

Optimization of Environmental Conditions for Magnetic Alignment of Carbon Crystallites under a 6-Tesla Field and Its Potential Impact on Graphite Preparation Energy

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Graphite production often requires temperatures as high as 3000 K, which leads to significant energy consumption. Reducing this energy demand while maintaining material quality is essential for sustainable graphite production. We have previously reported that energy consumption can be reduced by approximately 10% by applying a magnetic field to a portion of the graphite production process [1]. In this process, carbon microcrystals, the building blocks of graphite precursors, were effectively oriented in the early stages and their interconnections were strengthened during graphite formation at temperatures above 1000 K. This behavior suggests that the amount of energy required for graphite production decreases. Herein, we aimed to accelerate the orientation of carbon crystallites under a magnetic field. During the carbonization of coal tar pitch, low-molecular-weight hydrocarbons (LMwHCs) melt, and the carbon crystallites aggregate into spherical domains behaving as single units. Magnetic orientation of the spherical domains occurs readily in the liquid phase, which solidifies to yield highly oriented graphite precursors. Optimizing the amount of carbon microcrystals and low molecular weight hydrocarbons (LMwHC) in the coal tar pitch during the carbonization process at 600-800 K increased the size of the spherified particles and improved the orientation of the carbon microcrystals under the influence of magnetic fields. Spheronization increased the magnetic torque acting on these domains, improving their response to the applied magnetic field and facilitating orientation. Carbonization of this highly oriented precursor by heat treatment at up to 1523 K reduced energy consumption by more than 25%, demonstrating the potential for lower energy graphite production.

[1] A. Hamasaki, *et al.*, AIP Adv. **11**, 025041 (2021).