Application Bulletin

How to Craft a Better Brew

Activated Carbon Applications in Brewing

The brewing and enjoyment of malted beverages can be traced back to ancient Egypt and to the time of the pyramids. In this respect, brewing and activated carbon share a history of beneficial coexistence. Brewing has in modern times developed into as much a science as an art, and activated carbon still plays a vital role in many aspects in the brewing process. Incoming water treatment for the removal of trihalomethanes (THMs), tastes, odors, chlorine, chloramine, pH and alkalinity control; process treatment of tannin and de-colorization of "clear" beers; vapor treatment of carbon dioxide (CO_2), SO_2 and odor control from wort kettle steam, and fumigant emission control, are all applications for which activated carbon can be effectively used. To understand how carbon performs in these applications, the fundamentals of carbon adsorption will first be explained. Then, a synopsis of the above listed carbon applications in a brewery and how carbon is used is presented, followed by a summary chart identifying the typical carbon used for each application.

How Activated Carbon Works

Activated carbon is similar to crude graphite, the material used in pencils. Activated carbon, diamonds and graphite are forms of carbon and contain almost no nitrogen, hydrogen, halogens, sulfur or oxygen. From a chemist's perspective, activated carbon is an imperfect form of graphite. This imperfect structure results in a high degree of porosity and more than a million-fold range of pore sizes, from visible cracks and crevices to gaps and voids of molecular dimensions. Porosity is what distinguished activated carbon and makes it "activated".

Intermolecular attractions in the smallest pores result in adsorption forces. Carbon adsorption forces are analogous to gravity, but operate on a molecular, not astronomical, scale. They cause a reaction similar to precipitation, where adsorbates are removed from solution or vapor stream. To develop a strong adsorption force, the distance between the carbon platelets and adsorbate must be decreased by decreasing its pore size, or the number of carbon atoms in the structure must be increased by increasing the density of the carbon. Chemical reactions and chemical bonding can also occur between the adsorbing molecules and the carbon surface or its inorganic ash impurities. This is referred to as chemical adsorption or chemisorption. However, physical adsorption is what activated carbon does best. Physical adsorption removes taste and odor causing organic compounds, volatile organic compounds (VOCs), trihalomethanes (THMs) and other halocarbons from process water and vapor streams.

Water Treatment

Taste, Odor and Chlorine Removal: The characteristics of brewing water have a great influence on the character of the beer. Even when the incoming process water is from a municipal drinking water source, the water may contain residual tastes, odors, disinfection by-products, and free and combined chlorine. Molecules with carbon-sulfur bonds often smell and taste bad, but these are often preferentially adsorbed on carbon. The same is true of molecules with aromatic rings. Carbon's de-chlorinating capability results from its ability to act as a reducing agent that reacts with strong oxidizing agents such as hypochlorous acid or chlorine dioxide. Activated carbon such as Filtrasorb 200, which meets the Food Chemicals Codex testing protocols, is an effective treatment to assure water that is contaminant, taste and odor free.

Chloramine: The chlorination of drinking water can also result in the formation of chloramine by-products in water. These compounds exist in water in three forms: monochloramine (NH_2Cl, at pH>7), dichloramine ($NHCl_2$, at pH 4.4-7) or trichloramine (NCl_3, at pH <4.4). Because of the pH range, monochloramine is the most common. Until now, this compound has been the most difficult to remove using activated carbon. However, Calgon Carbon's new CENTAUR® carbon, has catalytic properties as well as adsorption properties, which makes CENTAUR more effective in monochloramine removal than standard activated carbons. Now the removal of all types of chloramine is feasible and cost effective.

Trihalomethanes (THMs): THMs and halocarbons are among a special group of VOCs. The more chlorine substituted on a molecule, the more strongly it is adsorbed on carbon, so carbon-chlorine or carbon-

bromine compounds are better adsorbed than carbon-hydrogen compounds.THMs and halocarbons vary from weakly- to strongly- adsorbing. Carbon requirements can, therefore, vary according to the concentration of common THM and halocarbon contaminants and the type of carbon used. Calgon Carbon manufactures special Filtrasorb products using a unique coal base, creating a fine pore structure targeted toward the adsorption of THMs and halocarbons.

pH and Alkalinity Control: Other aspects of brewing water which can affect the character of the finished beer are pH and alkalinity. To assure the stability of the carbon treated water, Calgon Carbon has two lines of Filtrasorb products: Filtrasorb pH for control of PH rise alone; or Filtrasorb pHA for the control of pH and alkalinity rise. The mechanism responsible for the pH excursion is an interaction between the anions present in the water (SO_4, Cl, NO_3, etc.), the hydroxide ion (OH), the hydronium ion (H_3O^+), and the surface groups of the activated carbon. The magnitude and duration of the pH and alkalinity excursions depend upon the type of carbon and the characteristics of the water to be treated, especially the water pH. Calgon Carbon's two lines of pH patented products overcome these effects while allowing the benefits of carbon adsorption to be realized.

Process Applications

Tannin Treatment: The treatment of tannic acid for flavor and odor removal is a process application in brewing where carbon adsorption is used. Since the tannic acid is treated at a low pH, Calgon Carbon recommends an acid washed carbon for this application.

De-colorization of "Clear" Beers: Carbon is also used to remove color from malts for use in clear beers and other flavored malt beverages. Several granular and powdered products can be used for this type of application. Generally, granular carbons such as CAL are more efficient than powdered carbons, and avoid disposal issues. However, where powdered products are needed for batch processing, Calgon Carbon has several types available.

Vapor Phase Applications

Carbon Dioxide (CO_2) Recovery: During the fermentation process, sugars are converted to alcohol and carbon dioxide is liberated by the action of the yeast. The use of this CO_2 to supplement the natural carbonation of the beer is prevented due to contamination with odorous hydrocarbons. However, this off-gas can be treated with activated carbon and recovered, reducing or eliminating the need to purchase outside supply.

Wort Kettle Steam: Another vapor source where odorous compounds may create an environmental problem for the brewery is from the wort boiling kettles. During wort boiling evaporation is used to remove undesired volatile compounds, such as dimethyl sulfide. However, just as the brew master does not desire these compounds in the final product, regulators and brew house neighbors do not want these compounds in the air. Carbon can effectively remove odorous compounds from this stream, keeping regulators and neighbors happy.

Fumigant Emission Control: Phosphine fumigation is utilized to protect grains, hops and barleys from infestation and damage by insects. Because it is listed under the Clean Air Act as a hazardous air pollutant, many companies are evaluating abatement technologies. Calgon Carbon's phosphine abatement technology has been proven to accomplish such a task. Calgon Carbon's Centaur carbon can be utilized to remove the phosphine that is generated in railcars and storage silos. The Centaur carbon converts the phosphine into strongly adsorbed phosphorous compounds and prevents air pollution. In addition to the Centaur carbon, Calgon Carbon can provide systems and services for fumigant emission control.

What Carbon to Use

The following chart identifies the type of carbon typically used for each of the brewery applications discussed above. (1)

Application

Carbon Type	Taste & Odor: Chlorine	Chloramine	Trihalomethanes	pH	pH & Alkalinity	Tannin	Dechlorinization	Carbon Dioxide	Wort Kettle Steam	Fumigant Emmision Control
Filtrasorb 200	●									
Centaur HSL		●								
Filtrasorb 200-AB			●							
Filtrasorb pH				●						
Filtrasorb pHA					●					
CPG						●				
BL							●			
BPL 4X10								●		
Centaur 4X6									●	●

(1) Carbons can be applied in more than one application. The chart merely highlights the carbon typically used for the given application. Consult you Calgon Carbon Technical Sales Representative to determine the best carbon to meet your specific requirements.

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