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SAXS study on PEDOT:PSS thin films

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1. Introduction

Poly(3,4-ethylenedioxythiophene):polystyrenesulfonate (PEDOT:PSS) becomes the most successful intrinsically conductive polymers in terms of the practical application. Because PEDOT:PSS can be dispersed in water and some polar organic solvents, it can be processed into thin films by solution processing techniques like coating and printing. A pristine PEDOT:PSS film has a conductivity of only 10^{-1} S/cm, and the conductivity can enhance by "secondary doping".[1] For instance, the conductivities are ~800 S/cm and >3000 S/cm after the PEDOT:PSS films are treated with DMSO and H_2SO_4, respectively. It was also reported that the thermoelectric properties of PEDOT:PSS can be improved by forming composites with nanoparticles.[2] The conductivity and thermoelectric properties are related to the morphology of the PEDOT:PSS films. We try to study the morphologies of various PEDOT:PSS by SAXS.

2. Experiment

Pristine PEDOT:PSS, H_2SO_4-treated PEDOT:PSS films and composite films of PEDOT:PSS and TiO_2 nanoparticles were studied by SAXS at the Aichi Synchrotron Radiation Center.

3. Results and Discussions

The SAXS result indicates that the pristine PEDOT:PSS film is armouphous (Fig.1). This is consistent with the AFM and SEM results and its low conductivity of 10^{-1} S/cm. Some features along the lateral and vertical directions can be observed after the DMSO treatment. This suggests the morphological change by the DMSO treatment. The feature size becomes larger when the PEDOT:PSS film is treated with H_2SO_4. The SAXS results are consistent with the conductivity of the PEDOT:PSS films. The DMSO or H_2SO_4 treatment can enhance the conducivity to ~800 S/cm or >3000 S/cm, respectively. However, no ring similar to some crystalline polymers was observed. This implies that these PEDOT:PSS films do not have large grains with high crystalinity. The feature observed on the PEDOT:PSS/TiO_2 film indicates the TiO_2 parricle size of ~25 nm. This is consistent with the TiO_2 nanoparticle size. This suggests that the TiO_2 nanoparticles can be dispersed well in the PEDOT:PSS film.

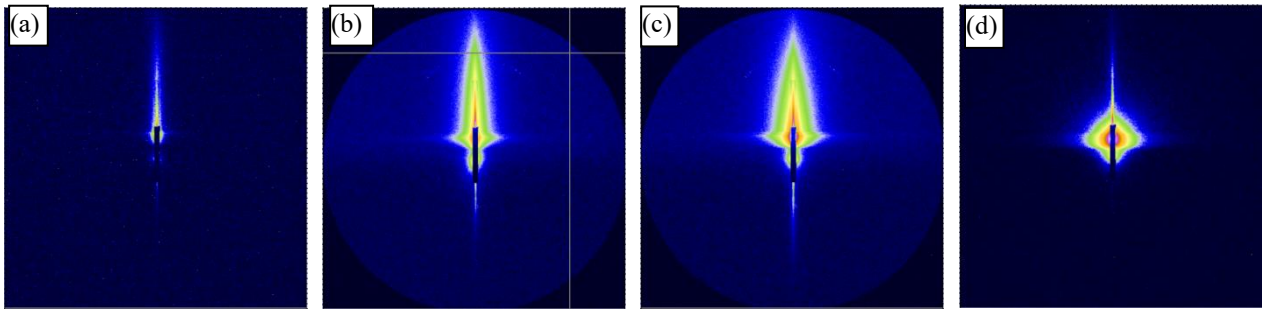

Fig. 1 SAXS of (a) pristine PEDOT:PSS, (b) DMSO-treated PEDOT:PSS, (c) H_2SO_4-treated PEDOT:PSS and (d) PEDOT:PSS/TiO_2 composite.

4. References

1. J. Ouyang, *Displays* (2013), 34, 423–436
2. H. Yao, et al., *Macromolecular Rapid Communications* (2018), 39, 1700727.