CALGON CARBON CORPORATION

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Filtration and Separation

Catalysis boosts activity of adsorptive carbon

Lower volume needed, environmental benefits accrue

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Activated carbon has been used in the chemical industry for many years as an adsorbent for purification, concentration and separation.

Surface area and pore structure have always been the prime considerations for effectiveness but, recently, a new development in the manufacture and use of the product has emerged.

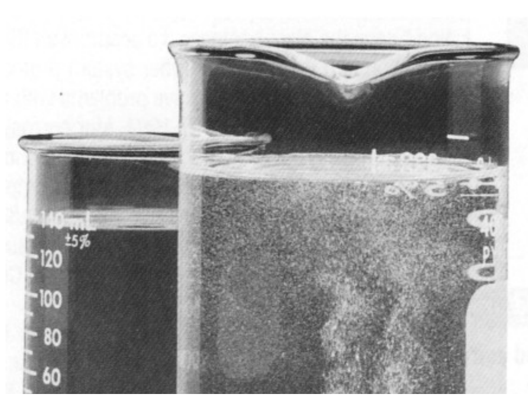
A new catalytic adsorptive carbon enhances the catalytic properties by one or two orders of magnitude, allowing it to bring new efficiencies to a number of chemical industry processes.

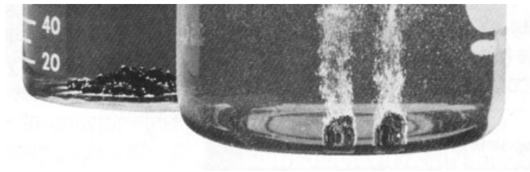
Adsorption/catalytic action

Activated carbon is already well associated with adsorption - a physical process in which molecules adhere to the internal surface. Catalytic carbon retains the adsorptive characteristics of conventional activated carbons, but combines them with the ability to catalyze chemical reactions. The dual action concentrates reactants by adsorption and then promotes their reaction on pore surfaces.

Among benefits of catalytic carbon are that it:

- Promotes fast reactions, resulting in smaller adsorption equipment and less carbon on line;
- Eliminates or minimizes need for chemical additions;
- Works well at low reactant concentrations;
- Is recyclable, and can be regenerated in place or removed, thermally reactivated and reused.
- Can replace metal- and alkali-impregnated carbons in oxidation/reduction reactions.





Enhanced decomposition of hydrogen peroxide is demonstrated by catalytic activated carbon in the front beaker; conventional activated carbon in the rear beaker reacts more slowly.

Development history

The first challenge in the development of catalytic activated carbon, which began 10 years ago, was to establish a method to measure catalytic activity.

From this work, a test called "Peroxide Number (PN)" evolved. The procedure measures the rate (in minutes) at which carbon decomposes hydrogen peroxide, thus providing an index of the carbon's catalytic activity in a variety of applications. The lower the PN, the greater the ability to accelerate a chemical reaction.

Catalytic carbons normally produce a PN of less than 14 min, about 1/4 that of conventional bituminous coal-based activated carbons, and less than 1/10 that of most coconut-shell or wood-based products (see Table 1).

Table 1. Peroxide number of activated carbons	
Type	**Typical peroxide No.**
Catalytic	˚˚ 10
Bituminous	˚˚ 40
Coconut shell	˚ 120
Wood-based	>120

Catalytic reactions occur in the following three-step process.

Step 1: Adsorption.

- Reactants are transported to active sites within carbon structure;
- Adsorption takes place at catalytic sites.

Step 2: Catalysis

- Chemical reaction occurs on carbon surface;
- Reaction products are formed.

Step 3: Site restoration.

- Desorption of the reaction product;
- Removal of retained products;
- Catalytic sites are restored.

Impregnated carbons

Although catalytic carbon performs similarly to chemical- and metal-impregnated carbons, it contains no impregnants. This eliminates some potential problems such as toxicity, thermal instability, difficulty of regeneration and disposal limitations.

Catalytic˚ carbon offers an improved trace organic removal capacity that reduces carbon usage and increases capacity per unit volume of carbon. It delivers consistent results while handling a wide variety of inlet concentrations.

Catalytic sites are an inherent feature of the catalytic activated carbon surface, making chemical or metal impregnants unnecessary to impart the increased activity required for a number of applications.

The ignition temperature of many impregnated carbons is low, often about 225^{o}C.

The ignition temperature of catalytic carbon, on the other hand, approximates that of unimpregnated carbons (typically 350-400^{o}C).

Impregnated carbons lose some of their adsorptive capacity because of the volume occupied by the impregnant. Because catalytic carbon does not rely on an impregnant for its catalytic activity, the full adsorptive capacity of the carbon is available.

The absense of an impregnant avoids the disposal problems sometimes encountered with metal-impregnated carbons. Also, caustic-impregnated carbons require a potentially hazardous caustic wash during regeneration. With catalytic carbon, a water wash or thermal regeneration will restore the adsorptive capacity in some applications.

An additional feature of catalytic carbon is a generous adsorptive pore volume that can retain a number of non-reactive organic compounds.

This generous pore volume also contributes to catalytic carbon's ability to tolerate wide fluctuations in inlet concentrations from both an adsorptive and catalytic standpoint.

Ending control room corrosion

Corrosion control units (CCU) are installed throughout a southern paper mill in rooms containing computers, circuit breakers, process controllers and other electric and electronic equipment.

The mill monitors environmental corrosion levels to protect the sensitive equipment from corrosive hydrogen sulfide (H_2S). Chlorine used in bleaching paper products further aggravates the problem.

Corrosion test racks containing copper and silver coupons are used to measure levels of the corrosive contaminants. Coupons are collected every 30-90 days and analyzed to determine thickness of surface corrosion films, providing a measure of the air's corrosivity over the time of exposure. Coupon data can be used to estimate projected corrosion (Table2).

Table 2. Coupon film thickness and projected corrosion.

Class	Film thickness, ?	Projected corrosion
I	0-400	Very low
II	401-1,200	Mild (max acceptable)
III	1,201-6,000	Moderate (improvement required)
IV	> 6,000	Severe (control losses within 6 months)

To reduce corrosion, H_2S and Cl_2 are removed from the air by passing it through a purification system containing activated carbon or aluminum oxide that has been impregnated with caustic, permanganate or a proprietary chemical agent.

"We currently monitor 55 rooms containing more than 120 air purification and re-circulation units," says the plant engineer. "It would cost around $ 150,000 to change media in all those systems, so we are comparison shoppers when it comes to activated carbon."

The search for the most cost-effective adsorbent led the mil to evaluate catalytic activated carbon. "As a user, I know the only true test of a product is in a live application," says the plant engineer. To accomplish this, the mill installed 4x6 mesh catalytic carbon in a deep-bed scrubber system protecting the brown stock washer control room, which was known to have problems with higher than standard H_2S levels.

In a year-long trial in 1993-1994, four corrosion tests of catalytic carbon were conducted in a three-pass scrubber serving the control toom. Catalytic carbon was loaded into the first pass, the second pass was left empty and the third was loaded with conventional activated carbon. The mill elected to use the conventional carbon in the third pass as a safeguard against breakthrough because it had no previous experience with catalytic carbon. Corrosion coupon results are shown in Table 3.

Table 3. Corrosion coupon tests in catalytic activated carbon protected control room

Test	Location	Extrapolated film thickness, ?	Class	Degree of corrosion
1	Scrubber inlet	˚8,681	IV	Severe
1	Empty 2nd pass	˚˚ 278	I	Very low
2	Scrubber inlet	38,391	IV	Severe
2	Empty 2nd pass	˚˚˚ 230	I	Very low
3	Scrubber inlet	˚4,856	III	Moderate
3	Empty 2nd pass	˚˚ 115	I	Very low
4	Scrubber inlet	˚8,428	IV	Severe
4	Empty 2nd pass	˚˚ 230	I	Very low

The catalytic carbon performed well for the 12 months it was in service, cleaning Class IV air at the scrubber inlet to Class I with a single pass. H_2S levels were reduced to non-detectable values.

"We were very satisfied with the catalytic carbon," the plant engineer says. "It proved effective in removing large amounts of H_2S from the air in the control room"

"It’s not a question of ability," notes a maintenance engineer. "Virgin activated carbons can and do produce the same end results if operated in multiple-pass adsorbers. The big difference is that catalytic carbon, like chemically impregnated carbon, does the job in one pass."

Catalytic carbon can be regenerated at the mill by water washing, producing a dilute acid stream that can be easily neutralized or slowly blended into the waste treatment plant. Because it contains no impregnants, spent catalytic adsorptive carbon can also be regenerated by thermal reactivation.

Applications

Catalytic carbon promotes a range of chemical reactions, including:

- Oxidation/reduction for hydrogen sulfide removal, sulfur dioxide, nitrogen oxide and phosphine abatement;
- Decomposition reactions for peroxide destruction, chloramine removal and hydrazine decomposition.
- Centaur“ catalytic activated carbons - Calgon Carbon Corp., Pittsburgh, PA.

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