TEACHER REFERENCE PAGES-CAFFEINE EXTRACTION LAB

Introduction

Extraction and purification of natural products from common tea bags would help students familiarize themselves with chemistry on a molecular basis.

In this experiment, students will extract caffeine from tea and purify it by sublimation. Caffeine is an example of an alkaloid. Alkaloids are nitrogen-containing ring compounds of plant origin that usually have a bitter taste and some biological activity. Morphine, nicotine, and quinine are three examples (see Figure A). Caffeine is a central nervous system stimulant. Because its ingestion results in wakefulness, it is the principal ingredient of No-Doz tables. It is also used to counteract the hypnotic effect of other drugs and is found in a number of analgesics.

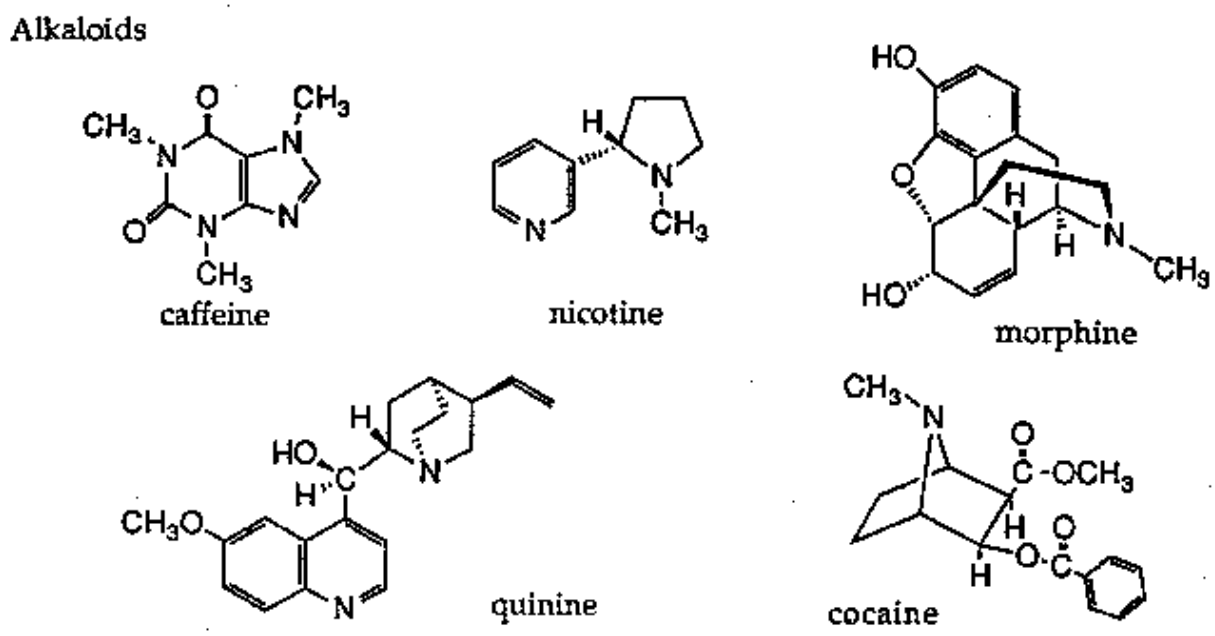

Figure A

The caffeine content of some common foods and drugs is summarized in Table 1.

Table 1. Caffeine Content of Common Food and Drugs

Coffee	80 - 125 mg/cup
Coffee, decaffeinated	2 - 4 mg/cup
Tea	30 -75 mg/cup
Cola	35 - 60 mg/12 oz
No-Doz	100 mg/tablet

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Equipment

Centrifuge
Analytical Balance

Supplies

10	Hot plates
10	Lab service dishes (purple)
10	Centrifuge tubes
	Tea bags
10	DI Water bottles
	Pasteur Pipets
10	10 mL Glass Pipets
10	Pipet pumps
10	100 mL Glass Beakers
10	50 mL Glass Beakers
	Vials 1M Na_2CO_3
	Vials Na_2SO_4
	Vials 1,1,1-Trichloroethane
100	Vials, empty
10	Stirring rods
2	Large hot plates
2	Large Aluminum pans for sand baths
	Sand
	Foil
	Ice
	Kimwipes

Purpose

To extract and measure the caffeine in a tea bag.

Key Words

These terms should be clear to students before running the lab:
Sublimation, Extraction, Purification, Alkaloid, Caffeine, Decaffeinated.

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Procedure

Refer to student handout for procedure. The sodium carbonate solution is used instead of water because caffeine is more soluble in it.

Reducing the volume to less than 10 mL is step 4 is important because the centrifuge tubes only hold 12 mL. Students will add 3 mL of solvent and then use a Pasteur pipette to remove liquid, and too much liquid will overflow the tubes. It is best to have only 6-8 mL of concentrated solution in order to obtain the maximum caffeine and to ease the extraction procedure.

Caution students regarding step 5 and the release of pressure in the vial. If the mixture in this step is shaken too vigorously, it may spew out when pressure is released, or an emulsion may form, making the extraction step more difficult.

Make certain that the centrifuge is balanced by equally distributing centrifuge tubes.

Demonstrate the technique for step 7.

The lab may be stopped after step 10 and continued the next day if necessary.

The sodium sulfate in step 11 is used to remove any water remaining in the 1,1,1-TCE extract.

Due to moisture contamination and condensation, the mass of a beaker at room temperature will be different from one which is cooled by ice or heated on the hot plate. All efforts should be made to compare masses of beakers with and without caffeine at the same temperature.

The ideal solvent for this extraction of caffeine is **methylene chloride**, but that chemical is not permitted in high school classrooms. 1,1,1-TCE is not as good a solvent for caffeine, but it does successfully demonstrate the techniques of this lab.

Questions

1. What is the solubility of caffeine in water? In 1,1,1 trichloroethane?

   solubility in water: 22 mg/mL @ 25°C, 180 mg/mL @ 80°C, and 670 mg/mL @ 100°C, somewhat soluble in 1,1,1-trichloroethane (teachers, we're trying to determine the precise solubility. If any one knows, please let us know.)

2. Why is 1,1,1 trichloroethane a better solvent for this extraction than water?

   the tannins, etc. are not soluble in it. (Teachers, we usually would expect to use a solvent which would dissolve more of the caffeine, and that improved solubility would be another reason. In this case, that is not true.)

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3. How does sublimation differ from vaporization?

   substance goes directly from a solid to a gas, not from a solid to a liquid and then to a gas

4. What was the purpose of the sublimation step of this lab?

   to remove the caffeine from the pigments and other impurities

5. Based on your knowledge of caffeine explain the reasons for this concern and possible effects on the body.

   excess known to cause birth defects

6. In your local grocery store you will find decaffeinated coffee and tea. Based on what you learned in this experiment propose a method by which the decaffeination process occurs.

   extraction with solvents such as 1,1,1-trichloroethane or methylene chloride. Current common commercial process involves extraction with liquid carbon dioxide (under pressure). also "Swiss water process"

References

1. L. F. Fieser and K. L. Williamson, Organic Experiments, 6/e, D. C. Heath and Co., Lexington, MA, 1987.
2. D. L. Pavia, G. M. Lampman, G. S. Kriz, R. G. Engel, Introduction to Organic Laboratory Techniques, A Microscale Approach, Saunders College Publications, San Francisco, 1990.