
BIOINSPIRED NANOSTRUCTURED TiO₂ COATINGS FOR SUSTAINABLE ANTIFOULING: HIGH PHOTOCATALYTIC ACTIVITY, LOW TOXICITY, AND LONG-TERM STABILITY

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Abstract

Marine biofouling is a major economic and ecological challenge, prompting the development of sustainable antifouling solutions. This study proposes a nanostructured TiO₂-based films, obtained by Aerosol-Assisted Chemical Vapour Deposition (Aerosol-Assisted MOCVD), and inspired by the natural antifouling mechanisms observed in certain microalgae. These bio-inspired surfaces are based on the generation of reactive oxygen species (ROS) and a nanometric topography. The surface topography of these films is characterised by the formation of microflower-like structures with petals of nanometric size, increasing the specific surface area and photocatalytic activity. Two synergistic effects were demonstrated: (1) increased generation of ROS (-OH, HO) under UV/visible irradiation, reducing *Vibrio harveyi* biofilm formation by 85%; (2) a physical anti-adhesive action, reducing *Cylindrotheca closterium* attachment by 49%. The ecotoxicological assessment carried out on *Artemia salina* and *Phaeodactylum tricornutum* revealed low acute toxicity (mortality < 10%) and no growth inhibition or cellular damage, even after prolonged exposure. Post-exposure monitoring (78 h) confirmed the absence of any residual effect, with cells maintaining a normal growth profile. Furthermore, accelerated ageing tests in a simulated marine environment demonstrated that the TiO₂ coatings maintain their surface chemical integrity and initial photocatalytic performance, confirming their robustness and long-term stability. These results highlight the biocompatibility and durability of nanostructured TiO₂ films under marine conditions, reinforcing their potential as environmentally friendly alternatives to conventional biocidal coatings. This approach aligns with the goals of the blue economy: high performance, long-term sustainability, and low environmental impact.

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