Small-angle neutron scattering on materials based on semicrystalline polymers

Aurel Radulescu
Jülich Centre for Neutron Science, Forschungszentrum Jülich GmbH, 85748 Garching, Germany

Materials based on semicrystalline polymers are used in different fields of applications, from high temperature to plastics, elastomers and fibers, from biomedicine to aerospace, from oil industry to fuel cells. Such materials exhibit a hierarchical morphology in solution and melt, as bulk or film, with structures ranging from nanometre to millimetre scale. A much more complex morphology occurs when semicrystalline polymers are combined with other types of polymers such as amorphous, stimuli-responsive, etc., in different geometries and architectures. Understanding the correlation between the microstructure and the macroscopic properties of such complex systems in different conditions is essential for the optimization of their applicability and the development of new materials.

Small-angle neutron scattering technique plays an important role in resolving the complex morphology of such hydrocarbon systems over a wide length scale. As unique probe, neutrons offer the advantage of different interactions between the ^{1}H and ^{2}H (deuterium, D) hydrogen isotopes. The large difference in the coherent scattering length density between hydrogen and deuterium represents the basis of the contrast variation and contrast matching methods. With this technique, selected constituents in a complex system can be labeled by isotope exchange and be made visible or invisible in the scattering experiment without chemically altering the system. Combining classical pinhole, focusing (with lenses or mirrors), and time-of-flight (with chopper) methods, while simultaneously providing high-neutron intensities delivered by modern neutron sources combined with the possibility of a tunable resolution, modern SANS diffractometers enable the investigation of soft matter systems from nm to μm length scale.

Application of SANS techniques in the study of structure and morphology of some semicrystalline polymers and semicrystalline-amorphous copolymers relevant for energy applications will be presented.