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Sustainable L-tyrosine based bio-benzoxazines for efficient protection of mild steel surfaces from marine environment

Mohamed Mydeen K[a], Hariharan Arumugam[a,**], Balaji Krishnasamy[a,***], Subramanian Sathy Srikandan[b], Alagar Muthukaruppan[a,*]

[a] Polymer Engineering Laboratory, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore, 641 062, India
[b] Department of Applied Science, PSG College of Technology, Peelamedu, Coimbatore, 641 004, India

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ABSTRACT

In the present work, a new type of bio-based tyrosine-dipeptide (TB) was successfully synthesized and it was converted into a structurally modified benzoxazine (TB-Bz) using three different amino compounds (aniline (a), dodecylamine (dd) and furfurylamine (ff)) and formaldehyde at appropriate reaction conditions. The molecular structure of these benzoxazines (TB-a, TB-dd and TB-ff) was elucidated using Fourier transform infrared (FTIR) spectroscopy and ^{1}H nuclear magnetic resonance spectroscopy. The curing behaviour and thermal stability of the benzoxazines were analyzed using differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) respectively. The ring opening polymerization of TB-a, TB-dd and TB-ff benzoxazines were observed at 222 °C, 231 °C and 233 °C respectively. Data obtained from thermal analysis, the char yield of corresponding poly-benzoxazines (poly(TB-a), poly(TB-ff) and poly(TB-dd)) were observed at 43%, 51% and 25% at 850 °C respectively. The hydrophobic behaviour of poly(TB-a), poly(TB-ff) and poly(TB-dd) was ascertained from the measurement of water contact angle studies and the values obtained are 139°±2, 143°±2, 146°±2, respectively. The corrosion protection studies of the mild steel specimen surfaces were carried out using open-circuit potential, electrochemical impedance spectroscopy, and potentiodynamic polarization. Among the mild steel specimens, coated with different benzoxazines, the poly(TB-ff) coated specimen was found to be less aggressive towards corrosion and possesses about 98.3% corrosion protection efficiency. The data obtained from different studies suggest that the bio-based tyrosine dipeptide benzoxazines developed in the present work can be considered as a better coating material for the protection of surfaces of mild steel against corrosion under adverse environmental conditions.

1. Introduction

The polybenzoxazine is a modified phenolic resin, which attracts the more attention of researchers from both industry and academic institutions in the recent past, due to its advanced properties, such as near-zero shrinkage, good mechanical, thermal properties and very low water uptake, and excellent chemical resistance properties [1]. Polybenzoxazines possess superior properties making suitable for a wide range of applications in the fields of electronic packaging, aerospace, transportation, sealants and encapsulants. On the other hand, conventional polybenzoxazine has some shortcomings, such as a high curing temperature and high brittleness. To alleviate these short comings and to enhance their performance, the design and synthesis of multifunctional benzoxazines and other suitable functional groups containing benzoxazines such as allyl [2], propargyl [3], cyanate ester [4], maleimide [5] and etc. were carried out by different researchers around world at present. In addition, with a view to improve their properties, the benzoxazines were blended with other compatible polymeric materials like epoxy [6], [–] [8] cyanate ester [9–11], unsaturated polyester [12], bismaleimide [13–16] and so on. Furthermore, benzoxazine based composites were developed for high performance engineering application using suitable reinforcements and other functional additives

* Corresponding author.
** Corresponding author.
*** Corresponding author.
E-mail addresses: hariharannalan@gmail.com (H. Arumugam), balaji.psgtech@yahoo.co.in (B. Krishnasamy), muthukaruppanalagar@gmail.com (A. Muthukaruppan).

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