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Evaluation of Electrophoretic and Electrospray Deposition Methods for Preparing Graphene and Activated Carbon Modified Nano-Fibre Electrodes for Hydrogen/Vanadium Flow Batteries and Supercapacitors

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Abstract : In this work, we perform electrophoretic deposition of activated carbon on a number of substrates to prepare symmetrical coin cells for supercapacitor applications. From several recipes that involve the evaluation of a few solvents such as isopropyl alcohol, N-Methyl-2-pyrrolidone (NMP), or acetone to binders such as polyvinylidene fluoride (PVDF) and charging agents such as magnesium chloride, we display a working means for achieving supercapacitors that can achieve 100 F/g in a consistent manner. We then adapt this EPD method to deposit reduced graphene oxide on SGL 10AA carbon paper to achieve cathodic materials for testing in a hydrogen/vanadium flow battery. In addition, a self-supported hierarchical carbon nano-fibre is prepared by means of electrospray deposition of an iron phthalocyanine solution onto a temporary substrate followed by carbonisation to remove heteroatoms. This process also induces a degree of nitrogen doping on the carbon nano-fibres (CNFs), which allows its catalytic performance to improve significantly as detailed in other publications. The CNFs are then used as catalysts by attaching them to graphite felt electrodes facing the membrane inside an all-vanadium flow battery (Scribner cell using serpentine flow distribution channels) and efficiencies as high as 60% is noted at high current densities of 150 mA/cm^2. About 20 charge and discharge cycling show that the CNF catalysts consistently perform better than pristine graphite felt electrodes. Following this, we also test the CNF as an electro-catalyst in the hydrogen/vanadium flow battery (cathodic side as mentioned briefly in the first paragraph) facing the membrane, based upon past studies from our group. Once again, we note consistently good efficiencies of 85% and above for CNF modified graphite felt electrodes in comparison to 60% for pristine felts at low current density of 50 mA/cm^2 (this reports 20 charge and discharge cycles of the battery). From this preliminary investigation, we conclude that the CNFs may be used as catalysts for other systems such as vanadium/manganese, manganese/manganese and manganese/hydrogen flow batteries in the future. We are generating data for such systems at present, and further publications are expected.

Keywords : electrospinning, carbon nano-fibres, all-vanadium redox flow battery, hydrogen-vanadium fuel cell, electrocatalysis
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