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Structural properties of elastomer thin films bound to model filler interfaces

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The interfaces between polymers and inorganic materials are of pivotal academic and industrial interest. An example of this is the interface in nanocomposites, a class of materials composed of polymers (matrix) and inorganic nanoscale powders (fillers). In general, the performance of a nanocomposite strongly depends not only on the physical properties of the matrix but also on the interaction between the matrix and the filler material. It is noteworthy that the physical response of a composite can be modulated via the interactions resulting from the attachment/detachment of polymers to the fillers. This means that an understanding of the interfaces between the polymer matrix and inorganic fillers is essential to construct highly functionalized nanocomposites.

A specific example is tire materials; because the rubber used for tires consists mainly of a polymer elastomer matrix and carbon/silica fillers, an understanding of the interface between the polymer and the filler is important for improving quality. In the case of a carbon filler, a nanometer-thick layer called the bound rubber layer (BRL), is typically formed on the carbon surface and is resistant to be dissolved even in a good solvent. In theory, the interactions between polymers and carbon material surfaces restrict molecular motion, which correlates with increased resistance to mechanical deformation compared to free polymers that are located away from carbon material surfaces.

Significant effort has been made in industry to manufacture high-performance tires using surface-modified fillers. Since the structure and/or thermal molecular motion of polymers at the filler/polymer interface is affected by the interactions with the fillers, it is believed that surface modification changes the properties of the BRL, resulting in an improvement in the tire's performance. However, this is still hypothetical, because there is insufficient evidence and empirical data, e.g., on the influence of surface modification on the BRL. The relationship between the BRL and tire performance needs to be evaluated to develop guiding principles for improving tire performance. Although the number of reports on the general BRL framework is increasing, it is still unclear how the surface modification of fillers affects the structural and mechanical properties of BRLs.

In this study, we have investigated the distribution of rubber polymer on model filler surfaces (carbon or silica) using neutron reflectometry (NR) at SOFIA reflectometer in J-PARC. The experimental results show that the heterogeneous distribution of rubber polymer near the carbon surface depending on the surface energy. Additionally, we investigated the distribution change depending on the kind of coupling agent at the silica surface.

Topic

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