Temperature-Dependent Crystallization Behavior of Natural Rubber during Stretching Studied by In-situ WAXS

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Natural rubber is known to undergo strain-induced crystallization (SIC) during stretching. As shown in Figure 1, comparing the two-dimensional WAXS patterns before deformation and at approximately 400% strain reveals the appearance of crystalline reflections, indicating the progress of crystallization. Although SIC is strongly affected by temperature, its detailed temperature dependence remains insufficiently clarified.
In this study, we investigated the temperature dependence of crystallization behavior during stretching of natural rubber using in-situ wide-angle X-ray scattering (WAXS). Measurements were conducted with a Rigaku DicifferX system combined with a Linkam MFS tensile stage, enabling simultaneous control of temperature and strain. Samples were stretched at a constant rate while two-dimensional WAXS patterns were continuously recorded. From these data, we analyzed the onset of crystalline reflections and evaluated how the strain required for crystallization varies with temperature.
The results provide key insights into the temperature-dependent kinetics governing SIC. This study deepens the understanding of SIC in the structural design of rubber materials and demonstrates the effectiveness of in-situ WAXS for monitoring dynamic crystallization processes under coupled thermal and mechanical fields.

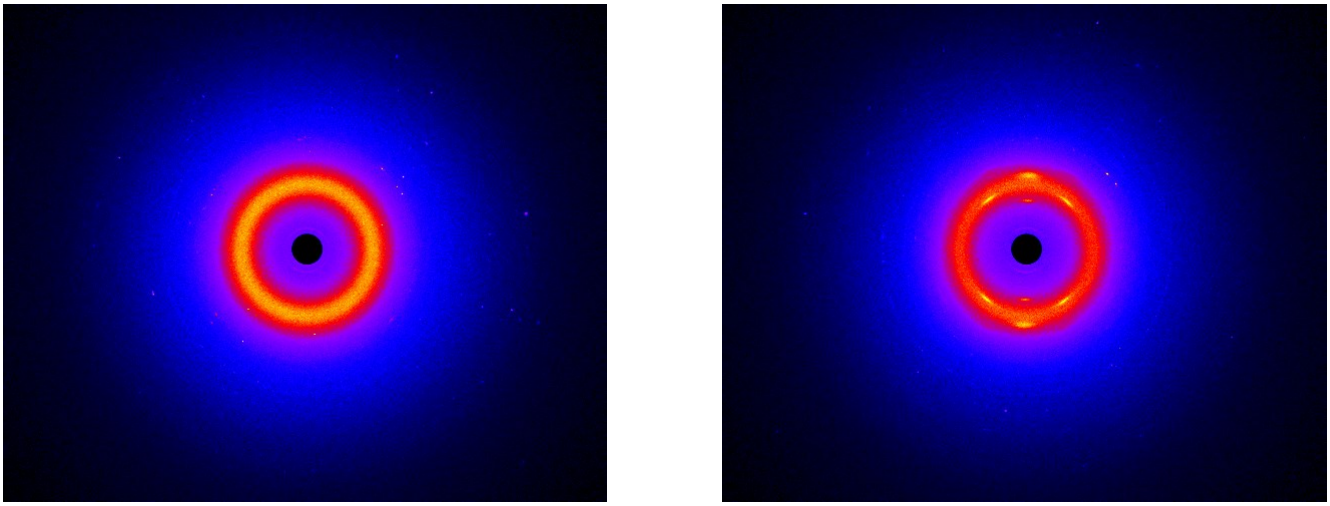


Figure 1. *Two-dimensional WAXS patterns of natural rubber before stretching (left) and at 400% strain (right).*

[1] A. S. Turner et al., Rubber Chem. Technol. (2004). 77, 417–432.
[2] P. Smith et al., Polymer (2005). 46, 11798–11805.