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Bio-thymol containing new high-performance thymolphthalein based polybenzoxazine: Thermal, superhydrophobic and dielectric properties

Harinei Srinivasan [a], Hariharan Arumugam [a b], Sarawut Rimdusit [b], Alagar Muthukaruppan [a]

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Abstract

An increase of global population and consequent cause of environmental concerns, significant efforts have been made to reducing the use of fossil-based precursors and chemicals. The sustainable bio-benzoxazine resins were prepared using thymolphthalein and different amines systems such as aliphatic amines [butylamine (ba), hexylamine (ha), 2-ethylhexylamine (eha), dodecylamine (dda), octadecylamine (oda)), aryl amines (aniline (a), 4-fluoroaniline (fa), 3-trifluoromethylaniline (tfma)], and miscellaneous amines [cyclohexyamine (cha), allylamine (aa) and furfurylamine (ffa)] with paraformaldehyde through Mannich condensation. The molecular structure of corresponding benzoxazines was analysed using FTIR and ^{1}H NMR spectroscopic techniques. Superhydrophobic cotton cloth was prepared using aliphatic amine based benzoxazine coating. The reinforcements bio-silica from bamboo ash and graphitic carbon nitride (GCN) from melamine precursors were separately prepared and functionalized under appropriate experimental conditions, which are used as reinforcement for the development of polybenzoxazine composites. Thermal stability, morphology and hydrophobicity of cardanol functionalized-GCN and GPTMS functionalized bio-silica reinforced polybenzoxazine composites were studied using TGA, FESEM and goniometer respectively. The poly(THP-oda) coated cotton fabric possesses the value of highest water contact angle of 154°. Further the poly(THP-oda) coated cotton fabric was tested for its efficiency towards oil-water separation. The value of dielectric

constant of 15 wt% of bamboo ash silica reinforced poly(THP-ffa) and 15 wt% of C-GCN reinforced poly(THP-tfma) are 1.9 and 7.9 respectively.

Graphical Abstract

Thymolphthalein based benzoxazine resins were developed for various application, such as superhydrophobic coating on cotton fabric, bamboo ash silica reinforced composites for low-k and C-GCN reinforced composites for high-k application.

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Keywords

Thymolphthalein; Polybenzoxazine; Bio-silica; Graphitic carbon nitride; Thermal stability; Hydrophobicity; Oil-water separation; Dielectric constant

1. Introduction

High-performance thermosets have been a significant expansion in their range of applications in recent years, including space radiation shielding, electronic packaging, brake-pad materials and other day to day life uses. Thermosetting resins like polybenzoxazines have exceptional behaviours like zero percent shrinkage during polymerization, high glass transition temperature, high resistance towards heat, good mechanical strength, insulating nature, and low surface energy. The benzoxazine monomers are simple to synthesize via Mannich condensation with phenolic derivatives, primary amines and formaldehyde [1]. Benzoxazine resins need not require any catalysts for curing and simple thermal heating is sufficient. By taking the advantage of flexible and tunable molecular design, numerous benzoxazine monomers with varying molecular skeleton were developed and reported. Qichao Ran et al., developed a silicon-containing main chain type polybenzoxazines for signal transmission application [2]. They studied the thermal and dielectric properties of the polybenzoxazines by modifying the structure with and without incorporation of acetylene group. Rui Yang et al., designed a phosphaphenanthrene-functionalized benzoxazines