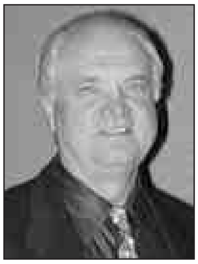


Frank Altmayer, MSF, AESF Fellow
AESF Foundation Technical Education Director
Scientific Control Labs, Inc.
3158 Kolin Ave., Chicago, IL 60623-4889
E-mail: faltmayer@sclweb.com

That Lump of Coal - Part 4

Dear Advice & Counsel,
My company has asked me to look into recycling our treated wastewater back to our plating lines. While I think I have a handle on the basics, like TDS reduction using ion exchange, I'm not sure I know enough about organics removal using carbon. Can you shed some light on this topic?

Signed,
Fusili Carbonera

Over the summer, I have offered this series on carbon treatment of wastewater. Continuing our discussion:

Powder versus granular

Powdered activated carbon (PAC)

Powdered activated carbon is made up of crushed or ground carbon particles. ASTM defines PAC as particles corresponding to an 80-mesh sieve (0.177 mm) and smaller. PAC is difficult to use in pressurized systems, as the material compacts and creates significant "head-loss," requiring larger, more sophisticated liquid handling systems. It can be added to a pre-coat on a vacuum rotary filter or on a filter press to partially treat wastewater.

Powdered activated carbon is most suitable for batch treatment of wastewater. In such applications, a "batch" of wastewater is mixed with PAC for 30 to 60 minutes. Equipment required is very basic: a tank, a mixer and pumping system. The carbon is typically added manually, but can be pumped as a water slurry.

PAC systems handle a carbon that is more prone to producing dust, and dusts can be a safety issue (dust explosion).

A PAC system can more readily be adjusted to remove only a portion or selectively remove organics from a given wastewater, by adjusting the dosage of virgin/regenerated carbon to the system.

An important factor in powdered carbon products is the ability of the powder to allow for easy and rapid filtration (in continuous filtration systems) and settling (during a batch treatment). Filterability and settleability are related to particle size, distribution, shape, wetting ability and density. The raw material used and manufacturing techniques employed will determine whether a given carbon filters and settles well.

Granulated activated carbon (GAC)

Granular activated carbon is typically made of particles that are larger than those passing a 50-mesh sieve (0.297 mm). For most wastewater treatment applications in metal finishing, flow rates, concentrations and the chemical characteristics of the raw water can change throughout the operational day. While PAC systems have been developed to deal with such conditions, a GAC system typically does a better job of compensating for such variations.

Granular carbon may also produce some dust, the amount depending upon particle size to some degree. If or when preparing a carbon slurry, the powder or granules should be added to the water as fast as the material can be wetted. Use of a closed slurry tank that has a ventilation/dust collection system minimizes fugitive carbon dust emissions.

Granulated activated carbon has a relatively large particle size compared to powdered activated carbon and consequently, presents a smaller external surface and much less head-loss under pressurized conditions. Due to over-all performance benefits, GAC is the preferred media in water treatment.

GAC is designated by sizes such as 8 × 20, 20 × 40 or 8 × 30 for liquid phase applications. Downflow systems typically employ 8 × 30 mesh coarse granular carbon. This mesh may also be employed when the wastewater contains a significant amount of suspended solids, when the flow rate is high, or if high percentage reduction of organics is not critical. 12 × 40 mesh is recommended in upflow systems, when flow rates are low, in the absence of suspended solids or when a high efficiency of organic removal is required. A 20 × 40 carbon is made of particles that will pass through a U.S. Standard Mesh Size No. 20 sieve (0.84 mm) (generally specified as 85% passing) but be retained on a U.S. Standard Mesh Size No. 40 sieve (0.42 mm) (generally specified as 95% retained). AWWA (1992) B604 uses the 50-mesh sieve (0.297 mm) as the minimum GAC size. The most popular granular carbon types used in wastewater applications are the 12 × 40 and 8 × 30 sizes because they have a good balance of size, surface area and head-loss characteristics.

Other carbon products

Porous carbons impregnated with various ions such as iodine, silver, aluminum, manganese, zinc, iron, lithium and calcium have been employed in ambient air pollution control applications such as museums and galleries. Silver-loaded activated carbon may be employed as an adsorbent for purifications of domestic water (the silver ions act as a biocide). Impregnated carbons have also been used for the adsorption of inorganic and organic sulfide bearing compounds to improve taste. Activated carbon is also available in the form of filter cartridges, cloths and fibers.

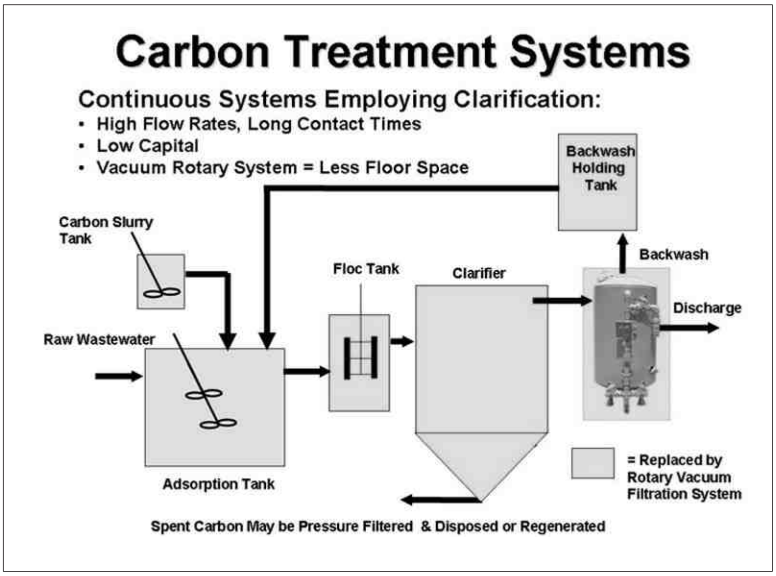
The condition of the wastewater to be carbon-treated

The raw water routed to a carbon treatment system needs to be consistent in pollutant concentration and flow. Suspended solids should be less than 20 mg/L. Other water pollutants that can affect the performance of the system include any compound that increases BOD5, organics such as methylene blue active substances, phenol and dissolved oxygen.

The backwash on a carbon treatment system should not be considered as a license to route inadequately cleaned water into the system. Filtration prior to carbon adsorption is highly recommended. Undesirable "live" organisms may grow in the humid conditions within the carbon column, creating a slime that can foul the granules of carbon. While some recommend adding biocides, UV destruction has been successfully employed prior to entry into the carbon column(s).

To reduce fouling of the carbon, oil and grease in the raw water needs to be below 30 mg/L, preferably much lower.

According to Chein-Ho Huang,[*] the ionic strength (conductivity) of the water to be carbon treated plays a major role in the efficiency of adsorption. He postulated that increased conductivity increased flocculation and charge shielding of an organic pollutant in solution and, consequently, resulted in higher adsorption levels. Huang found that addition of strong acid cationic ion exchange resin to the water to be treated significantly improved the adsorption efficiency of carbon on rinsewater from nickel plating processes.



Carbon filtration

Carbon treatment may be accomplished using batch or continuous equipment. Equipment designs may employ either granular or powdered carbon, but powdered carbon is mostly used in batch systems while granular carbon can be found in either type of system.

Batch powdered carbon treatment systems

A typical batch carbon treatment tank may include heating coils to adjust temperature, a mixing system such as a prop mixer or air agitation spider and a slurry mixing tank for adding the carbon to the water and mixing it up prior to addition to the main treatment tank. A filter is required to separate the carbon from the treated water, along with a storage tank for holding the treated water for recycling, further treatment or testing prior to discharge.

The contact time between the carbon and the wastewater to be treated may vary from any laboratory bench tests, as mixing is generally better in small vessels versus very large ones. Typical contact times are on the order of 30 to 60 minutes.

Filters

There are several types of filters that can be employed in batch carbon treatment systems. With any of these, the carbon quickly becomes the filtration media, as the carbon particles lodge in the virgin pores of the filter media. During the initial use of the filter, the filtrate will contain fine carbon particles. Some systems utilize a recycle loop to return the cloudy filtrate back to the treatment tank until the filtrate is very clear. For example, a precoated vacuum type filter can deliver a clear effluent from the start. Choice of filter depends on the maximum flow rate required, the solids holding capacity, cost of operation and capital cost. Typical flow rates for batch type filters are 30-40 gal/ft^2/hr.

Precoat filters

Blinding of the media by fine particles and cloudy filtrate can be avoided by using a "pre-coat" on the filter. A popular choice for such conditions is a rotary vacuum filter, which can be used on a batch or continuous basis.

Continuous carbon treatment systems

A continuous carbon treatment system, as shown in the figure would be employed when flow rates are very high, required contact times are relatively high and the equipment budget is relatively low. The flow rates for such systems are typically 0.4 to 2.0 gpm/ft^2 of clarifier settling area. The carbon withdrawn from the bottom of the clarifier is typically disposed as is, but may be pressure filtered to reduce hauling fees and make the carbon more readily regenerated.

An alternate continuous system would employ a vacuum rotary filter to take the place of the floc tank, clarifier and multimedia filter (It would not need the backwash tank either.). Floor space would be lower, but equipment cost may be higher. Carbon usage in any of these systems can not be predicted by isotherms and laboratory simulation. *P&SF*

---

* C-H. Huang, "Effective Removal of Organics from Nickel Wastewater by Modified Carbon Adsorption", *Plating & Surface Finishing,* **79** (4), 50 (1992).

Test Your Plating I.Q. #445

By Dr. James H. Lindsay

Alloy Plating

1. Normally, increasing the current density in an alloy plating bath tends to increase the percentage of the more noble metal in the alloy deposit. True or false?

2. The effect of current density on alloy composition is liable to be greater in _____________ primary salt solutions than in _____________ primary salt solutions.

3. Increasing solution agitation tends to increase the percentage of the more noble metal in the alloy deposit. True or false?

4. Confining the question to binary alloys, what factor has the most influence in determining alloy composition in the deposit?

5. What is essential for plating an alloy on an irregularly-shaped workpiece?

Answers on page 15.