Mix It Up with Oil and Water

A science shake-up activity from Science Buddies

* By [Science Buddies](https://www.scientificamerican.com/author/science-buddies/), [Megan Arnett](https://www.scientificamerican.com/author/megan-arnett/) on May 24, 2018

A little mixup: Use kitchen chemistry to make oil and water blend.  Credit: George Retseck

**Key concepts**  
Chemistry  
Surfactants  
Density  
Polarity

**Introduction**  
You may have heard people say, “Those two mix like oil and water,” when they’re describing two people who don’t get along. Maybe you’ve also noticed shiny oil floating on the surface of water puddles after it rains. In both cases you understand that water and oil don’t go well together—but have you ever wondered why? So many other things can dissolve in water—why not oil? In this activity we’ll explore what makes oil so special, and we’ll try making the impossible happen: mixing oil and water!

**Background**  
Unlike many other substances such as fruit juice, food dyes or even sugar and salt, oils do not mix with water. The reason is related to the properties of oil and water. Water molecules are made up of one oxygen atom and two hydrogen atoms. In addition to having this very simple structure, water molecules are polar, which means there is an uneven distribution of charge across the water molecule. Water has a partial negative charge from its oxygen atom and partial positive charges on its hydrogen atoms. This polarity allows water molecules to form strong hydrogen bonds with each other, between the negatively charged oxygen atom on one water molecule and the positively charged hydrogen atoms of another. Other molecules such as salts and sugars are able to dissolve in water because of its polarity as well. The charges at either end of the water molecule help break up the chemical structures of other molecules.

Oils, by contrast, are nonpolar, and as a result they’re not attracted to the polarity of water molecules. In fact, oils are hydrophobic,or “water fearing.” Instead of being attracted to water molecules, oil molecules are repelled by them. As a result, when you add oil to a cup of water the two don’t mix with each other. Because oil is less dense than water, it will always float on top of water, creating a surface layer of oil. You might have seen this on streets after a heavy rain—some water puddles will have a coating of oil floating on them.

In this activity we will test the power of surfactants to help us mix oil and water. The surfactant we will use is dish detergent, which helps break up the surface tension between oil and water because it is amphiphilic: partly polar and partly nonpolar. As a result, detergents can bind to both water and oil molecules. We’ll see the results of this property in this activity!

**Materials**

* 2 clear plastic water bottles with lids
* 2 cups of water
* One-half cup of oil (olive, cooking or vegetable oils will all work)
* Liquid dishwashing soap
* Clock or timer
* Permanent marker
* Measuring cup
* Measuring spoon
* Food coloring (optional)

**Preparation**

* Remove any labels from your water bottles.
* Use your marker to label the bottles: Label the first “Oil+Water” and the second “Oil+Water+Soap.” Write the labels as close to the tops of the bottles as possible.
* Pour one cup of water into each bottle.

**Procedure**

* Carefully measure and pour one-quarter cup of oil into the bottle labeled Oil+Water. Allow the bottle to sit on a countertop or flat surface while you observe the water and oil. *Does the oil sink to the bottom of the bottle, sit on top of the water or mix with it?*
* Repeat this step, adding one-quarter cup oil to the bottle labeled Oil+Water+Soap. *Does the oil sink to the bottom, sit on top of the water or mix with it?*
* Carefully add three tablespoons of dish soap to the bottle labeled Oil+Water+Soap. Try not to shake the bottle as you add the dish soap.
* Make sure the bottle caps are screwed on tightly to each bottle.
* Holding a bottle in each hand, vigorously shake the bottles for 20 seconds.
* Set the bottles down on a flat surface with plenty of light.
* Note the time on your clock or set a timer for 10 minutes.
* Observe the contents of each bottle. Hold them up to a light one at time so you can clearly see what is happening inside the bottle. *Did anything change when you shook the bottles? Do the mixtures look the same in the both? If not, what is different between them? How would you explain the differences that you observe?*
* After 10 minutes have passed look at the contents of the bottles and note the changes. *What does the oil and water look like in each bottle? Has the oil mixed with the water, sink to the bottom or rise to the top?*
* **Extra:**Add food coloring to the water to get a lava lamp effect
* **Extra:**Test other types of soap, such as toothpaste, hand soap and shampoo by mixing them with oil and water.

**Observations and results**  
In this activity you combined oil and water then observed how adding dish detergent changed the properties of this mixture. First you should have noticed that when you added the oil to the water they did not mix together. Instead the oil created a layer on the surface of the water. This is because oil is less dense than water and therefore it floats to the surface. When you shook the Oil+Water bottle you might have noticed the oil broke up into tiny beads. These beads, however, did not mix with the water. After you let the Oil+Water bottle sit for 10 minutes you should have observed the oil and water starting separating again almost immediately, and after another 10 minutes there was once again two distinct layers in your bottle.

In contrast you should have found shaking the Oil+Water+Soap bottle resulted in a lot of foam, but instead of immediately starting to separate, the mixture was a cloudy, yellow color. Eventually the oil and water should have separated into two layers again, but these layers should have appeared less distinct and cloudier than the layers in your Oil+Water bottle.

The difference between the two bottles results from adding dish detergent to the Oil+Water+Soap bottle. The detergent molecules can form bonds with both water and oil molecules. Therefore, although the oil and water aren’t technically mixing with each other, the dish detergent molecules are acting as a bridge between oil and water molecules. As a result, the oil and water molecules aren’t clearly separated in the bottle. Instead, you see a cloudy mixture, resulting from the oil, soap and water chains you’ve created by adding dish detergent.

<https://www.scientificamerican.com/article/mix-it-up-with-oil-and-water/>

# Science Projects on Separating Oil and Water

Updated April 24, 2017

By Michael Judge

While oil and water do not mix and so will naturally separate, it can be difficult to actually remove the oil from the water. Large oil spills, such as the Exxon Valdez tanker spill in 1989 and the BP Deepwater Horizon incident in 2010, highlight the importance of this issue. There are several interesting science projects, ranging from simple to advanced, that illustrate different approaches to oil separation.

## Natural Separation

One project you can do with oil and water is to show the natural separation of the two liquids. Put some water in a clear container and add food coloring to make the separation more obvious. Pour in some oil; it can be cooking oil, motor oil or some other kind. The oil may initially drop to the bottom due to the force of falling, but it will quickly rise to lie on top of the water. If you cap the container and turn it upside down, the oil will still make its way to the top. This experiment shows two scientific principles. First of all, the water and oil do not mix because they are very different chemically. The water is polar, which means each molecule has parts with small positive and negative electric charges. Oil is very nonpolar, which is why it doesn't mix well with polar liquids. As well, the density of oil is lower than water, so it naturally rises up, just like a helium balloon rises in air.

## Separating an Emulsion

Take the container holding water and oil and shake it vigorously. The mixture will turn cloudy and you won't see two obvious layers anymore. You have made what is called an emulsion. An emulsion is a mixture of oil and water in the form of tiny droplets of the two liquids. Some common foods we eat are emulsions of oil and water, like salad dressing. An oil spill in a wavy ocean could form an emulsion, making the oil difficult to separate. You can experiment with ways to break the emulsion. Let your emulsion sit undisturbed for awhile and the oil may again form a separate layer. Adding salt to the mixture is one way to speed up the process; the salt dissolves in the water and makes it even more polar and less likely to mix with the oil.

Brought to you by [Sciencing](https://sciencing.com/)

## Absorbance

Another way to separate oil from water is to soak up the oil. Most absorbent materials we use, like paper towels, are better at soaking up water, but pads made from polypropylene work the opposite way. This is because polypropylene is nonpolar like the oil and so prefers to absorb the oil layer. Polypropylene pads can be bought at auto supply stores and other outlets. Possible experiments could include testing which brand of pads works best and how long it takes to absorb a set quantity of oil.

## Temperature

Water will become less dense when frozen into ice and this gives us another technique to separate oil and water. Although this would not be practical on a large scale, you can use it on a small scale to illustrate how densities change with temperature. Place some water and oil into a concave container, like a plastic bowl. The oil will rise to the top. Put the container in the freezer for a few hours and then take it out. The container will now have the oil on the bottom, underneath a slab of frozen water that you should be able to remove, thus separating the two.

## Bioremediation

Strangely, there are bacteria that will eat oil spills. One such bacteria that scientists have experimented with is Pseudomonas. A challenging but fascinating experiment can be carried out by mixing colonies of Pseudomonas with different types of oils and nutrients and seeing which conditions give the best bacterial growth rates. This type of experiment should always be done with caution though since some strains of Pseudomonas can cause disease in humans.

<https://sciencing.com/science-projects-separating-oil-water-8029374.html>