Fe_3O_4–CONTAINING MULTILAYER GRAPHENE FOR ENHANCED LITHIUM STORAGE CAPABILITY

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Graphene is considered as replacement for graphite, the state-of-the-art material for lithium-ion battery (LIB) anodes [1]. However, it is not clear whether it can really outperform graphite in terms of delithiation voltage, cycling stability and volumetric capacity [1,2]. In this respect, we present a novel ionic liquid microwave-assisted synthesis of Fe_3O_4-containing multilayer graphene (hereinafter called MUG-Fe_3O_4) showing exceptional high rate performance due to the formation of metallic iron upon the 1st lithiation.

The characteristic structure and morphology of the composite has been investigated, through different physical and chemical analysis, in order to prove its peculiarity in terms of structural arrangement between the Fe_3O_4 nanoparticles and the multilayer graphene matrix (Fig. 1).

The use of MUG-Fe_3O_4, as LIB anode active material, and its comparison with the bare multilayer graphene (hereinafter called MUG) and commercial graphite, revealed the enhanced lithium ions storage properties of this material in the 0.005V-1V potential range. Indeed, especially at high currents (i.e., 5 A g^{-1}), improved rate capability, remarkable cycling stability, low average delithiation voltage (0.244 V) (Fig. 2 a,b) and a substantial increase of volumetric capacity with respect to commercial graphite (58.7 Ah L^{-1} vs. 9.5 Ah L^{-1}) are achieved (see Table).

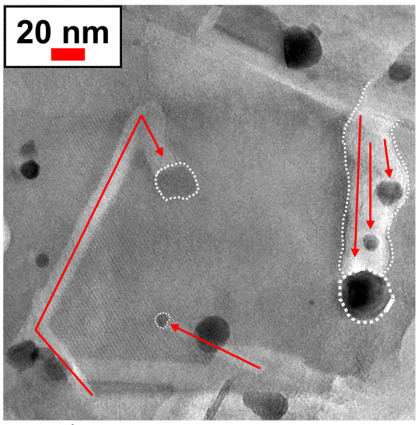
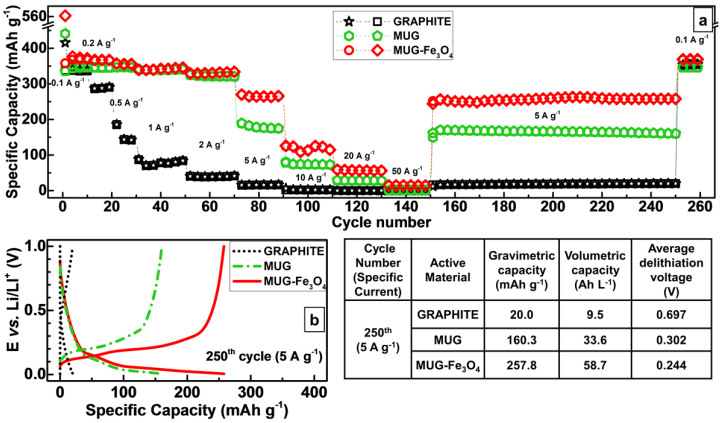


Figure 1: MUG-Fe_3O_4 TEM micrograph. Fe_3O_4 nanoparticles are outlined with white round dot dashes and, the carving paths, are indicated with red arrows



Cycle Number (Specific Current)	Active Material	Gravimetric capacity (mAh g^{-1})	Volumetric capacity (Ah L^{-1})	Average delithiation voltage (V)
250th (5 A g^{-1})	GRAPHITE	20.0	9.5	0.697
	MUG	160.3	33.6	0.302
	MUG-Fe_3O_4	257.8	58.7	0.244

Figure 2: Graphite, MUG and MUG-Fe_3O_4: (a) rate capability test comparison at different specific currents and (b) potential profiles of a selected cycle (250th) at 5 A g^{-1}.

Table: Comparison of the specific gravimetric and volumetric capacities and average delithiation voltages.

[1] R. Raccichini, A. Varzi, S. Passerini, B. Scrosati, Nat. Mater. 14 (2015) 271-279.

[2] M.N. Obrovac, V.L. Chevrier, Chem. Rev. 114 (2014) 11444-11502.