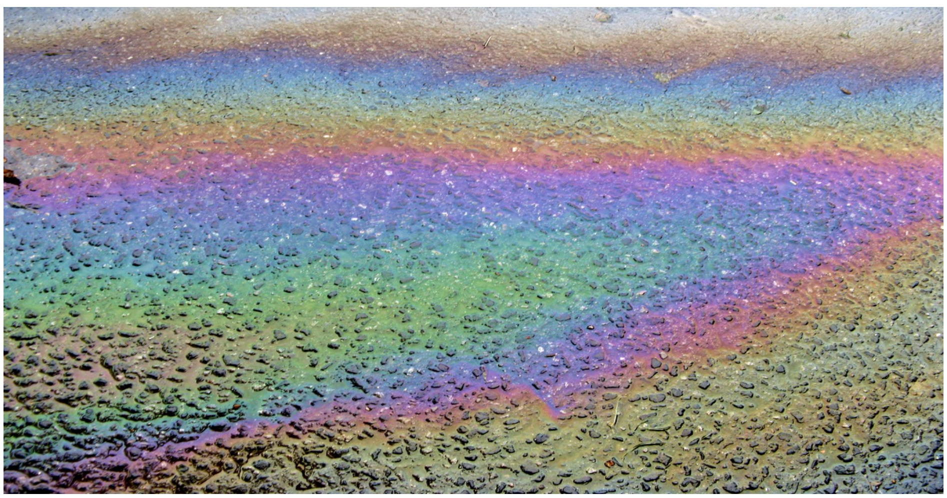
SENIC—Nanoscale Science and Engineering
Exploring Thin Films

Explore!

1. Place a black square under water so that just its corners are exposed.
2. Using the brush, drop one small bead of clear nail polish from the bottle on to the water.
3. Wait and watch the colors appear as the drop spreads out into a thin film!
4. Carefully lift the square to catch as much of the film as possible, draining off excess water. Do not let the film slide off the square. Let it dry.



texture by alicepopkorn

Creating Colors by Changing Scale

Here we make a very thin film from a drop of clear fingernail polish. Flattening the droplet to a film of microscopic (a few thousand nanometers) thickness makes the material appear brightly colored. The sheen you see in soap bubbles and the 'rainbow' effect in some oil slicks are examples of this same thin film phenomenon. Closely related are the iridescent colors that appear on CDs and DVDs, in some bird feathers, butterfly wings, and some beetles. These result from the material having a regular, repeated structural unit that is about the same size as the wavelength of light – a few hundred nanometers. Nanoscale materials often have unique properties that differ from the macroscale.

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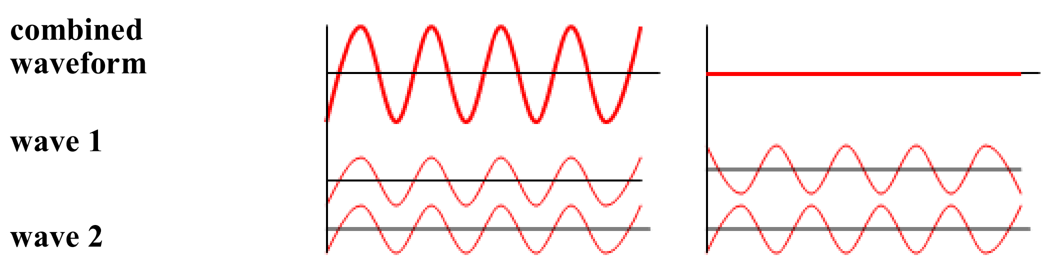
Why does a clear liquid become a colorful film?

As the small drop of liquid spreads out on the water, its thickness decreases to a few microns. The bright iridescent colors in the film result from the interference of light reflecting from the top and bottom of this thin film.

Most light passes through the clear film. But some of the light from above reflects back up off the smooth top surface of the film; and some of the light passes into the film and then reflects back up off the bottom surface of the film.

This light reflecting back from the bottom surface of the film then emerges from the top surface but, because it has traveled very slightly further than the light reflecting from the top surface, is now out of phase with the light reflecting off the top surface. The two sources – reflections from the top and bottom surfaces of the thin film – interfere with one another; sometimes they reinforce each other, producing bright colors, and sometimes they cancel each other out, producing no color (see the diagram below).

The varying thickness of the film at its edges produces these bands of changing colors called ‘interference fringes.’ Much of the center of the film is of uniform thickness and thus will tend to be of a single color.



Two waves in phase **Two waves 180° out of phase**