

# Match treatment type to carbon type

The 'universal' adsorbent media comes from different raw materials.



**By Ken Schaeffer**

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▶ Activated carbon filter media is commonly used in point-of-use/point-of-entry (POU/POE) water treatment applications. It can be used either by itself, such as to remove chlorine from tap water, or in combination with other water treatment processes such as reverse osmosis (RO), ultraviolet (UV) and ion exchange for treatment of more complex water streams containing various contaminants.

Activated carbon is known as the universal adsorbent because it has the capacity to adsorb a myriad of compounds and remove them from a liquid or vapor stream. It is commonly used in water filters in granular form or in block form (made from powdered activated carbon) to remove taste- and odor-causing chemicals and additives such as chlorine or chloramine.

It works both as an adsorbent, adsorbing organic compounds such as chloroform or geosmin from water, and as a catalyst, such as reacting with chlorine to break the chemical bond producing chloride ions as a result.

The block form of carbon filter also acts as a mechanical filter and can be rated as 1-micron, 5-micron, etc. Carbon blocks are made from coal, coconut shell and wood powdered carbons, and each manufacturer has its own guarded recipe for block-making.

**The carbon family**

According to ASTM D 2652, *Standard Terminology Relating to Activated Carbon*, activated carbon is defined as: a family of carbonaceous substances manufactured by processes that develop adsorptive properties.

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

Carbonaceous substances are the raw materials used to make activated carbon, and the most common are:

- Wood (hardwood and softwood)
- Peat
- Coal (lignite, sub-bituminous and bituminous)
- Palm shell
- Coconut shell.

Other types of raw materials used to a lesser extent include fruit pits, nut shells, and agricultural waste such as rice hulls. The most common types used for water treatment carbon are coal, coconut shell and wood.

**Activation yields surface area**

The standard process used to manufacture steam-activated carbon involves putting the carbonaceous substance through a manufacturing process that heats the raw material, creates a char and then is activated in a furnace at high temperatures of 1,700 to 1,800 degrees F with steam in the absence of oxygen.

In the steam-activation process, all volatile compounds in the carbon material evacuate the particle, and the following steam-carbon reaction ...



... removes excess carbon and enlarges the pores, leaving behind a carbon skeleton.

Some wood-base carbons are made using a chemical activation process that uses heat and phosphoric acid.

This "activation" process results in the creation of an enormous surface area — on the order of 600 to 1,200 square meters per gram (m<sup>2</sup>/g), depending upon the raw material and process dynamics.

A good-activity carbon with a surface area of 1,000 m<sup>2</sup>/g would have 125 acres of surface area per pound.

**Important: porosity type**

Granular activated carbons are sized using particle size distribution according to ASTM D 2862, and typical sizes include 20 x 50, 12 x 40, 8 x 30 and 8 x16 mesh.

Activated carbon used in POU/POE

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the main application, then either type of carbon will do because chlorine removal is a surface reaction and not adsorption.

### Contrasting the carbons

The three coal-base materials — lignite, sub-bituminous, and bituminous — each result in an activated carbon with different physical characteristics. If you consider that some coal carbons are direct-activated and some are reagglomerated and activated, then even more differences are apparent.

Lignite coal granular carbons are not typically used in POU/POE applications due to their lower attrition resistance, higher ash content and lower activity level (surface area) compared with other coal carbons, but lignite powdered activated carbon (PAC) is commonly used by municipal water treatment plants for seasonal taste and odor control.

Comparing attrition resistance and activity, sub-bituminous and bituminous coals produce similar activated carbons, but bituminous carbons have lower total ash, and reagglomerated bituminous carbon is a bit more dense and is more macro-porous.

Coconut shell activated carbon has the greatest density, highest hardness, lowest



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ash and highest activity level in the activated carbon family tree.

### Water treatment carbon selection

Lignite, sub-bituminous, and bituminous coal and chemically activated wood-base carbons are manufactured in the United States and also imported, because domestic production cannot meet the demand for product. All coconut shell activated carbon is imported because there is no domestic production.

When buying activated carbon cartridge filters or in bulk for a specific POU/POE application, you need to know the carbon base material in order to select the proper carbon for the job:

- If the main carbon function is chlorine removal, then either a coal base or coconut shell base carbon will suffice, but ...

- If the application is to remove larger molecules such as color, then a coal base or wood base PAC is probably the best choice.

- If your concern is chlorine and some low-level suspended solids, then a carbon block type filter may be required and it could be made with coal or coconut shell carbon.

- If activated carbon has been in service for chlorine removal and the local municipality changes from adding chlorine to adding chloramine to the water (to reduce disinfection byproducts such as trihalomethanes [THMs]), the options are to increase the amount of carbon, reduce the flow rate to increase contact time, switch to a higher-surface-area carbon or replace the regular carbon with an enhanced-surface-area carbon (for higher catalytic capability).

- In some cases a carbon with antimicrobial properties may be needed, and some special carbons are marketed for that purpose. They use impregnants such as silver or iodine to curb bacterial growth in the carbon filter.

### Not just any carbon will do

To obtain the best performance from activated carbon media, do some investigation about the desired results for the water treatment system. Match the type of activated carbon that will provide the needed activity (surface area and pore size distribution), attrition resistance (abrasion or hardness number), total soluble ash level, particle size and density.

Since activated carbon pricing has been escalating, it is critical to talk to your activated carbon supplier and make a knowledgeable decision on carbon type and grade for the application.



## Pore Size Comparison

Raw Materials	Availability of Pore Shapes			Average Pore Size
	V	U	U	
Wood	-	-	U	●
Coal	V	U	U	●
Coconut Shell	V	-	-	●