World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:16, No:01, 2022

Effects of Commonly-Used Inorganic Salts on the Morphology and Electrochemical Performance of Carboxylated Cellulose Nanocrystals Doped Polypyrrole Supercapacitors

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Abstract : Polypyrrole(PPy), as one of the most promising pseudocapacitor electrode materials, has attracted large research interest due to its low cost, high electrical conductivity and easy fabrication, limited capacitance, and cycling stability of PPy films hinder their practical applications. In this study, through adding different amounts of KCl into the pyrrole and CNC-COO^- system, three-dimensional, porous, and reticular PPy films were electropolymerized at last without the assistance of any template or substrate. Replacing KCl with NaCl, KBr, and NaClO4, the porous PPy films were still obtained rather than relatively dense PPy films which were deposited with pyrrole and CNC-COO^- or pyrrole and KCl. The nucleation and growth mechanisms of PPy films were studied in the deposited electrolyte with or without salts to illustrate the evolution of morphology from relatively dense to porous structure. The capacitance of PPy/CNC-COO^--Cl-(ClO4-)_0.5 films increased from 160.6 to 183.4 F g^{-1} at 0.2 A g^{-1}. More importantly, at a high current density of 2.0 A g^{-1} (20 mA cm^{-2}), the PPy/CNC-COO^--Cl-(ClO4-)_0.5 films exhibited an excellent capacitance of 125.0 F g^{-1} (1.19 F cm^{-2}), increasing about 203.7 % over PPy/CNC-COO- films. 103.3 % of its initial capacitance was retained after 5000 cycles at 2 A g^{-1} (20 mA cm^{-2}) for the PPy/CNC-COO^--Cl-(ClO4-)_0.5 supercapacitor. The analyses reveal that the porous and reticular PPy/CNC-COO^--salts films open up more active reaction areas to store charges. The stiff and ribbonlike CNC-COO^- as the permanent dopants improve strength and stability of PPy/CNC-COO^--salts films. Our demonstration provides a simple and practical way to deposit PPy-based supercapacitors with high capacitance and cycling ability.

Keywords : polypyrrole, supercapacitors, cellulose nanocrystals, porous and reticular structure, inorganic salts
Conference Title : ICECHPS 2022 : International Conference on Electrochemical Capacitor and Hybrid Power Sources
Conference Location : Rome, Italy
Conference Dates : January 14-15, 2022