DEVELOPING ANTIFOULING AND FIRE-RESISTANT EPOXY COMPOSITE COATINGS USING ROSIN–TiO_2 HYBRID PARTICLES AND HYDROPHOBIC SILANES

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Biofouling represents a major technological and environmental challenge, particularly in the naval sector, where microbial colonization and biofilm formation can increase fuel consumption by up to 40% due to increased hydrodynamic drag. Conventional antifouling epoxy coatings rely on the release of toxic biocides, posing ecological risks, and often require phosphorus-based flame retardants, listed among critical raw materials, to compensate for their intrinsically poor fire performance [1]. Sustainable and multifunctional alternatives are therefore urgently needed. In this work, we report the development of biocide-free epoxy coatings incorporating a rosin-modified hybrid TiO_2 filler (T-Abi), synthesized via a sol-gel route and functionalized in-situ with hydrophobic silanes [2]. The interaction between rosin and Ti^{4+} ions leads to the formation of charge-transfer complexes capable of generating and stabilizing reactive oxygen species at the coating surface, resulting in pronounced antimicrobial activity. After 11 weeks of exposure to aggressive fungal strains, the coatings exhibited negligible mass loss and minimal chromatic variation, confirming high stability and resistance to biodeterioration. Silane functionalization promoted filler migration toward the composite surface, increasing the water contact angle above 120° and significantly reducing fungal adhesion. In addition to antifouling performance, the synergistic action of silanes and TiO_2 improved fire behavior (see Figure 1): cone calorimetry tests revealed a 38% reduction in peak heat release rate, while burn-through experiments showed a 50% increase in burn-through time compared to pristine epoxy [2]. Notably, hexadecyltrimethoxysilane delivered comparable or superior antimicrobial and flame-retardant performance relative to perfluorinated silanes, highlighting alkylsilanes as cost-effective and environmentally preferable alternatives.

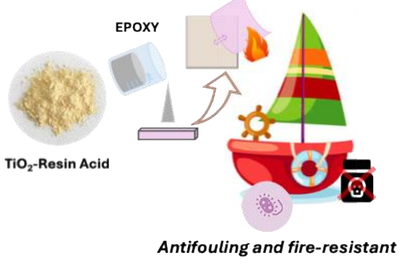

Figure 1. Antifouling and fire-resistant epoxy composite coatings via rosin–TiO_2 hybrid particles.

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References

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