Division of Multidisciplinary Chemistry
– Polymer Materials Science –

https://www.scl.kyoto-u.ac.jp/~polymat/index.html

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Scope of Research

The structure and molecular motion of polymer substances are studied, mainly using scattering methods such as X-ray, neutron, and light with intent to solve fundamentally important problems in polymer science. The main projects are studied on 1) the morphologies and the dynamics of self-assembling processes in block copolymers, 2) the hierarchical structures in crystalline polymer and rubber-filler systems, 3) the viscoelastic effects in glassy materials, 4) formation processes and ordering structures in polymer thin films.

KEYWORDS

Polymer Physics
Self Assembly
Hierarchical Structure
Polymer Properties
Softmatter

Recent Selected Publications

Takenaka, M.; Nishitsuji, S.; Watanabe, Y.; Yamaguchi, D.; Koizumi, S., Analyses of Hierarchical Structures in Vulcanized SBR Rubber by Using Contrast-Variation USANS and SANS, *J. Appl. Cryst,*. **54,** 949-956 (2021).

Nakanishi, Y.; Mita, K.; Yamamoto, K.; Ichino, K.; Takenaka, M., Effects of Mixing Process on Spatial Distribution and Coexistence of Sulfur and Zinc in Vulcanized EPDM Rubber, *Polymer*, **218,** 123486 (2021).

Ogawa, H.; Takenaka, M.; Miyazaki, T., Molecular Weight Effect on the Transition Processes of a Symmetric PS-b-P2VP during Spin-Coating, *Macromolecules*, **54,** 1017-1029 (2021).

Effects of Mixing Process on Spatial Distribution and Coexistence of Sulfur and Zinc in Vulcanized EPDM Rubber

The vulcanization of rubbers is attained by the mechanical mixing of rubbers, sulfur and zinc oxide (ZnO). Sulfur crosslinks the rubber by reacting to double bonds in the rubber and ZnO accelerates the vulcanization of the rubbers with sulfur efficiently. The amount of coexistence of sulfur and ZnO is an important factor to attain the effective crosslink as well as their dispersion. We have successfully observed spatial distributions of sulfur and zinc and their spatial correlation in vulcanized ethylene–propylene–diene copolymer (EPDM) rubber by using Microscopic X-ray fluorescence mapping with synchrotron radiation. We found the mixing processes strongly affected the amount of coexistence of sulfur and ZnO as well as the spatial distributions of each component. The better spatial cross-correlation and homogeneity of sulfur and zinc improved the performance of the EPDM rubber.

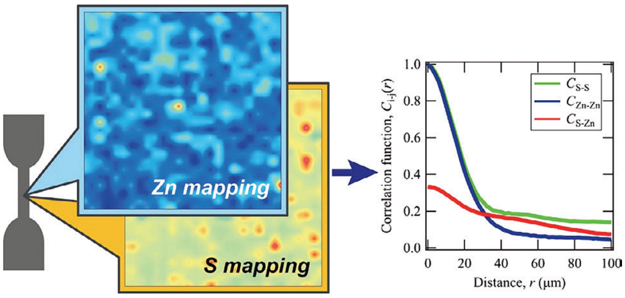

Figure 1. The μ-XRF mapping images of the vulcanized EPDM samples.

Artifact Removal in the Contour Areas of SAXS-CT Images by Tikhonov-L1 Minimization

Small-angle X-ray scattering (SAXS) coupled with computed tomography (CT), denoted SAXS-CT, has enabled the spatial distribution of the characteristic parameters (*e.g.*, size, shape, surface, characteristic length) of the nanoscale structures inside samples to be visualized. In this experimental geometry, we often face to the serious problem that the reflection of incident X-rays interferes with the 2D SAXS patterns near the sample edge which kinds of anomalous scattering (artifact) seriously damage the reconstructed CT image. We attempted to remove streak-derived intensities as noise from the sinogram by implementing Tikhonov-L1 optimization. We treated the removal procedure of the streak-derived noise as a constrained convex optimization problem, where we imposed Tikhonov-type regularization on the sinogram to exploit the underlying smoothness of the sinogram and used L1 norm regularization to characterize the sparsity of streak-derived noise. For a sample, we employed a crystalline polymer exhibiting an isotropic peak in the SAXS scattering pattern originating from lamellar structures. We successfully removed the noise due to streak scattering from the sinogram image and were able to reconstruct the CT image free from artifacts in the contour regions. This technique is useful for removing spot-like noise not only for SAXS-CT but also for conventional X-ray CT.

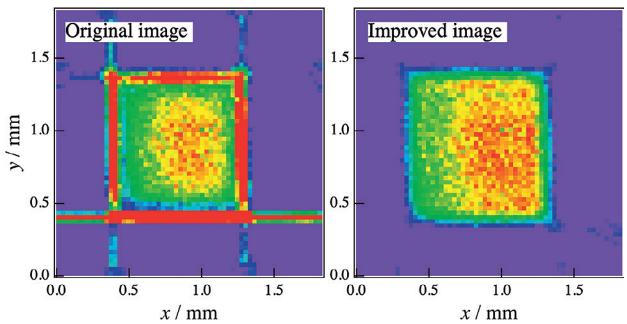

Figure 2. Original and improved CT images from the sinogram of the signal components.