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Micro- and Nanoparticles in UV-cured Thin Films

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Micro- and Nanoparticles in UV-cured Thin Films

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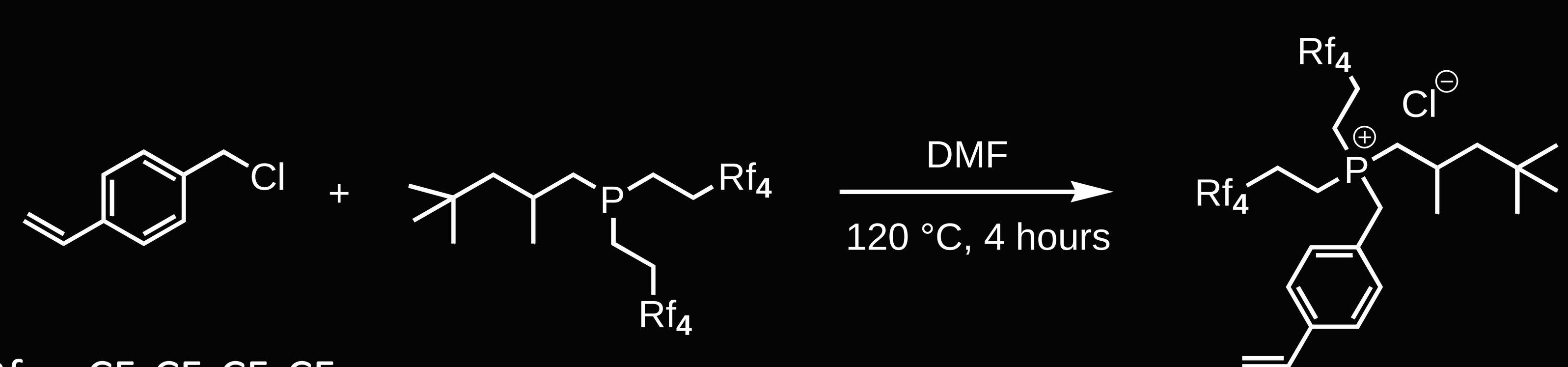
Tailored Ionic Liquids

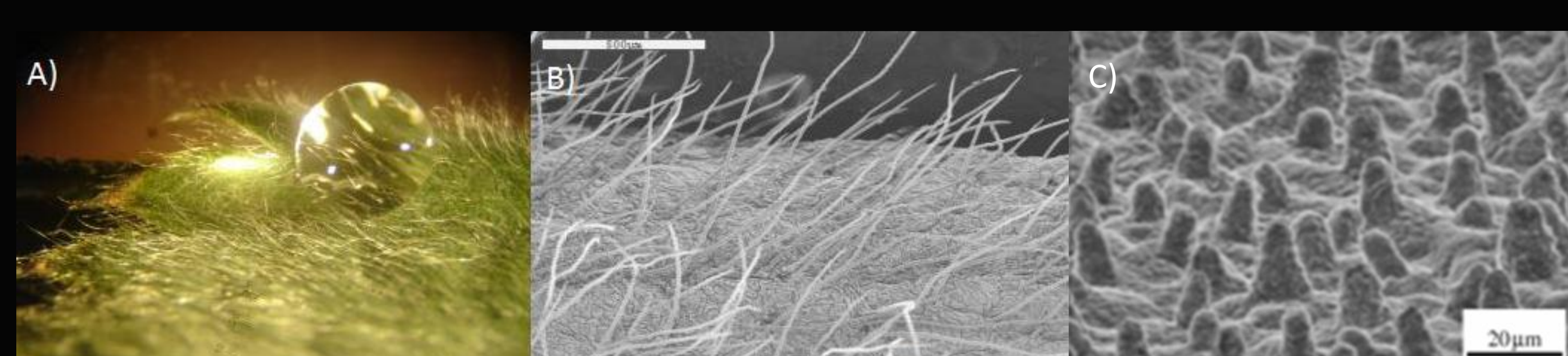
An intelligently designed phosphonium ion that includes a polymerizable group and highly-fluorinated chains has been UV-cured, forming water-repellent polymer films.[1] The phosphonium ion is an excellent choice for this work as it is air-stable and the well understood phosphorous chemistry allows for easy variation of the bound moieties.[2]



$Rf_4 = CF_2CF_2CF_2CF_3$

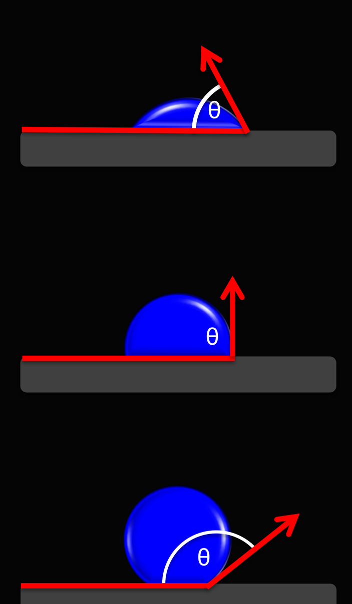
Incorporating Particles

Strongly hydrophobic surfaces are pervasive throughout nature. These self-cleaning, water-repelling surface arise from roughness at both the micro- and nanoscales as well as low free energy coatings.[3] In order to replicate these features, we are exploring the effects of incorporating micro- or nanoparticles in our UV-cured films.



A) Water droplet sitting on the surface of a lady's mantle *(Alchemilla mollis)* leaf, WCA ≈ 160
B) SEM image of the same leaf [4]
C) SEM image of the surface of a lotus *(Nelumbo nucifera)* leaf, WCA ≈ 160 [5]

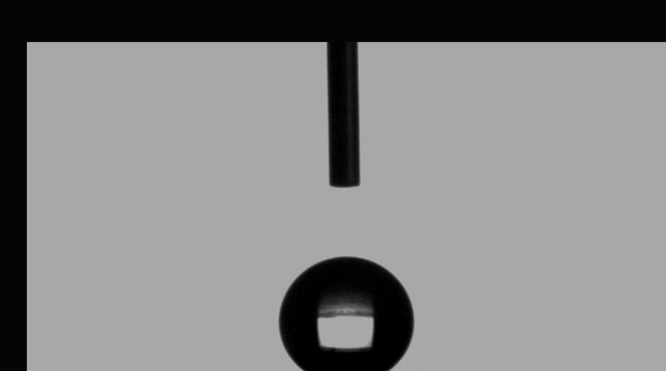
Water Contact Angles



Hydrophilic θ < 90°

Hydrophobic θ ≥ 90°

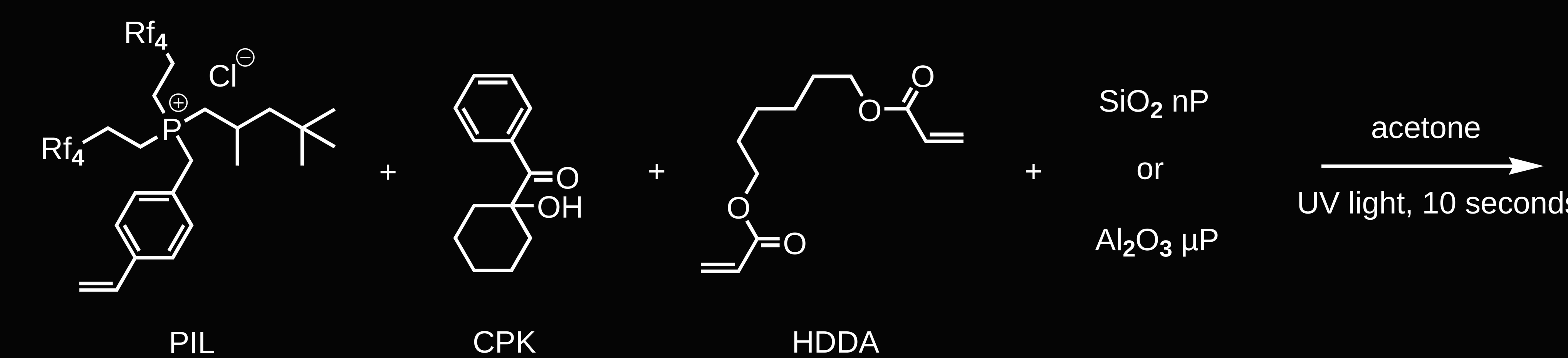
Superhydrophobic θ > 150°

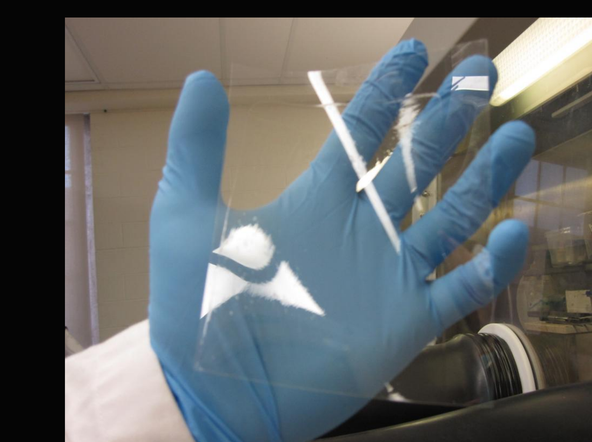


Examples	θ
Above Droplet	≈ 167°
Teflon	≈ 115°
Polyester Substrate	≈ 75°

Matrix Composition

Films were prepared on a polyester substrate using the drawdown method. The following general formula was used for preparation of films:

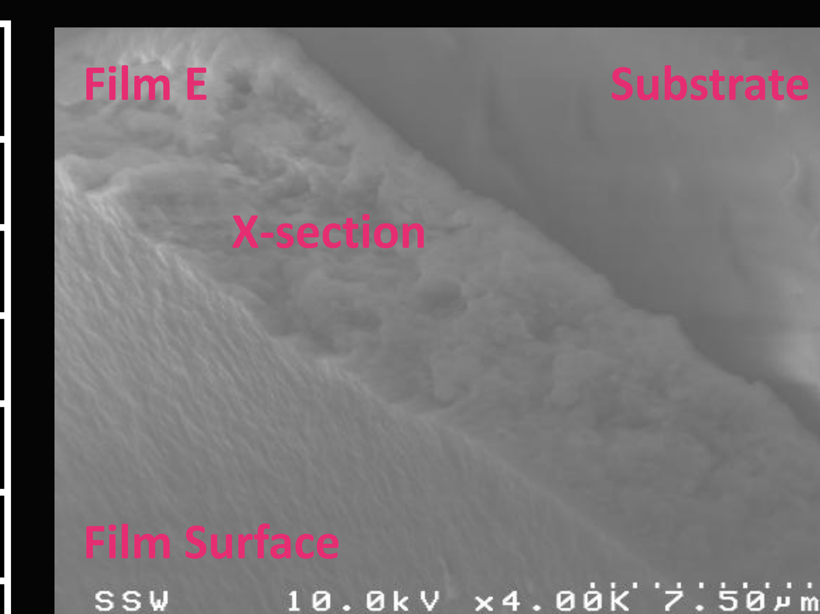


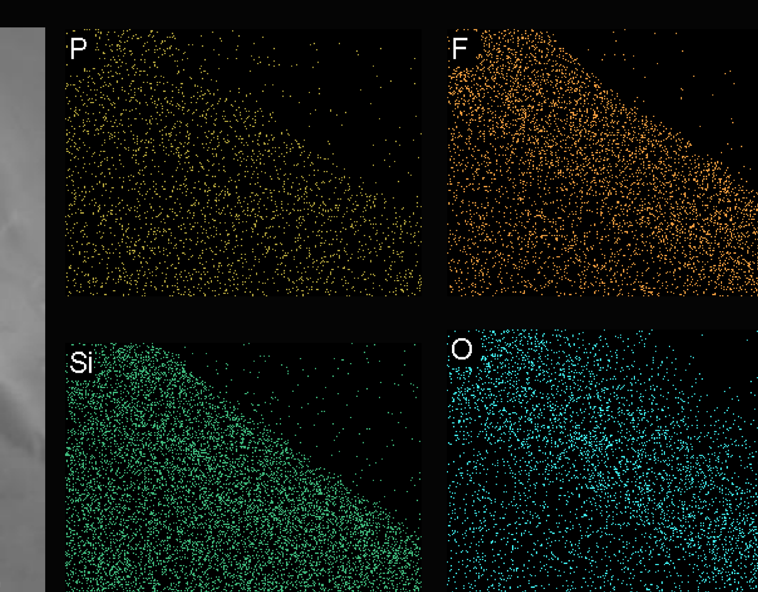


Film Characteristics

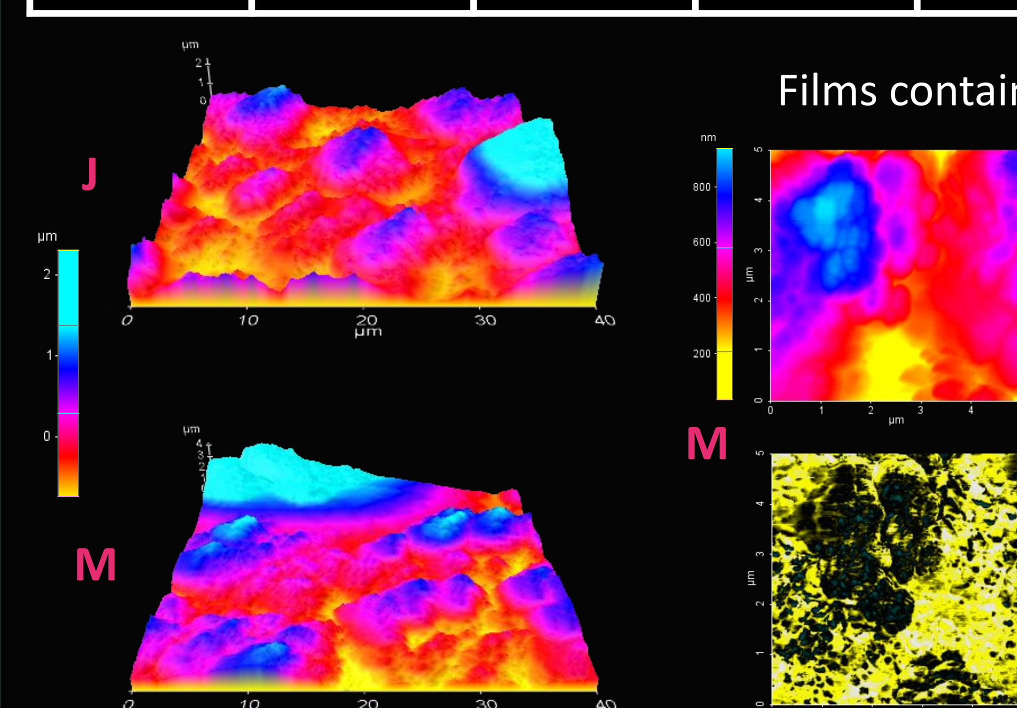
A series of films was made with ≈20 nm silica nanoparticles suspended in HDDA (50:50 np:HDDA)

Film	PIL (w%)	SiO_2 nP (w%)	HDDA (w%)	CPK (w%)	WCA (°)
A	95	0	0	5	85 ± 1
B	80	7.5	7.5	5	84 ± 2
C	65	15	15	5	89 ± 1
D	50	22.5	22.5	5	89 ± 1
E	35	30	30	5	85 ± 2
F	20	37.5	37.5	5	88 ± 1
G	5	45	45	5	83 ± 1





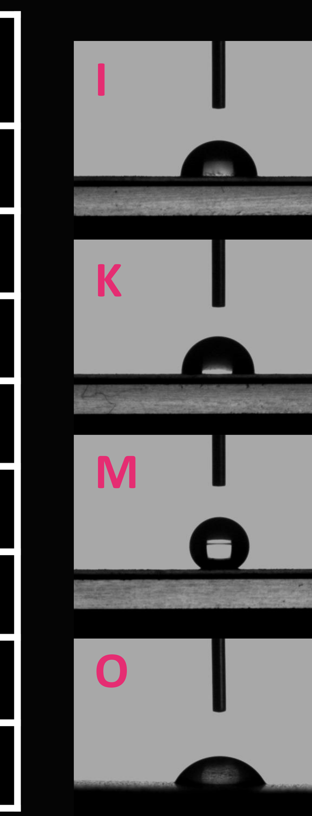
SEM image of Film E (above), with EDX results (for same image) showing even distribution of P, F, Si and O atoms throughout the film (above, right)



AFM images of films J and M (above left) showing surface roughness. The phase shift in film M (above right – topography on top, phase below) shows that the alumina clumps erupt through the matrix at higher particle loadings.

Films containing ≈2.5 μm alumina microparticles produced excellent results at high w% loadings

Film	PIL (w%)	Al_2O_3 μP (w%)	CPK (w%)	WCA (°)
H	94	0	6	85 ± 2
I	75	20	5	86 ± 3
J	57	40	3	88 ± 3
K	38	60	2	88 ± 2
L	28	70	2	144 ± 1
M	19	80	1	141 ± 1
N	9	90	1	145 ± 1
O	0	100	0	64 ± 3



Conclusions

Nanoparticles have little effect on the surface morphology (and water contact angles) of these films at less than 50 weight percent, as they are evenly embedded within the matrix.

High weight percent loading of microparticles produces films with markedly improved water contact angles.

Acknowledgements

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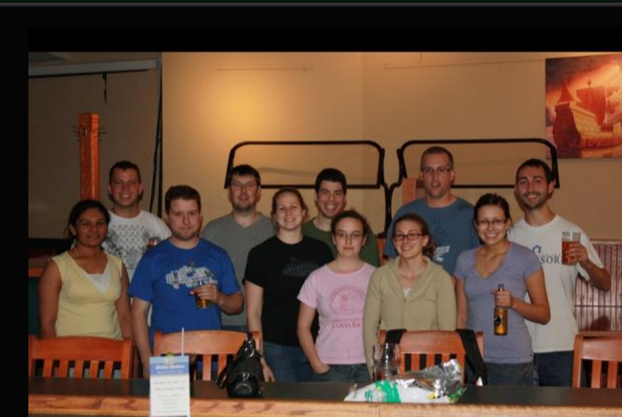

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1) Chan, J. *Strengthening the Frontiers of Polystyrene-Backboned Ionic Liquid Films: UWO Honours Thesis*, **2011**, 11. 2) Tindale, J. J.; Ragogna, P. J. *Chem. Commun.* **2009**, 1831–1833. 3) Lafuma, A.; Quere, D. *Nat. Mat.* **2003**, *2*, 457–460. 4) Shu, S.; Sigmund, W. W. *Langmuir*, **2010**, *26*, 1504–1506. 5) Nosonovsky, M.; Bhushan, B. *Phil. Trans. R. Soc. A.*, **2009**, *367*, 1511–1539.