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Multifunctional Syntactic Foams

Guoqiang Li*

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Abstract

Polymeric syntactic foams, a lightweight composite with hollow particles dispersed in a polymer matrix, have found wide applications in various sectors, from aerospace to marine structures. As compared to open-cell forms, syntactic foams are close-cell, leading to enhanced mechanical properties and water tightness. In the past years, our lab has been working on smart polymer based syntactic foams, including shape memory polymers, vitrimers, 3D printable polymers, and flame-retardance smart polymers. In this presentation, I will discuss the several multifunctional syntactic forms designed, synthesized, and tested in our lab.

Failure Analysis of Polymer Matrix Composites with Manufacturing Defects

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Abstract

Polymer matrix composites are manufactured by a variety of methods, ranging from labor-intensive hand layups to fully automated techniques employing robotics. Depending on the degree of control in the manufacturing process, different defects appear in the final product. These defects can be described as deviations from the intended morphology of the internal structure of a composite. Examples are nonuniformity of fiber distributions and misalignment of fibers, imperfect fiber-matrix bonding, and voids in the polymer matrix. All such defects can be initiators of local damage that can lead to deterioration of the composite performance. This presentation will discuss a strategy for performance evaluation of composite structures accounting for the severity of manufacturing defects. A statistical methodology for construction of representative volume elements combined with local stress and failure analysis applicable to polymers will be presented.

Biomimetic Polymer-encapsulated Catalytic Nanoplatform for Tumor-specific, Self-accelerating Chemodynamic Cancer Therapy

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Abstract

Chemodynamic therapy (CDT) represents a promising strategy for cancer treatment by generating lethal hydroxyl radicals (•OH). However, the therapeutic efficacy of traditional CDT is significantly impaired within the tumor microenvironment (TME) due to insufficient hydrogen peroxide (H_2O_2) levels, rapid Fe^{3+} precipitation, and a slow Fenton reaction cycle. To address these challenges, tumor-activated, self-accelerating CDT nanocatalysts are synthesized, comprising poly(lactic-co-glycolic acid) (PLGA) encapsulated Ca-Fe peroxide clusters and polyarginine (R). Nanocatalysts were camouflaged with cancer cell membrane to enhance tumor targeting. Additionally, polyarginine tailored the PLGA responsiveness to low H_2O_2 levels (50 - 100 μM). H_2O_2 triggered degradation of PLGA, releasing CaFe clusters to produce Fe^{3+} /Fe^{2+} and additional H_2O_2, sustaining the Fenton reaction. Simultaneously, polyarginine released nitric oxide (NO) in the presence of H_2O_2, facilitating Fe^{3+} reduction to Fe^{2+} and amplifying •OH generation. *In vitro* cellular studies demonstrated significantly improved homotypic tumor

targeting (6.5-fold increase) and deep spheroid penetration (>120 μm), resulting in improved tumor permeability and elevated •OH generation. Additionally, the nanoparticles exhibited dose-dependent cytotoxicity, and polyarginine notably enhanced the cytotoxicity of curcumin-PLGA-calcium ferrite nanoparticles, reducing the IC_{50} value from 216.9 μg/mL to 43.38 μg/mL. Apoptosis/necrosis assay revealed that the elevated •OH generation by CCM-PLGA-CaFe-R NPs preferentially induced necrosis, effectively inhibiting tumor cell proliferation by 76.3% ± 8.4% over a 7 day treatment. Consequently, this TME-responsive, self-accelerating CDT platform demonstrates enhanced therapeutic efficacy through improved tumor targeting, sustained Fenton reaction, and amplified radical generation, offering a versatile nanomedicine strategy to boost the precision and effectiveness of traditional cancer CDT.

Advancing Wound Healing: Exploring Electrospun Fibers and Cell Culture Dynamics

Baylee Mabry* **and Sharon K. Hamilton***

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Abstract

Wound healing is a multi-billion-dollar global industry that impacts millions of people worldwide. Advances in wound healing research have led to biodegradable alternatives to traditional gauze and bandages, which offer limited support for active tissue regeneration. A promising method for enhancing wound healing is electrospinning, which produces nanofibrous constructions with architectures similar to that of the extracellular matrix. For this study, sodium alginate, a natural polymer shown to maintain a moist environment and exhibit biocompatibility in wounds, was modified to create a bioactive and degradable alginate (oxbAlg) that mimics the functionality of collagen. Characterization of the and oxbAlg was performed via infrared and UV-Vis spectroscopy to ensure successful functionalization and to quantify the degree of oxidation. The oxbAlg was electrospun with poly(vinyl alcohol) (PVA) that had been dissolved in CaCO3 and epichlorohydrin as a cross-linker. These nanofiber mats were analyzed *in vitro* using HaCaT cells, a spontaneously immortalized human keratinocyte cell line, using a live/dead assay, a scratch assay, and an MTS assay conducted to assess cell viability, migration, and proliferation. Future work will be focused on testing the hemostatic capabilities of the mats as it is anticipated that these constructions will lend themselves to a variety of biomedical applications, particularly wound healing.

3D Functional Aerogels for Water Purification

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Abstract

Water contamination by micro/nanoplastics poses escalating risks to human and ecosystem health. Conventional treatment technologies, such as membrane filtration or chemical coagulation, often face limitations including high energy demands, fouling, and incomplete pollutant removal. To address these challenges, nanocellulose/chitosan/polydopamine based novel three-dimensional (3D) functional aerogels were developed as sustainable solid-phase adsorbents for micro/nanoplastic removal. Our approach leverages the inherent high porosity, tunable surface chemistry, and lightweight architecture of aerogels. As-synthesized aerogels exhibit enhanced adsorption capacity and selectivity across diverse contaminants. The open 3D network provides rapid mass transport of 0.2 L/min and energy-efficient gravity-driven flow. As-produced aerogels demonstrated outstanding adsorption capacities of over 300 mg/g and a removal rate of over 95% for various micro/nanoplastic species, including submicron polystyrene, polyethylene, polypropylene, and poly(methyl methacrylate). Prototype demonstrations include continuous-flow column systems capable of removing microplastics at environmentally relevant concentrations without clogging and biofouling after continuous operation for 72 h. Comparative studies highlight superior performance relative to conventional membranes, particularly in terms of adsorption efficiency and energy efficiency. Moreover, the aerogels are engineered for reusability through simple washing or light-driven regeneration, addressing cost and sustainability concerns. This work reveals the potential of 3D functional aerogels as next-generation water treatment media, combining structural innovation with surface chemistry to meet pressing global needs in freshwater protection. This research opens pathways for scalable manufacturing of functional aerogels for the applications in environmental sustainability.

Synthesis and Properties of Dopamine-appended Polyoxazolines

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Abstract

Mussels anchor themselves to rock surfaces in water by secreting adhesive protein-containing byssus threads. These byssus threads can adhere not only to rocks and inorganic materials, but also to various organic polymers and metals. Because the catechol moieties in adhesive proteins possess a key role to their adhesive properties, a wide variety of polymers carrying dopamine (DA) as a catecholamine in the side chains have been synthesized in recent years, and they are expected to be used as biomimetic adhesive materials. Most DA-appended polymers reported to date possess polymer backbones such as polystyrene, poly(meth) acrylate, and polyacrylamide. In this study, we synthesized novel DA-appended polymers [poly(OxDA)] with a polyoxazoline [poly(Ox)) backbone, focusing on functionalizing both the main chain and side chains. Because polyoxazolines are known to be biocompatible, DA-substituted poly(OxDA) is expected to be a highly biocompatible adhesive material for biomedical applications. Poly(OxDA) was synthesized by the nucleophilic substitution of the oxidation product of the precursor, poly(2-ethylthio-2-oxazoline) [poly(EtSOx)], with DA without the need for protection of its catechol group. The precursor poly(EtSOx) derivatives were synthesized by living cationic ring-opening polymerization of the corresponding oxazoline derivatives, allowing for molecular weight control and the synthesis of copolymers with 2-ethyl-2-oxazoline (EtOx) at different composition ratios. In this study, we synthesized DA-appended polyoxazoline copolymers [poly(OxDA-co-EtOx)] with varying DA content and evaluated their adhesive properties and biocompatibility.

Developing Modern Polymeric Materials for Biomedical Applications

Sharon K. Hamilton*, Baylee Mabry, Gracie Moore, Tatum Smith and Alex Browning

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Abstract

Recent evolutions in the field of biomaterials have focused on developing materials that can facilely interface with biological systems to treat or replace tissues or functions of the body. Natural polymers including polysaccharides have been investigated as suitable biomaterials to mimic the environment of body tissues and facilitate tissue regeneration. Chitosan, collagen, and sodium alginate are water-soluble, natural macromolecules that have been used in applications such as cell scaffolding, drug delivery, and wound healing. Additionally, biocompatible synthetic polymers, such as poly(acrylic acid) and polylactones, are of significant importance within the fields of tissue engineering, drug delivery, and biomedical implants. Both natural and synthetic polymers can be modified to attach biomimetic and bioactive moieties to further enhance the final macromolecular product. Electrospinning polymers into nanofibers or cross-linking networks of polymers into hydrogels yields materials that have shown promise in a variety of biomedical applications, including tissue scaffolds. Modern wound healing treatments have capabilities including preventing infection and encouraging cell growth; however, little research has been published on the development of synthetic analogs to costly biomolecules. My lab investigates the development of biomimetic polymers through the modification of commercially available polymeric backbones as well as the polymerization of functionalized monomers. It is anticipated that these biomimics will prove to be suitable materials for use in a variety of applications including wound healing.

Experimental Characterization of Gamma Attenuation Properties of Metal-filled Polymer Composites and Prediction for Unseen Compositions Using Machine Learning: Preliminary Findings

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Abstract

In this study, the radiation attenuation properties of composite materials produced with high-density polyethylene using two different Bismuth and Tungsten metal powders, were experimentally investigated. The composite raw materials were homogeneously mixed using a two-screw mixer extruder and then formed into bulk samples by injection molding. The composites were prepared with additives at 1%, 3%, 5%, 10%, and 15% and were tested at three different photon energy levels: 32 keV, 59 keV, and 81 keV. The attenuation capacity of each sample against gamma photons was determined, and a preliminary dataset was generated based on these data. Modeling studies were conducted using three different machine learning regression methods

(Random forest, K-nearest neighbors, and XGBoost) using the Python programming language. The performance of the models was evaluated using various metrics such as prediction accuracy, error rates, and parameter optimization. The comparative analysis revealed that the XGBoost method provided the lowest error rate and the highest level of accuracy compared to the other models. In this context, the XGBoost emerged as the most suitable model. However, despite the model's high performance, this study, limited to only preliminary test data, demonstrates that the generalizability of the model can be further enhanced. Initial results, particularly on non-model examples, indicate that the robust structure of the XGBoost method can be further enhanced by supporting its potential with larger data sets. Accordingly, future work aims to make the model's predictive capabilities more robust and comprehensive.

Preparation of Interpenetrating Polymer Network by Using Water-soluble Glycopolymers

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Abstract

Fluorogenic glycomonomers have been used to determine biological interactions and water-soluble and forester resonance energy transfer (FRET)-sensitive glycopolymers have been reported. A FRET-sensitive polymer was conveniently prepared in high yield from a fluorogenic donor monomer and a fluorogenic acceptor monomer by simple radical polymerization. Continuous fluoroscopic monitoring of the polymer in the presence of an enzyme was performed, and the results showed the possible practical application of the FRET-sensitive glycopolymer. In addition to the use of an aqueous solution phase, the water-soluble and FRET-sensitive glycopolymer was completely captured into an interpenetrating polymer network (IPN) by means of radical polymerization with a combination of acrylamide and bis-acrylamide as the crosslinking reagent system. The IPN, including the FRET-sensitive glycopolymer, was allowed to react with amylases in an aqueous buffer solution at 37 °C, and the enzymatic reaction was continuously and conveniently monitored by means of fluorometric spectroscopy. In this presentation, details of the preparation and application of IPN materials for capturing glycopolymers will be discussed.

Triboelectric and Piezoelectric Nano-generators for Energy Harvesting and Self-powered Sensing

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Abstract

The ongoing trend toward miniaturization and flexibility in the development of electronic devices and sensors has raised urgent and challenging requirements for their power sources. The conventional electrochemical batteries, as the mostly used power sources, are heavy, bulky, and rigid. In addition, the general use of batteries is inconvenient (the need to be frequently charged or replaced) and has big environmental impacts. A fundamental solution to this challenge would be the employment of energy-harvesting technologies that can constantly convert energy from the ambient environment into electricity. Various methods that scavenge ambient energy in different forms (solar, electromagnetic, mechanical, thermal, and so forth) have been explored through photoelectric, electromagnetic, electrostatic, piezoelectric, triboelectric, thermoelectric, and pyroelectric transduction mechanisms at different scales. Among them, harvesting the most ubiquitous and constantly available mechanical energy with piezoelectric and triboelectric nanogenerators have been proven to be a highly efficient, cost-effective, and robust approach especially when high mechanical flexibility and even stretchability are strictly demanded, for instance, powering stretchable electronics. Meanwhile, these piezoelectric and triboelectric nanogenerators are natural candidates for the self-powered active sensors. The self-powered active sensing is revolutionary compared to passive sensing in which the sensors are externally powered by conventional batteries. This presentation summarizes our efforts at National Research Council on the development of piezoelectric and triboelectric nanogenerators for energy harvesting and self-powered sensing.

Device and Materials Physics of All-polymer Printed Field-effect Transistors

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Abstract

Conducting polymers enable the fabrication of field-effect transistors (FETs) and integrated electronic circuits through solution processing, which allows device patterning via selective material deposition and direct additive printing of all the layers. However, to reach high spatial resolutions similar to lithographic techniques, without compromising device performance, the complex interplay of material properties with the figures of merit of the device must be studied. To elaborate on this topic, my talk is divided into two parts. In the first part, I will introduce a state-of-the-art method developed for achieving a scalable all-polymer FET using direct writing fabrication that can attain resolutions equivalent to lithographic processes. In the second part, I will focus on the methodology to tune the energy levels of the conducting polymer electrode that is used for charge carrier injection. Subsequently, I will provide a perspective on downscaling the printed FET when the injection electrode is no longer a perfect metal.

Polyethylene Resin from Exon Mobil

Sushant Roy[*]

ExonMobil, United States

Abstract

ExxonMobil is a Global leader in the field of polyethylene resins and manufactures polymers that caters to different segments of the packaging industry such as Food packaging films, Agricultural films, Industrial packaging films (to name only a few). This presentation will focus on one of the recently launched polymers having exceptional processability and physical properties.

Advanced Hydrogel Platforms for Sensing, Actuation, and Sustainable Applications

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University of Manitoba, Canada

Abstract

This presentation highlights recent innovations from my research group in the development of multifunctional hydrogel systems designed to address pressing challenges in healthcare, environmental sustainability, and bio-integrated electronics. We begin with tough yet self-healing, 3D-printable hydrogels engineered for next-generation bioelectronics, including electronic skin (E-skin), electronic noses (E-noses), and laser-controlled soft actuators. Next, we explore a class of egg white–derived hydrogels that combine exceptional stretchability, 3D printability, and self-healing capabilities, making them ideal for soft electronic sensors and actuators. We then introduce a self-powered, plant-wearable hydrogel that functions both as an LED power source and a growth-monitoring sensor, offering a sustainable solution for smart agriculture. Finally, we present smart wound dressings equipped with integrated sensors for real-time monitoring of the wound healing process and the surrounding microenvironment. Together, these examples illustrate the transformative potential of hydrogel technologies at the interface of biology, electronics, and the environment.

Metallic-luster Films Derived from Poly(3-Methoxythiophene)/polyester Blends

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Chiba University, Japan

Abstract

Metallic luster and colors, deeply embedded in society, culture, and religion, often symbolize luxury and nobility. Conventional metallic paints rely on effect pigments, namely aluminum or zinc flakes dispersed in a binder resin solution with colorants. However, such flakes face drawbacks, including corrosion, color migration, increased coating weight, electromagnetic shield-

ing, and environmental concerns. Recently, metal-free organic solids exhibiting metallic luster have emerged as promising alternatives. We developed gold-like luster films using poly(3-methoxythiophene) synthesized via chemical polymerization of 3-methoxythiophene. Furthermore, we prepared poly(3-alkoxythiophene) derivatives with linear or branched side chains to examine how substituent structures influence film properties. Depending on substituent differences, metallic luster films with distinct color tones were obtained. We also extended our study to selenophene, a heavier thiophene analog. Owing to its smaller HOMO–LUMO gap, stronger quinoid character, and higher polarizability of selenium atoms, polyselenophene exhibits a more rigid backbone and larger refractive index, leading to metallic films with optical properties different from polythiophene. Based on these findings, we investigated the influence of copolymerization of different heteroaromatic monomers on film formation. Copolymers of 3-methoxythiophene with 3,4-dimethoxythiophene, 3-methoxyselenophene, or pyrrole were synthesized by oxidative polymerization. In all cases, metal-like luster films were obtained. For comparison, physical blends of the corresponding homopolymers were also processed, but they resulted in films with inferior smoothness and different appearances. These results demonstrate that copolymerization enables smooth films with metallic luster and unique color tones, unattainable through simple polymer blends.

Visualization of the Lamellar Structure of Polyvinylidene Fluoride using Phase-plate Scanning Transmission Electron Microscopy

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Abstract

Polyvinylidene fluoride (PVDF) is a crystalline polymer known for its excellent piezoelectric properties and flexibility. PVDF exhibits crystalline polymorphism, and the β-type structure has attracted attention due to its excellent piezoelectric properties. However, due to a lack of local structural information, the details of its piezoelectric mechanism remain unclear. Nanoscale structural analysis is essential to understand the piezoelectric mechanism of PVDF. In this paper, as a first step toward elucidating the piezoelectric properties of PVDF, we observed thermally stretched PVDF using a newly developed phase-plate scanning transmission electron microscope (P-STEM). P-STEM is a technique that can enhance phase contrast and is particularly effective for observing polymeric materials composed of light elements. As a result, we successfully visualized a lamellar structure consisting of layered crystalline and amorphous regions without the need for staining for electron microscopy. The period of the lamellar structure was approximately 7 nm, which was in good agreement with the results of small-angle X-ray scattering. Furthermore, high-magnification P-STEM images revealed bundled structures oriented along the stretching direction. Based on the image contrast, these regions are considered to correspond to crystalline regions. These results demonstrate that P-STEM can directly observe nanoscale crystalline regions in PVDF, demonstrating that this technique is effective for studying detailed local information in solid polymers, such as the orientation of polymer chains.

Preparation and Characterization of the Ground Mixture of Rebamipide Commercial Tablets and Hydroxypropyl Cellulose-SSL by Ball-milling

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Abstract

In the present study, to prepare dispersoids with high dispersion stability that can be used as mouthwash, ground mixtures of commercial rebamipide (RB) tablets and hydroxypropyl cellulose (HPC-SSL) samples were prepared by dry milling. The physicochemical properties of the ground mixture of HPC-SSL and the powder obtained from the preliminary ground RB tablets were then compared. The dispersoids' physicochemical properties, dispersion stability, retention, and diffusiveness to the mucosal surfaces were evaluated *in vitro*. By co-grinding with HPC-SSL, RB transformed into fine particles around 303.6 - 361.5 nm that tended to prevent particle agglomeration in solution over time. The sample microparticles formed with HPC-SSL also avoided agglomeration on the mucosal surface for 24 h, improving oral retention. Furthermore, the ground mixture of HPC-SSL and the powder obtained from the preliminary ground RB tablets dispersed and permeated the mucus gel layer on the mucosal surface (24.2%) but not the mucosal cells, indicating that RB remained on the mucosal surface. These results suggest that ground mixtures of commercial RB tablets and HPC-SSL samples can be applied as a powdered suspension preparation because they showed high dispersion stability and oral mucosal retention.

Unraveling Synergies: The Influence of Hydrogel Mechanics and Biofunctionalization on MSC Osteogenic Differentiation and Breast Cancer Spheroid Cultivation

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Abstract

The design of hydrogels for cell culture that mimic the cell microenvironment is complex given the numerous factors involved. This research explores the synergistic effects of mechanical properties and biofunctionalization on mesenchymal stem cell (MSC) differentiation, with a focus on bone regeneration and on breast tumoroid culture for drug testing of patients' samples for personalized medicine. Although the influence of the mechanical properties of hydrogels on stem cell differentiation or tumoroid culture is beginning to be recognized, the study of the impact of elastic and viscoelastic properties on MSC or tumoroid culture is recent. In addition, the synergistic interaction between mechanical properties and biofunctionalization remains poorly understood. In this work, poly(ethylene glycol) diacrylate hydrogels (PEGDA) were designed with varying shear moduli and loss tangents. This research uniquely investigates the combined effects of mechanical properties and biofunctionalization, by co-functionalizing the hydrogels with a mixture of arginine–glycine–aspartic acid (RGD) and a bone morphogenetic protein-2 (BMP-2) mimetic peptide. Our results demonstrated that the mechanical properties of hydrogels are a primary factor in driving differentiation, as biofunctionalization alone is not sufficient to induce bone cell differentiation. We have also designed a new topological type of synthetic polymer precursor for hydrogels based on norbornene-terminated PEG. Using PEG bis-dendrons, we have obtained a library of hydrogels via thiol-ene cross-linking with branched PEGthiol. This research uniquely investigates the combined effects of mechanical properties and biofunctionalization, by co-functionalizing the hydrogels with RGD peptides. Triple-negative breast cancer spheroids encapsulated in bioactive hydrogels with elasticity below 300 Pa successfully survived for at least 7 days in culture.

Adsorption of Oligosaccharides and Drugs on Double-stranded DNA for Drug Delivery Systems: A Molecular Dynamics Study

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Abstract

For the solubilization of hydrophobic drugs, a great interest in pharmaceutical applications is focused on complexes involving β-cyclodextrins (β-CDs) for their ability to encapsulate poorly soluble drugs, transport them, increasing their bioavailability. The transport and adsorption of drugs on double-stranded DNA are important aspects in cancer therapy. The adsorption process of drugs or drug carriers or both on the double-stranded DNA structure could represent an important aspect, an interesting challenge for molecular dynamics (MD) simulations at the atomistic level. In the present theoretical work based on molecular mechanic (MM) and MD methods, the adsorption of β-CDs and quercetin, a flavonoid drug important for its anti-inflammatory, antioxidant, and anticancer properties, on the double-stranded DNA structure is investigated. After MD simulations at room temperature, the adsorption process occurs due to the intermolecular van der Waals interactions between the included hydrophobic drugs and β-CD cavities. In addition, the H-bonds between β-CDs, drugs, and DNA structure stabilize the formed supramolecular complex. These theoretical simulations could be an interesting tool to better understand the intermolecular interactions between drugs, vectors and DNA for biomedical applications.

Novel Hydrogel-based Biochips for Highly Sensitive Multiplexed Bioassays

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Abstract

Protein quantification in cells and biofluids can provide important information on health status. Immunoassays have been widely used for protein detection, but conventional assays lack sensitivity and often require a relatively large number of samples which are not always available. In addition, the assay total time can be up to 24 h, leading to long turnaround time and delayed response. In this work, we have developed several highly sensitive and simple-to-implement platforms for simultaneous protein quantification from a small number of samples with rapid turnaround. We characterized the 3D structure of the hydrogels immobilized on a glass slide using different microscopy techniques such as a confocal microscope. The images showed the average height and diameter of the hydrogel droplets. Further, we integrated gold nanoparticles for metal enhanced fluorescence and optimized the nanoparticle size and concentration to achieve high fluorescent signals. Using several representative cancer-related markers, we demonstrated the application of these platforms in measuring complex biological samples.

On the Interphase in Amorphous Crystalline Polymers

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Abstract

Most polymeric materials exhibit some ordered regions, frequently recognized as crystallites and some disordered areas, defined as amorphous. This two-component picture for homopolymers was frequently used to define the degree of crystallization by various experimental methods such as differential scanning calorimetry (DSC), wide angle X-Ray scattering, fourier transform infrared, and Raman data. A critical review of phase transitions and phase composition in homopolymers, polymer blend and polymer-based nanocomposites is presented in detail. The presentation will reveal the benefits of a three component (phase) model for amorphous-crystalline polymers, where the third component is the interphase. The subtle deconvolution between interface and interphase is analyzed in detail. The extreme case of phase transitions will be briefly discussed. DSC data reveal the crystallization and glass transition on the cooling branch respectively the melting and glass transition on the heating branch. In most polymers, the local strains are not relaxed and consequently three heating-cooling cycles are necessary. The lowest temperature should represent the glass transition; the highest temperature should be greater than the melting temperature and an isothermal step should be included at both ends (lowest and highest temperatures). First cycle reflects the sample's status as the thermal analysis starts. The local strains should be eliminated during this step; the second cycle will reflect the DSC features of the sample with local strains relaxed. Third cycle should be identical to the second one, confirming the quality of experimental data. The effect of the interphase on the parameters derived from DSC data are discussed.

Design of a Quaternary Photocurable Resin for 3D Printing via Acrylate Integration into Epoxy/Thiol-ene Networks

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Abstract

A novel quaternary photocurable formulation has been developed for ambient-temperature 3D printing, leveraging the exothermic nature of acrylate polymerization to activate a hybrid epoxy/thiol-ene system (ETES). This system integrates an acrylate monomer with an epoxy resin, a multifunctional thiol, and a tetraallyl-functionalized ditertiary amine curing agent. While conventional ETES requires thermal activation at 85–95 °C, the inclusion of acrylates enables photoinitiated curing under milder conditions through a cascade of synergistic reactions: acrylate homopolymerization, thiol–acrylate and thiol–ene photopolymerizations, Michael-type additions involving thiolates and acrylate double bonds, and anionic epoxy ring-opening catalyzed by tertiary amines. To tailor the formulation for additive manufacturing, key parameters such as reactivity, heat release, and viscosity were systematically optimized. The resulting printed materials were characterized using differential scanning calorimetry, dynamic mechanical analysis, and thermogravimetric analysis, revealing distinct thermal and viscoelastic profiles. Compared to networks derived from pristine acrylates, the quaternary systems exhibited a moderated crosslink density, which translated into enhanced toughness and improved mechanical adaptability. This work underscores the potential of multi-component photopolymer systems to expand the design space of 3D-printable resins. By orchestrating orthogonal reaction path-

ways within a single formulation, it becomes possible to fine-tune network architecture and performance, paving the way for advanced applications in structural prototyping and functional materials.

Effective Removal of Microplastic Particles from Wastewater Using Hydrophobic Bio-substrates

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Abstract

The rapid increase in soil and water pollution is primarily attributed to anthropogenic factors, notably the mismanagement of post-consumer plastics on a global scale. This exploratory research design evaluated the effectiveness of natural hydrophobic cattail (Typha Latifolia) fibers (CFs) as bio-adsorbents of microplastic particles (MPPs) from wastewater. The study investigates how the composition of the adsorption environment affects the adsorption rate. Straightforward batch adsorption tests were conducted to evaluate the "spontaneous" sorption of MPPs onto CFs. Five MPP materials (Polyvinyl chloride, polypropylene, low-density polyethylene, high-density polyethylene, and nylon 6) were evaluated. Industrial wastewater (PW) and type II distilled water (DW) were employed as adsorption environments. The batch test results show that CFs are effective in removing five MPP materials from DW and PW. However, a higher removal percentage of MPPs was observed in PW, ranging from 89% to 100% for PVC, PP, LDPE, and HDPE, while the adsorption of nylon 6 increased to 29.9%, a removal increase of 50%. These findings indicate that hydrophobic interactions drive the "spontaneous and instantaneous" adsorption process and that adjusting the adsorption environment can effectively enhance the MPP removal rate. This research highlights the significant role that bio-substrates can play in mitigating environmental pollution, serving as efficient, sustainable, non-toxic, biodegradable, low-cost, and reliable adsorbents for the removal of MPPs from wastewaters.

Touch-spun 3D Scaffolds for Tissue Engineering and Cellular Agriculture: Progress and Prospects

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Abstract

The fabrication of advanced fiber scaffolds with adjustable structural characteristics is a crucial goal in modern tissue engineering. While conventional electrospinning methods are commonly used to produce randomly aligned nano- and microscale fibers, newer mechanical drawing techniques – such as touch-spinning and STEP (spinneret-based tunable engineered parameter) – enable the precise deposition of fiber arrays with specific diameters, interfiber spacing, and alignment. Since different cell cultures require distinct morphological features, mechanical fiber drawing allows for the customization of these features, which promotes efficient cell adhesion, differentiation, and migration across a variety of cell lines. This study aims to create advanced 3D microfiber scaffolds based on polycaprolactone and cellulose acetate, employing a modified touch-spinning apparatus and additive manufacturing technology. The research focuses on characterizing the morphology, arrangement, and crystallinity of the touch-spun fibers through scanning electron microscopy, atomic force microscopy, and X-ray diffraction analysis. We explore the potential of the materials produced for tissue engineering and cellular agriculture applications by culturing 3T3 green fluorescent protein fibroblasts and dicentrarchus labrax embryonic cells, respectively. Current data on long-term cell culture indicate that the 3D touch-spun scaffolds are effective in supporting cell growth, ultimately leading to dense tissue formation.

Copolymerization of Ethylene and 1,3-Butadiene through 1,4-Selective Insertion Using FI Catalysts: Synthesis of Metathesis Degradable Copolymers with Internal Olefins in the Main Chain That can be Converted into Telechelic Polyethylene

Tadashi Naito*, Ryohei Ogawa and Yusuke Mizobuchi

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Abstract

A novel quaternary photocurable formulation has been developed for ambient-temperature 3D printing, leveraging the exothermic nature of acrylate polymerization to activate a hybrid epoxy/thiol-ene system (ETES). This system integrates an acrylate monomer with an epoxy resin, a multifunctional thiol, and a tetraallyl-functionalized ditertiary amine curing agent. While conventional ETES requires thermal activation at 85 - 95 °C, the inclusion of acrylates enables photoinitiated curing under milder conditions through a cascade of synergistic reactions: acrylate homopolymerization, thiol–acrylate and thiol–ene photopolymerizations, Michael-type additions involving thiolates and acrylate double bonds, and anionic epoxy ring-opening catalyzed by tertiary amines. To tailor the formulation for additive manufacturing, key parameters such as reactivity, heat release, and viscosity were systematically optimized. The resulting printed materials were characterized using differential scanning calorimetry, dynamic mechanical analysis, and thermogravimetric analysis, revealing distinct thermal and viscoelastic profiles. Compared to networks derived from pristine acrylates, the quaternary systems exhibited a moderated crosslink density, which translated into enhanced toughness and improved mechanical adaptability. This work underscores the potential of multi-component photopolymer systems to expand the design space of 3D-printable resins. By orchestrating orthogonal reaction pathways within a single formulation, it becomes possible to fine-tune network architecture and performance, paving the way for advanced applications in structural prototyping and functional materials.

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