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Hung

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(54) **CARBON MATERIALS METAL/METAL OXIDE NANOPARTICLE COMPOSITE AND BATTERY ANODE COMPOSED OF THE SAME**

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(52) **U.S. Cl.** **429/231.8**; 252/182.1; 252/503

(58) **Field of Classification Search** 429/231.4, 429/231.8, 231.95, 232; 252/182.1, 503
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,543,378	A	8/1996	Wang	502/174
5,569,561	A	10/1996	Exnar et al.	429/335
5,795,679	A	8/1998	Kawakami et al.	429/218.1
5,965,297	A	10/1999	Fanteux et al.	429/231.8
6,007,945	A	12/1999	Jacobs et al.	429/218.1
6,103,393	A	8/2000	Kodas et al.	428/570
6,130,007	A	10/2000	Bi et al.	429/231.2
6,143,448	A	11/2000	Fauteux et al.	429/231.8
6,183,912	B1	2/2001	Nazri	429/231.8
6,232,264	B1	5/2001	Lukehart et al.	502/339
6,248,477	B1	6/2001	Howard, Jr. et al.	429/224
6,255,017	B1	7/2001	Turner	429/218.1
6,268,085	B1	7/2001	Manthiram et al.	429/214
6,316,143	B1	11/2001	Foster et al.	429/218.1
6,391,494	B1	5/2002	Reitz et al.	429/219
6,495,291	B1 *	12/2002	Kohno et al.	429/231.8
6,761,744	B1 *	7/2004	Tsukamoto et al.	429/231.95 X
6,797,428	B1 *	9/2004	Skotheim et al.	429/231.95 X

OTHER PUBLICATIONS

Ching-Cheh Hung, "Ferric Chloride-Graphite Intercalation Compounds Prepared from Graphite Fluoride." Carbon, vol. 33, No. 3, pp. 315-322, 1995, month unknown.

Ching-Cheh Hung, "Carbon Materials Embedded with Metal Nanparticles as Anode in Lithium-Ion Batteries," Carbon Conference 2001, Lexington, KY, Jul. 14-19, 2001.

* cited by examiner

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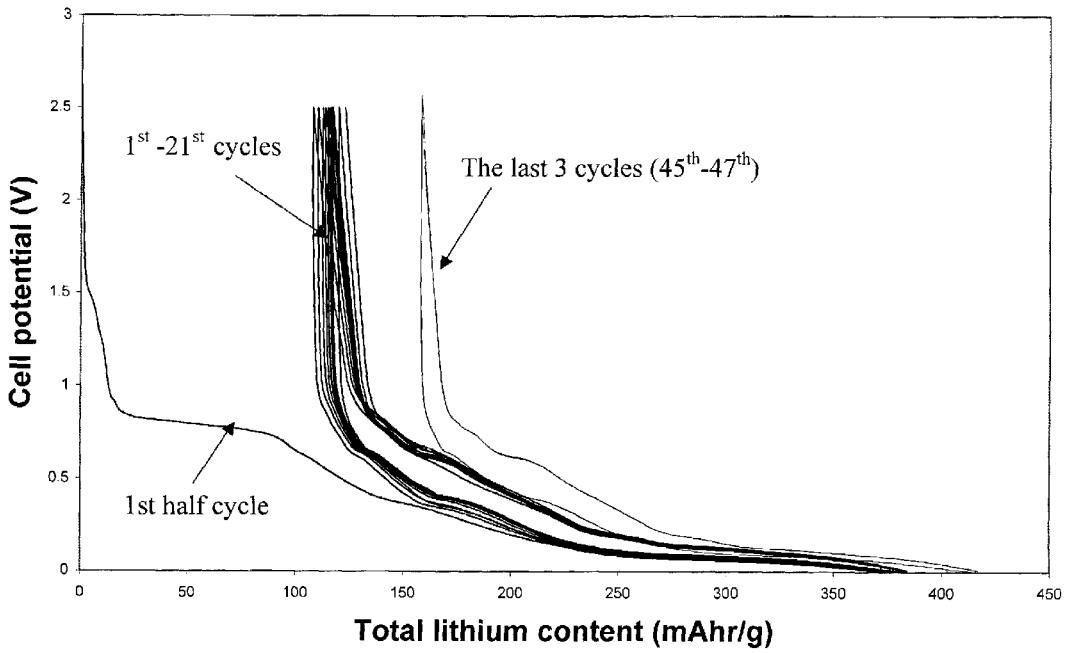
(57) **ABSTRACT**

A method of forming a composite material for use as an anode for a lithium-ion battery is disclosed. The steps include selecting a carbon material as a constituent part of the composite, chemically treating the selected carbon material to receive nanoparticles, incorporating nanoparticles into the chemically treated carbon material and removing surface nanoparticles from an outside surface of the carbon material with incorporated nanoparticles. A material making up the nanoparticles alloys with lithium.

12 Claims, 4 Drawing Sheets