SUPPORTING INFORMATION

Fabrication of Superhydrophobic Polycaprolactone/Beeswax Electrospun Membranes for High-Efficiency Oil/Water Separation

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S1 details of beeswax collection and extraction

Collected beeswax from local apiculture field (Calicut, Kerala, India) specifically from *Apis cerana indica* bees colony. The beeswax has been collected from the honey chamber rather than brood chamber in order to get high purity beeswax. The wax has been cleaned off from the remaining honey and pollen-grains by melting in enough hot water to float the wax. Up on cooling the wax was removed and the process repeated two more times for further purification.

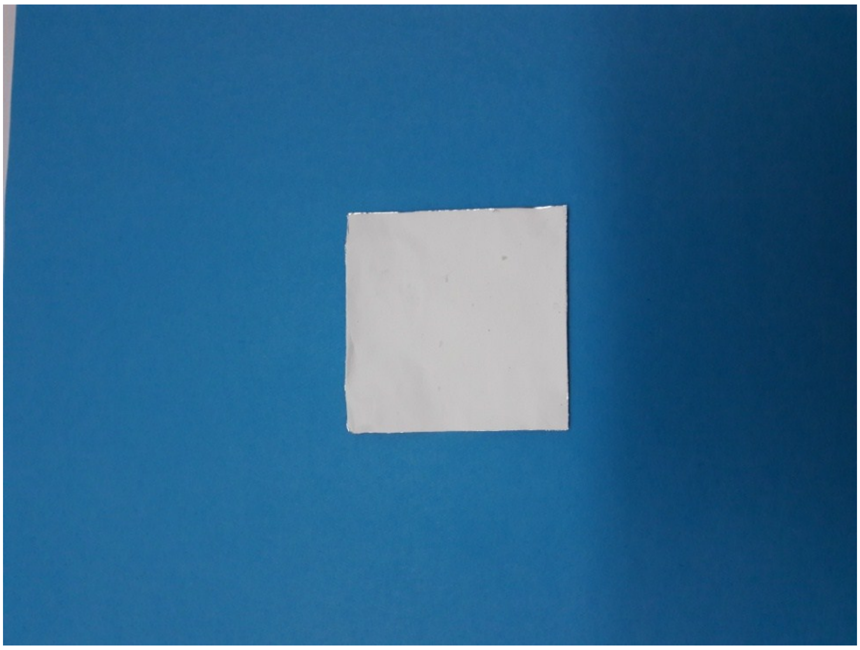

Figure S2: Photograph of prepared PCL-25BW membrane

S3. Porosity and Pore-size

The porosity (ε) of electrospun nanofibrous membrane calculated using the following equation

$$\frac{\rho o - \rho}{\rho o} \times 100$$

ρ is the density of polymer raw material and the density of PCL is 1.145, ρo is the density of nanofibrous membrane. The density of electrospun nanofibrous membrane was calculated by determining the mass, thickness and area of electrospun mat. The thickness is calculated using a micrometer.

Mean pore radius (r) of electrospun nanofibrous membrane was calculated using the following equation.

$$r = \frac{\sqrt{\Pi}}{4}\left(\frac{\Pi}{2\log\left(\frac{1}{\varepsilon}\right)} - 1\right)d$$

ε is the porosity and d is the average fiber diameter of electrospun nanofibrous membrane.

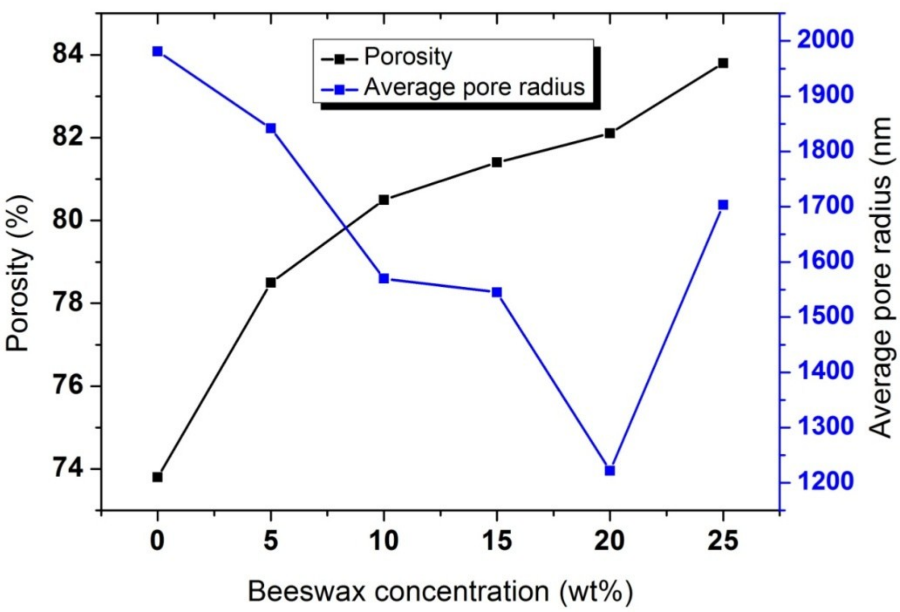

Fig. S3 Porosity and average pore size of different PCL/bees wax electrospun membranes.

Porosity and mean pore radius of electrospun PCL/BW nanofibrous membranes are represented in Fig. 1. Addition of 5 wt% to 25 wt% of BW to the PCL solution led to a gradual increase in porosity from 73.7 % to 83.8% in electrospun membranes. The porosity increases with decrease in average fiber diameter due to decrease in adhesion point between the nanofibers. Mean pore radius of different PCL/BW electrospun fibers also been calculated.

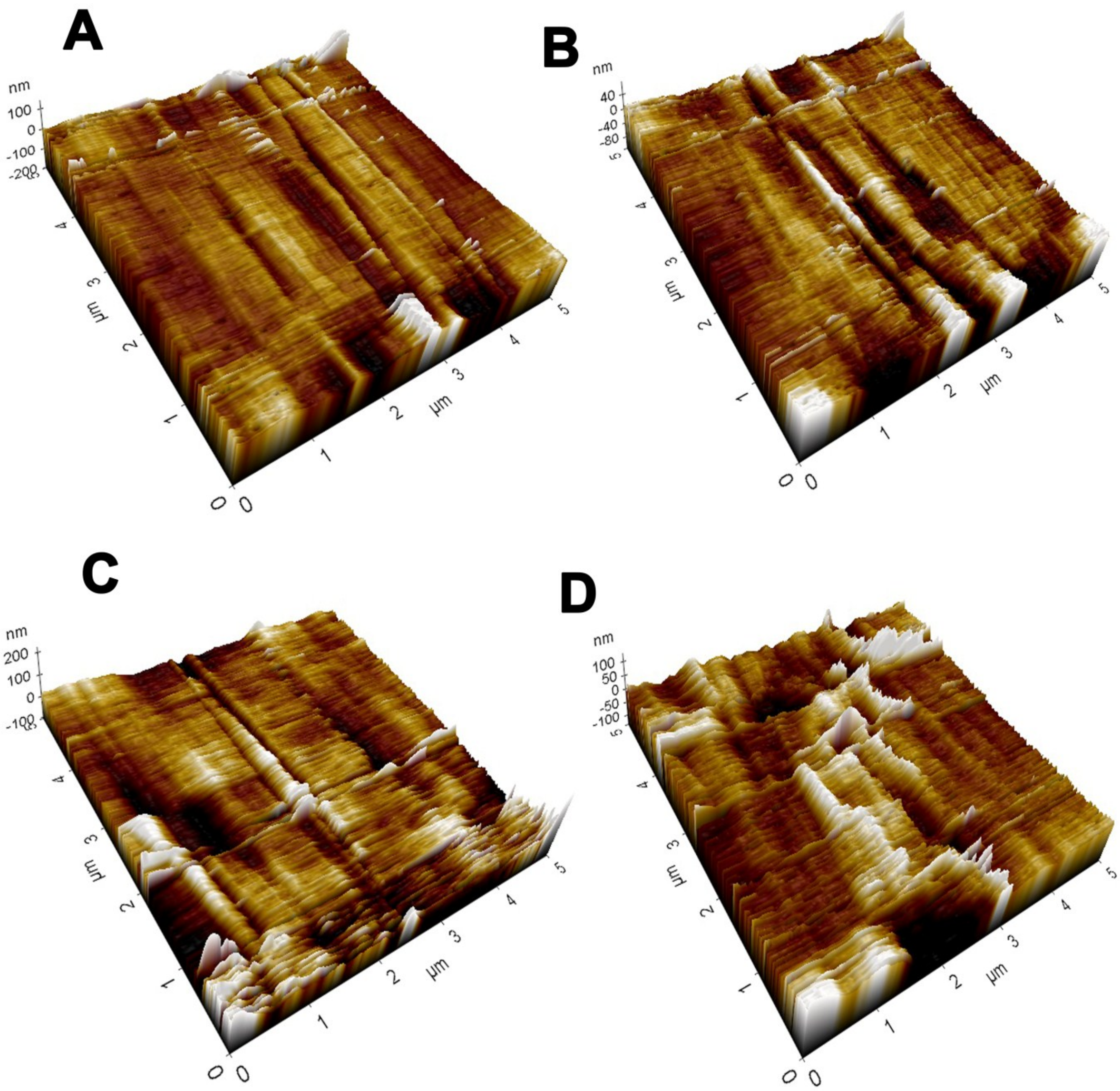

Fig. S4. AFM images of PCL/BW electrospun membranes (A) PCL-5BW, (B) PCL-10BW, (C) PCL-15BW, (D) PCL-20BW.

S5. Surface free energy

The surface free energy of PCL/BW electrospun membrane has been calculated using Owens-Wendt method by considering both polar and dispersion component of surface energy of solid (ref.S1). Equation (1) and (2) used for calculating the dispersion and polar component. The two unknown quantities are measured by calculating contact angle of membrane with respect to two liquids. Here we are chosen water and glycerol as the two solvent for measuring contact angle. Surface tension values of water and glycerol are listed in Table 1.

$$(\gamma_s^d \gamma_{li}^d)^{0.5} + (\gamma_s^p \gamma_{li}^p)^{0.5} = 0.5\gamma_{li}\ (1 + \cos\theta i) \quad (1)$$

$$(\gamma_s^d \gamma_{lj}^d)^{0.5} + (\gamma_s^p \gamma_{lj}^p)^{0.5} = 0.5\gamma_{lj}\ (1 + \cos\theta j) \quad (2)$$

γ_{li}^d and γ_{li}^p are the dispersion and polar components of surface tension of water. γ_{lj}^d and γ_{lj}^p are the dispersion and polar components of surface tension of glycerol. γ_s^d and γ_s^p are the dispersion and polar component of surface energy of electrospun membrane.

Liquid	γ_l	γ_l^d	γ_l^p
Water(i)	72.8	21.8	51
Glycerol(j)	63.4	37	26.4

Results

Contact angle values of water and glycerol on electrospun PCL-BW membranes and surface energy values are listed in Table. 2.

Sample	**Contact angle value in water**	**Contact angle value in glycerol**	**Surface energy**
PCL-5BW	132	116	8.57
PCL-10BW	133	118	7.42
PCL-15BW	141	129	3.59
PCL-20BW	148	138	1.57

PCL-25BW	153	143	1.29

Reference

S1. M. Żenkiewicz* Methods for the calculation of surface free energy of solids Journal of Achievements in Materials and Manufacturing Engineering, 2007, 24, 137.