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The Education University of Hong Kong
2021-2022 Quality Education Fund Thematic Network – Tertiary Institutes
STEM Project Team

SCHOOL: CHRISTIAN AND MISSIONARY ALLIANCE SUN KEI SECONDARY SCHOOL (S4)

TOPIC: MATERIAL SCIENCE WITH SPECTROPHOTOMETER 2 - GRAPH

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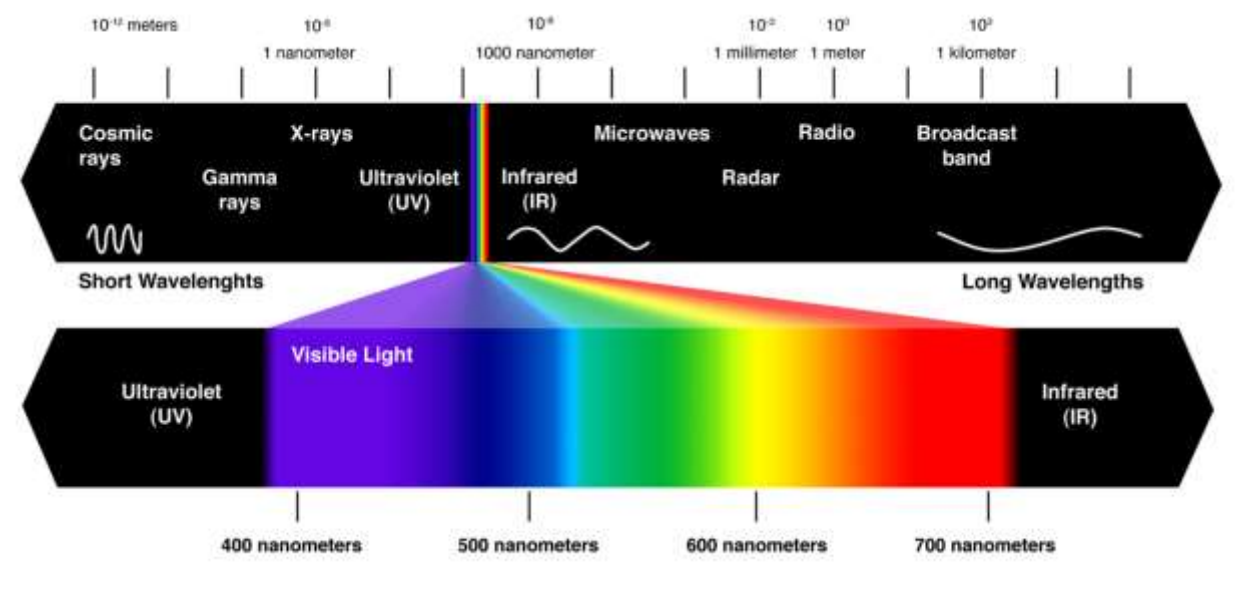
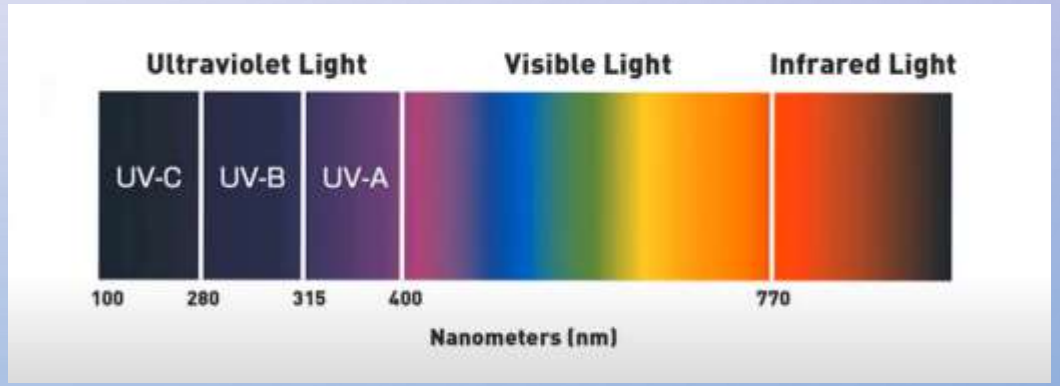
1
SEN-15050 SPARKFUN TRIAD SPECTROSCOPY SENSOR - AS7265X





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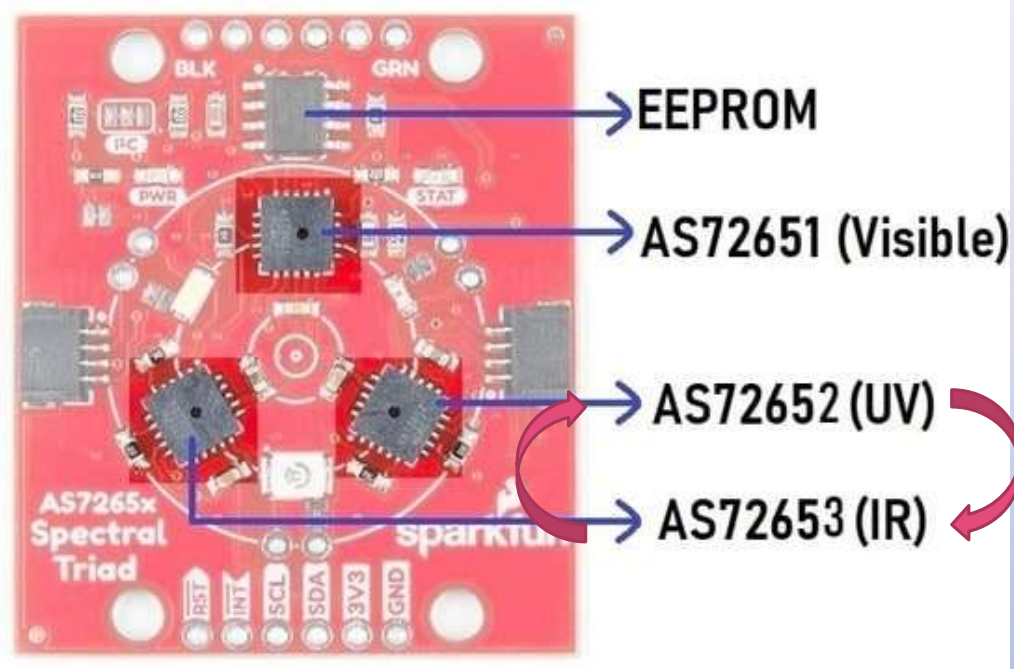
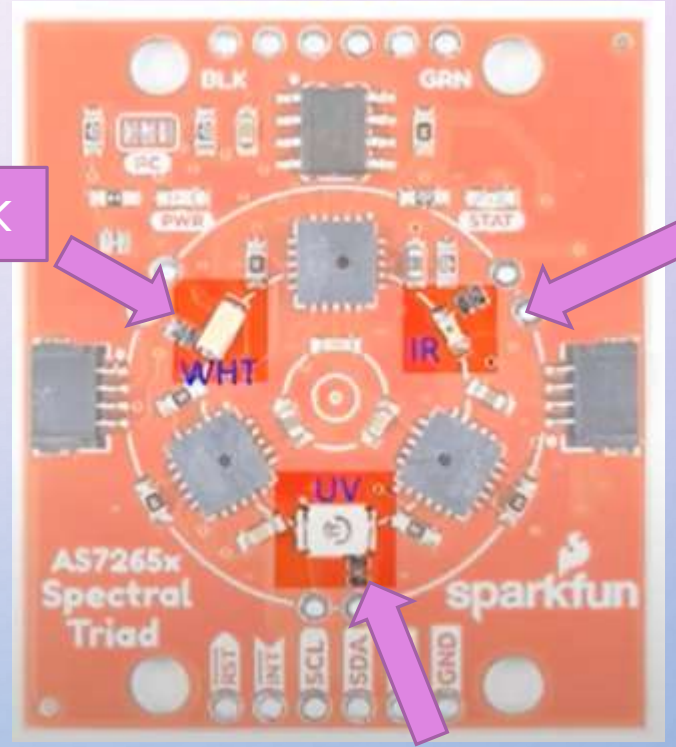
MORE ABOUT SEN-15050 SPARKFUN TRIAD SPECTROSCOPY SENSOR - AS7265X

410nm to 940nm





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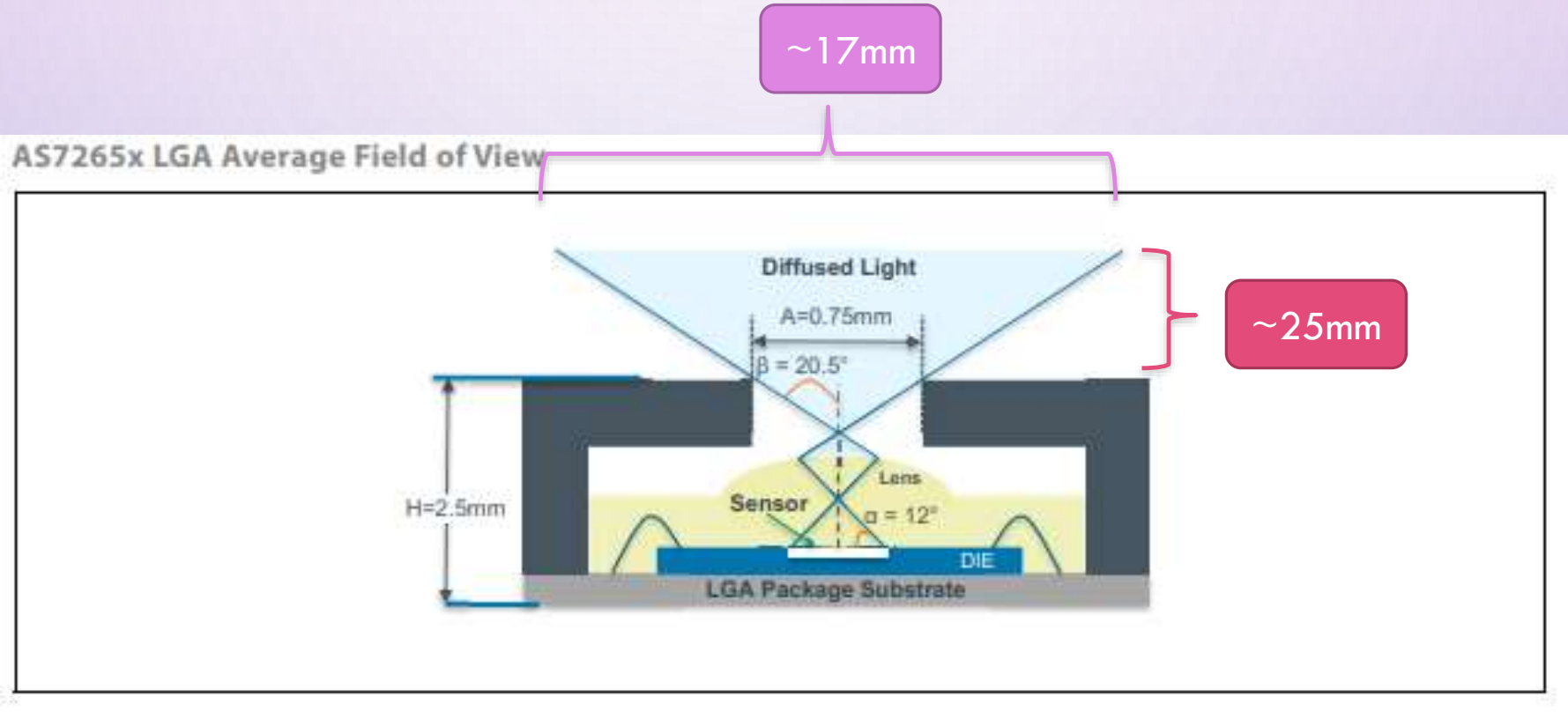
MORE ABOUT AS72651, AS72652, AND AS72653



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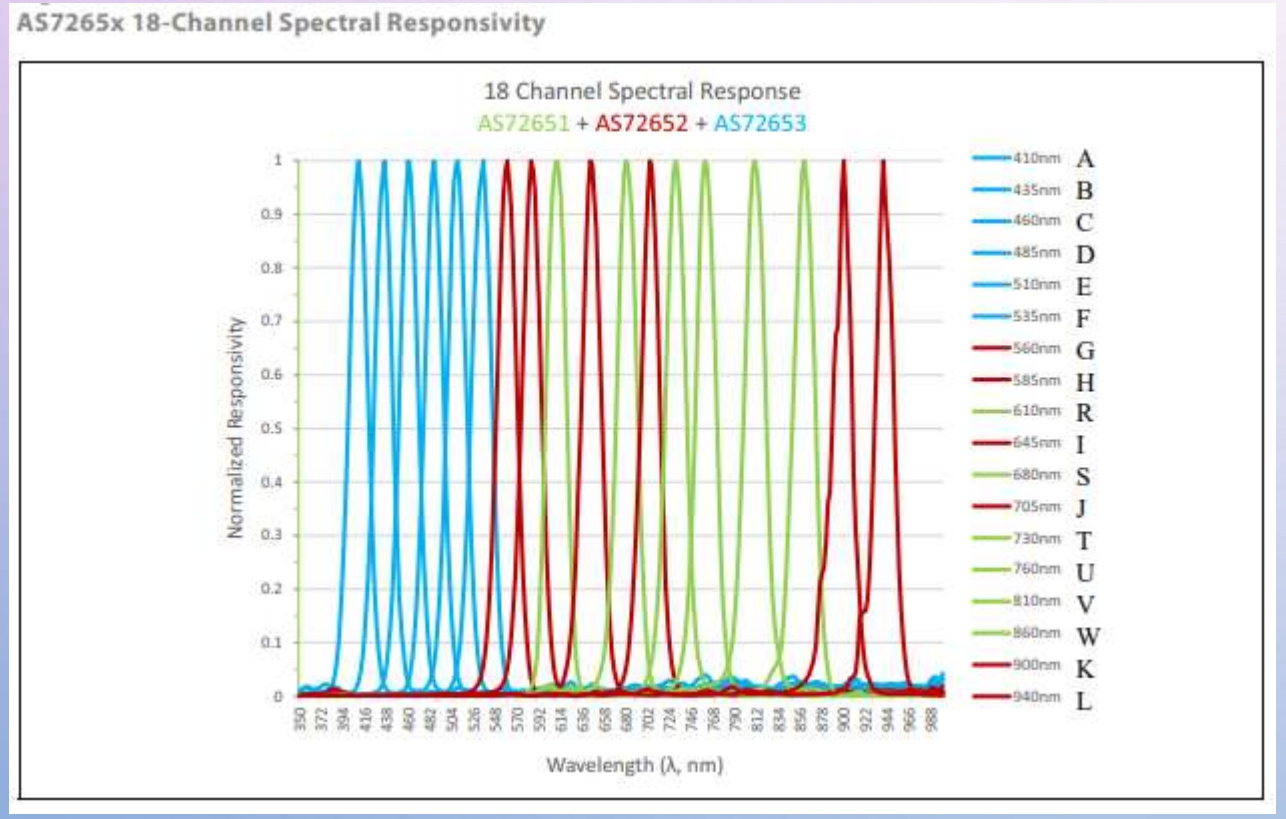
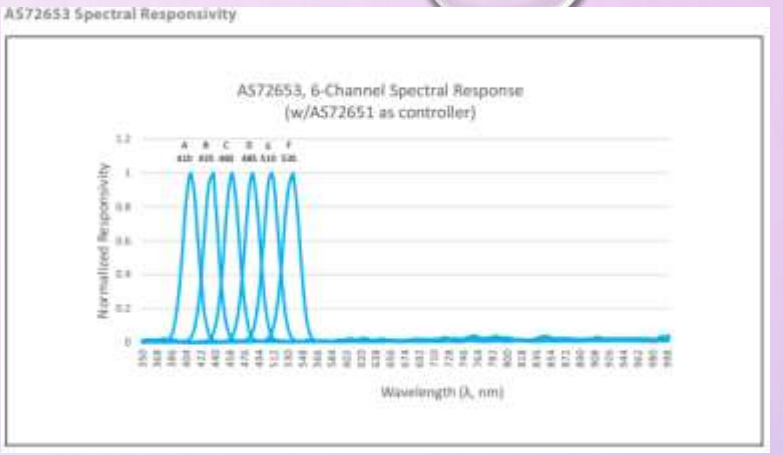
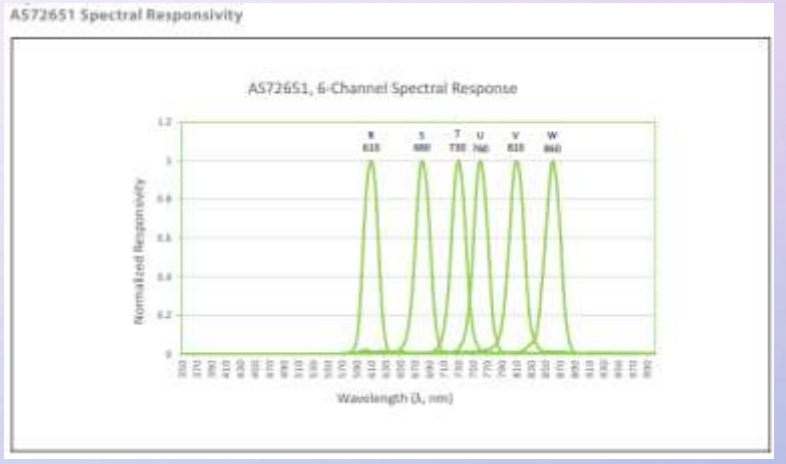
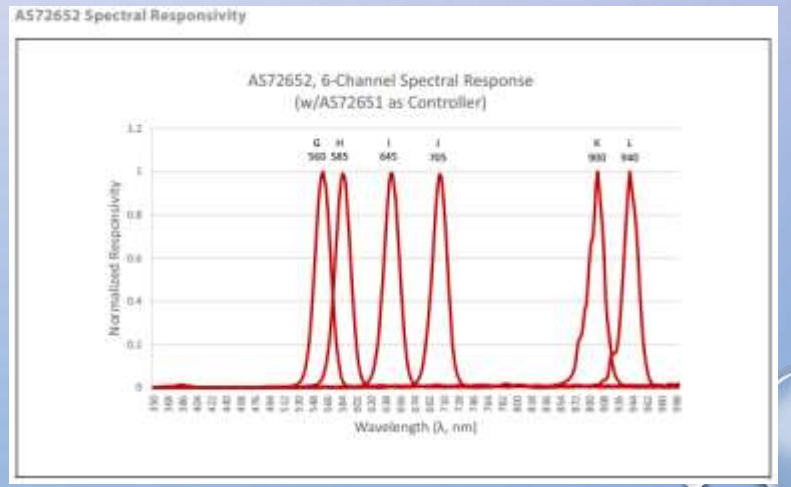
TOTAL 18 CHANNEL SPECTRAL RESPONSE









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TEST 1.1

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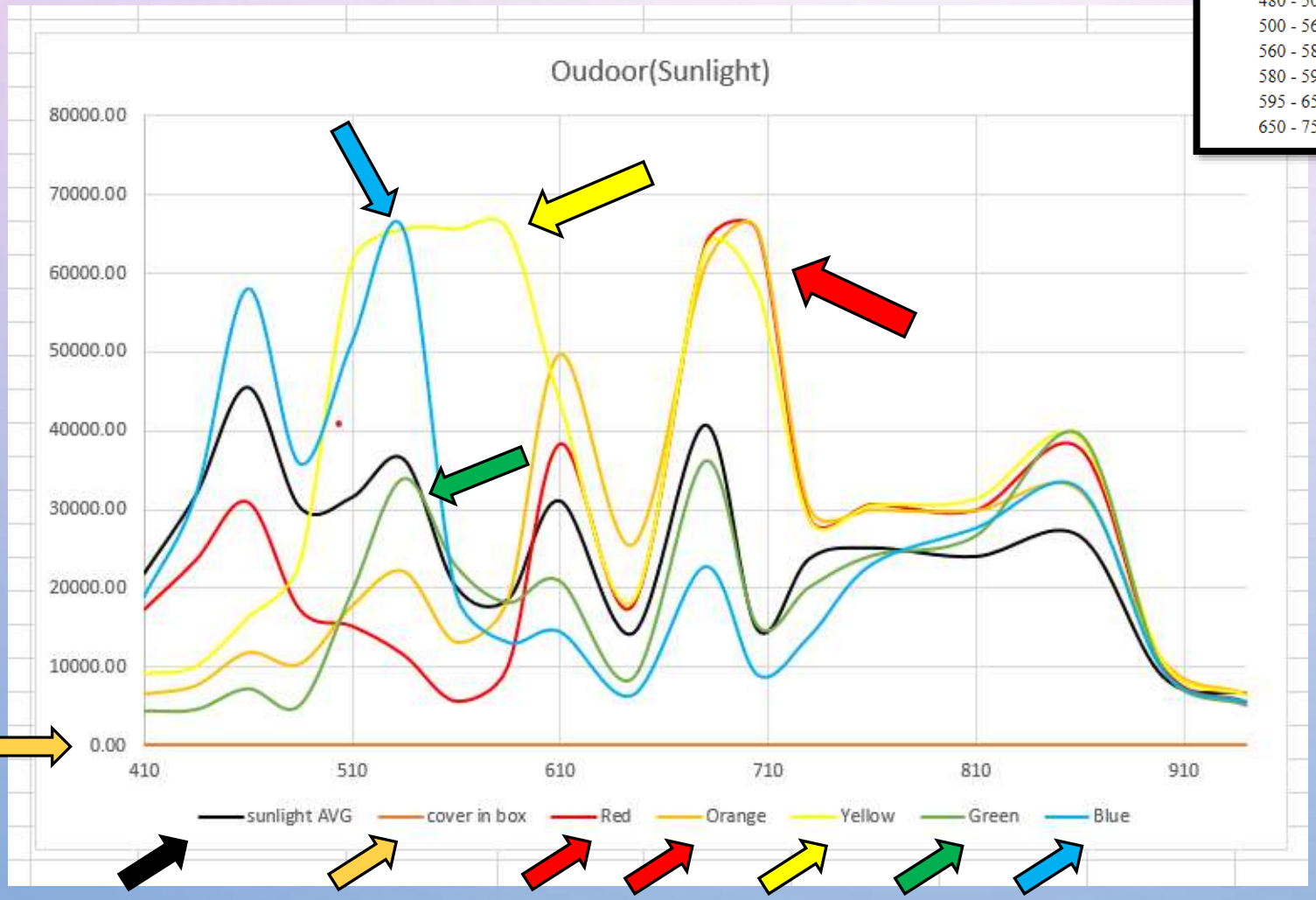
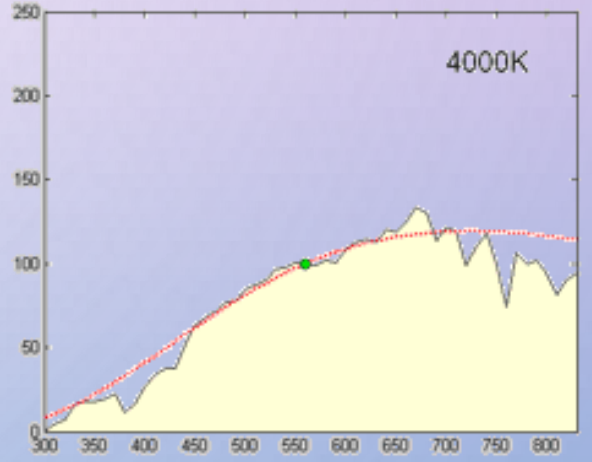
CHECK DATA

Complementary Colors		
Wavelength (nm)	**Color of Light**	**Complementary Color**
400 - 435	violet	green - yellow
435 - 480	blue	orange
480 - 500	green - blue	red
500 - 560	green	red-violet
560 - 580	yellow - green	violet
580 - 595	yellow	blue - violet
595 - 650	orange	blue
650 - 750	red	blue - green





Color of daylight and a blackbody, compared.

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TEST 1.2

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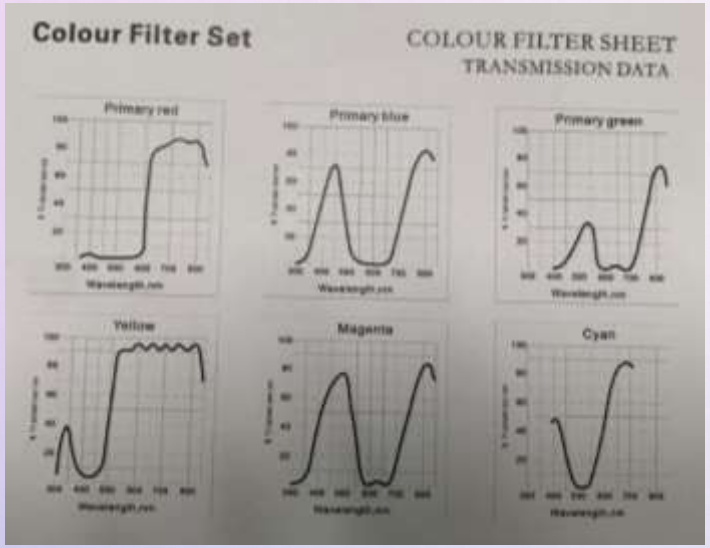
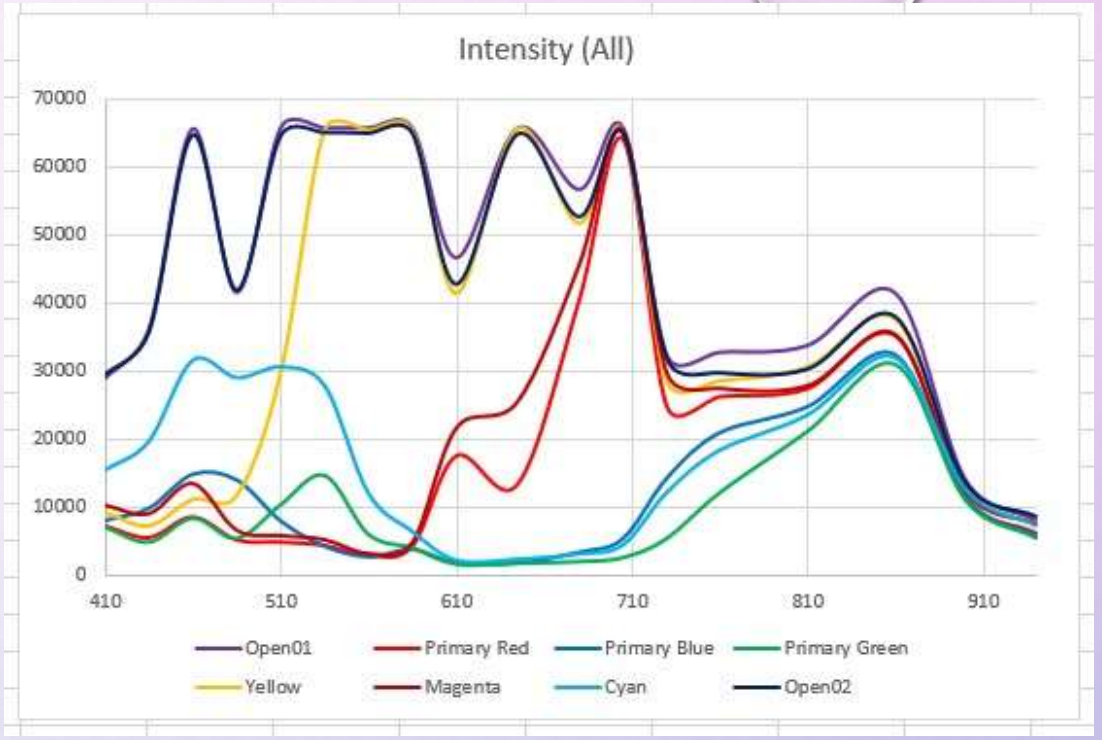
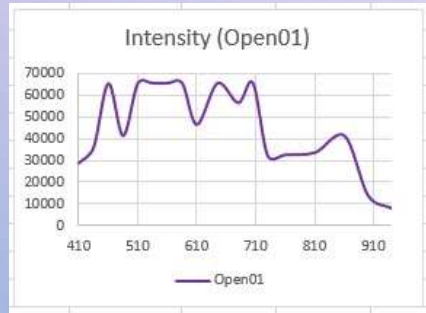
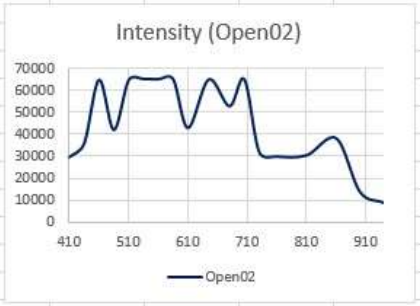
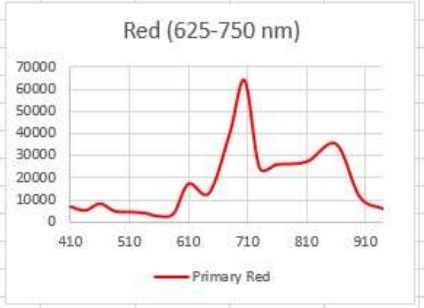


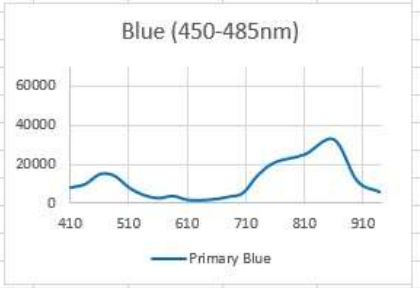
RESULT

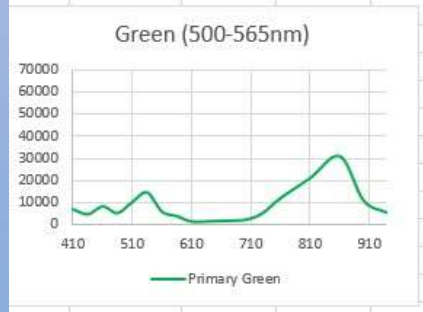


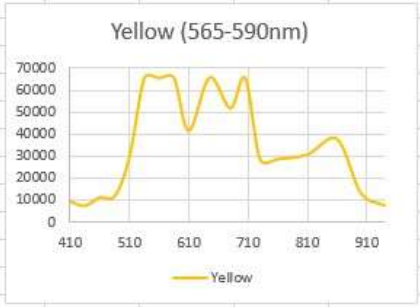


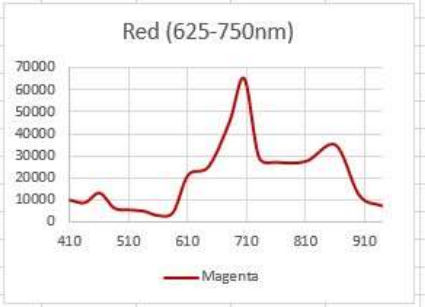












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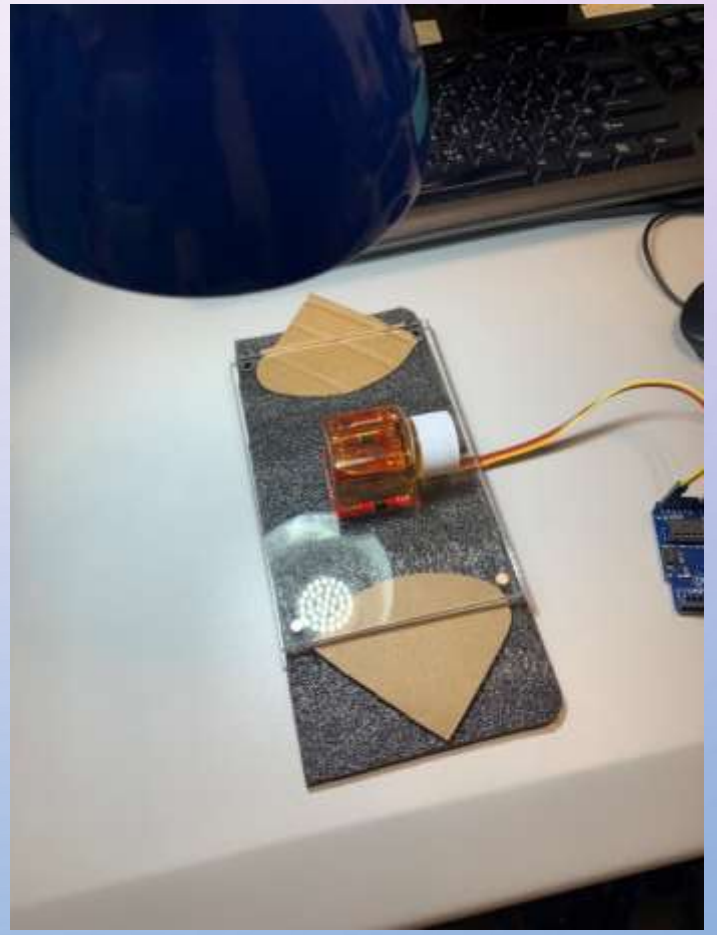
TEST 2 – MATERIALS TEST



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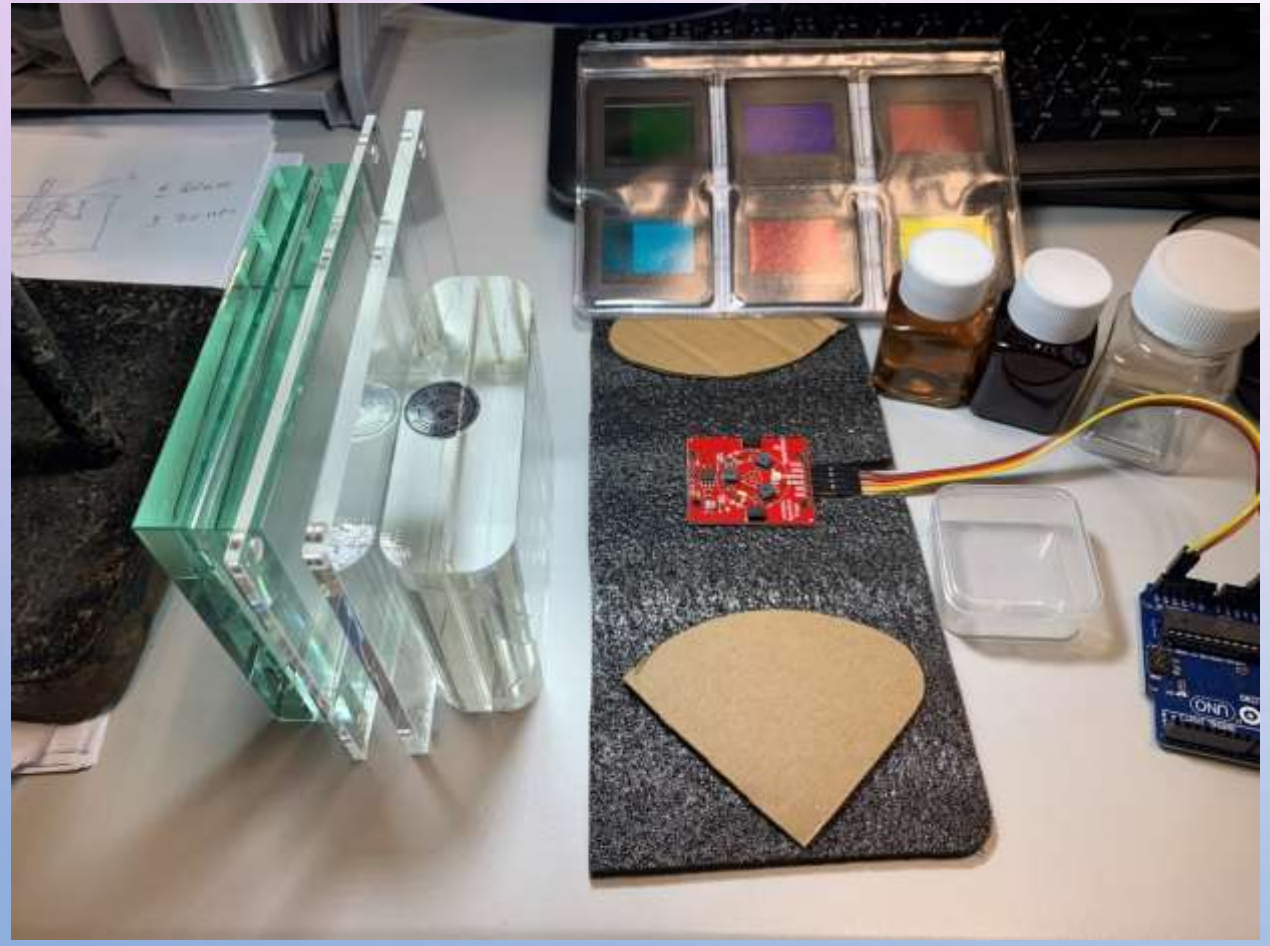
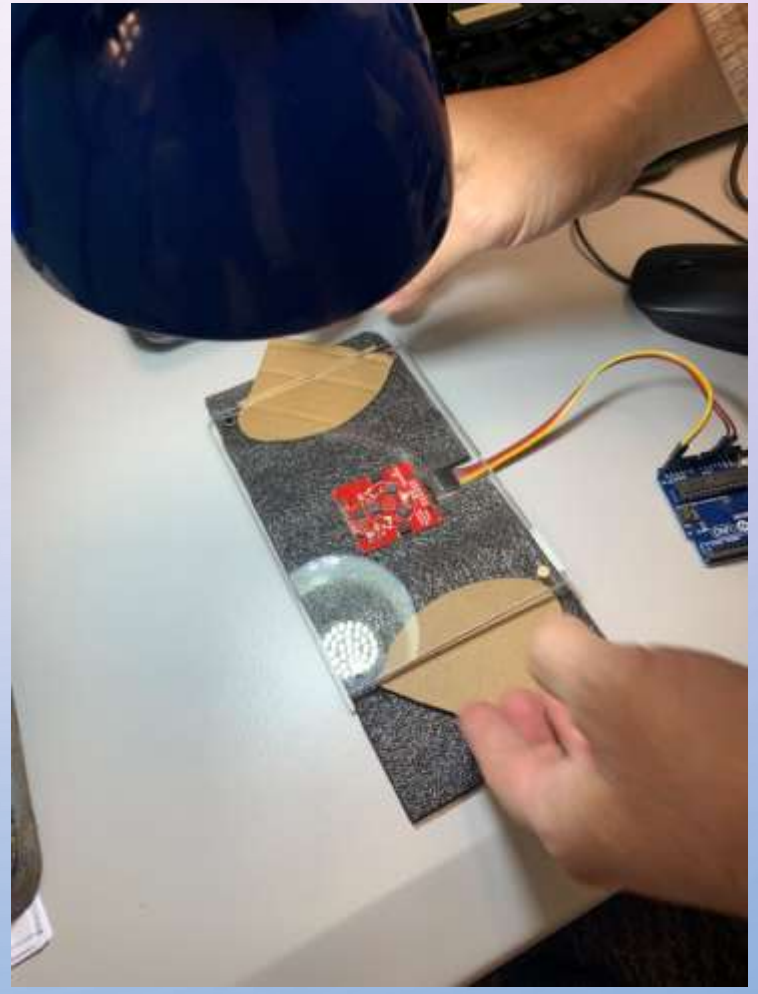
RESULT





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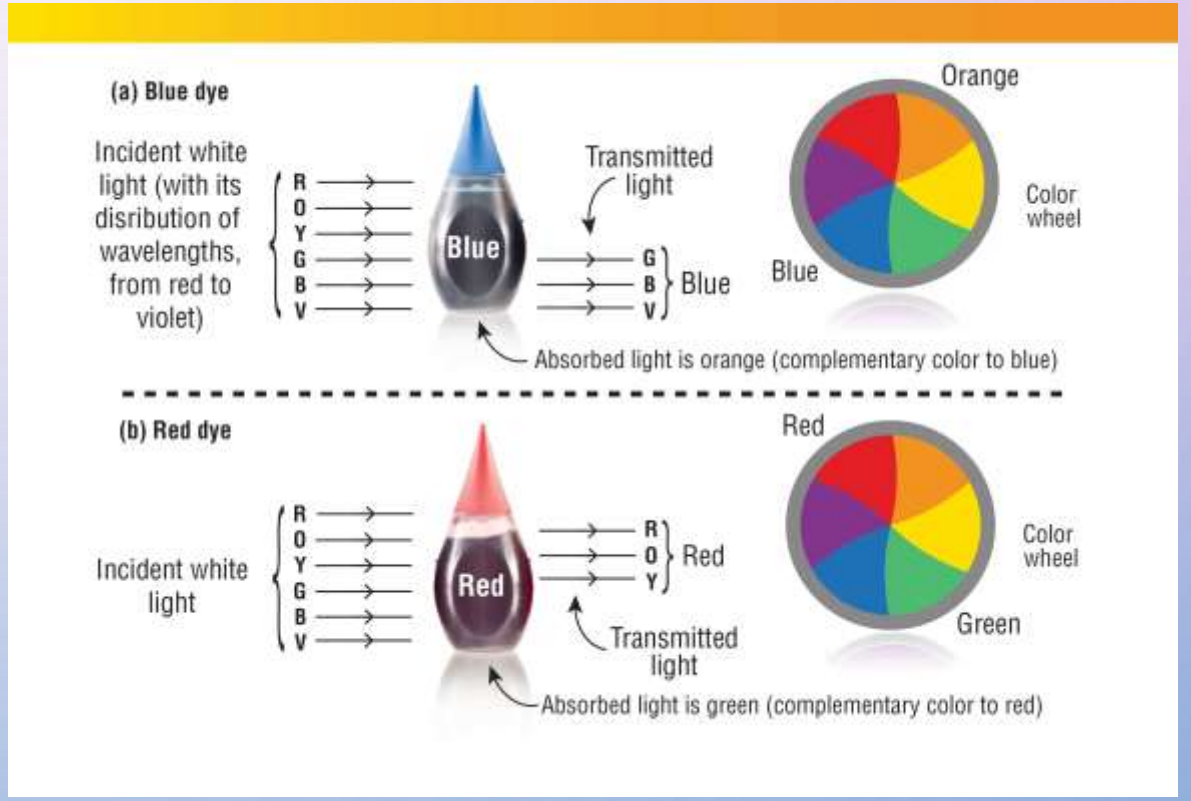
NITRITE CONTENT & FOOD DYE



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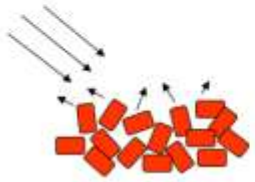
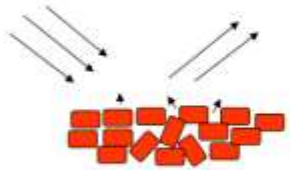
REFERENCE: DIFFUSE REFLECTANCE SPECTROSCOPY

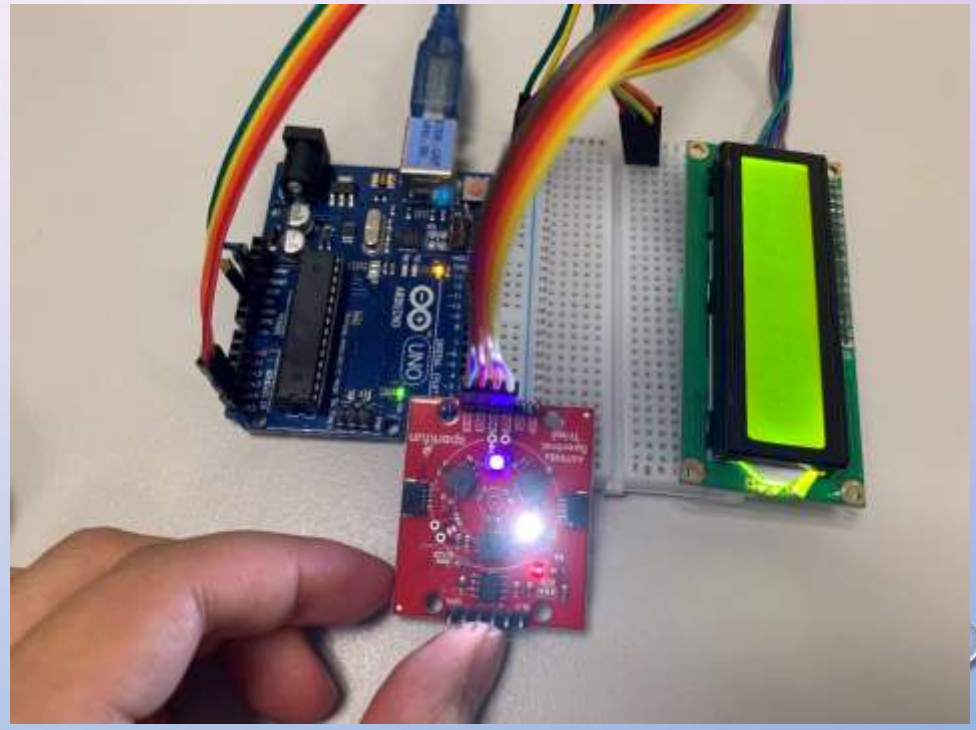
Diffuse Reflection



- Randomly oriented crystals in a powder: light diffusely reflected



- Flattening of the surface or pressing of a pellet can cause orientation of the crystals, which are “elementary mirrors”
- Causes “glossy peaks” if angle of observation corresponds to angle of incidence
- Solution: roughen surface with (sand)paper or press between rough paper, or use different observation angle!



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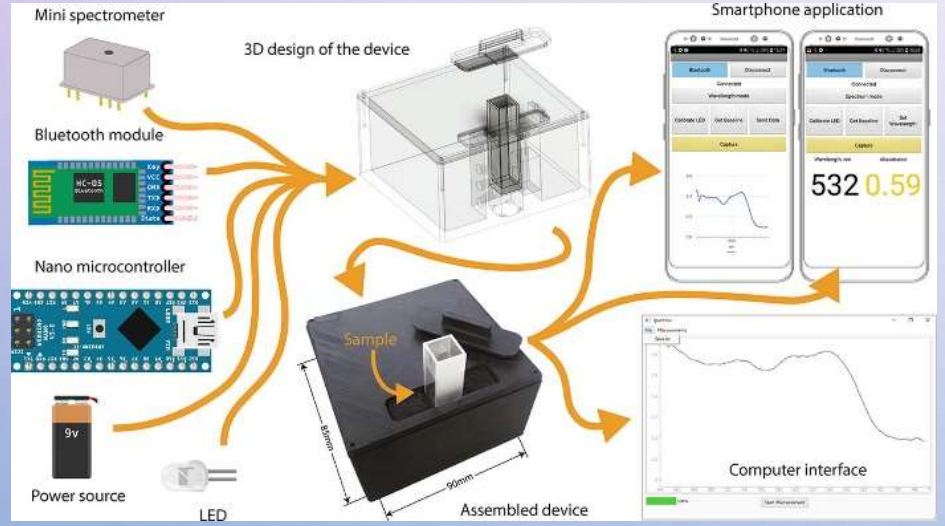
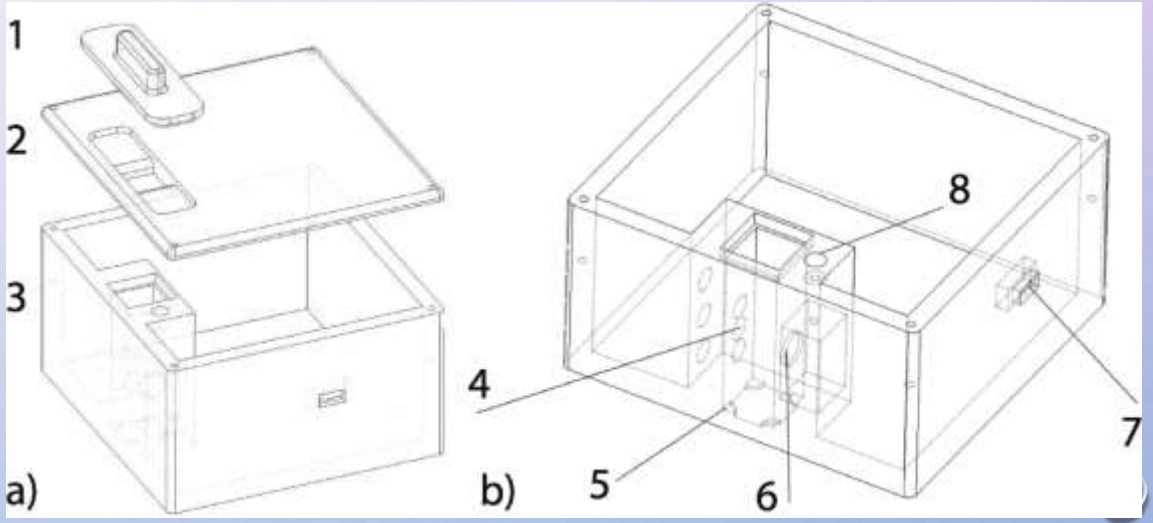
PORTABLE LOW-COST OPEN-SOURCE WIRELESS SPECTROPHOTOMETER

https://www.sciencedirect.com/science/article/pii/S246806722030016X





Sample distance ~3”

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MORE INFO (ABSORBANCE AND BEER'S LAW)

- https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Physical_Methods_in_Chemistry_and_Nano_Science_(Barron)/04%3A_Chemical_Speciation/4.04%3A_UV-Visible_Spectroscopy

$$A = \varepsilon bc$$


CHEMISTRY
LibreTexts

4.4: UV-Visible Spectroscopy

Last updated: Mar 22, 2021

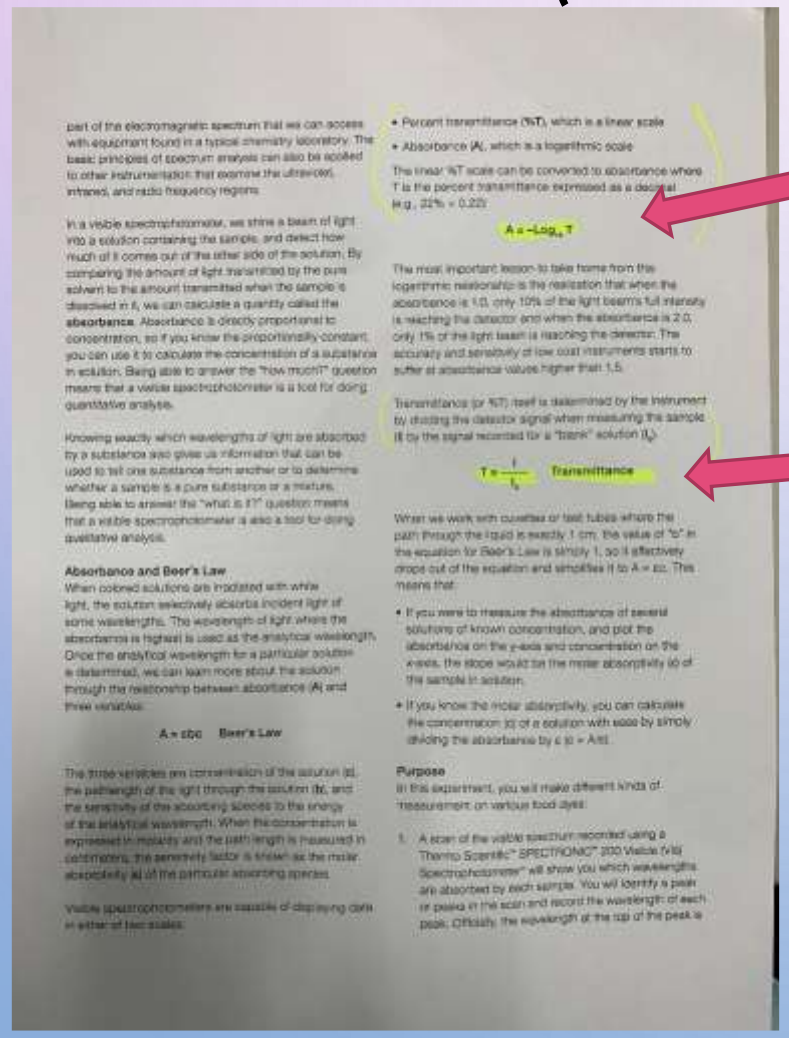
Ultraviolet-visible (UV-vis) spectroscopy is used to obtain the absorbance spectra of a compound in solution or as a solid. What is actually being observed spectroscopically is the absorbance of light energy or electromagnetic radiation, which excites electrons from the ground state to the first singlet excited state of the compound or material. The UV-vis region of energy for the electromagnetic spectrum covers 1.5 - 6.2 eV which relates to a wavelength range of 800 - 200 nm. The Beer-Lambert Law, Equation 4.4.1 , is the principle behind absorbance spectroscopy. For a single wavelength, A is absorbance (unitless, usually seen as arb. units or arbitrary units), ε is the molar absorptivity of the compound or molecule in solution ($M^{-1}cm^{-1}$), b is the path length of the cuvette or sample holder (usually 1 cm), and c is the concentration of the solution (M).

$$A = \varepsilon bc \qquad (4.4.1)$$

All of these instruments have a light source (usually a deuterium or tungsten lamp), a sample holder and a detector, but some have a filter for selecting one wavelength at a time. The single beam instrument (Figure 4.4.1) has a filter or a monochromator between the source and the sample to analyze one wavelength at a time. The double beam instrument (Figure 4.4.2) has a single source and a monochromator and then there is a splitter and a series of mirrors to get the beam to a reference sample and the sample to be analyzed, this allows for more accurate readings. In contrast, the simultaneous instrument (Figure 4.4.3) does not have a monochromator between the sample and the source; instead, it has a diode array detector that allows the instrument to simultaneously detect the absorbance at all wavelengths. The simultaneous instrument is usually much faster and more efficient, but all of these types of spectrometers work well.

A = absorbance (logarithmic scale)
B = the path length of the sample holder
C = the concentration of solution ($M^{-1}cm^{-1}$)

MORE INFO (ABSORBANCE AND BEER'S LAW)



part of the electromagnetic spectrum that we can access with equipment found in a typical chemistry laboratory. The basic principles of spectrum analysis can also be applied to other instrumentation that examine the ultraviolet, infrared, and radio frequency regions.

In a visible spectrophotometer, we shine a beam of light into a solution containing the sample, and detect how much of it comes out of the other side of the solution. By comparing the amount of light transmitted by the pure solvent to the amount transmitted when the sample is dissolved in it, we can calculate a quantity called the **absorbance**. Absorbance is directly proportional to concentration, so if you know the proportionality constant, you can use it to calculate the concentration of a substance in solution. Being able to answer the "How much?" question means that a visible spectrophotometer is a tool for doing quantitative analysis.

Knowing exactly which wavelengths of light are absorbed by a substance also gives us information that can be used to tell one substance from another or to determine whether a sample is a pure substance or a mixture. Being able to answer the "what is it?" question means that a visible spectrophotometer is also a tool for doing qualitative analysis.

Absorbance and Beer's Law

When colored solutions are irradiated with white light, the solution selectively absorbs incident light of some wavelengths. The wavelength of light where the absorbance is highest is used as the analytical wavelength. Once the analytical wavelength for a particular solution is determined, we can learn more about the solution through the relationship between absorbance (**A**) and three variables:

$A = \varepsilon b c$ **Beer's Law**

The three variables are concentration of the solution (**c**), the pathlength of the light through the solution (**b**), and the sensitivity of the absorbing species to the energy of the analytical wavelength. When the concentration is expressed in molarity and the path length is measured in centimeters, the sensitivity factor is known as the molar absorptivity (**ε**) of the particular absorbing species.

Visible spectrophotometers are capable of displaying data in either of two scales:

- Percent transmittance (%T), which is a linear scale
- Absorbance (**A**), which is a logarithmic scale

The linear %T scale can be converted to absorbance where T is the percent transmittance expressed as a decimal (e.g., 22% = 0.22):

$A = -\text{Log}_{10} T$

The most important lesson to take home from this logarithmic relationship is the realization that when the absorbance is 1.0, only 10% of the light beam's full intensity is reaching the detector and when the absorbance is 2.0, only 1% of the light beam is reaching the detector. The accuracy and sensitivity of low cost instruments starts to suffer at absorbance values higher than 1.5.

Transmittance (or %T) itself is determined by the instrument by dividing the detector signal when measuring the sample (**I**) by the signal recorded for a "blank" solution (I_0):

$T = \frac{I}{I_0}$ Transmittance

When we work with cuvettes or test tubes where the path through the liquid is exactly 1 cm, the value of "b" in the equation for Beer's Law is simply 1, so it effectively drops out of the equation and simplifies it to $A = \varepsilon c$. This means that:

- If you were to measure the absorbance of several solutions of known concentration, and plot the absorbance on the y-axis and concentration on the x-axis, the slope would be the molar absorptivity (**ε**) of the sample in solution.
- If you know the molar absorptivity, you can calculate the concentration (**c**) of a solution with ease by simply dividing the absorbance by ε (c = A/ε).

Purpose

In this experiment, you will make different kinds of measurement on various food dyes:

1. A scan of the visible spectrum recorded using a Thermo Scientific™ SPECTRONIC™ 200 Visible (Vis) Spectrophotometer™ will show you which wavelengths are absorbed by each sample. You will identify a peak or peaks in the scan and record the wavelength of each peak. Officially, the wavelength at the top of the peak is

$A = -\text{Log}_{10} T$

$T = \frac{I}{I_0}$ Transmittance

T = Percent transmittance(%T) (linear scale)

The linear %T scale can be converted to absorbance where T is the percent transmittance expressed as a decimal (e.g., 22% = 0.22)

Transmittance (or %T) itself is determined by the instrument by dividing the detector signal when measuring the sample (I) by the signal recorded for a "blank" solution(I_0)