Safe Swimming with Sodium

Single Replacement Reactions

FLINN SCIENTIFIC CHEM FAX!

Introduction

No chemistry class is complete without the spectacular demonstration of alkali metals reacting with water. *Safe Swimming with Sodium* is a novel variation that is much safer to perform than the standard demonstration of simply dropping a small piece of the sodium metal into a beaker of water.

Concepts

- Alkali metals
- Single replacement reactions

Materials

Lithium metal, Li, 1 small piece (optional)
Phenolphthalein, 0.5% solution, a few drops
Sodium metal, Na, 1 small piece
Water, 200 mL
Glass cylinder, approximately 500 mL
Mineral oil, 200 mL
Ring stand and clamp

Safety Precautions

Sodium metal is a flammable, corrosive solid and is dangerous when exposed to heat or flame. Sodium also reacts vigorously with moist air, water, or any oxidizer. The pre-cut pieces provided for this demonstration greatly reduce the potential hazard of the material. Sodium reacts with water to produce flammable hydrogen gas and a solution of sodium hydroxide. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Clamp a hydrometer cylinder or large graduated cylinder to a ring stand for support.
2. Add about 200 mL of water to the cylinder along with a few drops of phenolphthalein solution.
3. Add 200 mL of mineral oil, forming a layer above the water. Tilt the cylinder to reduce mixing at the interface.
4. Drop a piece of sodium, about the size of a kernel of corn, into the cylinder and observe the reaction.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Do not dispose of anything until the sodium has completely reacted. The mineral oil can be stored and reused for future demonstrations and labs. The aqueous solution can be flushed down the drain with excess water according to Flinn Suggested Disposal Method #26a.

Tips

- The colorless water–phenolphthalein layer can be regenerated by the addition of a small amount of dilute acid, such as 1 M HCl. The setup can be used several times during the day.
- Sometimes during the first few reactions, the sodium metal may react very vigorously and briefly melt. If this occurs, the sodium becomes porous and "too light" to sink in the mineral oil. This piece of sodium will no longer swim—try another piece. This sometimes occurs because the mineral oil is wet or becomes wet during the setup.

Discussion

When added to the cylinder, sodium will sink in the mineral oil until it reaches the interface between the oil and water layers, at which time it reacts with water, forming hydrogen gas and sodium hydroxide, a strong base. The reactions of sodium and other alkali metals with water are classified as single replacement reactions or oxidation–reduction reactions. Sodium metal is oxidized to sodium ions, which "replace" the formal H^+ ions in water molecules. The hydrogens in water are reduced to elemental hydrogen gas.

$$2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq)$$

The evolution of hydrogen gas is evident, and hydrogen bubbles adhering to the sodium will carry it into the hydrocarbon layer, temporarily stopping the reaction. The amount of hydrogen and heat evolved is kept under control by this "swimming" behavior, making this demonstration quite safe. The piece of sodium repeatedly dives down to the water–hydrocarbon interface, reacts, then "swims" back up into the hydrocarbon layer until the reaction is complete. During the reaction, the piece of sodium is largely devoid of corrosion, allowing the students to view its gray, metallic appearance. The aqueous layer contains phenolphthalein and turns pink due to the production of a base, sodium hydroxide.

Density is an important physical property that can be used to separate materials or control reactions. Sodium has a density of 0.97 g/mL and sits at the interface of the water and oil layers. Lithium, in contrast, has a density of 0.54 g/cm^3, and will float on top of the hydrocarbon layer. (Try it!) The interface between two immiscible solvents is an effective site for controlling chemical reactions. Many industrial processes use this concept to react aqueous salts with nonpolar hydrocarbons.

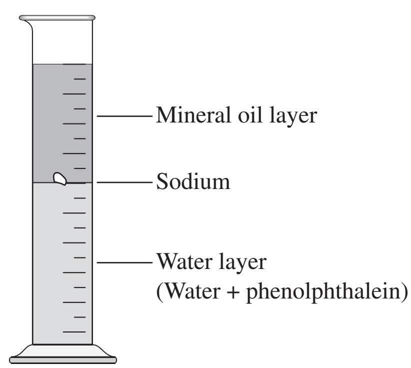
Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Systems, order, and organization
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Answers to Worksheet Questions

1. Draw the setup for this demonstration.



2. Describe what happened in the demonstration.

When the sodium was added to the hydrometer, it sank through the layer of oil on the top until it reached the interface between the layer of oil and the layer of water. The sodium reacted with the water and then rose back into the layer of oil. The sodium sank once again and continued reacting when it reached the water. This process repeated several times, and eventually the layer of water turned pink.

3. Why does the sodium metal sit at the interface between the oil and the water?

The density of sodium is greater than that of mineral oil but less than that of water.

4. Why does the sodium metal suddenly "jump up" from the interface?

When the sodium reacted with the water, it produced hydrogen gas and sodium hydroxide. Some of the bubbles of hydrogen gas adhered to the sodium and carried it back into the layer of mineral oil.

5. Why does the layer of water eventually turn pink?

The sodium produced sodium hydroxide when it reacted with the water. Phenolphthalein, an acid–base indicator, had been added to the water layer. Since sodium hydroxide is a base, and phenolphthalein is clear in an acid but pink in a base, the water turned pink.

6. Write the balanced chemical equation for the reaction of sodium with water.

$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Safe Swimming with Sodium* activity, presented by Irene Cesa, is available in *Single Replacement Reactions*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Safe Swimming with Sodium* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Safe Swimming with Sodium—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

Catalog No.	Description
AP8916	Safe Swimming with Sodium—Chemical Demonstration Kit
S0329	Sodium, bottle of 5 small pieces for demonstration
M0064	Mineral oil, light, 500 mL
P0115	Phenolphthalein indicator solution, 0.5%, 100 mL
AP8599	Hydrometer cylinder, 600-mL
L0057	Lithium, 2.5 g

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Safe Swimming with Sodium Worksheet

Discussion Questions

1. Draw the setup for this demonstration.

2. Describe what happened in the demonstration.

3. Why does the sodium metal sit at the interface between the oil and the water?

4. Why does the sodium metal suddenly "jump up" from the interface?

5. Why does the layer of water eventually turn pink?

6. Write the balanced chemical equation for the reaction of sodium with water.