**ULTRAVIOLET SPECTROSCOPY**

**PURDUE UNIVERSITY INSTRUMENT VAN PROJECT**

# UV AND YOU : THE ULTRAVIOLET TRANSMITTANCE OF SUNGLASSES

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## INTRODUCTION

Many sunglasses on the market today are advertised as being able to protect your eyes from the harmful effects of ultraviolet radiation by being "blue blockers" or having ultraviolet-resistant coating. The purchase tags on most sunglasses state the percentage of ultraviolet radiation that they can block. Are these claims accurate? Are they measurable? This experiment is designed to help you find out.

The visible portion of the electromagnetic spectrum ranges from approximately 700 nm to 400 nm. This is the light we see as the familiar ROYGBIV (red, orange, yellow, green , blue indigo, and violet) colors of light. The ultraviolet portion of the electromagnetic spectrum ranges in wavelength from approximately 400 nm to 10 nm.[1,2] The portion of the UV spectrum nearest the visible spectrum, from about 400 to 320 nm, is sometimes called UVA. The radiation from 320 to 290 nm is called UVB.[3] The remaining portion of the UV spectrum is known as UVC.

..........................700nm.........400nm......320nm...290nm....10nm....................................

←Infrared    Visible UVA    UVB    UVC    x-rays→

---------------------------INCREASING ENERGY-----------------------------------------→

The waves in the ultraviolet portion of the spectrum are relatively high in energy. Microbiologists often use the germicidal properties of ultraviolet lamps in their work.[2] You are familiar with the effects these waves have on the cells of your skin when you get a tan or a sunburn. The lower energy UVA waves are mostly responsible for the tan, while the higher energy UVB causes the sunburn.

Your eyes can be affected by the ultraviolet radiation just as your skin can.[4] On Earth, the atmosphere is able to screen out most wavelengths below 300 nm.[5,6] Those UVA and UVB wavelengths that penetrate the atmosphere can be prevented from affecting the eyes by sunglasses that are manufactured to block this radiation.

Sunglasses are made of glass or plastic that will allow much of the visible light to be transmitted and can be designed to absorb ultraviolet radiation. Since we are interested in the amount of ultraviolet radiation that passes through the sunglasses into your eyes, we will measure **transmittance** of the visible and ultraviolet light through lenses. **Absorbance** and

**transmittance** are terms which refer to the amounts of radiation "soaked up" or "allowed to pass through" the lenses. To conduct this experiment successfully, you should become familiar with the basics of ultraviolet spectroscopy and the difference between absorbance and transmittance of light. In this experiment you will use the Beckman DU Series 64 Spectrophotometer. This instrument provides sources of both visible and ultraviolet radiation.

## PURPOSE

The purpose of this experiment is to:

A. measure the transmittance of ultraviolet and visible radiation by a set of standards.

B. observe the transmittance of visible and ultraviolet radiation by sunglasses and compare with a set of standards (if available) to see if sunglasses block out the amount of radiation claimed by the manufacturer.

## SAFETY

Normal safety procedures apply to this lab. IMPORTANT! Students must run **ONE CELL** or glasses will be crushed by the cell changer and could damage the instrument.

## PRE-LAB QUESTIONS

Directions: Answer these questions in complete sentences on your own laboratory paper.

1. Which kind of ultraviolet radiation contains the most energy? What is the range of wavelengths of this radiation?

2. Which form of ultraviolet radiation is most damaging to your eyes? What is the range of wavelengths for this radiation?

3. Which type of radiation should sunglasses block?

4. Describe the difference between absorbance and transmittance.

5. An absorbance spectrum shows a peak at 540 nm. What does this mean?

6. A transmittance spectrum shows a peak to 80% between 480 nm and 524 nm. What does this mean?

7. Why must you use a sample of air for the first trial?

8. Why must you select "one cell" when using your sunglasses in the spectrophotometer?

9. Do you predict there will be any difference between the transmittance of **glass** lenses versus **plastic** lenses?

MATERIALS

Beckman DU-64 Spectrophotometer
lens standards (if available)
cuvettes
sunglasses (provided by students)
Kimwipes®

PROCEDURE

**A. To Run % Transmittance of Standards**

1. Turn on spectrophotometer from power bar. It will take approximately four minutes for the instrument to warm up. When it is warmed up, it will print the message ***"Diagnostic Test Complete"***.

2. Turn on lamp source **vis uv [V/U] or Vis**.

3. Select **[%T]**.

4. From the user mode press **[PROG]** to enter directory mode.

5. Keep pressing **[STEP]** until ***"PROG. 7:6Spl Scn"*** appears on the screen.

6. Press **[R/S]**(Run / Stop) to begin program execution. The following questions will appear on the display:

***"Starting wl"*** Key in 700 as the starting wavelength and press **[ENTER]**

***"Ending wl"*** Key in 200 as the ending wavelength and press **[ENTER]**

***"Spd"*** Key in 1 and press **[ENTER]**

***"Upper limit"*** Key in 100 and press **[ENTER]**

***"Lower limit"*** Key in 0 and press **[ENTER]**

***"Enter # of Cells"*** Key in 1 and press **[ENTER]**

(* If you make an error and want to restart the program, press **[R/S]** once and **[PROG]** twice and you will begin the program again.)

7. The screen will display ***"Ins blk & Spls"***, place the blank into the cuvette and place in the first cell.

8. Replace the black cover and instrument chamber cover.

9. Press **[R/S]**.

10. When scanning has finished, press **[R/S]** to print out the blank. Adjust paper if needed between printings by pressing the **[ONLINE]** button once. When the paper has stopped, press the **[ONLINE]** again to turn the printer back on line.

11. Remove the blank out of the first cell.

12. Replace with the next standard. Next, replace black cover and instrument chamber cover and press **[R/S]**. The printer should print out the spectrum of the standard.

13. Repeat Step 12 for the other standards.

**B. To Run % Transmittance of Sunglasses**

1. By doing Part A. Steps 1-11, the spectrophotometer should be programmed to do scans of the sunglasses. If you have changed any of the parameters from Part A., then repeat Steps 1-11.

2. **Gently** place your sunglasses in the spectrophotometer under the supervision of the instructor. (Note - put sunglasses upside down if possible and far to the back of the machine so that one lens is behind the black box and the other lens is behind the hole where the radiation comes out - see teacher for check.)

3. Close the instrument chamber cover and press **[R/S]**.

DATA

You data is comprised of all of your printouts of spectra.  Please staple your spectra to your laboratory report.

DATA ANALYSIS

**Analysis of Spectra: Table A: Data for Standards**

| Wavelength (nm) | Color Absorbed | Color Transmitted | Percent Transmittance<br><br>Standard 1 | Percent Transmittance<br><br>Standard 2 | Percent Transmittance<br><br>Standard 3 |
|---|---|---|---|---|---|
| 200-290 | | | | | |
| 290-320 | | | | | |
| 320-380 | | | | | |
| 380-435 | | | | | |
| 435-480 | | | | | |
| 480-490 | | | | | |
| 490-500 | | | | | |
| 500-560 | | | | | |
| 560-580 | | | | | |
| 580-595 | | | | | |
| 595-610 | | | | | |
| 610-750 | | | | | |

**Analysis of Spectra: Table B: Data for Sunglasses**

| Wavelength (nm) | Color Absorbed | Color Transmitted | Percent Transmittance<br><br>Sunglasses 1 | Percent Transmittance<br><br>Sunglasses 2 | Percent Transmittance<br><br>Sunglasses 3 |
|---|---|---|---|---|---|
| 200-290 | | | | | |
| 290-320 | | | | | |
| 320-380 | | | | | |
| 380-435 | | | | | |
| 435-480 | | | | | |
| 480-490 | | | | | |
| 490-500 | | | | | |
| 500-560 | | | | | |
| 560-580 | | | | | |
| 580-595 | | | | | |
| 595-610 | | | | | |
| 610-750 | | | | | |

## POST-LAB QUESTIONS

Directions: Answer these questions in complete sentences on your own lab paper.

1. What kind of sunglasses did you have? Why? (Describe in terms of %T and UV blockage)

2. What are some special characteristics of your spectrum?

3. Did your sunglasses live up to their claim? Please explain.

## DATA

Remember to attach your **spectra** to your lab report.

## CONCLUSIONS

Directions: Answer these questions in complete sentences on your own lab paper.

1. Compare the spectrum from your sunglasses with that of two or more of your professional colleagues. Write a paragraph in which you compare all of your results. Be sure to name your colleagues, the kind of sunglasses they have, and then describe their results.

2. Based on this experiment, what general suggestions would you make to your parents or friends when they are ready to buy sunglasses?

## REFERENCES

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7. Peters, Dennis G.; Hayes, John M.; Heiftje, Gary M. (1974). Separations and Measurements: Theory and Practice of Analytical Chemistry (p. 616). Philadelphia, W. B. Saunders Company.

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# TEACHERS' GUIDE
# UV AND YOU: THE ULTRAVIOLET TRANSMITTANCE OF SUNGLASSES

## NOTE

There may be a spike in your spectrum as the lamps switch from Vis to UV.

## TYPICAL CLASSROOM USAGE

This lab is appropriate for first year chemistry. It would also work well with a physical science class.

## CURRICULUM INTEGRATION

This lab would fit well with a chapter dealing with the electromagnetic spectrum and wave behavior. It would also be fun before spring break.

## PREPARATION

Students will need to bring in sunglasses for the lab. It would be helpful to review the following concepts before running the experiment: ultraviolet radiation, visible light, absorbance. transmittance, color, spectrum, etc. In **UV / VIS Spectrophotometer Instructions** there is a chart of wavelengths vs. color absorbed and color seen.

## TIME

It probably would take one lab group of two students approximately 15 minutes to run the standards and approximately 15 minutes to run two pair of sunglasses.

## SAFETY AND DISPOSAL

Students must chose "one cell" as an option or the cell holder will move and damage both the instrument and the sunglasses.

## QUESTIONS FOR FUTURE STUDY

1. How does the curvature of the lens (prescription) affect the results?

2. How does having a different prescription for each lens affect the results?

3. Transmission data seems more consistent than absorbance data. Why?

4. Do polarized lenses give different results than nonploarized lenses? Why?

NOTES ON PROCEDURE

1. The instructor can elect to do either Procedure A or B or both depending on time constraints and availability of standards.

2. When testing bifocal lenses (the teachers?) the experimenter should be careful not to let the line interfere with the beam of radiation through the glasses.

3. In Procedure Step 6, the instructor may choose to run all the standards at once by selecting the number of cells to correspond to the number of standards, or the instructor may choose to run the standards one at a time in cell one. We chose to write the lab procedure to run one standard at a time to prevent students from forgetting to choose "one cell" to run the spectra for their sunglasses.

POSSIBLE ANSWERS TO PRE-LAB QUESTIONS

1. Ultraviolet radiation called UVC has the most energy. The range of wavelengths is from 10 nm to 290 nm.

2. Ultraviolet radiation called UVC is most damaging to your eyes. The range of wavelengths is 10 nm to 290 nm.

3. Ideally, sunglasses should block all ultraviolet radiation. Realistically, sunglasses should block wavelengths of 400 nm to 290 nm. Ultraviolet radiation of wavelengths less than 290 nm is already screened to some extent by the Earth's atmosphere.

4. In this experiment, absorbance describes the amount of radiation "soaked up" by the material. The amount of absorbance depends primarily upon the identity of the sample, characteristics of sample concentration and sample size, the wavelength of the incident radiation, and the temperature of the sample.[7] Transmittance describes the amount of radiation "allowed to pass on through" the material. Transmittance is mathematically related to absorbance.[7] For our purposes, the percent transmittance of

ultraviolet and visible radiation through the sample will provide the most useful information for analysis of the samples.

5. An absorbance spectrum that shows a peak at 540 nm indicates that the sample absorbed radiation that had a wavelength of 540 nm. This wavelength corresponds to green light being absorbed.

6. A transmittance spectrum that shows a peak between 480 nm and 524 nm indicates that these wavelengths of light were transmitted by the sample. These wavelengths correspond to the colors of orange and purple, respectively.

7. A blank - in this case, a cuvette of air or clear film - must be used in the first trial so that the instrument is calibrated. Future trials will be compared to this blank.

8. You must select "one cell" when testing sunglasses so that the cell holder does not move and crush the sunglasses.

9. (Student answers)

## ASSESSMENT

You could grade the students' spectra and answers to the post-lab questions. You could also have the students report back to the class to explain if their sunglasses lived up to the claims of the manufacturers.

It would also be reasonable to complete a checklist similar to the following for each student:

CHECKLIST IDEAS

While conducting this experiment:

is the student on task?

is the student wearing goggles?

does the student work appropriately with his/her partner(s)?

did the student program the instrument according to directions?

did the student set up the printer properly?

did the student use a blank cuvette for his/her first trial?

did the student produce a spectra for all samples?

if the student determined the spectra of sunglasses, did the student use the "one cell" program selection?

did the student make a reasonable interpretation of his/her data?

did the student compare his/her data with that of fellow students?

did the student complete all data tables and answer all pre-lab and post-lab questions?

ADDITIONAL ACTIVITIES

1. Have the students interview an optometrist or ophthalmologist about ultraviolet radiation and report back to the class.

2. Have students investigate and report the meanings of claims that certain sunglasses block "95% UVA and 60% UVB".

3. Have students investigate the characteristics necessary for suntan lotions to block ultraviolet radiation.

4. Prepare posters describing the results of any tests on sunglasses for school-wide display.