DISPERSION OF CARBON NANOFIBERS IN WATER

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Introduction

Carbon nanotubes (CNTs) or carbon nanofibers (CNFs) are of great interest from both the fundamental and practical points of views. A particular effort is being directed toward their use in composite materials for a variety of applcations, including electrostatic discharge, structural reinforcement, and thermal dissipation. However, the research studies and applications of CNTs or CNFs have been hindered by the poor solubility and processibility of them. Recently, the dispersion of CNTs via covalent or noncovalent methods is considered an efficient method to overcome these difficulties. In particular, the dispersion of CNTs by noncovalent methods has shown useful for improving their solubility without impairing their physical properties. On the other hand, few studies have been reported on the dispersion of CNFs. Herein, we report on the dispersion of CNFs in water via noncovalent method.

Experimental

In this study, a vapor grown carbon fiber (VGCF: supplied by Showa Denko Co., Japan), a kind of CNFs , was used. Other reagents were commercially available and used without further purification. The dispersion method is as follows. CNFs were sonicated for 30 min in aqueous solution of various dispersion reagents, and then the suspensions were centrifuged at 3000 rpm for 30 min. The resulting suspensions were investigated by Scanning electron microscopy (SEM) and Transparent electron microscopy (TEM) observation.

Results and Discussion

Several materials have been reported as the dispersion reagent of CNTs. For example, Gum Arabic, Nafion, sodium dodecylbenzenesulfonate and a pyrene derivative disperse CNTs in water. First, we tried to disperse CNFs in water by means of these materials. CNFs are effectively dispersed in water by their sonication in the presence of Gum Arabic or Nafion. In particular, Gum Arabic led to a stable dispersion. TEM observation (Fig. 1) showed that the dispersion was formed due to physical adsorption of the polymer. On the other hand, sodium dodecylbenzenesulfonate did not have dispersion effect for CNFs. These results suggest that polymer materials are effective for dispersion of carbon nanofibers. Since the surface of CNF is hydrophobic, water-soluble amphiphilic polymers may be useful for the dispersion of CNFs.

On the basis of the above results, we explored amphiphilic polymers with the dispersing power on CNF, and tested sodium alginate and sodium polystyrenesulfonate. We found that sodium alginate could act as an efficient dispersing agent for CNFs in aqueous solutions. Figure 2 shows an image of the dispersions of CNF in aqueous solutions of sodium alginate and sodium polystyrenesulfonate. In the presence of sodium alginate, a black ink-like suspension was obtained.

The good dispersion of CNFs in aqueous sodium alginate solution enabled us to fabricate CNF/alginic acid composites. The composite was made by drop-casting a dispersion solution on clean glass substrates. After the solution dried, a black homogeneous film formed which was uniform to the eye. We also got a black fiber of alginic acid containing CNFs by spinning the dispersion solution into yarn in aqueous HCl solution. The CNFs were well dispersed in the CNF-alginic acid composite film (Fig. 3).

Conclusions

In conclusion, our findings indicate that the use of sodium alginate as a dispersing agent for CNF provides a useful avenue for preparing CNF-polymer composites. We are currently investigating the physical properties of these matrials, which may be progressive due to improved dispersion of the CNFs.

Acknowledgement: We acknowledge fund support of "Cluster" by Ministry of Education, Sports, Culture, Science and Technology of Japan.

References

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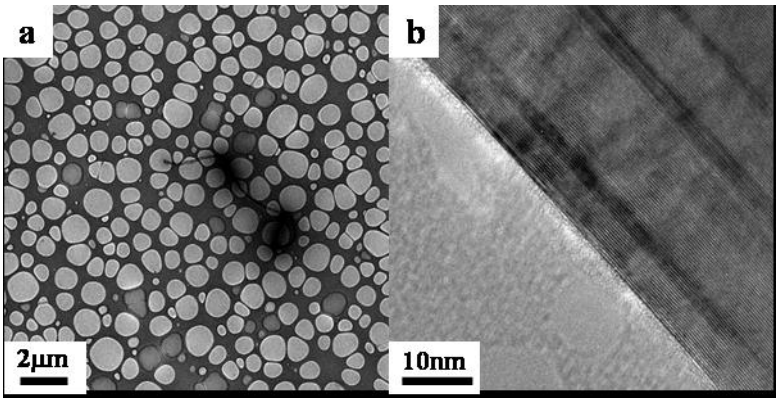

Fig.1 (a) CNF dispersed in water with Gum Arabic, (b) Around surface of CNF by TEM observation.

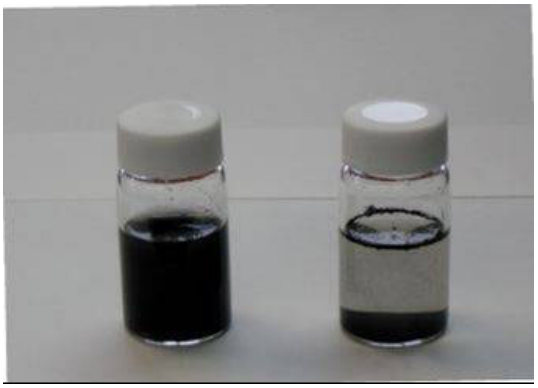

Fig.2 Photograph of vials containing VGCF (0.05%) in 5 wt% aqueous sodium alginate solution (left) and in poly(sodium 4-styrenesulfonate) (right).

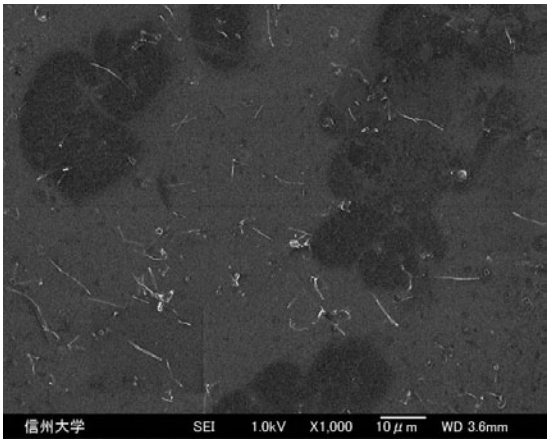

Fig.3 SEM photograph of VGCF-alginic acid film.