

Assessing the corrosion inhibition potency of some selected pure phytocompounds for steel protection in oil and gas applications

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Abstract In line with the use of nontoxic, biodegradable, green and sustainable materials for corrosion inhibition, we present a comprehensive evaluation of three natural phytocompounds, namely synephrine, troxerutin and epigallocatechin gallate (EGCG), which were correspondingly isolated from immature bitter orange, sophora flower and green tea leaves, as environment friendly and cost-effective corrosion inhibitors for steel in 1 M HCl solution. Following their isolation, the phytocompounds were unambiguously characterized using FTIR and NMR spectroscopies before subjection to a series of experimental (EIS, potentiodynamic polarization (PDP), and SEM) and computational (quantum chemical parameters and molecular dynamics simulation) investigations. The evaluations were achieved with respect to the concentrations of the phytocompounds, time of steel exposure to the acidic environment and the temperature of the test environment. Moreover, PD revealed that synephrine, troxerutin and EGCG exhibited mixed-type corrosion inhibition behavior for steel with strong dependence on their concentration. Troxerutin reached an optimum inhibition efficiency of 98% at 2 g/L while those for synephrine and EGCG were 84% and 78%, respectively. Furthermore, time-dependent EIS experiments showed that troxerutin manifested the highest impedance ($492.9 \Omega\text{cm}^2$) at the start of immersion, and the value progressively declined to $63.5 \Omega\text{cm}^2$ after 168 h. Similarly, the value for EGCG decreased from 32.4 after 1 h to $10.1 \Omega\text{cm}^2$ after 168 h. Synephrine initially increased from $140.7 \Omega\text{cm}^2$ to $430.0 \Omega\text{cm}^2$ after 2 h, and then slowly decreased to $27.9 \Omega\text{cm}^2$ after 168 h. For the protection of steel, the phytocompounds followed the trend: troxerutin > synephrine > EGCG. The metallic protection was validated by the presence of adsorbed film layers on the surface of steel from SEM examination, whereas computational evaluations allowed the description of the adsorption characteristics and molecular interactions/orientations of the phytocompounds on Fe substrate. This study advances the development of commercialized bio-based corrosion inhibitors.

Keywords Carbon steel, Acid environment, Corrosion inhibition, Phytocompound, Electrochemical measurement, Computation