Ultrasonically sprayed flexible thin film electrodes for implantable bio-fuel cells

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Carbon nanotubes are a promising material for flexible thin film electrodes for implantable bio-fuel cells due to their biocompatibility, their particular structure, and their conductivity [1]. CNTs demonstrate also exceptional chemical and mechanical properties (Young's modulus: 1.1 TPa, tensile strength: 37 TPa) [2], which makes them a promising material for use in flexible electronics [3, 4].

In this study, we have investigated an innovative technique to produce flexible thin CNT films by spraying multi-walled carbon nanotubes suspensions, dispersed by tween 80, on porous carbon paper substrates (Gas Diffusion Layer GDL). CNTs and carbon papers are both superhydrophobic and spray coating is a non-contact technique. So, here we discuss factors that control superhydrophobicity and CNTs network homogeneity. The spray deposition parameters investigated include inks viscosity, flow rate and air pressure.

Tween 80 acts like a wetting agent and prevent CNTs aggregation on substrate [5]. The affinity between the formulated ink and the substrate wettability were controlled by contact angle measurements.

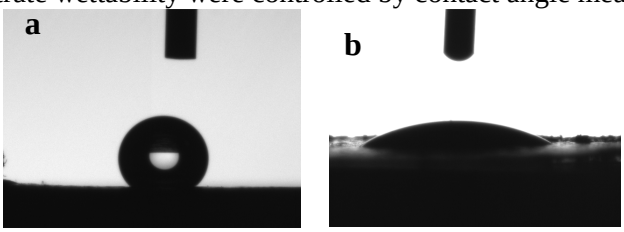

Fig. 1: Effect of surfactant on surface tension: (a) 5µl droplet of water without surfactant; and (b) 5µl droplet of CNTs/Tween 80 ink. The surfactant decreases clearly the surface tension of the droplet

Scanning electron microscopy (SEM) revealed high surface area carbon nanotube networks.

Sprayed film thickness, controlled by the sprayed layer number and the flow rate, were between 0.5 and 1.7 µm. Deposited weight was estimated via thermogravimetric analysis.

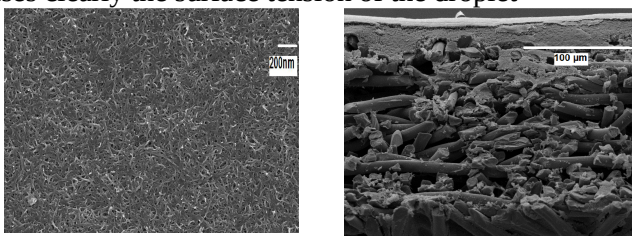

Fig.2 CNTs coated GDL (a) side view (b) cross view

To avoid any enzyme denaturation during flexible electrode fabrication process, a soft CNT-post-functionalization technique was adapted, namely: the electropolymerization of novel pyrrole monomers. This technique achieves soft and efficient immobilization of laccases to spray-deposited CNT on GDL substrates, affording flexible electrodes for efficient bioelectrocatalytic oxygen reduction. High catalytic current densities were obtained for the oxygen bioelectrocatalytic reduction by flexible electrode functionalized by laccases.

The effect of the number of spray-deposited layers was studied and experiments demonstrate that an optimal number of layers are necessary to maximize catalytic current densities and CNTs network homogeneity.

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