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Review

Preparation and characterization of graphite foams

Ji-Hyun Kim [a], Euigyung Jeong [b], Young-Seak Lee [a,*]

[a] Department of Applied Chemistry and Biological Engineering, Chungnam National University, Daejeon 305-764, Republic of Korea
[b] The 4th R&D Institute-4, Agency for Defense Development, Daejeon 305-600, Republic of Korea

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ABSTRACT

Graphite foams can be prepared by various methods, such as a blowing, the use of polymer based templates, and the compression of graphite and/or graphite sheets. Adding fillers to graphite foams can lead to improved thermal conductivity and compressive strength. The mechanical properties of graphite foam with carbon material added are negatively affected by the low dispersibility, alignment and interfacial adhesion of the fillers in the foam. This study reviews studies that have investigated various fabrication methods, the addition of carbon materials, and surface treatments of graphite foams to improve their thermal and mechanical properties.

Contents

* Corresponding author. Tel.: +82 42 821 7007; fax: +82 42 822 6637.
E-mail address: youngslee@cnu.ac.kr (Y.-S. Lee).

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Introduction

Graphite foams have high thermal conductivity, low weight and a large specific surface area, which allow them to endure high temperatures up to 3000 °C in an inert atmosphere. Additionally, graphite foams are used as furnace heating elements, heat insulating material and other various components. Carbons are produced from pitches, polymers and bio-materials treated at temperatures of 1000–1300 °C. Amorphous carbon changes to graphite materials with a crystalline structure in the temperature range of 2500–3000 °C. Graphite foams have chemically inert characteristics at room temperature and typically do not react with all organic materials [1–4].

The various fabricating methods of graphite foams have been studied using polymers, coal tar pitch and petroleum pitch as base materials. Polymer-based graphite foams are highly suitable to control the high compressive strength and porosity, although they are high in cost. Otherwise, coal tar and petroleum pitch-based graphite foams can be prepared at low cost and have high compressive strength and thermal conductivity [5–12].

The various properties of graphite foams have been studied, and their properties can be applied to various fields. The properties of graphite foam are typically determined by their porosity, thermal conductivity and compressive strength. The porosity of graphite foam has a large affect on its physical properties, thermal conductivity and compressive strength, which increase as the true and bulk density decrease with decreasing porosity. Graphite foams with highly developed properties can be applied in various fields, such as thermal transfer devices, electrical transfer devices and electrochemical super capacitors, catalyst supports, gas adsorbents, filtration systems, batteries and electrical magnetic shielding [13–18].

Additionally, adding fillers to graphite foams can increase the foams' thermal conductivity and compressive strength. The most common fillers include carbon nanotubes (CNTs), graphite and graphene; single-walled CNTs have a particularly high thermal conductivity of 3000 W/m K and could act as a bridge in the graphite foam, thus improving the compressive strength of the graphite foam. Furthermore, graphite and graphene have similar thermal conductivities and half weights compared to the aluminum or copper; thus, the thermal conductivity of graphite foam increases considerably with the addition of fillers into the graphite foam [19]. In addition to using fillers, the surface treatment of graphite foam affects the increased electric capacitance of batteries because the electron mobility of the electrode is extremely high due to the introduction of active sites onto the graphite foam via the surface treatment. Additionally, the surface treatment improves the oxidative stability of the graphite foams via a fast reaction between the functional groups and oxygen [20,21].

This study reviews studies that have investigated various fabrication methods, the addition of carbon materials, and surface treatments of graphite foams to improve their thermal and mechanical properties.

Preparations of graphite foams

Various methods can be used to prepare graphite foams. First, the blowing method is used to prepare graphite foams with various properties at different pressures, temperatures and pitch concentrations. Thereafter, an economical and simple method to prepare graphite foams was developed, which typically utilizes polyurethane (PU) foam as a template that is removed via heat treatment, producing graphite foams with a porosity according to the template size. In addition to these methods, simple methods of fabricating graphite foams based on the compression of graphite or graphene have also been studied.

Blowing methods to prepare graphite foams

Under the blowing method, graphite foams are prepared using a carbon precursor via heat treatment or heat treatment with blowing additives under various pressures, temperatures and pitch concentrations. The foams had different bubble diameters for the different pressure and temperature conditions, and thereafter, the graphite foams were prepared through stabilization, carbonization and graphitization of the foams. The development of graphite foams is typically investigated using pitch as the carbon precursor, which is placed into the pressure vessel under different temperature, pressure and pitch conditions. Thereafter, the acquired green foam is carbonized and graphitized to prepare the graphite foam, as shown in Fig. 1. Klett et al. investigated the preparation of graphite foams with different pressure parameters using the

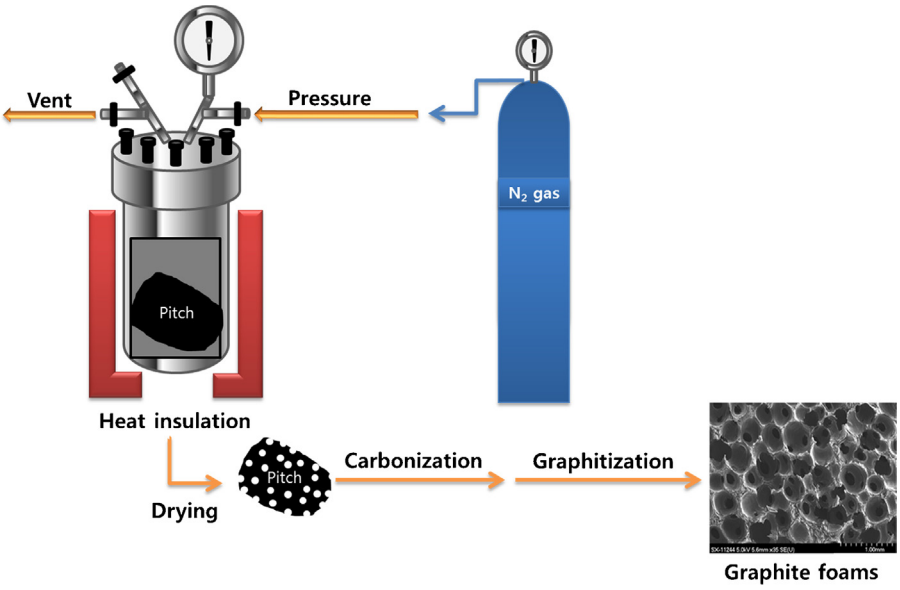

Fig. 1. Process of preparing graphite foams via the blowing method.