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RESEARCH ARTICLE

Eco-friendly bio-based polybenzoxazine composites derived from sustainable thymol: A versatile approach and multifaceted study for enhanced applications

K. Mohamed Mydeen, Balaji Krishnasamy, Hariharan Arumugam, Alagar Muthukaruppan

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Abstract

This work studied the sustainable approach for the development of bio-based polybenzoxazine composites derived from sustainable thymol and utilized for diverse applications viz., superhydrophobic, high dielectric, and resistant to bacterial corrosion. The molecular structure of benzoxazines was ascertained from spectral analyses and curing behavior was assessed using differential scanning calorimetry (DSC) analysis. The benzoxazines were polymerized through ring-opening polymerization to assess their thermal stability using TGA. Among the synthesized polybenzoxazines, the poly(BT-fa) developed using bis-thymol (BT) and furfurylamine (fa) which possesses the furfural core contributes to higher thermal stability with the enhanced value of char yield of 43%. Thus, poly(BT-fa) was chosen for the preparation of composites, and found that 15 wt% chicken feather carbon (CFC) and 15 wt% cashew nutshell cake carbon (CSC) used as reinforcements exhibit significantly enhanced decomposition temperature with char yield of 77% and 69% respectively. Dielectric performance of the composites with high *k* values of 7.66 and 8.66 was obtained for 15 wt% of the CFC and CSC bio-carbon reinforcements respectively. These bio-based benzoxazines also exhibited substantial antibacterial activity, indicating their potential utility toward resistance against microbial colonization. Among polybenzoxazines, poly(BT-sa) exhibits the highest value of water contact angle (WCA) of 151°. To exploit the superhydrophobic properties of polybenzoxazines, the cotton fabrics were coated with poly(BT-sa). It was found that poly(BT-sa) coated cotton fabric possesses an excellent WCA value of 161°, which indicates its suitability for self-cleaning and water-repellent applications. Further, poly(BT-oa) possesses enhanced anti-corrosion-resistant behavior than that of other polybenzoxazines and contributes to better protection of mild steel surfaces from corrosion. The values of tensile modulus /flexural modulus and tensile strength and flexural strength obtained for poly(BT-fa) are 5.1/3.7 GPa and 66 ± 1/103 ± 1 MPa, respectively. Data obtained for bi-functional bio-based polybenzoxazine composites from