Influence of Carbon on the Structure and Electrochemical Performance of $Li_4Ti_5O_{12}$ Electrodes

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Introduction

$Li_4Ti_5O_{12}$ has a good reversibility and experiences no structural change (zero-strain insertion material) during the charge discharge cycling. Thus $Li_4Ti_5O_{12}$ is a good candidate as negative electrode for solid state lithium ion batteries and liquid type. In this work, we report on synthesis of zero-stain insertion material with carbon additives. The influence of carbon of the carbon on the structure, particle morphology and particle size were investigated. of the material and its particle shape and size are studied.
The intent of the present paper is to extend our previous studies[1, 2] on $Li_4Ti_5O_{12}$ by providing a systematic analysis of a series of materials with different microstructures and morphologies obtained by a new synthesis procedure.

Experimental

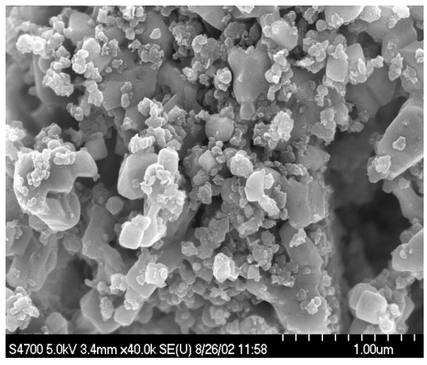
The $Li_4Ti_5O_{12}$ (Li-Ti-O ternary phase) powders were prepared from TiO_2 (Anatase), Li_2CO_3 and carbon that was mixed by two methods: jar milling and ball milling. These mixtures were then heat treated at 850°C in flowing nitrogen to obtain the desired phases. X-ray diffraction and SEM were used to analyze the products and to identify TiO_2 residue in the final powder. The weight loses of ternary powders was monitored by TGA to optimize the reaction temperature for synthesis. The electrochemical studies were carried out on electrodes prepared from slurries containing $Li_4Ti_5O_{12}$, carbon black and PVDF binder that was coated on Al Exmet. The electrodes were dried under vacuum at 85°C for 24 h before use. The studies were performed in 4-cm^2 laboratory cells (two electrodes) with Li counter electrodes;
Li metal(-)/EC-DMC-$LiClO_4$/$Li_4Ti_5O_{12}$(+).
The discharge-charge cycles and slow cyclic voltammery were carried out galvanostatically and potentiostatically (Macpile^R, Claix, France). All experiments were performed at 25°C.

Results

The color of the samples obtained by both methods were gray, indicating that the samples were electronic conductors. The SEM images (Fig. A, B) show that different particles shapes are obtained, depending on the carbon precursor used in the synthesis of $Li_4Ti_5O_{12}$. The carbon particles form an electronic network between the lithium titanate particles. During discharge, the voltage drops quickly to below 2 V and decreases as the reaction proceeds until the voltage reaches about 1.5 V. The cells were cycled between 1.2 V and 2 V. The results suggest that $Li_4Ti_5O_{12}$ has a very good cycle life. The wide variety of particle sizes (from nano to sub-micron) and shapes that were obtained leads us to conclude the synthesis procedure is suitable for optimization of the physical properties of the particles.

References
1 A. Guerfi, S. Sévigny and K. Zaghib , 11 IMBL, Monterey CA, June 2002, abstract N° 45.
2 A. Guerfi , S. Sévigny, M. Lagacé, P. Hovington and K. Zaghib, The 100th Meeting of the Electrochem. Soc., Philadelphia, Extended Abstract N° 823, May 2002.

A) With carbon black (50m^2/g)



B) With high surface area carbon (2000m^2/g)