Study on vulcanization reaction of synthetic rubbers and new design for eco-friendly rubber materials

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Nowadays, emulsion-polymerized styrene-butadiene rubber (SBR) is the most widely used among general-purpose grade synthetic rubbers [1]. Its major usage is in pneumatic tire treads, especially those for passenger cars. Rubber materials generally become useful by cross-linking reactions to afford a network structure. Therefore, a study on characteristics of cross-linking reaction for SBR becomes important in order to produce an eco-friendly tire. Among the network formations, a cross-linking reaction by sulfur (vulcanization) is the most traditional and popular chemical process in polymer industries [2]. However, the mechanism of vulcanization has not been conclusively clarified yet, due to complicated chemical reactions. In this study, structural characteristics of sulfur cross-linking reaction of emulsion-polymerized SBR are investigated by small-angle neutron scattering (SANS).

Sulfur cross-linked SBR (S-SBR) samples were prepared by conventional milling with cross-linking reagents and heat-pressing at 160 °C. SANS experiments were carried out at SANS-U (C1-2), JRR3M in JAEA (Tokai). The wavelength was 7 angstrom. The sample-to-detector distances were 1.00 and 8.00 m. Swollen samples in deuterated (D-) toluene were subjected to the SANS measurements.

The following conclusions were obtained: (1) When sulfur and accelerator were increased under the receipt of 2 parts per hundred rubbers by weight (phr) of stearic acid and 1 phr of ZnO, the reaction progressed to result in the decrease of both the size of network domains and the mesh size of the rubbery matrix as shown in Fig.1. (2) The small mesh in the SBR matrix restricted a variation of the size of swollen network domains regardless of the progress of sulfur cross-linking reaction in the domains. (3) ZnO combined with sulfur and accelerator was found to form the rigid network domains. These considerations were in good agreements with results of X-ray absorption fine structure spectroscopy, deferential scanning calorimetry and infrared spectroscopy.

References

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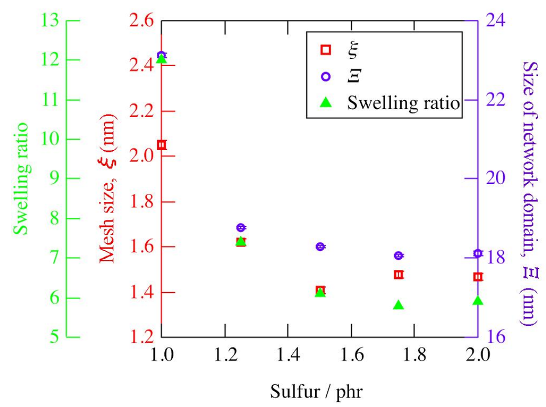

Fig. 1. Effect of sulfur content on the mesh size and the size of network domain of S-SBR samples.