Supplementary Information

Water-assisted fabrication of porous bead-on-string fibers

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The supplementary information is included with one Experimental section and one Figure as follows:

Supplementary Experimental Section

Materials

Epoxy resin provides the best overall performance, such as, good mechanical properties, chemical resistance, and low shrinkage. Hence, it is the most widely used thermoset resin. Due to good compatibility between carbon fiber and epoxy resins, PAN-based carbon fiber was chosen as main fiber to fabricate the BOS via Rayleigh instability break-up into droplet technique. The carbon fiber was manufactured by Institute of Coal Chemistry, Chinese Academy of Sciences. The epoxy resin E-44 (molecular weight: ~ 440.25; epoxy value: 0.41 ~ 0.47) was produced by Guangzhou Epoxy Base Electronic Material Corporation and the FTIR curve and ^{1}H-NMR Spectrum were shown in Fig. S3, S4. Diethylenetriamine and acetone were from Beijng Chemical Works. All chemicals were used as received.

Preparation of BOS

Carbon fiber was cleaned by acetone extractions before use. The single fiber specimens were fixed by an adhesive tape on a U-shaped holder with a certain amount of tension and the length of the fiber was about 5 cm. During the preparation of the resin system, epoxy E-44 and diethylenetriamine were mixed in the ratio of 10: 1, in order to get proper viscosity and reaction rate (the resin could solidify quickly at high ratio. For high ratio (5:1), the resin could solidify quickly (18 min) and for low ratio (20: 1), the viscosity of resin is high and the fiber would break when it was drawn out. After different reaction time, carbon fiber specimens were immersed in the resin solution and drawn out horizontally at different velocities (50~200 mm min^{-1}). A cylindrical film of polymer solution was then formed on the fiber surface and spontaneously broken up into polymer droplets along the fiber owing to the Rayleigh instability. After the fiber was dried completely in the given conditions, BOS were formed.

Water collection and observation

In order to observe the behavior of water drops, the smooth, homogenous porous and gradient porous BOS placed on a small U-shaped holder were put in a chamber of sample. Numerous tiny water drops generated by an YC-E350 ultrasonic humidifier (Beijing YADU Science and Technology Co., Ltd.) were introduced into the sample chamber and condensed on the beads. The behavior of water drop was recorded by the optical contact angle meter system (OCA 40, Dataphysics Instruments GmbH, Germany) with time scale.

Characterization of microstructure

The structures of BOS were observed by scanning electron microscope (SEM, Quanta FEG 250, FEI) at 25 kV with gold plating.

Supplementary Figure Legend

Fig. S1:

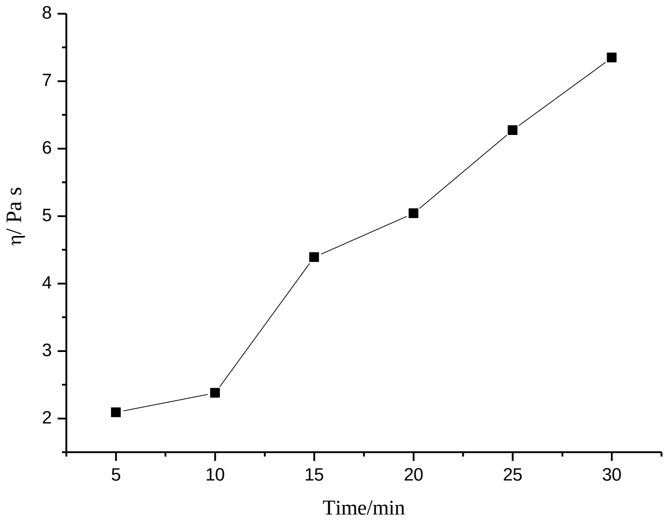

Fig. S1. Viscosity-time curves of resin system at 25^{o}C. The solution viscosity increases obviously after 10 min.

Fig. S2:

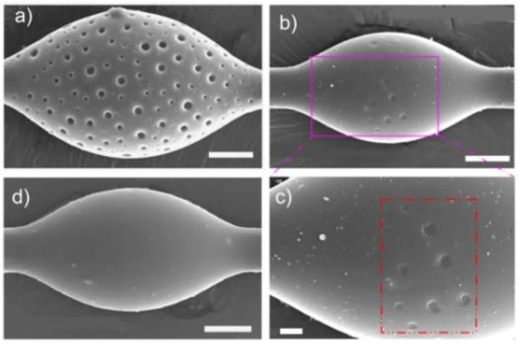

Fig. S2. SEM images of porous polymer BOS fabricated after different reaction temperature. (a) 25 ^{o}C, (b, c) 50 ^{o}C, (d) 75 ^{o}C. Scale bars, 10 μm.

Fig. S3:

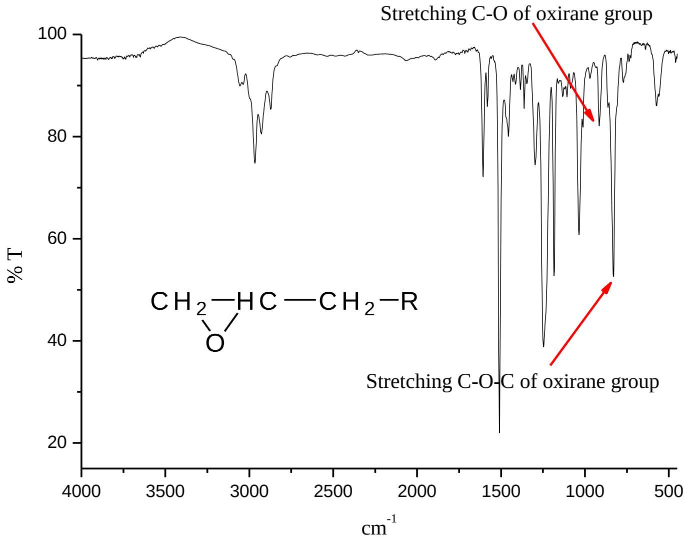

Fig. S3. FTIR curve of epoxy resin E-44. The bands at 913, 834 cm^{-1} were attributed to the characteristic bands of E44.

Fig. S4:

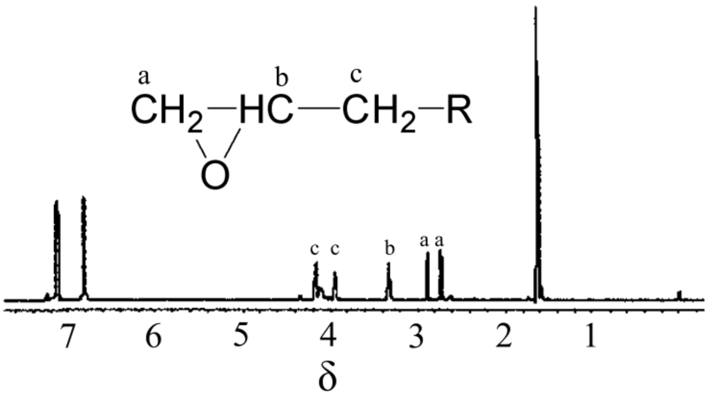

Fig. S4. ^{1}H-NMR Spectrum of epoxy resin E-44.