# When Metals Eat Each Other: Galvanic Oxidation in the Home

*by*
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Ale, the oldest brother of the Luna family, and his sister Cori were watching their favorite show when the power suddenly cut off. They both yelled at the same time: "No way! What happened?" At first Ale thought it was a blackout in the area, but he ran to the window and noticed the neighbors still had power.

Ale grabbed an old flashlight and went downstairs to inspect the electrical panel. It was dark, the flashlight was not working properly, and he couldn't see clearly. He came upstairs for his cell phone.

Cori was still sitting on the couch. "What happened? What did you see?"

"I couldn't see anything. Have you seen my cell phone?"

"Yes, it's in your room."

Ale made his way through the darkened house to his bedroom, grabbed his cell phone, and used the flashlight app to return downstairs to look at the panel. He saw a bunch of red and white electrical cables coming out of a rusted metal box. The sight gave him goose bumps because it reminded him of a movie he saw when he was four years old about an electrical panel that caused a house fire and left a family homeless. He closed the panel without attempting to fix anything. As he went back upstairs he noticed he felt nervous and a little afraid; the fact that his sister might sense his fear and make fun of him made matters worse. "So, did you fix it?" she asked.

"Sure, Cori, that's why it's still so dark in the house."

"No need to be sarcastic! What did you see?"

"A bunch of cables and the electrical panel is rusted. It doesn't look safe; I think we better wait for Dad."

That wasn't good enough for Cori; they were missing their tv show. "Did you look for a tripped breaker?"

"No, I didn't, and I'm not going downstairs again."

"Ale, stop being a scaredy-cat!"

"I'm *not* being a scaredy-cat! If you're so eager, you can go do it yourself."

Cori grabbed her phone, went downstairs and found the tripped breaker, but when she tried to reset it a big spark occurred. She came upstairs, pale and shaking. "What happened?" asked Ale.

"You were right, it's not safe, let's call Dad," Cori replied.


*Figure 1.* Electrical panel.

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Mr. Luna came home and looked at the panel, and the kids were right, it looked scary. He decided to call an electrician. Miguel, an experienced electrician, came an hour later. After checking the electrical panel, he said "Mr. Luna, you need to replace the whole panel. I can clearly see that in your panel metals are eating each other."

"Wow, how is that possible? Mr. Luna asked.

"This is a common issue in houses built between the 1960s and 1970s. I can make a quick repair, but if you don't change the panel this will happen again."

"Ok," Mr. Luna replied, "let's do a quick repair for now and can you please give me an estimate for the replacement of the electrical box?"

"Sure, I will fax it to you. Today's visit is $150, and that will be deducted from your bill if you decide to repair your electrical panel with us."

Mr. Luna thought, "Wow, that's a lot of money for just saying that metals were eating each other."

After Miguel left, Mr. Luna kept thinking what he meant by "metals eating each other." Could metals really eat each other? He decided he needed to do a little research before he would be willing to pay what was sure to be a lot more than the $150 for the house call.

Mr. Luna soon found the topic on the internet and that the expression used by the electrician was basically correct. He learned that when dissimilar metals are in direct contact a spontaneous process known as galvanic oxidation starts and produces rust. Galvanic corrosion is a term almost always associated with electrical applications since direct contact between metals is required. The more he read the more he wanted to learn, but he was having a hard time understanding some of the terms. He then remembered his son Ale was currently taking chemistry and might be able to help him with the terminology.

"Ale? Can you please check in your chemistry text book—what does 'galvanic oxidation' mean?"

"Yes, Dad! Galvanic oxidation refers to the process in which two incompatible metals undergo galvanic oxidation."

After a few seconds of puzzlement, Mr. Luna exhaled deeply and said, "Ale, please, all I need is some help understanding the terms, not just reading their meaning from a textbook. Can you explain yourself a little better?"

"Sorry, Dad. Do you at least know that metals are made of atoms and atoms can lose or gain electrons?"

Mr. Luna noticed his son was giving him a little attitude. Slightly ashamed of his lack of knowledge, Mr. Luna responed: "Of course, I took chemistry a long time ago but I still remember the atomic models."

"Ok, let's start by saying that corrosion occurs when two dissimilar metals are in direct contact with each other in the presence of an electrolyte. The electrolyte is the media that will allow the movement of electrons. Metals are said to be dissimilar when they have opposite tendencies to lose or gain electrons. These tendencies are intrinsic to the nature of each element and are experimentally measured and tabulated as potential difference. This table can also be called a galvanic series."

"Ok, I understand that," said Mr. Luna. "I remember that metals like lithium and sodium have high tendencies to lose electrons. I also remember when my chemistry teacher explained the reactivity of sodium in water. Am I correct?"

"Yes, Dad." Ale had a smile on his face.

"I think I get it now. So in this table negative means easy to lose electrons and positive means easy to gain electrons?"

"Correct!"

"So are all these terms related to electrochemistry?"

"Yes, Dad. Galvanic oxidation is an example of a redox reaction; in other words dissimilar metals in direct contact and in the presence of an electrolyte can undergo a redox reaction. The element that loses electrons is oxidized and the element that gains electrons is reduced."

"Ok, now I understand that dissimilar metals have different signs in the galvanic series. But are both metals corroding?"

"Good question, Dad. Let me see."

Ale read in his textbook for a while and then came back to his dad to explain. "OK, when two dissimilar metals are in contact the more anodic element will corrode. This is the element that loses electrons and has negative potential value. And the element that gains electrons is cathodic and is the one with positive potential."

"Wow, so many terms. But basically, galvanic oxidation happens because of the contact of an anode and a cathode, which also means that one element loses electrons while the other one gains electrons. If the metals in contact have the same sign for the potential that means they are compatible and no galvanic oxidation should occur. Correct?"

"Yes, Dad!"

"Then where is the electrolyte in our electrical panel?"

"Ummhhh, I don't know about the electrolyte in the electrical panel."

"Well, Son, I'm proud of you. And thank you for helping me with electrochemistry."

"No problem."

"So now let's try to figure this out. The electrician said that houses built between 60s and 70s had this problem, so that means they have a lot dissimilar metals in contact."

| *Metal* | *Symbol* | *Electrode Potential Difference (volts)* |
|---|---|---|
| Lithium | Li | -3.04 |
| Rubidium | Na | -2.92 |
| Potassium | K | -2.92 |
| Calcium | Ca | -2.87 |
| Barium | Ba | -2.80 |
| Sodium | Na | -2.71 |
| Magnesium | Mg | -2.37 |
| Aluminum | Al | -1.67 |
| Zinc | Zn | -0.76 |
| Chromium | Cr | -0.74 |
| Iron | Fe | -0.44 |
| Nickel | Ni | -0.24 |
| Tin | Sn | -0.14 |
| Lead | Pb | -0.13 |
| Hydrogen | H | +0.00 |
| Copper | Cu | +0.34 |
| Iodine | I | +0.54 |
| Silver | Ag | +0.80 |
| Gold | Au | +0.80 |
| Mercury | Hg | +0.80 |

*Figure 2.* Table of electrode potential differences.

Mr. Luna went back to the basement and carefully looked for wires that were in direct contact. Most of the copper wire connections had a lot of rust. He also noticed some of the wires were copper and some were aluminum. In one spot these different wires were in contact with each other and the area between them was very corroded; to his surprise there were even burn marks around that spot. Mr. Luna wondered if this is what the electrician meant when he mentioned the problem of houses built in the 1960s.

He came back upstairs and told his son: "Ale, I'm afraid the electrician is correct; in our electrical panel metals *are* eating each other."

## Questions

1. What does the expression "metals eating each other" as used by the electrician refer to? Explain and give an example.

2. What are the possible electrolytes in the rusted panel?

3. Using the table for electrode potential differences (Figure 2) identify the possible composition of the screws responsible for the corrosion observed in the contact area with the copper wire.

4. Why is copper considered a noble metal?

5. Suppose zinc and copper are in contact by an electrolyte. Which material will corrode (see Figure 2)?

6. Why is it important to account for the compatibility of metal in structural design?

7. Plating is a process used to protect a metal from being oxidized by another metal. In some cases, a more anodic metal is used to coat a less anodic metal. The result of this process is known as a sacrificial anode; the more anodic metal is corroded instead of the metal it protects. Give an example of a more anodic metal that can be used to protect tin.

8. The Statue of Liberty, completed in 1886, used a copper exterior skin supported by a cast iron structural frame. In 1984 it was closed to the public. The structural frame was replaced by stainless steel while the exterior skin remained copper. Why do you think iron cast was replaced by stainless steel?

9. Are rusted panels a fire hazard? Explain.

10. Are there any hazards associated with aluminum wires joined with copper wires by twisting? Why was aluminum used in electrical wires in houses built in the mid-1960s?

11. Galvanic pain is a term used to describe the pain caused by dental restorations made with dissimilar metals. Use the concepts learned in this case to discuss the following statement: the metallic contact between gold and silver amalgam fillings will cause galvanic pain and should be considered malpractice.

12. We have discussed how in galvanic oxidation the contact of dissimilar metals initiates the loss of electrons in the more anodic metal. Can the loss of electrons from the more anodic metal create an electric current during the corrosion process? Explain.