The Issue of pH Adjustment in Acid-Washed Carbons

By Francis J. DeSilva

Summary: *Though its popularity as a water treatment alternative is increasing, activated carbon can have a substantial effect on pH. These "spikes" in pH become even more pronounced in various high-purity applications. Pre-wetted carbons, however, answer many of those concerns in a sufficient manner.*

Activated carbon is one of the most commonly used media for water and wastewater treatment. It's multifunctional in use and has been considered a "scavenger medium" for its ability to dechlorinate and remove organics, color, taste and odor. Dechlorination is important prior to ion exchange and reverse osmosis systems to prevent oxidation of the resin or membranes.

An important function of activated carbon when used in dialysis systems is the removal of chlorine and chloramines to prevent hemolysis, which is the rupturing of blood cells in dialysis patients. In this application, the carbon must also exhibit a near-neutral effluent pH and be free of impurities such as metals that can be present in the ash content of the carbon.

Spikes and implications

Any activated carbon that is not acid-washed usually produces an initial effluent with a pH greater than 7. The actual rise in pH depends on several factors such as the ash content of the starting material, total dissolved solids (TDS) of the influent water, and pH of the influent water. The observed effluent pH can be much higher than 7, new carbon can have an initial pH of 9.5 to 10.5, with a TDS of about 1,000 parts per million (ppm). The increased pH will dissipate as the soluble ash is rinsed out of the media during use and the effluent pH will eventually approach neutral. This elevated pH effect, however, can last for up to 150-to-300 bed volumes.

The pH excursions or spikes that occur during activated carbon treatment can elevate the pH to levels that are not acceptable for potable water or downstream treatment devices. A high pH causes a bad taste that's often described as "metallic." You can sometimes tell by taste when you reach a neutral pH.

The pH spikes are aggravated by influent water that has a low or a high (non-neutral) pH. It was once believed a rise in pH was only a function of inorganic ions being leached out of the carbon. Now, we know that it's also due to adsorption of chlorides, sulfates, nitrates and bicarbonates onto the carbon from the influent water.

Other carbons

Nutshell carbons generally have very low soluble ash (sodium and / or potassium carbonates) that rinse off very quickly. Five-to-10 bed volumes of rinse water may be adequate to bring the pH from 9 or 10 to near 7, although these carbons may also exhibit buffering properties that increase rinse times required to achieve neutral pH. Use of nutshell carbons is no guarantee it still won't take a lot of time to reach neutral pH, considering most units operate under a low flow rate.

Chemically treated, wood-based carbons sometimes have residual phosphoric acid (low pH) unless they're neutralized. They can also be neutralized "in situ" or onsite by rinsing with copious quantities of water. Rinse volume requirements vary with the TDS and ionic makeup variations of water.

Surface oxides are culprits

Proper control of the activation step of carbon manufacture can produce either of two forms of carbon. They've been classified as "H-type" and "L-type" carbons in *Activated Carbon: Surface Chemistry and Adsorption from Solution*.

The "H-type" carbon is produced when high activation temperatures are used, greater than 750°C, and the carbon is exposed to steam or carbon dioxide (CO_2), followed by exposure to air at room temperature. This is the type produced by most manufacturers. These carbons are hydrophobic and take on a positive charge by absorbing hydrogen (H+) ions when immersed in water. The normal effluent pH from "H-type" carbon is slightly elevated because most of the surface oxides present are basic in nature.

The "L-type" carbon is produced at lower activation temperatures, 200-to-400°C and the carbon is exposed to air during the activation. The resultant carbon is hydrophilic. It absorbs hydroxyl (OH-) ions when immersed in water. The normal effluent pH from "L-type" carbon is acidic because most of the surface oxides that are formed on the carbon are acidic.

Wetting the carbon

Most activated carbon is hydrophobic and can be difficult to "wet." To hydrate the carbon, it's often necessary to soak new carbon in the vessel overnight. After 24 hours of soaking, carbon is still only 90 percent wetted. Warmer water wets the carbon faster than cooler water. The initial backwash to rid the material of fines can take up to several hours. Lastly, if the effluent pH of the activated carbon unit is "off-spec," more time is needed to rinse to an acceptable level.

It can be difficult to wet carbon with entrapped air in the particles. Some of the carbon will actually float. One method to deal with this is to subject the carbon to an initial "downflow" rinse during the soaking period, then proceed with the initial backwash to remove fines.

Even an acid-washed carbon can take 2-to-4 hours to rinse to a neutral pH. This rinse is relatively short compared to standard grades. Carbon that's not acid-washed or a carbon that has been reactivated can sometimes take up to two to three days of rinsing to reach a neutral pH.

Time, rinse requirements

An important factor to consider in field installations is the time, labor, and rinse water demands of an activated carbon system. It can take between 100-to-300 bed volumes of water to rinse a carbon before the pH drops to an acceptable range. This equates to 750-to-2,250 gallons of water per cubic foot of carbon. This can translate to 12-to-38 hours to rinse to acceptable quality at a rinse flow rate of 1 gallon per minute per cubic foot (1.0 gpm / cu. ft. or ft^3). That can be an unacceptable length of time or amount of wasted water for your customer. What customer can tolerate a rinsing of his system for that long?

What complicates matters these days is the trend toward use of chloramines for disinfection of city waters. Monochloramine is the most effective disinfectant form of chloramine and it's necessary to maintain a pH of about 8 to keep the chloramines in the monochloramine form.

Organics removal

Removal of organics by activated carbon is more effective at pH levels less than 7. It has also been observed that organics are more effectively removed by activated carbon in the presence of hardness ions in the water. An activated carbon material that starts out with a very high pH may not be effective at organics removal, until the pH rinses to a lower level for two reasons—the primary effect of the high pH itself and the potential for precipitation of hardness in the bed.

There are several methods of dealing with the rise in pH. The first option is to ignore the rise in pH if it has no effect on downstream processes or is acceptable for discharge or ultimate use. Unfortunately, this isn't a viable option in most cases. Another method of dealing with the rise in pH is recycling of high pH water to a point upstream and continuing the rinse or keep rinsing to drain if that's permissible. Adding acid downstream of the activated carbon can also drop the pH back to acceptable levels. However, adding acid to the water isn't an advisable option when dealing with a system that's producing water for dialysis, pharmaceutical or other high purity uses where "added substances" are prohibited. Nor is it recommended for home use.

The ideal option is to use a media that has been pretreated to diminish the potential for pH spikes when the activated carbon is put into service.

FYI—Questions to ask about special tests

You should ask your carbon suppliers if they perform the following special tests on their media:

- pH (in tap water)
- Conductivity (in DI water and tap water)
- Color Throw (in DI water and tap water)
- Percentage of Floating Carbon (will give you an indication of ease of wettability)
- Acid-Soluble Metallic Impurities (indicates effectiveness of acid wash)

In addition to standard tests, which include:

Apparent density: Weight of the media in pounds per cubic foot or grams per cubic centimeter.

Screen size: U.S. standard mesh size of the material, usually stated in a range. For example, in a 12-to-40 mesh, most of the material will pass through a 12-mesh screen but retained on a 40-mesh screen.

Iodine number: Amount of iodine in milligrams adsorbed from a 0.02 N iodine solution by one gram of carbon. Gives an approximation of the surface area and an indication of ability to remove low molecular weight organics.

Molasses number: An optical measurement of the degree of the removal of color from a stock solution by an activated carbon. Gives an indication of the ability to remove large molecular weight organics such as tannins and lignins.

Processed carbon products

Several activated carbon manufacturers can supply special grades of specially treated activated carbon that minimize the pH spikes upon startup. These special grades of carbon have usually been acid-washed and then treated to adjust the pH to a desired range, and / or preoxidized so that the raw water anions will have a minimal effect on effluent pH. They can be shipped in a pre-moistened condition so they're "pre-wetted" in addition to pH adjusted. Using a moist pre-wetted carbon eliminates most of the dust problems associated with changing out activated carbon.

Conclusion

A pre-moistened activated carbon that's pre-treated to minimize pH spikes upon startup also makes for a much cleaner vessel loading scenario—no dust nuisance. Adjacent equipment, walls and ceilings, and personnel will not be covered with airborne carbon dust. Time and savings can be substantial:

- A quick, clean vessel loading operation;
- No soak period required;
- Only a brief initial backwash step to get rid of the fines generated during shipment, and
- No significant pH rise.

Plus, system performance will be much more reliable, particularly for dialysis, pharmaceutical or other high-purity uses. q

References

1. Clark, R.M., and B.W. Lykins, *Granular Activated Carbon*, Lewis Publishers, Chelsea, Mich., 1991.
2. Cooney, D.O., *Adsorption Design for Wastewater Treatment*, Lewis Publishers, Boca Raton, Fla., 1999.
3. Mattson, J.S., and H.B. Mark Jr., "Activated Carbon: Surface Chemistry and Adsorption from Solution," Marcel Dekker, New York, 1971.
4. McGowan, Wes, *Residential Water Processing*, Water Quality Association, Lisle, Ill., 1997.
5. Shuliger, Wayne, "The Blame Game," *Industrial Wastewater*, January / February 2001.
6. Specification sheet, ResinTech AGC-MG, ResinTech Inc., Cherry Hill, N.J., March, 1999.
7. Specification sheet, Calgon REACT pH, Calgon Carbon Corp., Pittsburgh, Pa., 1994.
8. Specification sheet, Envirotrol NoRise, Envirotrol Inc., Conyers, Ga., 2000.
9. Specification sheet, Pica USA GX300, Rev. 2, PICA USA, Columbus, Ohio, June 1998.

About the author

S *Frank DeSilva is national sales manager for ResinTech Inc., of Cherry Hill, N.J. ResinTech is a manufacturer and supplier of ion exchange resin, activated carbon products and the Aries line of laboratory demineralizers and cartridges. DeSilva operates out of Jensen Beach, Fla. He can be reached at (561) 225-0763, (561) 334-1099 (fax) or email: fdesilva@resintech.com*