Editorial

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Developments in Polymer Science and Engineering

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Introduction

Creating new hybrid materials able to satisfy multiple performance constraints in engineering, biomedical, and consumer product applications requires novel synthetic strategies [1]. Polymer composites, or nanocomposites, composed of natural or synthetic polymers and natural or synthetic siliceous sources, including clays, have been targeted as promising materials during the last decade [1]. The grand challenges of the 21st century require new and sustainable approaches to polymer materials development. Polymers are molecules that contain many atoms, typically tens of thousands to millions [2]. While many polymers occur naturally as products of biological processes, synthetic polymers are made by chemical processes that combine many small units, called monomers, together in chains, branched chains, or more complicated geometries [2]. Starch, cellulose, proteins, and DNA are examples of natural polymers, while nylon, teflon, and polyethylene are examples of the synthetic variety [3]. The rapid pace of advances in polymers, which has led to their present pervasive use, has been remarkable [2]. Synthetic polymers are so well integrated into the fabric of society that we take little notice of our dependence on them. Society benefits across the board—in health, medicine, clothing, transportation, housing, defense, energy, electronics, employment, and trade [2].

Our perspectives towards polymer research are two folds:

- Polymer Synthesis and Characterization and
- Commercialization.

Polymer Synthesis and Characterization

Our focus in this editorial is to highlight the current new emerging fascinating synthesis and characterization in the field of polymer science. Typically, polymers are made from small molecules called monomers. There are mainly two polymerization techniques to synthesize polymers from monomers: Free radical and Condensation. In addition to those polymerization techniques, there have been great opportunities in modifying polymers via reactive groups for critical application like polymerizable surfactants. Such surfactants have found its application in developing in-situ biopolymer mesoporous composites [1,4-8].

Understanding the structure property relationship of the polymers and/or polymer composites is important to find its application area. Several characterization techniques such as dynamic light scattering, dynamic thermal analysis, dynamic mechanical analysis, dielectric spectroscopy have been the useful tool to determine the mechanical, electrical, etc. properties of polymers/composites. In last decade, solid-state Nuclear Magnetic Resonance (ssNMR) has been seen as the new emerging characterization technique that helps in understanding the molecular dynamics of the polymer at the molecular level to understand the structure property relationship of the polymer at particular conditions such as high strain rates etc. For instance, in the phase mixed polymers like polyurethane urea (that possess hard and soft segments), ssNMR is potentially able to provide a unique perspective to the broad glass transitions in that it could stay at a given temperature indefinitely and measure the participating populations and their dynamical states at this temperature [9-11]. This is unlike DSC, DMA, or DES, which must continuously scan through the entire temperature (or frequency) window. By taking successive NMR measurements at each temperature step, the broad transition can then be dissected to slices or subpopulations, with each slice having its own Tg [9,10,12]. This would provide a unique and in-depth understanding of the transition mechanisms. ssNMR has been helpful not only to elucidate the monomer sequencing of the complex gradient polymers but also in industry process and quality control for large scale production [13,14].

Commercialization

Scientific understanding is now replacing empiricism, and polymeric materials can be designed on the molecular scale to meet the ever more demanding needs of advanced technology [2,3]. Polymers research has been producing polymers to meet the day to day activities of human beings. Although the growth of polymer science in the last few decades is remarkable there is still a need in finding solutions to the problem in the technology areas listed below. Continual improvement in the polymer chemistry with a possibility of ease of commercialization and the characterization techniques; we expect to see the growth in polymer research that leads to successful commercialization of the product targeting the technology areas listed below [2]:

Energy [2]: Polymers play an important role to shift to alternate fuels and energy sources. New polymeric materials enable the development of batteries and fuel cells with significantly enhanced energy output and durability. Lessening dependence upon fossil fuels will have a positive impact on the environment.

Sustainability [2]: Polymers and complex polymer composites offer the potential to develop cheap, lightweight, and easy-to-process structural materials. Scientific polymer innovations will lead to the development of more "green" materials, decrease our reliance on petroleum-based products, and minimize the impact of manufactured goods on the environment. Polymer science holds the key to finding alternative sources of raw materials and new methods of materials production that can continue technological progress, foster economic competitiveness, and have minimal impact on the environment.

Health care [2]: Polymer science and technology have contributed to transformative technological changes in healthcare through the development of artificial heart valves, contact lenses, and dental composites. Even with these advances, the full potential impact of polymers has not been realized. New advances in drug design and delivery, systems biology, nano-medicine, genomics, and control of cell differentiation and behavior ensure that the potential of polymer science and technology to improve health care is stronger than ever.

Low VOC resins [2]: Large portion of conventional commercial structural adhesives and coatings derived from resins consist of volatile organic compounds (VOC), which are often dangerous to human health and cause harm to the environment. In addition to human health concerns, VOCs also react with sunlight to create the air pollutant ozone, which can significantly reduce lung function, induce respiratory inflammation, and cause irreparable harm to agricultural crops and forest ecosystems. In response to the dangers posed by VOCs, many governments have imposed regulations requiring the use of low or zero VOC adhesives, necessitating the creation of new, environmentally-friendly adhesives. However, many of the low-VOC adhesives and coatings previously developed are still petroleum-based, and are therefore still somewhat toxic. Additionally, the synthesis of low-VOC adhesives and coatings has proved to be complicated, time consuming, and expensive. As VOC regulations become stringent over the years the need to shift from solvent borne coatings to water borne is inevitable. Therefore, waterborne technologies that uses bio-derived monomers or and/or biocompatible/biodegradable polymers have a tremendous growth in coatings sector which will help in reducing VOC level and maintain the healthier environment for living beings [2,15,16].

Summary

In summary, while continuing the position of associate editor of Polymer Sciences we expect to see the new emerging polymer research that leads to successful commercialization of the product targeting the aforementioned technology areas without compromising the ecosystem.

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