ScienceDirect

Polymer

Volume 315, 17 December 2024, 127801

Bio-inspired sustainable benzoxazine based composites containing aniline derivatives: A comprehensive study on anti-microbial, advanced coatings, oil-water separation and electronic utilizations

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https://doi.org/10.1016/j.polymer.2024.127801

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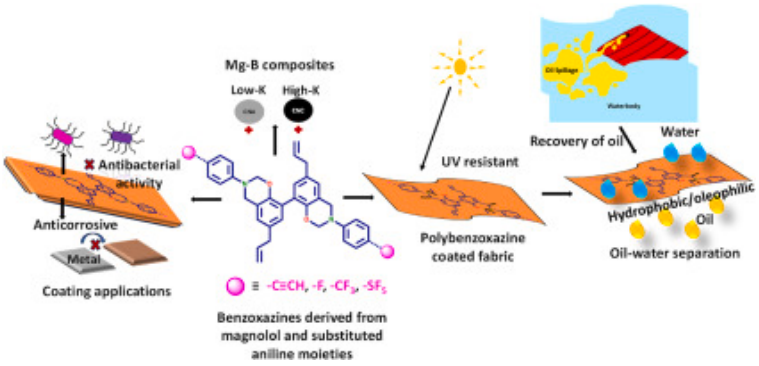
Highlights

- Hybrid benzoxazines were synthesized from sustainable magnolol.
- Polybenzoxazine containing ethynylaniline showed higher thermal stability, LOI and HRI.
- Higher fluorine content higher resistance to microbial growth and imparting low cytotoxicity against L-929cell lines
- Hydrophobic nature of polybenzoxazines led to development of oil-water separation membrane with efficiency of 97%.
- Bio-fillers reinforced polybenzoxazines exhibited high (6.91) and low (2.71) dielectric constant.

Abstract

A comprehensive study of benzoxazines derived from magnolol and five different substituted aniline moieties through Mannich condensation was carried out. The structural confirmation was ascertained using different spectral analyses. Mg-a exhibited a lowest polymerization temperature of 220 °C than that of other monomers. Whereas, poly (Mg-ea) showed relatively the higher initial thermal stability until 411 °C with char yield of 56% at 850 °C and enhanced values of limiting oxygen index (LOI) and statistic heat resistance index (HRI) than rest of polybenzoxazines. The Mg-pfa benzoxazine monomer exhibits significant antibacterial behavior with a maximum of 22 mm zone of inhibition and less cytotoxicity with IC50 value of 162 μg/ml as well as better corrosion resistant properties with 99% corrosion inhibition efficiency. The hydrophobic studies indicated that poly (Mg-tfa) exhibited the highest water contact angle (CA) value of 143°. Poly (Mg-tfa) coated cotton fabric was resistant to chemical and UV treatments along with the 97% of oil water separating efficiency. Polybenzoxazine composites were derived from poly (Mg-fa) matrix and cashew nut shell residue ash (CNA) and cashew nut shell carbon (CNC) fillers to ascertain influence on thermal, dielectric and hydrophobic properties. Poly (Mg-fa) composites reinforced with 15 wt% of CNA and 15 wt% of CNC exhibited dielectric constant values of 2.71 and 6.91 respectively at a frequency of 1 MHz. Findings from multifaceted studies indicate that the polybenzoxazines and composites reported in the present work can be utilized for anti-corrosion, anti-microbial, oil-water separation and electronic applications for improved performance and enhanced longevity.

Graphical abstract



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Introduction

A deviation from the conventional practice of synthesizing benzoxazines from petroleum resources is considered as an essential practice to reduce the depletion of fossil materials. Utilization of polybenzoxazines for industrial applications derived from sustainable precursors is a supreme way to reduce the carbon emission and footprint. Development of polymeric materials from sustainable/renewable resources, substantially alleviates the environmental pollution and prevents the hazardous toxic effects towards living beings.

In this context, a plant-based phenolic precursor viz. magnolol has been chosen in the current work to develop a series of polybenzoxazines with varying molecular skeleton, which are systematically characterized using different analytical techniques to ascertain their suitability for varied industrial