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Opinion

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Sustainable hydrology through an Eco-friendly Xanthone-based approach in coating solutions

Abstract

Traditional antifouling (AF) biocides have raised environmental concerns, prompting a search for sustainable alternatives. This study addresses this pressing issue by reviewing xanthone derivatives as promising candidates for environmentally friendly AF coatings, showcasing a balance between enhanced AF activity and minimal environmental impact. Furthermore, an innovative, scalable, and highly versatile methodology based on a green nanopalladium-supported catalyst on biochar is presented as an interesting alternative to synthesize diverse xanthone derivatives. This approach aligns with sustainable practices in organic synthesis and expands the repertoire of potential antifouling solutions.

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Opinion

Traditional antifouling biocides have raised environmental concerns. Synthetic xanthones emerge as a promising solution for the following reasons:

I. The adoption of alternative antifouling agents aligns with a growing global responsibility and consciousness towards environmentally friendly practices.

II. By transitioning to these compounds, the marine industry can contribute to the reduction of ecological harm caused by traditional antifouling agents and thrive without compromising the health of our oceans.

III. Embracing these alternatives reflects a commitment to responsible environmental stewardship and industries that lead this shift set a precedent for responsible practices, encouraging others to follow suit.

Introduction

Organic compounds for antifouling coatings

I. Synthetic xanthones, as exemplified by 3,4-dihydroxyxanthone, offer a sustainable alternative to traditional antifouling biocides.[1]

II. Recent advancements present an eco-friendly protocol employing a nanopalladium-supported catalyst on green biochar for the efficient synthesis of xanthone derivatives.[2]

III. The recoverable and reusable nature of the catalyst underscores the commitment to sustainability.[3]

Substituent influence on AF activity

I. Disubstitution with small, oxygenated groups enhances antifouling efficacy. Bulky hydrophobic or hydrophilic groups may compromise AF effectiveness.[4]

II. The application of a green nanopalladium-supported catalyst on biochar, demonstrating versatility in the synthesis of xanthones.

III. The resulting compounds encompass a range of structural variations, including those with dual methoxy substitutions (2,3-dimethoxyxanthone and 2,3-dimethoxy-5-methylxanthone), as well as derivatives featuring singular methoxy and hydroxy substitution.

IV. This structural diversity not only attests to the catalyst's versatility but also presents potential candidates for effective antifouling properties.[5]

Environmental fate and ecotoxicity

I. 3,4-dihydroxyxanthone has been identified as non-persistent, non-bioaccumulative, and non-toxic. Competitive ecotoxicity potential compared to commercial biocides.

II. The synthesis of these compounds through the proposed methodology aligns seamlessly with green and sustainable principles, offering a promising avenue for expanding the repertoire of environmentally friendly antifouling agents.

III. Synthetic xanthones represent a balance between enhanced AF activity and minimal environmental impact. Further research and development crucial for advancing green antifouling solutions.[6]

IV. Immobilization of marine coatings:

V. Preliminary studies of water solubility of xanthone derivatives in UPW and TSW at 24±1 °C quantified by HPLC show low release, indicating a reduction in the leaching of antifouling agents into the marine environment. Compound degradation in water was also analyzed through DT_{50} in several stress conditions to mimic a natural degradative process with positive results.

VI. Promising anti-macrofouling effects found through inhibition studied of *M. galloprovincialis* larvae, showcasing effectiveness in inhibiting the attachment and growth of fouling organisms.[7]

Results

Synthetic xanthones offer a sustainable alternative to traditional antifouling biocides. Their efficient synthesis using a green

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nanopalladium-supported catalyst on biochar is scalable and environmentally friendly. Promising anti-macrofouling effects demonstrate their potential in reducing marine environmental impact. This green approach aligns with the global shift towards sustainable antifouling solutions.

Discussion and conclusion

The adoption of synthetic xanthones for antifouling coatings, coupled with a green and scalable synthesis methodology, presents a significant stride towards sustainable marine practices. This approach not only offers effective alternatives to traditional biocides but also aligns with the global commitment to reduce environmental impact. Embracing these innovations contributes to the preservation of marine ecosystems, marking a pivotal step in responsible environmental stewardship.

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Conflicts of interest

The authors declare that no conflict of interest could be perceived as prejudicing the impartiality of the research reported.

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