A High Capacity Natural Swedish Graphite - The Beneficial Effect of Jet-milling

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Natural graphite from several parts of the World (China, Brazil, Madagascar, etc.) have been tested as anodes in lithium-ion batteries. In 1996, Sanyo presented the first commercial battery exploiting natural graphite. The use of new natural graphite from the Swedish Woxna mine will be presented as an anode material in Li-ion batteries.

From an economic point of view, a natural graphite as anode material is an obvious choice. From a battery performance viewpoint, natural flake-shaped graphite is excellent. Flake-shaped graphite has high discharge capacity and packing density.[1] Natural graphite often contains two phases: hexagonal (2H) and rhombohedral (3R). In the 2H phase, graphene sheets are packed in an ABA… sequence; while, in the 3R phase, graphene sheets are packed in an ABCA... sequence. There is some controversy in the literature regarding precisely how the amount of 3R affects lithium-ion battery performance.[2-4] Several reports conclude that the presence of the 3R phase coincides with reduced irreversible capacity by inhibiting exfoliation from co-intercalation of solvents during cycling. It would therefore be interesting to find a method to increase the amount of 3R phase in natural graphite, reduce the often large particle sizes, yet retain the flake-like particle shape.

We found jet-milling to be such a method (Fig. 1). In jet-milling, the particles are accelerated by a high pressure jet stream, and the milling is accomplished as the particles collide with one another. Appropriate jet-milling gives deintercalation capacities (Table 1) as high as 371mAh/g: nearly equal to the theoretical value of 372mAh/g. Current density tests show that jet-milling also enhances the rate capability (Fig. 2).
Results from crude, Woxna high-purity fine grade, and jet-milled natural graphite will be presented. Electrode performance, current density testing, long term cycling results, etc. are correlated with the properties of the graphite.

Table 1. Electrochemical performance of Woxna natural graphites.

Sample	*Deintercal. cap. 1st cycle /[mAh/g]*	*Coulumbic efficiency ./%*
Jet-milled	371	76
Crude	330	83

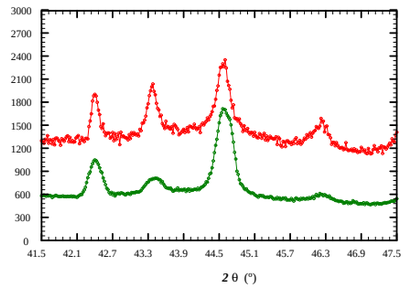

Fig 1. A region of the graphite XRD pattern. The upper trace is jet-milled graphite. The lower trace is Woxna high-purity fine grade. The two peaks from the 3R phase [(101) at 43.42° and (012) at 46.18°] are clearly larger for the jet-milled sample.

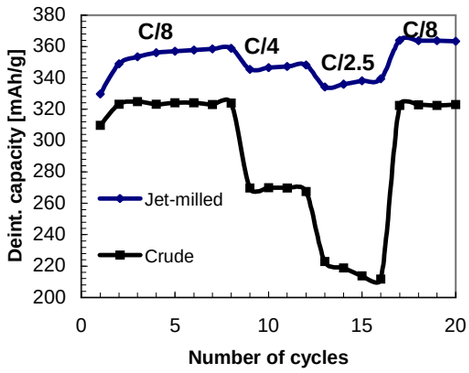

Fig 2. Current density testing for two graphite types.

REFERENCES

[1] F. Cao, I.V. Barsukov, H. J. Bang, P. Zaleski, and J. Prakash, J. Electrochem. Soc., **147**, 3579 (2000)
[2] H. Shi, J. Baker, M. Y. Saidi, and R. Koksbang, J. Electrochem. Soc., **143**, 3466 (1996)
[3] H. Huang, W. Liu, X. Huang, L.Chen, E.M. Kelder, and J. Schoonman, Solid State Ionics **110**, 173 (1998)
[4] K. Guerin, A. Fevrier-Bouvier, S. Flandrois, M. Couzi, B. Simon, and P.Biensan, J. Electrochem. Soc., **146**, 3660 (1999)