Structure of Mesophase Pitch-based Carbon Fibers Produced By Melt Blow-Spinning

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Introduction

High-performance pitch-based carbon fibers are commercially produced by melt spinning. Productivity and efficiency for both fiber spinning and thermal processing is low, which results in high costs of final products. An alternative process, melt blowing has been developed and immense efforts have been made from lab scale to commercial plant. Some fiber materials with excellent properties have been produced, indicating the potential for this process. Since UTSI received the donation of this technology, the fiber making process has been reproduced and partially-oriented fiber spinning technique verified. Preliminary results on some unique microstructure of carbon fibers thus produced are reported here.

Experimental

The fiber precursor was a solvated mesophase pitch. The green pitch fibers were made, using blow-spinning technique, from a multi-nozzle spinning system with partial aligning devices integrated. The green fibers were processed (dried, stabilized oxidatively and carbonized) at temperatures up to 1500°C in the UTSI lab. The carbonized fibers were examined microscopically as part of systematic fibers characterization.

Results

A cross sectional overview of a small strand of carbonized fibers is shown in Figure 1. The fibers have quite uniform diameters, about 10 microns or less, with essentially straight outlines in their axial directions. Some fibers contained a longitudinal crack. Figure 2 shows more detailed structure in terms of principal arrangements of graphene staking across the fiber surfaces. Although the carbonization temperature was insufficient to develop graphite structure, quite varied textures with mesophase-derived characteristics have been observed under SEM in the same batch of fiber samples. The dominant texture can be classified into three categories, radial wavy or folded structure (photos A and B in Figure 2), radial wavy staking with single (arrowed in C and D) or double swirls (arrowed in E and F). The swirl center may have at least a disclination of π or 2π with other graphene staking bent around. Much higher heat treatment temperatures may convert some of the double swirl fibers to texture similar to the so-called Pan Am shape as observed by others from different melt-blown carbon fibers. [1)]

The longitudinal cracks occurred in some fibers, e.g. photo D in Fig. 2, were caused probably by internal stresses within the anisotropic mesophase materials during fiber processing. Additionally, small ridges or tracks at the outer surface along the fibers were also characteristic of mesophase pitch precursors. [1, 2)]

Synopsis

Under current spinning and processing conditions, melt-blown pitch fibers had been successfully processed into partially-oriented continuous carbon fibers with uniform and small diameters. Three distinct cross-sectional microstructures coexisted, radial wavy and the inclusions of one or two off-center swirl areas. All these structures seem to be compatible with high tensile strength and modulus, as well as high thermal and electrical conductivity. Selectively producing any specific type of microstructure for certain applications by controlling fiber making and processing conditions is an interesting on-going research area, along with more detailed structural characterizations of the carbon fibers made at higher heat treatment temperatures.

Acknowledgement
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Reference
1. F.Watanabe, Y. Korai et al, Carbon, 38(7), 741, 2000.
2. K. Robinson and D. Edie, Carbon, 34(1), 13, 1996.

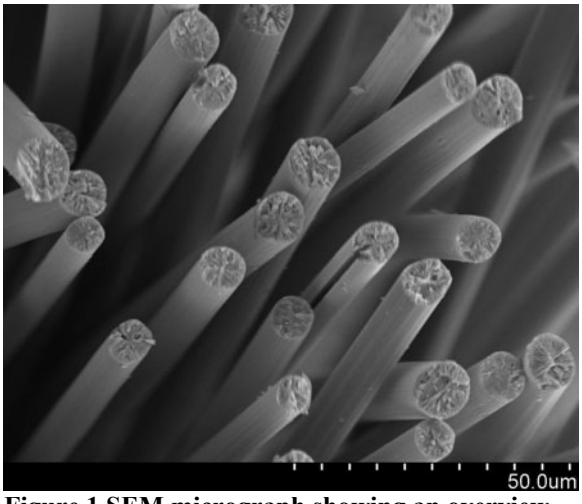

Figure 1 SEM micrograph showing an overview.

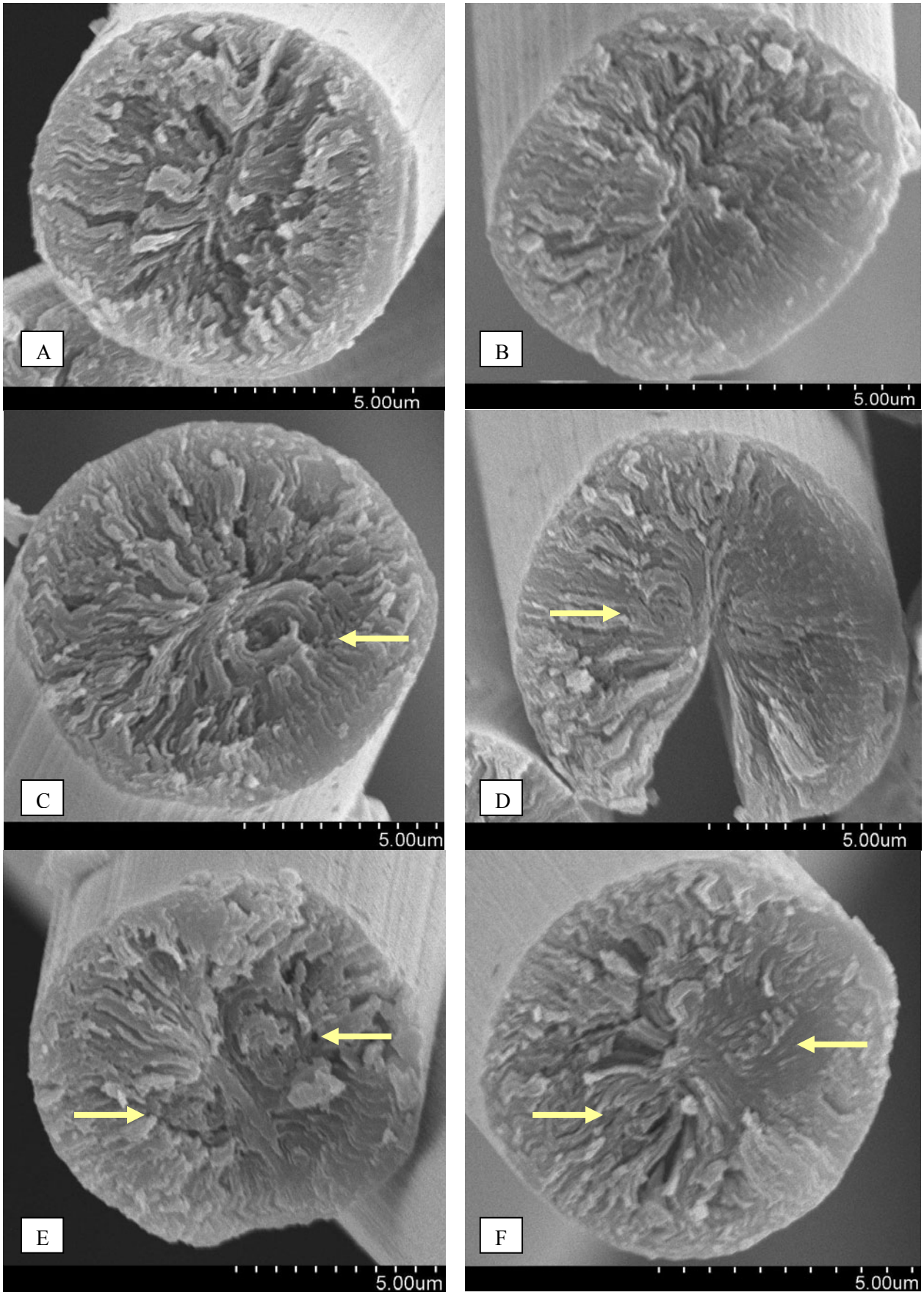

Figure 2 SEM micrographs showing cross sectional microstructure of individual carbon fibers.