Dopant-Driven Morphological Control of SnO_2 Nanofibres – from Solid to 'Loose-tube' Fibres

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Tin oxide-based materials have received considerable attention as electrode materials for a wide range of applications in the field of energy storage and conversion. Recently, SnO2 has been used as an alternative to conventional carbon electrocatalyst support in Proton Exchange Membrane Fuel Cells (PEMFC)[1]. One of the principal driver behind the search for an alternative to carbon is to overcome the issue of degradation of the carbon support caused by corrosion or oxidation as this leads to aggregation, migration and loss of the electrocatalyst nanoparticles, degrading the PEMFC electrode performance.

In particular, one-dimensional (1D) nanostructured SnO_2 such as nanofibres and nanotubes are of particular importance with their potentially unique electronic and structural properties. However, facile preparation of high-order nanostructured materials is not a trivial exercise. Several synthetic routes such as hydrothermal, microwave-assisted, templating, and gas-phase methods methods have been proposed, but they generally require strict synthetic conditions or complicated procedures. In contrast, electrospinning has emerged as a versatile and efficient method to fabricate organic and inorganic 1D materials[2]. Using electrospinning, SnO_2 hollow fibres or nanotubes are generally achieved by using multi-step processes and/or multiple-needles[3]: for instance, coaxial electrospinning, where phase separation between liquid phases is the main driver behind core/sheath and the derived hollow structures, and electrospinning of sacrificial template fibres followed by deposition of materials at the surface. Recently, the preparation of SnO_2 hollow structures by single-needle electrospinning has been reported, but under rather specific conditions, and without variation or control of the morphologies.

In this poster, we describe the fabrication and formation mechanism of complex hollow "fibre-in-tubes" structures using a one-pot, single-needle electrospinning method. The variation in morphology from dense fibres to "loose-tubes" (to borrow a terminology from fibre optic cables, where a fibre is located non-concentrically within a loose external sheath) can be controlled through solution/fibre composition and post-synthesis thermal treatment of the electrospun materials[4].

Previous study on SnO_2 hollow fibres have generally attributed such structures to a combination of the Kirkendall effect and gas expansion due to carrier polymer decomposition. Our study elucidated the formation mechanism of such 1D structures, showing that controlling the solution and hence the fibre composition drives the nanofibre morphology towards hollow, loose-tube structures through the alteration of the dominant factor affecting hollow fibre formation. This allows control of the morphology and dimensions of SnO2 electrospun materials through parameters such as heating rate, dopant and precursor concentrations. The obtained materials have been characterised by electron microscopy, thermogravimetric analysis, Raman spectroscopy, XPS, and XRD, and initial studies on their electronic conductivity, specific surface area measurements, and accelerated corrosion tests show that these SnO2 loose-tubes are promising electrocatalyst support material for fuel cells.

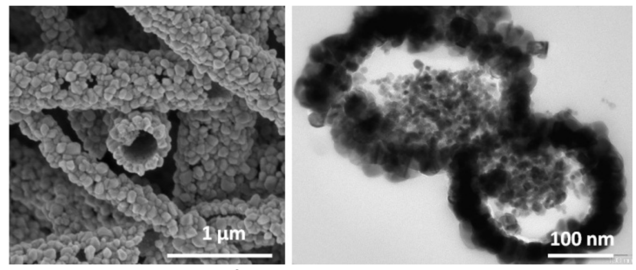

Figure 1. SEM (left) and TEM cross-section (right) images of the SnO_2 loose-tube fibres

References

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