Lab 6: Electroplating and Corrosion

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Introduction

Objectives:

- To define corrosion and be able to identify five engineering examples of corrosion that require materials selection.
- Conduct electrodeposition.
- Characterize corrosion behavior of galvanized and ungalvanized steel in various environments.
- Discuss and compare the advantages and disadvantages of different corrosion protection approaches.

Approach:

- To conduct electrodeposition, we electroplated zinc onto steel using an electric cell.
- To characterize corrosion behavior in galvanized and ungalvanized steel, we observed the differences between the two types of nails in various solutions.

Results

Part 1: Electroplating Zinc onto Steel

Material	$m_i\ (g)$	$m_f\ (g)$	Length after Deposition (cm)	Width after Deposition (cm)
Steel	15.77	15.92	28.91	26.16

Actual thickness of the Zinc Coating:

$$t\frac{m}{2\rho wh} = \frac{15.92-15.77\ g}{2(7.14g/cm3)(28.91cm)(26.16cm)} = 1.3889 \times 10^{-5} cm$$

Number of zinc atoms deposited onto the steel surface:

$$N_{e-} = \frac{I\times s}{e-} = \frac{(1A)(598s)}{1.6E-19} = 3.74 \times 10^{21}\ electrons$$

$$N_{Zn} = 1/2 \times N_{e-} = 1.87 \times 10^{21}\ zinc\ atoms$$

Theoretical change in mass:

$$\Delta m = \frac{I\times s\times M_{zn}}{2\times e-\times N} = \frac{(1A)(598s)(65.38g/mol)}{2(1.6E-19)(6.02E23)} = 0.203g$$

Theoretical change in thickness:

$$\Delta t = \frac{\Delta m}{\rho\times wh} = \frac{0.203g}{(7.14g/cm3)(28.91cm)(26.16cm)} = 3.75 \times 10^{-5}\text{cm}$$

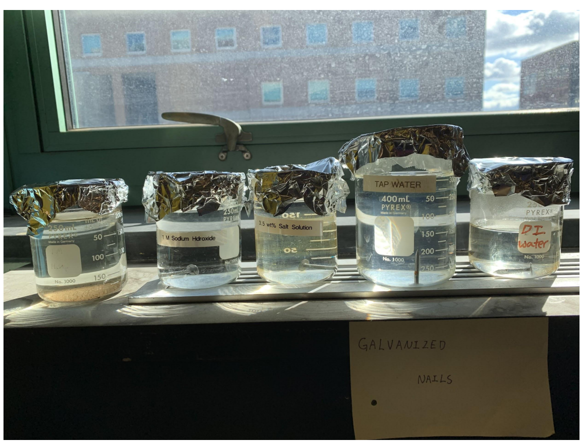
% Error:

Mass: 26.1% error

Thickness: 64.30% error

Part 2: Effects of Zn coating on steel corrosion

	1M H_2SO_4	**1M Sodium Hydroxide**	**3.5% wt salt solution**	**Tap Water**	**DI Water**
Plain	Black, bubbling, has lost its shape, partially dissolved	Slightly less lustrous, no change in shape or color	Partially corroded, rust color on the exterior, small amount of rust deposition	Corroded, rust colored, lots of deposition on the bottom of the beaker	Corroded, rust colored, lots of deposition on the bottom of the beaker
Galvanized	Black, bubbling, has lost its shape, partially dissolved	No change in shape or color	No change in shape or color, slight salt deposition on the surface, not as lustrous	No change in shape or color,	No change in shape or color



Discussion and Conclusions

After performing the lab, it has been found that depending on a material's chemical composition, it can experience different reactions in certain environments. Steel is known for being sensitive to oxidation and corrosion, and thus it is typically layered with a material to act as a preventative barrier to keep the steel from corroding. The process of incorporating extraneous materials into steel's composition was exemplified in Part 1 of the lab, where a 15.77 gram Steel slab was plated with Zinc via an electrodeposition process. In this scenario, Zinc acted as the sacrificial coating, which meant that some of its mass would be transferred to Steel. Using a simple circuit setup, with a voltage of about 1 Volt and a current of 1 Ampere being transmitted through the two metals submerged in an electrolyte solution in series, an electroplating procedure was conducted between Zinc and Steel. From the instant that the voltage and current were introduced to the two metals, a stopwatch was initiated from zero, and at approximately 598 seconds, the procedure was halted to analyze the results. It was found that the mass of the Steel had increased by a magnitude of 0.15 grams to a final mass value of 15.92 grams. This, along with the coating layer that was visible on the area of the steel that was submerged in the electrolyte solution, showed that a portion of the mass of the Zinc was transferred to the Steel slab, living up to the initial hypothesis of the experiment. Using the length and width dimensions of the Zinc coating on the Steel slab, as well as the change in mass of the Steel, the thickness of the Zinc layer was obtained, where the actual thickness of the zinc solution was calculated as 1.3889 E-5 cm compared to the theoretical thickness, calculated at 3.75 E-5 cm. Also, the actual mass of the steel deposit was calculated as 0.15 g where the theoretical change in mass was calculated as 0.203g. This resulted in a 26.1% error for mass and a 64.3% error for thickness. A source of error in this lab could have been from the resistances of the circuit. The resistor could have not actually been 1 Ohm, and the internal resistance of the circuit contributed to a voltage drop. As a result, the current through the circuit was not exactly 1A. In addition, the sample could have still been slightly wet while its final mass was being measured, resulting in a smaller change in mass. Besides the slight imperfections present in the experimentation process, the results show the effectiveness of the electroplating process even under such simple conditions. In Part 2 of the lab, the properties of plain and galvanized Steel were observed. In nearly every solution, the galvanized Steel presented little to no signs of reaction to its environment. On the other hand, the plain Steel in the same solutions showed signs of deterioration and corrosion in the form of bubbling, color change and flakiness of the material. The exception was H_2SO_4, which showed strong signs of deterioration in both cases, perhaps due to how strong the solution is, at a point where a Zinc coating made no difference. In brief, the electroplating process was proven effective through the experimentation process in Part 1 of the lab, and from the observations made in Part 2, the benefits of this process lived up to its hypothesized effectiveness.

Broader Impacts

Electroplating can be used in numerous applications. Corrosion resistance, as demonstrated in the lab, is one of these applications. Additionally, electroplating can be used in minimizing the cost of electronics. Gold and silver are good conductors of electricity, however they are very high cost materials, electroplating is often used to coat other metals in a layer of these more expensive conductive metals to help conduct electricity. Electroplating can also be used for aesthetics, for example in jewelry. Similarly to electroplating for use in electronics, a cheaper metal is plated with a layer of a more expensive precious metal such as gold or silver, however the purpose is not conduction but to give the product a better look at a lower cost.

References

"Uses of Electroplating with Its Practical Applications in Real Life." *BYJUS*, BYJU'S, 28 Aug. 2020, https://byjus.com/physics/uses-of-electroplatin