ScienceCube

The Effectiveness of Sunscreens

1. **Measure the UV index of sunlight using a UV sensor.**
2. **Compare the effectiveness of the sunscreen's SPF indicated on the product with the actual value measured by the UV sensor.**

Fundamental Concept

1. UV Index

Sunlight consists of various rays with different wavelengths, including gamma rays, X-rays, ultraviolet (UV) rays, visible light, infrared rays, and radio waves. UV rays are shorter than visible light's violet rays and are abbreviated as UV (Ultraviolet).

The UV index is classified into 10 grades, with 0 indicating very low risk from overexposure and 9 or above indicating very high risk from overexposure.

The UV index calculation varies slightly by country.

UV INDEX	0	1	2	3	4	5	6	7	8	9	10	11+
EPA*	MINIMAL			LOW		MODERATE		HIGH			VERY HIGH	
CANADA	LOW				MODERATE			HIGH		EXTREME		
KOREA	MINIMAL			LOW		MODERATE		HIGH		VERY HIGH		
WHO	LOW			MODERATE			HIGH		VERY HIGH			EXTREME

※ EPA: US Enviromental Protection Agency, WHO: World Health Oganization

Level	Description and precautions
 **Extreme (11+)**	Extremely dangerous if exposed to the sun, and exposed skin can burn within minutes. Wear clothing, a hat, and sunglasses, and apply sunscreen generously every two hours.
 **Very high (8-10)**	Very dangerous if exposed to the sun, and exposed skin can burn quickly. Wear clothing, a hat, and sunglasses, and apply sunscreen.
 **High (6-7)**	Dangerous if exposed to the sun, and protection is needed when exposed. Wear clothing, a hat, and sunglasses, and apply sunscreen.
Moderate (3-5)	Moderate risk if exposed to the sun; take precautions such as wearing clothing and applying sunscreen.
Low (2 or below)	Low risk for most people from UV radiation.

2. Sun Protection Factor (SPF)

(1) Definition: SPF is a measure of a product's ability to block UVB rays.

$$\text{SPF} = \frac{Minimum\ Erythema\ Dose\ on\ protected\ skin}{Minimum\ Erythema\ Dose\ on\ unprotected\ skin}$$

※ Minimum Erythema Dose (MED): The smallest amount of UVB radiation (290-320nm)

that causes redness on the skin 16-24 hours after exposure.

(2) Significance: SPF indicates how long one can be exposed to the sun without getting sunburned. Higher SPF products should be used for sensitive skin.

3. Variations in UV Intensity Based on Surrounding Environment

(1) The intensity of UV rays varies with time, climate, season, latitude, and altitude.

(2) The UV index is higher near the equator, at high altitudes, in coastal areas compared to inland regions, and in rural areas compared to cities.

(3) UV radiation is strongest in the summer, between 10 AM and 2 PM, and is about 50% lower on cloudy days compared to clear days.

(4) UV intensity also varies based on the reflectivity of different locations.

Career Exploration

'Cosmetic Chemical Engineer'

Job Overview

Research, design, and develop chemical processes and equipment related to consumer goods such as soap and cosmetics, and oversee the operation and maintenance of plants..

Job Duties:

Analyze and develop new products related to consumer goods industries such as soap and cosmetics.
Design or improve production processes.
Analyze raw materials and finished products using various measuring devices.
Monitor the construction, modification, operation, and maintenance of plants.
Develop guidelines and specifications for handling hazardous materials, environmental protection, and standards for food, materials, and consumer goods.

Required Skills/Abilities

Interest and talent in basic science, understanding and applying engineering concepts, numerical skills, technical analysis skills, and quality control analysis skills.

Good interpersonal relationships and teamwork skills are essential.

Computer operation and experimental equipment handling skills.

Attention to detail and judgment due to handling toxic substances in the laboratory.

Education/Qualifications

A degree in chemical engineering or a related field and at least two years of work experience.

A master's degree is required for research and design positions.

Certifications related to safety and environmental fields are beneficial for career advancement.

Career Outlook

With the advancement of new scientific fields and increasing interest in cosmetics, cosmetic engineering is emerging as a high-value industry.

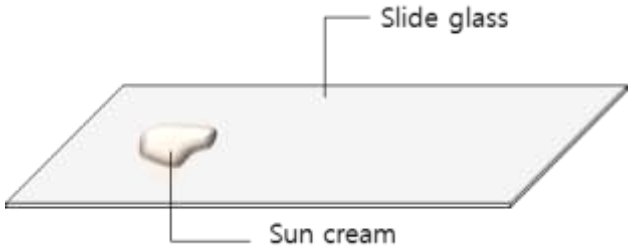
Experiment

Materials Needed

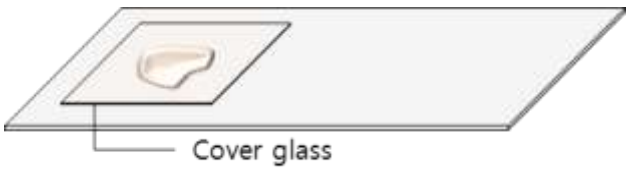
Interface, Science# program, UV sensor, Sunscreens with different SPFs (3), Microscope slides (3), Cover glasses (3), Permanent marker

Experimental Setup

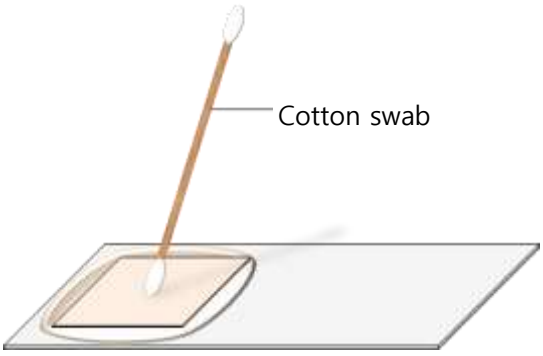
1. Squeeze a small amount of sunscreen onto one side of the microscope slide.



2. Cover the sunscreen with a cover glass.

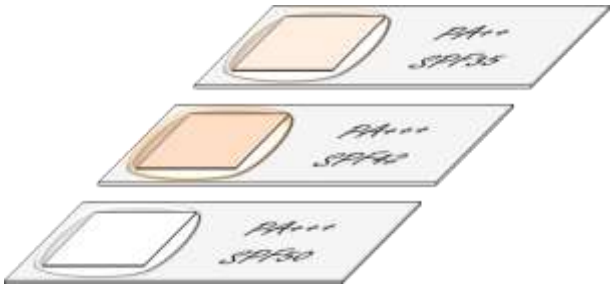


3. Use a cotton swab to spread the sunscreen evenly by pressing down on the center of the cover glass.



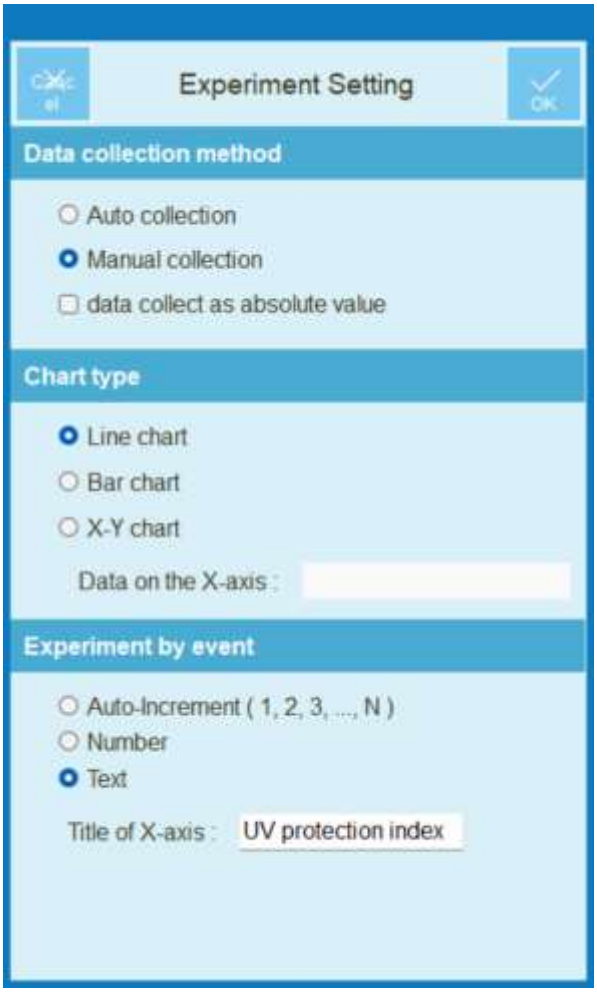
4. Label the slide with the SPF and other information using a permanent marker..

5. Prepare the other sunscreen samples in the same manner.



Interface Setup

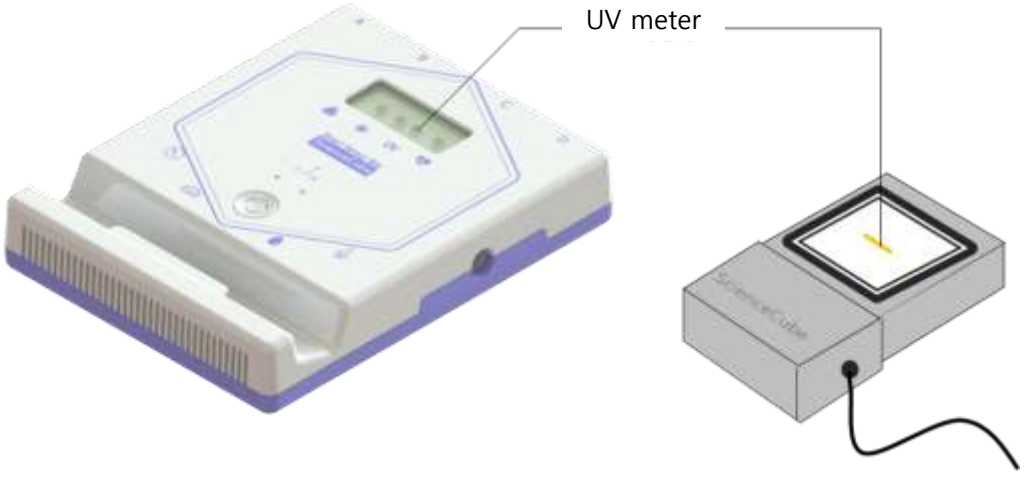
1. Run the Science# program.
2. Connect the UV sensor to the interface or sensor box.
3. Press to set up the experimental environment as shown or press for automatic setup.



Automatic setup

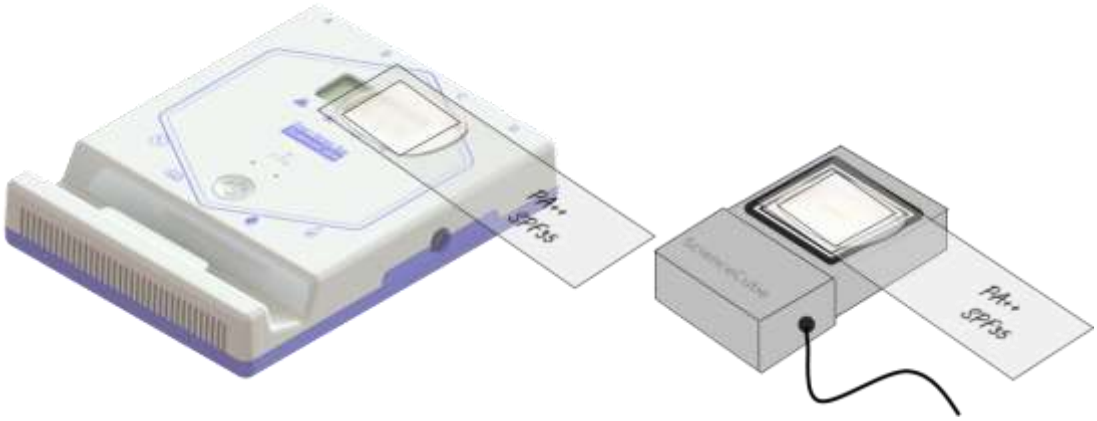
Data Collection

1. Press to set up the bar graph.
2. Press to start data collection.
3. Place the UV sensor in direct sunlight on a clear day to measure the UV index of the sunlight.



[When using the built-in sensor of the smart sensor box] [When using the UV sensor]

4. Once the values stabilize, press and enter "Sun" in the text input box.
5. Place the sunscreen sample over the UV sensor, ensuring the sunlight passes through the sample.



[When using the built-in sensor of the smart sensor box] [When using the UV sensor]

6. Once the values stabilize, press and enter the SPF value of the sunscreen (e.g., SPF50 PA+++).
7. Measure the UV transmitted through the other sunscreens in the same manner and record the values.
8. Press to end data collection..

Data Analysis

Recording Data

1. Measure and graph the UV index of sunlight and the UV index after passing through each sunscreen.

2. Record the information and measured UV index for each sunscreen in the table below.

Category	Sunscreen A	Sunscreen B	Sunscreen C
Name			
SPF Index			
Color			
Type (Gel, Cream, Lotion)			
UV Index of Sunlight			
UV Index after passing through Sunscreen			

3. Calculate the UV blocking rate for each sunscreen using the following formula.

$$\text{UV Blocking Rate}(\%) = \frac{\text{UV Index of Sunlight} - \text{UV Index after passing through Sunscreen}}{\text{UV Index of Sunlight}} \times 100$$

Category	Sunscreen A	Sunscreen B	Sunscreen C

UV Blocking Rate (%)			

Data Application and Extension Activities

1. Compare and list the sunscreens in order of highest SPF and highest UV blocking rate as measured by the UV sensor..

Order of Highest SPF	
Order of Highest UV Blocking Rate	

2. Summarize your findings from the experiment based on the recorded data.

3. Research and explain whether the UV index is consistent throughout the year. Look up the changes in the UV index by time throughout the year..
   (※ Korea Meteorological Administration UV Index site: https://www.climate.go.kr:8005/index.html)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
UV												

4. Should sunscreen be applied indoors where sunlight does not directly enter? Write your opinion and explain your reasoning.

5. Investigate whether the type of sunscreen (gel, cream, lotion, spray, etc.) affects the blocking rate. Conduct experiments using different types of sunscreens with the same SPF..