A Solar Processing for the Exfoliation of Intercalated Graphite Compounds

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Abstract

Expanded Natural Graphite (ENG) has a wide field of application, connected to both its mechanical and thermal properties. Some advanced thermal processes designed and developed by CNRS-IMP at the University of Perpignan, France, are using components made of ENG for the enhancement of solid-gas reactions.

ENG is produced by a rapid heating of Graphite Intercalation Compounds (GICs) obtained from natural graphite flakes. Classical industrial processing are performed in torch flames. A semi-continuous solar processing for the synthesis of ENG is investigated and significant results are presented in this work. This entirely new solar processing is implemented in the small-scale solar facilities of CNRS-IMP in Odeillo, France. The graphite flakes are irradiated by concentrated solar energy at the focal plane of a solar furnace. A very fast heating is obtained. A vertical glass tube contains the flakes that are pushed-up at constant speed up to the upper tip of the tube, where the reaction takes place. The expanded materials are collected and flown in a horizontal glass tube. The treatment is performed under air atmosphere. Under the action of the rapid heating, the lamellar structure of the graphite flakes is transformed into a vermicular structure by exfoliation along the c-axis of the graphite crystal.

Experiments were performed under various operating conditions. The concentrated solar flux densities ranged between 800 W/cm^2 and 1800 W/cm^2, and various velocities of the feeding were operated. The resulting heat treatments yielded to various apparent densities of ENG, in the range 2 - 10 kg/m^3. Consolidated graphite matrices were then prepared, by pressing Expanded Natural Graphite in a mould. Blocks of very porous material were produced. The analysis of their

microstructure and the measurement of their transfer properties are of prime interest to appreciate the general performance and the capabilities of the solar processing.

Helium pycnometry and mercury porosimetry analysis showed that the open porosity of the matrices increases with increasing concentrated solar flux density. The gas permeability ranged between 10^{-12} and 10^{-15} m^2, and increases by decreasing the concentrated solar flux density. It was established that the geometry of the flow path greatly influences the permeability as well as the open porosity. The thermal conductivity of the graphite matrices presents an elevated rate of anisotropy: λ=4 $W.m^{-1}.K^{-1}$ in the axial direction and λ=10 $W.m^{-1}.K^{-1}$ in the perpendicular direction of compression.

Very satisfying and large transfer properties of consolidated materials made of solar-processed ENG were achieved. The solar exfoliation offers many additional advantages: simple, economical, very good yield (70-80%). This processing competes with the conventional torch flames processing, and opens a promising field of investigations.