose nanoparticles (*fibers, crystals and whiskers*) can be extracted from agro waste resources such as jute, coir, bamboo, pineapple leafs, coir etc. Chitin is the second most abundant biopolymer after cellulose, it is a characteristic component of the cell walls of fungi, the exoskeletons of arthropods and nanoparticles of chitin (*fibers, whiskers*) can be extracted from shrimp and crab shells. Chitosan is the derivative of chitin, prepared by the removal of acetyl group from chitin. Starch nanoparticles can be extracted from tapioca and potato wastes. These nanoparticles can be converted into smart and functional biomaterials by functionalization through chemical modifications (*esterification, etherification, TEMPO oxidation, carboxylation and hydroxylation etc.*) due to presence of large amounts of hydroxyl group on the surface. The preparation of these nanoparticles includes both a series of chemical as well as mechanical treatments; crushing, grinding, alkali, bleaching and acid treatments. Transmission electron microscopy (*TEM*), scanning electron microscopy (*SEM*) and atomic force microscopy (*AFM*) are used to investigate the morphology of nanoscale biopolymers. Fourier transform infra-red spectroscopy (*FTIR*) and x-ray diffraction (*XRD*) are being used to study the functional group changes, crystallographic texture of nanoscale biopolymers respectively. Since large quantities of bio wastes are produced annually, further utilization of cellulose, starch and chitins as functionalized materials is very much desired. The cellulose, starch and chitin nanoparticles are currently obtained as aqueous suspensions which are used as reinforcing additives for high performance environment-friendly biodegradable polymer materials. These nanocomposites are being used as water purification filters, biomedical composites for drug/gene delivery, nano scaffolds in tissue engineering and high-performance sustainable tire engineering. The reinforcing effect of these nanoparticles results from the formation of a percolating network based on hydrogen bonding forces. The incorporation of these nano particles in several bio-based polymers has been discussed. The role of nano particle dispersion, distribution, interfacial adhesion and orientation on the properties of the ecofriendly bio nanocomposites will be carefully evaluated

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NOVEL AND ADVANCED MEMBRANES FOR ENABLING SUSTAINABLE AIR-COOLING SYSTEMS

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Abstract

The rising global demand for space cooling—particularly in arid and hot climates—poses serious challenges to energy sustainability and environmental health. Conventional vapor compression cooling systems are energy-intensive and depend on hydrofluorocarbons (HFCs), which contribute significantly to global warming. A promising alternative lies in the integration of energy-efficient evaporative cooling with membrane-based air dehumidification, offering a pathway to eliminate HFCs while reducing energy consumption. However, this approach hinges on the development of advanced membrane materials that exhibit high water vapor permeance, selectivity, fouling resistance, mechanical durability, and cost-effectiveness.

This presentation highlights our recent advancements in the design and engineering of novel membrane materials tailored for air dehumidification applications. Special emphasis is placed on graphene oxide (GO) membranes, metal-organic framework (MOF)/ionic liquid composites, and innovative mixed matrix polymeric systems. We explore how molecular-level innovations in membrane chemistry and architecture translate into enhanced performance and system-level energy savings. Furthermore, a comparative techno-economic and life cycle assessment is presented to demonstrate the environmental and economic advantages of integrating these membrane technologies into next-generation sustainable air-cooling systems.

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POLYURETHANE–POLYBORODIMETHYLSILOXANE INTERPENETRATING POLYMER NETWORKS AS SHEAR-THICKENING ENERGY ABSORPTION MATERIALS AND PBDMS-GFRP COMPOSITES

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Abstract

This present study reports the synthesis of polyborodimethylsiloxane (PBDMS) via condensation of hydroxyl-terminated polydimethylsiloxane with boric acid, yielding soft viscoelastic polymeric gels with dynamic Si–O–B linkages. FTIR confirmed the successful incorporation through a distinct absorption band at 1340 cm^{-1} along with the characteristic Si–O–Si and Si–CH_3 stretching vibrations. The precursor PDMS molecular weight strongly affected the network architecture: lower-M_w PDMS precursors promoted denser crosslinking and higher stiffness, whereas higher-M_w chains resulted in softer, more flexible gels. Rheological studies further revealed that PBDMS exhibited a well-defined linear viscoelastic region, with modulus and relaxation behaviour governed by dynamic bond formation. Temperature sweeps demonstrated reversible softening and recovery of mechanical properties, highlighting the thermally tuneable and supramolecular nature of these networks. Together, these features establish PBDMS as an adaptable material platform with molecular-level tunability of viscoelasticity. To exploit these properties, polyurethane–polyborodimethylsiloxane (PU–PBDMS) semi-interpenetrating polymer networks (IPNs) were developed to enhance impact resistance and energy dissipation. IPN foams with varying PBDMS content were prepared using a two-step in-situ foaming method. FTIR spectroscopy confirmed the incorporation of PBDMS via characteristic Si–O–Si and Si–CH_3 absorption bands. SEM analysis revealed that PBDMS promoted open-cell structures with microporous walls, facilitating superior energy dissipation mechanisms similar to neat polyurethane foam (PUF). Tensile testing demonstrated that IPN-2 at 10 wt.% PBDMS, exhibited optimal mechanical performance with a tensile strength of 5.9 kg cm^{-2} and elongation at break of 120%, surpassing PUF values (5.2 kg cm^{-2}, 79.6%). The improvements are attributed to enhanced interfacial bonding, microstructural reinforcement, and optimized pore morphology and energy ability B-O-Si bonds anchored into PUF. The findings suggest that PBDMS-modified IPNs are promising candidates for advanced impact-damping applications in automotive, defence, and aerospace sectors.

Additionally, the role of PBDMS as a multifunctional modifier in epoxy–GFRP laminates was also investigated. Epoxy matrices incorporating 0–20 phr PBDMS were fabricated into glass fibre reinforced composites and tested for mechanical performance. At an optimal loading of 15 phr, the laminates exhibited a significant 60% increase in impact strength, a 31% increase in tensile modulus, and a significant 27% increase in flexural modulus as compared to neat epoxy composites. FTIR and rheological studies confirmed the formation of dynamic Si–O–B linkages and shear-thickening behaviour, while SEM–EDS revealed improved fibre–matrix adhesion and homogeneous stress distribution. The shear-thickening nature of PBDMS enabled dynamic stiffening under impact, contributing to superior energy absorption and crack resistance. At higher concentrations (20 phr), phase separation and globule formation caused cavitation, reducing modulus but still retaining higher impact strength as compared to the control. These results demonstrate that PBDMS provides an effective dual function in epoxy composites, toughening the matrix and reinforcing the fibre–matrix interface, highlighting its potential for multifunctional high-performance GFRP laminates. Importantly, such modification directly addresses the key drawback of conventional epoxy–GFRP composites: low impact

resistance and brittle failure, without sacrificing stiffness. Owing to its strain-rate-sensitive shear-thickening behaviour, PBDMS-modified laminates are particularly advantageous under crash, blast, or sudden dynamic loading conditions. This makes the approach highly relevant for applications in automotive crash components, aerospace structural parts, wind turbine blades, marine hulls, and protective defence gear, where lightweight strength combined with adaptive impact tolerance is critical.

Keywords: PBDMS, Polyurethane, Shear Thickening Gel, Impact, GFRP composites

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DESIGN AND DEVELOPMENT OF HIGH-PERFORMANCE IONIC POLYMER MATERIALS AND THEIR MEMBRANE APPLICATIONS

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Abstract

It is highly fascinating to introduce ionic species such as ionic liquids (ILs) into polymeric systems, either by directly incorporating ionic moieties or by converting polymer backbone functional groups into ionic groups, especially in highly permeable polymers with significant Fractional Free Volume (FFV). Recently, we focused on designing and synthesizing various bisimidazole-based monomers that can be polymerized through Menshutkin reactions to produce integrated poly(IL)s called ionenes, an IL-inspired platform where the polymer backbone contains cationic groups (Figure 1). We investigated novel ionic polymers through both qualitative and quantitative analyses, including detailed studies with MD simulations and key gas separation characterization, such as pure gas permeability, solubility, diffusivity, and the ideal selectivities of Ionic-PIM membranes. We developed two simultaneous approaches to convert polymers of intrinsic microporosity (PIM) into ionic backbones; these are highly rigid, contorted polymers that exhibit extensive FFV elements, which are significant in membrane gas separation. The first approach involves synthesizing novel Ionenes from PIMs based on Spirobisindane-derived diimide (SBI) and Tröger's base-based diimide (TBI) monomers with diimidazole functionalities. The second approach introduces an innovative technique for directly converting the polymeric backbone into ionic polyimides (Ionic-PIMs). Membranes made from these new ionene polymers demonstrated high CO2 separation performance along with excellent mechanical and thermal stability. In this work, we establish design principles for integrating CO2-philic ionic groups with microporous polymer membrane structures to achieve high-performance separation. Furthermore, the newly developed Ionic polymers are targeted at various membrane applications such as wastewater treatment and energy storage devices.

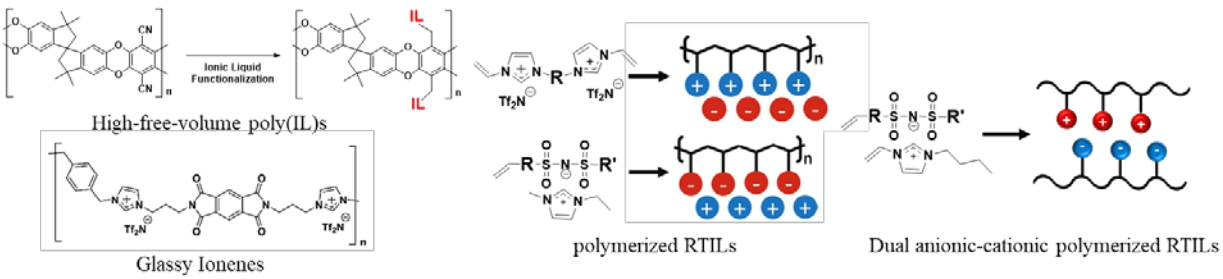

Figure 1. Several proposed IL-mediated approaches.

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BIOPOLYMER-BASED MEMBRANE MATERIALS FOR ENHANCED SEPARATION PERFORMANCE

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Abstract

Membrane technologies offer a promising approach for separating liquid mixtures containing components with varying molecular weights. The optimal membrane process, type (porous or non-porous), and material must be carefully selected for each specific separation task. Simultaneously, achieving highly efficient separation necessitates developing and implementing novel, advanced membrane materials with tailored and improved properties. Modifying the polymer matrix by introducing inorganic and/or organic fillers, creating mixed matrix membranes (MMMs), and surface modification are promising methods for enhancing both porous and non-porous membrane characteristics. This work focuses on developing non-porous membranes for pervaporation, a membrane process for separating liquid mixtures containing primarily low-molecular-weight components, which permeate through the membrane via evaporation on the downstream side. Pervaporation is an environmentally friendly method for separating azeotropic mixtures and close-boiling liquids, utilizing compact equipment, offering versatility, mild process conditions, and continuous operation. Various polymers, including thermoplastics, synthetic, and natural polymers, are used as membrane materials for pervaporation membranes.

In this study, novel non-porous mixed matrix membranes were developed based on the biopolymer's chitosan and carboxymethyl cellulose, chosen for their high hydrophilicity, good film-forming properties, availability, and low cost. Chitosan and carboxymethyl cellulose membranes are utilized in various membrane processes, with particularly interesting research focusing on nanoparticle modification. To improve transport and physicochemical characteristics, bulk modification with graphene oxide and surface modification via polyelectrolyte layer-by-layer deposition were performed. The developed membranes were characterized using scanning electron microscopy, atomic force microscopy, infrared spectroscopy, nuclear magnetic resonance, thermogravimetric analysis, contact angle measurements, and swelling experiments. Membrane transport properties were evaluated in the pervaporation separation of water/isopropanol mixtures of varying compositions. The results demonstrate that these modifications significantly alter both the physicochemical and transport properties of the developed non-porous membranes.

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Keywords: pervaporation, biopolymers, chitosan, carboxymethyl cellulose, mixed matrix membranes, graphene oxide

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HOW NANOPARTICLES ENHANCE OIL RECOVERY: THE ROLE OF STABLE EMULSIONS, INTERFACIAL BEHAVIOUR, AND RESERVOIR IMPACTS

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Abstract

Smart water and nanofluid injections have recently emerged as promising strategies for Enhanced Oil Recovery (EOR), particularly in heavy oil reservoirs. Under specific conditions, these methods can promote the formation of water-in-oil emulsions, which enhance oil mobility. However, if not properly optimized, emulsification may also increase oil viscosity and negatively affect production efficiency.

This study explores the complex role of nanoparticles in EOR, focusing on their contribution to interfacial phenomena, emulsion stability, and fluid transport within porous media. Due to their high surface area and mobility, nanoparticles facilitate key EOR mechanisms such as interfacial tension (IFT) reduction, wettability alteration, and emulsion stabilization. Specifically, at low concentration, nanocomposites enhance emulsion stability significantly by promoting the adsorption of asphaltenes at the oil–water interface.

Through a comprehensive analysis of flooding experiments and literature data, this work investigates the effects of different types and concentrations of nanoparticles on oil recovery. The findings show that increasing nanoparticle concentration enhances oil production by shifting reservoir wettability toward more water-wet conditions and lowering IFT. However, excessive adsorption of nanoparticles may lead to pore blockage, increasing injection pressure—a trade-off that can nevertheless mobilize trapped oil in smaller pore channels.

Keywords: Enhanced Oil Recovery (EOR), Emulsion Stability, Interfacial Tension (IFT), Wettability Alteration

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S

ECO-FRIENDLY CARBON DOTS IN WOUND HEALING: ANTIOXIDANT, ANTIBACTERIAL, AND SELF-HEALING PERSPECTIVES

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Abstract

As metabolic byproducts, reactive oxygen species (ROS) are essential to both physiological and pathological processes. research on controlling ROS levels to treat diseases have garnered a lot of attention lately. This research mostly focuses on antioxidant therapy, which is mediated by ROS scavengers, and ROS-induced toxicity therapy, which is mediated by ROS producers. Many nanomaterials with ROS-modulating qualities have been developed as a result of advances in nanotechnology; carbon dots (CDs) stand out as notable ROS-modulating nanomedicines due to their unique physicochemical features, high stability, and exceptional biocompatibility. The main reason for these problems could be the complex combination of surface states, defects, and core structure that is present in CDs that makes it difficult to make a reliable generalization. This study examines the antibacterial and antioxidant properties of carbon dots, as well as how these factors may impact the self-winding heeling feature. With a focus on the interaction between intrinsic structure and ROS generation or scavenging capabilities, it specifically examines well-established treatment approaches based on CDs-regulated ROS. In addition to highlighting a number of significant technological obstacles and open scientific questions, the conclusion looks ahead to the full development of CD-based ROS-modulating therapy.

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ECO-FRIENDLY WATER PURIFICATION THROUGH SURFACE FUNCTIONALIZED NANOCELLULOSE-BASED AEROGELS

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Abstract

Water pollution has been a major environmental concern for the last several decades due to ineffective wastewater management practices. To address the related challenge, various water treatment techniques have been developed. Among them, nanocellulose (NC) based aerogels, considered as the third generation of aerogels, have emerged as promising adsorbents for wastewater treatment due to their high porosity, high specific surface area, low density, and easy modification. Various surface functionalization techniques have been applied to improve the property and adsorption performance of NC-based aerogel. This review discusses preparation techniques, types of surface functionalization and application prospects of nanocellulose composite aerogel for wastewater treatment, including removal of organic dyes, heavy metal ions, antibiotics, and oil-water separation. Finally, the challenges and future prospects of nanocellulose-based aerogel are highlighted.

Keywords: Nanocellulose, aerogel, functionalization, wastewater treatment

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MARINE POLYSACCHARIDE-BASED HYDROGELS: A SUSTAINABLE PLATFORM FOR ADVANCED WOUND HEALING

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Abstract

Wound healing remains a major global health challenge, especially in chronic wounds, where traditional passive wound scaffolds fall short. The use of bioactive and biodegradable hydrogels is a promising candidate and the research on hydrogels as wound dressings shows a trend of increasing especially in the past decade. Marine-derived polysaccharides such as alginate, chitosan, carrageenan and fucoidan offer unique structural and biological features, including biocompatibility, tunable gelation, anti-microbial and angiogenic potential making them ideal candidates for hydrogel formulation. This abstract outline a conceptual framework for developing multifunctional hydrogels from marine polysaccharides to overcome the limitations of traditional wound care materials. The review will critically summarize recent progress in the field, and discuss strategies for functionalization with bioactive agents and nanomaterials. Emphasis will be given on the design of smart hydrogels capable of providing controlled drug release, moisture balance and real time monitoring of the wound microenvironment. Finally, scalability challenges, clinical translation and regulatory approval will be discussed. This discussion aims to provide a comprehensive outlook on marine polysaccharide-based hydrogels as next generation wound healing platforms.

Keywords: Marine polysaccharides, hydrogel, wound healing, smart dressings

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SYNERGISTIC MODIFICATION OF CARRAGEENAN BIOCOMPOSITES FOR EDIBLE FOOD PACKAGING APPLICATIONS

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Abstract

The global demand for sustainable and health-conscious food systems has intensified the search for eco-friendly, bio-based packaging alternatives to replace petroleum-derived plastics. Carrageenan, a red seaweed-derived polysaccharide, has emerged as a versatile matrix for developing biodegradable, functional packaging materials. This study explores the development of carrageenan based edible biocomposites incorporating glycerol and sorbitol as plasticisers, and potassium chloride (KCl) as the crosslinking agent to modulate physicomechanical and water-interactive properties. Uniform, transparent films of 60 mm thickness were fabricated, and their structural, surface and mechanical characteristics systematically evaluated. Results demonstrated distinct yet complementary roles of glycerol, sorbitol and KCl. Sorbitol significantly enhanced tensile strength, while glycerol preserved flexibility. Incorporation of KCl further reinforced sorbitol-containing films, yielding the highest tensile strength, whereas glycerol-KCl films maintained structural integrity with improved flexibility. Plasticiser addition increased hydrophilicity, with sorbitol exerting a stronger effect than glycerol. Interestingly, KCl modulated surface wettability, decreasing contact angle in glycerol containing biocomposite films, but increasing it by 16° in sorbitol containing counterparts, highlighting synergistic effects. Diffusion studies confirmed reduced swelling ratios, with glycerol containing biocomposites showing the least water uptake, further restricted by KCl addition. These findings underline the multifunctionality of carrageenan biocomposite films, where careful regulation of plasticiser and crosslinker concentrations allows fine-tuning of strength, flexibility and hydrophilicity. By establishing clear structure-property relationships, this work demonstrates the potential of carrageenan-based biocomposites as a sustainable, adaptable and edible alternative to conventional synthetic food packaging materials.

Keywords: carrageenan, glycerol, sorbitol, potassium chloride, edible food packaging

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EXPLORING THE ROLE OF NANOCELLULOSE IN CARRAGEENAN-BASED EDIBLE COATINGS: MECHANICAL, OPTICAL, AND FUNCTIONAL PERFORMANCE

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Abstract

In fresh fruits and vegetables, respiration and microbial spoilage are the causes that leads to a shorter shelf life during transportation and storage, sustainable packaging act as a remedy to extend shelf life However, conventional food packaging materials such as glass, paper, metals, and plastics are universally applied but having certain demerits such as decompose slowly and degrade into microplastics and nano-plastics, often end up in oceans and landfills, and their incineration emits gases that threaten the ozone layer and bring about global warming, endangering both human health and the environment. Edible coating plays a vital role in protecting food products by acting as a barrier against mechanical, chemical, biological, and physical hazards. This protection is mainly from water, oxidation, and enzymatic activity. The addition of plant extracts, essential oils, crosslinkers, and nanomaterials enhances the mechanical, physical, and barrier properties of the packaging and the food products it encloses. In this context, edible films synthesized from natural biopolymers, such as lipids, proteins, polysaccharides, and composite polymer. This study explores the development of edible carrageenan (CGN)-based films reinforced with cellulose nanocrystals (CNC) as a biodegradable alternative to synthetic food packaging budget-friendly, renewable, safe, and non-toxic properties. The composite films were prepared using the solvent casting method with varying CNC concentrations (1–10%) and plasticized with sorbitol to improve flexibility and the morphological, mechanical and properties of films were evaluated. The films incorporated with sorbitol shows superior tensile properties and the lowest hydrophilicity, an ideal combination for food packaging applications. When the concentration of carrageenan increases the wettability of the film improved in addition to increase in moisture absorption, solubility, and water vapor permeability. The mechanical properties of the films were improved by CNC addition and higher carrageenan content. The produced films showed effective UV radiation barriers and biodegradability. They can be utilized respectively by spraying on fruits/vegetables during harvesting since they consist of components actively used in the food industry. The merit of the using such components occurs in the form of properties viz. moisture resistance, water-soluble nature, gelling properties, good thermal and mechanical properties, antimicrobial activity, SEM analysis, heat-based sealing, flexible colorless, etc. The films were applied as coatings on apples, gooseberries, and ivy gourd using spray and dip-coating methods. Coated samples exhibited reduced weight loss and improved preservation. These findings demonstrate the potential of CGN-CNC films as effective, eco-friendly coatings for extending the shelf life of perishable produce.

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A NOVEL ECO-FRIENDLY STARCH CHITOSAN BLEND WITHOUT ANY CROSSLINKING AGENT FOR THE EFFECTIVE REMOVAL OF CONGO RED DYE

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Abstract

Pollution of our water bodies by various chemicals is one of the greatest environmental issues faced by mankind in the recent scenario. Among the various water-polluting chemicals, dyes, which were released from various industries, are a major polluting material. Congo red is a very important anionic dye that is highly soluble in water bodies. The aromatic amine containing Congo red is a carcinogenic, azo group-containing material. Due to its high solubility in water, it may persist in water for a long time and may affect the natural water bodies with a great impact. Cost-effective and environmentally benign materials like starch chitosan blend films were used to study the adsorption capacity to remove Congo red dye. Different characterization methods like FTIR, SEM, EDAX, UV-Visible Spectroscopy, etc. They were employed to investigate the degree of Congo Red adsorption on different starch-chitosan mix films. To characterize the films' adsorption capacity, adsorption isotherm models such as the Freundlich, Temkin, Langmuir, etc., were employed. A variety of models were used to analyze the adsorption kinetics, including Elovich, Pseudo Second Order, Pseudo First Order, and interparticle diffusion. Adsorption kinetic studies were carried out using a 10ppm Congo red solution. The values of qe Cal (17.66784) and qe Exp (17.7926) are nearly identical, as shown by Qcal, which is derived from the slope and intercept of the linear curve.. From these values, it is clear that the adsorption of Congo red on starch chitosan blend films follows pseudo-second order kinetics.

KS

EFFECT OF MILLING TIME OF WOOD FLOUR IN WOOD POLYPROPYLENE COMPOSITES

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Abstract

Environmentally friendly natural fiber-reinforced composite materials, or green composites prepared by combining bio-based fillers with a biodegradable resin can be selected as one of the most appropriate materials for minimizing the use of petroleum-derived materials.[1] To adopt a method which supports the industry by considering the ease of production and economic factors are in demand. The study is focused on knowing the effect by analyzing the changes in characteristics properties like particle size, morphology, diffraction pattern, particle size distribution in the wood flour on milling and the on the final properties of the wood composite. The highest value of tensile strength and fatigue life was observed for 1-hour milled wood flour based composites. On increasing the milling time the smaller particle size increases the surface area of the particles causing the smaller particles to get agglomerate together. The detailed analysis of SEM with a higher resolution microscope shows the destruction of fiber bundles and formation of cracks and the particle changing to flaky structure initially and then to spherical particles for 4 and 8 hr milled samples .After 1 hour milling time, both tensile strength and fatigue life started to decrease due to the decrease in size of wood fiber with increase in milling time. A decrease in contact angle was observed in the PP /wood flour composite. Although there was an initial drop in contact angle which indicates the presence of wood flour in the PP matrix, for the composite prepared with 1hr milled wood flour, the contact angle was found to get increased. The decrease of the water absorption and an increase in contact angle can be related to the absence of free hydroxyl groups in the composite structure. Thus, 1 hour ball milled wood flour could be selected as the appropriate time to mill the wood fiber for better property enhancement.

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PLASMA-ASSISTED SURFACE ENGINEERING OF TIN-BASED PEROVSKITES FOR ENHANCED PHOTOVOLTAIC PERFORMANCE

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Abstract

Tin halide perovskites (THP) are one of the most promising and less toxic alternatives to lead-based perovskite solar cells. These materials have gained increasing interest in recent decades due to their exceptional optoelectronic properties and related tunability, straightforward processing and high efficiencies, approachable to silicon solar cell's ones. Despite the outstanding properties of THPs, one of the main disadvantages of this class of materials is the high concentration of defects present in the bulk, due to Sn (II) instability and intrinsic tendency to oxidise over time. The consequent self p-doping of the perovskite leads to increased free-charge recombination rate and reduced efficiency of solar cells. Engineering the surface passivation of tin perovskites is one of the key strategies to address both stability and performance enhancement of solar cells, for example by using additives, such as tin halides or hydrazine, which is a potent reducing agent able to compensate for tin vacancies.

Among the various strategies explored, mainly solvent-based, we investigated for the first time an innovative use of plasma as a solvent-free, reproducible and scalable approach, 1,2 to gently modify the perovskite surface and reduce surface defects. A preliminary study focused on nitrogen-based plasma treatment, applied to a DMSO-free FASnI3 perovskite surface [3]. The mild nature of the plasma process enabled subtle surface modifications, effectively suppressing the natural tendency of tin (II) to oxidize, as confirmed by the XPS analysis performed on aged films. Subsequently, we extended this approach to a FASnI2.7Br0.3 perovskite, employing a plasma generated from a mixture of N2 and H2 gases. Owing to the reducing character of hydrogen-based plasma, we observed a notable enhancement in device performance, accompanied by increased photoluminescence and reduced non-radiative recombination. The reactive hydrogen species generated within the plasma interact with the perovskite surface, mitigating carrier losses associated with self-doping, thereby contributing to improved device efficiency. [4]

These studies establish the basis for a novel application of plasma technology to enhance tin-based perovskite solar cells, offering an approach that is not only effective but also readily scalable for industrial implementation.

References

1. Armenise, V., Covella, S., Fracassi, F., Colella, S. & Listorti, A. Plasma-Based Technologies for Halide Perovskite Photovoltaics. Solar RRL (2024) doi:10.1002/solr.202400178.

2. Perrotta, A. et al. Plasma-Driven Atomic-Scale Tuning of Metal Halide Perovskite Surfaces: Rationale and Photovoltaic Application. Solar RRL (2023) doi:10.1002/solr.202300345.

3. Covella, S. et al. Plasma-Based Modification of Tin Halide Perovskite Interfaces for Photovoltaic Applications. ACS Appl Mater Interfaces (2024) doi:10.1021/acsami.4c09637.

4. Covella, S. et al. manuscript in preparation.

KS

DEVELOPMENT OF EDIBLE CELLULOSE-BASED BIOPOLYMER FILMS TO INCREASE THE SHELF LIFE OF AGRICULTURAL PRODUCTS

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Abstract

Due to the high perishability of fruits and vegetables, synthetic coatings and preservatives are widely used during their storage and transportation, whereas agro-industrial by-products represent a promising renewable and low-cost source for the development of natural polymers. In this study, a multifunctional biopolymer edible film AP-CS-CMC-CNC-HT based on apple pectin (AP), corn starch (CS), sodium carboxymethylcellulose (CMC), and nanocrystalline cellulose (CNC) was fabricated by the wet casting method with the addition of *Hibiscus trionum L.* extract. Glycerol was used to provide elasticity. All major components used for film fabrication were extracted from locally available plant raw materials, derived from by-products of the agro-industrial field. The films were characterized in terms of physicochemical and organoleptic properties, as well as biocompatibility and potential antimicrobial activity against gram-positive and gram-negative bacteria. The addition of *H. trionum L.* extract improved the functional properties of the films, providing color and potential antioxidant and antimicrobial activity. These properties were confirmed using apple samples, where coating application effectively reduced weight loss during storage, while the pH-dependent color change of anthocyanins provided an additional visual indication of product freshness. The developed films show strong potential for agricultural food preservation and can serve as a natural biodegradable alternative to synthetic packaging.

Keywords: edible coating, biopolymer film, fruit preservation, antimicrobial activity, *Hibiscus trionum*, cellulose

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ETHNOMEDICINAL FABRICATED ECO-FRIENDLY METAL-OXIDE NANOPARTICLES: UNVEILING A NEW AVENUE FOR SUSTAINABLE NANO-BIOMEDICINE DEVELOPMENT

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Abstract

The emergence of nanotechnology has reshaped the field of biomedicine, contributing revolutionary therapeutic strategies and diagnostic tools. However, the wild methods of nanoparticle synthesis involve hazardous chemicals and energy-intensive processes, posing health and environmental concerns. Wild approaches suffer from the challenging concern of stability, sustainability, and biocompatibility. Designing eco-friendly nanoparticles has become a persistent necessity. Synthesis of inorganic metal oxide nanoparticles offers a better alternative for handling different health complications in nano-biomedicine. But environmental bio-degradation hinders its long-term stability. Ethnic botanicals, rich in potential phytochemicals, render a favourable solution for fabricating biogenic metal-oxide nanoparticles (BMNPs). This technique influences the reducing and capping properties of plant extracts to synthesize stable BMNPs, showcasing unique physicochemical properties. This nanocomposite makes them suitable for various biomedical applications, including targeted drug delivery, imaging, and pharmacological therapy. The study aims to provide a comprehensive overview of the ethnic plant-mediated synthesis of BMNPs, highlighting their potential for green sustainable nano-biomedicine, emphasizing Indian traditional-plant extract-plugged metal-oxide nano-phytopharmaceutical formulation, including their probable challenges and future scopes in this emerging field for industrial scale-up. Current investigation framed model zinc-oxide nanoparticles (ZnO-NPs) fabricated by *Acmella paniculata* flower extract. UV-VIS spectroscopy(λ_{max} at **251 nm),** TEM assessed particle-size **(45 nm),** FT-IR spectroscopy showing a sharp peak at **1076 cm^{-1}** due to the reference compound, **Spilanthol**, and zeta potential value (**-5.8mV)** unravel its sustainable standardisation. Morphological characterisation of the AP-ZnONPs analysed by XRD, FESEM-EDAX, TEM, and DSC techniques were found to be inspiring for standardisation. AP-ZnONPs displayed remarkable IC_{50} of **28.57, 34.58 , 41.01, 71.45** µg/ml for *in vitro* DPPH anti-oxidant, H_2O_2 radical scavenging, anti-protein denaturation, and α-amylase inhibition activity, respectively. It showcased efficient photocatalytic degradation of Rhodamine B by 45.84% within 60 minutes. The study suggests that AP-ZnONPs could be used as a potential bio-remedial agent and nano-biomedicine for treating inflammation, diabetes, compared to empty ZnONPs.

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ORGANOCATALYTIC SYNTHESIS OF POLYBORODIMETHYLSILOXANE (PBDMS) VIA DBU: A GREEN STRATEGY FOR DYNAMIC SUPRAMOLECULAR ELASTOMERS

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Abstract

Polyborodimethylsiloxane (PBDMS), belonging to the class of dynamic supramolecular elastomers, was synthesized through a solvent-free, DBU-catalyzed condensation of hydroxy-terminated polydimethylsiloxane (OH-PDMS) with boric acid (BA). The strategy provides a sustainable, metal-free, and energy-efficient organocatalytic route for designing advanced elastomeric materials. In this process, DBU acts as a highly effective organobase catalyst by abstracting protons from silanol groups, thereby generating reactive siloxide species that readily undergo condensation with boric acid. This reaction pathway accelerates the formation of Si–O–B linkages, which serve as reversible and dynamic cross-linking points within the polymeric matrix. Such dynamic covalent interactions endow the material with self-adjustable network characteristics, rapid gelation ability, and enhanced structural adaptability under mild, solvent-free conditions. Compared to conventional thermal polycondensation, which requires elevated temperatures and prolonged reaction times, the DBU-mediated method achieves nearly complete conversion within hours, highlighting its environmental compatibility, operational simplicity, and scalability for industrial processing. The structural development of PBDMS was systematically characterized using spectroscopic, chromatographic, and rheological techniques. FTIR confirmed cross-linking through Si–O–B bands, while gel permeation chromatography evidenced controlled polycondensation with increased molecular weight and narrow dispersity. Rheological analysis revealed higher cross-link density, elevated storage modulus, and a clear liquid-to-solid transition, confirming the transformation of PDMS into a supramolecular elastomeric network. Beyond synthetic efficiency, the persistence of DBU-associated FTIR signals suggested remarkable catalyst stability and the potential for recyclability, reinforcing the green chemistry credentials of this method. The ability to recycle the catalyst without compromising performance enhances both economic and environmental sustainability, offering a practical advantage over traditional methods. This study establishes DBU-catalyzed PBDMS synthesis as a recyclable and environmentally benign strategy for creating tunable supramolecular elastomers. Dynamic Si–O–B linkages impart adaptable mechanics and stimuli-responsiveness, making the material suitable for applications such as flexible electronics, damping systems, impact absorbers, and adaptive soft matter. By uniting sustainable processing with structural versatility and advanced performance, DBU-mediated PBDMS offers a promising platform for next-generation elastomeric materials.

Keywords: Polyborodimethylsiloxane; DBU; Viscoelastic properties; Supramolecular interactions; Molecular weight distribution; Chain growth.

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A METHODOLOGY FOR PROCESSING EPOXY BASED GFRP NANOCOMPOSITES REINFORCED WITH COMPATIBILIZED POLYMERIC FILLERS AND SILANIZED NANOCLAY FOR IMPROVED IMPACT STRENGTH

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Abstract

Glass fibre reinforced plastics (GFRPs) containing epoxy as the matrix material and nanoclay as a reinforcement provide good static mechanical properties like high flexural strength, tensile strength, and tensile modulus but these GFRPs lack in impact strength. To improve the impact performance of the cross-linked brittle epoxy based GFRPs, researchers recently developed multi-scale filler reinforced GFRPs containing clay as the nano-reinforcement and thermoplastic polymer fibres as the micro-reinforcement. However, it was observed that addition of polymer fibres in the pristine state degrade the mechanical properties of epoxy based GFRPs. To overcome this issue, polymer fibers are compatibilized (surface treated) to improve their compatibility with other constituents of the GFRP nanocomposite system. This significantly improves the impact performance of such systems. The primary methods for surface modification of reinforcing thermoplastic polymer fibres include (i) silane treatment of fibers, and (ii) maleic anhydride grafting (MAH grafting) of fibers. The interfacial adhesion among various constituents of the composite system is enhanced through the use of these compatibilization procedures. These procedures generate active functional groups on the surface of the reinforcing polymeric fillers which improves the interfacial bonding among various constituents. GFRPs with high impact strength along with good tensile-flexural properties find applications in hulls and decks of ships, dashboards and chassis of racing cars, bicycle frames, archery bows etc.

Keywords: Epoxy; Nanoclay; Surface treatments; Impact Strength; GFRPs.

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INNOVATIVE LIQUID BANDAGE FOR NON-INVASIVE MANAGEMENT OF EARLY CARIOUS LESIONS- AN IN-VITRO STUDY

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Abstract

The present study aimed to develop a cocoa-based liquid spray bandage containing nano-theobromine and evaluate its remineralization potential against early carious lesions. The formulation was prepared by incorporating nano-sized theobromine isolated from cocoa beans into a polymer solution, along with glycerin, methyl paraben, and propyl paraben, followed by sonication and transfer into spray bottles. The prepared spray bandage was characterized for viscosity, pH, stability, film thickness, tensile strength, drug content, and release profile. The developed spray bandage exhibited a neutral pH of 7.96, viscosity values ranging from 25 cp to 4.38 cp at different RPMs, and a film thickness of 0.002 mm. Healthy extracted human premolars were sectioned into enamel blocks and divided into three groups: placebo, control with 5% sodium fluoride varnish, and the developed theobromine-based liquid bandage. After inducing subsurface enamel lesions through a 7-day demineralization process, all samples were subjected to a 28-day remineralization phase. Evaluation with Scanning Electron Microscopy revealed that both the fluoride varnish and theobromine spray bandage promoted remineralization, with theobromine showing slightly higher mineral deposition. A statistically significant difference (P = 0.001*) in calcium and phosphorus levels was observed among the groups. These findings indicate that the nano-theobromine liquid spray bandage has encouraging remineralization potential for early enamel lesions, with superior performance compared to fluoride varnish. The formulation is safe, biocompatible, easy to apply, and provides prolonged adhesion, making it a promising natural alternative for non-invasive caries management.

Keywords: Cocoa, Remineralization, Demineralization, Subsurface Enamel Lesion, Theobromine

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FACILE FABRICATION OF DURABLE SUPERHYDROPHOBIC FELT TEXTILES USING IONIC LIQUID FOR EFFICIENT OIL/WATER SEPARATION

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Abstract

Superhydrophobic poly (ionic liquid) coating via UV curing polymerization was developed and applied to felt textiles to enhance their oil/water separation performance and durability. The main coating system comprised hydrophobic silica nanoparticles and ionic liquid. Dip-coating was used to apply the formulated solution onto felt substrates, followed by UV curing and thermal treatment to ensure uniform adhesion and crosslinking. Characterization via contact angle measurements revealed a significant increase in hydrophobicity, with water contact angles rising from 132.1° (pristine) to 151.9° (modified). Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray Spectroscopy (EDS) confirmed the successful deposition and elemental uniformity of the coating. The treated textiles demonstrated exceptional oil/water separation efficiency, achieving a peak value of 99.98% and maintaining an average efficiency of $99.5 \pm 0.45\%$ over ten cycles. Fourier Transform Infrared Spectroscopy (FTIR) further validated the presence of key functional groups responsible for hydrophobicity. This facile, reusable, and scalable approach presents a promising strategy for fabricating robust materials for efficient oil/water separation applications.

Keywords: Superhydrophobic, Microfiber, Ionic liquid, Oil/Water Separation

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CARBON BASED HYDROGEN STORAGE MATERIALS

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Abstract

Hydrogen is an alternative source of energy due to its various advantages, such as higher energy density, non–polluting characteristics and renewable nature. This study intended to develop mesoporous templated carbon and graphene-based materials for solid state hydrogen storage. In this study, the low-cost alumina based mesoporous templates were developed and the efficiency was compared with that of templated carbons prepared using commercially available microporous zeolite and mesoporous silica gel templates. The effects of non-metal (nitrogen) and metal (platinum, palladium or nickel) doping on templated carbons were also investigated. The graphene-based materials were developed by chemical and thermal treatments of graphene oxide. The effects of exfoliation temperatures (200–500°C) and carrier gases (hydrogen, argon, or air) were studied. The effects of preparation conditions and incorporation of metals (platinum, palladium or nickel) were also investigated. The hydrogen storage properties of the prepared samples were determined at –196 °C at 25 or 30 bar using volumetric adsorption analysis. The heat of adsorption, reversibility and cycle stability of samples were also determined. The alumina based templated carbons were mesoporous (2–10 nm) having agglomerated tubular/noodle like structures. At –196 °C and 25 bar, the hydrogen uptake capacity for nitrogen doped surfactant modified alumina templated carbon was 3.9 wt.% which enhanced to 4.1 wt.% on co–doping with platinum and to 5 wt.%. on co-doping with palladium. The increase may be assigned to additional adsorption sites for hydrogen provided by dopants. Also, the highest heat of adsorption of 22.9 kJ/mol was obtained for the same sample. The chemically hydrazine reduced graphene oxide (RGO) had wrinkled layered, while thermally exfoliated graphene oxide samples had fluffy layered structure. The BET surface area was highest for RGO (461 m^2/g), while O/C value was highest for EGO (Air). The exfoliation temperature of 300 °C was observed to be optimum. The maximum hydrogen uptake of 3.34 wt.% was obtained for EGO (Air) at –196 °C and 30 bar followed by that of RGO. The hydrogen uptake capacity was observed to increase with O/C ratio as the presence of highly electronegative oxygen may have facilitated the interaction with incoming highly electropositive hydrogen. On addition of palladium metal to RGO and EGO, the hydrogen uptake capacity was enhanced from 2.5 to 3.2 wt.% and 3.3 to 3.5 wt.% respectively at –196 °C and 30 bar.

Keywords: Templated carbon, Graphene, Physiochemical properties, Hydrogen storage

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THE ROLE OF BIODEGRADABLE POLYMER COMPOSITES IN THE TECHNOLOGY OF GROWING TALL BLUEBERRIES (VACCINIUM CORYMBOSUM L.) WITH A CLOSED ROOT SYSTEM

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Abstract

The article presents a study on the role of biodegradable polymer composites in the cultivation technology of highbush blueberry (Vaccinium corymbosum L.) with a closed root system. The research object was blueberry plants grown in containers made of biodegradable polymer materials. The aim of the study was to provide a scientific rationale for the effectiveness of using this type of composite in container-based cultivation of the crop. Within the framework of the experiment, a comprehensive assessment was carried out to evaluate the impact of biodegradable containers on the formation of the root zone, the activity of mycorrhizal associations, plant survival, growth, and development. It was established that the use of containers made of biodegradable polymer composites contributes to creating optimal conditions for the functioning of the root system and symbiotic microorganisms, enhances plant adaptability to stress factors, and ensures stable development. Moreover, it was demonstrated that the use of such materials performs a complex function: it creates a favorable environment for blueberry growth, increases the environmental sustainability of the technology, and reduces the carbon footprint of production

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NANO PARTICLES AND HOMEOPATHY
A DYNAMIC SCIENTIFIC PERSPECTIVE

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Abstract

Homeopathy is the most controversial alternative system of medicine and second largest popular system of medicine. It is controversial due to absence of chemically identifiable and detectable ingredients of the medicinal substance initially used in the preparation of the potentized homeopathic medicine. As per consideration of Avogadro's hypotheses, any homeopathic medicine beyond 12^{th} Centesimal or 24^{th} Decimal potency, cannot have presence of atoms or molecules of the original medicinal substance, as per the currently accepted doctrines of Chemistry. The commonly used potentized homeopathic medicines include centesimal preparations of 30^{th}, 200^{th}, 1000^{th}, 10000^{th}, 50000^{th}, 100000^{th}, etc., which are clearly beyond 12^{th} potency and working effectively homeopathically, but chemically remain negative for atoms and molecules during the process of chemical analysis. Recent scientific developments had identified presence of nanoparticles in high dilution homeopathic medicines. Even after the identification of the nanoparticles, the important questions remain – what are these nanoparticles and how it acts curatively in human beings or in any living organisms including in animals and plants. Dynamic Science is a new scientific paradigm developed and introduced by the author of this presentation and it explains in modern scientific perspective; how mind, vital force and DNA; and how matter and energy are interconnected. It explains many unexplained things like: how cancer develops; how DNA regulation takes place; etc. All these new hypotheses give clear and easy understanding about homeopathy, explaining what is acting curatively in homeopathic medicine and how homeopathic medicines work.

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SEAWEED-DERIVED ADVANCED MATERIALS FOR POTENTIAL ENVIRNMENTAL APPLICATIONS

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Abstract

India has ~7500 km long coastline that is accessible for seaweed activities including seaweed cultivation. Seaweeds represent one of the most significant and auspicious sources for numerous natural products including gelling polymers such as agar, carrageenan and alginates. Moreover, seaweed polymers have been widely used as a key ingredient in the pharmaceutical, food, cosmetics, and dairy industries as stabiliser. Under the value addition programme of seaweed biopolymers, we developed sustainable advanced materials and tested them for the separation of oil-water and organic-water mixtures without applying external force. Developed advanced porous materials were characterized using advanced analytical tools such as scanning electron microscopy (SEM), FTIR, UV. Hence, this talk provides progress toward the development of seaweed-derived sustainable materials for potential water remediation applications.

Keywords: Seaweed-derived polymers, Advanced materials, Environmental applications

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ECO-FRIENDLY SYNTHESIS OF GOLD NANOPARTICLES USING *BOMBYX MORI* SILK FIBROIN: OPTICAL STUDIES AND AMMONIA DETECTION

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Abstract

Biopolymer material were used to fabrication of nanoparticles has magnetic scrutiny. In the present investigation, use the aqueous polypeptide protein chain as renown as silk fibroin (SF), extracted from the Bombyx mori cocoons shells. Silk fibroin plays a major role in the origination of numerous size and shape of gold nanoparticles (GNPs) during the synthesis. Formed gold nanoparticles were characterized by numerous analytical techniques. UV-Visible spectroscopy (UV-Vis) exhibited the establishment of gold nanoparticles by screening surface plasmon resonance (SPR) intensity band at λmax from 518 to 534 nm. X-ray diffraction (XRD) investigation evidenced the crystalline and face centered cubic (FCC) nature of gold nanoparticles. Fourier transfer infrared spectroscopy (FTIR) demonstrated the functional groups in SF were responsible creation of Au^{3+} to Au^{0}. Surface morphology of gold nanoparticles were scrutinised by using scanning electron microscopy (SEM). Fluorescence spectroscopy (FL) confirmed formation of gold nanoparticles by redox of tyrosine groups in the silk fibroin. Ammonia sensing investigation of biopolymer gold nanoparticles were accomplished by optical approach based on SPR intensity band. The execution of ammonia optical sensor were studied which yield outstanding result. The detection limit of ammonia is 1 ppb.

Keywords: Silk fibroin, GNPs, UV, FTIR; FL and Ammonia detection.

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DEVELOPMENT OF AN INDUSTRIAL FORMULATION FOR ROTATIONAL MOLDING BASED ON RECYCLED POLYETHYLENE

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Abstract

The mitigation of polyethylene (PE) pollution is a pressing global issue, for which mechanical (secondary) recycling is the most effective approach. This study examines the use of recycled polyethylene (rPE) in formulations for rotational molding (rotomolding). Specifically, we investigated how the content of industrial recycled linear medium-density polyethylene (rLMDPE; 0–100% in 5% increments) affects the mechanical properties of the material—ultimate tensile strength (UTS), elongation at break (L), and elongation at yield (L1)—as well as an acoustic parameter, the third-harmonic amplitude (VTH). Incorporating 5–10% rLMDPE into the formulation leads to a sharp decrease in UTS by 35% (from 20 to 13 MPa), in L by 41%, and in L1 by 45%. However, increasing the rLMDPE content to 25% results in an improvement of all studied mechanical parameters, with UTS rising by 23% in particular. A further increase of rLMDPE to 50% and 100% again causes a decline in mechanical performance. The dependence of VTH on rLMDPE content exhibits a similarly complex, non-monotonic behavior, with three pronounced maxima at 10–20%, 50%, and 90–100%. A pronounced inverse correlation is observed between VTH and the mechanical properties of the samples: higher VTH values correspond to lower mechanical performance. This correlation warrants further investigation. On the basis of these findings, we recommend an industrial formulation containing 25% rLMDPE. The practical significance of the work lies in proposing a promising material for rotational molding that combines satisfactory mechanical properties with the environmental benefit of utilizing recycled polyethylene, thereby reducing its environmental impact.

Keywords: rotational molding, plastic recycling, ultrasound, mechanical properties

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ARTIFICIAL NEURAL NETWORKS USED IN DENTAL MATERIAL ANALYSIS: A COMPREHENSIVE REVIEW

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Abstract

Artificial Neural Networks (ANNs) have revolutionized data analysis and prediction capabilities across various fields. This review paper explores the applications of ANNs in the analysis and design of dental materials. Essential for dental restorations and treatments, these materials require precise characterization of their mechanical and biological properties to ensure durability, effectiveness, and biocompatibility. The paper discusses how ANNs can predict and optimize properties such as strength, wear resistance, fracture toughness, and biocompatibility. Key optimization techniques, including backpropagation, gradient descent, and the Adam optimizer, are reviewed for their role in enhancing ANN performance. Significant case studies are highlighted to demonstrate the successful prediction of behavior in dental composites, ceramics, and alloys. The paper also addresses the advantages, limitations, and future prospects of integrating ANNs with emerging technologies like big data analytics and machine learning to advance dental material science. This review underscores the potential of ANNs to transform the design and analysis of dental materials, paving the way for innovative solutions in dental research and clinical practice.

Keywords: ANNs, dental material, biocompatibility, Optimization Techniques

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SYNTHESIS AND APPLICATIONS OF NANOSTRUCTURES BASED ON POLYANILINE DERIVATIVES

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Abstract

Conducting polymers have shown great potential in the fields of electronic materials, battery, and sensing applications. Here we present adhesive polymers based on aniline linker. The nature of linker gives some flexibility in terms of self-assembly which led to generation of versatile nanostructures. Formation of these nanostructures depends on polymerization conditions, doping, pH and solvent effects. Self-assembly-directed polymerization could be controlled to form nanorods, further directed to form nanobowl/hollow-spherical structures. Through controlling the structures, adhesive conducting polymeric films was developed, exhibiting strong adhesiveness with the formation of gecko-like structures demonstrate similar adhesiveness (around 8 N/cm2) as gecko-finger hails. Also polyaniline based hydrogen sensors will be discussed. Three different polyaniline nanostructures which consisting of hollow tube, film and short nanofiber were evaluated for hydrogen sensing.

Keywords: polyaniline, conducting polymers, adhesiveness, hydrogen sensing

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S

CHARACTERIZATION OF TREATED AND UNTREATED ARECA CATECHU FIBER AND WALNUT SHELL POWDER AS SUSTAINABLE COMPOSITE REINFORCEMENTS

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Abstract

In recent years, global interest in natural fiber-reinforced polymer (NFRP) composites has grown significantly due to their advantageous properties, including cost-effectiveness, availability, low density, and manufacturing feasibility. This study details the extraction and characterization of Areca catechu stem (ACS) fiber and walnut shell powder (WSP). ACS fibers were extracted from the Areca palm (Dypsis lutescens) and treated with sodium hydroxide (NaOH) at concentrations of 6 wt%. The behaviors of alkali-treated and untreated ACS fibers and WSP filler were investigated through physicochemical analysis, X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), tensile testing, and thermogravimetric analysis (TGA). Chemical modification using alkali treatment yielded a 28.9% increase in cellulose content, accompanied by a reduction in amorphous matter and moisture content. The ACS fibers treated with 6% NaOH exhibited optimal mechanical properties, with a tensile strength of 524.71 ± 42.27 MPa, a modulus of 7.57 ± 1.08 GPa, and an elongation at break of 5.91 ± 1.62%. The surface morphology and roughness of ACS fibers and WSP fillers were analyzed to assess structural integrity, fibrillation, and texture changes from alkali treatment. Thermal stability was also evaluated to determine degradation resistance and suitability for composite reinforcement. The potential of using ACS fibers and WSP as reinforcement materials in polymer composites has been reported.

Keywords: Natural fiber, Sodium hydroxide (NaOH), Single fiber testing, Fourier transform infrared spectroscopy, scanning electron microscopy.

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S

IMIDAZOLIUM-BASED IONONE HYDROGELS- A VERSATILE MATERIAL FOR POLLUTANT REMOVAL AND TARGETED DRUG DELIVERY

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Abstract

In recent years, ionic liquids (ILs) have gained significant attention for their unique properties, including ionic nature, low melting point, minimal volatility, low vapor pressure, and often non-flammability and green solvent potential. These features have enabled ILs to be used in various fields such as fine chemical synthesis, catalysis, extraction, and electrochemistry. Incorporating ILs into solid materials has become important and research on polymers containing IL-like units has been an attractive research field and which offers a promising way to harness the advantages of ILs. Considering the above, here in we report the synthesis and characterization of imidazolium-based ionone gel membranes formed by the reaction of poly(4-vinylimidazole) with a terminal dibrominated poly(ethylene glycol) (PEG) the this work aims to obtain a PIL-based material, in which the formation of the ionized matrix is driven by the quaternization of imidazole nitrogen atoms with PEG chains as cross-linking joints, which act as the main active sites for the adsorption of anionic molecules such as sodium diclofenac (DCl) and methyl orange (MO), respectively. The presence of PEG chains will serve as an idoneous cross-linker starting material, endowing the material with remarkable hydrophilicity and allowing it to attain the above-mentioned swelling properties. The hydrogel loaded with the pharmaceutical drug DCl was used as a model system for drug delivery experiments, in which the hydrogel was able to release almost 60% of DCl to the medium within 1 day of exposure. The hydrogel containing DCl exhibits ease of washing, indicating significant potential for repeated use across multiple adsorption cycles.

Keywords: ionic liquids, ionone’s, hydrogels, drug delivery

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WEARABLE PIEZOELECTRIC NANOGENERATORS BASED ON SUSTAINABLE CHITIN-POLYMER COMPOSITES FOR SELF-POWERED SENSING AND ENERGY HARVESTING

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Abstract

This study explores the development of high-performance wearable piezoelectric nanogenerators (PENGs) by integrating chitin nanofibers (CNFs) into electrospun polyvinylidene fluoride (PVDF) nanofibers. Due to their ability to convert mechanical energy from human motion into electrical power, these PENGs hold significant promise for self-powered healthcare and energy harvesting applications. The synthesized PVDF-CNFs (PC-NFs) composites were characterized for their structural, thermal, and piezoelectric properties. Our findings show that the inclusion of 2 wt% CNFs substantially enhances the piezoelectric performance of the composite, yielding a maximum output voltage under mechanical deformation that is significantly higher than that of pristine PVDF nanofibers. The resulting PC-NFs-based PENG devices demonstrated exceptional sensitivity to human body movements, successfully generating electrical signals from motions of the finger, elbow, and foot. We further validated their utility by using the devices to charge a capacitor and power LEDs. These results highlight the potential of using sustainable and biocompatible chitin nanofibers to create eco-friendly piezoelectric devices, paving the way for their application in next-generation wearable sensors and energy harvesting technologies.

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References

1. Abhijith, V., Akhila, B., Pramod, K., Mohanty, T. R., Sivakumar, C., Ramakrishnan, S., ... & Sreekala, M. S. (2025). Recent advances in metal oxide reinforced polymer composites for efficient piezoelectric energy harvesting applications. *Applied Energy*, *397*, 126335.
2. Hiba, T. R., Abhijith, V., Akhila, B., Thomas, S., & Sreekala, M. S. (2025). Recent Advances in Polymer Based Energy Harvesting Systems for Efficient Wound Healing Applications. Materials Today Communications, 113152.
3. Shen, Z., Liu, F., Huang, S., Wang, H., Yang, C., Hang, T., ... & Xie, X. (2022). Progress of flexible strain sensors for physiological signal monitoring. *Biosensors and Bioelectronics*, *211*, 114298.
4. Sebastian, M. S., Larrea, A., Gonçalves, R., Alejo, T., Vilas, J. L., Sebastian, V., ... & Lanceros-Méndez, S. (2016). Understanding nucleation of the electroactive β-phase of poly (vinylidene fluoride) by nanostructures. *RSC advances*, *6*(114), 113007-113015.

S

DESIGNING IMIDAZOLIUM-MEDIATED POLYMER ELECTROLYTES FOR LITHIUM-ION BATTERIES USING MACHINE-LEARNING APPROACHES: AN INSIGHT INTO IONENE MATERIALS

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Abstract

Over the past few decades, lithium-ion batteries (LIBs) have gained significant attention due to their inherent potential for environmental sustainability and unparalleled energy storage efficiency. Meanwhile, polymer electrolytes have gained popularity in several fields due to their ability to adapt to various battery geometries, enhanced safety features, greater thermal stability, and effectiveness in reducing dendrite growth on the anode. However, their relatively low ionic conductivity compared to liquid electrolytes has limited their application in high-performance devices. This limitation has led to recent studies revolving around the development of poly (ionic liquids) (PILs), particularly imidazolium-mediated polymer backbones as novel electrolyte materials, which can increase the conductivity with fine-tuning structural benefits, while maintaining the advantages of both solid and gel electrolytes. In this study, a curated dataset of 120 data points representing eight different polymers was used to predict ionic conductivity in imidazolium-based PILs as well as the emerging ionene substructures. For this purpose, four ML models: CatBoost, Random Forest, XGBoost, and LightGBM were employed by incorporating chemical structure and temperature as the models' inputs. The best- performing model was further employed to estimate the conductivity of novel ionenes, offering insights into the potential of advanced polymer architectures for next-generation LIB electrolytes. This approach provides a cost-effective and intelligent pathway to accelerate the design of high-performance electrolyte materials.

Keywords: Poly (ionic liquids); Polymer electrolytes; Lithium-ion batteries; Machine learning; CatBoost model

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DEVELOPMENT OF ANTIMICROBIAL PHOTODYNAMIC NANOCOMPOSITES FOR THE CONTROL OF BIOFILMS

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Abstract

The skin microbiota is essential for preserving human health and influencing the onset of illness. It includes a variety of bacterial species that interact with the host immune system and aid in preventing the colonization of dangerous pathogens, including *Streptococcus*, *Staphylococcus*, *Pseudomonas*, *Corynebacterium*, and anaerobes. On the other hand, microbial dysbiosis during acute and chronic wound development results in the growth of pathogenic species that hinder the healing process. The most found pathogens in chronic and non-healing wounds are *Staphylococcus aureus* and *Pseudomonas aeruginosa*, which form intricate polymicrobial interactions. Most of these microbial populations create biofilms, which give them a high level of resistance to antibiotic therapy. A promising alternative approach for the removal of resistant bacteria and associated biofilms is antimicrobial photodynamic therapy (aPDT). This approach effectively destroys microbial cells by utilizing reactive oxygen species (ROS), offering an innovative method to treat wound polymicrobial infections. Reactive oxygen species (ROS) are generated through aPDT using a photosensitizer, a particular wavelength of light, and molecular oxygen. Recent studies show notable decrease in the bacterial load and biofilm integrity which emphasize its potential in the field of therapeutic wound treatment. Nevertheless, draw backs such as instability, poor solubility and untargeted delivery prevents its clinical applications. This review deals with the conjugation of nanocomposites with photosensitizers for the antimicrobial and antibiofilm applications. The combination nanocomposites and photosensitizers enhance the stability, targeted release and delivery and light penetration for the efficient removal of mono and polymicrobial biofilms. This review will explore the mechanisms of aPDT, its advantages over conventional treatments, and recent advancements in photosensitizer development using nanocomposites. Additionally, we will discuss its potential clinical applications and future directions for optimizing this technology to enhance its efficacy against polymicrobial infections.

Keywords: Nanocomposites, polymicrobial biofilms, antimicrobial photodynamic therapy, delivery, photosensitizer

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KS

NANOCOMPOSITES OF SILVER NANOPARTICLES WITH ANTIBIOTICS: A NEW WAY TO COMBAT ANTIBIOTIC RESISTANCE

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Abstract

This study is devoted to the development of innovative nanocomposites to combat antibiotic-resistant infections. Silver nanoparticles (SNPs) were obtained using environmentally friendly extracts of Jerusalem artichoke tubers, which ensures biocompatibility and sustainability of production. Further, widely used antibiotics, Cefazolin and Ceftriaxone, were added to the SNPs to create synergistic nanocomposites. The studies included: Physicochemical characteristics: Study of the structure and properties of nanocomposites using UV spectroscopy and the dynamic light scattering method (DLS). Assessment of antibacterial activity: Testing of the obtained nanocomposites against various pathogenic bacteria, including resistant strains, to determine their increased effectiveness. Toxicological assessment: A preliminary assessment of the safety of nanocomposites by studying their toxicity in mice. The results show that nanocomposites based on SNPs and antibiotics have significantly greater potential than the antibiotics themselves to increase the effectiveness of infection treatment, reduce the risk of developing resistance, and improve the safety of the therapies used. This research opens up new perspectives for the development of modern antibacterial drugs.

Keywords: silver nanoparticles, nanocomposites, Jerusalem artichoke tuber extract, antibiotic resistance, least toxic dose

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AN OVERVIEW OF FAILURE MECHANISMS AND THE ROLE OF ADVANCED MATERIALS AND TECHNOLOGIES IN SUSTAINABILITY

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Abstract

This study presents an overview of failure mechanisms in materials and components across diverse sectors, including infrastructure, electronics, biomaterials, aerospace, mining, buildings and water systems. While failures are widespread, their underlying causes are not always accurately identified. Analyses often focus on a single dominant factor, overlooking secondary mechanisms that may significantly influence performance. In many cases, interactions between mechanisms - such as corrosion initiating pits that later accelerate through fatigue, or the combined effects of creep, wear, or fretting - play a critical role in driving failure.

A key challenge is that no single factor governs failure in real applications. Standard laboratory tests are typically designed to isolate individual mechanisms under controlled conditions, but these do not fully represent the complexity of real service environments where temperature fluctuations, stress transients, and environmental variations act simultaneously. The ability to combine the right factors through advanced simulations and to correctly apportion their contributions to failure remains one of the main obstacles in accurate life prediction and prevention strategies.

This study further investigates how advanced materials and emerging technologies can help prevent and mitigate these complex failures. New testing devices capable of detecting hidden or undercoating damage, such as corrosion on non-visible surfaces, improve early diagnosis and intervention. Advances in materials and manufacturing processes, including innovative coating methods for biomaterials, enhance durability and biocompatibility. In addition, smart sensors applied across industries enable continuous monitoring and early detection of failure, allowing preventive action before catastrophic breakdowns occur. Together, these approaches - combined with predictive maintenance, digital twins, and artificial intelligence - improve reliability, extend service life, reduce costs, and save lives. Beyond technical performance, they contribute to sustainability by lowering waste, reducing resource and energy consumption, and strengthening the resilience of industrial and societal systems.

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S

LINKING MOLECULAR STRUCTURE OF SBS POLYMER WITH PERFORMANCE OF MODIFIED BITUMEN AND ITS IMPLICATIONS FOR ECONOMIC SUSTAINABILITY OF HIGHWAYS

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Abstract

Styrene-Butadiene-Styrene (SBS) polymer is an effective modifier of bituminous binder which is used for the surface course construction of high-volume flexible pavements. SBS characteristics and its content affects the properties of modified bitumen in a significant way. The molecular structure is one of such key characteristics of SBS polymer, an effective selection of which can improve the binder properties and can economise the overall pavement construction. In this study, two different modified binders are prepared utilizing linear and branched SBS to determine how molecular structure of SBS affects the properties of modified bitumen and subsequently the thickness and construction cost of surface bituminous layer. The results of physical and rheological tests clearly established that branched SBS structure resulted in the improvement of binder parameters in a much greater way as compared to linear structure. Further, mechanistic-empirical design approach is adopted to evaluate the layer thickness and cost study is conducted to determine its construction cost. The stability-flow measurements were recorded for each bituminous mix prepared separately using both the modified binders. The ratio of stability and flow was used to theoretically calculate the resilient modulus of mix specimen and the design thickness of bituminous course is calculated accordingly. The bituminous course thickness was found to get reduce by 4-5% in case of branched SBS modified binder as compared to the linear SBS modified binder. It eventually resulted in the cost saving of approximately INR 0.5 million (11,000 $) per km for a 2-lane highway. The results may play a crucial role to economise the highway construction through appropriate selection of type of SBS polymer by the highway practitioners. This study is expected to be a game changer for the road industry and a major contributor towards the construction of sustainable highways.

Keywords: bituminous concrete, economic sustainability, performance parameters, resilient modulus, rheology, SBS modified bitumen

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S

INFLUENCE OF ACTIVATION OF BENTONITE CLAYS ON SORPTION PROPERTIES

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Abstract

Natural clay is one of the most studied additive materials. A review of scientific literature has shown that compositions based on organic and inorganic polymers, especially polymer-clay systems, are of great interest to researchers. One of the most interesting and little-studied drug carriers are polymer-clay composite materials (PCCM). Bentonite clays are used in pharmacy to prepare various dosage forms, including adsorption and slow-release drugs, wound coatings and many other purposes. The main reasons for this are the inertness of bentonite clays in relation to other substances, their sorption, swelling, complexing properties, the ability to form homogeneous dispersed systems, cost-effectiveness and simplicity of purification and preparation processes. These properties make them almost ideal carriers.

In the presented work, clays from the Orta Tentek deposit in the Almaty region of the Republic of Kazakhstan were activated with distilled water using the method of D.P. Salo. Elemental analysis was performed using a Rigaku NEX CG II X-ray fluorescence spectrometer (Japan). Structural and morphological characteristics of clays before and after treatment were studied using an Auriga Crossbeam 540 scanning electron microscope, Carl Zeiss (Germany). The chemical structure was analyzed using FTIR SALD-2201 infrared spectroscopy. X-ray phase analysis was performed using an X´PertPRO diffractometer. The zeta potential of water-activated and initial clay materials was determined using a Malvern Zetasizer NanoZS 90 device. The thermal properties of bentonite samples were studied by thermogravimetric analysis (TGA) using a synchronous thermal analyzer SKZ1060A (China). The parameters of the porous structure of bentonite samples were determined by low-temperature nitrogen adsorption using a high-speed gas sorption analyzer DSD 660S (China).

The study showed that the main components of Orta Tentek clays are silicon, iron and aluminum. It was found that activation with water leads to a change in the elemental composition of clays. Compared with the initial clays, a decrease in the content of potassium, sodium and calcium is observed. In general, it can be seen that the FTIR spectrum is characteristic of aluminosilicate compounds. The results of X-ray diffractometric analysis showed that the clay samples contain a predominant amount of montmorillonite, as well as a small amount of kaolinite, quartz, mixed-layer clay minerals, smectite and mica. Activation with water affects the morphology of the clay surface, leading to the opening of the interlayer space, an increase in sorption properties and an improvement in cation exchange capacity. It can be concluded that the high adsorption capacity of bentonite has a high potential for use in the pharmaceutical industry.

As a result of the study of the zeta potential of the initial and water-activated clay materials, it was established that they have a negative charge. Therefore, the use of non-ionic or negatively charged polymers allows for the sorption of positively charged drugs, heavy metal ions, and the production of biostimulants.

Keywords: clay, montmorillonite, Orta Tentek clay, bentonite, activation of clay.

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S

EPOXY-BASED NANOCOMPOSITE COATINGS WITH GRAPHITIC CARBON NITRIDE AND CARBON QUANTUM DOTS FOR INDUSTRIAL CORROSION APPLICATIONS

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Abstract

Mild steel is extensively used in industrial applications but is highly susceptible to corrosion, resulting in significant economic and environmental losses. Epoxy-based coatings provide effective protection due to their strong adhesion and resistance against water and aggressive ions; however, their long-term performance is often limited. Nano-modification of epoxy systems using fillers such as nano-clays, CNTs, and graphene derivatives has shown promise, but challenges including high cost, poor dispersibility, large-scale reproducibility, and limited industrial feasibility restrict their widespread adoption. To overcome these barriers, our work explores the incorporation of graphitic carbon nitride (g-C_3N_4) and nitrogen/sulfur-doped carbon quantum dots (N/S-CQDs) as sustainable, cost-effective nano-fillers in epoxy coatings. g-C_3N_4 offers a high surface area and excellent thermal and chemical stability, while N/S-CQDs possess abundant functional groups that promote complexation and retard corrosion reactions. A simple fabrication route involving homogenization, probe sonication, and mechanical stirring ensures uniform dispersion of fillers in the epoxy matrix. The developed nanocomposite coatings are applied on mild steel substrates and systematically evaluated through corrosion testing to assess protective performance. The proposed approach highlights a scalable, environmentally sustainable pathway for developing advanced epoxy-based coatings with enhanced corrosion resistance, demonstrating strong potential for translation into industrial and on-site applications.

Keywords: Corrosion, Epoxy coatings, Graphitic carbon nitride (g-C_3N_4), Carbon Quantum Dots (CQDs), sustainable, nano-fillers

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S

CRYOGELS WITH MINERAL FILLERS AS PROMISING SORBENTS FOR WATER PURIFICATION

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Abstract

Cryogels are a unique class of macroporous polymer materials produced under cryogenic conditions, where the ice phase acts as a pore forming agent. Their interconnected porous structure and mechanical elasticity make them promising candidates for applications in water sorption and purification.

In the study, cryogels were synthesized based on microcrystalline cellulose (MCC) in combination with acrylamide (AAm) and hydroxyethylacrylate (HEA) as monomers. Modified bentonite clays from local deposits were used as mineral fillers. Polymerization was performed using ammonium persulfate (APS) as an initiator in the presence of N,N,N',N'-tetramethylethylenediamine (TEMED) and N,N'-methylene bisacrylamide as a crosslinking agent. The cryogels obtained after freezing and thawing formed stable monolithic structures with a clearly defined macroporous structure. Preliminary observations have shown their high swelling ability in aqueous media, good structural restoration with multiple compression cycles, and improved sorption properties against model pollutants, including organic dyes and metal ions. The introduction of modified bentonite did not disrupt the cryostructural framework, but provided additional active sites for sorption and improved the stability of water absorption. These results highlight the potential of mineral-filled cryogels as effective sorbents for water purification. Future research will focus on quantifying sorption kinetics, capacity, selectivity, and the use of antimicrobial agents such as silver nanoparticles.

Keywords: cryogels, bentonite, sorption, water purification, microcrystalline cellulose.

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RICE HUSK BIOCHAR FOR HIGH-PERFORMANCE ADSORPTION OF WASTEWATER CONTAMINANTS

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Abstract

The pressing demand for sustainable wastewater treatment solutions has catalyzed the creation of advanced biomass-derived adsorbents. This study details the production of highly porous biochar from rice husks via thermal pyrolysis and potassium hydroxide (KOH) activation, optimized for enhanced safranin dye (SMS) removal from aqueous solutions. The physicochemical properties of biochar were meticulously characterized through X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, Field emission scanning electron microscopy (FESEM), Brunauer–Emmett–Teller analysis (BET), Zeta potential measurement, and X-ray photoelectron spectroscopy (XPS) to investigate surface chemistry and structural characteristics. Batch adsorption experiments examined the influences of initial dye concentration (8–16 ppm), contact duration (30–180 min), pH (2–12), and temperature (30-50°C) on the adsorption efficacy. The adsorption behavior adhered to the Langmuir isotherm (q_{max} 370.37 mg/g) and followed pseudo-second-order kinetics. Thermodynamic parameters revealed that the adsorption process is spontaneous and endothermic. Mechanistic investigations, substantiated by XPS and zeta potential analyses, demonstrated that safranin adsorption is influenced by electrostatic attractions, hydrogen bonding, and π–π interactions between the oxygenated functional groups of biochar and the aromatic structure of the dye. These results highlight the capacity of this biochar as an exceptionally efficient, economical, and environmentally benign adsorbent for the remediation of dye-polluted wastewater, presenting considerable implications for sustainable water purification methods.

Keywords: rice husk, biochar, wastewater, removal, Safranin, adsorption.

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S

DATA-DRIVEN MODELING TO PREDICT CO_2/N_2/OIL IFT USING EXPERIMENTAL DATA

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Abstract

The oil and gas industry is investigating CO_2 injection as a method of storing carbon dioxide in underground reservoirs. The injection of CO_2 can, however, also involve gases such as natural gas and nitrogen, either already present or introduced as impurities. These additional gases influence CO_2's interaction with oil and condensate in reservoirs, where interfacial tension (IFT) determines miscibility, fluid mobilization, and phase behavior. To effectively apply gas injection techniques, it is important to understand the IFT between the injected gases and reservoir fluids under actual reservoir conditions. IFT is one of the most important parameters for designing CO_2 flooding processes in oil reservoirs, and it changes a great deal depending on different parameters such as pressure and temperature. It is therefore essential to obtain accurate IFT measurements at reservoir conditions to ensure successful reservoir management and development. There are several experimental methods to calculate the IFT of oil and CO_2/N_2 mixture, while these techniques have human and equipment errors, are expensive, and time-consuming. To face these issues and solve these problems, we developed four novel, intelligent models, including the AdaBoost model, CatBoost model, XGBoost model, and the Gradient Boosting model (GB) to predict the IFT of oil and CO_2/N_2 mixture. The big dataset, including 1006 data points collected from literature and input variables are consists of temperature (ºC), pressure (MPa), oil density (g/cm^3), mole fraction of CO_2 (%), and N_2 (%). The results of this work illustrate that the CatBoost model outperforms other models with a coefficient of determination (R^2) value of 0.9941 and root mean squared error (RMSE) value of 0.5353. In addition, the SHAP analysis shows that the pressure (MPa) has the highest impact and the temperature (ºC) has the lowest effect on the IFT values. Moreover, trend analysis indicates the behavior of all input features on the IFT values.

Keywords: IFT, Crude oil, CO_2, N_2, Machine learning, CatBoost

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SILICON-CONJUGATED GRAPHENE POLYMER NANOCOMPOSITES: A REVIEW ON FABRICATION CHALLENGES AND MECHANICAL ADVANCEMENTS FOR MULTIFUNCTIONAL APPLICATIONS

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Abstract

Graphene's exceptional thermal, mechanical, and electrical properties with silicon's high theoretical capacity and favourable electrochemical traits. Integrating these materials into polymer matrices enhances dispersion, structural integrity, and processability, resulting in multifunctional composites ideal for advanced applications in research, industry, and academia. This study aims to improve mechanical performance by leveraging the stiffness, strength, and interfacial adhesion of silicon-conjugated graphene, yielding composites with superior tensile strength, toughness, and durability. The graphene core ensures high tensile resilience, while the silicon coating promotes effective load transfer and bonding with the polymer, maintaining flexibility and resistance to deformation under repeated stress. Their lightweight nature makes them especially suitable for high strength-to-weight applications like automotive and aerospace. Addressing a key research gap, the study introduces a systematic approach involving functionalized nanofiller preparation, integration into rubber matrices, and optimized composite fabrication. Thermal, mechanical, and dynamic characterizations assess performance enhancements and highlight the novelty of the final products. Comparative analyses underscore the potential of these advanced systems in achieving superior tire properties, while the review categorizes existing studies on silicon-conjugated graphene polymer nanocomposites and their diverse applications.

Keywords: Silicon-conjugated graphene, Polymer nanocomposites, Mechanical performance

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ECO-FRIENDLY SYNTHESIS OF CHITIN NANOCRYSTALS FROM SHRIMP SHELL CHITIN THROUGH OXALIC ACID-COUPLED STEAM EXPLOSION METHOD

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Abstract

The development of sustainable and efficient methods for the extraction of chitin nanocrystals (ChNCs) from shrimp shell chitin is essential for advancements in various fields such as biomedicine, packaging, energy harvesting, etc. In this study, a novel oxalic acid-coupled steam explosion (OSE) method was employed for the synthesis of ChNCs with improved yield and stability. The optimized process achieved a yield of 74.23%, with a crystallinity index of 70.8% and a degree of deacetylation (DD) of 84.51%. The ChNCs exhibited a zeta potential of +39.2 mV, indicating excellent colloidal stability. Characterization using transmission electron microscopy (TEM), dynamic light scattering (DLS), Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), and thermogravimetric analysis (TGA) confirmed successful production and retention of the α-chitin nano crystalline structure. The OSE approach described in this study is simple, fast, and efficient, requiring less acid concentration and quantity compared to conventional hydrolysis, thereby enhancing scalability. Furthermore, the distinctive properties of the ChNCs highlight their promising potential for value-added applications, contributing to the sustainable utilization of marine waste products.

References

1. Soibam Ngasotter, K.A. Martin Xavier, Layana Porayil, Amjad Balange, Binaya Bhusan Nayak, Shibu Eapen, K.J. Adarsh, M.S. Sreekala, Rupam Sharma, George Ninan, Optimized high-yield synthesis of chitin nanocrystals from shrimp shell chitin by steam explosion, Carbohydrate Polymers, Volume 316, 2023, 121040, ISSN 0144-8617, https://doi.org/10.1016/j.carbpol.2023.121040.

2. Mariya Mathew, C.D. Midhun Dominic, K.V. Neenu, P.M. Sabura Begum, P. Dileep, T.G. Ajith Kumar, Akshay Alax Sabu, Dhiraj Nagane, Jyotishkumar Parameswaranpillai, Michael Badawi, Carbon black and chitin nanofibers for green tyres: Preparation and property evaluation, Carbohydrate Polymers, Volume 310, 2023, 120700, ISSN 0144-8617, https://doi.org/10.1016/j.carbpol.2023.120700.

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MIXED MATRIX MEMBRANES FROM SODIUM ALGINATE MODIFIED WITH GD-BASED METAL–ORGANIC FRAMEWORK FOR ENHANCED PERVAPORATION DEHYDRATION

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Abstract

The development of energy-efficient and sustainable methods for separating azeotropic mixtures is a critically important task. This work presents the synthesis and comprehensive investigation of novel mixed-matrix membranes based on hydrophilic sodium alginate (SA) modified with the metal-organic framework Gd-BTC for the pervaporation dehydration of isopropanol. Gd-BTC was employed as a modifier for the first time, which is justified by its high hydrophilicity and potential for forming coordination bonds with the polymer matrix. Both dense and supported composite membranes with filler loading were fabricated. Comprehensive characterization by Fourier-transform infrared spectroscopy, scanning electron microscopy, and atomic force microscopy confirmed the successful incorporation of the filler and alterations in membrane morphology. The membrane with 20% Gd-BTC content (SA-20) demonstrated optimal transport properties, enhancing permeability by a factor of 1.6–2.3 compared to the unmodified membrane while maintaining high selectivity for mixtures with varying water content. Additional ionic cross-linking with a calcium chloride solution further improved the selectivity (>99.9%) and stability of the membranes. Based on the optimal composition, a supported membrane was fabricated, which exhibited exceptionally high permeability while retaining acceptable selectivity. The results of this study demonstrate that modifying sodium alginate with Gd-BTC is a highly effective strategy for fabricating membranes with an improved permeability-selectivity trade-off for the industrial dehydration of alcohols.

Keywords: sodium alginate, metal-organic framework, Gd-BTC, pervaporation, isopropanol dehydration

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LATEX-BASED BIO-NANOCOMPOSITE MEMBRANES FOR SUSTAINABLE TRIBOELECTRIC NANOGENERATORS

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Abstract

The development of flexible and eco-friendly energy harvesting devices is critical to address the growing demand for sustainable power sources in wearable electronics and self-powered sensors. Natural rubber latex (NRL), a renewable and biodegradable polymer, provides excellent elasticity, mechanical robustness, and biocompatibility, making it a promising candidate for triboelectric nanogenerators (TENGs). In this work, latex-based nanocomposite membranes were designed by incorporating bio-derived nanofillers such as cellulose nanocrystals (CNCs), chitosan, and lignin. The synergistic reinforcement of NRL with nanofillers enhanced dielectric constant, charge retention, and surface roughness, resulting in improved triboelectric output performance. Fabricated membranes demonstrated stable operation under repeated mechanical stress and maintained performance under humid conditions, a common challenge in bio-based systems. These results highlight the potential of latex-based nanocomposites as a scalable, green alternative to conventional petroleum-derived TENG materials. The study contributes toward expanding the materials library for sustainable nanogenerators and paves the way for their integration into wearable technologies and environmental monitoring systems.

Keywords: natural rubber latex, bio-nanocomposite, triboelectric nanogenerator, cellulose nanocrystals, chitosan, lignin

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HIERARCHICAL N AND O CO-DOPED POROUS CARBON DERIVED FROM WALNUT SHELLS AND ITS TWO-STEP CHEMICAL ACTIVATION FOR HIGH PERFORMANCE SUPERCAPACITOR APPLICATIONS

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Abstract

In this study, we have prepared N and O co-doped porous carbon from walnut shells and significantly improved its physico-chemical properties by a two-step chemical activation approach using $ZnCl_2$ and KOH. The synergistic effect of $ZnCl_2$ and KOH activation resulted in a well-developed hierarchical porous architecture with a high specific surface area (901 $m^2.g^{-1}$) and abundant N and O functional groups, as confirmed by XPS analysis. These features facilitated efficient ion transport and enhanced charge storage capacity. Tested in a symmetrical supercapacitor configuration using a 1 M H_2SO_4 electrolyte, the optimized carbon electrode exhibited a high specific capacitance of 520 $F \cdot g^{-1}$ at 1 $A \cdot g^{-1}$, and outstanding cycling stability over 5,000 cycles with a capacity retention greater than 99%. This work presents a sustainable and efficient route to designing high-performance electrode materials from biowaste for next-generation energy storage devices.

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STARCH-CELLULOSE BASED ANTIBACTERIAL FILM - SYNTHESIS AND ANTIBACTERIAL PROPERTIES

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Abstract

The synthesis and characterization of starch–cellulose based antibacterial films reinforced with nanomaterials were carried out for potential agricultural applications. The film matrix was prepared from nanocellulose fibers, microcrystalline cellulose, and oxidized starch. To provide antibacterial functionality, silver, copper, and zinc oxide nanoparticles were incorporated into the structure. Among the obtained films, the copper-containing sample exhibited the most effective antibacterial activity against common bacterial strains. Structural and morphological properties were analyzed by SEM, XRD, and FTIR, confirming uniform nanoparticle dispersion and strong polymer–filler interactions. As a practical application, the developed films were tested as mulching materials, demonstrating both biodegradability and antibacterial efficiency. The biofilm was characterized in terms of its mechanical stability, water absorption, and biodegradation potential. It exhibited a tensile strength of 0.78 MPa and a low water uptake of 0.21%, while maintaining a biodegradation rate of 0.008%. Although the incorporation of cellulose nanofibers improved the structural integrity of the nanocomposite, the material preserved its inherent biodegradability, confirming its suitability for sustainable applications. The observed balance between mechanical reinforcement and environmental degradability highlights the potential of this biofilm to replace conventional, non-biodegradable plastics in packaging and related sectors. These findings suggest that starch–cellulose based films with copper nanoparticles are promising for sustainable agricultural use, particularly as antibacterial mulching films.

Keywords: microcrystalline cellulose, cellulose nanofibers, nanocomposite, antibacterial film

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References:

1. K. Akatan, S. Kabdrakhmanova, T. Kuanyshbekov, Z. Ibraeva, A., K. S. Joshy & S. Thomas: Highly-efficient isolation of microcrystalline cellulose and nanocellulose from sunflower seed waste via environmentally benign method. March 2022, Cellulose, Volume 29, pages 3787–3802
2. K. Akatan, A. Battalova, S. Kabdrakhmanova, et al. (2024). Oxidized Starch/CMC based Biofilm: Synthesis and Characterization. Physical Sciences and Technology, 11(1-2). https://doi.org/10.26577/phst2024v11i1a7
3. C. Yang, Y. Zhu, Z. Tian, C. Zhang (2024). Preparation of nanocellulose and its applications in wound dressing: A review. Int J Biol Macromol, 254 (Pt 3), 127997.

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ABSORPTION-DOMINANT SHIELDING: HIGH-PERFORMANCE PVA/CCB/MnO_2 HYDROGELS FOR X AND K BAND EMI ATTENUATION

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Abstract

We report a soft, and flexible, EMI shielding composite—PVA/CCB/MnO_2 hydrogels—engineered to block unwanted signals in the X-band (8.2–12.4 GHz) and K-band (18–26.5 GHz). By tuning the filler composition, we achieved a remarkable transformation in shielding performance, with total shielding effectiveness (SET) soaring from ~7 dB to ~37 dB in the X-band and a stunning ~25 dB to ~75 dB in the K-band. Even more impressive, the shielding was absorption-dominated, ensuring minimal signal reflection and maximum internal dissipation—ideal for stealth and secure electronics. These hydrogels combine the softness of polymers, the conductivity of carbon black, and the dielectric strength of MnO_2 into a next-generation material that is not only efficient but also lightweight and sustainable. This study opens new doors for advanced EMI shielding in flexible electronics, wearables, and aerospace systems.

Keywords*:* Absorption, Electromagnetic waves, Hydrogels, Polymer composite

S

FABRICATION AND ANALYSIS OF A RECYCLABLE AND SELF-HEALABLE NATURAL RUBBER ANHYDRIDE EPOXY VITRIMERS

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Abstract

Investigation of rubber vitrimers as a sustainable alternative for conventional static crosslinked rubber systems has become the focus of the rubber industry and related research. This concern aligns with the development of reprocessable and self-healing rubber materials, which hold promise for the future and are attracting significant interest. The reversible dynamic network attained via transesterification reaction is the methodology rented here, and usually it works through an associative covalent crosslinking mechanism. Herein, natural rubber (NR) grafted with maleic anhydride (MA) was reacted with epoxy resin with the intermediation of the catalyst zinc (II) acetylacetonate (Zn(acac)2), which ultimately produced a recyclable and self-healable vitrimer. The key focal point of this paper is to analyse how the different contents of MA support the properties of the vitrimers. The morphology and properties of the newly developed vitrimers were carefully analysed through techniques such as SEM, FTIR, DSC, TGA, DMA, and mechanical measurements. Our findings reveal that the vitrimers exhibit promising mechanical properties and recyclability. The tensile strength of the optimised vitrimer with 10 phr MA content showed a tremendous increase as compared to the neat sample. The newly suggested vitimers showed excellent self-healing properties. Finally, mechanical properties have been correlated with morphology and crosslink density measurements.

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STABILIZED EMULSION FORMATION THROUGH SURFACTANT CORE FLOODING: IMPLICATIONS FOR ENHANCED OIL RECOVERY

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Abstract

Emulsions play an important role in the current enhanced oil recovery (EOR) processes. Specifically, they delay the breakthrough time and improve the vertical sweep efficiency by selectively blocking larger pores and altering the injected fluid's viscosity. In this study, a series of core flooding experiments were conducted to evaluate the influence of different anionic surfactant concentrations on emulsion stability and oil recovery. Alpha-olefin sulfonate (AOS) surfactant with concentrations of 1000, 2000, and 3000 ppm was used during the experimental study. The stability of the generated emulsions was further examined by assessing droplet size distribution and structural integrity using a microscope. Surfactant flooding was performed on a Berea sandstone core with a high permeability of 624 mD following an initial water flooding stage. The experimental results revealed that in situ emulsification induced by surfactant injection improved the cumulative oil recovery by 26% relative to the residual oil remaining after conventional secondary water flooding. These findings demonstrate that surfactant injection can substantially enhance oil recovery by promoting the formation of stable in situ emulsions within sandstone reservoirs.

Keywords: Core flooding, EOR, High permeability, In-situ emulsion, Stability, Surfactant

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HYDROGEN STORAGE MATERIAL BASED ON CELLULOSE-CARBON COMPOSITE

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Abstract

Cellulose-based composites are gaining increasing popularity in the field of energy materials due to their flexibility, low weight, thermal stability, high porosity, and ability to enhance surface area through functionalization [1,2].

In this work, a composite material for hydrogen storage was synthesized using microcrystalline cellulose (MCC) obtained from agricultural waste in combination with polyacrylamide. To improve sorption capacity, surface-modified activated carbon was additionally incorporated into the composition, which contributed to an increase in specific surface area and enhancement of the structural–sorption characteristics of the material. The introduction of carbon significantly improved the specific surface area and porosity of the material while maintaining the structural stability of the cellulose–polymer framework. FTIR and XRD analyses confirmed the formation of hydrogen bonds between hydroxyl groups of cellulose and amide groups of polyacrylamide, as well as the contribution of carbon to the development of microporous domains. BET analysis results showed that the cellulose–carbon composite exhibited an increased specific surface area (582.32 m^2/g) and pore volume compared to the pure MCC/PAm material, ensuring a higher sorption capacity. Thermal and mechanical tests confirmed the stability of the composite under operational conditions, while SEM analysis revealed a uniform pore distribution formed by the carbon phase. The results demonstrate that the cellulose–carbon composite can serve as a stable and efficient storage material with potential applications in hydrogen storage systems, water purification, and environmental remediation.

Keywords: cellulose, aerogel, activated carbon, sorption, composite, storage material

Acknowledgments

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References:

[1] Andersson J, Grönkvist S (2019) Large-scale storage of hydrogen. Int J Hydrogen Energy, 44, pp. 11901-11919. https://doi.org/10.1016/j.ijhydene.2019.03.063

[2] Akatan K, Kabdrakhmanova S, Kuanyshbekov T, Ibraeva Zh, Battalova A, Joshy K.S., Thomas S (2022) Highly-efficient isolation of microcrystalline cellulose and nanocellulose from sunflower seed waste via environmentally benign method. Cellulose 29:3787–3802. http://dx.doi.org/10.1007/s10570-022-04527-4

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HYBRID REINFORCEMENT STRATEGIES FOR HIGH-IMPACT STRENGTH EPOXY-BASED GFRP NANOCOMPOSITES: A REVIEW

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Abstract

Epoxy-based glass fiber reinforced polymer (GFRP) composites are widely employed in aerospace, automotive, and structural applications due to their excellent specific strength and stiffness. However, their relatively low impact resistance continues to limit safe and long-term performance under dynamic loading. Literature reports reveal that the addition of nanoclay improves stiffness, tensile strength, and thermal stability of epoxy systems but has limited influence on impact strength. Conversely, the incorporation of elastomers or thermoplastic fillers enhances toughness but typically compromises tensile properties. This trade-off has motivated research into hybrid reinforcement strategies that combine nanofillers with micro-sized polymeric or elastomeric phases. This review critically examines advances in dual-filler epoxy GFRP nanocomposites, with emphasis on nanoclay–polymer/elastomer hybrid systems. Reported studies highlight that nanoclay contributes to matrix stiffening through exfoliated morphologies, while polymeric fibers and elastomeric particles enable energy absorption via cavitation and crack-bridging mechanisms. A key challenge remains the poor interfacial compatibility of micro-fillers, which often leads to agglomeration and property deterioration. To overcome this, surface modification approaches such as silane coupling and maleic anhydride (MAH) grafting have been explored, demonstrating significant improvements in filler dispersion, interfacial adhesion, and overall composite performance. The collective findings suggest that optimal filler concentrations and compatibilization strategies are crucial to achieving simultaneous enhancement of tensile and impact properties. Hybrid epoxy GFRP nanocomposites thus offer a promising route for next-generation structural materials with balanced mechanical performance. The review further identifies research opportunities in advanced surface treatments, scalable processing routes, and application-driven design, paving the way for high-performance composites in safety-critical engineering sectors.

Keywords: Epoxy, GFRP, Nanoclay, Elastomers, Hybrid Nanocomposites, Compatibilization

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CARBOXYMETHYLCELLULOSE/CARBON NANOPARTICLE COMPOSITE MEMBRANES: FABRICATION, ANALYSIS AND APPLICATION

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Abstract

Growing interest in sustainable processes has highlighted membrane technology, particularly pervaporation and nanofiltration, for water treatment. These methods offer advantages over traditional techniques like distillation, which are energy-intensive and generate waste. Nanofiltration effectively separates dyes and heavy metal ions, while pervaporation targets low-molecular-weight substances like organic solvents. Developing efficient membranes from materials with tailored characteristics is crucial. This study focused on sustainable membranes from carboxymethylcellulose (CMC), a biodegradable and renewable polysaccharide valued for its wide range of applications. To improve CMC membrane performance, carbon nanoparticles were incorporated to create mixed matrix membranes (MMMs). Graphene oxide (GO) and its functionalized derivatives (GO-NH_3, GO-TiO_2, GO-COOH) were evaluated as modifiers. The resulting composites were characterized using spectroscopic and microscopic methods, thermal analysis, and contact angle measurements. Supported membranes with a thin CMC-based selective layer were developed to improve performance for perspective industrial application. Transport properties were assessed via pervaporation dehydration of isopropanol and nanofiltration of dyes and heavy metal ions for water treatment.

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Keywords: nanofiltration, pervaporation, carboxymethylcellulose, graphene oxide, mixed matrix membranes

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FLEXURAL BEHAVIOR OF LOW-COST JUTE FIBER-REINFORCED POLYMER SANDWICH PANELS: EXPERIMENTAL AND NUMERICAL ANALYSIS

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Abstract

Sandwich structures have become more popular in the aerospace, marine, and automotive industries due to their superior structural rigidity and lightweight construction, which is provided by their low-density core and face sheet construction. Sandwich panels are made up of many different variations of cores and face sheets. The core of the sandwich panel can be varied to suit the needs of the panel; for example, honeycomb core has been used for more impact resistance, and corrugated sheets are used for their higher bending stiffness. The primary failure in the case of the sandwich panel is the junction of the faceplate and the core when tested in flexure. Surface preparation is essential for adhesives to attach to surfaces correctly. If no surface preparation is done, it may cause premature failure in the sandwich panel. The natural fibers are low-cost, biodegradable, and readily available. Natural fiber composites offer numerous advantages, serving as fully biodegradable materials with low-energy production requirements, making them environmentally friendly alternatives to synthetic fibers in laminated composites. The Jute or gunny bags used here are readily available in the grain market and can be used as the fibers are treated during manufacturing. The sandwich panels are fabricated using a hand lay-up method with a low-cost GP polyester and were subjected to four-point flexural loading tests to evaluate their structural performance. This study investigates the flexural behavior of low-cost Jute fiber-reinforced polymer (JFRP) sandwich panels through experimental and numerical analyses. Numerical simulations were conducted using ABAQUS software, employing a cohesive zone model to simulate delamination between the core and faceplates, as the noted failure is in the junction of the core and face sheet. The study focused on the influence of various parameters, including the contact area length (15 mm, 20 mm, 25 mm, and 30 mm) and the core height (25 mm, 37.5 mm, 50 mm, and 100 mm), on the failure modes and structural integrity of the panels. Results from the experimental tests revealed that the panels withstood a maximum load of 1.58 kN without experiencing the anticipated shear failure, instead undergoing core densification. The numerical analysis has shown that a contact area of 20 mm is the most resistant to flexural loading. At the same time, the core height of 37.5 mm was found to be optimum, and increasing it further changed the failure mode and lowered the load-carrying capacity.

Keywords: Finite Element Modelling; Cohesive Zone Model; Numerical Analysis; Natural Fiber Composites; Sustainable Structural Applications; Sandwich Panels.

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MECHANICAL METHODS FOR GENERATING STABLE NATURAL-BASED WATER-OIL EMULSIONS

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Abstract

The application of water-oil emulsions in the chemical, petroleum, and petrochemical industries has been steadily increasing in recent years. Water-oil emulsions play a particularly important role in EOR. Natural-based W/O emulsions generated by polar components, such as asphaltenes present in asphaltic crude oils, offer a promising alternative to conventional chemical additives.

Three distinct methods of mechanical homogenization, ultrasonic bath treatment, and oven heating were employed to generate natural W/O emulsions. For homogenization, the sample was processed for 15 min at 70 °C and 60% power; oven heating was performed at 60 °C for 24 h; and ultrasonic treatment was performed at 30 °C and 20 kHz for 2 h. The resulting emulsions were characterized using a microscope to evaluate the droplet size range and stability. The findings revealed that the emulsion is produced with very small dispersed droplets in the 2–10 μm size range that remained stable for up to 4 days.

This in situ emulsion procvess not only improves oil recovery efficiency but also mitigates the environmental risks associated with the use of synthetic chemical agents, highlighting its potential as a sustainable alternative for asphaltic and heavy oil reservoirs applications.

Keywords: Droplet size, Emulsification, Enhanced oil recovery (EOR), In-situ emulsion, Water-oil emulsion

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S

ADVANCEMENTS AND CHALLENGES IN PEROVSKITE SOLAR CELLS

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Abstract

Perovskite solar cells (PSCs) have considered as the one of the widest-growing photovoltaic technologies, demonstrating better light absorption, higer charge-carrier mobilities, and excellent power conversion efficiencies, attain 25% in laboratory conditions. Their, tunable bandgap, defect tolerance facilitate, wide absorption spectrum enable them for lightweight, flexible, and building-integrated solar modules. Perovskite solar cells (PSCs) can be fabricate efficiently and cheaply using low-temperature solution processes, which empower large-scale, continuous production methods like roll-to-roll manufacturing. Ongoing research focuses on overcoming the intense limitations, such as structural and environmental stability, toxicity of the material and the durability of the modules. now they converging Innovations take in interfacial engineering, new encapsulation materials, and the introduction of stable alternatives to lead-based perovskites. Furthermore, PSCs' adaptability extends to emerging applications beyond traditional solar panels, including flexible electronics, opto-electronics like light emitting diodes and potential use in space technology. With continued advances in durability, large-scale manufacturing, and eco-friendly design, perovskite solar cell's ability to enable a sustainable and versatile future for global solar energy deployment, accelerating the transition to clean energy across diverse industries.

Keywords: Perovskite, solar cells, efficiency, scalability, stability, tandem, flexible electronics, sustainability

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S

SYNTHESIS AND CHARACTERIZATION OF SUSTAINABLE STARCH CHITOSAN FOAMS FOR EFFICIENT DYE ADSORPTION

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Abstract

Industrial dye effluents are among the most persistent water pollutants, posing serious risks to ecosystems and human health. To address this challenge, biodegradable potato starch–chitosan foams were synthesized through freeze-drying method for efficient dye adsorption from wastewater. Structural (FTIR) and morphological (SEM) analysis of foams confirmed strong starch–chitosan interactions and highly porous structure favorable for adsorption. Alizarin Red was employed as a model pollutant, and UV–Visible spectroscopic studies demonstrated that higher chitosan content enhanced dye adsorption through electrostatic attraction and hydrogen bonding. The 70:30 starch–chitosan foam achieved the highest efficiency (99.1%) and adsorption capacity (3.71 mg/g), indicating a synergistic effect at this composition. These results highlight starch–chitosan foams as cost-effective, sustainable adsorbents with significant potential for water purification and broader environmental remediation applications

Keywords: Potato starch, Chitosan, Starch chitosan foams, Freeze drying, Sustainable, Dye adsorption

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References:

[1] X. Zhao, X. Wang, and T. Lou, "Preparation of fibrous chitosan/sodium alginate composite foams for the adsorption of cationic and anionic dyes," *J. Hazard. Mater.*, vol. 403, p. 124054, 2021, doi: https://doi.org/10.1016/j.jhazmat.2020.124054.

[2] S. Heydarifard, Y. Pan, H. Xiao, M. M. Nazhad, and O. Shipin, "Water-resistant cellulosic filter containing non-leaching antimicrobial starch for water purification and disinfection," *Carbohydr. Polym.*, vol. 163, pp. 146–152, 2017, doi: https://doi.org/10.1016/j.carbpol.2017.01.063.

[3] A. Zamani, D. Henriksson, and M. J. Taherzadeh, "A new foaming technique for production of superabsorbents from carboxymethyl chitosan," *Carbohydr. Polym.*, vol. 80, no. 4, pp. 1091–1101, 2010, doi: https://doi.org/10.1016/j.carbpol.2010.01.029.

[4] P. A. Mistry, M. N. Konar, S. Latha, U. Chadha, P. Bhardwaj, and T. K. Eticha, "Chitosan Superabsorbent Biopolymers in Sanitary and Hygiene Applications," *Int. J. Polym. Sci.*, vol. 2023, no. 1, p. 4717905, 2023, doi: https://doi.org/10.1155/2023/4717905.

[5] S. H. Othman, N. R. A. Kechik, R. A. Shapi'i, R. A. Talib, and I. S. M. A. Tawakkal, "Water Sorption and Mechanical Properties of Starch/Chitosan Nanoparticle Films," *J. Nanomater.*, vol. 2019, no. 1, p. 3843949, 2019, doi: https://doi.org/10.1155/2019/3843949.

S

DESIGN AND OPTIMIZATION OF PENTACENE DERIVATIVES WITH FULLERENE (C_{60}) FOR ORGANIC SOLAR CELLS: INSIGHTS FROM DFT AND TD-DFT CALCULATIONS

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Abstract

Organic photovoltaics, OPVs, provide a low-cost, flexible approach with tunable electronic properties for the next generation of solar energy conversion. Functionalization of pentacene derivatives improves their electronic and optical properties, leading to better performance in OPV applications. In this work, we perform a systematic computational screening of 28 modified structures to see the impact of nucleophilic substitution of functional groups on pentacene derivatives. Our calculations on the electronic structure, excitation properties, and charge transfer (CT) states are performed for long-range interactions in donor-acceptor systems with density functional theory (DFT) and time-dependent DFT (TD-DFT). The most reactive sites of pentacene were identified through Fukui function analysis, which served as a guide in the functionalization process. We further explore how the modifications affect the singlet fission (SF) properties, which show that SF-driving forces are favorable in derivatives that enhance photocurrent generation in OPV devices. The UV–visible absorption spectra redshift their λmax toward longer wavelengths, broadening the spectral range of absorption to include the solar spectrum. From the results derived, three promising adsorptives, P14, P15, and P19, were selected for further adsorption studies with C_{60}. DFT calculations of the adsorption behavior of these derivatives with C_{60} confirm that functionalization enhances the donor-acceptor interaction. Binding energies indicated much stronger adsorption stability over pristine pentacene; participation by electron-donating groups (-NH_2, -OCH_3, -CH_3, and -OH) in enhancing adsorption energy and charge transfer efficiency was noted to be crucial. These results indicate that tailored pentacene derivatives have the potential for high OPV performance.

Keywords: Organic photovoltaics, Pentacene derivatives, DFT, TD-DFT, Donor-acceptor interactions, Fullerene (C_{60}).

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S

PRODUCTION OF MOISTURE-RETAINING MATERIALS TO ADDRESS THE PROBLEM OF EXCESS MOISTURE IN ORES DURING THEIR TRANSPORTATION UNDER HIGH AIR HUMIDITY CONDITIONS

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Abstract

In this work, biodegradable superabsorbent hydrogels were developed and characterized based on microcrystalline cellulose (MCC) derived from sunflower husks and acrylamide. Environmentally friendly processing methods were used to obtain MCC of high purity and well-developed crystallinity, which served as an effective matrix for hydrogel synthesis. The hydrogels were synthesized via radical polymerization of acrylamide and MCC with N,N′-methylenebisacrylamide (MBA) as a crosslinking agent. Fourier-transform infrared spectroscopy confirmed the presence of functional groups responsible for hydrophilicity and water absorption, while thermogravimetric analysis demonstrated hydrogel stability up to 220 °C and X-ray diffraction revealed the semicrystalline nature of MCC. SEM images showed a highly porous structure providing excellent water-retention capacity. Mechanical tests indicated that increasing MBA content enhanced compressive strength but reduced swelling ability. Swelling and compression studies in water, buffer solutions, and organic solvents revealed pH sensitivity, dependence on ionic strength, and solvent polarity effects, with optimal water retention achieved at minimal MBA concentration. Tests on bauxite ores demonstrated a significant reduction in moisture content, particularly in lignite and Bayer-type bauxites, when hydrogels were applied at different ratios. These findings highlight the potential of MCC-based hydrogels as effective agents for moisture control in the mining and transportation industries. The production and application of these hydrogels contribute to the sustainable utilization of agricultural waste, reducing environmental impact and enabling broader implementation in industrial practice.

Keywords: microcrystalline cellulose, hydrogels, water retention, bauxite, sustainability

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SOLAR-ASSISTED SYNTHESIS OF AG NANOPARTICLES DECORATED LAYERED DOUBLE HYDROXIDE NANOSHEETS FOR ELECTROCHEMICAL SENSING OF DOPAMINE

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Abstract

Layered double hydroxides (LDHs) are hydrotalcite-like materials belonging to anionic clay family, have greatly attracted attention for electrode surface modification owing to their charge transfer, large surface area, anion exchange and biocompatible properties.[1-3] Inspite of having low conductivity, the redox-active LDHs containing transition metals such as Ni, Co, or Mn, conduct electricity by electron hopping between nearby metal centres or by ionic displacement inside/outside the material. This study presents a flexible strategy to enhance the electrochemical performance of Ni–Al layered double hydroxides (LDHs) decorated with noble metal nanoparticles. Ni-based LDHs were selected as electrode modifiers owing to the presence of the Ni^{2+}/Ni^{3+} redox couple, which facilitates faster electron transfer at the electrode surface and enhances electrochemical activity. The decoration of Ag nanoparticles on LDHs further imparts superior catalytic properties, along with notable biocompatibility, antifouling, and antibacterial characteristics. Compared to noble metals such as Pt and Rh, Ag offers the advantages of abundance and cost-effectiveness. Therefore, the Ag/LDH-modified electrode is expected to exhibit improved electrochemical sensing performance relative to pristine LDHs, attributed to the suppression of nanoparticle agglomeration and the availability of more active sites.

Herein, we synthesized Ag/LDH hybrid nanostructures using one-step coprecipitation method. Using sunlight assisted reduction of nanoparticles, the use of hazardous reducing agents was avoided. The XRD pattern confirms the hydrotalcite-like LDH structure. The SEM images showed the spherical structures of Ag nanoparticles over LDH nanosheets and TEM images also confirmed its ultrathin layers. Electrochemical studies showed that the Ag/LDH material modified electrode exhibited enhanced electrochemical performance towards electrooxidation of dopamine with a broad linear response range and high sensitivity with a detection limit of 37 nM . The results are due to its peculiar hierarchical structures with high exposure of active sites and fast electron transfer pathway. Therefore, this works provide a simple and feasible method for synthesizing porous LDH structures as a material for modifying elctrodes for electrochemical sensing application.

References

1. W. Sun, Y.Q. Guo, Y.P. Lu, A.H. Hu, F. Shi, T.T. Li, Z.F. Sun, Electrochim. Acta 91, 130–136, 2013.

2. C. Z. Yuan, B. Gao, L. F. Shen, S. D. Yang, L. Hao, X. J. Lu, F. Zhang, L. J. Zhang and X. G. Zhang, Nanoscale, 2011, 3,529.

S

NANOCELLULOSE-BASED NANOSORBENT FOR REMOVING HEAVY METALS FROM WASTEWATER

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Abstract

In recent years, rapidly expanding industry, which accounts for approximately 20% of global water consumption, has become a serious environmental problem, polluting water systems with various toxic substances. This not only causes significant damage to ecosystems but also limits access to drinking water [1]. In particular, pollutants containing heavy metals continuously enter the environment through wastewater. Heavy metal ions from wastewater enter the ecosystem, enter the natural cycle of substances, and pose a risk of accumulation in the bodies of animals, microorganisms and plants [2].

Commonly used traditional wastewater treatment methods include chemical precipitation, membrane separation, ion exchange and electrochemical treatment [3]. However, most of these methods are not suitable for large-scale water purification. Therefore, scientists are focusing on the synthesis of biocompatible and biodegradable materials based on nanocellulose obtained from agricultural waste, which effectively absorb heavy metal ions and are economically affordable. Nanosorbents based on cellulose derivatives are considered "green" products because they decompose spontaneously in natural conditions and do not harm the environment. Furthermore, modification of the functional groups in their structure enhances their ability to interact with metal ions. For example, the introduction of chelated functional groups or corresponding charged fragments that bind metal ions through electrostatic interaction significantly increases the efficiency of heavy metal ion sorption by nanosorbents [4].

In this study, hydrogels (HG) based on nanocrystalline cellulose (CNC), nanofibrous cellulose (CNF), and acrylamide were synthesized, which were obtained by acid hydrolysis from sunflower seed husks, an agricultural waste, and studied their kinetic, physicochemical, and Cu^{2+} sorption properties. The morphological structure of the obtained nanosorbents was determined by scanning electron microscopy (SEM), chemical structure by infrared spectroscopy (FTIR), crystal structure by X-ray diffraction (XRD) and thermal stability by thermogravimetric analysis (TGA).

The study showed that nanocellulose-based hydrogels are capable of swelling in an aqueous solution by 1020–1090 times their initial volume, and the sorption capacity of Cu^{2+} ions is 330.2 mg/ml, i.e. 48.4%, for the HG_{CNF} hydrogel, and 310.1 mg/ml, i.e. 51.5%, for the HG_{CNC} hydrogel.

This property of hydrogels allows for the purification of industrial wastewater from heavy metal ions.

Keywords: nanocrystalline cellulose, nanofibrous cellulose, hydrogels, biodegradation, water absorbent, heavy metal ions, kinetic properties, wastewater treatment, FTIR, crystal structure.

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References

1. Honglin Zhu, Sunni Chen, Yangchao Luo. Adsorption mechanisms of hydrogels for heavy metal and organic dyes removal: A short review // Journal of Agriculture and Food Research. – 2023. – Vol. 12. – P. 100552. https://doi.org/10.1016/j.jafr.2023.100552

2. Nasime Mirhoseini Renani, Nasrin Etesami, and Tayebeh Behzad Synthesis and Characterization of Novel Magnetic Nano-Biocomposite Hydrogels Based on Starch-g-poly (acrylic acid) Reinforced by Cellulose Nanofibers for Cu^{2+} Ion Removal ACS Omega 2023 8 (24), 21929-21940 https://DOI: 10.1021/acsomega.3c01655

3. Honglin Zhu, Sunni Chen, Yangchao Luo, Adsorption mechanisms of hydrogels for heavy metal and organic dyes removal: A short review, Journal of Agriculture and Food Research,Volume 12,2023,100552, https://doi.org/10.1016/j.jafr.2023.100552

4. Chen, J., Jiang, X., Yin, D., & Zhang, W. Preparation of a Hydrogel-Based Adsorbent for Metal Ions through High Internal Phase Emulsion Polymerization. ACS Omega, 2020, 5, 32, 19920–19927. https://doi:10.1021/acsomega.9b03405

S

OBTAINING PHYTOMELANIN AND CELLULOSE AS AN EFFECTIVE USE OF SUNFLOWER SEED HUSK

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Abstract

Among agricultural wastes, sunflower seed husks are an accessible, cost-effective raw material for cellulose production, requiring targeted use [1]. However, it has been established that the presence of additional carbohydrates, such as phytomelanin, lignin, and hemicellulose, directly impacts the yield and physicochemical properties of the resulting cellulose fibers [2].

In the course of the study, it was established that the cellulose mass obtained from pre-processed raw materials has a high content of α-cellulose and a low content of additional carbohydrates, such as lignin and hemicellulose. This allows to reduce the process of extraction of low-molecular organic compounds and bleaching [4]. It also reduces the release of additional chemicals into the environment used for household and bleaching applications, thereby mitigating environmental problems. In [5], sunflower husks are considered a waste product after the extraction of phytomelanin pigment. Therefore, it is important to determine the potential for producing cellulose from secondary raw materials after the extraction of phytomelanin pigment from sunflower husks.

In this study, the husks (raw material) of Pioneer 10 sunflower seeds were pre-washed with distilled water and then treated with a 4% NaOH solution. Microcrystalline cellulose (MCC) was obtained from the alkali-treated raw material (SFH-NaOH) using the organosolvent method at the following raw material-to-solvent ratios: 1/8, 1/10, 1/12, 1/14, 1/16, 1/18, 1/20, 1/22, and 1/24. The yield of the obtained MCC, its physicochemical properties, and its effective elastic hydromodulus were 1/12. Also, MCC was obtained from sunflower seed husks, untreated (SFH) and pre-treated with distilled water (SFH-H2O) in a water-module of 1/12, and compared with MCC in an effective water-module and studied.

As a result, the yield of MCC obtained from the raw materials SFH, SFH-H_2O and SFH-NaOH was 36.50%, 41.72% and 55.73%, respectively, while the residual lignin content was 13.0%, 21.92% and 24%. In addition, compared with the MCC obtained from the raw materials SFH and SFH-NaOH, the MCC obtained from SFH-NaOH was characterized by a higher content of α-cellulose (55.73%) and lower ash content (0.12%). X-ray structural analysis showed that the crystalline structure of the product obtained from the raw materials SFH, SFH-H2O and SFH-NaOH corresponds to microcrystalline cellulose [6].

The results of IR-spectroscopy showed that the structure of MCC obtained from raw materials SFH, SFH-H2O and SFH-NaOH did not change and was similar to the structure of cellulose obtained from annual plants [7]. The morphology of the surface of MCC revealed the porous structure of the samples. The results of the comparative SEM analysis showed that MCC obtained from the husk of sunflower seeds, treated with sodium hydroxide, had a light gray color and thinner fibers. The average size of cellulose fibers obtained from raw material SFH-NaOH was 131 μm in length and 20-23 μm in width.

Phytomelanins were extracted from the spent alkaline solution by acidification with a 25% hydrochloric acid solution, followed by precipitation and washing of the pigment with deionized water to a pH of 7. The yield of phytomelanins was 8.56% of the raw material weight. UV absorption at a wavelength of 220 nm indicates the presence of π-bonds in the phytomelanin molecule. Also, the IR spectra at wavelengths of 1032 cm−1, 1250 cm−1, 1500 cm−1, 1600-1700 cm−1 contain signals of C-O, C=C, and -COO, indicating the presence of phenolic and ether groups. Absorption of CH_2, CH_3, and NH groups was observed at 2900 cm−1. The graphene-like structure in SEM micrographs and the amorphous structure in XRD diffraction patterns prove that the extracted pigment is phytomelanin[8].

In conclusion, it should be noted that pre-treatment of the raw material with sodium hydroxide solution affects the dimensional characteristics of the resulting microcrystalline cellulose, making it accessible to the delignifying agent solution during hydrolysis. Equally important is the production of phytomelanin, which has antibacterial and antioxidant properties, due to the limited availability of its sources. This, in turn, allows for the targeted use of sunflower seed husks to obtain phytomelanin and MCC, as well as the use of nanocrystalline cellulose and phytomelanin to produce nanocomposites.

References

1. .https://eldala.kz/specproekty/17608-podsolnechnik-prevzoshel-pshenicu-po-rentabelnosti-v-kazahstane.
2. K. Akatan, S. Kabdrakhmanova, T. Kuanyshbekov, Z. Ibraeva, A. Battalova, Joshy KS, Sabu Thomas., Highly-efficient isolation of microcrystalline cellulose and nanocellulose from sunflower seed waste via environmentally benign method, // Cellulose 29(7), May 2022. DOI:10.1007/s10570-022-04527-4
3. A.K. Battalova, S.K. Kabdrakhmanova, K.Akatan, M.M.Beisebekov, N. Kantay, Zh.E.Ibraeva, A.M. Mausumbayeva, L.B. Merck., Features of microcrystalline cellulose produced from sunflower seeds of different oil content // International Journal of Biology and Chemistry 16, № 1 (2023)., https://doi.org/10.26577/ijbch.2023.v16.i1.08.
4. Pham C.D., Le T.M., Nguyen C.T.X., Vo N., Do N.H.N., Le K.A., Mai T.P., Le P.T.K., 2022, Review of The Role of Pretreatment Step in Nanocellulose Production from Rice Straw, Chemical Engineering Transactions, 97, 67-72 DOI:10.3303/CET2297012.
5. Ivanova, L.A.; Fomenko, I.A.; Sergeeva, A.; Churmasova, L.A.; & Kabarzhan, Zh.K. Development of technologies for obtaining phytomelanins from oil production waste. Health, Food & Biotechnology. 2019, 1(2), 245. (in Russian).
6. Akatan, K.; Kabdrakhmanova, S.; Kuanyshbekov, T.; Ibraeva, Z.; Battalova, A., Joshy, KS.; Thomas, S. Highly-efficient isolation of microcrystalline cellulose and nanocellulose from sunflower seed waste via environmentally benign method. Cellulose. 2022, 29(7).
7. Battalova, A.K.; Kabdrakhmanova, S.K.; Akatan, K.; Beisebekov, M.M.; Kantay, N.; Ibraeva, Zh.E.; Mausumbayeva, A.M.; Merck. L.B. Features of microcrystalline cellulose produced from sunflower seeds of different oil content. Int. j. biol. chem. 2023, 16, № 1.
8. Capozzi, Vito & Perna, Giuseppe & Carmone, Patrizia & Gallone, Anna & Lastella, M. & Mezzenga, Emilio & Quartucci, G. & Ambrico, Marianna & Augelli, V. & Biagi, P. & Ligonzo, Teresa & Minafra, A. & Schiavulli, Luigi & Pallara, Mauro & Cicero, R.. (2006). Optical and photoelectronic properties of melanin. Thin Solid Films. 511. 362-366. 10.1016/j.tsf.2005.12.065

Key words: sunflower husk, preliminary processing, MCC, lignin, hemicellulose.

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S

SYNTHESIS AND CHARACTERIZATION OF PCZDBTO-AGNO$_3$-DOPED TIO$_2$ FOR ENHANCED HER ACTIVITY

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Abstract

The search for clean and sustainable energy alternatives has intensified in response to the global reliance on fossil fuels and the consequent rise in greenhouse gas emissions. Hydrogen is considered a promising next-generation fuel due to its high energy density, non-toxicity, and emission-free combustion. However, efficient hydrogen production remains a critical challenge, as most conventional methods rely on non-renewable sources or energy-intensive processes. Photocatalytic water splitting has emerged as an attractive solution, offering a direct, solar-driven route to hydrogen generation. Yet, the practical application of this technology is limited by the low visible-light activity and high charge carrier recombination rates of conventional photocatalysts such as titanium dioxide (TiO_2). This work reports the synthesis and photocatalytic evaluation of silver-doped titanium dioxide (TiO_2) and its polymer-based composites with PCzDBTO for visible-light-driven hydrogen evolution. TiO_2 was doped with silver nitrate at concentrations of 0.1%, 1%, and 5%, and further combined with PCzDBTO to extend visible light absorption. Photocatalytic performance was assessed using a water–methanol–triethylamine system under Xe lamp irradiation, with hydrogen production quantified by gas chromatography. The 1% Ag-doped TiO_2 sample achieved the highest hydrogen evolution rate of 4286.8 μmol h^{-1} g^{-1}, outperforming both pristine and polymer-only composites. While silver doping enhanced charge carrier separation and HER activity, excessive loading (5%) reduced efficiency due to strong surface plasmon resonance effects. UV-Vis spectroscopy confirmed improved absorption in the visible region, and DLS analysis showed particle size increases with higher doping levels. These results demonstrate that moderate Ag doping and polymer integration synergistically improve TiO_2-based photocatalysts, offering a promising pathway for efficient, sustainable hydrogen production.

S

DEVELOPMENT OF A MULTIFUNCTIONAL GELATIN COMPOSITE HYDROGEL FOR SKIN REGENERATION APPLICATIONS

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Abstract

Gelatin-based hydrogels have gained widespread attention in skin tissue engineering due to their inherent biocompatibility, biodegradability, and similarity to the extracellular matrix. However, the poor mechanical strength and rapid degradation of gelatin limit its direct application in regenerative medicine. To address these drawbacks, gelatin is often incorporated into composite hydrogels with natural polymers and nanomaterials to enhance structural and functional properties. In this study, we developed a novel nanocomposite hydrogel comprising gelatin, chitosan, and nanocellulose, which was designed to combine the advantages of each component of the composite. While gelatin provides a cytocompatible environment, chitosan offers antibacterial properties and promotes wound healing, and nanocellulose contributes to mechanical reinforcement and improved stability. Additionally, egg shell membrane protein (ESMP) was incorporated into the hydrogel, serving as a bioactive additive. The presence of ESMP not only enhances the biological functionality of the composite but also plays a role in improving crosslinking interactions, thereby contributing to better structural integrity. This multifunctional hydrogel system demonstrates promise as a scaffold for skin tissue regeneration by integrating biocompatibility, antibacterial activity, and enhanced mechanical performance. Such a composite approach highlights the potential of natural biomaterial-based nanocomposites in advancing wound healing applications.

Keywords: Gelatin Hydrogel, Nanocomposite, Chitosan, Nanocellulose, Egg Shell Membrane Protein, Skin Tissue Regeneration.

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CELLULOSE BASED COMPOSITE HYDROGEL WITH HIGH ABSORPTION CAPACITY

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Abstract

Hydrogels are three-dimensional polymeric matrices capable of extensive swelling in aqueous media due to the retention of a large volume of liquid within their structure without dissolution [1]. This property determines their application across diverse fields — from biomedicine to agriculture, and from sensing devices to drug delivery systems [2]. In recent decades, increasing attention has been directed toward the development of biodegradable hydrogels of natural origin, obtained from renewable resources, primarily of polysaccharide nature, including cellulose, alginates, chitosan, and their derivatives [3].

The use of natural polymers for the fabrication of biohydrogels is associated not only with their environmental safety but also with their high degree of biocompatibility, low cytotoxicity, and the wide availability of raw materials.

In this study, carboxymethyl cellulose (CMC) and hydroxyethyl cellulose (HEC) were synthesized from microcrystalline cellulose (MCC) derived from local agro-industrial waste, and the possibility of obtaining hydrogels through crosslinking of CMC and HEC with citric acid was investigated. The physicochemical properties of the resulting hydrogel were determined.

Keywords: cellulose, hydrogel, carboxymethyl cellulose, hydroxyethyl cellulose, local agro-industrial waste

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References:

1. Aswathy, S. H., NarendraKumar, U., & Manjubala, I. (2022). Physicochemical Properties of Cellulose-Based Hydrogel for Biomedical Applications. Polymers, 14(21), 4669. https://doi.org/10.3390/polym14214669

2. Koshenaj, K., & Ferrari, G. (2024). A Comprehensive Review on Starch-Based Hydrogels: From Tradition to Innovation, Opportunities, and Drawbacks. Polymers, 16(14), 1991. https://doi.org/10.3390/polym16141991

3. Manuel, M., & Jennifer, A. (2023). A Review on Starch and Cellulose-Enhanced Superabsorbent Hydrogel. Journal of Chemical Reviews, 5(2), 183–203.

S

REVIEW ON NATURAL RUBBER/ CELLULOSE BIO COMPOSITES: MORPHOLOGY, MICROSTRUCTURE, AND MECHANICAL PROPERTIES

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Abstract

Natural rubber/cellulose bio-composites are gaining increasing attention as sustainable alternatives to petroleum-based materials. This work reviews their development with a focus on morphology, microstructure, and mechanical properties. The incorporation of cellulose, in both micro and nano forms, significantly improves filler dispersion and interfacial adhesion within the rubber matrix. These improvements lead to enhanced tensile strength, modulus, and durability while maintaining the inherent flexibility of natural rubber. Microstructural studies show that the arrangement of cellulose contributes to network formation and reinforcement efficiency, with hybrid combinations of micro- and nano-cellulose showing higher performance compared to single-scale fillers. The outcomes of natural rubber/cellulose bio-composites not only provide enhanced mechanical functionality but also reduce the usage of conventional synthetic fillers, thereby supporting eco-friendly material design. This review emphasizes their potential contribution to green polymer technology and outlines their relevance for future applications in automotive, biomedical, and packaging industries

Keywords: Natural Rubber, Cellulose bio composites, Morphology, Microstructure, Mechanical Properties

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EXPLORING THE OPTICAL PROPERTIES OF POLYVINYLIDENE FLUORIDE/ZINC SELENIDE-BASED HYBRID THIN FILMS FOR PHOTONIC APPLICATIONS

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Abstract

This work explores the influence of nanofiller concentration on the optical behaviour of Polyvinylidene fluoride (PVDF) and the II-VI Metal Chalcogenide, Zinc Selenide (ZnSe) based hybrid thin films, with a focus on their suitability for photonic and optoelectronic applications. Enhanced thermal stability was observed with increasing ZnSe content, indicating improved resistance to thermal degradation. UV-Visible spectroscopy revealed a marked rise in absorption intensity, attributed to nanoparticle-induced light scattering and localised field effects. Concurrently, systematic tuning of the optical band gap was achieved, enabling modulation of electronic transitions within the polymer matrix. Photoluminescence (PL) analysis showed progressive quenching with higher filler loading, suggesting efficient charge transfer and dominant nonradiative recombination pathways. Raman spectroscopy confirmed strong interfacial interactions between PVDF and ZnSe, reflecting structural modifications that underpin the observed optoelectronic behaviour. Collectively, these findings demonstrate the potential of PVDF/ZnSe nanocomposite thin films as versatile platforms for next-generation photonic devices.

Keywords: Metal chalcogenide; Hybrid films; Optoelectronics; Photoluminescence quenching; Optical properties

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NANOPARTICLE-ASSISTED EMULSION STABILIZATION DURING SURFACTANT FLOODING: MECHANISTIC INSIGHTS AND RECOVERY ENHANCEMENT IN SANDSTONE RESERVOIRS

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Abstract

The application of emulsions in EOR has gained attention due to their ability to improve sweep efficiency by altering fluid mobility and selectively restricting flow in larger pores. Although surfactant-based emulsions have been widely studied, their stability often diminishes under reservoir conditions, limiting their recovery efficiency. To address this, the present work investigates the combined use of anionic surfactants and NPs for emulsion stabilization. A series of core flooding and laboratory-scale experiments were performed on Berea sandstone cores with a permeability of 624 mD. Alpha-Olefin Sulfonate (AOS) surfactant was employed at concentrations of 1000, 2000, and 3000 ppm, while three types of nanoparticles—silica (SiO_2), zinc oxide (ZnO), and iron oxide (Fe_3O_4)—were introduced at concentrations ranging from 0.05 to 0.3 wt.%, selected based on previous EOR nanofluid studies. Emulsion stability was systematically evaluated using stability index measurements, rheological analysis, and microscopic droplet size distribution. The addition of nanoparticles significantly improved emulsion stability by reducing droplet coalescence and enhancing viscosity control. Core flooding tests further confirmed the generation of in situ emulsions within the porous medium, resulting in incremental oil recovery beyond that obtained from conventional water flooding and surfactant-only injection. These findings establish that surfactant–nanoparticle hybrid systems, which combine cost-effective surfactants with robust nanoparticle stabilizers to enhance emulsion performance and maximize oil recovery under sandstone reservoir conditions, represent a promising EOR strategy.

Keywords: Core flooding, EOR, In-situ emulsion, Surfactant Stability, Nanoparticles

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NATURAL RUBBER-BASED TRIBOELECTRIC NANOGENERATORS

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Abstract

In 2012, Professor Zhong Lin Wang and his team introduced the first concept of the Triboelectric Nanogenerator (TENG), opening new horizons for addressing global challenges in sustainable energy and healthcare. The advancement of this technology requires a comprehensive understanding of the materials employed in its development. Among these, natural rubber has attracted significant attention due to its intrinsic properties, including high elasticity, flexibility, eco-friendliness, and its ability to form composites with various functional fillers.

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References

[1] BUNRIW, Weeraya, et al. TiO2/Ag hybrid filler with synergistic effect of dielectric modulation and photocharge generation in the natural rubber-based triboelectric nanogenerator. *Materials Research Bulletin*, 2025, 113682.

[2] WATTANASARN, Hassakorn, et al. Cutting-Edge Triboelectric Nanogenerators: Electrically Conductive Rubber Reinforced with Nano Barium Titanate. *Materials Research Bulletin*, 2025, 113635.

[3] FU, Chongyang, et al. Road-compatible triboelectric nanogenerator applied to intelligent transportation systems. *Journal of Materials Science*, 2025, 1-11.

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GLUCOSE RESPONSIVE POLYMER VESICLES FOR INSULIN DELIVERY

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Abstract

Glucose-responsive polymer vesicles have emerged as a promising platform for the smart delivery of insulin, aiming to provide better glycemic control for diabetic patients. These vesicular nanostructures are engineered to sense changes in blood glucose levels and release insulin in a self-regulated manner, thereby mimicking the natural function of pancreatic β-cells. By incorporating glucose-sensitive moieties such as phenylboronic acid, glucose oxidase, or concanavalin A within polymeric frameworks, the vesicles achieve selective recognition of glucose and trigger-controlled disassembly or permeability changes. This responsive behaviour ensures on-demand insulin release, minimizing the risk of hypoglycemia and reducing the need for frequent external administration. Furthermore, polymer vesicles offer advantages such as biocompatibility, tunable stability, and high loading efficiency, making them attractive candidates for next-generation diabetes therapy. Overall, glucose-responsive polymer vesicles represent a significant step toward developing intelligent, patient-friendly insulin delivery systems.

Keywords: Glucose-responsive Polymer vesicles, Insulin delivery, Smart drug delivery, Phenylboronic acid, Glucose oxidase

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SUGAR BEET PULP AS A SOURCE OF VALUABLE BIOPOLYMERS AND NANOSTRUCTURED MATERIALS

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Abstract

The sugar industry in Kazakhstan annually generates a considerable amount of by-products, primarily sugar beet pulp (SBP). This biomass is mostly used as animal feed or left unutilized, which can lead to environmental issues. Due to its chemical composition (pectin, cellulose, hemicellulose, lignin, and low-molecular-weight carbohydrates), SBP can be regarded as an alternative raw material for the production of valuable biopolymers and functional nanomaterials.

In this study, a comprehensive investigation of sugar beet pulp was carried out. Pectin was extracted using standard methods (with a yield of approximately 10%) and its structure was analyzed by Fourier-transform infrared (FTIR) spectroscopy and scanning electron microscopy (SEM). Cellulose was obtained through organosolv treatment and further characterized by FTIR spectroscopy. Additionally, carbon dots were synthesized from liquid extracts via a hydrothermal method, and their optical properties were examined by spectroscopic techniques.

The results demonstrate the high potential of sugar beet pulp as an accessible and renewable feedstock for the production of biopolymers and nanostructured materials. Such products may find applications in the food, pharmaceutical, and medical industries, as well as in various areas of nanotechnology.

Keywords: sugar beet pulp, pectin, cellulose, carbon dots, nanomaterials, biomass valorization

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S

FABRICATION AND CHARACTERIZATION OF CHITOSAN-MODIFIED STARCH FILMS - A GREEN ALTERNATIVE FOR FOOD PACKAGING

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Abstract

The increasing environmental concerns associated with petroleum-based plastics have accelerated the search for sustainable and biodegradable alternatives in food packaging. Starch has emerged as a promising biopolymer due to its film-forming ability, biodegradability, and compatibility with other natural polymers. To overcome the inherent drawbacks of native starch, blending with chitosan, a naturally occurring biopolymer derived from chitin, has gained significant attention. The incorporation of chitosan not only improves mechanical and barrier performance but also imparts functional properties such as antimicrobial protection, which is highly beneficial for extending food shelf life. Chitosan-modified starch films represent a green, multifunctional, and cost-effective alternative to conventional plastics, aligning with the principles of circular bioeconomy and sustainable packaging solutions. Chitosan-blended potato starch films were prepared using the solution casting method, with glycerol as a plasticizer and acetic acid as a crosslinker at the optimum gelatinization temperature. Initially, acetic acid crosslinked starch films were prepared and evaluated for their tensile strength; the formulation exhibiting the highest mechanical performance, 4.25MPa (5g PS+4% AA) from 2.55MPa (control), was subsequently selected for the development of chitosan-blended starch films. The increasing concentration of chitosan significantly affects the solubility, swelling, moisture absorption, and biodegradability of films. The antibacterial activities of the starch-chitosan films were analysed, which showed promising activity against Staphylococcus aureus and Escherichia coli. The antimicrobial action is mainly due to the presence of chitosan, which is involved in the disruption of the bacterial cell membrane. All the starch films show significant biodegradation in the soil environment within a short time.

References

C. Qiao, X. Ma, X. Wang, and L. Liu, “Structure and properties of chitosan films: Effect of the type of solvent acid,” LWT, vol. 135, p. 109984, Jan. 2021, doi: 10.1016/j.lwt.2020.109984.

B. Balla, A. Bartos, D. Kun, E. Csiszár, J. Móczó, and E. Fekete, “Improving mechanical and water sorption properties of thermoplastic starch by incorporating chitosan filler,” Polym. Test., vol. 10.1016/j.polymertesting.2021.107278.

M. S. Hernández, L. N. Ludueña, and S. K. Flores, “Citric acid, chitosan and oregano essential oil impact on physical and antimicrobial properties of cassava starch films,” Carbohydr. Polym. Technol. Appl., vol. 5, p. 100307, Jun. 2023, doi: 10.1016/j.carpta.2023.100307.

Y. Fang, J. Fu, C. Tao, P. Liu, and B. Cui, “Mechanical properties and antibacterial activities of novel starch-based composite films incorporated with salicylic acid,” Int. J. Biol. Macromol., vol. 155, pp. 1350–1358, Jul. 2020, doi: 10.1016/j.ijbiomac.2019.11.110.

C. Menzel, “Improvement of starch films for food packaging through a three-principle approach: Antioxidants, cross-linking and reinforcement,” Carbohydr. Polym., vol. 250, p. 116828, 2020.

S

GRAPHENE OXIDE-EMBEDDED PVDF COMPOSITE FOR SUPERIOR PIEZOELECTRIC ENERGY HARVESTING APPLICATIONS

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Abstract

In order to explore self-charging powered systems (SCPSs) and therefore meet the need for flexible, intelligent, and ultra-compact wearable electronic devices, tremendous research efforts have been focused on creating polymer-based piezoelectric nanogenerators (PENG). In this work, graphene oxide (GO) was introduced in varying amounts to polyvinylidene fluoride (PVDF) mats. Prior to the mixed PVDF solution, GO nanosheets were subjected to a 5-minute sonication treatment. A thorough investigation on the GO incremental impact was carried out. A texture analyser and a scanning electron microscope (SEM) were used to investigate the mechanical and microstructural characteristics. Additionally, a number of experiments, such as frequency effect, d33 coefficient, charging and discharging analysis, and impulse response, were used to evaluate the piezoelectric capabilities. According to experimental data, adding GO nanosheets improves piezoelectric characteristics at all concentrations. This is related to the rise in the β phase inside the nanofibers, which has a big potential to improve the performance of nanogenerators. With a significantly larger boosting impact, PVDF-GO 1.5 weight percent increases the electroactive β-phase and γ-phase. Additionally, the output voltage increased as the impact force increased. All results are in line, showing better performance for PVDF-GO 1.5 wt.% for almost all concentrations.

References

1. Hu, D., Yao, M., Fan, Y., Ma, C., Fan, M., & Liu, M. (2019). Strategies to achieve high performance piezoelectric nanogenerators. Nano energy, 55, 288-304.

2. Lu, L., Ding, W., Liu, J., & Yang, B. (2020). Flexible PVDF based piezoelectric nanogenerators. Nano Energy, 78, 105251.

3. Haque, R., Kou, L., Terban, M. W., Ali, N. Z., Haque, R., Mohammad Haniff, M. A. S., ... & Ooi, P. C. (2025). Structural School of Chemical Sciences, Mahatma Gandhi University, Kottayam 97 and Phase Analysis of Poly (vinylidene fluoride)/Poly (vinylidene fluoride-trifluoroethylene)-Based Ultra-responsive Piezoelectric Nanogenerators. Industrial & Engineering Chemistry Research.

S

CATALYTIC PERFORMANCE OF A ZINC(II) POLYMER COMPLEX BASED ON SUCCINATE AND 2-AMINO-1,3,4-THIADIAZOLE

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Abstract

A polymer complex of zinc(II) succinate with a 2-amino-1,3,4-thiadialole ligand, denoted as [Zn2L2(suc)2]n, was synthesized and characterized by NMR, ESI-MS, FTIR, and FT-Raman spectroscopy, TGA, and X-ray crystallography. The polymer complex crystallizes in the orthorhombic noncentrosymmetric *Pna*21 space group and features a five-coordinate zinc ion in a distorted spherical square pyramidal geometry. The catalytic activity of the complex was tested, interestingly, that showed good results for Biginelli reactions with distinct substrate scope in good to high yield at mild reaction conditions. The catalytic efficiency the [Zn2L2(suc)2]n complex in a one-pot Biginelli reaction illustrated a good results with 1 mol% catalyst loading under mild and neat reaction conditions in 10-15 minutes. The easy removal of retained catalyst from the product makes the reaction process a simpler one and as reliable catalyst. Twenty examples of different substrate variety comprise of aromatic, substituted aromatic, fused aromatic, heteroaromatic and aliphatic aldehydes were showing good to high yields of respective pyrimidinones. Hence, our complex may be utilized as efficient catalyst in synthesis of dihydropyrimidinones as active pharmaceutical ingredients in medicine.

Keywords: Thiadiazole, Succinate, Zinc, polymer complex, Biginelli reactions, dihydropyrmidinones.

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FREE-STANDING BIODEGRADABLE POLYMER NANOCOMPOSITE FILMS

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Abstract

Biodegradable polymers like starch and polyvinyl alcohol (PVA) show unique properties and have attracted considerable interest for the development of sustainable and eco-friendly materials. However, to overcome their inherent drawbacks for practical applications, such polymers are mixed or cross-linked with different salts or nanoparticles to form free-standing nanocomposite films through both in-situ and ex-situ methods. For the fabrication of cross-linked starch-gold nanocomposite films, gold nanoparticles (AuNPs) were incorporated into the starch matrix, which could enhance their structural and functional properties. On the other hand, the thermal decomposition of PVA facilitates the reduction of metal ions into metal nanoparticles (NPs), which then oxidize to metal oxide NPs in the PVA matrix, and such PVA-metal/metal oxides films could enhance their structural and physical properties. The nanocomposite films were characterized using various spectroscopic, microscopic, and scattering techniques. Mechanical testing, particularly stress–strain analysis, demonstrated notable improvements in flexibility and elongation at break of the composite films, highlighting the strengthening effect of metal or metal oxide nanoparticles within the starch and PVA matrix. Disc diffusion analysis for PVA nanocomposite films showed excellent antimicrobial activity against test pathogens, including gram-negative, gram-positive, and fungal pathogens, with PVA-CuO nanocomposite films having the highest activity. These findings thus may help to fabricate biodegradable polymeric films with excellent flexibility, thermal stability, and antimicrobial effects, suitable for applications such as biodegradable packaging materials and antimicrobial coatings.

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S

ANTIBACTERIAL PROPERTIES OF BENTONITE CLAY COMPOSITE MATERIAL

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Abstract

Bentonite, kaolin, montmorillonite and other similar natural clays are known to be used as basic materials for compostite materials in various industrial spheres, such as oil industry, construction, cosmetology, pharmacy, agriculture and as food additives for animals [1]. There are various microelements in bentonite composition, therefore it exerts high adsorptive and ion exchange properties, which made its use promising in medical application [2].

Currently, scientists are focusing on the use of bentonites as an antiseptic matrix for the development of dressings for the treatment of external injuries, and as a drug carrier by obtaining nanobentonites by pre-modification [3]. The total stock of bentonite clays in Kazakhstan is about 55 million tons [4]. The chemical composition and practical application of the most deposits have not been fully studied. This indicates, that there is enough raw material for the development of composite materials based on bentonite clay used in various fields. In addition, the study of physico-chemical properties of clay minerals provides a great opportunity to determine the scope of its practical application.

In this regard, the physical and chemical properties of natural bentonite clay obtained from 5 horizons in the Tagan deposit, East Kazakhstan region were studied. The phase structure of bentonite was studied by X-ray diffraction, chemical structure by infrared spectrometer (IR), surface morphology by scanning electron microscope (SEM), surface area and pore sizes by BET method, sorption properties by methylene blue adsorption, and the amount of montmorillonite in bentonite was determined. Compliance with the requirements of the pharmacopoeia was studied in order to determine the possibility of using the Tagan deposit bentonite in medicine.

According to the obtained results, it was known that bentonite clay belongs to the montmorillonite type. It was found that the average particle size of bentonite is between 848 nm and 2 μm, and the degree of sorption of methylene blue is high. This showed that the bentonite of the Tagan deposit has great potential for use in the preparation of sorbents used in pharmaceuticals and biomedicine.

References

1. Dhar, A. K., Himu, H. A., Bhattacharjee, M., Mostufa, M. G., & Parvin, F. (2023). Insights on applications of bentonite clays for the removal of dyes and heavy metals from wastewater: a review. Environmental Science and Pollution Research, 30, 5440-5474
2. Selvasudha, N., Dhanalekshmi, U.-M., Krishnaraj, S., Harish Sundar, Y., Sri Durga Devi, N., & Sarathchandiran, I. (2021). Multifunctional Clay in Pharmaceuticals. IntechOpen. doi: 10.5772/intechopen.92408
3. Moosavi M. Bentonite Clay as a Natural Remedy: A Brief Review. Iran J Public Health. 2017 Sep;46(9):1176-1183. PMID: 29026782; PMCID: PMC5632318.
4. Belousov P.E., Krupskaya V.V. (2019). Bentonite clays from Russia and neighboring countries. Georesources, 21(3), c. 79-90. DOI: https://doi.org/10.18599/grs.2019.3.79-90

Keywords: bentonite, montmorillonite, medicine, Tagan deposit.

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MXENE-DRIVEN ELECTROCHEMICAL APPLICATIONS FOR HEALTHCARE AND SUSTAINABLE TECHNOLOGIES

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Abstract

MXene-based materials represent a transformative class of two-dimensional nanostructures, characterised by metallic conductivity, tunable surface terminations, a large surface area, and robust mechanical stability. These attributes have positioned MXenes at the forefront of advanced electrochemical applications, particularly in the fields of healthcare and sustainable technologies. Recent progress has emphasised the strategic design of MXene hybrid composites through integration with graphene derivatives and metal nanoparticles, resulting in multifunctional platforms with enhanced electrochemical performance. In healthcare applications, such engineered MXene-based composites have demonstrated exceptional capabilities as electrochemical sensors for biomolecule detection. Notably, ternary MXene-based systems exhibit high sensitivity, selectivity, and stability in sensing applications, with proven applicability in complex biological compounds. These advancements highlight the potential of MXene-driven materials to contribute to early diagnosis, continuous health monitoring, and management of neurological disorders. Beyond biosensing, MXene also offer remarkable promise in sustainable technologies, including hydrogen evolution catalysis and energy storage applications. The same surface chemistry and hybridisation strategies applied in sensing can be tailored to optimise electrocatalytic activity, durability, and cost-effectiveness. This convergence of healthcare and sustainability highlights the versatility of MXene-based systems and their ability to bridge fundamental nanomaterial design with solutions to global challenges, thereby advancing the development of scalable and impactful electrochemical technologies.

Keywords: MXene, MXene-based composite, Electrochemical sensing, Sustainable Technology, Electrocatalysis, Healthcare

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S

SILVER-COATED NANOCELLULOSE AEROGELS FOR WATER REMEDIATION APPLICATIONS

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Abstract

Nanocellulose has attracted significant attention owing to its abundance, non-toxicity, renewability, and exceptional characteristics, including high surface activity, excellent hydrophilicity, flexibility, ease of surface modification, superior mechanical strength and cost-effectiveness. Functionalised nanocellulose demonstrates remarkable potential across diverse fields, with water remediation being a particularly promising application.

In this study, nanocellulose aerogels were successfully extracted from cotton fibres through a combination of chemical and mechanical treatments and subsequently modified with silver nitrate to yield silver-coated aerogels (Ag-CNCs). The antimicrobial activity of Ag-CNCs, evaluated using the well diffusion method, revealed effective inhibition against both Gram-positive and Gram-negative bacteria. Furthermore, the efficacy of Ag-CNCs in water treatment was confirmed using the MPN test. While untreated samples showed a positive presence of *E. coli* in both presumptive and confirmed tests, water samples treated with Ag-CNCs exhibited a complete absence of contamination.

This work highlights the transformative role of nanocellulose in environmental remediation, particularly in developing sustainable and effective solutions for clean water.

Keywords: Nanocellulose aerogels; CNC; Antimicrobial application; Water remediation

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References

1. Chen Y., Zhang L., Yang Y., Pang B., Xu W., Duan G., Jiang S., & Zhang K. (2021). Recent Progress on Nanocellulose Aerogels: Preparation, Modification, Composite Fabrication, Applications. Advanced Materials, 33(11), 2005569. https://doi.org/10.1002/adma.202005569
2. Long L.Y., Weng Y.X., & Wang Y.Z. (2018). Cellulose Aerogels: Synthesis, Applications, and Prospects. Polymers, 10(6), 623. https://doi.org/10.3390/polym10060623
3. Gopiraman M., Jatoi A. W., Hiromichi S., Yamaguchi K., Jeon H.-Y., Chung I.-M. & Soo K. I. (2016). Silver Coated Anionic Cellulose Nanofiber Composites for an Efficient Antimicrobial Activity. Carbohydrate Polymers, 149, 51-59. https://doi.org/10.1016/j.carbpol.2016.04.084

S

FUNCTIONAL ROLE OF BENTONITE AND SILVER NANOPARTICLES IN 3D-PCM-D: TOWARD ADVANCED BIOMEDICAL FILMS

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Abstract

The development of advanced wound-healing materials requires multifunctional systems that ensure antimicrobial protection, controlled drug release, and biocompatibility. This study introduces a 3D polymer–clay composite material with prolonged action (3D-PCM-D) that combines Kazakhstani bentonite clays from the Kalzhat and Orta Tentek deposits with green-synthesized silver nanoparticles (AgNPs) incorporated into a biopolymer matrix of gelatin, starch, and carboxymethyl cellulose. Bentonite was purified and decationized by the D.P. Salo method, enhancing its sorption capacity and ion-exchange ability, while AgNPs synthesized using plant extracts of *Syzygium aromaticum*, *Hibiscus sabdariffa*, and *Aloe vera* acted as eco-friendly antimicrobial modifiers. The composite films were fabricated by dispersing AgNP-modified bentonite and therapeutic agents (chlorhexidine and methyluracil) in the polymer mixture, followed by casting and drying at room temperature. Structural and physicochemical analyses confirmed successful nanoparticle immobilization, increased surface area, improved thermal stability, and uniform morphology. Antimicrobial testing against *Escherichia coli* and *Staphylococcus saprophyticus* demonstrated inhibition zones up to 15 mm, with the activity ranking *Syzygium* > *Hibiscus* > *Aloe vera*, proving the synergistic effect of bentonite's sorptive properties and AgNPs' bactericidal action. The resulting 3D-PCM-D films exhibited controlled hydrophilicity, stable swelling behavior, high drug-loading capacity, and prolonged antimicrobial efficiency, highlighting their potential as eco-safe, cost-effective, and multifunctional materials for next-generation wound-healing applications.

Keywords: polymer clay composite materials, bentonite, silver nanoparticles, physicochemical properties, antimicrobial activity, wound healing, drug delivery, nanostructured materials.

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S

COMPOSITE HYDROGELS WITH MICROCRYSTALLINE CELLULOSE AND BENTONITES: INFLUENCE OF MODIFICATIONS ON THE STRUCTURE AND PROPERTIES

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The aim of the work is to evaluate the influence of the type of bentonite modification on the pore structure, swelling, mechanical and sorption properties of composite hydrogels based on polyacrylamide with microcrystalline cellulose (MCC). Sodium-activated, acid-activated, and organo-modified bentonites were used. Hydrogels were synthesized by radical polymerization of acrylamide with methylenebisacrylamide in the presence of MCC and clay dispersions. Porosity and morphology were assessed using a scanning electron microscope, swelling in environments with different pH and ionic strength, mechanical properties under uniaxial compression and sorption using models of transition metal ions and organic dyes.

MCC has been shown to improve clay distribution and form a more stable framework. Sodium-activated bentonite provides the highest and fastest swelling. Acid-activated filler increases compressive strength but reduces equilibrium water absorption. Organo-modified filler improves cyclic stability and reduces particle loss. The resulting relationships allow for targeted filler selection for water sorption and purification applications.

Keywords: composite hydrogels, microcrystalline cellulose, bentonite, modification, porosity, swelling, mechanical properties, sorption.

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S

BOMBYX MORI SILK FIBROIN AS NATURAL BIOTIC POLYMER FOR SYNTHESIS OF GOLD NANOPARTICLES: OPTICAL CHARACTERIZATION AND CALORIMETRIC DETECTION OF AMMONIA

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Abstract

Biopolymer material were used to fabrication of nanoparticles has magnetic scrutiny. In the present investigation, use the aqueous polypeptide protein chain as renown as silk fibroin (SF), extracted from the Bombyx mori cocoons shells. Silk fibroin plays a major role in the origination of numerous size and shape of gold nanoparticles (GNPs) during the synthesis. Formed gold nanoparticles were characterized by numerous analytical techniques. UV-Visible spectroscopy (UV-Vis) exhibited the establishment of gold nanoparticles by screening surface plasmon resonance (SPR) intensity band at λmax from 518 to 534 nm. X-ray diffraction (XRD) investigation evidenced the crystalline and face centered cubic (FCC) nature of gold nanoparticles. Fourier transfer infrared spectroscopy (FTIR) demonstrated the functional groups in SF were responsible creation of Au^{3+} to Au^{0}. Surface morphology of gold nanoparticles were scrutinised by using scanning electron microscopy (SEM). Fluorescence spectroscopy (FL) confirmed formation of gold nanoparticles by redox of tyrosine groups in the silk fibroin. Ammonia sensing investigation of biopolymer gold nanoparticles were accomplished by optical approach based on SPR intensity band. The execution of ammonia optical sensor were studied which yield outstanding result. The detection limit of ammonia is 1 ppb.

Keywords: Silk fibroin, GNPs, UV, FTIR; FL and Ammonia detection.

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P

PREPARATION AND CHARACTERIZATION OF CHITOSAN-GELLAN POLYELECTROLYTE COMPLEXES

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Abstract

Polyelectrolyte complexes (PECs) derived from polysaccharides offer a versatile platform for diverse applications. This study investigates the formation and characterization of PECs formed by chitosan and gellan gum, two biocompatible and biodegradable polysaccharides. The aim is to elucidate the complexation mechanism and optimize the PEC properties.

Polysaccharide-based PECs are attracting significant attention due to their potential applications in various fields, including drug delivery, tissue engineering, and food packaging. Chitosan, a cationic polysaccharide derived from chitin, and gellan gum, an anionic polysaccharide produced by *Sphingomonas elodea*, are excellent candidates for PEC formation due to their opposite charges and biocompatible nature. This work focuses on synthesizing and characterizing chitosan-gellan PECs to understand their formation mechanism and optimize their properties for targeted applications. A variety of other polysaccharides have the ability to form PECs as well, and can be combined using a number of methods to yield various results.

Potentiometric and conductometric titration, coupled with turbidimetry, indicated a near 1:1 (mol/mol) optimal stoichiometric ratio for complex formation (Figure 1). DLS measurements revealed a strong dependence of particle size on the mixing ratio. Large aggregates formed at intermediate ratios (e.g., 1:9 and 3:7 mL/mL), while smaller, more stable nanoparticles (≈370–580 nm) were observed near the stoichiometric composition. Zeta potential analysis confirmed the charge reversal from negative values in gellan-rich systems (-90 to -156 mV) to positive values in chitosan-rich systems (+120 to +140 mV), with a near-neutral point at equimolar ratio of gellan and chitosan. TGA demonstrated that the thermal stability of the PECs is lower than that of pure chitosan and gellan, consistent with non-covalent interactions. FTIR spectra confirmed electrostatic interactions between the $-NH_3^+$ groups of chitosan and the $-COO^-$ groups of gellan, along with the formation of new hydrogen bonds, indicating structural rearrangements within the complex.

This study provides a comprehensive understanding of the formation and characteristics of chitosan-gellan PECs. The elucidated interactions and structural properties suggest the potential of these PECs for applications in biopolymer-based nanostructures and functional biomaterials. Future work will focus on exploring specific applications of these PECs, such as targeted drug delivery and controlled release systems.

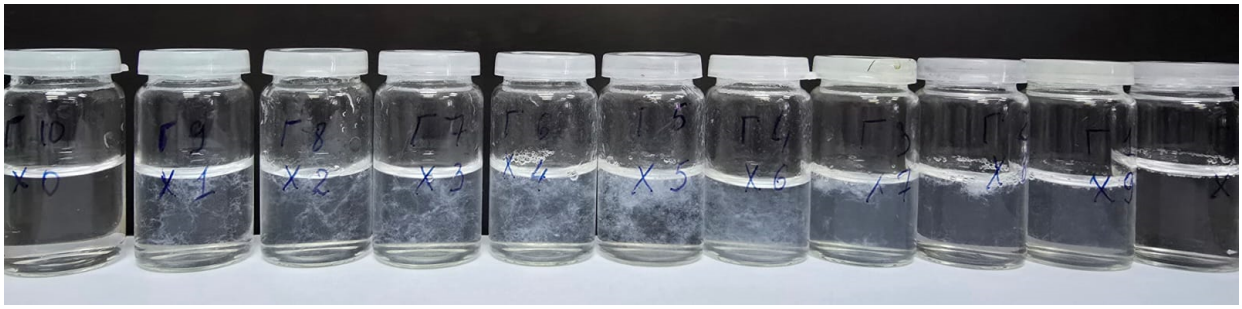

Fig. 1. Formation of chitosan-gellan PECs depending on volume ratio of interacting components

Keywords: Polyelectrolyte complex, chitosan, gellan, polysaccharides, characterization.

P

SYNTHESIS AND CHARACTERIZATION OF COMPOSITE FILMS BASED ON MCC AND PANI

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Abstract

Composite materials, especially ones that combine organic and natural substances can exhibit great physical and chemical properties, as well as being more ecologically and environmentally safe [1]. In recent times, scientists are aiming to design bio materials that possess favorable electrical characteristics. One of the promising substances is the polyaniline (PANI), a polymer of aniline. Namely, there is an emeraldine - dark green powder substance that is stable compared to other polyaniline isomers, leucoemeraldine and pernigraniline [2]. However, while showing superior conductivity compared to other polymers, there is an obstacle - its low structural sustainability and aggregability [3]. Microcrystalline cellulose (MCC), on the contrary, offers excellent mechanical properties - low density, structural integrity, elasticity, durability and castability, although it exhibits poor electrical properties [4]. On top of that, MCC is a biodegradable, non-toxic, non-harmful substance that can be obtained from a variety of plants and also agricultural waste, benefiting the ecology even further. Combining these two substances may result in synergy between suitable electrical properties as well as mechanical stability, thus creating composite with a wide field of applications.

This paper focuses on the preparation of the composite films derived from PANI and MCC via in-situ polymerization. The synthesis was performed by dispersing aniline on the cellulose matrix and adding ammonia persulfate in hydrochloric acid, with required temperature and medium adjustments. Several films with different mass ratios of cellulose to polyaniline were made: 70:30, 80:20 and 95:5 respectively. Synthesised films were studied via XRD, SEM, IR, TGA, texture analyzer and the 4-point probe method.

Obtained results show electrical properties similar to that of PANI, with electrical conductivity rising when the MCC content is increased, ranging from 0.0926 up to 2.5 S/cm. Mechanical tests reveal high structural stability, flexibility and TGA results indicate thermal stability up to 250 degrees Celsius. SEM images show fibrilles of synthesized PANI embedded onto the cellulose structure and high surface homogeneity.

Keywords - cellulose polyaniline composite, MCC, PANI.

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Reference

[1] - Dixit S, Goel R, Dubey A, Shivhare PR, Bhalavi T. Natural Fibre Reinforced Polymer Composite Materials - A Review. Polymers from Renewable Resources. 2017;8(2):71-78. doi:10.1177/204124791700800203

[2] - T. Zaharescu, “Electrochemical deposition of polyaniline thin films on carbonic substrates for the application as hydrogen mediator and self catalyst in fuel cells,” International Journal of Hydrogen Energy, vol. 28, no. 6, pp. 663–672, Jun. 2003.

[3] - Y. Zhang, Y. Wang, Y. Liu, and Y. Wang, “Recent advances of polyaniline composites in anticorrosive coatings: A review,” Progress in Organic Coatings, vol. 149, p. 105873, Dec. 2020.

[4] - M. A. El-Sakhawy and M. M. Hassan, “Physical and mechanical properties of microcrystalline cellulose prepared from agricultural residues,” International Journal of Biological Macromolecules, vol. 37, no. 4, pp. 222–230, Oct. 2005.

P

SYNTHESIS OF CARBON MATERIAL FROM ANNUAL PLANTS AND STUDY OF ITS PHYSICOCHEMICAL CHARACTERISTICS

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Abstract

Modern environmental challenges associated with pollution and the accumulation of industrial waste require the development of efficient and eco-friendly materials for water and air purification. In this regard, carbon materials obtained from renewable plant raw materials and agricultural waste are of particular interest, since their use not only contributes to biomass utilization but also enables the creation of functional materials with high practical value. [1,2] Sunflower seed husk, as an abundant agricultural by-product, represents an environmentally sustainable source for the synthesis of carbon-based adsorbents. [3]

In this study, carbon materials were synthesized by low-temperature vacuum carbonization with preliminary chemical treatment. Their physicochemical properties were analyzed using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), Brunauer–Emmett–Teller (BET) analysis, and scanning electron microscopy (SEM). In addition, sorption studies were carried out to evaluate their efficiency in removing heavy metal ions from aqueous solutions.

The results showed that the synthesized materials are characterized by a well-developed porous structure, a significant specific surface area, and the presence of functional groups that provide high sorption activity. It was found that the iodine sorption capacity is 125%, the removal efficiency of metal ions reaches 98%, and the specific surface area of the activated carbon is 1619.48 m²/g. These indicators confirm the effectiveness of the obtained carbon materials and demonstrate their potential for applications in wastewater purification, pollutant adsorption, as well as in the development of sensor systems.

Keywords: carbon materials, biomass, SEM, BET

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References

1. Kumar, K., Kumar, R., Kaushal, S., Thakur, N., Umar, A., Akbar, S. S., & Baskoutas, S. (2023). Biomass waste-derived carbon materials for sustainable remediation of polluted environments: A comprehensive review. *Chemosphere*, 140419. https://doi.org/10.1016/j.chemosphere.2023.140419

2. Muzammal H. et al. Green Adsorbents for Water Purification //Water Purification–Present and Future. – 2023.

3. Radenkovic, M., Petrović, J., Pap, S., Kalijadis, A., Momcilovic, M., Krstulović, N., & Zivkovic, S. (2023). Waste biomass derived highly-porous carbon material for toxic metal removal: Optimisation, mechanisms and environmental implications. *Chemosphere*, 140684. https://doi.org/10.1016/j.chemosphere.2023.140684

P

DEVELOPMENT OF EDIBLE BIOPOLYMER FILMS BASED ON CELLULOSE FOR EXTENDING THE SHELF LIFE OF AGRICULTURAL PRODUCTS

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Abstract

Due to the high perishability of fruits and vegetables, synthetic coatings and preservatives are widely used during their storage and transportation, whereas agro-industrial by-products represent a promising renewable and low-cost source for the development of natural polymers. In this study, a multifunctional biopolymer edible film AP-CS-CMC-CNC-HT based on apple pectin (AP), corn starch (CS), sodium carboxymethylcellulose (CMC), and nanocrystalline cellulose (CNC) was fabricated by the wet casting method with the addition of *Hibiscus trionum* extract. Glycerol was used to provide elasticity. All major components used for film fabrication were extracted from locally available plant raw materials, derived from by-products of the agro-industrial field. The films were characterized in terms of physicochemical and organoleptic properties, as well as biocompatibility and potential antimicrobial activity against gram-positive and gram-negative bacteria. The addition of *H. trionum* extract improved the functional properties of the films, providing color and potential antioxidant and antimicrobial activity. These properties were confirmed using apple samples, where coating application effectively reduced weight loss during storage, while the pH-dependent color change of anthocyanins provided an additional visual indication of product freshness. The developed films show strong potential for agricultural food preservation and can serve as a natural biodegradable alternative to synthetic packaging.

Keywords: edible coating, biopolymer film, fruit preservation, antimicrobial activity, *Hibiscus trionum*, cellulose

P

OBTAINING MICROCRYSTALLINE CELLULOSE FROM SOYBEAN WASTE PRODUCTION OF KAZAKHSTAN AND STUDYING ITS PHYSICAL AND CHEMICAL PROPERTIES

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Abstract

The use of domestic natural raw materials for the synthesis of environmentally friendly and cost-effective biocomposite materials is currently becoming one of the most pressing scientific trends. The main driver of this trend is the availability of large reserves of valuable lignocellulosic biopolymers, such as cellulose, hemicellulose, and lignin, in the millions of tons of agricultural waste generated annually during the production of field and horticultural crops. Given the relatively low ash and protein content of this waste, using it as a source of biopolymers is an environmentally friendly and cost-effective solution.

Agricultural waste, rich in cellulose, is an inexhaustible resource for recycling and producing value-added products. Its availability, recyclability, biocompatibility, and complete degradability in the environment offer significant opportunities for the synthesis of biocomposite materials. These materials have significant potential for use in agriculture, medicine, the food industry, and other sectors. Furthermore, the efficient use of agricultural waste helps reduce carbon footprints and achieve specific development goals.

In this research study investigated the possibility of producing microcrystalline cellulose (MCC) from soybean husk (SBH), an agricultural waste product. During the research, priority was given to minimizing the use of chemical reagents, reducing energy costs, and minimizing environmental damage, and a method based on the principles of "green chemistry" was used. The qualitative characteristics of the obtained MCC were comprehensively studied, including the content of α-cellulose, hemicellulose, residual lignin, moisture, and ash content. Furthermore, the morphological structure of MCC was studied using scanning electron microscopy (SEM), its chemical structure using infrared spectroscopy (IR), its crystalline structure using X-ray diffraction (XRD), and its thermal stability using thermogravimetric analysis (TGA).

The study found that the effective water modulus of SBH_{MCC} is SBH:PAA 1:16 g/ml, resulting in a 37.3% MCC yield, 2.5% moisture content, 65.9% α-cellulose content, 3.2% residual lignin, 15.6% hemicellulose, and 2.1% ash content. The MCC fiber length averages 152–675 μm, the width is 14–35 μm, and the surface layer is relatively smooth, with a ribbon-like structure. The crystalline structure is typical of cellulose, and thermal stability is maintained up to 265°C.

The physicochemical properties of the obtained microcrystalline cellulose allow it to be used in agriculture for the synthesis of water-retaining biomaterials, in medicine as a sorbent for transporting drugs, and in the production of environmentally friendly biocomposites and functional polymers.

Keywords: soybean husks (SBH), organosolvent oxidation, microcrystalline cellulose, FTIR, crystal structure.

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P

PRODUCTION OF HIGH-POROSITY ACTIVATED CARBON FROM AGRICULTURAL WASTE FOR ELECTROCHEMICAL ELECTRODE APPLICATIONS

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Abstract

This study presents an efficient and sustainable approach to producing high-porosity activated carbon with a large specific surface area from agricultural biomass residues. Agricultural waste, including peanut shells and rice husks, was carbonized at moderate temperatures (400–500 °C) followed by chemical activation using potassium hydroxide (KOH) at 600–800 °C under controlled conditions. The activation parameters—including impregnation ratio, temperature, and duration—were systematically optimized to maximize the Brunauer–Emmett–Teller (BET) surface area and pore volume. Nitrogen adsorption–desorption isotherms revealed a surface area exceeding 2000 m^2/g with hierarchical micro–mesoporous structures suitable for rapid ion transport. Electrochemical measurements demonstrated that the prepared carbon exhibited excellent specific capacitance (>250 F/g at 1 A/g) and outstanding cycling stability (>95% retention after 5000 cycles) when tested as a supercapacitor electrode in a three-electrode system. The combination of low-cost raw materials, simple synthesis, and superior electrochemical performance highlights the potential of this approach for scalable production of high-value electrode materials from renewable resources.

Keywords: Activated carbon; Agricultural waste; Chemical activation; High surface area; Porosity; Supercapacitor electrodes; Energy storage; Sustainable materials; Potassium hydroxide activation; Biomass-derived carbon

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P

BIODEGRADABLE CAR WASH SOLUTION FOR TOUCHLESS CLEANING

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Abstract

The growing demand for sustainable and eco-friendly cleaning formulations has stimulated research on biodegradable surfactant systems that combine high washing efficiency with reduced environmental impact. In this study, blends of anionic (sodium lauryl sulfate, SLS), amphoteric (cocamidopropyl betaine, CAPB), and nonionic (alkyl polyglucoside, APG) surfactants were investigated with respect to foamability, wetting, viscosity behavior, and cleaning performance. Ross-Miles foam test results showed that SLS/CAPB and SLS/APG blends generated stable foams (up to 200 mm after 1 min) superior to SLS alone (175 mm). Wetting was significantly improved by synergistic interactions, with Draves wetting times as low as 2.9 s compared to 4.8 s for SLS. Viscosity measurements revealed a pronounced salt curve effect, reaching maximum viscosity at 3.5% NaCl. At pH values of 10–12, formulations exhibited both stability and enhanced chelating capacity of GLDA, further supporting cleaning in hard water conditions. Field trials on automotive surfaces demonstrated that optimized formulations achieved high foam stability, efficient soil removal, and satisfactory rinsing performance. These findings confirm that blends of biodegradable surfactants provide an effective and environmentally friendly alternative to conventional car wash products.

Keywords: surfactants, biodegradability, foam stability, wetting, eco-friendly cleaning

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