

Scanning microbeam WAXS on 5CB dispersed with silica nanoparticles

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Introduction

Nematic liquid crystal (NLC) is anisotropic at its nematic phase and serves as an anisotropic matrix for colloidal dispersions. Colloidal particles form distinctive structures in NLC [1-3] and remarkably modify properties of NLC [4]. In this experiment, scanning microbeam wide-angle X-ray scattering (WAXS) was performed to study the effect of dispersed silica nanoparticles on the matrix 5CB (NLC, Isotropic-to-nematic transition temperature is 35 °C), especially focusing on the orientation and structure change of 5CB.

Experiment

Silica nanoparticles with diameter around 100 nm were dispersed into 5CB with the surfactant Tween 60, which introduces normal anchoring of 5CB molecules to the surface of silica. The volume fraction of silica ϕ was 0.3, 0.5 and 5.0 %.

In this experiment, the X-ray energy was 11 keV, the camera length was 120 mm, and the detector was a CCD (Hamamatsu Photonics Ltd., C4880-50-26A) coupled with an X-ray Image Intensifier (Hamamatsu Photonics Ltd.). The beam size was focused to $5 \mu\text{m} \times 5 \mu\text{m}$, which enabled us to measure local structure of 5CB molecules. By scanning samples with this narrow X-ray beam, we studied the structural change of 5CB molecules. Experiment was performed at room temperature (RT) under which 5CB should be at nematic phase.

Results and discussion

Pure 5CB shows anisotropic scattering pattern at RT as shown in Fig. 1 (a). This pattern keeps almost invariable within a total scanning area $1 \text{mm} \times 1 \text{mm}$, revealing that 5CB molecules are well oriented under the experiment conditions. We found samples with ϕ equals to 0.3 % and 0.5 % also show anisotropic scattering patterns at RT. However the scattering patterns fluctuate at different scanning spots, indicating the director field of 5CB is distorted by the dispersed silica nanoparticles. Sample with ϕ equals to 5.0 % shows isotropic scattering pattern as Fig. 1 (b) illustrates.

Hermans orientation parameter f , which estimates the degree of orientation, was calculated as shown in Fig. 2 (left axis). f decreases with increasing ϕ , indicating that 5CB molecules become less oriented with increasing ϕ . This is a result of the increasing influence of silica nanoparticles on 5CB. This change of orientation results from the anchoring of 5CB molecules to the interfaces between silica nanoparticles and 5CB molecules. The interfaces become more condensed with increasing ϕ ,

which results in the generation of an effect on the orientation of 5CB molecules.

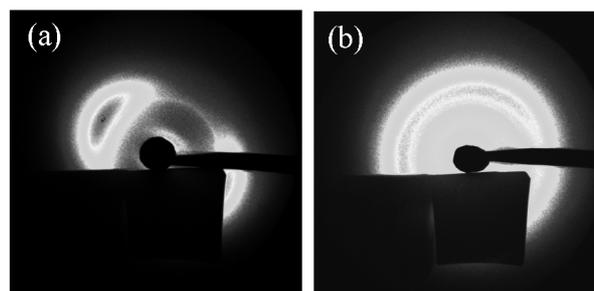


Fig. 1 Scattering patterns of (a) pure 5CB and (b) sample with ϕ equals to 5.0 %.

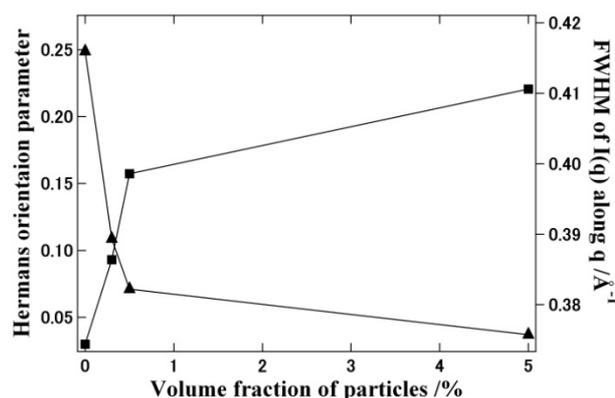


Fig. 2 Dependence of f (left) and FWHM of $I(q)$ along q (right) on ϕ .

Full width of half maximum of scattering intensity $I(q)$ as a function of scattering vector q was calculated for different ϕ , as depicted in Fig. 2 (right axis). This parameter characterizes the degree of x-ray peak broadening. Two effects are generally considered to cause x-ray peak broadening; one is grain refinement and the other one is the existence of microstress. These two effects are supposed to coexist in these samples and both of them become stronger with increasing ϕ , resulting in the increase of FWHM of $I(q)$ along q .

References

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