Inhibitory Effect of *Pinus massoniana* Needle Extract on Corrosion of Q235 Steel in Hydrochloric Acid Medium

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An extract of *Pinus massoniana* needles (PMNE) was obtained by soaking. The inhibitory effect of PMNE on the corrosion of Q235 carbon steel in 1 mol·L⁻¹ HCl was investigated by the weight loss method, potentiodynamic polarization curves, electrochemical impedance spectroscopy and a quantum chemical study. The results indicated that PMNE was an efficient inhibitor with a corrosion inhibition efficiency of 95%. The equilibrium constant, free energy of adsorption, adsorption enthalpy were calculated and discussed. Thermodynamic analysis revealed that the adsorption of effective inhibitory constituents of PMNE on the Q235 steel surface was in accordance with the Langmuir isotherm equation, and was classed as physical adsorption. Polarization curves, and electrochemical impedance spectroscopy demonstrated that the corrosion inhibitor was a mixed inhibitor. A protective film of PMNE on the Q235 steel surface was investigated using scanning electron microscopy. Quantum chemical parameters were determined within the framework of the density functional theory .

Keywords: *Pinus massoniana* needle; plant-derived corrosion inhibitor; Q235 steel; electrochemical impedance spectroscopy; quantum chemical parameter

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