ABC UTC ACCELERATED BRIDGE CONSTRUCTION UNIVERSITY TRANSPORTATION CENTER

Activity: Corrosion of Civil Infrastructure

Introduction

Materials durability of the aging civil infrastructure in the US including highway, drinking water, port and waterway systems have become of vital interest to maintain public safety and economic vitality. In particular, the direct cost of corrosion has been estimated to be over 3% of the nation's GDP. Recent high profile national news has highlighted the issue including compromised public health and safety. Recent projections have indicated that insufficient number of technical practitioners and engineers well-versed in corrosion engineering will be available to address this growing problem. It is of great importance to promote recruitment of students to the engineering fields and encourage multidisciplinary interests to address multifaceted problems such as materials durability and corrosion engineering

Basic Activity 1 ~45 minutes:

Awareness and discussion of infrastructure durability and corrosion issues at the national and state level.

A video exposé from the show 60 Minutes entitled "Falling Apart: America's Neglected Infrastructure" and a slide presentation by FIU faculty will be shown to the seminar participants to discuss the importance of the topic. Group discussion on importance of multi-disciplinary study to address complex problems will be made. For this activity it will be discussed that chemistry is as important as mechanics in addressing durability of structures.

Points to emphasize

Students should be encouraged to explore the engineering fields.
STEM topics should be promoted.
Multi-disciplinary study should be promoted

Basic Activity 2 ~30 minutes:

Introduction to electrochemistry: galvanic cells

Consideration of the environment and the selection of materials are important in the design of structures. A simple experiment showing that interaction of different metals can cause reactions to degrade the material. The reaction caused by the interaction of two common metals will also produce electrical current flow to light a light bulb.

Materials Needed

- 3-4 lemons/ lime
- 3-4 galvanized nails
- 3-4 pennies
- 4-5 electrical connection wires
- 1 low power LED light (~2-3V)
- 1 volt meter

Precaution. *A knife may be needed to cut a slit in the lemon to place the coin. Also, the nails will have a sharp tip. Well supervised students can conduct this experiment.*

Procedure

1. Create galvanic cells
    a. Place 1 galvanized nail in each of the lemons.
    b. Place 1 penny near but not touching the galvanized nail. (The effect of the orientation of the penny can be explored)
    c. Check the voltage developed between the nail and penny by placing one test lead wire from the voltmeter on the nail and the other on the penny. (Each cell, or instrumented lemon, should provide ~0.5-1V.
2. Attach cells in series to provide 2-3V. (It's like placing multiple batteries into an electrical device where contact is made between the + and – ends of the batteries.)
    a. Connect the penny of cell 1 to the nail of cell 2 with a connection wire.
    b. Connect the penny of cell 2 to the nail of cell 3.
    c. Connect another wire to the remaining nail.
    d. Connect another wire to the remaining penny.
    e. Check the voltage between the wires in step 2c and 2d with the volt meter. You should get the summation of voltage from the individual cells. Add additional cells until you get 2-3V.
3. Place the LED light to the wire in step 2c and 2d. The LED will have poles. You should refer to the packaging for forward and reverse voltage limits to avoid damaging the LED. The longer leg of the LED should be connected to the wire attached to the penny of cell 3. The shorter leg of the LED should be connected to the wire attached to the nail of cell 1.
4. The LED should light up. The light is probably going to be faint but noticeable.

Basic Activity 3 ~15 minutes:

Introduction to electrochemistry: electrolytic cells

Application of physical chemistry can be made to engineering systems in a controlled and predictable manner. For example, cathodic protection systems are often used to mitigate corrosion on structures. A simple experiment will demonstrate that reactions can be controlled. Here a nickel coin will be electroplated with copper from a penny.

Materials Needed

- Goggles
- Gloves
- 1 cup to hold ~25 mL liquid
- 1 penny
- 1 nickel
- 2 electrical connection wires
- 1 9 volt battery with test lead connectors

- ~25 mL copper-sulfate solution. (~1 M solution for example).

Precaution. MSDS sheet for copper-sulfate solution should be referred for safety and disposal. Well supervised student can perform this experiment but personal protection protocols must be adhered. Also, available resources to dispose of the solution should be considered.

Procedure

1. Connect 1 connection wire to the penny
2. Connect 1 connection wire to the nickel
3. Attach the wire in step 1 to the + terminal of the battery
4. Attach the wire in step 2 the – terminal of the battery.
5. Immerse both coins in the cup of solution without touching each other.
6. The nickel will be plated with copper.