

## Studies on Structural Nonuniformity of Natural Rubber

M. Shibayama(A), T. Suzuki(A), N. Oosaka(A), H. Endo(A), N. Higashitani(B),  
Y. Morita(B), Y. Kokubo(B), Y. Ikeda(B), and S. Kohjiya(C)

(A)ISSP-NSL, Univ. Tokyo, (B)Grad. Sch. Sci. Technol., Kyoto Inst. Tech.,  
(C)Fac. Sci., Mahidol Univ.

Crosslinked rubbers are one group of the traditional soft matters. It is well known that the crosslinked rubber has nonuniformity in its microstructure. However, this network nonuniformity has not been sufficiently elucidated due to the complexity of the composition and the complex preparatory processes. The goal of the study is an elucidation of nonuniformity of crosslinked natural rubber (NR). An upturn scattering was detected in SANS profiles of crosslinked and uncrosslinked NR, which were ascribed to the non-rubber components in NR [1]. Thus, a model research using a synthetic analogue of NR becomes necessary. In this study, the microscopic structure of peroxide-crosslinked and sulfur-crosslinked isoprene rubber (abbreviated as P-IR and S-IR, respectively) is investigated by SANS.

P-IR and S-IR were prepared by milling with crosslinking reagents and heat-pressed for curing at 155 °C and 140 °C, respectively. SANS experiments were carried out at SANS-U (C1-2), JRR3M in JAEA (Tokai). The wavelength was 7 Å. The sample-to-detector distances were 2.00 and 8.00 m. The scattered intensity was collected with an area detector and then circularly averaged. Swollen samples in deuterated (D-) toluene were subjected to SANS measurements.

The following conclusions were obtained: (i) In both samples, the inhomogeneity in their network structures was detected, which was speculated to be due to the presence of poor and rich phases of crosslinking sites. (ii) The scattering curves of swollen P-IR and S-IR in D-toluene were successfully reproduced by the Squared-Lorentz and Lorentz functions. (iii) The mesh size ( $\xi$ ) and the scale of inhomogeneity as-

cribed to the rich phase ( $\Xi$ ) in P-IR were decreased and increased, respectively, by the increase of network-chain density ( $\nu$ ) as shown in Fig.1. (iv) For S-IR,  $\nu$  was almost constant regardless of the amounts of sulfur and accelerator, whereas  $\xi$  increased with the increase of these amounts when definite amounts of stearic acid and ZnO were mixed. (v) The increase of ZnO resulted in the decrease of  $\xi$  and  $\Xi$ . The obtained results will be useful for a more systematic material design of future rubber products.

### Reference

- [1] T. Karino et al., Biomacromolecules, 8, 693(2007).

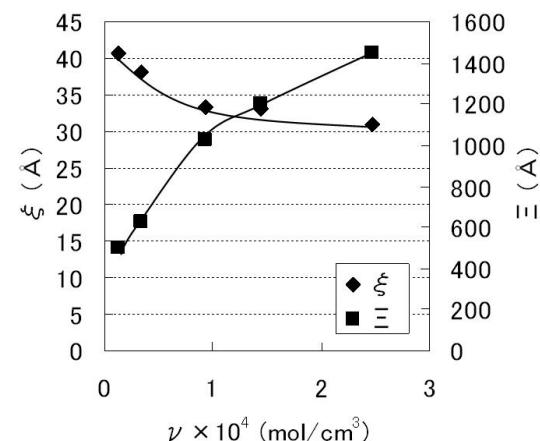


Fig. 1. Fig.1  $\nu$  dependence of  $\xi$  and  $\Xi$  for P-IR.  
The lines are guides for eyes.