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DIMENSIONAL CHANGES INDUCED IN PYROLYTIC CARBON BY HIGH TEMPERATURE FAST-NEUTRON IRRADIATION

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ABSTRACT

A variety of pyrolytic carbons with densities from 1.99 to 2.09 g/cm^3, Bacon anisotropy factors from 1.1 to 1.9, apparent crystallite heights from 120 to 145Å, and isotropic, granular, or high-temperature laminar microstructures were prepared from methane in a fluidized bed. Disk-shaped samples were irradiated at 600°C, 1180°C, 1330°C and 1650°C to fast-neutron exposures of 1.9, 2.6, 3.1 and 3.3 x 10^{21}nvt (E > 0.18 Mev), respectively. Changes in linear dimensions, density, apparent crystallite height, layer spacing, and anisotropy were measured.

Significant increases in preferred orientation resulting from irradiation at temperatures above 1100°C were observed. The Bacon anisotropy factor for many specimens increased by more than 20% due to the irradiation.

At 600°C all the carbons increased in density. The kinetics of densification were found to be first-order with respect to the density defect and independent of the microstructural appearance of the carbon. At irradiation temperatures above 1100°C, the densities of the carbons with initial densities less than about 2.06 g/cm^3 were increased by irradiation, but the densities of those with initial densities greater than this value were decreased.

The dimensional changes parallel to the deposition plane were measured directly and those perpendicular to the deposition plane were deduced from the density changes. All the carbons contracted parallel to the deposition plane by up to 13%, and all samples except the least oriented carbon irradiated at 600°C expanded perpendicular to the deposit by up to 28%. The crystallite dimensional changes, $\Delta X_c/X_c$ and $\Delta X_a/X_a$, were derived from the measured dimensional changes and the preferred orientations. The crystallite c-axis expansion rates ($\Delta X_c/X_c$ per unit dose), together with previously published crystallite dimensional change rates for carbons with densities above 2.0 g/cm^3 and for crystalline graphites, are shown in Figure 1. Below ~ 500°C, where the mobility of the irradiation-induced defects is low, the dimensional change rates show no dependence on crystallite size and decrease with increasing irradiation temperature. Above ~ 500°C, where the mean diffusion distance of the displaced atoms apparently becomes large compared with the crystallite size, dimensional change rates increase with increasing temperature and are higher for carbons with smaller crystallite sizes.

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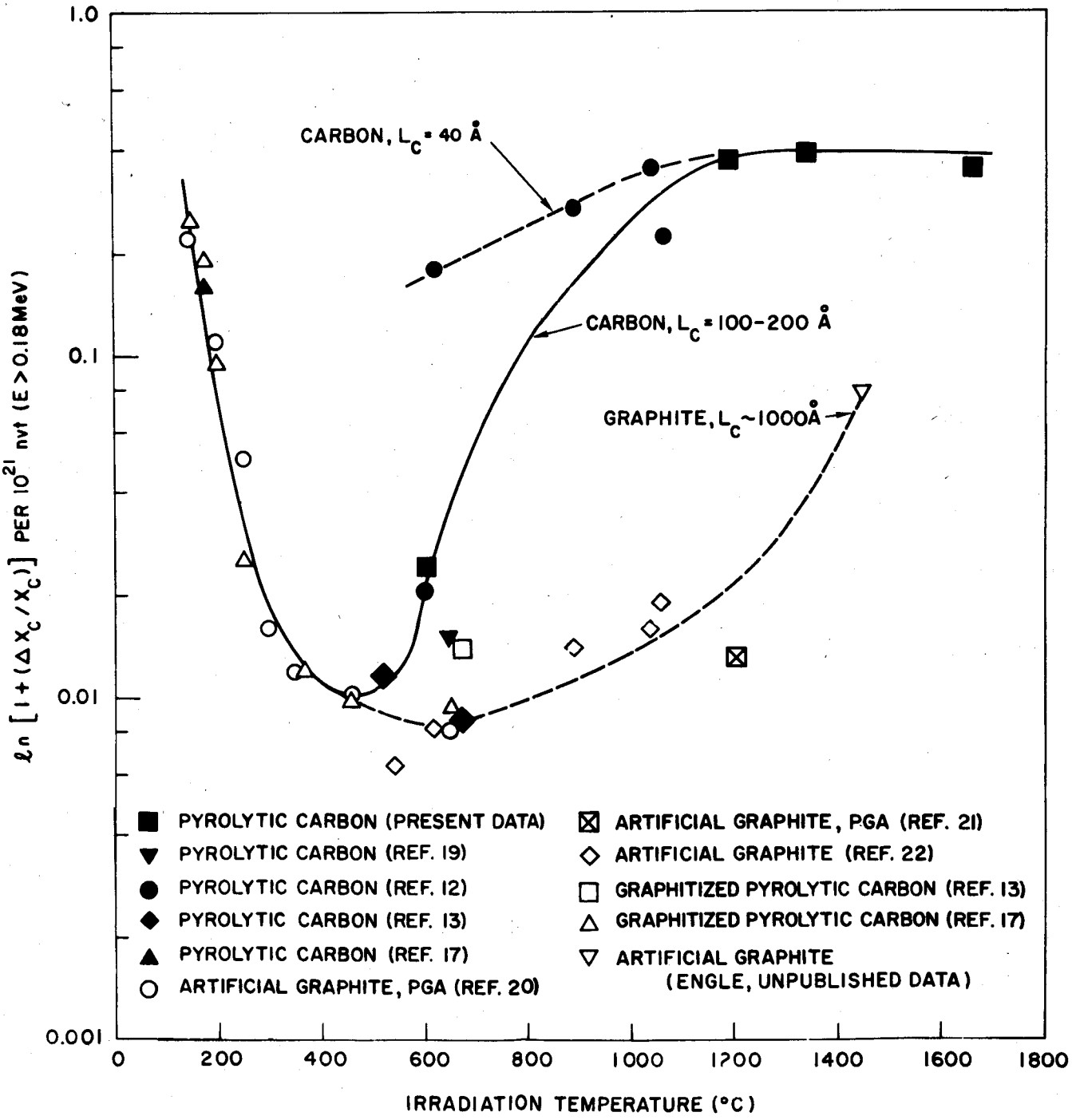

Figure 1. Average crystallite radiation-induced expansion rate in the c-direction for turbostratic carbons and for crystalline graphites versus irradiation temperature. The carbon data are restricted to material with a density greater than 2.0 g/cm^3.

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