



Chemical modification of talc with corrosion inhibitors to enhance the corrosion protective properties of epoxy-ester coating



Ali Bahrani^a, Reza Naderi^{a,*}, Mohammad Mahdavian^{b,*}

^a School of Metallurgy and Materials Engineering, College of Engineering, University of Tehran, P.O. Box 11155-4563, Tehran, Iran

^b Surface Coatings and Corrosion Department, Institute for Color Science and Technology, P.O. Box 16765-654, Tehran, Iran

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ABSTRACT

The present work aims to study the function of talc as a corrosion inhibitor reservoir and its ability to absorb and release corrosion inhibitors to achieve active corrosion protection in an epoxy ester coating. In this sense, zinc cation and 4, 5-imidazole dicarboxylic acid were used for talc modification. The performance of corrosion inhibitors was studied in the solution and coating phases using electrochemical and surface analyses. Results indicated that talc can adsorb the corrosion inhibitors and release them in saline solution. It was found that these inhibitors have a synergistic inhibition effect in the solution and coating phases.

1. Introduction

The coating active protection, particularly in the defects, has been reported to be achieved by direct or indirect addition of corrosion inhibitors to the formulation [1,2]. The direct addition to organic coatings has different drawbacks such as uncontrollable release of inhibitors which results in short-term protection and interference of inhibitors with curing reaction of organic coating [3–6]. One of the strategies to solve these problems is to use reservoirs for inhibiting species to activate the corrosion inhibiting process only when necessary [7]. Various methods have been applied to store active species such as corrosion inhibitors in these reservoirs. Ion-exchange inorganic particles, e.g. nanoporous and mesoporous metal oxide like titania, clays and zeolites have been employed to reach self-healing features in the organic coatings [7–10]. Organic and/or inorganic ionic species can be adsorbed onto or intercalated in the ion-exchange inorganic media to provide on-demand release in contact with corrosive environment. It has been shown that incorporation of organic anions, e.g. benzo-triazolate, ethyl xanthate, and oxalate in hydroxalate-like pigments in the polyvinyl butyral coating on an aluminum alloy provides active corrosion inhibition [11]. Snihrova et al. [3] showed that CaCO₃ microbeads doped with cerium nitrate and loaded into the water based epoxy coating are able to provide on-demand release and “smart” protective properties to the coating.

One of the effective methods to achieve a long-term corrosion protection is to use inorganic pigments [12]. Generally, the action of inorganic inhibitors depends on precipitation of insoluble compounds

and/or formation of a passive film [13]. For example, Ce (IV) acts as cathodic inhibitor through forming cerium oxide/hydroxide barrier film on mild steel [14] and chromates and phosphates act as anodic inhibitor through forming a passive film [12,15]. It has been shown the use of organic and inorganic inhibitors in the coatings can provide synergistic effect on the corrosion protection of metals. One of the main reasons for the synergistic effect is formation of insoluble complex between the organic and inorganic components on the metal surface [16]. It is important to note that the main inhibitive mechanism of organic corrosion inhibitors is adsorption on the metal surface [17–19]. This might be a result of the interaction between unoccupied orbitals of surface and electron donor parts of inhibitor molecules [20,21]. In a study, sodium montmorillonite clay (Na-MMT) was used as nanocontainers for Zn²⁺ and benzimidazole (BIA) inhibitors to improve the protective performance of an epoxy ester coating [16]. The highest corrosion resistance was observed when the Zn-MMT + BIA-MMT clay particles were used. It was found that the synergetic effect of BIA⁺ and Zn²⁺ cations to form insoluble complexes inside defect was responsible for the efficient active protection of this sample [16]. Alinejad et al. [22] studied the impact of zinc cation and 2-mercaptobenzoxazole (MBO) on the corrosion protection of a silane sol-gel coating on mild steel. The results indicated the superior protective performance of silane coating incorporating MBO/ZnCl₂ compared to the ones incorporating each inhibitor individually. Incorporating NaX zeolite nanoparticles doped with Zn²⁺ and 2-mercaptobenzimidazole (MBI) in an epoxy ester coating artificially defected, Rassouli et al. [23] reported an active corrosion protection as a result of precipitation of a layer

* Corresponding authors.

E-mail addresses: reznaderi@ut.ac.ir (R. Naderi), mahdavian-m@icrc.ac.ir (M. Mahdavian).

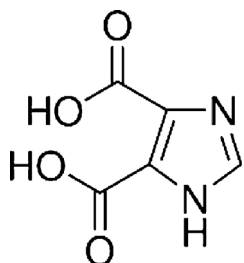


Fig. 1. Chemical structure of 4,5- imidazolecarboxylic (IDC).

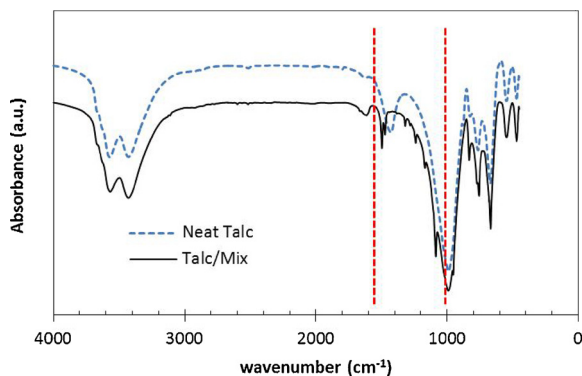


Fig. 2. FTIR spectra for the modified and unmodified talc particles.

mainly composed of zinc hydroxide, organic inhibitor, MBI-Zn/Fe complex in the scratch.

Talc as a natural mineral commonly used in organic coatings has been reported to improve the barrier corrosion protection of coatings [24]. Natural talc is a magnesium silicate that composed of sheets stacked on each other which is made up from magnesium–oxygen/hydroxyl octahedral sandwiched between two layers of silicon–oxygen tetrahedral [25,26]. Adsorption of heavy metals and naphthalene on talc, and its cation-exchange capability have been studied in the literature [27–30]; however, to the best of our knowledge, there is no study on doping of talc with corrosion inhibitors to obtain on-demand release in the organic coatings. Due to its low price, processing of talc to obtain advanced corrosion inhibitor release behavior can be of great interest for anticorrosion pigment manufacturing companies.

In the present study, 4,5- imidazolecarboxylic acid as an organic inhibitor and zinc cation as an inorganic inhibitor were separately loaded in talc to evaluate their on-demand release and their possible synergistic effect. For this purpose, the corrosion inhibition was

evaluated in solution and coating phases through electrochemical methods and surface analysis.

2. Experimental

2.1. Materials

The chemical structure of the organic inhibitor, 4,5- imidazolecarboxylic (IDC), used in this work is shown in Fig. 1. Zinc nitrate as inorganic inhibitor was used. Synthetic grade of these chemicals were purchased from Merck and used without further purification. The steel panels used in this study had the following composition: (composition wt.%: C:0.19, P:0.005, Si:0.415, Co:0.055, Cr:0.026, Mo:0.018, Mn:0.018, Nb:0.0481, S:0.005 and Fe: balance). Talc was purchased from Poodrsazan company (Iran) with grain size of 10 μm . Dispersing agent (DC4044, Delta Specialties, Egypt), cobalt drier (IS-DR-CO-10, Isatis, Iran), zirconium drier (IS-DR-ZR-12, Isatis, Iran), calcium drier (IS-DR-CA-10, Isatis, Iran), anti-skinning agent (Exkin, Rockwood, U.S.A) and epoxy-ester resin (P-1001-X-60, solid content 60% in xylene, Parspamchal, Iran) were used to prepare the coating material.

2.2. Sample preparation

2.2.1. Uptake of inhibitors on talc

In order to load the inhibitors on talc particles, 1 mM solution of each inhibitor in distilled water was prepared. For evaluation of synergistic effect of the two inhibitors, a solution with 1:1 mol ratio was also prepared. To uptake inhibitive species on talc, 1 g talc was added to each above solutions and stirred with 800 rpm for 24 h at 25 °C. After that, talc was filtered out and washed with distilled water and then, it was dried in ambient temperature.

2.2.2. Extract solution preparation

Dried talc was added to 3.5% NaCl solution and stirred with 800 rpm for 24 h at 25C followed by filtration. Inductively coupled plasma-optical emission spectrometer(ICP-OES, VISTA-PRO, Varian, Australia) and total organic carbon (TOC) content analyzer (TOC-L, Shimadzu, Japan) were employed to characterize the type and concentration of species released from talc.

2.2.3. Coating preparation

Modified and unmodified talc particles (2 wt.%) and dispersing agent (0.05 wt.%) were added to the epoxy-ester resin. The mixture was homogenized for 20 min to achieve a uniform dispersion of talc particles in the coating. The fineness measured by grindometer (Model 2050, Elcometer, England) was below 10 μm . Then, driers (0.03 wt.% of each

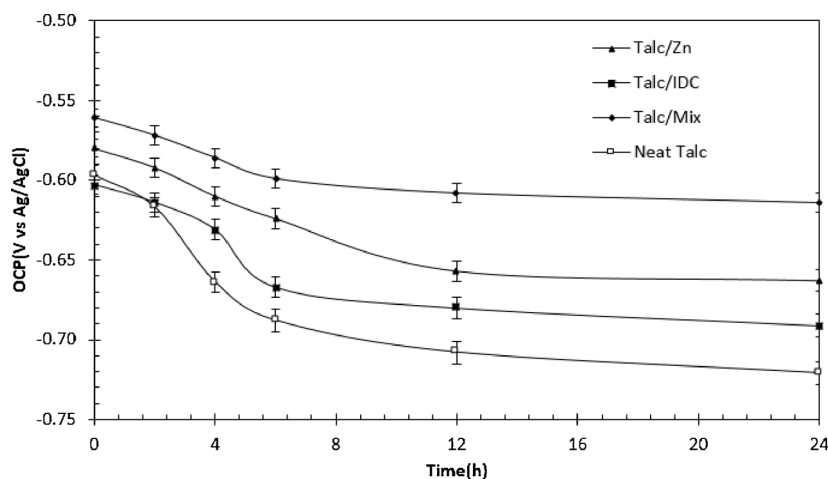


Fig. 3. The OCP values obtained during 24 h immersion in the test solutions. The scatter band shows the standard deviation of triplicates.

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