Screws & Liquids:A Chemical Reaction that forms Rust

Abstract

Rust can be seen anywhere on objects where iron can be found. However, rust works differently in different conditions. This phenomenon makes us wonder how a cast iron pan that has not been used in 7 months will be completely fine in a house but not in a forest. In this experiment, we will explore the effects of liquids on steel, a common metal that has iron in it.

Screws & Liquids:A Chemical Reaction that forms Rust

Metal is the most widely used material in the world by weight. Unfortunately though, despite its popularity, metal has a little problem: it is very likely to rust. According to Anne Marie Helmenstine (2024), rust is simply the sum of iron, oxygen, and water and is also known as iron oxide. If we want to be technical it's "iron oxide hydrate", because pure iron oxide isn't rust.

As a common name for iron oxide, rust is easily seen because of its reddish coating in most situations. Because iron has other oxidation states, you can also find rust forming in yellow, brown, orange and even green because of the variety of chemical compositions of rust (Helmenstine, 2024). When iron or its alloys are exposed to moist air, rusting occurs. Reacting with the metal to form the hydrated oxide is when oxygen and water in the air react. This reddish coating forms flakes on iron and steel (Fe_2O_3) however, all iron does not rust at the same rate (Helmenstine A, 2024).

For rust to form, it requires 3 chemicals: iron, oxygen and water. iron + water + oxygen → hydrated iron(III) oxide, as an example of an electrochemical reaction and corrosion: anodic dissolution or oxidation of iron going into aqueous (water) solution. 2Fe → 2Fe2+ + 4e-. In addition, cathodic reduction of oxygen that is dissolved into water also occurs, 2Fe2+ + 4OH- → 2Fe(OH)2.(Helmenstine A, 2024)

In this experiment I will be testing how liquid affects rust on iron objects. We must keep in mind that oxygen gas (O_2) is not the only source of oxygen in air or water, oxygen also contains carbon dioxide (CO_2). (Helmenstine A, 2024) When water and oxygen react, weak carbonic acid is formed. As a better electrolyte that pure water iron is dissolved forming iron

oxide which releases electrons and will flow to another part of the metal. This is when rusting starts to corrode the metal (Helmenstine A, 2024)

Method

To make this experiment steel (a metal with iron in it) screws were simply attached to the lid of glass bottles. Each bottle is filled a bit over halfway with different liquids: pure water, tap water, white vinegar, 91% isopropyl alcohol, bleach, and Coca-Cola. My initial hypothesis was that the lower the PH, the uglier the screw will get. This experiment was done over the course of 37 days and the screws were taken out on 21 of those days in order to make observations and take pictures. Notes from only seven days made it into this paper.

Results

On the first day, there was already some stuff happening to the screws. The vinegar and the Coke screws were getting dark. Bleach had a couple of dark spots around it. On the second day, rust was already visible on the vinegar's screw. A bit of rust was visible on the part of the screw that is not making contact with the vinegar. On the third day, the tap water’s screw had a couple of spots on it. On the seventh day, the bleach’s screw decided to contradict my hypothesis and the part of the screw touching the bleach started to fall apart in the form of orange dust. On the twelfth day, I noticed that the vinegar and the bleach were changing appearance. The vinegar was turning yellowish and the bleach was looking less foggy than it was at the start of the experiment. On the final day, the thirty-seventh day, I cleaned the vinegar and the bleach as best as I could and noticed that the vinegar's screw had a dent on it. Finally, the tap water’s screw started to rust.

Here are the results: The top of the purified water's screw is lighter than the bottom, sort of like a color gradient. The tap water's screw rusted a bit. The white vinegar's screw dissolved a bit in the vinegar and the top of it collected a lot of gunk. The 91% isopropyl alcohol's screw was perfect. The bleach's screw rusted a lot on the part touching the bleach. The Coca-Cola's screw was dark on the part touching the Coke.

Discussion

This experiment demonstrates how rust can be sped up by stuff around a piece of iron other than water and oxygen. For some of the liquids, the half of the screw that was not touching the liquid actually got some damage, showing how stuff in the air can also affect rust. This project can be used to see how different environmental conditions can affect the quality of iron objects. For example, swamps are usually acidic so leaving your cast iron pan in a swamp probably is not a good idea.

References

Helmenstine, A. (2024). *How Rusting and Corrosion Work*. ThoughtCo. https://www.thoughtco.com/how-rust-works-608461