Harnessing disorder in self-assembled block polymers for functional nanostructured materials

Self-assembled block polymers containing functional macromolecular components are versatile precursors to useful nanostructured materials. An interesting morphology used to generate nanostructured soft materials in this way is the double gyroid. The gyroid phase has the attractive feature of being bicontinuous and thus nanostructure orientation is not needed to achieve domain continuity while retaining a supporting mechanical phase. These features can be particularly useful for numerous membrane-based applications such as in ultrafiltration, photovoltaics, and polymeric electrolytes. While we have been able to access the bicontinuous double gyroid phase in, for example, polystyrene-block-polylactide copolymers, etching those structures results in nanoporous materials that are not mechanically robust. Moreover, the gyroid structure can only be accessed over a small slice of composition in the diblock copolymer morphology map. Thus, we have worked to access block polymer nanostructures that are bicontinuous and mechanically robust but that do not necessitate the formation of the gyroid or other related ordered morphologies. I will discuss our recent approaches to nanostructured, bicontinuous disordered morphologies through either thermal or light-induced chemical fixation of block polymers in the disordered state in close proximity to the order-disorder transition. This will include our recent work on (i) how we use the in situ and controlled formation of crosslinked block polymers to trap an emerging disordered state and (ii) how we use the thermally accessible order-disorder transition to decouple the formation of a disordered phase and chemical fixation. In both cases, composition fluctuations in disordered block polymers can be trapped. In the examples where one of the blocks is chemically etchable (e.g., polylactide), nanoporous polymers with narrow pore size distributions can be generated and utilized as, for example, ultrafiltration membranes for water purification. I will focus on the preparation, characterization and applications of this interesting class of nanostructured materials.

Marc A. Hillmyer

University of Minnesota, Department of Chemistry

McKnight Presidential Endowed Chair, University of Minnesota
Director, Center for Sustainable Polymers
Editor-in-Chief, Macromolecules

Biosketch:

Marc Hillmyer received his B.S. in Chemistry from the University of Florida in 1989 and his Ph.D. in Chemistry from the California Institute of Technology in 1994. After completing a postdoctoral research position in the University of Minnesota's Department of Chemical Engineering and Materials Science he joined the Chemistry faculty at Minnesota in 1997. He is currently the McKnight Presidential Endowed Chair in Chemistry and leads a research group focused on the synthesis and self-assembly of multifunctional polymers. In addition to his teaching and research responsibilities, Marc served as an associate editor for the ACS journal Macromolecules from 2008-2017 and is currently the editor-in-chief of Macromolecules. He is also the director of the Center for Sustainable Polymers headquartered at the University of Minnesota, a National Science Foundation Center for Chemical Innovation.