Absorption Spectrum of Active Ingredients in Sunscreens

CHEM 3710
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Introduction

In this experiment, you will extract the active ingredients from two sunscreen formulations and you will determine the intensity spectrum for these ingredients. This experiment will provide training in: using the balance to weigh quantities of reagents, dilutions, use of the pipets, use of a spectrophotometer to obtain spectra, analysis of spectra, and comparison of the relative effectiveness of the two sunscreens in protection against sunburn and skin aging.

Background Concepts

The sun produces a range of electromagnetic radiation, including ultraviolet, visible light, and infrared. The infrared is the radiation responsible for heating our planet. The visible light is what we see with our eyes, composed of the colors of the rainbow. The ultraviolet light, which we cannot see with the unaided eye, is the highest energy light of the three. The ultraviolet light is responsible for sunburns and suntan and can cause skin cancer. The ultraviolet spectrum is artificially divided into three ranges:

UVA is from 320 nm to 400 nm
UVB is from 290 nm to 320 nm
UVC is from 100 nm to 290 nm

UVC is blocked by the ozone layer in the upper atmosphere of the Earth and therefore does not reach the surface. The ozone layer also blocks some of the UVB. All of the UVA passes to the surface of the Earth. Generally, UVB has been blamed for sunburns and suntans, but recent studies indicate that UVA causes damage to skin, resulting in aging and potentially cancer.

Sunscreens are cosmetic formulations that contain active ingredients that are designed to block UV rays. Some of the UV rays still reach the skin, so tanning and even burning can still occur, but it takes much longer. Many years ago, the US government presented a rating called sun protection factor (SPF) that aims to provide some indication of the protection provided by sunscreens against UVB radiation. SPF 15 in theory indicates that you can stay in the sun 15 times longer than you would if you had no sunscreen. Despite new evidence that UVA also damages the skin (perhaps in even more severe ways), the FDA currently does not have a standard for sunscreens to indicate the level of protection against UVA rays. So, each manufacturer is left to define the level of UVA protection in their own way.

There are a number of different active ingredients that are found in sunscreens in the US. The list of active ingredients is regulated by the FDA, and few new ingredients have been added over the last 15 years. By contrast, many new ingredients are used in Europe, with most of the new additions providing strong protection against UVA.

In the experiment today, you are going to extract the active ingredients from 2 different sunscreen formulations and you will record the spectrum for these active ingredients. You will compare each for protection against UVA and UVB light exposure. The active ingredients in most sunscreens are not water soluble, so you will solubilize the active ingredients using an organic solvent, 2-propanol (also called isopropanol or rubbing alcohol).

Experiment Protocol

SAFETY:

As with any experiment, it will be absolutely crucial that everyone is wearing their goggles, full-length pants, and closed-toed shoes.

2-propanol is flammable. Avoid flames and sparks.

2-propanol vapors may be irritating to the eyes and respiratory system. Work in a well ventilated area.

2-propanol does not present any direct skin contact hazards. In the event of skin contact, wash your hands with soap and water.

DISPOSAL:

All materials in this experiment should be disposed of in the proper waste containers provided.

PROCEDURE:

Materials Needed:

Two sunscreen lotions.
2-propanol (150 mL)
2-50 mL screw cap graduated vials
2-15 mL screen cap graduated vials
Spatula
1-plastic (UV transmissible) cuvette

Pipet (1 mL)
Pipet tips
2-10 mL graduated pipets
Spectrophotometer

1) Begin by writing down all of the relevant information about the two sunscreens you will be examining.

2) Prepare a 0.10 % solution (w/v) of each sunscreen. Be sure to mark both the vial and lid for each. Place a 50 mL plastic tube (lid removed) on the balance and tare. Weigh 0.05 g of sunscreen by placing a large drop onto the end of a spatula and placing inside the inner wall of the tube. You can adjust the amount by adding to or removing some of the sunscreen with the tip of the spatula. After you have delivered 0.05 g, replace the screen lid. Add 2-propanol to each to the 50 mL graduation.

3) Shake each until the sunscreen is no longer visible.

4) Now do a 1:10 dilution of each solution prepared above. This is done by placing 9 mL of 2-propanol into a fresh 15 mL tube and then adding 1 mL of the sunscreen solution. Do this for each sunscreen, making sure to mark each tube and lid. Mix by inverting several times.

5) Calibrate your spectrophotometer as described by your lab TA.

6) Place 1 mL of 2-propanol into your cuvette and save a reference or blank spectrum.

7) Place your first 1:10 diluted sunscreen sample in a different cuvette to obtain the absorption spectra.

8) Place your second 1:10 diluted sunscreen sample in a different cuvette to obtain the absorption spectra.

9) Dispose of all solutions into the waste container in the laboratory.

REFERENCES:

David Katz, 2005. Sunscreens: Preparation and Evaluation.

Walters et al. 1997. J. Chem. Ed. 74, page 99.

Underwood and MacNeil. 2001. J. Chem. Ed. 78, page 453.

Moeur et al. 2006. J. Chem. Ed. 83, 769.

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Lab Partner:________________________
(Each student must submit their own lab report.)

Sunscreen Analysis

1. Write down the information from the bottle for each sunscreen used today. Include the brand, SPF rating, lot number, expiration date, UVA protection claim, and active ingredient information (with percent composition).

2. From your spectra, what is the maximum absorption value for each sunscreen? Give the wavelength and absorption values for each sample spectra.

3. Which product has the best absorption of UVA light? UVB light? Explain why considering both wavelength spectrum coverage and magnitude of absorption.

4. Which product would be best at protecting from UVA skin damage? Is the protection perfect? Explain why considering both wavelength spectrum coverage and magnitude of absorbance.