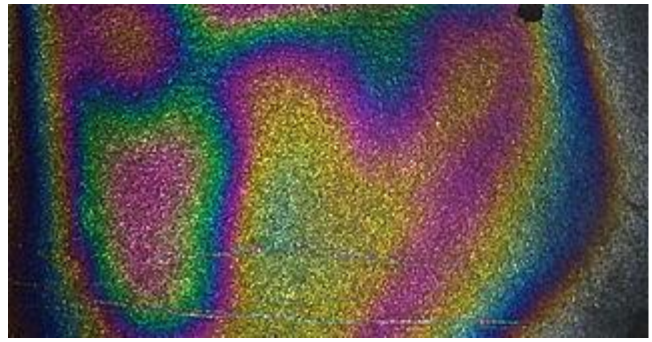
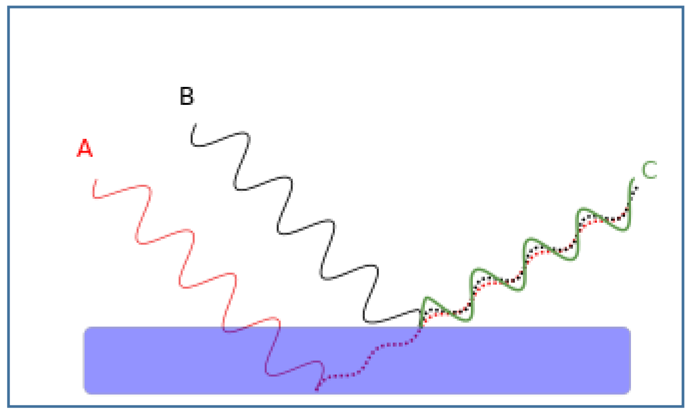
CLEAN ENERGY INSTITUTE
UNIVERSITY of WASHINGTON

Colorful Thin Film Bookmarks





Overview: In this activity students trap an extremely thin layer of clear nail polish which refraction light making a rainbow layer on a black bookmark.

Background: The reason the rainbow is seen is because the layer of clear nail polish is so thin that it reflects light in different wavelengths. Slight difference in thickness cause light waves of different length to interfere with each other-- sometimes cancelling and sometimes reinforcing. Other examples of where we see this in nature is with car oil spills on the wet roads, as well as when looking at many colorful bird feathers such as peacocks. The peacock feather is actually fairly dark brown and not colorful. But there are thin variations in the thickness of the colorful side, and this causes light to reflect in different wavelengths, producing the colors we see. If we were to smash a feather totally flat, the color would be greatly reduced.

Research Connection: In nanotechnology often properties emerge that are not present in bulk materials. In this case the layer is approximately 1 micron in thickness. This interference of light is used to measure thickness in an instrument known as an ellipsometer. Thin films are using for ant-reflective coatings on windows and solar panels which can control the light of a given wavelength that is reflected or absorbed.

NGSS Standards:

MS-PS4-2	Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]
MS-PS4-1	Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. [Clarification Statement: Emphasis is on describing waves with both qualitative and quantitative thinking.] [Assessment Boundary: Assessment does not include electromagnetic waves and is limited to standard repeating waves.]

HS-PS4-1.	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Materials:

- Clear nail polish
- Black card stock
- Water
- Petri dish or bowl
- Tweezers
- Hair dryer

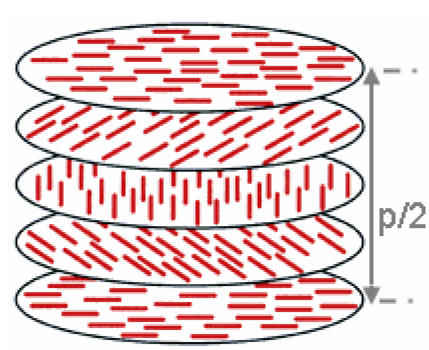
Procedure:

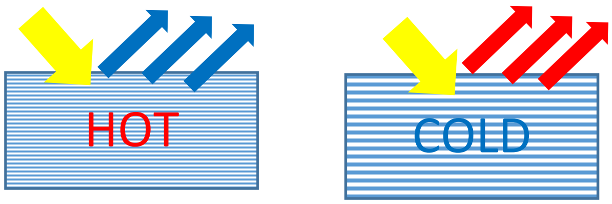
1. Fill the sample dish with water. This same water can be used until it gets really dirty/purple/black from dye in the paper bleeding into it. When this happens, replace the water.
2. Have kids use the silver sharpie markers to draw or write on their bookmark. They can draw whatever they want.
3. Place bookmark in water, and use tweezers to submerge it.
4. Drip one drop of nail polish onto surface of water and explain how the nail polish it is hydrophobic, meaning that it hates/repels water. This is why the nail polish spreads into an extremely thin film on the top of the water. It is a “thin film” in every sense of the word.
5. Pull the bookmark up thru the thin film, trying to deposit the film onto the bookmark.
6. This should create a rainbow effect on the bookmark when dry. Usually it looks sort of circular, depending on how the polish spread.
7. You may need to use the tweezers or a paper towel to occasionally clean/skim the extra nail polish off the water surface. You do not need to do this cleaning each time, but you will find that the bookmarks look a lot nicer if you have very little nail polish floating on the top when you start the experiment each time.

Alternative: Depending on the absorbance of the paper and the volatility of the nail polish you may be able to drop the polish and then immediately drop the dry bookmark on the surface and let the polish adhere to the paper. This will save time having to dry the bookmark.

Liquid Crystal Extension

Demonstrate the thermochromatic liquid crystal display or thermometer which also works on the principle of interference of light bouncing off of two layers of self aligning crystals. When the material is hot the layers are close together and they reflect blue, when it is cold the layers are farther apart and they reflect red. The thermometer has a series of liquid crystals each formulated to change at a different temperature.





Other resources

http://www.physicscentral.com/experiment/physicsathome/permanent-rainbow.cfm

http://www.ccmr.cornell.edu/education/educational-resources/lending-library-of-experiments/chemistry-kits/liquid-crystals/

Sources

Black Cardstock $5.12

https://www.amazon.com/gp/product/B008734L34/ref=oh_aui_detailpage_o00_s01?ie=UTF8&psc=1

Nail Polish $11.78

https://www.amazon.com/gp/product/B007U90J7S/ref=oh_aui_detailpage_o00_s00?ie=UTF8&psc=1

Liquid Crystal Themometer $5.99

https://www.amazon.com/gp/product/B06W5X1W1Z/ref=oh_aui_detailpage_o00_s01?ie=UTF8&psc=1

Liquid Cyrstal Sheet $11.89

https://www.amazon.com/gp/product/B002V05RWI/ref=oh_aui_detailpage_o01_s00?ie=UTF8&psc=1

