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# Electrodeposition of MnO<sub>2</sub> on VACNT and the use of these composites in supercapacitor devices

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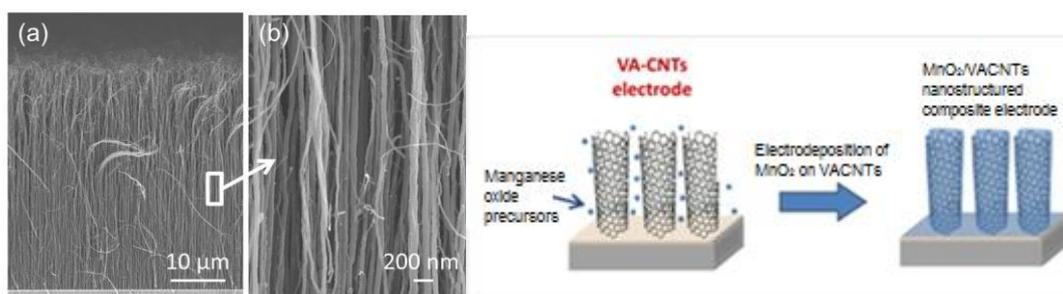
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Manganese oxide is one of the most promising oxide based composites due to its low cost, friendly environmental aspect and pseudocapacitive performances<sup>1 2</sup>. The electrochemical performances of MnO<sub>2</sub> are largely dependent on its morphological properties and specific surface area. The association of carbon nanotubes (CNT) with MnO<sub>2</sub> can be interesting in order to improve the electronic conductivity and the electrochemical performances of the composite. Nevertheless, the main works use a chemical way for the preparation of the composites that is why the morphological control is still difficult<sup>3 4</sup>.

In this work the vertically aligned CNT (VACNT) films previously grown on stainless steel by aerosol-assisted CCVD<sup>5</sup> are used as 3D matrix host for the electrodeposition of nanostructured MnO<sub>2</sub>. The main objective is to optimize the electrochemical parameters in order to deposit homogeneously the oxide inside the entire depth of the films. The MnO<sub>2</sub>/CNT ratio is optimized to obtain the best performances in term of specific capacitance and impedance. The electrodeposition is made in different media and from different MnO<sub>2</sub> precursors. Similarly, various electrochemical techniques such as cyclic voltammetry, chronopotentiometry or sequenced chronopotentiometry are used for the electrodeposition. Various parameters have been studied including the size of the CNTs and their coating depending on the used technique, the deposition time, the applied potential and/or current.

Electrochemical characterization (cyclic voltammetry, galvanostatic cycling, and electrochemical impedance spectroscopy) of the nanocomposite CNT-MnO<sub>2</sub> are performed. A three electrodes cell is used for the deposition and the electrochemical studies of the nanocomposite to highlight accurately the electrochemical behavior of the electrode. The materials and composites have been characterized by scanning and transmission electron microscopy (SEM, TEM, SEM-EDX and XPS) in order to examine the morphology, the localization and the thickness of the MnO<sub>2</sub> deposit. Indeed, in addition to its dependence to MnO<sub>2</sub>/CNT mass ratio, the electrochemical performances of the nanocomposite are also linked to the thickness (resistivity of the MnO<sub>2</sub> film) and the homogeneity of the deposits (depth of deposition). These composites are then used as electrodes for supercapacitors.



**Figure:** SEM micrograph of (a) VACNT carpet grown on stainless steel substrate (showing (b) the very good alignment degree of the nanotubes)

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