# Organic Contaminant Removal With Activated Carbon

**By Robert Potwora**

*Activated carbon is commonly used in point-of-use (POU) and point-of-entry (POE) water applications. Activated carbon is predominantly used to remove organic-based contaminants and inorganic contaminants like free chlorine and monochloramine from water. Other water treatment processes such as reverse osmosis or ion exchange are better suited for other inorganic chemicals that may be present in water.*

## Factors impacting contaminant removal

Activated carbon is a general term to describe a family of adsorbents that have been manufactured from a variety of carbon-based materials. Each base material results in an activated carbon with unique physical characteristics that determine its suitability for water treatment applications.

### Types of Activated Carbon

Some of the more common carbonaceous substances used as raw materials to make activated carbon are coal (lignite, sub-bituminous and bituminous), coconut shell and wood (hard wood and soft wood). Other types of raw materials used, but to a lesser extent, include fruit pits, nut shells and rice hulls. The most common types used for water treatment are coal and coconut shell.

The most common method to produce activated carbon is steam activation. The first stage of this method is carbonization, in which the majority of the volatile components present in the raw material are burned away, leaving a carbon char. The char is then "activated" in a second stage at temperatures of 1,600°F to 1,800°F with steam in a low-oxygen environment. All the volatile compounds in the carbon material are removed, and the steam reacts with the carbon. The water-gas reaction, $C + H_2O = H_2 + CO$, removes carbon, leaving behind a carbon skeleton. Activated carbon (AC) may also be produced by a low-temperature chemical activation process using phosphoric acid. Usually wood-based ACs are produced by this method, but wood-based ACs are not used to a large extent for POU/POE water treatment. Residual phosphate on wood-based AC can leach into the water and may cause water quality issues.

Different raw materials used to produce AC have a direct impact on its final properties. Table 1 compares the key properties of ACs used for water treatment produced from the most common raw materials: coconut shell,

**Table 1. Activated Carbon Properties**

| AC Base Material | Coconut Shell | Bituminous Coal | Sub-Bituminous Coal |
|---|---|---|---|
| Iodine number (mg/g) | 1050 - 1300 | 850 - 1000 | 1000 - 1100 |
| Molasses number | Less than 200 | 200 - 230 | Greater than 300 |
| Total ash (percent) | Less than 3 | 8 - 15 | 10 - 15 |
| Hardness number | 98 - 99 | 85 - 90 | 85 - 90 |

bituminous coal and sub-bituminous coal. The most common method to distinguish the micropore volume among ACs is the iodine number. Coconut shell ACs have a higher iodine number, which corresponds to a higher capacity to adsorb small molecules, such as volatile organic chemicals (VOCs). The molasses number test method is used to measure the amount of larger meso and macro pores. Bituminous coal-based ACs, especially sub-bituminous, have a much higher capacity to adsorb larger molecules like tannins.

## Factors Impacting Contaminant Removal

AC removes contaminants by either adsorption or catalytic reduction. The removal of free chlorine from water by AC is a catalytic process. The reaction of AC with chlorine occurs in a matter of seconds. Therefore, most ACs perform well regardless of the raw material used to produce them. The removal of monochloramine from water by AC is also a catalytic process, but the reaction of monochloramine with AC is a much slower process. To overcome this, special coal- or coconut-shell-based ACs are used that are surface enhanced to more readily break down the monochloramine.

Organic contaminants present in water supplies may come from manmade sources like VOCs or decaying plant life. There are many factors that determine how well an AC will adsorb a particular organic contaminant. The two most influential are molecular weight, or size of the organic molecule, and water solubility. In general, organic contaminants with a higher molecular weight are adsorbed more effectively by AC. Also, organic contaminants with low water solubility are adsorbed more effectively. Many VOCs have a low molecular weight, typically less than 150, and have low water solubility. These low-molecular-weight VOCs are adsorbed more effectively by a coconut-based AC. An Internet search can be conducted to find the molecular weight of a specific organic contaminate. Chloroform is a common VOC found in chlorinated surface waters. Chloroform has a molecular weight of 119; therefore, coconut-based AC is preferred to remove it from water. Common higher-molecular-weight organics found in water are tannins, which may give the water a brownish color.

Geosmin and methylisoborneol (MIB) are also high-molecular-weight contaminates. These two chemicals are byproducts of algae growth and can impart an earthy, musty taste and odor on the water. These contaminants have molecular weights ranging from 168 to more than 1,000. Therefore, a bituminous or sub-bituminous AC would be preferred to adsorb them. *wqp*

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