Visualization of polyolefin interface by small-angle neutron scattering

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As the importance of carbon neutrality grows, several initiatives in polymer materials are being pursued, including using biomass as a raw material, chemical recycling to convert used materials back into monomers, and material recycling that preserves the polymer's molecular structure (Figure 1). Among polymers, polyolefins (PO) are especially significant due to their large production volume. Polyethylene (PE) and polypropylene (PP), both key POs, make up about 47% of domestic plastic production (Source: Plastic Industry Federation 2021 Statistics).

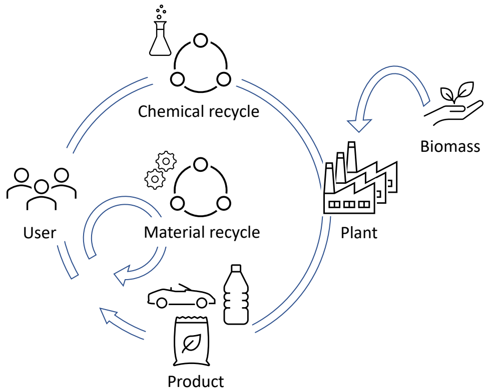

Figure 1. Conceptual diagram of carbon neutrality in polymer materials such as material recycling.

For achieving carbon neutrality in POs, material recycling is crucial since it can be implemented using general-purpose facilities suited for mass production. This involves collecting, grinding, and melt-kneading post-use plastics, but several technical issues remain. One major challenge is the difficulty in sorting different plastics, leading to the unavoidable coexistence of immiscible polymers, which significantly degrade the physical properties of recycled materials. This issue is compounded when inorganic substances such as glass and talc, or carbon fibers are present.

This study aims to visualize the PO/different material interface, which is critical for PO recycling, using a new contrast method. Modified PO, which stabilizes this interface, is important as a compatibilizer, but its structure at these interfaces is difficult to observe due to insufficient contrast. To address this, we used deuterated paraffinic mineral oil (d-MO), which has the same solubility as PE, instead of PE, to observe the interface structure formed by modified PO using contrast-variated small-angle neutron scattering (SANS). Although paraffinic mineral oils were previously considered unsuitable for deuteration, our team successfully achieved this (Polymer Chemistry, 2020). This d-MO enables us to realize a method to visualize the interface structure formed by modified PO under conditions equivalent to molten PE. By changing the ratio of d-MO to normal mineral oil (h-MO), the scattering profiles were effectively changed as shown in Figure 2; It was verified that this method can effectively evaluate interfacial structures.

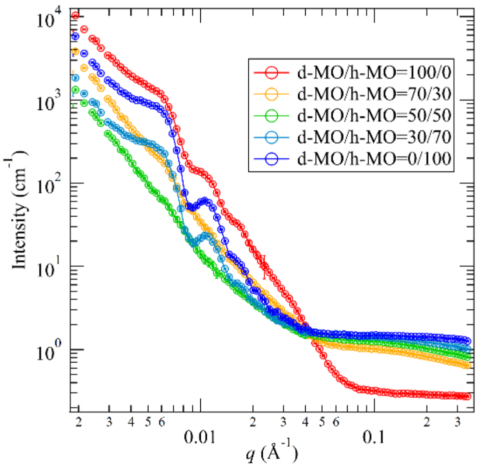

Figure 2. SANS profiles obtained by changing the ratio of d-MO/h-MO.

We will proceed with detailed analysis of the obtained data. Future work will involve exploring the effects of temperature and concentration and extending the method to systems where silica particles are coated with polymers such as polyamide or ethylene vinyl alcohol copolymer, or replaced by aluminum particles. These studies aim to clarify the structure of modified PO at various interfaces and provide guidelines for designing new compatibilizers.