Nanocomposites based on electronically conducting polymers / aligned carbon nanotubes for electrochemical storage in liquid media

Mathieu PINAULT[a], Florent TATARD[a,b], Marina PORCHER [a,b,c], Sébastien LAGOUTTE[b], François TRAN-VAN[c] , Fouad GHAMOUSS[c], Martine MAYNE-L'HERMITE[a] Pierre-Henri AUBERT[b]

[a] CEA-IRAMIS-SPAM, Laboratoire Francis Perrin, CNRS URA 2453, Gif-sur-Yvette, France
[b] Laboratoire de Physico-chimie des Polymères et des Interfaces (LPPI), EA 2528, Université de Cergy-Pontoise, France
[c] Laboratoire de Physico-chimie des Matériaux et des Biomolécules (PCMB), EA 4244, Université François Rabelais, Tours, France
e-mail: mathieu.pinault@cea.fr

Abstract

One of the obstacles in transportation (urban or military) is the use of autonomous electrical power sources (rechargeable batteries, fuel cells, etc.). These devices do not allow for high enough specific powers, needed for the different type of applications they are expected for and limit their dynamical performances. For several years, developments have been achieved and have led to the development of supercapacitors. These components are characterized by much higher specific energies compared to classical capacitors as well as higher specific powers compared to electrochemical batteries
Recently, with the development of supercapacitors, electronically conducting polymers (ECPs) have been suggested as promising materials for electrode elaboration due to their capacitance that can theoretically reach 200 to 1000F/g with polythiophene, polyaniline or polypyrroles derivatives.[1-4] Nevertheless, as most of the ECP, their low cyclability is still the limiting factor for a large development and their use for electrode elaboration often lead to an important decrease of electrode capacitance (80-100F/g). In order to solve this problem nanostructuration of the ECP and its use with ionic liquids could be considered as a promising way.
In this study, we present the elaboration of nanocomposites made of poly(3-methylthiophene) (P3MT) as ECP electrodeposited onto nanostructured electrode made of aligned multiwalled carbon nanotubes (CNTs) (Fig.1) obtained by aerosol-assisted CCVD [5-6]. We will present the optimization of the electropolymerization parameter leading to controlled thickness of the ECP on the CNT acting as a template electrode and to the homogeneity of the coating in the depth of the carpet (TEM, SEM), depending on several parameters (concentration, current density, galvanostatic profile…). SEM coupled with EDX analyses have been performed along the aligned MWNT carpet cross section after electropolymerization of the ECP in order to investigate the spatial chemical elements distribution and specially the sulfur one that could be linked to the presence of the P3MT at the surface of the MWNT. Figure 2b confirms the homogeneous distribution all along the carpet length from the bottom to the top. TEM images (Figure 2 c) have also been performed in order to confirm the presence of the polymer as a uniform layer covering the external surface of each MWNT and evaluate the morphology and thickness of the polymer layer. Preliminary results concerning the elaboration and the performance of nanostructured ECP/aligned nanotubes will be presented, showing a significant increase of the specific capacitance Cm of the nanocomposite (180 F/g) and the possibility to obtain self-supported and flexible nanocomposite carpets.

References

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Figures

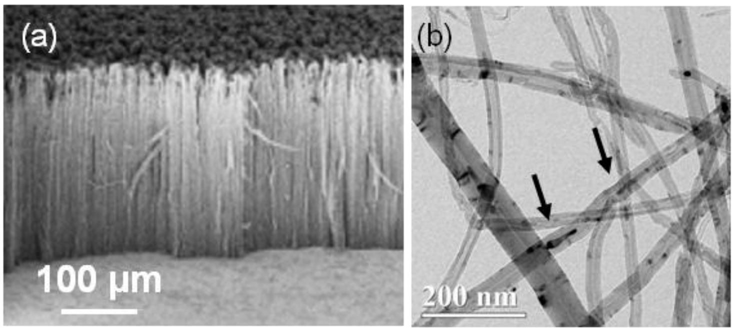

Fig. 1 SEM(a) and TEM (b) images of aligned MWNT carpets before polymers grafting.

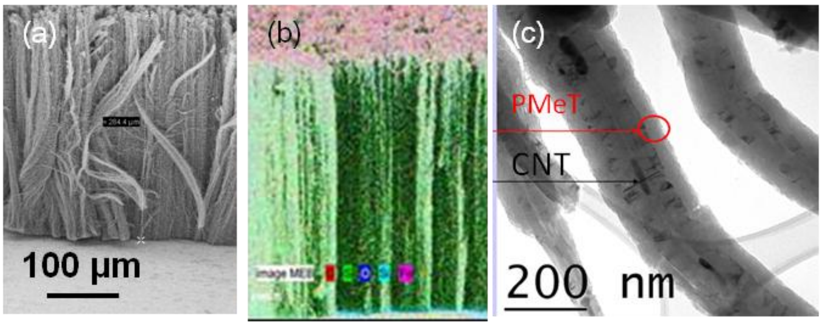

Fig. 2: (a-b) SEM-EDX micrograph showing the homogeneous sulphur atom (in green) localization onto the aligned nanotubes carpet. (b) TEM micrograph of individual CNTs recovered by an electrosynthesized P3MT in ionic liquid media