Nanoparticle-reinforced polysiloxane hydrophobic coating containing epoxy groups with excellent antifouling-anticorrosion ability and strong substrate adhesion

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Abstract Silicone coating is one of the promising eco-friendly antifouling technologies, while the shortcomings of low adhesion on substrates and poor mechanical properties limit its duration. To overcome the disadvantage, we devised a novel approach by synthesizing hybrid epoxy-polysiloxane nanomicelles through a stepwise water titration condensation reaction facilitated by γ-aminopropyl triethoxysilane, with crosslinking conducted at ambient temperature. The structure of epoxy-polysiloxane nanomicelles was characterized by Fourier Transform Infrared (FT-IR) and ^{1}H NMR spectra. Furthermore, we conducted a comprehensive analysis to unravel the influence of epoxy groups, nano-silica particle content, and the molecular weight of the epoxy-polysiloxane on the adhesion and mechanical properties of the coating. Additionally, the antifouling and anti-corrosion capabilities of coatings were evaluated. The findings reveal that the incorporation of epoxy groups and an increase in the molecular weight of polysiloxane enhances adhesion to substrates, albeit with a slight decrease when these parameters are excessively high. Notably, the uniform dispersion of SiO_2 nanoparticles within the coating significantly improves its mechanical properties and barrier efficacy. Remarkably, the developed coating demonstrates robust adhesion to a diverse range of substrates, including steel, bronze, ceramic, glass, and epoxy primer, with a maximum adhesion strength reaching 6.88 MPa. Moreover, this study underscores the coating's exceptional antifouling potential against bacteria and diatoms, effectively mitigating marine biofouling. Collectively, this research presents a promising strategy that concurrently achieves antifouling, anticorrosion, superior mechanical properties, and strong substrate adhesion, offering significant potential for the development of advanced marine coatings.

Keywords polysiloxane, molecular weight, strong adhesion, antifouling, anticorrosion