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CORROSION INHIBITORS BASED ON N- DODECYLPYRIDINIUM BROMIDE FOR STEEL IN DIFFERENT MEDIA

Metallic material such as steel in aggressive media is usually subjected to degradation, which induces its mass loss, alteration of their properties and limits their sustainability and usefulness.

To limit the corrosion deleterious effect on steel material, different approaches were developed, among which the use of inhibitors coating is the most popular. The efficiency of such coating depends mainly on its chemical composition and structure, concentration and its interaction with the metal surface. The most used organic inhibitors contain oxygen, sulphur and nitrogen atoms or aromatic heterocycle and/or double or treble bonds [1, 2]. Among these organic compounds, ammonium salt have proven their efficiency as anticorrosion coating for steel and iron in acidic medium [3].

In the present work, N-Dodecylpyridinium bromide compound synthesis was described, and its anticorrosion efficiency was evaluated using electrochemical measurements such as Tafel polarization.

For the synthesis of N-Dodecylpyridinium bromide, a mixture of 0.05 mol of pyridine and 0.05 mol of hexadecylbromide in 10 ml of acetone was refluxed for 1 h. The reaction mixture was cooled and the obtained product was filtered and dried in a vacuum desiccator. Elemental Analysis of the synthesized compound was found in % as follow: C, 62.15; H, 9.16; Br, 24.31; N, 4.22; whereas calculated one, %: C, 62.19; H, 9.21; Br, 24.34; N, 4.27.

The structure of synthesized compound was characterized by Nuclear Magnetic Resonance (NMR) spectroscopy. 1-Hexadecylpyridinium bromide ¹H NMR (CDCl₃) 0.8 (3H, t, J = 6.7 Hz, CH₃); 1.16-1.27 (26H, m); 1.95-2.00 (2H, m); 4.90 (2H, t, J = 7.6 Hz, N-CH₂); 8.13 (2H, t, J = 7.0

Hz, Ar-H); 8.50 (1H, t, $J = 7.8$ Hz, Ar-H); 9.41 (2H, d, $J = 5.5$ Hz, Ar-H). ^{13}C NMR 13.85; 22.41; 25.85; 28.84; 29.10; 29.20; 29.28; 29.35; 29.38 (br.); 29.40; 29.42 (br.); 31.64; 31.72; 61.88; 128.32; 144.85; 145.05.

The used steel has the following chemical composition (wt%): 0.22 C, 0.65 Mn, 0.17 Si, 0.04 P, 0.05 S, 0.08 As, 0.3 Ni, Cu, Cr and balanced Fe. Steel electrode was sealed with epoxy resin, and the exposed cross sectional area is 0.2 cm^2 . Furthermore, the steel electrodes (2 cm^2) were abraded with a series of emery papers (grade 400–2400), washed with acetone and distilled water and then dried in air.

Polished steel was modified with synthesized N-Dodecylpyridinium bromide, using electro grafting method according to the scheme on Fig. 1. The electrolyte was prepared by dissolving Pyridinium salt in acetonitrile under vigorous agitation at room temperature over 20 min, then the electro grafting of prepared compound is achieved by the voltammetry cyclic method.

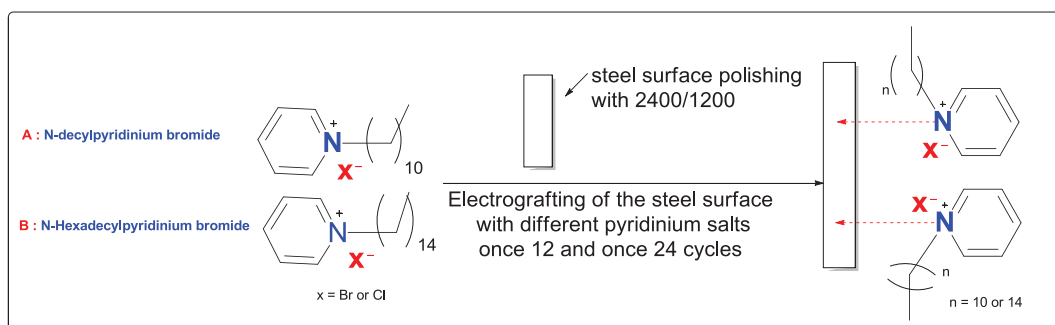


Fig. 1– Mechanisms of surface modification by electrochemical reduction of pyridinium salts

The electrochemical measurements were achieved in a three-electrode cell without stirring, with a steel as working electrode, a platinum as a counter electrode and Ag/AgCl as the reference electrode. Before starting the measurements, the electrodes were immersed in the electrolyte solution, at open circuit potential (OCP), during 20 min, which correspond to the time to reach a steady state. The potentiodynamic polarization curves were recorded in the potential range from -1300 to $+300$ mV versus Ag/AgCl with a scan rate of 5 mV/s . the grafting is achieved during different voltammetry cycles, 12 and 24 (Fig. 2).

To evaluate the effectiveness of the grafting, the surface morphology of bare and coated steel was investigated by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). It is well known that radical grafting is effective, when the formation of thin layers with controlled thicknesses is obtained. Furthermore, the effectiveness of the prepared inhibitor thin layer depends on the length and structure of the carbon chain of the organic molecule grafted on the electrode surface.

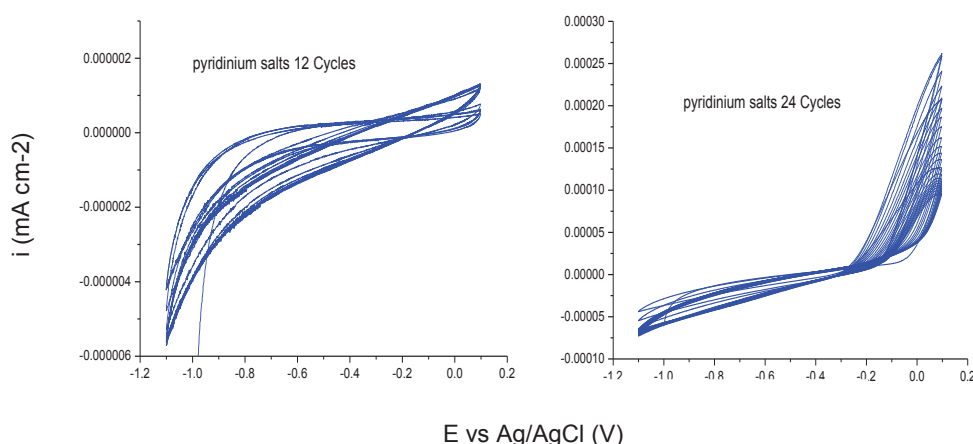


Fig. 2 – Cyclic voltammogram at scan rate of 10 mV and in pyridinium salts during 12 and 24 voltammetry cycles as indicated.

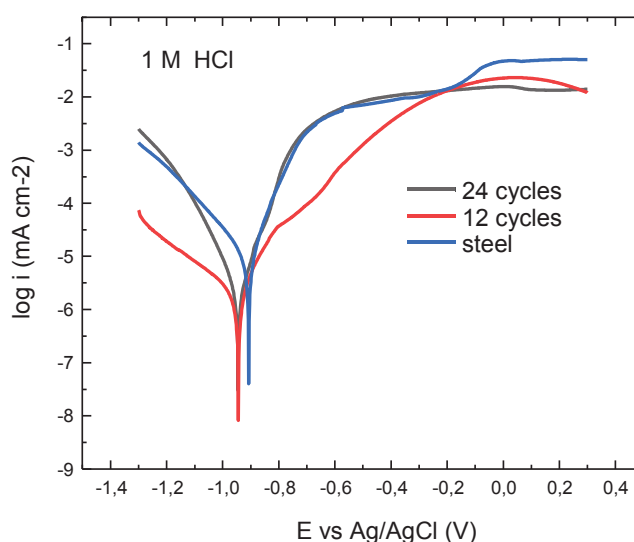


Fig. 3 – Polarisation curves of steel in 1M HCl without coating and with coating obtained after different voltammetry cycles as indicated

The Tafel polarization curves of different electrodes are depicted in Fig. 3. The corrosion current (I_{corr}), and corrosion potential (E_{corr}) as well as the cathodic (bc) and anodic (ba) slopes are determined by extrapolation of the linear region of the plots. Furthermore, from Fig. 3 it can be observed that both cathodic and anodic Tafel curves corresponding to bare steel and coated steel with N-Dodecylpyridinium bromide are parallel, which suggest that N-Dodecylpyridinium bromide in the aggressive solution does not change the mechanism of metal dissolution and the hydrogen evolution reaction. In addition, it can be also observed that the grafted steel during different numbers of voltammetry cycles shows low corrosion current compared to that of the bare steel. The current density

decreases from $5.91 \cdot 10^{-6} \text{ A/cm}^2$ to $4.16 \cdot 10^{-7} \text{ A/cm}^2$ for bare and coated steel, respectively. The corrosion current of coated steel electrode decreases, with the rising of the number of voltammetry cycles of electrodeposition process, suggesting the anticorrosion efficiency enhancement of the coating.

Furthermore, it was observed from Fig. 3 that the E_{corr} values are slightly shifted toward both cathodic and anodic potentials, without any definite trend. This reveals that N-Dodecylpyridinium bromide could inhibit both anodic and cathodic reaction at the same time.

In summary, N-Dodecylpyridinium bromide have been prepared in a simple and effective way, and its anticorrosive performance was evaluated for steel protection. It was demonstrated that N-Dodecylpyridinium bromide inhibitor provides a good protection against corrosion for steel in HCl solution. Electrochemical measurement reveals that N-Dodecylpyridinium bromide could inhibit both anodic and cathodic reactions at the same time.

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