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Microstructure Of "Ordinary" And High Modulus Carbon Fibers*

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ABSTRACT

The microstructure of carbonized cellulose fibers has been investigated by transmission electron microscopy of thin sections and surface replicas. Three types of fibers have been investigated.

"Carbon" fibers (~1000° C HTT): thin sections are relatively featureless on the 10-1000Å scale. Because this material is brittle, continuous sections are unobtainable; only small chips result from microtome sectioning. Replicas of transverse fracture surfaces are generally smooth, exhibiting occasional cleavage steps. However, an underlying texture does exist on the scale of 300-500Å, and this texture is believed to be derived from the internal fibrillar structure of the rayon starting material.

"Graphite" fibers (~2800° C HTT): thin sections exhibit a well-developed, slightly oriented micropore structure. Adjacent pores are ~60Å apart. Replicas of transverse fracture surfaces show a much rougher texture than that of the "carbon" fibers, indicative of a more well-developed "fibrillar" structure. Replicas of external filament surfaces show that this "fibrillar" structure has developed enough to become visible as ridges on the surface.

High modulus "graphite" fibers: thin sections reveal a highly oriented micropore structure. The pores are again ~60Å apart, but they frequently exhibit lengths of 1000Å or more. The pore walls are believed to consist of stacks of ribbon-like graphite layers. An estimate of pore wall thickness was made based on the above pore geometry, the filament density (1.52 gm/cm^3) and the X-ray interlayer spacing (3.50Å). The result was ~27Å or 8 layers, a value in excellent agreement with X-ray results obtained by Ruland from analysis of the (002) line contour. Replicas of transverse fracture surfaces exhibit an even rougher texture than observed in the "ordinary graphite" fibers, indicating a very uneven fracture surface. Replicas of external filament surfaces show very well aligned "fibrillar" structure.

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