

Tools for Materials Science - Challenge n°7 - 40'

UV Filtering Materials

The sun radiates energy in a wide range of wavelengths, most of which are invisible to human eyes. The shorter the wavelength, the more energetic the radiation, and the greater the potential for harm. Ultraviolet (UV) radiation that reaches the Earth's surface is in wavelengths between 290 and 400 nm; namely UV-A and UV-B:

- UVA: 400 nm - 320 nm
- UVB: 320 nm - 290 nm
- UVC: 290 nm - 100 nm

Since the mid-1970s, human activities have been changing the chemistry of the atmosphere in a way that reduces the amount of ozone in the stratosphere (the layer of atmosphere ranging from about 11 to 50 km in altitude). This means that more ultraviolet radiation can pass through the atmosphere to the Earth surface, particularly during certain periods of the year.

Besides health concerns, in everyday life fabrics and paper become brittle, fade in colour, or turn yellow when exposed to sunlight. Those changes are mainly due to exposure to the UV-light in solar radiation.

Last but not least Space exploration also calls for new materials able to filter strong UV radiation.



CAUTION!!!

UV beam !!!

-> USE the yellow/brown UV filters to fix on top of glasses !

-> Do NOT stare at the UV source !

-> Always close the box BEFORE turning the UV on !

1. **Sensor Calibration:** On the desk you see two sensors:

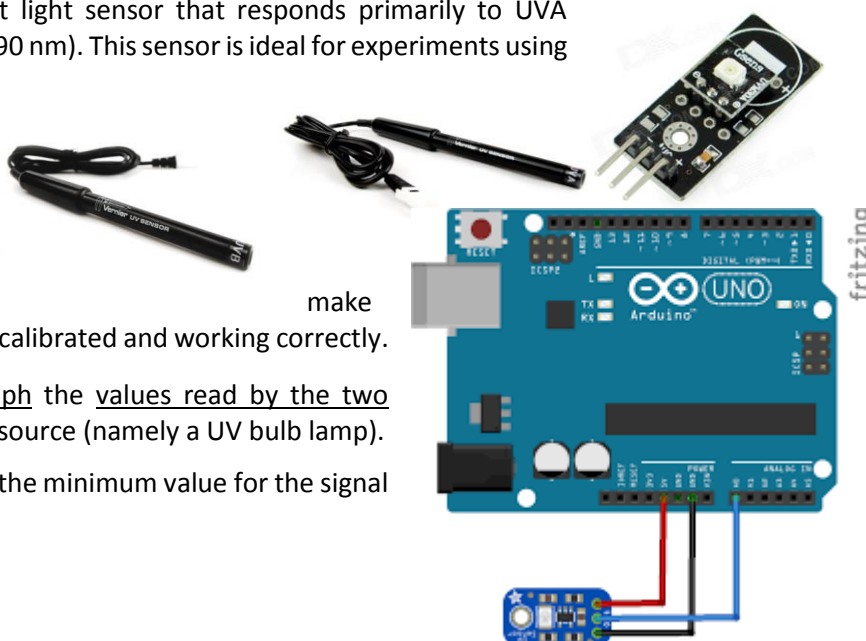
- one **UVB Vernier sensor** to use with **Logger Pro** software;
- one **UVM30A sensor** to use with **Arduino**
- The UVB Sensor is an ultraviolet light sensor that responds primarily to UVB radiation (approximately 290 to 320 nm). It is ideal for experiments using sunlight as your UV source
- The UVA Sensor is an ultraviolet light sensor that responds primarily to UVA radiation (approximately 320 to 390 nm). This sensor is ideal for experiments using UV lamps.

See the picture below for details on how to connect the sensor to Arduino.

Before testing samples about their UV filtering properties, we want to make sure that our cheap UV sensor is well calibrated and working correctly.

Therefore we will compare and graph the values read by the two sensors versus distance from the UV source (namely a UV bulb lamp).

With the UV filter on ¹you should get the minimum value for the signal (is it really zero?).



¹ It's a special glass UV filter

2. **Testing samples** – Once calibration is over insert the sensor UVM30A in the wooden box on the desk at the opposite end to the UV lamp. In the middle you will put the samples to test their UV filtering level. Here's a list of possible samples to test:

- 1) UV sun glasses or filters to apply to the glasses
- 2) T-shirt: "normal"
- 3) T-shirt: anti UV
[Compare the last two results: any difference?]
- 4) Glass: normal
- 5) Glass: quartz
[Compare the last two results: any difference?]
- 6) Plexiglass: "normal"
- 7) Plexiglass: anti UV (different kinds included the IR filtering one)
[Compare the last two results: any difference?]
- 8) Photoluminescent (Fluorescent) plastic
- 9) Sun screen cream – protective factor: 10 (on plexiglass or plastic sheet)
- 10) Sun screen cream – protective factor: 50 (on plexiglass or plastic sheet)
[Compare the last two results: any difference?]


OUTPUT WANTED:

-> Comparison data (Table 1) and graph for calibration of the two sensors.

-> Percent of incident UV transmitted by each sample (Table 2)

Answer sheet

GROUP N° _____

Ch.7 --- UV Filtering Materials

Table 1 Calibration.

Distance from UV source	Intensity of UV measured	
	<i>UVB Vernier sensor</i>	<i>UVM30A sensor</i>
Unit:	Unit:	Unit:

Report on a graph each point individuated by the couple of corresponding measures of UV-intensity made with the 2 sensors and draw the calibration curve.

Table 2 Testing

Sample Tested	Intensity of UV measured		% UV transmitted
	I_0 <i>without the filter</i>	I <i>with the filter</i>	$= I / I_0 \times 100$
	Unit:	Unit:	%
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Teacher's notes

Technical notes:

- **1: Calibration** - You may also want to go outside and compare the readings.
- **2: Testing** - While testing you may also want to roughly calibrate the UV sensitive beads (see picture) correlating their colour intensity to the reading in mV.



Organizational notes:

- Each student will keep a copy of the students' sheet but the group will collectively fill in the answer sheet and give it over to the teacher in charge at the end of the lab.

Correction grid

Question or Request	Note	Max. score
Table 1	1 point for each experimental data (for both sensor) of UV-intensity versus distance in table and/or for each point in the calibration graph	10
Table 2	1 point for each sample correctly tested	10

Key to Answer

Result of testing of the Sample:

We use this experiment to collect data to confirm some expected result:

- 1) UV sun glasses or filters to apply to the glasses
- 2) T-shirt: "normal"
- 3) T-shirt: anti UV
[Compare last two results: any difference? It should ! Someone says that wet T-shirt better protect from UV: it could be tested by this experiment]
- 4) Glass: normal
- 5) Glass: quartz
[Compare last two results: any difference? It should !]
- 6) Plexiglass: "normal"
- 7) Plexiglass: anti UV (different kinds included the IR filtering one)
[Compare last two results: any difference? It should !]
- 8) Photoluminescent (Fluorescent) plastic
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- 10) Sun screen cream – protective factor: 50 (on plexiglass or plastic sheet)
[Compare last two results: any difference? It should !]

Technical Specification

UVM-30A has a wide spectral range of 200nm-370nm. The module outputs electrical signal which varies with the UV intensity in an almost linear way (two lines: 1-200 and >200).

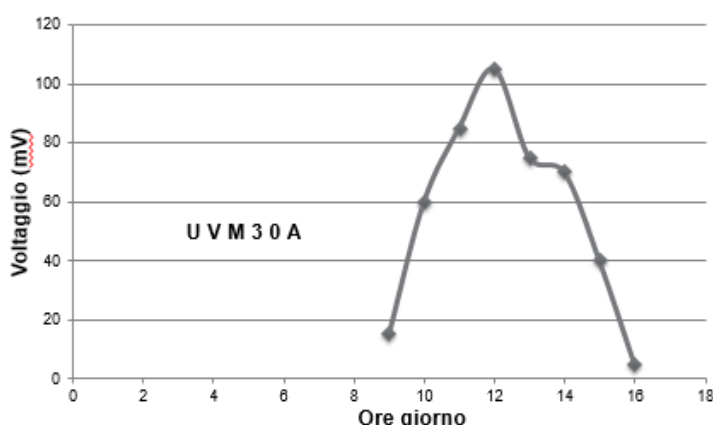
On the right measurements taken outdoor at different hours of the day.

Table Source: Wikipedia-

<https://en.wikipedia.org/wiki/Ultraviolet>.

Actually the best option is NOT the indoor

testing as black light emits in UVA, whose range is not totally covered by the sensor.



Name	Abbreviation	Wavelength (nm)	Photon energy (eV, aJ)	Notes / alternative names
Ultraviolet A	UVA	315–400	3.10–3.94, 0.497–0.631	Long-wave, black light, not absorbed by the ozone layer
Ultraviolet B	UVB	280–315	3.94–4.43, 0.631–0.710	Medium-wave, mostly absorbed by the ozone layer
Ultraviolet C	UVC	100–280	4.43–12.4, 0.710–1.987	Short-wave, germicidal, completely absorbed by the ozone layer and atmosphere

Moreover some of the most interesting materials, included the anti UV Tshirt (do they really work? How?) in real life are mainly exposed to sunlight rather than artificial light and they are intended to block the UV contained within solar radiation.

Below the basic Code for UVM-30A connected to Arduino.

```

/*
# This Sample code is for testing the UV Sensor .
#Connection:
  VCC-5V
  GND-GND
  OUT-Analog pin 0
*/

void setup()
{
  Serial.begin(9600); // open serial port, set the baud rate to 9600 bps
}
void loop()
{
  int sensorValue;
  sensorValue = analogRead(0); // connect UV sensors to Analog 0
  Serial.println(sensorValue); // print the value to serial
  delay(200);
}

```

References

- Wikipedia (https://it.wikipedia.org/wiki/Radiazione_ultravioletta)
- Vernier (<http://www.vernier.com/products/sensors/uv-sensors/uvb-bta/>)
- UVM30A (<https://sites.google.com/site/myterrarium23/domotique/uvm-30a-uva-uvb-sensor>)

- UV INDEX (https://it.wikipedia.org/wiki/Indice_UV)
- SunBurn Map (<http://sunburnmap.com>)

Where to buy

- UV beads - on Amazon or
- UV filter see plexishop or
- Anti UV Tshirt see Amazon (wide variety of costs)
- UVM-30A 15 euro approx. on line and in electronic stores

Photogallery



Top left: samples to test and cardboard sample holder to insert the samples in the box. Top right: the box with UV light source and hole drilled to insert the sensor . Bottom Left: UVM30A



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