New developments in polymer science through polymer chain imaging: empirical foundation research using scanning near-field optical microscopy

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【Outline of survey】

In the field of polymer science, structure and function in the spatial domain of 10 – 100 nm is of extreme importance. This is because a single molecular chain measures in the order of 10 nm, and the basic unit making up the material structure is within this scale. In this research, a new microscopic procedure called scanning near-field optical microscopy (SNOM) is used to directly observe the actual form of a single polymer chain existing within a polymeric material. As a result, empirical research on the main fundamental issues in polymer science such as the structure, solid-state properties and function of polymers, can be carried out at the single molecular chain level. Specifically, focus will be on the spreading, rigidity, orientation and intertwining of polymer chains, as well as the aggregate structure of microscopic phase separation and microscopic crystallization. The secondary structure and higher-order structure that are linked to the solid-state properties and function of polymeric materials should be considered in terms of the structure resulting from the primary structure, in other words the single molecular chain. Through research based on this new viewpoint, we will endeavor to develop the field of nanoscale polymer science which has the single polymer chain as its starting point.

【Expected results】

The relationship between the solid-state properties, function and structure of polymers will be elucidated empirically from the viewpoint of the single polymer string. Specific achievements which can be expected, include the following examples.

It will be possible to directly measure the spread of the polymer chain at the solid, surface and membrane, from the image of the polymer chain.

The correlation between deformation at the macroscale and the microscopic molecular morphology, related to the stretch of the polymer, can be made clear.

The diffusion phenomena of the polymer chain can be understood at the molecular level, and phase separation and interfacial diffusion processes can be explained molecularly.

The relationship between the morphology and electronic state of the polymer can be made clear through spectroscopic analysis.

Through this research, a method that does not rely on the use of assumptions can be developed for directly analyzing phenomena that have hitherto been described by the field of polymer science through the use of statistical methods, analysis models and functions.

【References by the principal researcher】

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- S. Ito and H. Aoki, “Fluorescence Probe Method for Investigating Polymer Structures in Nanometer Dimensions”, *Bull. Chem. Soc. Jpn.*, **76**, 1693-1705 (2003).

【Term of project】 FY2006－2010

【Budget allocation】35,700,000yen

【Homepage address】 http://photo.polym.kyoto-u.ac.jp/