EFFECT OF PROCESSING CONDITIONS ON PROPERTIES OF GRAPHITE FOAMS

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Abstract

Oak Ridge National Laboratory (ORNL) has developed a process for the production of mesophase pitch-based graphite foam. This foam has density values between 0.2 and 0.6 g/cc and can develop bulk thermal conductivity between 40 and 180 W/m·K. Foam properties can be modified by varying the precursor material, the processing conditions, and/or heat treatment conditions. In the current research, we studied the effect of precursor choice and processing conditions on the final properties of the graphite foam. The results will be presented and discussed.

Keywords: A. Mesophase pitch; porous carbon; C. SEM; D. Thermal conductivity

1. INTRODUCTION

Most of the graphite foams produced at Oak Ridge National Laboratory since their discovery in 1997 [1] have utilized a synthetic mesophase pitch produced by Mitsubishi Gas Chemical Co. This precursor material produced foams with an average pore size of around 300 μm. Initial trials with a petroleum-derived mesophase pitch have shown that graphite foams with a much smaller pore size (~50 μm) can be produced [2]. However, petroleum-derived mesophase pitches can vary in composition, purity, and softening point. A better understanding of the foaming behavior of petroleum-derived mesophases is required to be able to control foam properties and tailor them for a given application.

The research reported here focused on the evaluation of the foaming characteristics of three petroleum-derived mesophases (provided by Conoco), and compared them to the foaming characteristics of the synthetic AR mesophase pitch produced by Mitsubishi Gas Chemical Co.

2. EXPERIMENTAL

2.1 *Sample preparation*

Foam samples were prepared utilizing three petroleum-derived mesophases (supplied by Conoco), and the synthetic AR mesophase pitch produced by Mitsubishi Gas Chemical Co. The three Conoco mesophases varied in softening point, P1 having the highest softening point and P3 the lowest; however, all the Conoco mesophases had higher softening points than the AR mesophase.

The effect of three heating rates during foaming were investigated: slow (A), medium (B), and fast (C). All foam samples were carbonized and graphitized under the same conditions. Table 1 lists the twelve samples prepared under this project and their process conditions.

2.2 *Sample characterization*

Graphite foam samples were evaluated under SEM to determine the pore size and texture. Density, electrical resistivity, thermal conductivity, and anisotropy ratios were determined for all samples.

3. RESULTS AND DISCUSSIONS

Precursor Conoco P1 did not foam at heating rate A. Foams were obtained at all other conditions.

Figures 1, 2, and 3 show SEM images of all the foams produced in this project. From Fig. 1, it is observed that foam produced from precursor Conoco P2 at foaming heating rate A exhibited larger pores than foams produced from precursor P3 and AR at the same conditions.

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From Figs. 2 and 3, it is observed that foam produced from precursor Conoco P1, at either foaming rate B or C, exhibited the smallest pores; however, the presence of defects (voids and/or larger pores) was observed in these foams.

Foams produced from precursors P2, P3, and AR at foaming heating rates B and C had similar pore sizes; however, foams produced from precursor P3 exhibited pores that are more elongated.

4. CONCLUSIONS

Precursor P1 developed small pores at foaming heating rates B and C. Precursors P2 and P3 developed similar pore structure to that of AR mesophase despite their higher melting temperatures.

For a given mesophase choice, as heating rate increases thermal conductivity and density decrease, and electrical resistivity increases.

Of all conditions, foam produced from precursor Conoco P1 exhibited the best properties, i.e., high thermal conductivity, low electrical resistivity, high density, low anisotropy ratio.

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REFERENCES

[1] Klett JW. Process for making carbon foam; US Patent 6033506, 2000.

[2] Klett J, Hardy R, Romine E, Walls C, Burchell T. High Thermal Conductivity, Mesophase Pitch Derived Carbon Foams: effect of precursor on structure and properties. Carbon 2000; 38(7):953-973.

Table 1. Samples and their variables.

Precursor	Foaming Heating Rate		
	A	B	C
Conoco -P1	167-4	170-1	169-1
Conoco -P2	168-1	170-2	169-2
Conoco -P3	168-2	170-3	169-3
AR mesophase	168-3	170-4	169-4

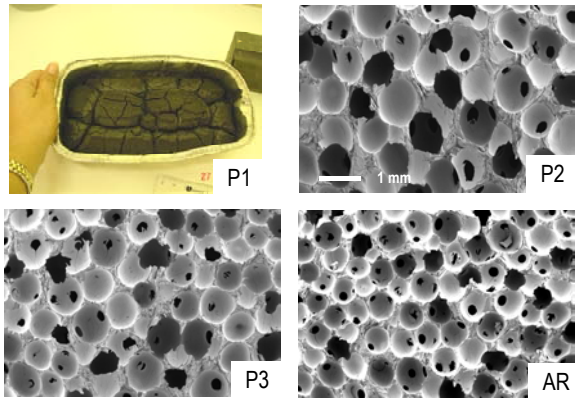

Fig. 1. Effect of precursor choice and **heating rate A** on pore size and texture (20X).

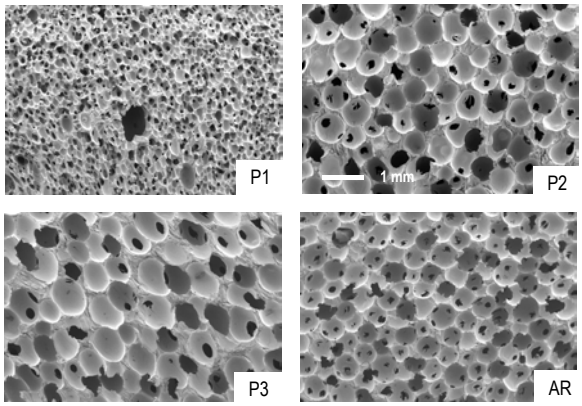

Fig. 2. Effect of precursor choice and **heating rate B** on pore size and texture (20X).

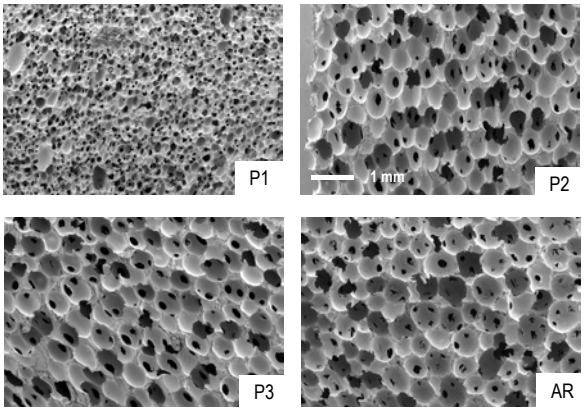

Fig. 3. Effect of precursor choice and **heating rate C** on pore size and texture (20X).

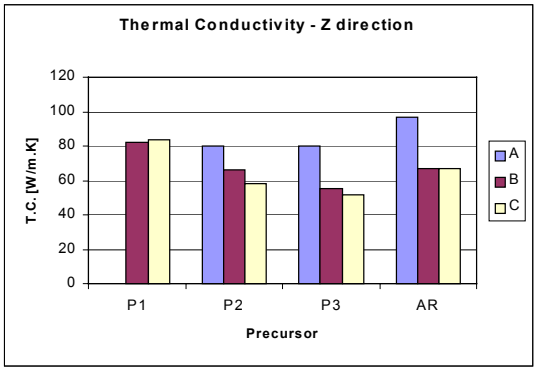

Fig. 4. Effect of precursor and heating rate on thermal conductivity.