MICROPLASTICS SERVE AS A POTENTIAL VECTOR FOR NAPHTHALENE FROM THE FRESHWATER SYSTEM TO THE HUMAN GASTROINTESTINAL SYSTEM

FARHAD AVAZZADEH SAMANI

Microplastics (MP), plastic particles in range of 1nm to < 5 mm, are ubiquitous pollutants that have attracted much attention in recent years. MP have been identified in the atmosphere, soil, and aquatic environments across the globe. A main concern is that MP may act as vectors for transporting chemical contaminants, metals, antibiotics, and microorganisms from the environment to sensitive receptors such as humans. There is a paucity of information on the vector effects of MP for toxic persistent organic pollutants (POP) in freshwater systems.

Once released in the environment, MP are subjected to biodegradation, physical abrasion, and chemical oxidation, among other aging processes. These processes influence the sorption of POP onto MP. In the present study, three non-biodegradable materials, i.e., medium density polyethylene (MDPE), polystyrene (PS), and polypropylene (PP), were selected as model MP, and naphthalene, a carcinogenic polycyclic aromatic hydrocarbon (PAH), as model POP. Model MP were subjected to simulated environmental aging consisting of three cycles: dry and wet, wet freezing and heating, and dry freezing and heating. As a whole, these three cycles represent approximately one year of aging and samples were artificially aged to ten years of environmental exposure.

These aged samples were compared to pristine MP through surface morphology, particle size, Brunauer-Emmett-Teller (BET) surface areas, crystallinity, and functional groups. Notable differences in physicochemical characteristics were observed, e.g., BET surface areas of MDPE, PP, and PS MP increased by 131%, 19%, and 15% after aging, respectively.

In the next step of this study, the sorption behaviour of naphthalene onto MP was investigated with batch experiments in simulated freshwater. Preliminary results suggest that MP can sorb more than 80% of naphthalene in solution. The affinity of contaminants to sorb onto MP depends on the physical and chemical characteristics of sorbates and MP as well as the characteristics of the medium, including pH, salinity, ionic strength, dissolved organic matter, temperature, and aging.

MP taken up through incidental ingestion may release sorbed contaminants into gastrointestinal fluids. This soluble portion is considered bioaccessible. Given that MP can sorb naphthalene to various degrees and considering the ever-increasing presence of MP in freshwater systems, the characterization of bioaccessibility of naphthalene associated with MP was studied as a model compound. A modified physiologically based extraction test (PBET), which simulates the digestion of gastric and intestinal phases humans in vitro, was conducted on the naphthalene-loaded MP to measure the bioaccessible fraction of naphthalene in each digestive phase. These bioaccessibility measurements may be applied to the estimation of risks by comparing the bioaccessible dose with toxicity reference value (TRV) or tolerable daily intake (TDI). Finally, the effects of aging on the oral bioaccessibility of naphthalene were investigated. The overall bioaccessible doses were deemed to present carcinogenic risks in humans.

A NOVEL "SANDWICH" ASSAY FOR MULTIPLEXED DETECTION OF PROTEINS IN PHYSIOLOGICALLY RELEVANT MEDIA

SHAMIM AZIMI

In this work, we report a novel and efficient sensing method that integrates SERS (Surface-enhanced Raman Spectroscopy) with electrokinetic phenomena to overcome the diffusion-dominated transport and low detection sensitivity that plagues the performance of many molecular detection assays. Specifically, the phenomena of (i) electrothermal force and (ii) dielectrophoresis are employed to deterministically transport and capture, respectively, the target molecule from the bulk of the sample to the detection surface (SERS substrate). Moreover, we demonstrate that amplification of detection by orders of magnitude is accomplished electrokinetically by subsequently attracting and depositing a layer of silver (Ag) nanoparticles on the captured target molecule. Numerical simulations were carried out to study the effect of electrokinetic phenomena on the sensor performance. The results showed that applying an alternating current bias to the side electrodes could create rapid convective flow, accelerating the transport of target molecules to the electrode surface. The "sandwich" assay is demonstrated here for the label-free, ultrasensitive detection of creatinine and albumin, two critical kidney disease biomarkers in physiologically relevant media with low at low concentrations and reasonably reproducible signals. In this work, we demonstrate that this sensor technology is promising and reliable for rapid, sensitive, and real-time monitoring of biomolecules in physiologically relevant media such as blood, urine, and saliva.
Keywords: Particle trapping, Sandwich assay, AC electrokinetics, SERS, biological fluids, Sensors.

HYBRID NANOPARTICLE-NANOHOLE ARRAY SERS-ACTIVE NANOSTRUCTURES

YAZAN BDOUR

Nanophotonics have become the backbone of many sensing platforms through its usage in surface enhanced Raman spectroscopy (SERS) and surface plasmonic resonance (SPR) techniques. SERS exploits the concentration of electromagnetic fields generated from surface plasmons, which leads to a tremendous increase in Raman signal. Metallic nanostructures, such as nanohole arrays (NHA), are not only capable of generating highly sensitive, rapidly responsive, propagating SPR waves across the apertures, but can also be used to support SERS signals. Metallic nanoparticles (NPs) are widely used in biomedical applications for their SERS signal generation. In this research, highly rapid and sensitive SERS-active nanostructures are created from the combination of metallic flow-through nanohole arrays and metallic nanoparticles. The nanohole arrays are used to generate near-surface electrokinetic phenomena to suspend the metallic nanoparticles atop the apertures to produce SERS active hotspots. These hotspots are precisely controlled through the externally-applied voltage, without the need of tags or ligands to control the distance between the nanoparticles and the nanohole arrays to generate ultrasensitive SERS signal. The overall assembly combines nanoplasmonics, and optofluidics to create SERS-active nanostructure that yields over 10^4 magnitude Raman signal enhancement compared to their individual nanostructures.

CONFINMENT AND COMPLEX VISCOSITY

STEACY COOMBS

Whereas much is known about the complex viscosity of polymeric liquids, far less is understood about the behaviour of this material function when macromolecules are confined. By *confined*, we mean that the gap along the velocity gradient is small enough to reorient the polymers. We examine classical analytical solutions [Park and Fuller, *JNNFM*, **18**, 111 (1985)] for a confined rigid dumbbell suspension in small-amplitude oscillatory shear flow. We test these analytical solutions against the measured effects of confinement on both parts of the complex viscosity of a carbopol suspension and three polystyrene solutions.

ACCOUNTING FOR TEMPERATURE EFFECTS WHEN PREDICTING MOLECULAR WEIGHT AND COMPOSITION DISTRIBUTION FOR GAS-PHASE POLYETHYLENE PRODUCED USING A MULTI-SITE CATALYST

LAUREN GIBSON

A dynamic model is developed for gas-phase ethylene/1-hexene polymerization with a three-site hafnocene catalyst. The model accurately predicts molecular weight and comonomer composition distributions for fifteen lab-scale copolymerization runs performed at different temperatures. The experimental runs used to fit this model were performed at temperatures between 60 and 85 °C. Gas-phase concentrations were measured every 2.7 minutes throughout each run. Predicted chain-length distributions are discretized to aid model development, keeping the number of ordinary differential equations manageable. Kinetic parameters at the reference temperature of 81 °C and activation energies are estimated. Using parameter subset selection techniques, it is determined that 53 of the 60 model parameters should be estimated using the product characterization and reactor data. An additional data set obtained at 85 °C is used for model validation, confirming the predictive power of the model. The proposed model and its parameter estimates will aid selection of operating conditions to achieve targeted polymer properties.

SURFACE MODIFICATION OF GRAPHENE NANOPLATELETS AND THEIR APPLICATIONS

HARITHA HARIDAS

We use a simple surface coating technique to non-covalently functionalize graphene nanoplatelets (GNP) using trimellitic anhydride (TMA). Surface coating is achieved via mixing desired amount of TMA with GNP in a counter rotating batch mixer at a temperature of 250 ^{0}C, during a thermomechanical exfoliation process. Adsorption isotherms of TMA on GNP to prepare TMA-GNP revealed the optimum amounts of TMA between 2-4 wt.%. Addition of TMA resulted in a drop in the SSA compared to unmodified GNP, evidencing the adsorption of the TMA on the GNP surfaces. From contact angle measurements we found an increase in the surface energy of the TMA-GNP to 58 mJ/m^2 compared to the unmodified GNP (46 mJ/m^2) as well as increase in oxygen content from XPS analysis, which both suggests an improved ability to interact with solvents and polymers. Stability tests verified that TMA-GNP dispersions were stable for longer durations in toluene and xylene as compared to the unmodified GNPs, while TMA-GNP formed dispersions that were stable for months in water, in contrast to GNP which aggregated and settled out immediately. This facilitates the application of this electrically and thermally conductive material in polymer composites, and in functional fluids and ink formulations with wide applications in printed electronics and as supercapacitors, without the use of toxic, unscalable organic solvents. Finally, we studied the effect of the TMA modification on the dispersion state and morphology in polyamide/GNP composites and its outcomes on the mechanical, thermal and electrical properties.

NOVEL HUMAN TRIPLE NEGATIVE BREAST CANCER SUBTYPING METHOD USING ARCHETYPAL ANALYSIS

XINRAN LI

Triple negative breast cancers (TNBC) are considered an aggressive type of breast cancer. TNBCs are characterized by lacking estrogen receptor (ER) and progesterone receptor (PR) expression as well as human epidermal growth factor receptor 2 (HER2) amplification. Patients with TNBCs have low survival rates because they do not respond to hormone therapy or other available targeted agents.

Next-generation sequencing based molecular subtyping is a promising therapeutic approach. Subtyping classifies each patient based on omic (genomic, transcriptomic, etc.) measurements of the tumor. Patients in a subtype may respond well to certain drugs and not to others, making subtyping useful. Molecular subtyping for TNBC is still an active research topic, due to its potential benefits but also challenges. Recent studies show that depending on the data set and computational methods, the molecular subtypes for TNBC can vary considerably.

Clearly, there is a major need for proper molecular subtyping for better personalized treatment and prognosis prediction. In this study, archetypal analysis is applied to gene expression profiles of TNBC patients to identify tumor archetypes. Survival curves for both the proposed approach and the state-of-the-art consensus k-means clustering is generated using survival data, which is then used to investigate the improvement in prognostic discrimination.

A MODEL-FREE REINFORCEMENT LEARNING DESIGN TECHNIQUE VIA LIE-BRACKET AVERAGING FOR A CLASS OF NONLINEAR SYSTEMS

MARYAM MOHAMADI

In this study, we propose an extremum-seeking control via Lie-bracket averaging approach for the approximation of optimal control problems for a class of unknown nonlinear dynamical systems. This model-free approach, combines an extremum-seeking control (ESC) via Lie-bracket averaging approximation with a reinforcement learning (RL) strategy. The proposed learning approach tries to estimate the unknown value function and the corresponding optimal control policy, by using the Bellman equation and set-based leastsquares estimation, which avoids the dual parameterization of the actor-critic methodology for RL. The Lie bracket approximations for ESC is used to approximate the optimal state feedback controller, which provides a model-free approach to avoid the overparameterization of the system's dynamics and the 1 related increase in the estimation bias that happens in typical model-free AC methods. The proposed approach is shown to provide reasonable approximations of optimal control problems without the need for a parameterization of the nonlinear system's dynamics.

EPOXIDIZED CANOLA OIL COMPATIBILIZED PLA/PBAT BLENDS FOR 3D PRINTING

MOHAMED WAHBI

Poly (lactic acid) (PLA) is a biodegradable thermoplastic polymer and it's widely used in 3D printing. However, PLA has many shortcomings such as poor mechanical properties. In this work, a series of compositions containing 20 - 40 wt% of Poly (butylene adipate-co-terephthalate) (PBAT) dispersed in the PLA matrix and 5 phr of an epoxidized canola oil compatibilizer (ECO) has been prepared. The compatibilized PLA/PBAT/ECO blends were investigated using SEM to explore the effect of the epoxidized canola oil compatibilizer on the morphology of the PBAT dispersed phase. The mechanical, rheological, thermal, and crystallization properties of the compatibilized and neat PLA/PBAT blends were studied. SEM imaging showed that ECO can be an effective compatibilizer of PLA/PBAT blends as it reduced the size of the PBAT particles and improved the adhesion between PLA and PBAT phases. Furthermore, the mechanical analysis showed that using only 5 phr of ECO can increase the elongation at break and the impact strength of PLA/PBAT 80/20 by over 300% and 61.44%, respectively. The processability of these formulations during a material extrusion process, using a 3D bioplotter is investigated.

OVERLAY: AN AUTOMATED TOOLBOX FOR CONTEXT-SPECIFIC GENOME-SCALE MODELLING

HERBERT YAO

Gene expression data of cell cultures is commonly measured in biological and medical studies to understand cellular decision making in various conditions. Metabolism, affected but not solely determined by the expression, is much more difficult to measure experimentally. Thus, finding a reliable method to predict cell metabolism for given expression data will greatly benefit model-aided cell engineering studies including cellular production of chemicals, foods, and therapeutics.

We have developed such a pipeline that can unbiasedly explore cellular fluxomics from expression data, starting from only a high-quality genome-scale metabolic model. This is done through two main steps: first, construct a protein-constrained metabolic model by integrating protein and enzyme information into the metabolic model, which further constrains the network. Secondly, overlay the expression data onto the modified model using a new two-step nonconvex and convex optimization formulation, resulting in context-specific models with optionally calibrated rate constants. The resulting model computes proteomes and

intracellular flux states that are consistent with the measured transcriptomes. Therefore, it provides detailed cellular insights that are difficult to glean individually from the omics data or metabolic models alone.

As a case study, we apply the pipeline to interpret triacylglycerol overproduction by *Chlamydomonas reinhardtii*, using time-course RNA-Seq data. The pipeline allows us to compute *C. reinhardtii* metabolism under nitrogen-deprivation and metabolic shifts after an acetate boost. We also suggest a list of possible 'bottlenecking' proteins that need to be overexpressed to increase TAG accumulation rate, as well as other TAG-overproduction strategies. The code is available open source with detailed documentation and is expected to aid cell engineering by providing intracellular metabolic insights for any measured transcriptome.