PVP-Oxime-SiO₂- Adenine, Antibacterial and Anticorrosive Behavior

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ABSTRACT

As nanotechnology developed, the chemical architecture of materials was modified. Our study aims to develop nanohybrid sol-gel processes comprising silica particles and a polymer resin, including functionalized carboxylic groups (typically epoxy or phenolic resins). A film of ceramic glass is formed when the metallic plate is coated. It is possible to obtain corrosion-resistant properties by incorporating these particles into polymeric matrixes. Researchers studied infrared spectroscopy and scanning electron microscopy to determine the structure of RF refers to phenolic resin, RFF refers to resin functionalized, and RF-SIO₂ and RFF-SIO₂ refers to their respective hybrids.

As a result of polarization, Polyvinylpyrrolidone (PVP) appears to act like a mixed-type inhibitor. The charge transfer process is largely responsible for preventing corrosion of the C-steel. Using weight loss as a measure of inhibitory efficacy ranged from 56 to 83% while using electrochemical methods, it was 60 to 90%. PVP adheres to steel and prevents corrosion, according to different tests. The Langmuir adsorption isotherm is found to govern PVP adsorption on the C-steel surface. An explanation for PVP's inhibitory action is suggested. A thermodynamic parameter Eapp is determined by the adsorbed PVP on the C-steel surface, *H, and *S decrease. As inhibitor concentration and temperature increase, so does PVP's inhibition efficiency.

Keywords- Antibacterial Property, Phenolic Resin, Nanohybrid sol-gel, Polyvinylpyrrolidone (PVP).

I. INTRODUCTION

A new approach using phenolic or epoxy resin substrates functionalized with Abietic Acid, followed by the reaction with silica particles, results in a hybrid (organic/inorganic) material [1, 2]. A growing number of inorganic-organic composite materials are emerging as alternatives to inorganic anticorrosion materials [3]; however, both their thickness and density cannot protect the metal surface sufficiently [4,5]. Incorporating nanoparticles into Novolac type resins or epoxy resins can improve their properties from a technological and scientific viewpoint [6].

Developing materials where the properties can be predicted before manufacture is crucial for progressing our understanding of hybrid materials [4.6]. The sol-gel reaction is used to create hybrid polymer resins resistant to corrosion by adding silica particles to polymer matrixes[7.8,9]. Functionalization involves carboxyl groups, which ensure strong interactions between polymers and copper surfaces and form an optically clear glass-ceramic coating. Various analytical techniques were used to determine these properties. Since these materials can be used to design experimental conditions for developing new nanomaterials, their characterization suggests they might have important applications in technology.

Many structural applications rely on iron and its alloys. In humid environments, their susceptibility to rust and their rapid dissolution in acidic environments make them inefficient for large scale use. An important technique for enhancing oil production is acidizing petroleum in oil wells. A 15-28% solution of hydrochloric acid is used during the process. They are diluted with inhibitors to prevent aggressive corrosion of the tubing and casings caused by acid solutions. Metals exposed to acidic environments are often protected against corrosion by inhibitors. A metal corrosion inhibitor usually adsorbs on the surface of the metal and retards it from corroding in aggressive media. It is critical to choose the right inhibitor for the metal at hand to prevent this. Nitrogen [1], Oxygen [2,3], and Food Extract [4] are organic compounds that inhibit enzyme activity. Studies have shown that corrosion prevention works by forming free electrons between the electrons within an inhibitor and the electrons present in a metal's open orbital. [5,6] Green inhibitors, or environmentally friendly inhibitors, have been getting more attention in recent months. Materials such as polyvinylpyrrolidone (PVP), polyethyleneimine (PEI) and caffeic acid (CA) fall into this category. Inhibiting steel and its alloys have been done extensively with acidic media [7-16].

The purpose of this study was to determine if polyvinyl pyrrolidone (PVP) could inhibit carbon steel corrosion in unstirred, aerated solutions containing 2M HCl. In alkaline solutions containing NaCl (four) and in neutral solutions (17), polyvinyl pyrrolidone (PVP) has been reported to inhibit corrosion. In this study, electrochemical methods, polarization potentiodynamics and gravimetric measures (weight loss) were utilized. The thermodynamic parameters of this green corrosion inhibitor are evaluated, and a mechanism is proposed to explain its inhibitory effect. www.ijrasb.com

II. METHODS & MATERIALS

Methods

Novolac-type resin was synthesized conventionally in this study, and carboxyl groups were added. The hybrid material was prepared in ethanol solutions by combining modified phenolic resin with silica.

This study analyzed a wide range of hybrid materials. To facilitate the identification of specific compounds among the diverse specimens, the following nomenclature is employed: (i) $SiO_2(y)/RF(x)$ or (ii) $SiO_2(x)$ -RFF/IC, where x and y (x+y=100) are the percentage weights of the two phases, and (ii) that after the hybrid synthesis an organic acid or base (IC) is added, the HF, HCl, or NH3 is displayed; otherwise, they would not be visible. It has been described elsewhere[1] how to prepare modified resins (RFF) and hybrid materials.

Steel for this tool is supplied by ODS (Germany). By percentage, the discs with the following composition (particle diameter 2.98, particle thickness 0.65,) were used: C is 0.46, Mn is 0.60, Si is 0.17, P is 0.016, S is 0.008, Cr is 0.17, Ni is 0.05, Mo is 0.01 and Cu is 0.06, Al is 0.02 and the remaining is Fe. From Sigma Aldrich, we purchased polyvinyl pyrrolidone (PVP). PVP has a molecular weight of 8000 grams per mole. Figure 1 illustrates its chemical structure. From concentrated HCl solution (from BDH) was prepared 2M HCl as a blank solution. Standardizing the solution with sodium bicarbonate gave the concentration of the solution. PVP was dissolved in a volumetric flask with HCl liquid to make the final concentration range between 800-2000 ppm by dissolving a certain weight of solid PVP in the flask.



Figure 1: PVP Structure

Discs of C-steel (area 19.65 cm²) were polished with emery paper (600- 1200 grade) using a polishing machine (Metaserve) until a mirror image was obtained. A Cole Palmer ultrasonic cleaner was used to clean the discs with acetone after they were washed with distilled water. The dimensions of each disc were determined prior to immersion in the test solutions. Weighed (0.0001 g, Mettler Toledo) C-steel discs were immersed in 50 ml of the test solution for 1 hour in a thermostated water bath before weight loss experiments were conducted. After running the discs through the ultrasonic cleaner with acetone, then drying and weighing the discs, they were rinsed with distilled water. It was determined how much weight was lost. Two experiments with identical weight loss were taken and expressed as a percentage.

In an ultrasound bath (Branson, model 3210), commercial copper plates (70x120x5 mm) were cleaned. A SiO₂-based film and RFF-based SiO₂-based film were prepared; the coating was applied from an ethanol solution, while the hybrid substrates were prepared using RF-SiO₂ and RFF-SiO₂ sols. Paint-brushed coating substances were applied to each Cu plate. Both the resin and in the case of the hybrid systems, were cured by thermal treatment at 180°C for these systems.

As per the ASTM, corrosion tests were conducted on Cu plates coated with PFR, FPFR, PFR-SiO₂, and FPFR- SiO₂ films using an ASTM-certified Q-FOG Cyclic Corrosion Tester 1100. This is standard B117-07a. Corrosion tests were conducted over 24 hours and 48-hour periods, the length of exposure time depending on the intensity of the corrosion attack.

For each of the applied coatings, we recorded how long it took for the first sign of corrosion to appear. The coatings' peeling resistance was evaluated according to ASTM D 1654-05. A scratch was asked of each copper plate after 96 hours of testing, from which max and min detachment were measured. Adhesion tests were conducted on dry coatings according to ASTM D 3359-02 Method B. Triplicates were performed. 2 mmdiameter cutting spaces and six cuts were performed. TABER Industries, Model 5050 abraser was used to conduct the abrasion tests in accordance with ASTM D 4060-07. A coating was exposed to these conditions three times with humidity of 57% and temperature of 23°C. 500 grams of load was applied, there were 100 cycles, and the abrasive type was CS-10.

III. DISCUSSION AND RESULTS

Figure 2 depicts Nyquist plots ranging from 2000 to 8000 parts per million. Impedance plots for inhibited and uninhibited electrodes are not significantly different despite the lack of significant variations. In Nyquist plots, the semicircular line does not change as the inhibitor increases; only the semicircular line does. As the impedance response characterizes the characteristic semicircles, our results suggest that the csteel dissolves in response to charge transfer control. Charge transfer resistance values (RCT) were determined by finding the diameters of semicircles in the Nyquist plots. Electron transfer across C-steel surfaces is inversely proportional to corrosion rate and Rct measurements. The diameter of semicircles increases with increasing inhibitor concentration, indicating greater inhibition potential [19-25].

The RFF results demonstrate that Novolac-type resins are functionalized when bands at 1737 cm⁻¹ and 1610 cm⁻¹ correspond to vibrations of asymmetric and symmetric carboxylic acids, respectively. The C-O-C

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bond vibrational bands have been observed by FT-IR spectroscopy before [8,9]. An asymmetric vibration for silica pure is 1112 cm⁻¹. whereas a symmetric vibration for Si-O-Si is 794 cm⁻¹. The Si-OH band appears to be around 952 cm-1 in the samples [10,11]. In the 3700-3000 cm⁻¹ region, there are bands caused by hydroxyl groups. RFF(40)-SiO₂(60) hybrid OH groups are observed to be associated with 3600- 3000 cm⁻¹ in ethanol, phenol, and silanol groups [11]. Since oxygen has a high electronegativity, in RFF polymer chains, a carbonyl group can bond with oxygen, allowing acidic groups like silanols to bond with oxygen.

The SEM photos of hybrid and non-hybrid materials were examined in this study[1,8]. This article describes the morphology and optical characteristics of materials that SEM has characterised.

A RF(x)- SiO₂ (y) system shows different optical properties (transparency or opacity) depending on the molar ratio of the RFF/ SiO₂ and the catalyst selected. In their high SiO₂ content, these materials are typically synthesized using HF or NH₃. A weak chemical reaction occurs across the interface between silica particles and RF resin (figure 3 a-d).

An optical and morphological study of a hybrid of RFF(x) with $SiO_2(y)$ is presented in figure 4 a-d. The clustering of silica particles alters the optical properties of the system[1]. The above analysis illustrates that, depending on the preparation conditions, the mean particle size of SiO_2 and the interface between the silica and RFF matrix are variables that can alter the transparency or opaqueness of the material. If the silica content is low enough, the hybrid materials will be transparent-translucent regardless of the catalyst used to promote gelation.



Figure 2: An EIS plot for HCl in the presence or absence of different inhibitor concentrations is shown in the figure (Source '' Farjami et. al., 2020'')

These plots illustrate that the high-frequency loop is depressed, whereas the low-frequency loop is inductive. A capacitive loop is usually caused by

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resistance resulting from charge transfer and delay caused by the electric double layer. The inductive loop may form when a reaction surface is covered with intermediates. An inhomogeneity causes a depressing form of a high-frequency wave at the interface or structural disturbances such as those experienced in adsorption processes [18]. In Figure 3 you can see the Randle cell, an equivalent circuit representation of the system. Solution resistance is represented by capacitance, while Rct represents charge transfer resistance. Variations in surface roughness alter the capacitance in the equivalent circuit depending on its frequency.



Figure 3: RF(60)- SiO₂(40) photos, RF(53)- SiO₂ (47) photos, RF(43)- SiO₂ (57) photos, RF(26)- SiO₂ (64) photos, RFF(53)- SiO₂ (47) photos, RFF(43)- SiO₂ (57) photos.

In Figure 4, we demonstrate C-steel's potentiodynamic polarization characteristics in the presence and absence of different substances, as well as the concentrations of PVP. An electrode's Tafel plot demonstrates a rather similar shape compared to an electrode that is uninhibited. In the presence of the inhibitor, the current density is reduced, but no other aspect of behaviour is affected. The adsorption of the inhibitor led to increased inhibition of corrosion (Ecorr). In addition to decreasing the anodic slopes of the Tafel,

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PVP also decreases the cathodic slopes. Therefore, PVP represents a mixed-type inhibitor that inhibits hydrogen oxidation and iron dissolution [15,16]. As PVP is present on the electrode surface, a protective film forms, which reduces the flow of positive and negative currents. In a 4000–8000 ppm range, the surface coverage and inhibiting efficiency increased with increasing PVP concentrations.





Figure 4: These micrographs demonstrate the SEM appearance of nanostructures (a) made up of RF(53)-SiO₂ (47); (b) made up of RF(43)- SiO₂ (57); (c) made up of RF(26)- SiO₂ (64)/NH3; (d) made up of RF(53)-SiO₂ (47); (e) made up of RF(43)- SiO₂ (57);

IV. CONCLUSION

It is concluded that PVP exhibits corrosion inhibitory properties even at high temperatures. The maximum IE was achieved after four hours. A double electronic layer was found to form on the surface of metals after PVP adsorption in solution using EIS. Based on the results of the Tafel study, PVP has mixed-type inhibitory effects on iron dissolution and hydrogen evolution. We find that the Langmuir adsorption isotherm holds for the weight loss experiment. The inhibition efficiency of PVP increases with increasing inhibitor concentration and temperature. The highest IE was achieved in WL using 8000 ppm as the maximum inhibitor concentration. EIS and Tafel showed the highest % IE at concentrations between 4000 and 8000 ppm of inhibitor. From the change in pH levels for HCl + PVP and HCl + PVP + C-steel solutions, the Eapp and G°ads values, and the positive nature of the C-steel surface in this study, it may be concluded that the molecules of PVP are chemically adsorption through negatively polarized oxygen atoms.

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