# Growth and elastic behaviors of $C_{70}$ nanowhiskers

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## Abstract

Here we show large elastic deformation of $C_{70}$NWs grown by the liquid-liquid interfacial precipitation (LLIP) method. The elastic properties were examined by the bending test. The $C_{70}$NWs with solvated structure including solvent exhibit large elastic deformation, as $C_{60}$NWs. It should be noted that the large elastic deformation is kept even for $C_{70}$NWs without solvent after the annealing. The elastic behavior of $C_{70}$NWs after the annealing is quite different from the brittleness of $C_{60}$NWs without solvent after the annealing. The large elastic deformation of $C_{70}$NWs without solvent might be related to the elliptical shape of $C_{70}$ molecules, compared with spherical shape of $C_{60}$ molecules. Our finding can provide an important insight for the understanding of elastic behaviors in fullerene crystals.

## 1. Introduction

Nano/microcrystals of $C_{60}$ and $C_{70}$ with solvated structure grown by solution method such as LLIP and reprecipitation method have been attracted much interest owing to their unique morphology and properties[1]. Such solvated crystals can be easily obtained for not only $C_{60}$ but also higher fullerenes such as $C_{70}$, although it is generally difficult to grow bulk crystals of higher fullerenes by sublimation method. Thus, the solvated crystals are of very interest for the understanding of fullerene crystals especially of higher fullerenes such as $C_{70}$. Recently we found that $C_{60}$NWs with solvated structure show a large elastic deformation[2]. It is considered that this large elasticity is ascribed to the molecular arrangement in the crystal and/or the intermolecular interaction between spherical $C_{60}$ and solvent molecules. The characterization of the mechanical properties of $C_{70}$NWs consisting of elliptical $C_{70}$ molecules is of very interest in comparison with $C_{60}$. In this study, we report the growth and the mechanical properties of $C_{70}$NWs.

## 2. Experiment (or Theory)

$C_{70}$NWs were grown by the LLIP method with *m*-xylene and 2-propanol as good and poor solvent, respectively. The mechanical properties were examined by the bending tests for both samples after air drying and heat treatment. The structure and composition were investigated by X-ray diffractometer (XRD) and Fourier transform infrared spectrometer (FT-IR).

## 3. Results and discussion

$C_{70}$NWs exhibit large elastic deformation in air as those in $C_{60}$NWs as reported previously. Figure 1 shows the successive images of the bending deformation of $C_{70}$NW after heating. In contrast to $C_{60}$NWs, the large elastic deformation of $C_{70}$NWs is kept even after the heat treatment. The bending strain of $C_{70}$NWs was 2.1 ± 0.43 % and 1.9 ± 1.2 % before and after heating, respectively. This shows that, in terms of the bending strain, the decreasing of the elasticity is only 0.2 %. It should be noted that the elasticity of $C_{60}$NWs decreases by 1.2 % after the heating. The FT-IR and XRD results show that as-grown $C_{70}$NWs have a solvated orthorhombic structure, whereas the structure changes to a desolvated face-centered cubic structure after heat treatment. Therefore, $C_{70}$NWs became slightly brittle since the solvent molecules in the crystal were desorbed by the heat treatment. These results are in good agreement with previous models for $C_{60}$NWs[2)]. However, it should be noted that the $C_{70}$NWs maintained as much as 90 % of the elasticity, while desolvated $C_{60}$NWs maintained only about 56 % of the elasticity. This unique elastic behavior of $C_{70}$NWs cannot be explained by only the solvated structure. Similar elastic behaviors have been reported for some molecular crystals composed of planar (aromatic) molecules[3)]. Our result may be owing to the asymmetric shape of the $C_{70}$ molecule, similar to the interlocking structure of planar molecules.

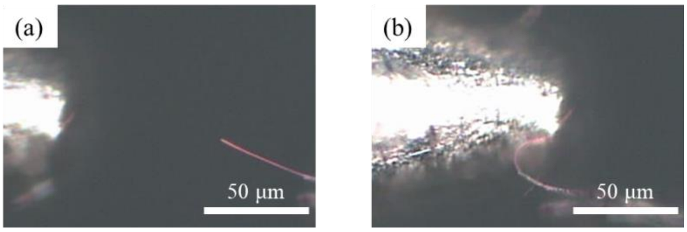

Fig. 1 Optical micrographs of bending test for heat-treated $C_{70}$NW (a) before applying the force (b) while bending

## 4. Conclusions (or Summary)

We have shown the bending deformation of $C_{70}$NWs composed of elliptical molecules, obtained by the LLIP method. The $C_{70}$NWs exhibit large elastic deformation in both solvated and desolvated structures. This unique mechanical property may be owing to the asymmetric shape of the $C_{70}$ molecule. Our results on $C_{70}$NWs of elliptical molecules shown in this work provide a crucial insight for the comprehensive understanding of elastic behaviors in molecular crystals and characteristics of the $C_{70}$ crystals.

## References

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