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Eco-Friendly Silicone/Graphene-Based Nanocomposites as Superhydrophobic Antifouling Coatings

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Abstract : After the 2003 prohibition on employing TBT-based antifouling coatings, polysiloxane antifouling nano-coatings have gained in popularity as environmentally friendly and cost-effective replacements. A series of non-toxic polydimethylsiloxane nanocomposites filled with nanosheets of graphene oxide (GO) decorated with magnetite nanospheres (GO-Fe_3O_4 nanospheres) were developed and cured via a catalytic hydrosilation method. Various GO-Fe_3O_4 hybrid concentrations were mixed with the silicone resin via solution casting technique to evaluate the structure–property connection. To generate GO nanosheets, a modified Hummers method was applied. A simple co-precipitation method was used to make spherical magnetite particles under inert nitrogen. Hybrid GO-Fe_3O_4 composite fillers were developed by a simple ultrasonication method. Superhydrophobic PDMS/GO-Fe_3O_4 nanocomposite surface with a micro/nano-roughness, reduced surface-free energy (SFE), high fouling release (FR) efficiency was achieved. The physical, mechanical, and anticorrosive features of the virgin and GO-Fe_3O_4 filled nanocomposites were investigated. The synergistic effects of GO-Fe_3O4 hybrid's well-dispersion on the water-repellency and surface topological roughness of the PDMS/GO-Fe_3O_4 nanopaints were extensively studied. The addition of the GO-Fe_3O_4 hybrid fillers till 1 wt.% could increase the coating's water contact angle (158°±2°), minimize its SFE to 12.06 mN/m, develop outstanding micro/nano-roughness, and improve its bulk mechanical and anticorrosion properties. Several microorganisms were employed for examining the fouling-resistance of the coated specimens for 1 month. Silicone coatings filled with 1 wt.% GO-Fe_3O_4 nanofiller showed the least biodegradability% among all the tested microorganisms. Whereas GO-Fe_3O4 with 5 wt.% nanofiller possessed the highest biodegradability% potency by all the microorganisms. We successfully developed non-toxic and low cost nanostructured FR composite coating with high antifouling-resistance, reproducible superhydrophobic character, and enhanced service-time for maritime navigation.

Keywords : silicone antifouling, environmentally friendly, nanocomposites, nanofillers, fouling repellency, hydrophobicity
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