2017

Silica Nanoparticles Functionalized with Zwitterionic Sulfobetaine Siloxane for Application as a Versatile Antifouling Coating System

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Publication Details

Knowles, B. R., Wagner, P., MacLaughlin, S., Higgins, M. J. & Molino, P. J. (2017). Silica Nanoparticles Functionalized with Zwitterionic Sulfobetaine Siloxane for Application as a Versatile Antifouling Coating System. ACS Applied Materials and Interfaces, 9 (22), 18584-18594.

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Abstract

The growing need to develop surfaces able to effectively resist biological fouling has resulted in the widespread investigation of nanomaterials with potential antifouling properties. However, the preparation of effective antifouling coatings is limited by the availability of reactive surface functional groups and our ability to carefully control and organize chemistries at a materials' interface. Here, we present two methods of preparing hydrophilic low-fouling surface coatings through reaction of silica-nanoparticle suspensions and predeposited silicananoparticle films with zwitterionic sulfobetaine (SB). Silica-nanoparticle suspensions were functionalized with SB across three pH conditions and deposited as thin films via a simple spin-coating process to generate hydrophilic antifouling coatings. In addition, coatings of predeposited silica nanoparticles were surface functionalized via exposure to zwitterionic solutions. Quartz crystal microgravimetry with dissipation monitoring was employed as a high throughput technique for monitoring and optimizing reaction to the silica-nanoparticle surfaces. Functionalization of nanoparticle films was rapid and could be achieved over a wide pH range and at low zwitterion concentrations. All functionalized particle surfaces presented a high degree of wettability and resulted in large reductions in adsorption of bovine serum albumin protein. Particle coatings also showed a reduction in adhesion of fungal spores (Epicoccum nigrum) and bacteria (Escherichia coli) by up to 87 and 96%, respectively. These results indicate the potential for functionalized nanosilicas to be further developed as versatile fouling-resistant coatings for widespread coating applications.

Disciplines

Engineering | Physical Sciences and Mathematics

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Supporting Information

Silica Nanoparticles Functionalized with Zwitterionic Sulfobetaine Siloxane for Application as a Versatile Antifouling Coating System

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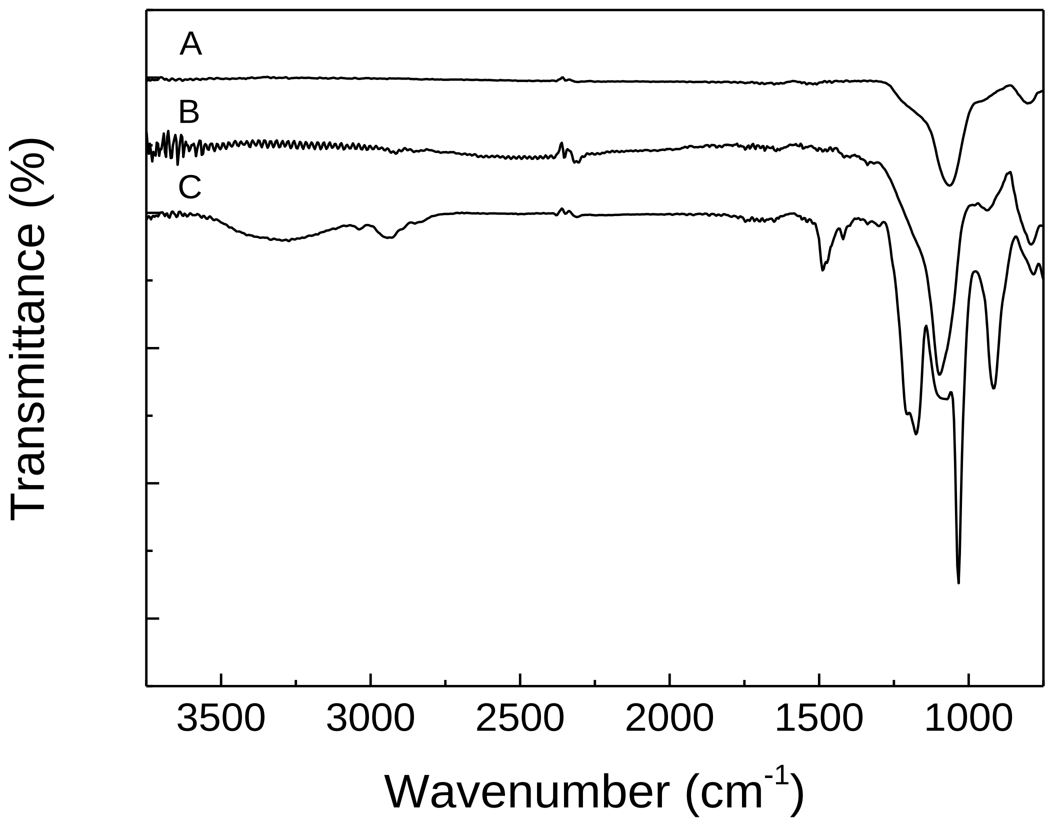

Figure S1. FTIR of (A) unfunctionalised SiNP, (B) SiNP + SB and (C) SB.

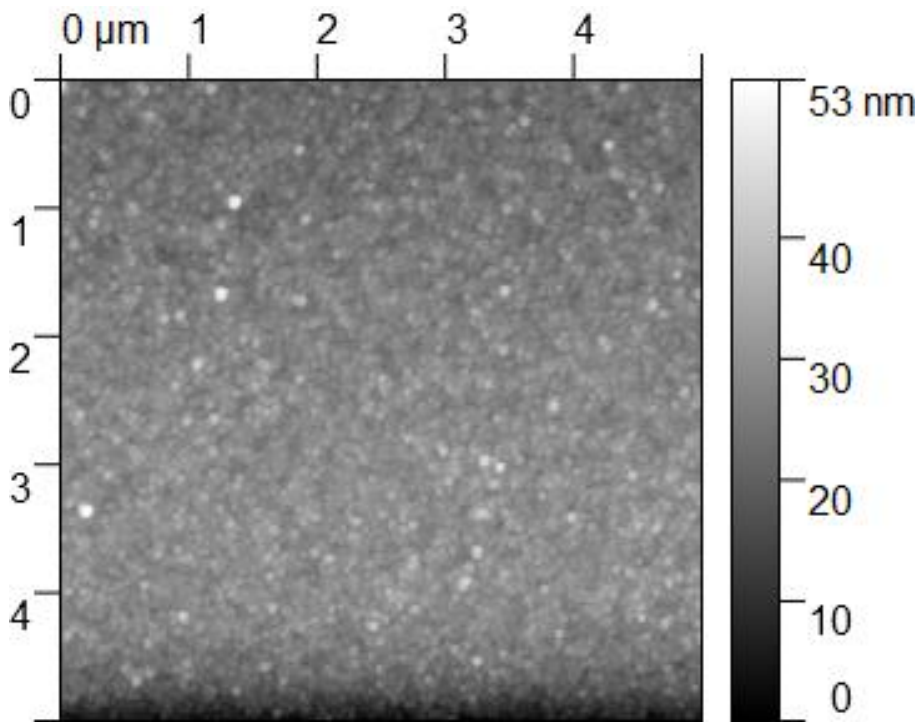

Figure S2. AFM scan (5 µm x 5 µm) of a Ludox + SB (pH9.5) particle coating.

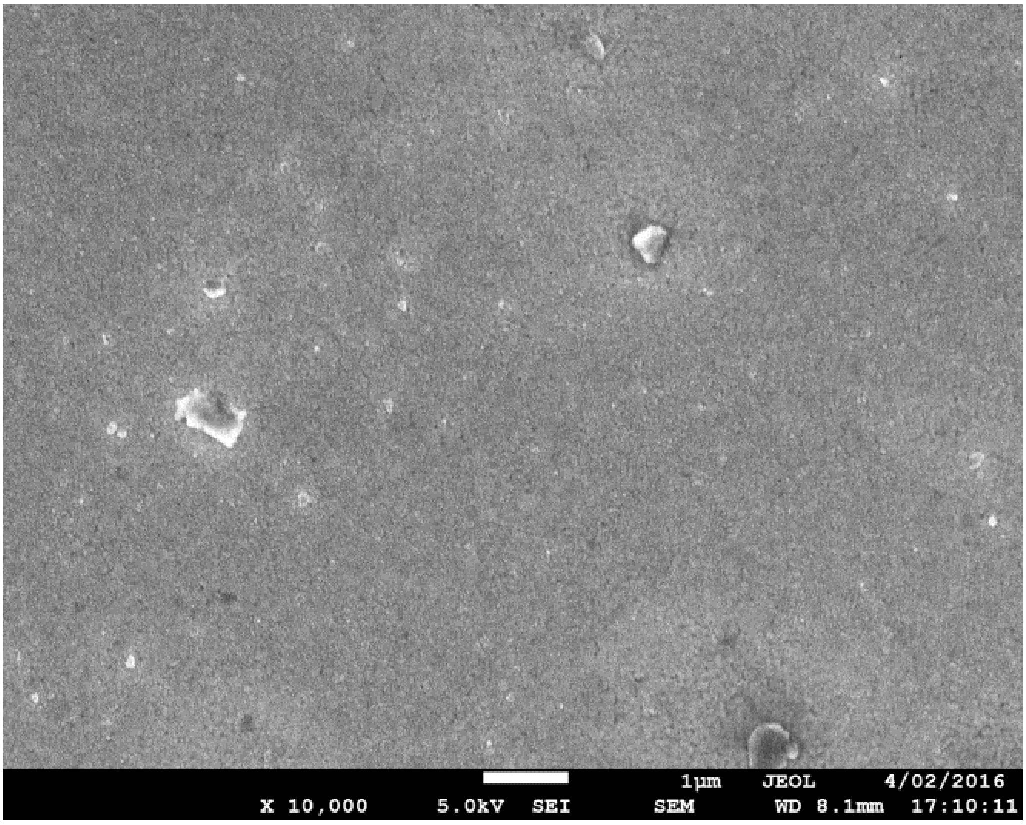

Figure S3. SEM image of Ludox + SB (pH3.5) coating showing the presence of aggregates

Table S1. Water contact angles of coatings prepared from 4wt% silica nanoparticle solutions.

	Contact Angle (°)			
Coating	**Control**	**pH3.5**	**pH7.0**	**pH9.5**
SiNP Control	9.5 ± 0.3	-	-	-
SiNP - 1mM SB	-	6.1 ± 0.4	5.6 ± 0.5	5.4 ± 0.4
SiNP - 10mM SB	-	5.9 ± 0.5	5.6 ± 0.7	5.9 ± 0.4
SiNP + SB	-	3.6 ± 0.3	4.8 ± 0.7	5.3 ± 0.2

Table S2. Hydrodynamic diameter and polydispersity index (PDI) of SiNPs after functionalisation with SB at various pH conditions.

	Z-Ave (d.nm)	**PDI**
SiNP Control	18.29	0.20
SiNP + SB (pH3.5)	147.93	0.51
SiNP + SB (pH7.0)	24.93	0.46
SiNP + SB (pH9.5)	30.10	0.49

Table S3. Degree of surface functionalisation as determined by TGA analysis.

SiNP + SB	**% Mass loss**	**umol/m^2**	**silanol/nm^2**
pH3.5	4.54	0.78	0.47
pH7.0	6.92	1.22	0.73
pH9.5	6.11	1.06	0.64