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Characteristic Analysis of Bulk Graphite according to Mixing Ratio of Carbon-based Filler and Organic Binder

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Introduction

Bulk graphite is fabricated by mixing a carbon-based filler and binder, repeating the process of shape forming, carbonization, impregnation, and re-carbonization, followed by graphitization at high temperatures in the range of 2,500 to 3,000℃ [1]. The mechanical, electrical, and thermal properties of bulk graphite are determined by filler amount, distribution of particles, and particle size. Among the various factors, the primary characteristics are determined by the mixing ratio of filler and binder[2].
This study measured the mechanical and electrical properties of bulk graphite in relation to the mixing ratio of a carbon-based filler and organic binder in order to determine the optimal mixing ratio that enhances each property.

Materials and Methods

This study used graphite waste remaining after processing EDM graphite (hereinafter "byproduct") as a carbon-based filler, and an organic binder. Bulk graphite was created by varying the amount of organic binder in the range of 5 to 25 wt.% during mixing with the byproduct. Uniform particles measuring 45 um to 63 u were used, and the fabricated mixing powder was pressed by uniaxial pressing at 120 MPa for 30 seconds. Carbonization was performed under N_2, with the temperature raised to 700℃ at 2℃/min and maintained for one hour. The flow rate of N_2 was 2 l/min.
Density, porosity, flexural strength and specific resistance were measured to analyse the mechanical and electrical properties of the fabricated bulk graphite. Measurements could not be obtained for a mixing ratio of 95wt.%:5wt.% due to the formation of cracks and fractures in the carbonization process. Density and porosity were measured based on the Archimedes method, and specific resistance was obtained using the fall-of-potential method. Flexural strength was calculated by conducting a three-point flexural test with a universal testing machine.

Results and Discussion

1. Density and Porosity

Fig. 1 shows the density and porosity of bulk graphite fabricated by mixing the byproduct and a phenol resin at varying ratios followed by shaping and carbonization.

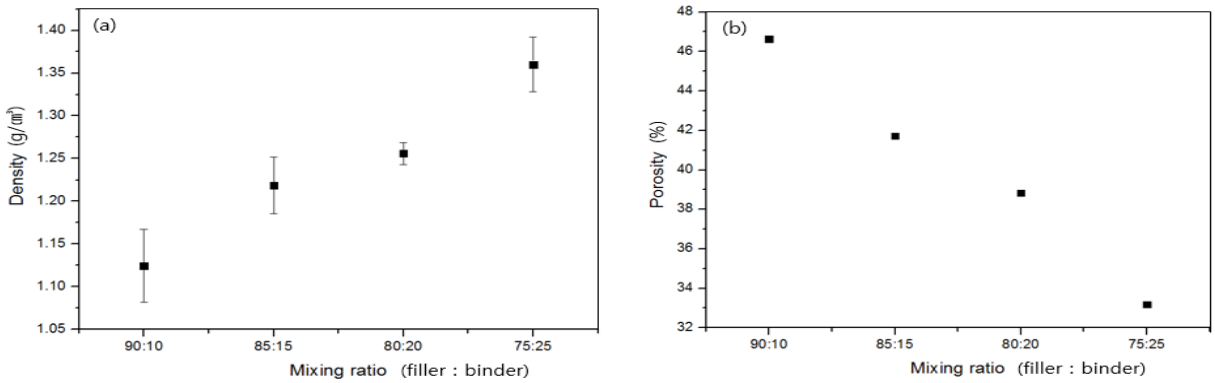

Figure 1 (a) Density and (b) porosity graphs of the fabricated bulk graphite on the ratio

The analysis of the mixing ratio of the byproduct and phenol resin showed that a ratio of 75wt.%:25wt.% gave the highest density and the lowest porosity.

2. Flexural Strength and Specific Resistance

Fig. 2 presents the flexural strength and specific resistance of bulk graphite fabricated by mixing the byproduct and phenol resin at varying ratios followed by shaping and carbonization.

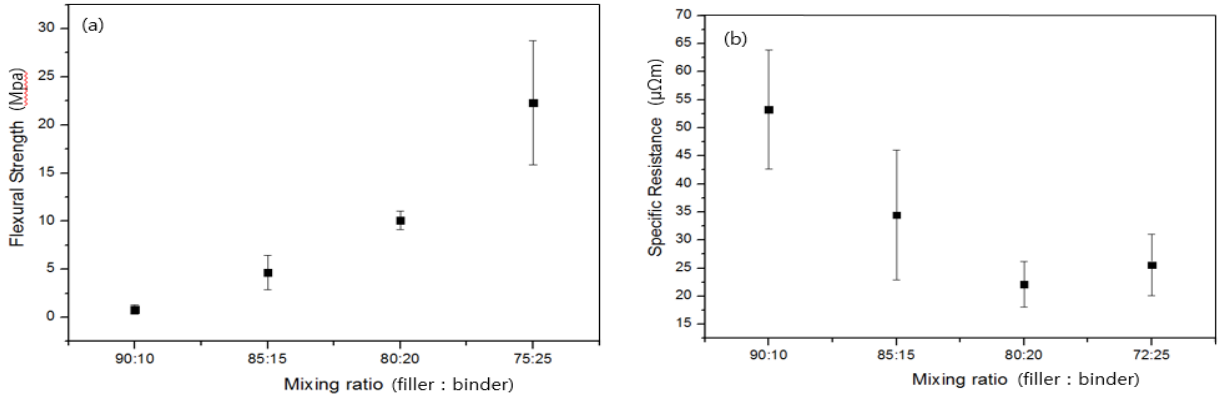

Figure 2. (a) Flexural strength and (b) specific resistance graphs of the fabricated bulk graphites according to the mixing ratio

The highest flexural strength of 22.3 MPa was obtained at a mixing ratio of 25 wt.%, and the smallest specific resistance of 22.1 μΩm was obtained at a mixing ratio of 20 wt.%. Density and flexural strength were the highest at a mixing ratio of 75wt.%:25wt.% because of the low porosity [3]. The binder wraps around each filler particle and connects the particles. The binder must be sufficiently available to connect the filler particles while minimizing porosity from the triple point between the three filler particles. A greater amount of binder is required to connect four or more filler particles. As such, filler particles cannot be connected three-dimensionally if the binder amount is less than 25 wt.%, which also leads to higher porosity and lower strength.

For the fabricated bulk graphite to have outstanding electrical conductivity, electrons should be able to flow easily from filler particles of high graphite crystallinity to other particles. Electrical conductivity is maximized when the filler particles are in direct contact with other particles. The increase in specific resistance at a binder amount of 25 wt.%, which gives the lowest porosity, can be explained by the binder interfering with direct contact between filler particles and other particles. As such, the lowest specific resistance is exhibited in specimens containing binder at 20 wt.% and having relatively higher porosity.

Conclusions

This study found that the amount of binder should be increased (25 wt.%) to improve the strength of bulk graphite, and slightly decreased (20 wt.%) to obtain higher electrical conductivity.

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