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The Development of novel polymers: using in situ/operando neutron reflectometry to unveil structure-function relationships

Neutron has many extraordinary properties, e.g., highly penetrating, particularly sensitive to light elements like hydrogen and carbon, power of polarization and magnetic moment. All these characteristics make neutrons excellent probes of materials, providing details about the structure and motion of atoms that cannot be easily obtained with other research techniques. Neutron reflectometry (NR), a neutron scattering technique, is a powerful tool to investigate surface and interfacial structures of thin films in a non-destructive and non-invasive fashion. The Liquids Reflectometer (LR) at the Spallation Neutron Source at Oak Ridge National Laboratory measures specular neutron reflectivity in a horizontal sample geometry, and tracks changes of layer thickness, scattering length density, and roughness as a function of depth. LR provides valuable information over a wide variety of scientific and technological applications, such as, interfacial reactions in energy conversion and storage materials, phase separation in polymer films, surfactants at interfaces, protein adsorption, biological membranes in intermolecular interaction, and so on. The exceptional sample environment at LR offers the capability to conduct in situ electrochemistry to probe the morphological and structural changes at the solid/liquid interfaces during operation as a function of chemical and electrochemical gradients over time. Furthermore, event mode data collection at LR can be carried out continuously over a reduced Q range and binned into 60-second (or even shorter) intervals. The improved time resolution of the NR measurement can help elucidate the kinetic behavior of surface/interfaces under dynamic conditions and bring a unique perspective to equilibrium studies. Two specific examples of applications in novel polymer development by using in situ/operando NR will be presented. The example studies shed light on fundamental understanding of the structure-function relationships of the polymers. NR plays a key role in creating new, and more efficient polymer systems through rational design of the structure and operating conditions.

Topical Area

Soft matter: polymers, and complex fluids

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