Innovative Infrastructure Solutions (2023) 8:155
https://doi.org/10.1007/s41062-023-01126-5

TECHNICAL PAPER

Studies on nano-hybrid biopolymer composite coating on corroded steel to improve the corrosion resistance and hydrophobicity of the surface

Arun Murugesan[1] · R. Joselin[2] · Abdul Aleem Mohamed Ismail[1] · Deepasree Srinivasan[1]

Received: 6 March 2023 / Accepted: 18 April 2023 / Published online: 27 April 2023

Abstract

Metals corrode easily which leads to environmental hazards, structural cracks and economic loss. To mitigate metals from corrosion, the organic coating was preferred since it aids as a barrier to separate oxygen, corrosive ions and water. However, some organic inhibitors are toxic in some extent. The significance of the research is to deepen the corrosion studies using natural biopolymer materials especially rich in nitrogenous matter. Zinc oxide, titanium dioxide, papaya leaves and DGEBA (diglycidyl ether of bisphenol A) were used in this study. The presence of alkaloid material and nitrogenous matter in the papaya leaf provides a beneficiary effect by accelerating the corrosion resistance in carbon steel. Mechanical properties/electrochemical behavior of carbon steel was studied by impedance and polarization test in an acidic environment. The microhardness of nano-hybrid composite was found to be 800 HV_{200} with surface wettability of 109.5° (hydrophobic). In addition, corrosion rate of composite coating was reduced by 79% and 22.5% from virgin and DGEBA coating medium, respectively. An acoustic emission (AE) test was also taken to monitor the characterization of these materials. The acoustic emission parameters are within the error margin of around 60% of the operating load. Microstructural analysis shows the morphological behavior of the coated substrate. Biopolymer shows a prominent anti-corrosive performance for carbon steel at 0.5 mol/L. The results are justified in comparison with nano-hybrid composite biopolymer coating (ZnO–TiO_2–PLE) to the organic polymer coating (DGEBA).

Keywords Anti-corrosion · Nano-composite · Biopolymer · Alkaloid material · Hydrophobic · Acoustic emission

Introduction

The world is adversely facing a corrosion problem, which reduces the span of a structure. Normally, corrosion inhibitors were used to resist the substrate against corrosion; in general, organic coatings were preferred because it acts as a physical barricade to the hazards causing corrosion. Water plays a unique role by penetrating into the metal surface and thus weakening the barrier which leading to corrosion [1]. The traditional method of organic coating without any modifications might have disadvantages. Generally, chemically treated coatings will protect the metals from corrosion and these chemical coatings will also enhance the adhesion, environmental protection, wear resistance and easy operation [2–5]. Yuqin Tian [6] used phosphate coating in carbon steel for corrosion resistance, resulting in a reduced roughness index of the metal. However, the phosphate coating of the metal surface for corrosion resistance does not satisfactory due to its porous nature [7, 8]. Various studies have been also made on the inhibition of fillers into the matrix in order to enhance the durability of the substrate [9–11]. These fillers block the cavities and micropores present in the matrix and improve the corrosion resistance [12–14]. Yangshuhan Xu [15] used hydrophobic nano-silica as a filler material to resist corrosion, but resulted in weaker durability of the matrix. In addition to this, waste from industries such as fly ash and slag was also used to resist the corrosion [16]. The prolongation of the durability of metal surface depends on (1) incorporation of fillers [3, 9–11, 17–20], (2) addition of

✉ Deepasree Srinivasan
deepuscool2@gmail.com

1 Department of Civil Engineering, PSG Institute of Technology and Applied Research, Coimbatore 641062, India

2 Department of Mechanical Engineering, Trichy Engineering College, Trichy 621 132, India