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Effect of benzene–acetylene compositions on carbon black configurations produced by benzene pyrolysis

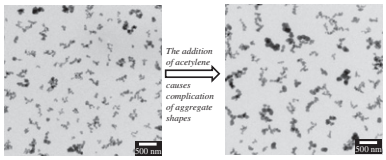
Kiminori Ono [a,*], Miki Yanaka [a], Yasuhiro Saito [a], Hideyuki Aoki [a], Okiteru Fukuda [b], Takayuki Aoki [b], Togo Yamaguchi [b]

[a] Department of Chemical Engineering, Graduate School of Engineering, Tohoku University, 6-6-07 Aoba, Aramaki, Aoba-ku, Sendai, Miyagi 980-8579, Japan
[b] ASAHI CARBON CO., LTD., 2 Kamomejima-cho, Higashi-ku, Niigata 950-0883, Japan

HIGHLIGHTS

- Aggregate shapes become complex with an increase in acetylene concentration.
- The number flow rate increases with an increase in furnace temperature.
- The mean primary diameter decreases with an increase in furnace temperature.
- The shapes most complicate when benzene–acetylene concentration ratio is about 2:1.

GRAPHICAL ABSTRACT



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ABSTRACT

A mixture of benzene and acetylene is pyrolyzed in an inert atmosphere to investigate the influence of the benzene–acetylene composition on the configurations of carbon black. The effects of benzene concentration, acetylene concentration, and furnace temperature on the mean primary particle diameter and the aggregate shape in carbon black are investigated. When the acetylene concentration is varied and the benzene concentration is made constant, aggregate shapes become complex with an increase in acetylene concentration. However, in the case where the acetylene concentration is greater than that of the benzene concentration, the variation of aggregate shapes is small with increasing acetylene concentration. The results of this study suggest that nucleation has progressed and aggregate shapes appear complicated when the ratio of the benzene concentration to the acetylene concentration is appropriate (in this study, the ratio is 2:1) and the furnace temperature is high. However, when the benzene or acetylene concentration is high, and the furnace temperature is low, aggregate shapes are simplified because of the formation of small polycyclic aromatic hydrocarbons (PAHs), which contributes to surface growth.

1. Introduction

Carbon black is a type of soot that is produced industrially and is used for composite materials such as tires and electrode materials of batteries. Although the smallest individual units of carbon black are aggregates, transmission electron microscopy (TEM) images show that these aggregates appear to be formed by spherical particles that are fused together [1]. The aggregate shape is one of the factors that affect the properties of composite materials. In the furnace process, carbon black is produced by the continuous pyrolysis of hydrocarbons, which are sprayed into a high-temperature field (1500–2000 K) inside the furnace. The process is complicated owing to the fact that chemical reactions occur rapidly with heat and mass transfer, and therefore, it is difficult to control the aggregate shape. Hence, the aggregation mechanism of carbon black has not yet been completely understood. At present, because the technique used to control the aggregation of carbon black particles is a trial-and-error process, a theoretical solution is required to precisely control the aggregate shape.

* Corresponding author. Tel.: +81 22 795 7251; fax: +81 22 795 6165.
E-mail address: kiminori@tranpo.che.tohoku.ac.jp (K. Ono).

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