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EDITORIAL

Charge transporting nanostructured polymers for electrochemical systems - a themed collection

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Nanostructure-forming charge transporting polymers have the potential to enable new electrochemical systems for electrical energy storage and water purification. For example, block copolymers spontaneously self-assemble into nanoscale domains wherein one domain transports ions while the other domain imparts mechanical strength. Such materials can be used to build all-solid rechargeable batteries. Moreover, block copolymers can be designed to have one ion-conductive phase while the other phase is electronically conductive, which can serve as binder materials to enable reversible redox reactions in electrodes. Nanostructured polymeric materials provide a platform for engineering multi-functionality; separate domains can be employed to perform different tasks such within the materials. In this themed collection, we showcase cutting-edge research and perspectives on the design and development of nanostructured polymers for controlling the transporting both charged species such as ions as well as neutral species such as water.

The articles in this themed collection brings together researchers with expertise in synthesis, characterization, and theory. Hall and Epps emphasize the synergy between experimental and computational approaches to facilitate material design and synthesis of lithium-ion transporting block copolymers (DOI: 10.1039/C8ME00105G). A common thread seen in multiple articles are how nanoscale structure and nanoconfinement controls charge transport. Winey's perspective article emphasize the importance of precision polymer synthesis and the formation of nanoscale layers on promoting ion transport (DOI: 10.1039/C8ME00086G). Park's perspective article showcases the intimate connection between transport and confinement effects through end-group chemistry, precise sequencing of ions, single-ion transport, and crystalline ion channels (DOI: 10.1039/C8ME00117K). By leveraging block copolymer lithography, Arges, Nealey and Kumar investigate the relationship between nanoconfinement and counterion condensation in polyelectrolyte brushes (DOI: 10.1039/C8ME00081F). Balsara's article highlights the anisotropic nature of ion diffusion across a disorder-to-order phase transition of nanostructured block copolymer electrolytes composed of organic and inorganic moieties (DOI: 10.1039/C8ME00077H). Verduzco's work on capacitive de-ionization effects reveals trade-offs in water uptake, salt permeability, morphology, and performance in sulfonated pentablock copolymer membranes (DOI: 10.1039/C8ME00115D). While the focus so far has been on polymers, Kato studies nanoscale self-assembly of liquid crystalline anilinium salts, and the challenging task of achieving one-dimensional thermal switching behavior of ion conductivity (DOI: 10.1039/C8ME00099A).

The contributions in the themed collection highlights polymeric ionic liquids (PILs) as an emerging class of charge transporting polymers. The perspective article from Zhang and Armand, which covers the wide landscape of ionic-liquid-like moieties

and polymeric architectures, emphasizes the versatility of PILs as electrolytes and binders for Li-based batteries (DOI: 10.1039/C8ME00103K). Segalman's perspective describes the inter- and intra-molecular interactions that control multivalent transport in PILs, highlighting the need for further synthetic and computational approaches to fully realize the potential of these systems (DOI: 10.1039/C8ME00096D). The perspective from Ganesan summarizes key developments and open questions on understanding ion transport mechanisms in PILs (DOI: 10.1039/C8ME00114F). The research article from Evans on crosslinked network PILS reveals odd-even effects on the glass transition temperature, ionic conductivity, and dynamic fragility (DOI: 10.1039/C8ME00087E).

We are heartened to see contributions focusing on electronic transport in polymers. The review article from Luscombe summarizes the effect of morphology on the mixed electronic and ionic conduction performance of polymers (DOI: 10.1039/C8ME00093J). Seki's research article showcases their work on π -conjugated two-dimensional polymers where the imine linker position controls optoelectronic performance (DOI: 10.1039/C8ME00079D).

By design, this themed collection emphasizes fundamental understanding rather than device performance and optimization. We thank the authors, the students, post-docs and principal investigators, for their contributions. We hope readers enjoy reading these articles as much as we have.

Biographical Sketches



Shrayesh N. Patel is currently an assistant professor in the Institute for Molecular Engineering at The University of Chicago, and holds a joint appointment at Argonne National Laboratory. Previously, he was a postdoctoral research scientist at the University of California, Santa Barbara in the Materials Research Laboratory and received his PhD in Chemical Engineering at the University of California, Berkeley. Prof. Patel's research resides at the intersections of polymer science, ion transporting materials, organic electronic materials, and electrochemistry.



Nitash P. Balsara is a chemical engineer with a bachelor's degree from the Indian Institute of Technology (IIT) in Kanpur, India, in 1982, a master's degree from Clarkson University in Potsdam, NY, in 1984, a Ph.D. from Rensselaer Polytechnic Institute (RPI) in Troy, NY, in 1988. He did postdoctoral research at the University of Minnesota in Minneapolis, followed by a second postdoc at Exxon Research and Engineering Company in Annandale, NJ. In 1992, he joined the faculty of Department of Chemical Engineering at Polytechnic University in Brooklyn, NY. In 2000, he joined the faculty at the Department of Chemical Engineering at the University of California, Berkeley, and Lawrence Berkeley National Laboratory as a faculty scientist. He has managed to hang on to both jobs. His work on salt-containing polymers is inspired by his colleague and mentor at Berkeley, Professor John Newman. He cofounded two start-ups, Seeo and Blue Current.