

# Application Bulletin

## CAN 'SULFUR WATER' BE CURED WITH CARBON?

Reprinted from *Water Technology*

### *It may help oxidize one odor-causing gas.*

Hydrogen sulfide ( $H_2S$ ) is a nuisance to homeowners and water treatment professionals alike, but more effective ways of dealing with it are being introduced. One approach is to use catalytically active activated carbons.

$H_2S$  is formed through the anaerobic microbial process associated with decomposition of organic matter. At concentrations in the parts per billion (ppb) range,  $H_2S$  and related sulfides add objectionable sulfur-like taste and "rotten egg" odor to drinking water. Left untreated, it can lead to corrosion in drainage pipes and concrete sewers.

Groundwater systems are the most common drinking water source for sulfide contamination because of the anaerobic environment in which groundwater exists. Sulfide problems in surface water sources are much less frequent because of the natural aeration that occurs in most flowing surface water sources.

In groundwater, sulfide can exist in three forms: hydrogen sulfide ( $H_2S$ ), bisulfide ( $HS^-$ ) and sulfide ( $S^{2-}$ ). The sulfide species present is dictated by pH. At pH values of less than 6, the  $H_2S$  species predominates. In the pH range of 7 to 12.5,  $HS^-$  is the predominant species.  $S^{2-}$  doesn't become significant until pH is greater than 12. Because the pH of most groundwater ranges from 6 to 9, a combination of  $H_2S$  and  $HS^-$  is often present.

### **Common Treatment Methods**

Drinking water that contains offensive sulfur taste and odors is typically treated by aeration and chlorination. Aeration is the most common treatment method in terms of volume of water treated annually because it's inexpensive, easy to maintain and doesn't produce potentially harmful reaction products such as trihalomethanes (THMs).

Aeration uses ambient air to strip sulfide compounds from contaminated water. It's typically used by municipal water authorities to treat large water flows prior to distribution. Aeration, however, is impractical for point-of-entry (POE) residential treatment because treated water must be re-pressurized for distribution within the house and objectionable odors that are removed from the water are put into the surrounding air.

Chlorination usually involved the use of sodium hypochlorite ( $NaOCl$ ), which converts  $H_2S$  and related sulfides to odorless reaction products. This has long been considered the most practical method for POE systems, but is often difficult to implement because continuous chemical addition and ongoing maintenance are required. The formation of THMs is also a concern with this method because the oxidation process isn't specific to sulfides.

Activated carbon has typically not been used in sulfide treatment of drinking water because of its limited adsorption capacity for sulfides. Catalytic activated carbons, however use a different mechanism for sulfide removal whereby adsorption capacity is not the limiting factor. Instead, catalytic carbons promote the oxidation of sulfides with dissolved oxygen present in the water.

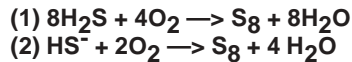
Research made public in 1982 and the American Water Works Association's Water and Technology Conference shows catalytic oxidation of sulfides does occur to some extent with conventional activated carbons. Nonetheless, catalytic activated carbons have enhanced catalytic ability and are considerably more efficient at removing sulfide compounds from drinking water. The oxidation reactions involved are complex and not fully understood. Two prominent reaction mechanisms have been theorized, each of which includes two reactions. This is because sulfide exists as either  $H_2S$  or  $HS^-$  in the pH range of typical drinking water.



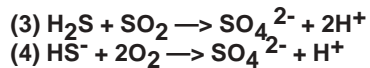
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### Mechanism 1



### Mechanism 2



In the August 1984 issue of *Fuel* magazine, researchers theorized dissolved oxygen that is adsorbed onto the surface of the carbon forms reactive intermediates which react with the  $\text{HS}^-$  to form  $\text{S}_8$ , elemental sulfur and  $\text{SO}_4^{2-}$ , sulfate. Other minor side reactions may also take place.

## Using Carbons Effectively

Conventional activated carbon can show some affinity for sulfide removal in drinking water treatment, but the catalytic nature of conventional activated carbon is highly variable, uncontrolled and substantially lower than that of catalytic carbons.

Catalytic activated carbons, however, maintain consistent catalytic activity as measured by Peroxide Number (PN), according to proprietary research by one activated carbon manufacturer. They can therefore reduce required empty bed contact times and equipment size or lengthen bed life beyond what can be expected with conventional carbon.

Removal of sulfides with catalytic activated carbons first involves adsorption of the sulfide species and then catalytic oxidation. The rate-limiting step of the removal process is migration into the adsorption pore region of the particle. Once adsorbed, the sulfide species is quickly oxidized and converted to a non-objectionable compound.

Thus, smaller particle size allows quicker adsorption of contaminants and an overall faster removal rate. It's also expected that smaller particle size translates to greater bed life for a given treatment objective and contact time. As particle size decreases, however, pressure drop considerations increase, resulting in diminishing capacity improvements.

In most cases, an empty bed contact time (EBCT) of three minutes is sufficient to remove sulfides to tolerable levels - but EBCT is highly dependent on sulfide concentration, solution pH and the presence of dissolved oxygen.

EBCT can also impact sulfide removal dramatically (see graph on next page).

Catalytic activated carbons probably have a sulfide capacity of 10 percent to 20 percent by weight. Thus, a typical POE system containing 30 pounds of catalytic activated carbon will last for approximately five years treating a water stream containing 1 ppm of sulfides at 200 gallons per day. These estimates are also highly dependent on influent sulfide concentration, pH, dissolved oxygen and organic containment.

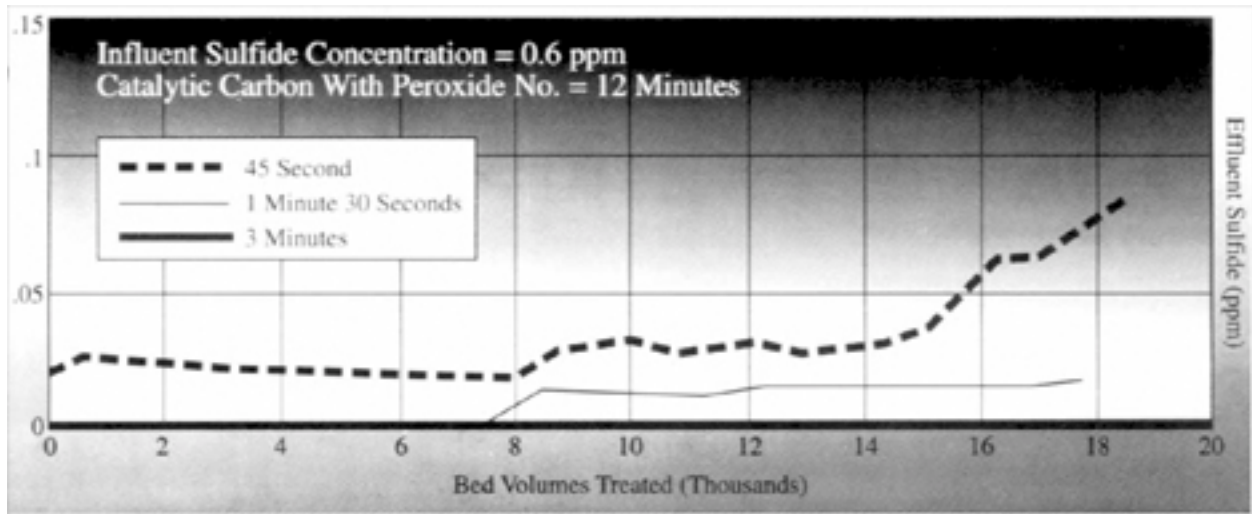
Using catalytic activated carbons to remove hydrogen sulfide and related sulfide compounds from drinking water offers water treatment professionals and end users a convenient alternative to chlorination and aeration. As a result, cost savings can be realized through reduced equipment and maintenance requirements.



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As the graph illustrates, adequate empty bed contact times (EBCTs) help you get the most out of catalytic activated carbons. Using a catalytic activated carbon with a Peroxide Number of 12 minutes, three different EBCTs were used to treat nearly 20,000 bed volumes of water. Treatment stream influent contained approximately 0.6 parts per million (ppm) of sulfides and between 2 and 4 ppm dissolved oxygen. Average pH was 8.7, in the range within which the predominant sulfide species is HS<sup>-</sup>

Best results occurred at three minutes EBCT, at which no sulfide breakthrough occurred. Because the 45-second EBCT curve looks similar to a typical carbon breakthrough profile, catalytic carbons may have a finite capacity for sulfides, depending on the removal mechanism. One theory suggests reaction products are adsorbed on the carbon surface and eventually occlude the catalytic sites, leading to breakthrough.

by Neal E. Megonnell



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