Enhancement of capacitive performance in titania nanotubes modified by an electrochemical reduction method

ABSTRACT

Highly ordered titania nanotubes (TNTs) were synthesised by an electrochemical anodization method for supercapacitor applications. However, the capacitive performance of the TNTs was relatively low and comparable to the conventional capacitor. Therefore, in order to improve the capacitive performance of the TNTs, a fast and facile electrochemical reduction method was applied to modify the TNTs (R-TNTs) by introducing oxygen vacancies into the lattice. X-ray photoelectron spectroscopy (XPS) data confirmed the presence of oxygen vacancies in the R-TNTs lattice upon the reduction of Ti^{4+} to Ti^{3+}. Electrochemical reduction parameters such as applied voltage and reduction time were varied to optimize the best conditions for the modification process. The electrochemical performance of the samples was analyzed in a three-electrode configuration cell. The cyclic voltammogram recorded at $200\,mV\,s^{-1}$ showed a perfect square-shaped voltammogram indicating the excellent electrochemical performance of R-TNTs prepared at $5\,V$ for $30\,s$. The total area of the R-TNTs voltammogram was 3 times larger than the unmodified TNTs. A specific capacitance of $11.12\,mF\,cm^{-2}$ at a current density of $20\,\mu A\,cm^{-2}$ was obtained from constant current charge-discharge measurements, which was approximately 57 times higher than that of unmodified TNTs. R-TNTs also displayed outstanding cycle stability with 99% capacity retention after 1000 cycles.

Keyword: Titania nanotubes; Electrochemical reduction method; Supercapacitor