Bring Science Home

CAPABLE CARBON FILTERS

An adsorbing science project by Science Buddies

- By Science Buddies on December 17, 2015

Key concepts:

Adsorption
Activated carbon
Physics
Chemistry
Water filter

Introduction

Do you filter your tap water before drinking? Maybe at home you have a water filter on your faucet, in the fridge or use special pitchers that have a filter in them. You have probably heard commercials that claim these filters make your drinking water cleaner and safer. But have you ever wondered what, exactly, these filters do and if the water is really cleaner in the end? Find out about the cleaning power of water filters in this activity—but with results you can see. You will "clean" a colored sports drink or colored soda!

Background

To find out how water filters work it is probably best to have a look inside the filter. Most of the filters that are used for home water treatment are carbon filters. That means the material inside the filter is carbon or a special form of it, called activated carbon.

What makes activated carbon special is that it is a very porous form of carbon—almost like a sponge—and has many tiny microscopic pores that soak up water. All these little micropores

create a huge inner-surface area. About five teaspoons (10 grams) of granular activated carbon has a surface area that is approximately the area of a football field.When water or liquid travels through the porous structure of the filter, impurities (such as small amounts of chemicals or metals) can be removed by a process called *adsorption*. Adsorption occurs when compounds physically or chemically adhere to the carbon surface and a film of the *adsorbate*, or the chemical impurities, is created on the *adsorbent* (carbon surface). This is also why the surface area matters. The more surface area, the more possible bonding sites there are for the impurities.

If all the bonding sites are taken up, then the impurities remain in the water and it is time to replace your water filter. Besides the surface area, the time the water spends in contact with the activated carbon is also an important factor that determines the efficiency of the filtration process. The longer the contact time or the slower the flow rate of the water, the more adsorption can take place. See for yourself in this activity. It's time to get started with your own adsorption experiment!

Materials

- Colored sports drink or colored soda
- Five plastic cups (Two-ounce cups work best.)
- Tablespoon
- Activated carbon (You can get this from a pet store. If you would like to taste your results, use food-grade activated carbon.)
- Timer
- Coffee filters (at least four)
- Permanent marker
- Paper towels
- White sheet of paper
- A working area that can tolerate some liquid splashes

Preparation

- Label five two-ounce plastic cups with: 0, 1a, 1b, 2a and 2b.
- Using half a tablespoon of activated carbon (about 1 gram) fill cup 1a. Do the same for 2a.
- Prepare two double-layered coffee filters. Insert one filter into another filter to form the two layers.
- Get your timer and colored sports drink ready.

Procedure

- Take the empty two-ounce plastic cup, labeled 0, and add about one tablespoon (approximately 10 milliliters) of colored sport drink or soda. *How does the drink look inside the cup? Is the color very intense*? Smell the sports drink in the cup. *Does it have a specific smell?*
- Set your timer for five minutes. Do not start it yet.
- To the two cups with activated carbon, labeled 1a and 2a, add about half a tablespoon of colored sports drink to each (about 5 milliliters per cup). Carefully swirl each cup to make sure that the solution mixes well with the activated carbon. *What happens when you add the solution to the activated carbon? What does the mixture look like?*
- Start your timer immediately after you have filled both cups.
- Take the double-layered coffee filter and hold it above cup 1b. Once the timer rings after five minutes, pour the contents of cup 1a (liquid and activated carbon) into the double-layered coffee filter. Collect the liquid that runs through the filter in cup 1b. *Did the appearance of the sports drink change? How? Smell the liquid again. Do you notice a difference compared with the original sports drink?*
- Set your timer for 25 minutes and start it immediately after you finished filtering the solution from cup 1a.
- While waiting, swirl cup 2a occasionally.
- Now prepare your second double-layered coffee filter, and once your timer rings after 25 minutes hold it over cup 2b. Pour the liquid and activated carbon from cup 2a into the filter and collect the liquid in cup 2b. *How does this solution look compared with the original sports drink and the solution in cup 1b? Do you notice any change in smell?*
- Finally, line up cup 0 with your original sports drink, cup 1b and 2b. Put them on a white sheet of paper so you can see the solutions better. Look at all three cups. *How did the sports drink change over time when it was in contact with the activated carbon?*
- **Extra:** If (and only if) you used food-grade activated carbon, you can taste each of your solutions. *Do you notice any differences compared with the original sports drink? How does the taste change?*

- **Extra:** Try different colors of sports drinks or sodas. *Do you see the same effect for all of them or does one drink work better than the others?*
- **Extra:** What happens if you change the ratio of activated carbon and liquid? Try this activity with different amounts of activated carbon in the same volume of sports drink. Or change the volume of your solution and keep the amount of activated carbon the same. *Do different activated carbon–liquid ratios lead to different results? What do you see after five minutes, for example, when you add more sports drink to the same amount of activated carbon?*
- **Extra:** Try to find other materials instead of activated carbon that could clean your solution. *Can you think of other adsorbing materials that would work the same way as activated carbon? What property does such a material need to have?*

Observations and results

Sports drinks come in a variety of colors. Looking at your plain drink in the plastic cup, you probably found that the color was very intense. Depending on the color or flavor, you might have noticed a fruity or sweet smell. When you poured your drink into the cups with activated carbon, did you see it fizzing and bubbling? This is because once the activated carbon becomes wet, all the air that is inside its many pores is replaced by liquid and, therefore, is released, which leads to the bubbling and fizzing.

The mixture now looks like a black slurry, and if you filtered it into cup 1b after five minutes, you probably noticed that the original color of the solution had become much less intense. And the fruity smell probably was very faint or not even recognizable anymore. If you check the ingredients list of your sports drink or soda, you probably will find that there are specific ingredients listed that make the color and flavor, such as "Blue no. 1," "caramel color" or "artificial flavor." These are mostly chemicals or organic compounds that will adsorb to the activated carbon surface and get trapped in its pore spaces. Thus, they will be removed from your drink. When treating your sports drink longer with the activated carbon, you can even remove all its color so you end up with an almost clear solution. Did your sports drink look clear in cup 2b once you filtered out the activated carbon after 25 minutes? The longer the beverage is in contact

with the activated carbon, the more its color and fragrance chemicals can be adsorbed to the carbon's surface. If you wait long enough, all the color and smell is gone.

If you play around with the ratio of liquid volume and amount of activated carbon, however, you might find that if you have a lot of liquid and only very little activated carbon, you will not be able to remove the color completely. This is because the activated carbon has a limited adsorption capacity, which means that once the surface area is completely covered with color and flavor compounds, no space remains to adsorb more. This is also the reason why you have to replace your water filters at home regularly.

If you used food-grade activated carbon and tasted the colorless sports drink, it probably did not taste like the original one at all! Now think of the water filter you use at home—it works exactly the same way. Many of the compounds (even some that you cannot see or taste) will be trapped in the activated carbon filter, and the only thing left is water for you to drink.

Cleanup
You can pour all the solutions into the sink. Collect the activated carbon in one container and discard it with your regular trash. Wipe your work area down with wet paper towels.

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