

Exploration of Anti-Corrosive Applications of Biomass waste derived N,S-doped Carbon Dots for Mild Steel in 5% HCl Solution

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Abstract Conventional corrosion inhibitors often rely on toxic chemicals, raising environmental and health concerns. Consequently, there is a burgeoning interest in developing green corrosion inhibition strategies that are effective and environmentally friendly. Carbon quantum dots (CDs), a novel category of zero-dimensional carbon nanoparticles, having size <10 nm is studied as efficient corrosion inhibitors for various metals. In response to the escalating emphasis on environmental sustainability, researchers have begun utilizing waste materials for CD synthesis, aiming not only to reduce costs but also to mitigate environmental pollution. In this investigation, CDs were synthesized via a hydrothermal method using sugarcane bagasse (biowaste) as the carbon source. The material characterization of the prepared CDs was conducted using Fourier Transform Infra-red spectroscopy (FT-IR), Energy Dispersive Spectroscopy (TEM), X-ray diffraction (XRD), and zeta potential analysis. Further, the corrosion inhibition performance of the resulting CDs on mild steel (MS) in a 5% HCl solution was evaluated through gravimetric measurements, electrochemical impedance spectroscopy (EIS), potentiodynamic polarization curve analysis, spectroscopic and surface analyses. The results unveiled that N,S-doped sugarcane bagasse -CDs exhibited 92% inhibition efficiency at a concentration of 120 mg/L at 35 °C after 6h immersion in HCl solution. Further increase in immersion time from 6 hr to 24 hr showed an increase in inhibition performance upto 97% at 120 ppm of CDs. Furthermore, the results of potentiodynamic polarization analysis confirmed that CDs effectively mitigated both the dissolution of the metal at anode and the generation of cathodic hydrogen ions. The adsorption behavior of CDs followed the Langmuir adsorption isotherm. Scanning Electron Microscopy (SEM)/Energy Dispersive

Spectroscopic studies supported the formation of a protective film by CDs onto the metal surface. XPS analysis further confirmed the adsorption of CDs on MS surface.

Keywords *Pickling, Metal Corrosion, Waste management, Green inhibitor*