Formation of Graphite Balloon through Catalytic Graphitization of Phenolic Resin Carbon by Globular Copper

Asao Oya, Masayuki Akiyama and Sugio Otani
Faculty of Technology, Gunma University
Kiryu, Gunma 376, Japan

(Received 10 January, 1980)

It has been well known that additions of some metals and inorganic compounds to carbon accelerate graphitization (so-called catalytic graphitization).\(^1,2\) In spite of many works carried out on this subject, less attention has been paid to the morphology of resulting graphite. The present authors obtained graphite balloons from a phenolic resin using globular copper as a graphitization catalyst. The structure and the formation mechanism of the balloons are briefly described in this note.

Globular copper (ca. 500 microns or less in diameter) was added to phenolic resin carbon by two procedures: (a) Copper was mixed with the phenolic resin\(^3\) at the curing stage in order to have good dispersion. The specimen was carbonized to 800°C in an inert atmosphere (Specimen A). (b) Copper was closely packed with the 800°C-phenolic resin carbon powder (−325 mesh) (Specimen B). Both types of carbon specimens containing copper were used for subsequent heat-treatment.

After heating the specimen A to above 2200°C at 50°C/min, balloons, approximately the same size as the original copper, were formed in phenolic resin carbon matrix as shown in Fig. 1. Some of them were taken off from the matrix (Fig. 2). In the specimen B, large irregularly shaped shells (Fig. 3) were also found together with the balloons. They were identified to be graphite by use of X-ray diffraction techniques. As can be seen from Fig. 2, the characteristic features of the balloons are (i) the existence of the pore suggesting a gush of the copper content after the formation of the graphite shell and (ii) orientation of graphite lamellae parallel to the balloon surface. Fig. 4 is a photograph of the shell near the pore indicated by the arrow in Fig. 2, where graphite crystals having a thickness of 2–3 microns (shown by the arrow) are observed. Copper was detected in the specimens heated below 2100°C but scarcely remained after heating to 2200°C.

On the basis of these observations, the following formation mechanism is suggested for the graphite balloon. During the heating process at 50°C/min, carbon dissolves into the copper particle, mainly near the particle surface, although its solubility is very low.\(^4\) When the heat-treatment temperature was further raised to near 2200°C, copper evaporates from the particle surface, resulting in the formation of the graphite shell encasing the original copper particle. To continue further removal of copper, a part of the encasing shell must be broken. As a result, the graphite balloon as shown in Fig. 2 is formed. The large one shown in Fig. 3 may come from a large copper particle formed through a coalescence of copper particles during heating.

It has been well known in cast iron that the morphology of the precipitated graphite is controlled from flake to spherulite by adding a small amount of specific elements.\(^5,6\) However, the catalytic graphitization technique has not been used for the preparation of graphite having a specific morphology. The ability of copper to produce such graphite balloons as shown in Fig. 2 is possibly dependent on the low carbon solubility in copper. If a large amount of carbon is rapidly dissolved throughout globular copper, the resulting graphite product should be formed not in the shape of a balloon but a spherulite. Copper disappears abruptly in a heat-treatment temperature range between 2100 and 2200°C. This phenomenon may be responsible for the formation...
Formation of Graphite Balloon through Catalytic Graphitization of Phenolic Resin Carbon by Globular Copper

Fig. 1

Fig. 2

Fig. 3

Fig. 4

of the pore shown in Fig. 2.

References