Influence of Electrospun Morphology on Superhydrophobicity

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BACKGROUND: Superhydrophobic surface have drawn considerable attention in recent decades due to its applicability to protective and self-cleaning textiles. According to the wetting theories such as Wenzel (Wenzel, 1936) and Cassie-Baxter models (Cassie & Baxter, 1944) creating fine roughness on a hydrophobic material is an effective way of fabricating a repellent surface. Previously, polystyrene (PS), a hydrophobic polymer, has been electrospun in various conditions to form diverse morphologies (Lin, Ding & Yu, 2010; Jarusuwannapoom, Hongrojjanawiwat, Jitjaicham, Wanatong, Nithitanakul, Pattamaprom, Koombhongse, Rangkupan, & Supaphol, 2005). However, little is investigated regarding the relationship between the varied morphology and the resulting repellency. **PURPOSE:** The purpose of this study is to investigate the influence of surface morphology and surface energy on the repellency (or wettability). To this end, PS nanowebs in various fiber morphologies were fabricated by varying the electrospinning conditions. **METHOD:** PS (surface energy~33 mN/m) was electropun to form varied surface morphologies. A smooth PS film was prepared via spin coating, as a control sample that does not have surface roughness. Air plasma treatment (Q150T, Quorum, UK) was performed on the PS substrates (film and the electrospun webs) to increase the surface energy via surface oxidation. In order to decrease the surface energy, 1H,1H,2H,2H-perfluorodecyltrichlorosilane (PFDTS, surface tension~17 mN/m) was vapor coated on both PS film and webs after being treated by air plasma. The surface structure of the electrospun web was characterized via scanning electron microscopy (SEM,Versa 3D DualBeam, FEI, USA). The repellency of surface was characterized by the static contact angle of water (CA). **FINDINGS:** The electrospinning with different polymer concentration and solvent mixing ratio (v/v) of tetrahydrofuran (THF) and dimethylformamide (DMF) generated different surface morphologies such as beads, wrinkles, and smooth fibers. A smooth PS film showed CA of 95˚; compared to the film's CA, CAs on an electrospun web were apparently increased, due to the increased roughness of the web for a hydrophobic PS material. Among the webs, the beaded electrospun web presented the superhdryophobcity with the highest CA of 161˚, without further treatment (Table 1). The PS substrates that was originally hydrophobic turned into being hydrophilic after air plasma treatment, as is shown in the reduced CAs of plasma treated PS substrates. The roughness in this case contributed to further increasing wettability, making the web completely wet to water. However, the presence of roughness on a lowered surface energy (by PFDTS coating) contributed to further enhancing the surface repellency. It is noteworthy that surface roughness of electrospun web can either increase or decrease the surface wettability, depending on the surface energy of the material. It can be concluded that introducing surface roughness on a hydrophilic surface (oxidized PS) enhanced the surface wettability, while the roughness on a

hydrophobized surface (PFDTS-treated PS) enhanced the surface repellency.
CONCLUSION/SIGNIFICANCE: Superhydrophobic PS surface with a high CA was fabricated via electrospinning process, by introducing fine roughness onto a PS electrospun web. The current research investigated the surface repellency to water. A future study is recommended to examine the repellent capability against liquids in various surface tensions. In addtion, it is highly desirable to investigate the mechanical properties of the electrospun webs to determine their durability under practial applications.

Table 1. Water contact angle (CA) of PS film and electrospun substrates with different surface morphology and surface energy

	Film	Electrospun webs		
PS conc. wt% (solvent)	12% (toluene)	10% (3:1 THF:DMF)	30% (0:4 THF:DMF)	30% (3:1 THF:DMF)
Surface morphology	Smooth and flat	Wrinkled beads on string (bead diameter ~10.8μm/ fiber diameter~0.2μm)	Smooth fibers (diameter~3.3 μm)	Grooved fibers (diameter ~5.1μm)
CA untreated	95˚ (±1.1)	161˚ (±2.7)	139˚ (±2.7)	155˚ (±2.1)
CA plasma-treated	21˚ (±1.4)	0˚ (N/A)	0˚ (N/A)	0˚ (N/A)
CA vapor coated	118˚ (±1.6)	172˚ (±2.0)	163˚ (±1.5)	169˚ (±3.5)

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