Safe Swimming with Sodium

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 sodium metal into a beaker of water.

Concepts

- Alkali metals
- Single replacement reactions
- Density

Materials

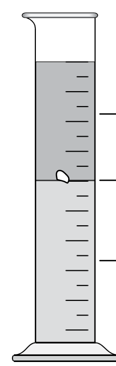
Lithium metal, Li, 1 small piece (optional)	Water, 200 mL
Mineral oil, 200 mL	Forceps
Phenolphthalein, 0.5% solution, a few drops	Glass cylinder, approximately 500-mL
Sodium metal, Na, 1 small piece	Ring stand and clamp

Safety Precautions

Sodium metal is a flammable, corrosive solid and is dangerous when exposed to heat or flame. Sodium reacts vigorously with moist air, water, or any oxidizer. Purchasing pre-cut pieces for performing this demonstration greatly reduces 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 review current 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 followed by 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. Using forceps, 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, and review all federal, state and local regulations that may apply, before proceeding. 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.
- A video of this demonstration, *Safe Swimming with Sodium*, presented by Irene Cesa, is available for viewing as part

of the Flinn Scientific "Teaching Chemistry" eLearning Video Series. Please visit the eLearning Web site at http://elearningflinnsci.com for viewing information. The video is part of the *Single Replacement Reaction* video package

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 (Equation 1).

$$2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq) \qquad \textit{Equation 1}$$

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.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
MS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions

Disciplinary Core Ideas: High School
HS-PS1 Matter and Its Interactions
PS1.A: Structure and Properties of Matter
PS1.B: Chemical Reactions

Science and Engineering Practices
Developing and using models
Constructing explanations and designing solutions

Crosscutting Concepts
Cause and effect
Structure and function
Stability and change

Acknowledgment

Special thanks to Ken Lyle, Duke University, Durham NC, for bringing this demonstration to our attention.

Reference

Alexander, M. D., J. Chem. Ed. 1992, 69, 418.

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

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 the Flinn Scientific website for current prices.

