ScienceDirect

Polymer

Volume 283, 22 September 2023, 126287

Development of hybrid polybenzoxazine composites from sustainable bio-phenol for dielectric and superhydrophobic water repellent utilizations

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https://doi.org/10.1016/j.polymer.2023.126287

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Highlights

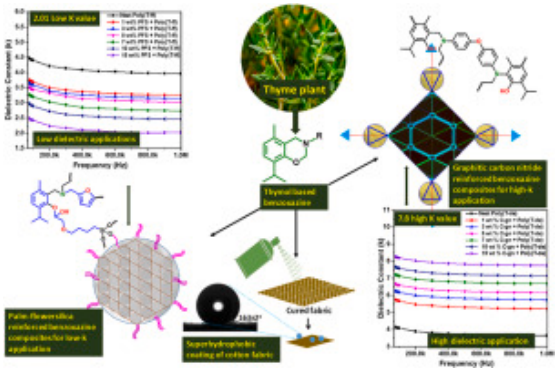
- Bio-thymol based mono and bi-functional benzoxazines have been synthesised.
- Bio-silica reinforced polybenzoxazine composites for low dielectric applications.
- The graphitic carbon nitride reinforced polybenzoxazine composites for high k applications.
- The polybenzoxazine coated on cotton fabrics for superhydrophobic applications.

Abstract

This study focuses on the synthesis, thermal and dielectric properties of sustainable bio-phenol viz. thymol based polybenzoxazines for applications including low dielectric, high dielectric and

water repellent coating applications. By following a simple one-pot method four unique set of thymol benzoxazines were synthesized using varied nature of amines such as laurylamine (l), stearylamine (s), aniline (a), fluoroaniline (f), trifluoromethylaniline (t), cyclohexylamine (c), allylamine (aa), furfurylamine (ff), Jeffmine D_{230} (j), isophoronediamine (i), methylenebis cyclohexylamine (m), diaminodiphenylmethane (dm), *p*-phenylenediamine (pp) and diaminodiphenylether (de). The synthesized four set of thymol benzoxazines have been studied for range of applications viz., water repellent coating on cotton fabrics (CFs), low and high k insulation applications. Char yield value of poly(T-de) has been noted as 40% which is greater than the rest of the other synthesized thymol based polybenzoxazines. Amidst the different benzoxazines, highest water contact value (146°) was noticed for poly(T-t). Poly(T-t) coated cotton fabric (CCF) exhibits the super-hydrophobic behavior, which shows the water repellent value of 163°. The 15 wt% of palm-flower silica (PFS) reinforced poly(T-ff) composites showed the lowest dielectric constant value of 2.01 with loss factor of 0.0024. Similarly, high k value of 7.80 with loss factor of 0.0021 achieved for 15 wt% of C-gn incorporated poly(T-de). The results from the different studies, the developed thymol polybenzoxazines and composites exhibited an excellent thermal and dielectric properties, making them suitable for sustainable, versatile coatings and microelectronics applications.

Graphical abstract



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Introduction

Benzoxazine resins are an emerging class of modified phenolic thermosetting polymers that possess an outstanding mechanical strength, thermal stability, dielectric behavior and resistance to moisture, flame and chemical [1]. It can be developed via one-pot reaction route between primary amino derivatives and phenolic molecule with formaldehyde in the absence of any catalysts [2]. Conventional benzoxazines (CBZs) made from petroleum-based sources are considered to be toxic, which in turn expected to contribute to environmental pollution and climate change, whereas bio-based benzoxazines (BBZs) are generally non-toxic and sustainable, making them suitable for wide range of applications [3]. BBZs are derived from renewable sources such as plants, crops and other organic sources, which are mostly environmentally friendly. They do not pose a serious threat to