Investigation of Electrical Properties in Different Structural Varieties of Sri Lankan Graphite

C. Thusyanthy, G. Amaraweera, N. Attanayake *and* A. Wijayasinghe
Uva Wellassa University, Badulla, Sri Lanka

Introduction

Graphite is a crystalline polymorphic form of elementary carbon and it consists of parallel sheets of carbon in a hexagonal arrangement. Graphite is a soft mineral with black lead streak having a metallic lustre. Sri Lanka is the world's only significant source of crystalline vein graphite. It is very popular all over the world for its high purity and its high carbon content graphite (97-99%) (Herath, 1995). Sri Lankan natural graphite is exported as a cheap raw material and the only local graphite based industry is the pencil industry. Sri Lankan natural vein graphite is found in various morphologies with different structural and physical characteristics (Balasooriya and Bandaranayake, 2010). Four common morphologies of vein graphite have been identified from the Bogala and Kahatagaha-Kolongaha mines. They are coarse flakes of radial graphite, coarse striated-flaky graphite, needle platy graphite and shiny-slippery-fibrous graphite.

Natural graphite is a host material for lithium intercalation and there is a potential of using it as an active anode material for the rechargeable lithium cells. Among the requirements to be such an active anode material, electrical conductivity is a main factor and the candidate material should possess sufficient conductivity in the order of around 10^2 Scm^{-1} at operating temperature to support the anode function (Pushpaka *et al*, 2008). Further, there is only very limited work reported on morphology and structural characteristics of Sri Lankan natural graphite. Any information on the electrical behaviour of them, specially the electrical conductivity, has not yet been reported elsewhere. By considering these factors, this study was performed to identify suitable verities of Sri Lankan graphite based on their electrical conductivity.

Methodology

Natural Sri Lankan vein graphite from the Bogala mine situated in Kegalle district was used for this study. Identification of different structural varieties was done by visual inspections and then the selected structure variety samples were separated as small chips. These chips were then crushed in to powders by using a disk mill, after that the powder samples were rained by a centrifugal ball mill (Model 06.102/2188).

Then the selected graphite powder was subjected to mild oxidation by heat treating at 550 ^0C in air for 6 h in a tube furnace (model CTF/12/65/550). Thereafter both the raw powder and heat treated powder were pelletized by pressing cold uni-axially at a pressure of 100 MPa. The electrical conductivity measurements on them were performed by using the d.c. four probe techniques at room temperature. The schematic diagram of the d.c. four probe techniques developed for this study is given in Figure 1.

Results and discussion

Four common morphologies of vein graphite were identified from the graphite investigated from Bogala mines. They were coarse striated-flaky (BNG03), coarse flakes of radial (BNG04), needle-platy (BNG05) and shiny- slippery-fibrous graphite (BNG06). These four common morphologies of vein graphite are shown in Figure 1.

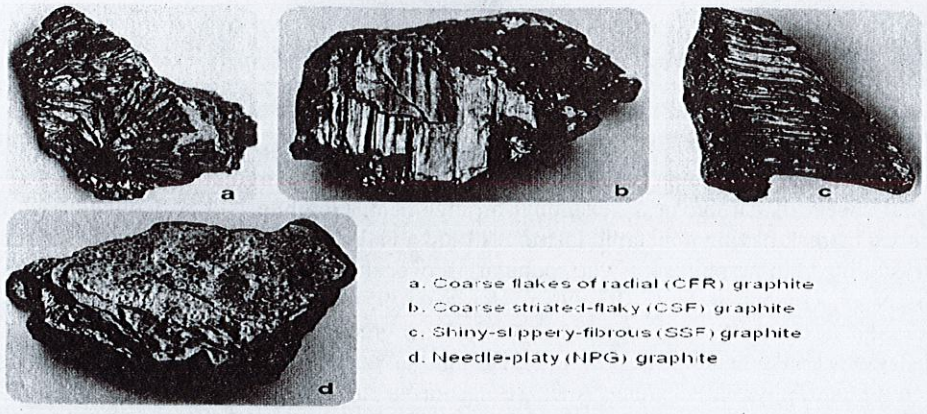

Figure 1: The four common morphologies of vein graphite identified in this study from the graphite investigated from Bogala mines.

Table 1: Electrical conductivity of different structural verities of Bogala graphite

Samples	Electrical conductivity σ[SCm^{-1}]	
	Raw samples (25^0C)	After heat treated (at 550^0C for 06 h)
Coarse striated-flaky graphite	1.16×10^3	3.99×10^2
Needle-platy graphite	9.24×10^2	1.20×10^3
Shiny- slippery-fibrous graphite	1.24×10^3	1.86×10^3

The electrical conductivity details of these structural varieties are given in Table 1. As seen in the table all these structural varieties of Bogala graphite possess the electrical conductivity in the order of around 10^2 Scm^{-1} at room temperature. Hence, it fulfils the electrical conductivity requirement to be an active anode material for the rechargeable lithium-ion batteries.

Further among these selected structural varieties, the Shiny-slippery-fibrous graphite structure shows the highest electrical conductivity. The mild oxidation by heat treatment of these structural varieties increases the electrical conductivity mostly in needle-platy graphite and shiny- slippery-fibrous graphite.

The present study reveals the promising characteristics of Sri Lankan natural graphite as intercalation anode material in rechargeable lithium battery applications due to its appropriate electrical conductivity, suitable morphology, low cost and high purity.

Conclusions

In the graphite samples collected at Bogala mines, four different structural varieties have been identified there are coarse flakes of radial graphite, coarse striated-flaky graphite, needle-platy graphite and shiny-slippery-fibrous graphite.

All these investigated Bogala graphites show of having sufficient electrical conductivity in the order of around 10^2 Scm^{-1} and show the potentiality for using as active anode materials for the rechargeable lithium-ion batteries.

Acknowledgements

The authors wish to thank the Institute of Fundamental Studies, Kandy and the Uva Wellassa University.

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