Synthesis of Carbon Nanofibres with Tailored Surface Properties via Electrospinning

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Statement of purpose: Carbon nanofibers because of their physical dimensions, electrical conductivity, high theoretical mechanical properties (2 TPa) and low weight-to-strength ratios find potential use in broad ranging applications including batteries, filteration systems, composites, and biomedical applications such as bio MEMS and orthopaedic/dental implants (1-2). Electrospinning has been recently reported for the synthesis of carbon nanofiber using polymers such as Poly(acrylonitrile) (PAN), and Poly(vinylidene fluoride) (3). In this study we report for the first time synthesis of electrospun carbon nanofiber from negative photoresist (SU-8) which can be potentially used for the aforementioned applications.

Methods: Ultrafine polymeric fibres from a negative photoresist (SU-8) (low, medium and high viscosity) were produced using the electrospinning technique. Effect of various electrospinning parameters like electric potential (1.2 kV/cm to 2.4 kV/cm), flow rate (100µl/hr to 500 µl/hr), electrospinning distance i.e. distance between electrode and collector (6cm to 20cm) as well as viscosity (high-middle-low) of the polymer precursor, on fibre diameter and surface morphology were studied. Electrospun nanofibers of SU-8 were collected on a Si wafer and cross-linked by UV exposure for 5 to 30 minutes before being pyrolysed at 900°C in an inert atmosphere with a heating rate of 5°C/min, N_2 flow rate of 0.3 lpm and a holding time of 1h at maximum temperature. The fiber morphology and roughness before and after pyrolysis were studied using scanning electron microscopy and atomic force microscopy. The surface energy of various electrospun morphologies were measured by contact angle measurement. The carbon nanofibers thus formed post pyrolysis were characterized for carbon content by raman spectroscopy.

Results and discussion: Ultrafine fibres of negative photoresist (SU-8) (high viscosity) were produced using an electrospinning voltage of 2kV/cm, electrospinning distance of 10cm and a polymer solution flow rate of 300µl/hr (**figure 1**). However, for the aforementioned parameters, medium and lower viscosity SU-8 enabled the production of beaded fibers and beads alone respectively (**figure 1**). The optimized parameters enable the synthesis of fibers having diameters in the range of 120-600 nm. The contact angles measured before and after pyrolysis were 112.5° and 127.9° respectively while the SU-8 thin film provided a value of 63.6° (**figure 2**). Similarly the contact angles for other morphologies such as the beaded fiber and beads alone were 130° and 133.2° respectively. This study demonstrated that significant increase in contact angle was achieved for

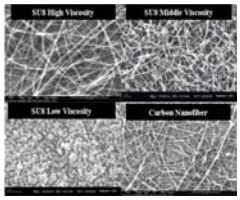

Fig. 1 SEM images of Electrospun nanofiber (high viscosity), Beaded nanofiber (middle viscosity), Beads (low viscosity) and carbon nanofiber(post pyrolysis)

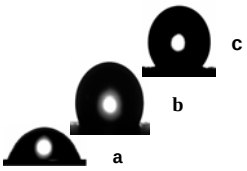

Fig. 2 Water contact angle on different morphologies. (a) 63.6° on smooth SU8 derived carbon thin film; (b) 112.5° for SU8 fibre surface; (c) 127.9° for SU8 derived carbon fibre surface.

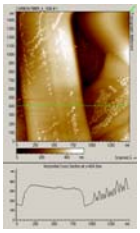

Fig.3 AFM Image of carbon fibre roughness: ~38.0nm

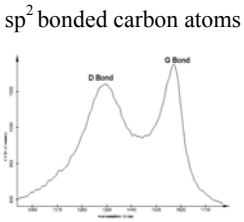

Fig 4: Raman spectra of carbon nanofibers

matrices that had an increased presence of beads (i.e. roughness). The AFM study demonstrated the surface roughness of carbon nanofiber (**figure 3**) to be around 38 nm. The raman spectra of carbon nanofibers generated after pyrolysis confirmed the presence of carbon via sp2 hybridization throughout the matrix (**figure 4**).

Conclusion: We report the synthesis of SU-8 negative photoresist elctrospun carbon nanofiber having morphologies ranging from pure fibers to beaded fibers to pure beaded structures. Further, the surface properties were significantly influenced by the morphologies as demonstrated by the contact angle studies. Hence, the SU-8-based carbon nanofibers because of the tailor able surface properties and morphologies show potential for use in biomedical applications.

References: (1) Kathy L.Elias, Biomaterials 2002: 23: 3279–3287; (2) Rachel L. Price J Biomed Mater Res 2004:70A: 129–138; (3) Yu Wang J Mat Sci Lett 2002:21: 1055-1057

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