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Sonochemical synthesis of nanostructured metal oxide coating on activated carbon for supercapacitor application

Kwang-Heon Kim and Kwang-Bum Kim
Department of Metallurgical Engineering, Yonsei University, 134 Sinchon-dong Seodamun-gu, Seoul, Korea

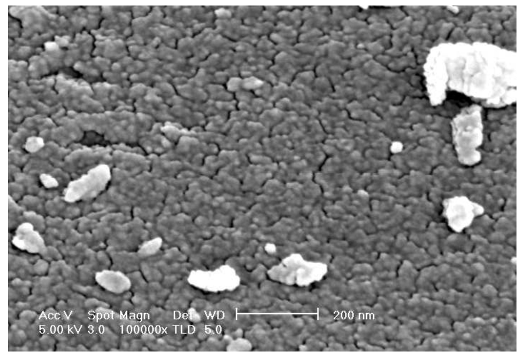
Carbon materials, such as activated carbon, carbon fibers, and carbon aerogels, are used for double layer capacitors because of their high surface area. On the other hand, comparatively lower surface area transition metal oxides, such as amorphous, hydrated ruthenium oxide, $RuO_2{\cdot}nH_2O$, have been studied for pseudocapacitors.

The double layer mechanism of energy storage is strictly a surface phenomenon, with higher active surface areas giving rise to higher specific capacitances. In contrast, the faradaic mechanism of energy storage is not limited to surface reaction; bulk reactions are also possible and contribute to energy storage in these kind of materials.

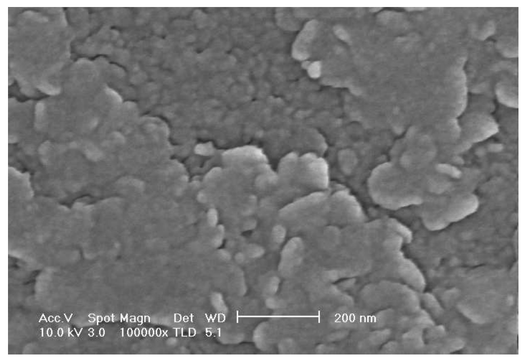
Charge storage on carbon electrodes is predominantly capacitive in the electrochemical double layer capacitor. There are, however, contributions from surface functional groups which are in general present on activated carbons and which can be charged and discharged giving rise to pseudocapacitance. In fact, with transition metal oxides like NiO, it appears that pseudocapacitance can amount to some 5-10% of theoretically realizable capacitance. It would be enhanced to nano-scale coat transition metal oxides such as $RuO_2{\cdot}nH_2O$, NiO, and MnO_2 throughout a high surface, double layer support such as activated carbon.

Sonochemistry, the use of power ultrasound to stimulate chemical process in liquid, is currently the focus in a wide range of chemical materials science and technology. The chemical effects of ultrasound arise from acoustic cavitation (the formation, growth, and implosive collapse of bubbles in a liquid). During cavitational collapse, intense heating of the bubbles occurs. These hot spots have temperatures of roughly 5000 K, pressures of about 1000 atmospheres, and cooling rates above 10^{10} K/s. These extreme conditions attained during bubble collapse have been exploited to prepare nanoparticles of metals, alloys, metal carbides, metal oxides, and metal sulfides.

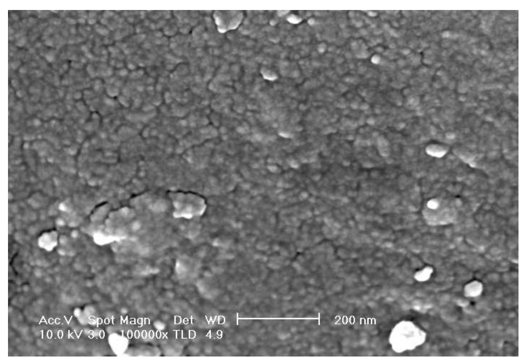
In this study, we prepared nanostructured metal oxide coated activated carbon powders using sonochemical synthesis. The morphological, thermal, and electrochemical properties of coated materials were investigated by XRD, Raman, TEM, SEM, and electrochemical methods.



(a)



(b)



(c)

Fig. (a) activated carbon(1500 m^2/g), (b)NiO - coated on activated carbon, (c) RuO_2 coated on activated carbon