

West Side Science Club – Event #24 – “Fuel Cells and Catalysts”

Original Presentation

Date: 1 March 2014
Time: 10 am to 12 pm
Site: West Side Science Club

Big Questions

- These questions are meant to frame the day’s event and might be written on the chalkboard
 - (1) How does a fuel cell work?
 - (2) What is a catalyst?

Concepts

- Concepts to cover from the “Work of CCI Solar” Mind Map: Reactions- oxidation/reduction, acid/base, yield, rate, starting materials, products; Social Aspects- climate change, greenhouse gases, global energy demand, fossil fuels, renewable vs nonrenewable energy; Energy- forms, storage, conversions.

Lesson Plan

Student Objectives

- Understand what a catalyst is and when they can be used in chemistry
- Become familiar with the mechanics behind a fuel cell and how it operates
- Be able to relate catalysts with fuel cells and why it can be beneficial to have a catalyst layer on your fuel cell membrane

Schedule/Agenda

- Review: Event #23– “Field trip to USC ” (10 min.)
- Activity: Testing Fuel Cell efficiencies (1hr min.)
- Activity: Cobalt Catalyst Color change (40 min.)
- Wrap-up (10 min.)

Materials

Activity: Testing Fuel Cell efficiencies

- Horizon fuel cell car kits
- Pt plated fuel cells from kit made in lab
- Multimeters
- Alligator clips
- Power supply

Activity: Cobalt Catalyst Color Change

- Cobalt chloride solution, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, 0.1 M, 12 mL
- Graduated cylinders, 100-mL and 25-mL
- Hydrogen peroxide solution, 6%, H_2O_2 , 40 mL
- Hot plate/stirrer
- Potassium sodium tartrate solution, 0.21 M, 100 mL
- Thermometer
- Beaker, 600-mL

Safety

- Safety glasses and gloves should be worn at all times, especially for the cobalt catalyst experiment
- Cobalt chloride waste needs to be saved in a waste container to be properly disposed of at Caltech
- Cobalt chloride is toxic by ingestion and causes blood damage. Hydrogen peroxide is an oxidizer and a skin and eye irritant

Review of Previous Event: Field trip to USC

- Recall the trip: Presentation on methanol fuel cells and lab tour of the Loker Hydrocarbon Research Institute

Facilitation Questions

- What were the researchers making in the lab at USC? What did their fuel cells take in and what did they put out? What types of devices did you see that day which can run on a fuel cell?

Activity: Testing Fuel Cell Efficiencies

Procedure

1. Recall the discussion of how the methanol fuel cells worked from last week
2. Using the fuel cell packs from the Horizon fuel cell car kits, explore how these hydrogen fuel cells work by visual inspection

3. Have a mentor charge up one of the fuel cells using a power supply and explain how it operates while it is running
4. Students now try on their own to charge the fuel cell and then test the voltage and current outputs on the cell using a digital multimeter, connected to the cell's leads by alligator clips.
5. Next, introduce a doctored up cell from one of the kits where a layer of Pt has been deposited on the membrane to act as a catalyst
6. Have the students determine voltage and current output from this cell using the multimeters

Facilitation/Concept Questions

- How is the fuel cell working?
- Is a power supply the only way to charge a fuel cell?
- What was the difference upon adding the Pt catalyst to the fuel cell? Is this a beneficial adjustment?

Activity: Cobalt Catalyst Color Change

Procedure

1. Using a graduated cylinder, measure out 100 mL of 0.21 M potassium sodium tartrate solution. Pour it into a 600-mL beaker.
2. Slowly warm the solution to 70 °C on a hot plate.
3. While waiting for the temperature of the solution to increase, measure out 12–14 mL of 0.1 M cobalt chloride solution in a 25-mL graduated cylinder. Show this solution to the class so that the students can note the pink color of the catalyst.
4. When the temperature of the potassium sodium tartrate solution reaches 70 °C, add 40 mL of 6% hydrogen peroxide and the cobalt chloride catalyst to the 600-mL beaker. Stir continuously.
5. The solution will go through a series of color changes as the cobalt chloride begins to catalyze the reaction. The solution will start out pink (the color of cobalt chloride) and then darken to a brown before lightening up to a yellow-orange and finally becoming an olive green color. At this point, the reaction mixture is bubbling vigorously.
6. Once the bubbling subsides, the solution will progress back through the series of colors and return to the original pink color of the cobalt chloride solution.

Facilitation Questions and Concepts

- What is a catalyst? What ingredient acts as a catalyst in this experiment? What evidence supports that ingredient as a catalyst?
- Predict what would happen if the catalyst was added to potassium sodium tartrate that was heated to 50°C instead of 70°C

Check for Understanding

- What is a catalyst? How are catalysts used in fuel cells?
- Is it a good idea to use a catalyst in your fuel cell car do you think? Why or why not?

Wrap Up: Event #25 Preparation

- Come up with design plans for building your own fuel cell racecar!

References

- (1) Cobalt Catalyst activity: "Pink Catalyst "
<https://www.flinnsci.com/media/621012/91413.pdf>
- (2) "Horizon Fuel Cell Car Science Kit"
<http://www.horizonfuelcellshop.com/americas/product/fuel-cell-car-science-kit/>