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Polymer hybrid composite thin-films with tailored hydrophobic properties

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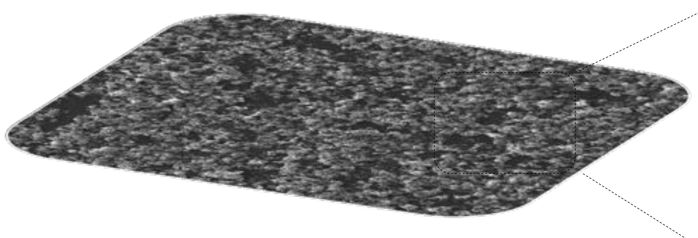
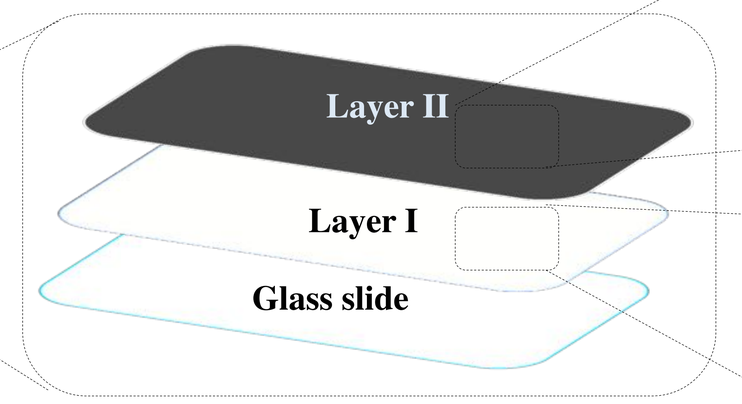
This paper presents a simple and novel strategy to prepare hydrophobic composite coatings with unique micro/nano hierarchical surface roughness.

FILM COMPOSITION:





Hybrid nanoparticles dispersion= magnetite nanoparticles prepared by mild oxidation of ferrous ions in alkaline solution[2], followed by amination with (3-aminopropyl) triethoxysilane (Fe_3O_4-NH_2)/hexadecyltrimethoxy silane (HSi)

Hybrid polymeric binder: chitosan bearing surface vinyl groups (CS*g*)[1] cross-linked with ethylene glycol dimethacrylate (EGDMA) using thermal initiation (2,2'-Azo bis(2-methylpropionamidine) dihydrochloride- I) / HSi

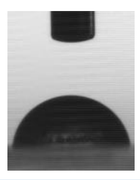
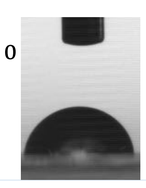
Coupling agent= pre-hydrolyzed/precondensed sol–gel solution of HSi[3]

Process parameter optimization

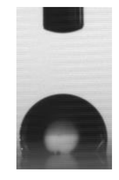
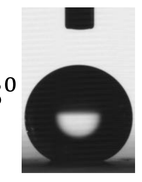
Radical polymerization of CS*g*

Batch/Composition	CSg-I1	CSg-I2	CSg-I3	CSg-I4	CSg-I5	CSg-I6	CSg-I7	CSg-I8	CSg-I9	CSg-I10
CSg (1% solid), mL	2	2	2	2	1	2	2	-	3	1
EGDMA, µL	12	36	24	18	24	36	48	36	36	36
I, µL	12	36	24	18	24	24	48	36	36	36

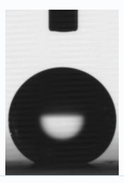
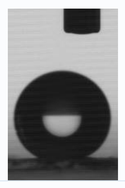
Wetting angle versus hybrid polymeric binder composition: one layer

Glass slide	CS	CS-HSi	CSg-I1/HSi	CSg-I2/HSi	CSg-I3/HSi
Contact angle	78.1° 	108.2° 	89.2° 	88.1° 	113.1° 
Hysteresis	3.9°	2.1°	4.9°	5.3°	2.9°

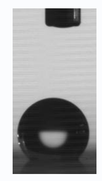
Wetting angle versus coating morphology: layer-by-layer

Glass slide	CS/HSi+Fe_3O_4-NH_2/HSi	CSg-I2/HSi+Fe_3O_4-NH_2/HSi
Contact angle	117.8° 	145.8° 
Hysteresis	2.1°	0.1°

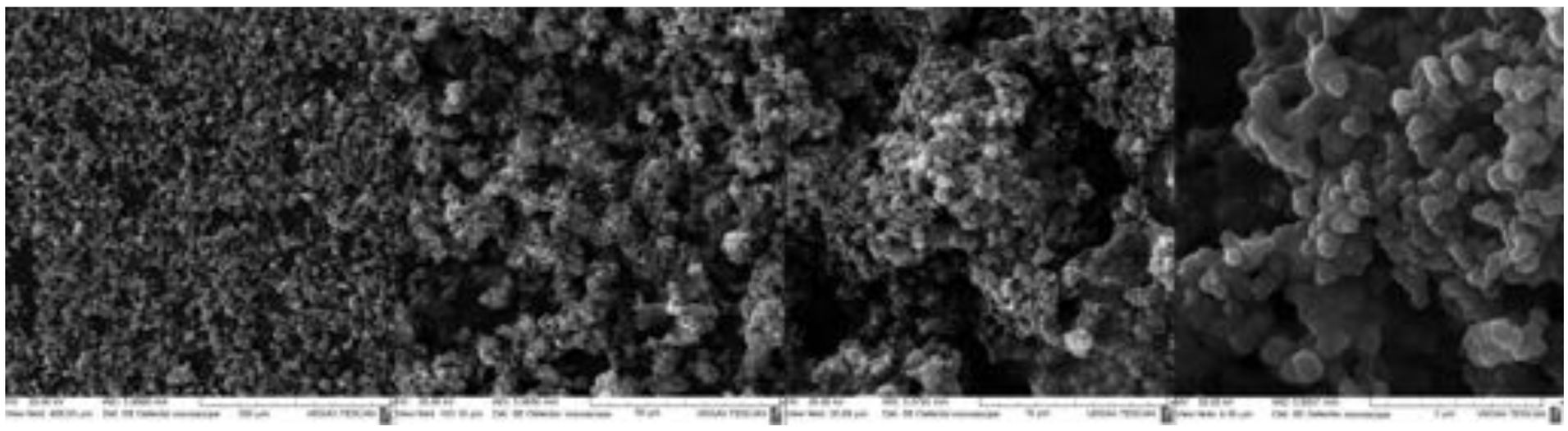
Wetting angle versus hybrid polymeric composition (EGDMA concentration): layer-by-layer

Glass slide	CSg-I2/HSi+Fe_3O_4-NH_2/HSi	CSg-I4/HSi+Fe_3O_4-NH_2/HSi	CSg-I7/HSi+Fe_3O_4-NH_2/HSi
Contact angle	145.8° 	141.4° 	141.7° 
Hysteresis	0.1°	1.52°	0.5°

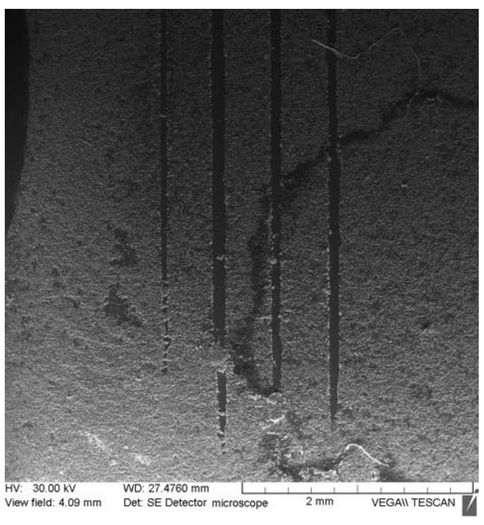
Wetting angle versus hybrid polymeric composition (CS*g* concentration): layer-by-layer

Glass slide	CSg-I2/HSi+Fe_3O_4-NH_2/HSi	CSg-I8/HSi+Fe_3O_4-NH_2/HSi	CSg-I9/HSi+Fe_3O_4-NH_2/HSi	CSg-I10/HSi+Fe_3O_4-NH_2/HSi
Contact angle	145.8.° 	148.1° 	127.4° 	138.6° 
Hysteresis	0.1°	1.3°	1°	1.3°

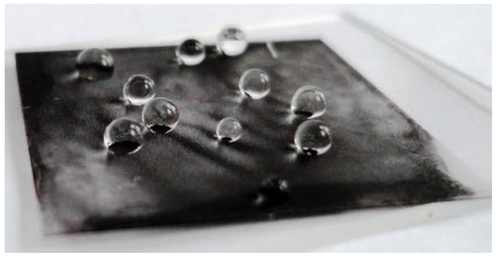
Coating morphology: layer-by-layer deposition of CSg-I2/HSi+Fe_3O_4-NH_2/HSi



Scratch test: critical adhesion load was 14.8 mN



Liquid droplets wetting/non-wetting capability



CONCLUSIONS

- Hybrid polymeric binder composition was studied in order to yield coatings with high wetting angle and good adherence to the substrate in a reproducible manner.
- The addition of iron oxide nanoparticles during the curing stage and HSi sol–gel solution both into the matrix and the nanoparticle suspension produced surfaces with hydrophobic properties.
- The newly developed hybrid coating formulation is easy to apply by spraying and it has medium adherence to the substrate. Future work: ice-repellent studies.

Reference
1. G. Dodi et al., Chem. Eng.J., 203 (2012) 130–141.
2. G. Dodi et al.., J. Magn. Magn. Mater., 388 (2015) 49–58.
3. Spirk et al., Carbohyd. Polym., 93 (2013) 285–290

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