Table 1

Forms of Chloramines

Species	Chemical Formula	Water Conditions Present
Monochloramine	NH_2Cl	PH7-9
Dichloramine	$NHCl_2$	PH 4.4-6[+]
Trichloramine	NCL_3	PH<4.4[++]
'Chloride/nitrogen ratios between 5-to-1 and 7.6-to-1. "Chloride/nitrogen rations exceeding 7.7.6-to-1		

Table 2

Activated Carbon Peroxide numbers

Activated Carbon	CAP* Number (minutes)
Catalytically Enhanced Bituminous Coal-Bassed	8
Conventional Bituminous Coal-Bassed	40
Sub bituminous Coal-Bassed	40
Lignite Coal-Bassed	80
Wood-Bassed	>120
Coconut-Bassed	>120
*Catalytic Activity Peroxide.	

Monochloramine removal

Traditionally activated carbon has been used for chloramines removal.

Al activated carbons have some catalytic functionality and act as a catalyst to decompose monochloramine. The following two parallel reactions are believed to be the paths of decomposition:

(1) $NH_2Cl + H_2O + C^* \rightarrow NH_3 + H^+ +$

$Cl + CO'$

(2) $2NH_2Cl + CO^* \text{-} N_2 + 2H^+ + 2Cl + H_20 + C$

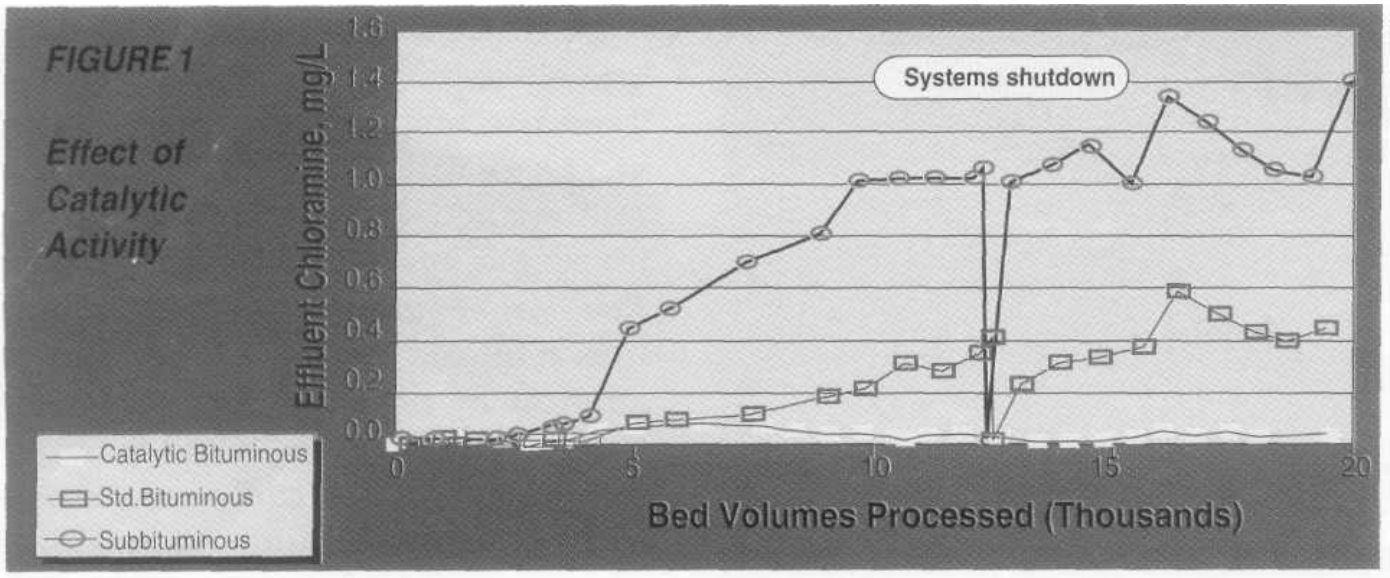
In the decomposition of monochloramine, the first reaction predominates when the system begins operation. In doing so, the carbon surface (C*) reacts with monochloramine to reduce the monochloramine to ammonia and oxidize the carbon surface to form surface oxygen groups (CO*). It is these CO* groups that can mask the catalytic activity of an activated carbon. Fortunately, as the number of surface oxygen groups increases, the second reaction begins. If a sufficient number of original catalytic sites are not present, however, the second reaction does not take place with enough frequency to regenerate the sites, leaving the carbon "spent."

Catalytically enhanced carbon

Catalytic carbon is developed through an advanced process, starting as a bituminous coal-based granular activated carbon (GAC). By altering the electron structure, the GAC offers enhanced catalytic capability enabling it to cause chemical reactions to proceed without changing its own basic structure. With more catalytic sites available for electron transfer, it also promotes a wide range of chemical reactions where conventional carbons are not effective.

To varying degrees, the existence of catalytic properties in activated carbon has been widely reported.[2] The fundamental significance of catalytic carbon is that its catalytic activity can not only be controlled, it can also be significantly enhanced during manufacturing—without the use of chemical impregnates. By modifying the electronic properties of the carbon surface, the manufacturing process results in 10-to-l 00 times greater catalytic functionality as compared to standard activated carbons.

The catalytic activity of a carbon can be measured by the rate at which a carbon decomposes hydrogen per oxide (H_2O_2). Carbons with more catalytic sites show higher catalytic activity and decompose hydrogen peroxide at a faster rate. Table 2 compares the catalytic activity "Peroxide Number" for several



types of activated carbon. The number given is the time in minutes required to decompose a fixed amount of peroxide. As shown in Table 2, catalytically enhanced bituminous coal-based carbon requires a fifth of the time of conventional bituminous coal-based carbons, 1 /10th the time of lignite-based carbons and less than 1 /15th the time of wood-and coconut-based carbons.

The effect of the increased catalytic activity on chloramines destruction is dramatic.

Actual test results in Figure 1 show the chloramines breakthrough for three carbons in a two-minute empty bed contact time (EBCT) reactor system. EBCT is the volume of the carbon divided by the volumetric flow rate. Although Figure 1 only illustrates the results up to 20,000 bed volumes, the system actually continued through five months of operation, treating 88,000 bed volumes without ever exceeding a 0.1-mg/L-treatment objective. It was then shut down.

System design considerations

As with any activated carbon system, proper system design is required to achieve the full benefits of a catalytic carbon system. Activated carbon particle size, EBCT and temperature of the influent stream all affect the performance of catalytically enhanced carbons in removing monochloramine.

A decrease in particle size will improve the rate and extent of monochloramine removal, although the effect is not as dramatic as that which is experienced in standard dechlorinating applications. Reducing the mesh size from 20 x 50 to 30 x 70 increases the bed volumes treated from 11,000 to 28,000 (at 30 seconds EBCT and 2 mg/L influent monochloramine concentration).

Increased contact times can dramatically improve the performance of the system. Increasing the EBCT from 10-to-30 seconds allowed 11,000 bed volumes to be treated as compared to 250 bed volumes (both systems utilized a 20 x 50 mesh catalytic carbon and 2 mg/L influent monochloramine concentration). A combination of reduced particle size and increased contact time can be used to give even more dramatic performance increases.

Because the destruction of monochloramine is a catalytic reaction, in creasing the temperature of the water speeds up the reaction and extends the life of the carbon. Raising the temperature of the water from 14°C to 22°C increases the bed volumes treated from 1,500 to 4,000 (at 30 seconds EBCT and 5 mg/L influent monochloramine concentration).

Conclusion

The development of catalytically enhanced carbon offers exciting, new opportunities for water dealers contending with chloramines. Replacing traditional activated carbon with catalytic carbon significantly improves the performance of water treatment systems, while at the same time increasing the volume of water that can be treated before experiencing chloramines breakthrough. Catalytic carbon makes it possible to use smaller systems that provide enhanced performance at less cost. For effective drinking water treatment, catalytic carbon offers dealers a much-needed alternative.□

References

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