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Do porosity templates improve the performance of supercapacitor electrode materials?

It is well recognised that to fully harness the potential of renewable energy generation, advances in materials to store and release that captured energy are required. Supercapacitors, with their fast charge-discharge rates, long life span, and high power density are one of the most promising targets for such applications. In order to maximise the performance of supercapacitors, electrode materials optimised to deliver high and stable capacitance as well as high conductivity over many charge-discharge cycles need to be developed. Recently mixed metal oxides have been investigated for this purpose as pristine transition metal oxides tend to be poor conductors. Binary transition metal oxides (BTMOs) are emerging as particularly intriguing novel material for the electrodes in these supercapcitors due to their wide potential window, superior conductivity, and improved stability. [1,2]

One of the main issues with these materials is a relatively low surface area and physical deformations that can occur during the charge-discharge cycle. This could be alleviated by making these materials more porous and the actual pore size and distribution may be controllable using a template during the synthesis of the electrode material.

We have investigated the use of nickel molybdate (NiMoO4) and two different soft-templating agents - naturally sourced eggshell membranes and fully synthetic polymethylmethacrylate (PMMA) – as electrode materials for supercapacitor applications. The egg shell membrane provides a fibrous random template while the PMMA is considered a more regular arrangement which we postulated would lead to differences in pore size and distribution throughout the synthesised material.

NiMoO4 electrode material with and without a pore template was synthesised from simple salts by a solvothermal combustion synthesis method. The electrochemical properties of the resulting materials revealed that NiMoO4 synthesised with eggshell membrane as a template showed superior performance to both non-templated material and that using a PMMA template. The best performing material had a specific capacitance of 260 Fg-1, four times greater than that of non-templated material, when tested with a two electrode cell configuration in 2M NaOH electrolyte. The superior electrochemical performance of the eggshell templated material will be discussed with respect to differences in the surface chemistry and mesoporosity of the templated material.

[1] Senthilkumar et al RSC Advances, 2013, 3, 352.
[2] Zhang et al. J. Mater. Chem. A, 2015, 3, 43.

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