

Adsorption Is Key to Removing Contaminants

When filtering impurities out of drinking water, mechanical filtration typically is used. But what happens if there are particles in water that are dissolved or are too small and cannot be removed by mechanical filtration? Fortunately, there is a process called adsorption, which can remove very tiny particles or dissolved contaminants from water such as lead, PCBs, some pesticides, viruses and asbestos fibers.

What is adsorption?

Adsorption is a physical process in which dissolved molecules or small particles (the adsorbate) are attracted and become attached to the surface of something larger (the adsorbent). The attraction is similar to that of a magnet on a refrigerator, but on an atomic or molecular scale. Energy differences and electrical attractive forces, known as van der Waals forces, cause molecules of the adsorbate to physically fasten and stick onto the adsorbent.

Common in nature, the laboratory and industry, adsorption often occurs between solids and liquids or gases. It is responsible for the transport of nutrients into the soil, assisting in plant and animal growth, the chemical separation of proteins and enzymes, and industrial processes like air purification, sugar refining and desalting of seawater.

Adsorption should not be confused with the completely different process of absorption, in which liquids and particles penetrate into another substance, such as a sponge that soaks in liquids.

The amount of material adsorbed depends on a number of factors including the degree of attraction, the surface area exposed to mobile particles, the concentration of the contaminants, and the pH and temperature of the liquid. Typically, the strongest adsorbents are microporous or finely divided solids (clays, charcoal, powdered metals) and liquids (fine droplets like aerosols and sprays).

The Role of Activated Carbon

Throughout history, people have used carbon (charcoal) as an effective adsorbent, in such processes as water treatment, sugar purification and color removal from liquids. In water treatment systems, an improved form of carbon, called "activated carbon," is the adsorbent most commonly used to attract and hold dissolved contaminants.

Activated carbon is made from carbon-based materials like coal or wood that is first heated without oxygen to produce charcoal and tar or pitch, which bubbles out. The charred material is then heated with steam or carbon dioxide to above 1000° Celsius, which further erodes and corrodes it to remove everything but the carbon. The result is an airy, delicate structure that is nearly pure carbon and full of holes. It is then crushed to a powder and mixed with binders to form granules of desired size ranges for different filter media.

Chemicals are sometimes added during activation of the carbon to produce different surface chemical natures that adsorb different contaminants. For example, acids produce carbon with maximum capacity for adsorbing heavy metals.

Activated carbon's enormous surface area is a critical factor in its effectiveness to adsorb various contaminants. The surface area typically is about 1,000 square meters per gram. As an example, a piece of carbon the size of a pea has an area the size of half a football field. The structure and distribution of pores in activated carbon are key factors for adsorption because they determine the size of molecules that can be adsorbed. Adsorption can only occur when molecules enter activated carbon's pores. As a result, the size and porosity of activated carbon determines the rate at which contaminants are adsorbed.

Depending on the desired results, activated carbon may be used in powdered or granular form. Granular activated carbon is commonly used in water treatment facilities where the water is passed through a granular carbon bed to remove tastes, colors, odors, and dissolved organics. Powdered carbon also is used in treatment facilities at various points for its quicker rate in removing various contaminants. Powdered carbon is the preferred choice in point-of-use water filtration systems because it is faster and is a better mechanical filter than granular activated carbon. It also takes up a minimum of space given its large surface area-to-volume ratio.

Filter Solutions

Filters with activated carbon are available in a variety of types and sizes, depending on use in the home or commercial operations. Their effectiveness at adsorption depends mainly on how long the water is in contact with the activated carbon. The longer that water is in contact with the activated carbon, the more materials can be adsorbed.

Point-of-use systems include faucet-mounted, countertop, pour-through and under-the-sink filters. The faucet-mounted is the most common filter, which can be easily and quickly installed by attaching it directly to a faucet outlet or on the counter attached with flexible tubing. Under-the-sink activated carbon systems come in two types, ones that filter all cold water passing through the faucet and others that attach to the cold water line and go to a separate faucet, in order to prolong the life of the filter.

Whole-house units filter all water serving a household. These systems are key in removing contaminants that can be absorbed through the skin during bathing or showering, or from inhalation. For activated carbon filters to be most effective, cartridges need to be replaced periodically. The life of the cartridge varies with the amount of water passing through the filter and the amount of impurities or contaminants present in the water. Expected minimum capacities are expected to be declared on product labels.

Effect on Water Quality

As activated carbon adsorbs dissolved molecules and sub-micron particles, the effect is the reduction of contaminants resulting in more aesthetically pleasing and healthy drinking water. Adsorption removes disinfectant chlorine both as "free chlorine" and a special "combined" form (mixture of chlorine and ammonia) that is often used in municipal water treatment. The taste and odor of disinfectant chlorine is the most common complaint and the most common reason people buy filters.

Adsorption also can remove many kinds of pesticides and other synthetic organic chemicals, including chlorinated hydrocarbons, gasoline, industrial solvents, and disinfection by-products. Adsorption also can remove heavy metals like lead and cadmium that get in water from corrosion of plumbing materials.

Everpure precoat filters are highly effective at removing dissolved and sub-micron contaminants. They contain Micro-Pure, a proprietary powdered media mix containing mostly powdered activated carbon. Finer than talcum powder, it is very efficient at removing dissolved chemicals and suspended particles because there is less space between carbon particles for contaminants to travel. Everpure precoat filters are small and convenient for foodservice and home use.

In an Everpure precoat filter, flowing water deposits Micro-Pure onto a septum, which is a supported fabric where the powdered media mix forms a firm layer known as the precoat cake. The cake captures dissolved chemicals through adsorption and particles through mechanical filtration. The treated water then passes through the septum and to the outlet. Everpure precoat filters remove 99.9 percent of particles one-half micron (1/50,000 of an inch) and larger. The filters also remove 99.9 percent of the protozoan cysts of *Cryptosporidium* and *Giardia*, which cause waterborne illnesses.

Everpure systems with Micro-Pure have achieved NSF International's highest ratings under Standard 42 for Aesthetic Effects and Standard 53 for Health Effects. NSF International is an independent testing agency that sets product standards and certifies the performance of point-of-use drinking water systems.

For more than 60 years, Everpure has been a leading manufacturer of water filtration and treatment systems for foodservice and residential use and offers a full line of systems to meet all water quality needs.

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