Tools for Materials Science -Challenge n°1 - 40'

TESTING OLIVE OIL WITH LIGHT

CAUTION! Laser beam. Do NOT shine into eyes! Do NOT stare at the bright spot or reflections! CLOSE the box BEFORE turning the laser on!

You want to bring back from Italy good olive oil and now you are in the supermarket in front of a full rack of bottles. Are you sure that what you get is exactly what you are going to pay for? Is it REALLY good olive oil ?

On the desk there are three test tubes filled with Extra-virgin Olive oil (n°1), Common Olive Oil (n°2), Mixed Seeds Oil (n°3). Can you distinguish between the three?

Most probably the answer is positive and based on colour. However it may not be always so simple. Actually many frauds have been reported in the Extra-virgin olive oil market. Therefore we want to test the oil samples with light using first a red and then a green laser.

1. Put the test tubes in the rack inside the box (row next to the side window) and insert the laser.
2. Close the box and turn the laser on.
3. Check and adjust the laser beam alignment from the side window.

What's the colour of the beam in the three test tubes? Write down your observations:

	Extra-virgin Olive Oil	Olive Oil	Mixed Seeds Olive Oil
Red laser			

4. Repeat with the green laser

	Extra-virgin Olive Oil	Olive Oil	Mixed Seeds Olive Oil
Green laser			

Q1. What's really happening when you use the green laser and why it's not happening with the red one?

Q2. Now take the additional samples numbered 4, 5, 6 and test them with the green laser. One of the samples is genuine extra-virgin olive oil, the other two have been adulterated mixing extra-virgin with a different kind of oil. Find the genuine one and order the remaining samples from the least to the most adulterated. [*NOTE: the percentage of adulteration are written on the sheet on the table; obviously NOT in the correct order.*]

Extra-virgin	Less adulterated	Most adulterated
Sample N°	Sample N°	Sample N°

Q3. Finally using the previous observations try to "guess" the percentage of not extra-virgin oil added to the last sample (n° 7).

Q4. Write down a specific strategy to deduce the correct answer to Q3. (No simple guessing!)

OUTPUT WANTED: **Answer to Q1, Q2, Q3, Q4 + at least 3 pictures (choose the most meaningful and most beautiful ones)**

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Answer sheet **GROUP N°_____**

Ch.1 --- TESTING OLIVE OIL WITH LIGHT

Q1

Q2

Extra-virgin	Less adulterated	Most adulterated
Sample N°	Sample N°	Sample N°

Q3

Q4

PICTURES [*Sent by Whatsapp to your group – See general instruction to share pictures or files*]

- **Picture1 description:**
- **Picture2 description:**
- **Picture3 description:**
- **[Additional Pictures description:]**

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Teacher's notes

Technical notes:

- The experiment works best in darkness or semi-darkness. In a well lit room it DOESN'T WORK!!!
- When you mix olive oil and mixed seeds oil, the latter is denser and they stratify into two layers: be careful to mix them with a glass stirring rod BEFORE the students come in.
- You need: oil samples, testing box, red and green laser, stirring glass rod, three types of oil and –if you want to have students working systematically on Q4 –additional test tubes + graduated pipettes (at least one)

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
Q1	2 points for citing **frequency**; 2 points for citing **fluorescence**	4
Q2	(1 point for only 1 correct answer)	2
Q3	(1 point if error < 10%; 2 points if error < 5 %)	2
Q4	See key to answer	4
Pic. 1	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2
Pic. 2	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2
Pic. 3	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2
Additional pictures	Meaningful (Yes/No: 1 point); beautiful (Yes/No: 1 point)*	2

*** Pictures**: are the pictures meaningful? [*To evaluate how "meaningful" see also the "Picture Description" on the Answer Sheet*] Are the pictures focusing on significant details or clearly showing the apparatus structure or the investigation results? Are they aesthetically beautiful?

Key to Answer

Q1. Red light has a lower frequency than green light, therefore it's not energetic enough to cause *fluorescence* (absorption of higher frequency and re-emission of a lower frequency). In fact green light is first absorbed and then re-emitted as orange (olive) or red (extra virgin) light. No fluorescenceis noticed in mixed seeds oil: the light ray is still green.

Q2 The genuine sample is n° _____ and the least adulterated is n° _____

Q3. The percentage of additional oil is _____%

Q4. A **systematic investigation** may be led by preparing test tubes with known decreasing percentages of extra-virgin and spurious oil and comparing the " X test tube" with them: move the X tube down the rack till the colour caused by fluorescence is pretty the same of one of the known percentages; in the end the X tube will be in the middle of two different percentages sample (say 80% and 70%) so you can estimate the percentage of the extra-virgin oil (say 75%, with an error that is in this case lower than 5%)

Note 1 - With a spectrophotometer and more time for testing (at least one full hour), this kind of investigation may become really quantitative, resulting in interpolation of the curve of re-emitted frequency VS percentage

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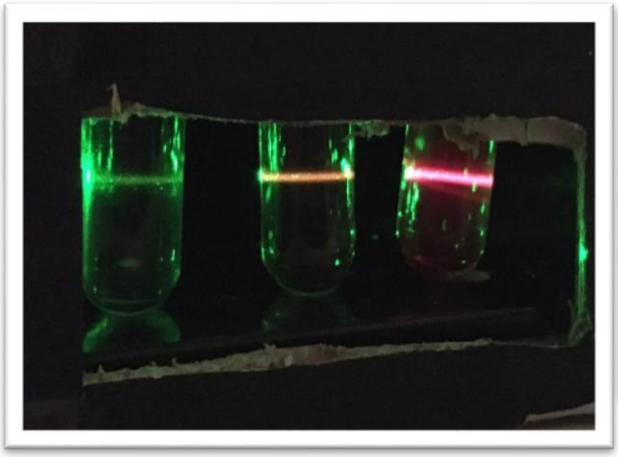
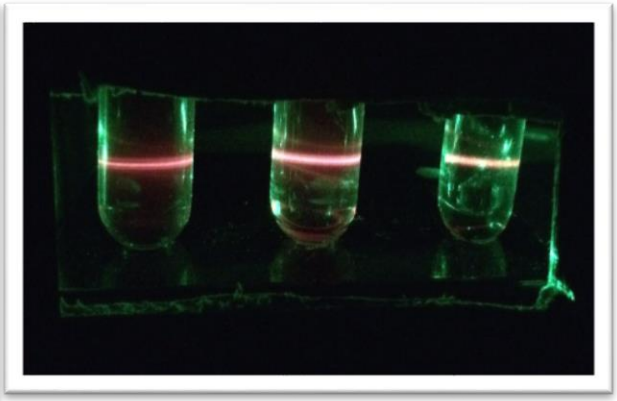
of added oil. The spectrophotometer gives out the frequency and the corresponding % is found from the curve.

Note 2 - With more time you may also extend the investigation to other kinds of oil, from Johnson baby oil to polluted water mixed with mineral oil (petroleum), fish oil etc…. However this is mostly working with a blue or UV laser. Moreover Mixed seeds oil is quite general and the fluorescent effect with mixed extra virgin olive oil may change quite a lot.

Note 3 – It could be a good idea to have the students observe the effect of the laser ray going through the samples inside the box by looking at their smartphone camera applied to the side window. This will result in added safety and, we found out, in the detection of an enhanced fluorescent effect. It may be the right moment to make students reflect on the different sensitivity of photo cameras compared to the human eye.





MoM Resources (http://www.mattersofmatter.eu/mom-materials/)

- **Light_interacting_materials_PPT**
- **Aperiscienza1_PPT** During MoM Summer School a Science aperitif session on Italian food was held. Among the proposed challenges with regard to fluorescence:

a) **Can tomato sauce screen UV?** (Yes!). The test was made shining UV light on a photoluminescent sheet under a clear glass plate first without and then with a small layer of tomato sauce interposed.

b) **Is wine fluorescent?** (YES! Particularly evident in white wine, with red wine you have to dilute it to perceive the fluorescence by naked eye) l'elevata sensibilità della fluorescenza permette di percepire piccolissime variazioni di composizione tra un campione e l'altro, rivelando eventuali sofisticazioni e alterazioni dovute ad esempio, a ossigenazione del vino, aggiunta di solfiti, etc…
http://www.teatronaturale.it/strettamente-tecnico/mondo-enoico/20148-il-sangiovese-toscano-e-un-cult-allora-cerchiamone-autenticita-e-qualita-dall-emissione-a-fluorescenza.htm

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c) **fluorescent beverages:** tonic water (because of the quinine used originally for malaria treatment in the colonies), power beverages (Gatorade, Powerade, etc because of taurine)

d**) How sensitive is fluorescence analysis?** Polluted water- invisible to the naked eye, may be easily detected under UV light. This is the case for instance with E. coli bacteria. You may simulate this with mixed natural and tonic water and try to determine to what percentage of dilution you are still able to detect the fluorescent signal under uv light.

References

- **http://laserclassroom.com/** - they sell red, green and blue lasers for education with an interesting magnetic system to stack them aligned or stick to metal boards . It's a US based company.
- **https://publiclab.org/** is an environmental DIY environmental science community. Among other things they have tested a kit to detect oil water pollution based on fluorescence https://publiclab.org/notes/warren/11-08-2013/fluorescence-of-bp-oil-with-uv-laser-success and some of the participants worked on testing olive oil adulteration https://publiclab.org/notes/warren/6-6-2012/testing-oil-fluorescence-green-laser and even wine (how much sugar has been added?) https://publiclab.org/notes/warren/1-19-2012/wine-spectroscopy-adam-hasler

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