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Electrochemical performance of supercapacitors formed by PAni/FC and PAni/CNT/CF

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Introduction

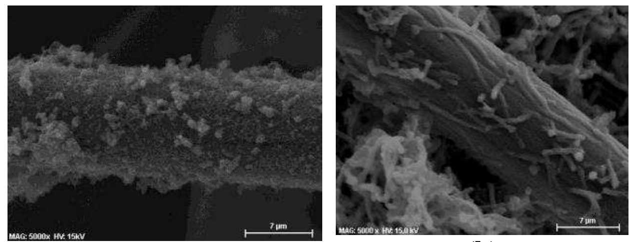
The development of modern devices, which enables solutions for the global energy problem with less environmental impact, has been the subject of intense research. Among them, supercapacitors and batteries are the most studied. These devices require the search of new materials as electrodes with high efficiency. In this context, the conductor polymers are widely studied, mainly the polyaniline (PAni) due to its characteristics, such as high electrical conductivity, good electrochemical reversibility, low weight and good stability in air [1,2]. However, it has some disadvantages for practical application, such as low stability during cycling due to changes in volume with the process of charge/ discharge. To reduce this effect, several authors used a matrix, which serves as a template for the growth of the polymer. In this case, carbonaceous materials such as carbon nanotubes (NTC), carbon fiber (CF) among others, have proven to be excellent materials to orient the polymer chains during the synthesis process. According to this purpose, this work shows the development of binary and ternary composites, consisting of PAni/CF and PAni/CNT/CF, respectively. These composites were produced and characterized in order to evaluate their applicability as electrodes for supercapacitors. The high specific surface area of CF and CNTs increased considerably the performance of these conducting polymer devices.

Experimental Parte

The PAni/CNT/CF composites were synthesized by oxidative polymerization. For production of the ternary composite PAni/CNT/CF, the CF were cut in size 2x1 cm and weighed. The CNTs multi walls with 90% (Aldrich) were functionalized with H2SO4 and HNO_3 in the ratio 3:1 for 24 h. Then filtered and dried were dispersed in aqueous solution containing 0.1 mol L^{-1} of the surfactant sodium dodecyl sulfate. This solution was added into another solution containing distilled aniline (12.6 mmol L^{-1}) and 1.0 mol L^{-1} HCl, 3.0 mol L^{-1}NaCl. The CF were fixed in a platinum wire and placed in reaction medium. Another solution containing 1.0 mol L^{-1} HCl, 3.0 mol L^{-1} NaCl and 0.03 mol L^{-1} ammonium persulfate, $(NH_4)_2S_2O_8$, was added to the aniline solution with 90 min of the deposition times at -10^oC with vigorous stirring. The binary composites, PAni/CF, were produced in the same condition described above, but without CNTs with aim to observe its influence in the electrochemical properties of the electrode. The resulting composites were filtered and washed with 1.0 mol L^{-1} HCl, then dried under vacuum for 24 h. The composite morphologies were analyzed by scanning electron microscopy SEM analyses using a JEOL JSM-5310 system. The cells were assembled as a supercapacitor device, with two symmetric composite electrodes of the PAni/CF and PAni/CNT/CF (area: 1 cm×1 cm). Cyclic voltammograms were recorded from -0.44 to 0.44 V at a scan rate of 10mV s^{-1} and was subjected to charge–discharge cycling in the same potential range. The electrolyte used in assembling the cell was 1.0 mol L^{-1} H_2SO_4.

Results and discussions

Fig. 1a shows the SEM image of PAni/CF. It was observed an uniform deposition covering the entire surface of CF, while the Fig. 1(b) shows the CNTs coated by the polyaniline that besides to recover them promoted their high adherence to the CF forming the PAni/CNT/CF composite.



(a) **(b)**

Figure 1. SEM images of the (a) PAni/CF and (b) PAni/CNT/CF composites.

The composites were studied by cyclic voltammetry (CV). In Fig. 2 can be observed the CV curves for both composites were characterized with rectangle-like shape and symmetric response of ideal capacitive behavior.

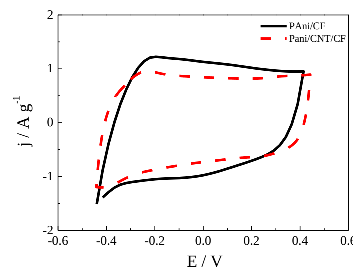


Fig. 2. Cyclic voltammetry of PAni/CF (solid line) and PAni/CNT/CF (dash line) electrode at 10 mV s-1.

The values of specific capacitance were calculated based on the weight of active materials for PAni/CF and in case of the PAni/CNT/CF including the CNT, in order to evaluate their capacitive performance. Fig.3 shows a small decrease in the capacitance value in the first 200 cycles, while the capacitance remains almost constant thereafter, which indicates that this electrode has a long-life electrochemical stability.

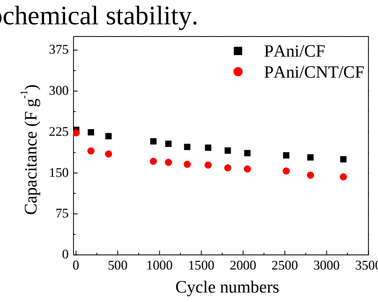


Fig 3. Stability tests of the PAni/CF and PAni/CNT/CF at constant i ±1.0 mA for 3200 cycles.

Conclusion

PAni/CF and PAni/CNT/CF composite electrodes showed high specific capacitance values, potentially viable for application in supercapacitors.

Acknowledgments

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[1] G. Boara, M.Sparpaglione, Synth Met 72(1995)135.
[2] K.A. Noh, D.W. Kim, C.S. Jin, et al. J. Power Sources 124 (2003) 593.