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Editorial: Editors' showcase 2023: polymers

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Editorial on the Research Topic
Editors' showcase 2023: polymers

Polymer science, a most colorful petal of the soft-matter flower, and certainly its economically most relevant subdiscipline, is at the core of the current challenges of humankind. Both the growing plastic pollution and climate change can be addressed by modern polymer materials being more sustainable and having wider functionality (Saalwächter, 2022). It is thus a great pleasure for me to present our most recent Editor's showcase of the section Polymers of Frontiers in Soft Matter, which features 7 articles that highlight the research scope and the dedication of the editors of our young journal to serve our society with innovative methods and developments, so as to address the pressing questions.

The development of new polymer materials is tightly linked to their in-depth characterization, allowing us to explore fundmental structure-dynamics-property correlations and thus to move forward in a targeted rather than trial-and-error way. In this vein, our current Showcase focuses on physical characterization techniques capable of revealing information that was not routinely accessible in the past. All contributions highlight how such enhanced understanding sheds new light on our ability to design better materials in the long run.

Semicrystallinity

For polymer materials that are often used in packaging and construction applications, one of the most relevant phenomena alongside the glass transition is their ability to crystallize partially, with a degree that is dependent on the chemical microstructure and on their thermal treatment. Tuning crystallinity thus enables one to realize a broad range of materials properties from rubber-elastic to stiff on the basis of a much smaller set of chemical structures. This will ultimately enable more sustainability by better recycling.

To aid such ends, Pérez-Camargo, Cavallo and Müller have undertaken a team effort to assemble a most comprehensive review of the last decade's applications of the successive self-nucleation and annealing (SSA) technique (Pérez-Camargo et al.), which can be applied on standard differential scanning calorimetry (DSC) instruments. This increasingly popular technique was conceived by Müller et al. (1997) and allows one to characterize the molecular heterogeneity, both inter- and intra-molecularly, in crystallizable (co) polymers. In this way, the interplay of chain regularity and crystallization is revealed,

providing a rational basis of the tuning of crystallinity by variations in the main-chain structure or the polydispersity.

DSC has also been used by Urciuoli et al. to study the isothermal crystallization kinetics of ethylene/1-octene multiblock copolymers. These systems, prepared by novel chain-shuttling catalysis, feature segmented chains with alternating crystalline and amorphous soft blocks, thus greatly expanding the application range of such poly (ethylene)-related materials. A more specific route to manipulate the crystallinity is explored by Wang et al. looking at syndiotactic polystyrene and selected styrene-substituted derivatives. The phenomenon of solvent-induced crystallization is studied by X-ray diffraction and IR spectroscopy, clarifying the role of small amounts of solvents, which may act either as plasticizers or may be accommodated as guest molecules in special polymorphs, the latter mediated by their interactions with the substituted phenyl rings.

Advanced methodologies

The works presented so far rely on standard laboratory equipment available to many polymers-science laboratories. Sometimes, however, a wider set of observables makes it worthwhile considering the application of more specialized equipment provided only in selected labs or even large-scale facilities. Along this line, Falus et al. use neutron-spin echo spectroscopy (NSE) to reveal functional dynamics in PEO-based model polymer electrolytes for lithium ions. Detailed insights into the ionic conduction mechanism are relevant for the development of more efficient separator membranes in batteries. Specifically, intermediate-range and extended-range ordering of the PEO chains around the lithium ions (IRO and ERO, respectively), the latter including neighboring chains, and their changes with time, are studied. With the lifetime of these ordered structures measured by NSE, accessing the lithium dynamics via isotope dilution, it is found that IRO and ERO are strongly correlated, have the same T dependence, and are directly correlated to lithium diffusion.

Moving to a more applied field, Tsapatsaris et al. showcases the application of X-ray photon correlation spectroscopy (XPCS) to elucidate the curing kinetics in epoxy adhesives through the sensing of local dynamics using silica nanofiller particles as probes. The authors highlight the significant advantages over conventional dielectric spectroscopy and rheology, owing to the sensitivity of their technique to ongoing processes even after full solidification. Sticking with X-rays, a unique hyphenation of synchrotron small-angle X-ray scattering (SAXS) with a microscale extrusion device (as it is used in 3D printing by fused-deposition modeling) is used in the work of Bomediano et al. focusing on pluronic-based cross-linkable hydrogels with a potential for biomedical applications. Their *in-operando* analysis of the 3D printing process including photo-crosslinking reveals the influence of the various printing parameters on the ordering of the micellar packing.

Finally, Säckel et al. has for the first time applied an unconventional variant of nuclear magnetic resonance (NMR) spectroscopy, namely, deuteron (^{2}H) fast field-cycling T_1 relaxometry, to reveal the existence of water species with distinct dynamics in "smart" hydrogels made of poly(N-isopropyl acrylamide). Above its critical solution temperature, the study reveals the emergence of a slowed-down water fraction associated with collapsed polymer being in fast exchange with the bulk-like water. Such information may be relevant for the optimization of materials parameters such as the actuation time of such responsive gels. I hope that the readers share my enthusiasm about the new avenues for polymer characterization highlighted in our Editor's Showcase 2023!

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