# Exfoliation of carbon fibers and its applications

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Preparation of exfoliated carbon fibers (ExCFs) was successfully carried out via intercalation compounds [1-3]. Intercalation compounds of mesophase pitch-based and PAN-based carbon fibers were formed by anodic polarization in nitric acid [4], sulfuric acid [5], formic acid[6] and other acid solutions [7]. Intercalation was confirmed by XRD for electrolyzed carbon fibers. Its intercalation behavior suggested that intercalation into carbon fibers proceeds from the free end of fibers to towards the fixed end with increasing electric charges. The intercalation by electrolysis and the exfoliation of intercalation compounds were found to depend on the degree of graphitization of pristine carbon fibers. By rapid heating to 800 to 1000 $^{o}$C for 5 to 15 sec, marked morphological changes were observed for mesophase pitch-based carbon fibers; a single fiber was converted to a bundle of thin filaments along the original fiber axis. In the case of PAN-based carbon fibers, scale-like fragments peeled off from original fiber after rapid heating to 800 to 1000 $^{o}$C. Both morphology changes indicated in Fig 1.

Application of ExCFs was discussed in present paper. The electric double layer capacitor (EDLC) composed by using ExCFs prepared from mesophase pitch-based carbon fibers showed a high capacitance of 160 F/g in 1 mol/dm$^3$ sulfuric acid electrolyte and about 550 F/g in 18 mol/dm$^3$ electrolyte [8,9]. On the other hands, the EDLC composed by using ExCFs prepared from PAN-based carbon fibers indicated much higher capacitance than pitch-based one in 1 mol/dm$^3$ $H_2SO_4$ electrolyte. Its capacitance which exceeded 500F/g was obtained in 1 mol/dm$^3$ $H_2SO_4$ electrolyte. High capacitance of them is strongly related the meso pores, and surface functional groups formed on unique morphology such as thin filaments and scale-like fragments of ExCFs.

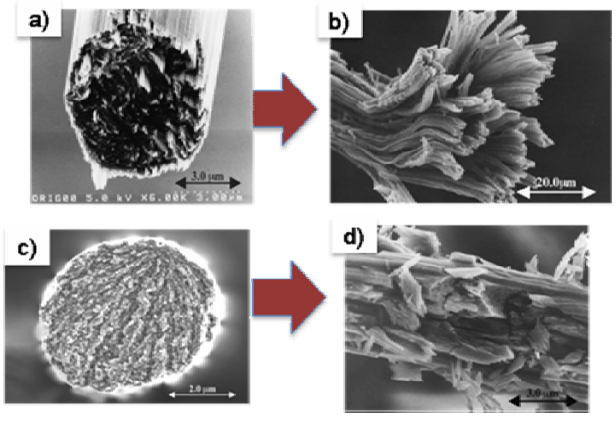


Fig. 1 Morphology changes in pitch- and PAN-based carbon fibers with rapid heat-treatment, (a) pristine mesophase pitch-based carbon fiber, (b) after rapid heat-treatment of it, (c) pristine PAN-based carbon fiber and (d) after rapid heat-treatment of it.

Dimension of their thin filaments and scale-like fragments of ExCFs derived high capacitance for the EDLC are less than sub-micrometers. Their filaments and fragments showing nano- to sub-micrometer size have good dispersiveness. Preparation of composites using their ExCFs shown

unique morphology has been investigated. ExCFs changed in nano- to sub-micrometer sized filaments and fragments by using sonication were composited with Poly Methyl Meth Acrylate (PMMA) in-situ polymerization process. Their mechanical properties were examined by using three-point bending test. Flexural strength and modulus of PMMA composite reinforced by ExCFs increased 166 % and 171 % at addition of only 2.0 wt% comparison with bulk PMMA and CNTs (carbon nano tubes) in Fig. 2 [10]. There is no significant aggregation in fracture surface, and homogeneous dispersion of ExCFs throughout the PMMA matrix was recognized in Fig.3. Homogeneous dispersion might be strongly related mechanical properties. ExCFs might be expected application to nano or micro composite.

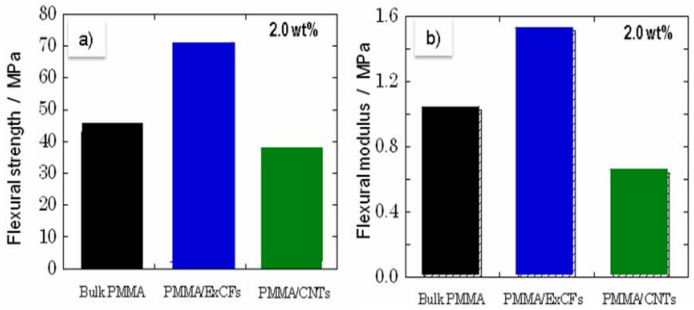


Fig. 2 Comparison of flexural strength and flexural modulus for Bulk PMMA, PMMA/ExCFs and PMMA/CNTs composites

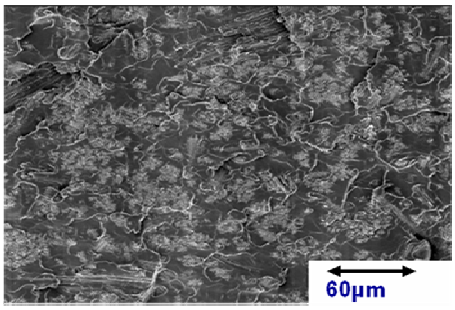


Fig. 3 Cross sectional morphology of PMMA / ExCFs composite

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