Optimisation of fibre structure for solid oxide fuel cell anode using electrospinning technique

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In a world destroyed by fossil fuel depletion, a new era of green energy is about to begin. The development of fuel cells is one part of the solution to the world's problems, starting with the optimisation of the fuel cell anode.

The demand for energy is increaseing worldwide and coupled with the need to decrease emissions of greenhouse gases, a boom of research in renewable energy systems has been generated. One of the most efficient devices to convert chemical energy to electrical energy is the fuel cell. It enables production of fully carbon free electricity where the only exhaust is air and steam. However, to achieve the best conversion in a fuel cell, an efficient anode is necessary. We have proved that the structure of the anode can be completely transformed by a few simple changes to the experimental setup.

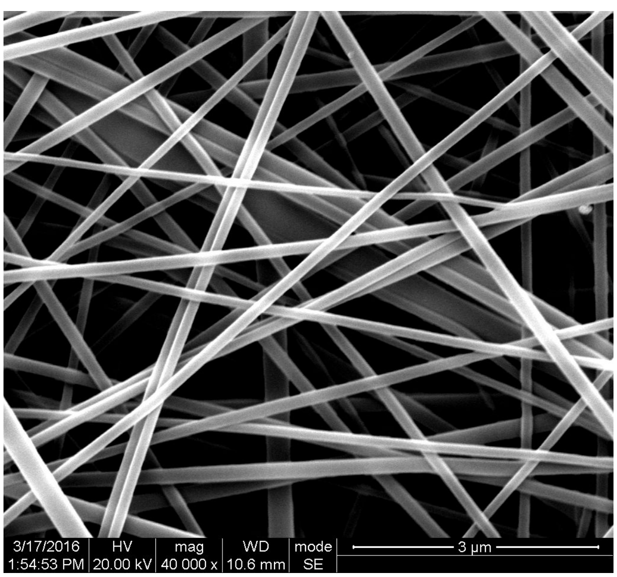

Figure 1: Electrospun nanofibres with 40 000x magnification

Nanofibres, or nanothreads, allow a high surface area per unit volume and consequently less material is needed. The most simple method for producing such fibres is called electrospinning and the only required equipment is; a high voltage power supply, a syringe and a collector plate. A solution containing the desired anode material and solvent is added to the syringe. The fibre production process is started by applying the voltage power and a constant flow of the solution. Fibres emerge when the strength of the electrical force of the voltage overcomes the surface tension of the solution. Like spider threads the fibres are elongated and attracted to the collector plate as a woven mat. Figure 1 displays a magnified image of the nanofibres.

This research has focused on a solid oxide fuel cell with nickel as the anode catalyst, a metal cheaper than platinum and gold which are common in commercialised fuel cells. Previous research at Louisiana State University has produced the structural core of the anode using electrospinning and then coated the nanofibres with the catalyst. In our work, the manufacturing steps needed have been decreased by combining nickel and the structural material during the electrospinning process, see figure 2, i.e. no additional coating step is necessary. By changing parameters such as the applied voltage, the distance between the needle and the collector, the polymer content (PVP), the desired fibre structure can easily be obtained.

A large surface area is required for the catalytic reactions, as the ones occurring in the anode. In our case, the total surface area of the anode is

Figure 2: A picture portraying a a) nickel containing fibre and b) nickel coated fibre

determined by the diameter of the fibres. While a smaller diameter will increase the surface area, it will decrease the strength of the material, making the anode more fragile. The balance of these properties is crucial in order to obtain a high performing fuel cell. The performed experiments established that the fibre diameter could be altered when changes to the electrospinning setup were made. When a higher strength in applied voltage was used it increased the diameter of the fibre. An increase in distance from needle to collector plate decreases the diameter. A connection between the PVP content, the viscosity and the fibre diameter was found. It was shown that higher polymer concentration increased the viscosity and gave broader fibres. This makes the material stronger but decreases the surface area needed for catalytic activity. Our research allows for more precise design of the diameter of the nanofibres, which makes it possible to produce fibres with a perfect balance between material strength and catalytic surface area. This will improve the performance and the strength of the material and move us one step closer towards a world run completely on renewable energy sources.

For further reading, see the full report:
Fabrication and evaluation of nickel containing nanofibres for solid oxide fuel cell anodes using electrospinning technique
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