History

Humans have been using charcoal in a variety of ways for thousands of years. Ancient Hindus used it to purify their water, and Egyptians used it topically to treat poisoning. In the 1700s, the adsorption properties of certain types of charcoal, such as charred animal bones, were discovered. Called bone-black, this charcoal was useful for removing impurities from water, sugar and other substances. Gradually the process of manufacturing activated charcoal became more sophisticated. By the turn of the 20th century, methods for deriving activated charcoal, also called activated carbon, from coal became more common and more effective.

Sponge-Like Structure

Electron microscope image of activated carbon (cdc.gov)

The secret of activated carbon, how it can filter and purify so well, is its sponge-like structure. This structure is created in the activation process. There are many ways to make activated carbon, starting with carbonaceous (carbon-rich) precursor materials, such as wood, coal, rye starch and coconut shells. Some methods use extreme heat to decompose the precursors, while others use hot gases or acids. The efficiency of the end product varies based on the method and the number and size of the holes the process creates.

Adsorption

When tiny holes are created in the carbon, its actual surface area becomes enormous--a single gram of activated carbon can have a surface area of 500 square meters and a pound of it is equal to 125 acres. This is important because activated carbon has a natural ability to adsorb organic and some inorganic substances. Adsorption is a process in which substances attach to the surface of the activated carbon, as opposed to Absorption, where one substance becomes completely diffused into another. That's why the increased surface area is more important: the greater the surface area, the more the activated carbon can adsorb--the more icky stuff it can filter from your fish tank, for example. Over time, those little holes fill up and the carbon starts to become ineffective, so activated carbon needs to be changed regularly if it's used for regular filtration. Some types of activated carbon can be cleaned and reused as well.

The van der Waals interaction

Close-up of a gecko foot

Activated carbon adsorbs substances so readily because of something called the van der Waals interaction, which describes intermolecular forces. The adsorption by activated carbon is similar to the method geckos use to climb walls. The gecko has tiny hairlike setae on its feet--each 1/36 the width of a human hair--that create a large surface area. Each setae has between 100 and 1,000 even tinier spatulae on its tip. Every spatulae that touches a surface creates a tiny bond between the molecules of the wall and the molecules of the spatulae. The combined force of the bonds on the spatulae of even one toe is enough to allow a gecko to hang suspended from smooth glass. Similarly, the large surface area of activated carbon allows it to bond to just as large an amount of many substances.

Many Uses

Activated carbon is used in a variety of applications--from water filtration to fish tanks to treating attempted suicides--and has been for millenia. Its ability to purify water has saved countless lives, as has its ability to adsorb poisons after they're ingested.