Preparation of Carbon Nanofibers from Poly(ethylene glycol) with Controlling Their Structure

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Carbon nanofibers (CNFs) are among the most promising materials because of their unique structures and excellent features, which offer a variety of potential applications such as fuel cells, lithium-ion batteries, chemical catalysis, adsorbents, and so on [1]-[5]. The most popular technique for carbon nanofiber (CNF) synthesis is currently chemical vapor deposition (CVD), which is able to synthesize various CNFs selectively such as platelet (in which graphene layers are aligned at right angles to the fiber axis), cup-stacked (in which graphene layers tilt and truncate conically along with the fiber axis), and herring-bone CNFs (in which graphene layers tilt at an angle to the fiber axis). Recently, a novel CNF synthesis method was developed by Huang and Li [6]. This method employing the pyrolysis of poly(ethylene glycol) (PEG) is easier and safer as compared to CVDs and has possibility to prepare novel CNFs with unique structure[7]. However, PEG methods still have some problems involving selective synthesis, growth mechanism and control, and so on. Therefore, in this study, synthesis methodologies of above-mentioned three kinds of CNF and the relationship between the synthesis conditions and resultant CNF structures were experimentally investigated.

As a result of the experiments, above-mentioned CNFs (platelet, cup-stacked, and herring-bone) were successfully fabricated by changing the synthetic conditions in this synthesis method. In the synthesis processes, the formation of Ni nanoparticles, which is essential for the growth of CNFs, was observed in the dried mixture of PEG and NiCl2. From a series of experimental results, it was known that the shape of Ni nanoparticles and CNF growth depend on the following factors: 1) the ratio of PEG /NiCl2, 2) drying time of the mixture, 3) state of PEG (liquid or solid) before temperature rising and 4) the rate of temperature rise. CNF synthesis with high purity requires proper control of these factors. For example, when the drying time of the mixture was excessively long, amorphous carbon film was synthesized without growing the CNFs.

In addition, it was found that when the mixture (PEG + NiCl2) was heated to 400°C, amorphous carbon film was fabricated before the growth of CNFs started. It was suggested by experiments that the amorphous carbon film plays a crucial role in the CNFs growth in this method, and its mechanism might be different from those in conventional CVD process.

Reference:

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