Adsorption Behavior of Polyphenolic Proteins onto High Strength Steel (HY80) and 5083 Aluminum Alloys

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Introduction

"Flash rusting" is the corrosion activity which occurs on metal surfaces under certain environmental conditions (i.e. high relative humidity) during the amount of time after a metal surface is being cleaned and before a new protective surface treatment can be applied. The rusting is influenced by the moisture condition at the exposure site (high relative humidity) and environmental contaminants (chlorides and sulfates) that contribute to coating deterioration when they are not completely removed during the surface preparation before recoating. In this case, the secondary surface preparation for steel is required to return steel surface to a "light" flash rust condition. Therefore, an environmentally friendly corrosion inhibitor system concerning the release of hazardous materials is apparently needed.

Biopolymers containing chemical groups involved in the formation of adhesive bonds to various substrates (man-made or natural) can be easily found from organisms in nature. The biopolymers utilized by organisms in a process known as quinone tanning contain a unique catecholic amino acid, namely 3, 4-dihydroxyphenyl-L-alanine (L-dopa). It has the ability to chelate or couple to the metallic ions or metal oxides that are present at the metal-solution interface. The formation of an insoluble metallo-polymer complex by metal ion bridging at the surface that acts as a stabilizer of the oxide layer can inhibit the process of corrosion. This peculiar capability could be utilized as an environmentally friendly flash rust inhibitor when applied to high strength steels in a humid environment. In the present work, five L-dopa containing proteins were isolated from the foot of the common blue mussel, ***Mytilus edulis***, named ***Mytilus edulis*** Foot Protein 1 through 5 (MeFP 1 through 5) with a wide range of molecular weights from 6-120kDa (Figure 1).

The goal of this study is to determine the biopolymer adsorption behavior of the various L-dopa containing proteins isolated from the blue mussel and ascidians on the high strength alloy steel (HY80) powder and the 5083 aluminum alloy (Al5083) powder. This work will presents and compare the effects of different concentrations of biopolymer on the surface of the metal substrates.

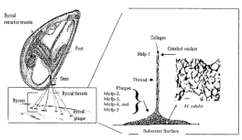

Figure 1. Blue Mussel

Figure 2. Experiment set-up

Materials and Methods

Adsorption behavior of the adsorbates onto high strength steel (HY80) and the 5083 aluminum alloy was determined based on the Langmuir Isotherm model (Eq. [1]). The Bradford protein assay was used to detect the solution concentration of non-adsorbed protein onto either alloy. Langmuir isotherm calculations were made to determine the adsorption behavior based on the differences of between the original concentration at time zero and the concentration at each time point. The experiment was set up as shown in Figure 2. Substrates were equilibrated with buffers in autoclaved 2.0-ml centrifuge tubes for 1h at room temperature with rotation end over end, prior to adding the measured volume of the adsorbate to yield the given bulk solution concentration. Isotherm measurements were made at time points 0, 1, 5, 15, 30, 60 and 120 min. Triplicate samples were monitored using the Bradford assay. The amount of adsorbates present in the bulk solution was calculated as a function of time. The experiment was conducted in 3% NaCl under the pH of 7.8 to approximate the chloride ion strength of seawater. Bovine Serum Albumin (BSA) and L-Dopa were used as the comparison to MeFP 1 through 5 onto HY80 and Al5083 powder.

Results and Discussion

Table 1 lists the adsorption isotherm measurements for BSA and L-Dopa onto HY80 and Al5083 obtained from individual concentration data. Based on the correlation coefficient values in Table 1, the relationship is linear except for HY80/L-Dopa. Experiments will be partially repeated (e.g. L-Dopa/HY80, which has a low value of r^2). Initial adsorption measurements were made without substrates, which show that there was no significant adsorption of the adsorbates onto the inner surface of the tubes in the control measurements.

A representative plot of the adsorption data shows good agreement with the adsorption model (Figure 3). The calculation of the resulting the values of max number of adsorption sites for BSA and L-Dopa onto HY80 and Al5083 powder show that the adsorption behavior of the two adsorbates on the 2 metal surfaces are different. However, more data points are needed to determine if the adsorption behavior can be adequately described by the Langmuir theory of adsorption. Adsorption measurements data of MeFP will be presented and discussed.

Table 1. Adsorption Parameters Calculated from Adsorption Isotherms of Each Adsorbate onto Metal Powder.

Metal	Adsorbate	Linearization correlation coefficient, r	Max number of adsorption sites, N (mol/m^2)	Affinity constant, K (mol^{-1})
Al5083	BSA	0.944	4.9463×10^{-8}	5.41×10^{11}
Al5083	L-Dopa	0.851	8.796×10^{-10}	1.431×10^{10}
HY80	BSA	0.96	1.6155×10^{-8}	-7.642×10^{-10}
HY80	L-Dopa	0.1801	1.23×10^{-8}	4.808×10^{-10}

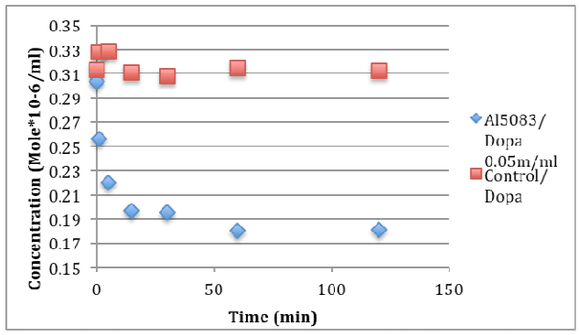

Figure 3. Adsorption measurement of L-Dopa adsorbed on Al5083 over time. Squares are control bulk solution concentrations of L-Dopa only; diamonds are bulk solution concentrations with powder in suspension.

References Cited

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