Student Activity
Petroleum and Petrochemicals: Comparing Catalysts
Companion Web page:http://www.chemheritage.org/classroom/chemach/petroleum/index.html

Introduction and Historical Context

Catalysts are important in many chemical processes, especially in the industrial production of chemicals. In the petroleum industry, for example, the larger molecules in the crude-oil mixture are broken up by catalytic cracking, a process that uses zeolites, compounds that contain aluminum and silicon, as the catalyst. Eugene Houdry developed an early silica-aluminum-catalyzed process for increasing the components of gasoline.

In another process straight-chain hydrocarbons are converted to branched-chain compounds using platinum as the catalyst. This process increases the octane rating of gasoline. John Sinfelt developed catalysts for this process. Paul Weisz also developed zeolite catalysts for petrochemicals and other synthetic compounds made from petroleum.

Catalysts have been known since the 1800s. Jöns Jakob Berzelius first coined the term in 1836. Humphry Davy first used platinum as a catalyst, and Wilhelm Ostwald studied acids and bases as catalysts.

On the consumption side of the petroleum industry is the catalytic converter for automobiles, which was developed in the 1950s in response to increasing air pollution resulting in part from car-exhaust emissions. Houdry extended his interest in catalysts to help develop an early catalytic converter that had little success because the lead, then added to gasoline, was deposited on the catalyst, rendering it ineffective. For more on how catalytic converters work see http://auto.howstuffworks.com/catalytic-converter.htm .

Purpose

In this activity you will determine the best catalyst for a chemical reaction. Catalysts are important chemicals in many industrial processes, including the petroleum and petrochemical industries. You can read about the discovery of some important petroleum-related catalysts in the *Chemical Achievers* section called “Petroleum and Petrochemicals.”

Safety

During the activity you will be required to wear eye protection.

Materials and apparatus

- 6 small test tubes
- Test-tube rack
- Scoop
- Hydrogen peroxide (H_2O_2), 3%, approx. 25 mL
- Manganese dioxide (MnO_2)
- Copper(II) oxide (CuO)
- Zinc oxide (ZnO)
- Iron(III) oxide (Fe_2O_3)
- Potassium iodide (KI)

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Stopwatch or watch that measures in seconds
Goggles

Pre-Lab Questions

1. What is the definition of a catalyst?
2. How can catalysts affect chemical reactions?
3. What is the catalyst in the reaction demonstrated to you by your teacher?
4. In the demonstration shown to you by your teacher, what effect does the catalyst have on the decomposition of hydrogen peroxide? What evidence does the demonstration provide?

Procedure

1. Place six small test tubes in the test-tube rack. Label five of the test tubes with the name of one of the catalysts. The sixth test tube will not have a catalyst.
2. Weigh out 0.002 mol of each catalyst available to you. Label each sample.
3. Add 10 mL of 3% hydrogen peroxide (H_2O_2) to each test tube. Do not place any solid catalyst in the first test tube.
4. Add the first catalyst to test tube #2. Measure and record the time required for the bubbling to stop—the reaction time.
5. Repeat step #4 using a different test tube and a new catalyst sample. Do this for the remaining samples.

Post-Lab Questions

1. Compare the reaction times in the test tubes with catalysts to the time in the one with no catalyst. Did each of the catalysts change the rate of decomposition for hydrogen peroxide?
2. What is the role of the first test tube with no catalyst?
3. Which catalyst had the greatest effect on the reaction rate? The least?
4. Put the catalysts in order of influence, greatest to least. Compare your results with those of other lab groups.
5. Were the catalysts visible after the reaction stopped? How do these observations fit with the definition of a catalyst?

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