USFilter

Three Midas odor control towers at a wastewater treatment plant in Las Virgenes, Calif.

VOCS AND NOx: BETTER CONTROL & LOWER COSTS

New techniques for measuring and eliminating VOCs and NOx cut the costs of environmental compliance

USFilter

Though it looks much like any other activated carbon, Midas from USFilter has a powerful ability to oxidize H_2S, thanks to the incorporation of magnesium oxide

USFilter's Midas odor-control activated carbon is the filling for this adsorption tower in Columbus, Ohio

Of the many different types of air pollution, two—volatile organic compounds (VOCs) and nitrogen oxides (NOx)—are found almost everywhere in the chemical process industries. VOCs will continue to be an issue for as long as organic solvents are used, though solvents are by no means the only source of VOC emissions. NOx, on the other hand, is mainly associated with combustion equipment such as boilers, furnaces and process heaters. Though these problems are nothing new, some innovative methods of measuring and eliminating pollutants have recently appeared.

The commonest techniques for removing VOCs from gas streams are condensation, oxidation and adsorption. Condensation is generally appropriate only at high VOC concentrations, because of the low temperatures required as partial pressures fall. Oxidation, either over a catalyst (catalytic oxidation) or in a direct flame (thermal oxidation) has low capital costs but can be wasteful and expensive to run. Adsorption, typically on activated carbon, is capital-intensive, but a new development promises to make adsorption competitive even on small plants.

Cutting costs for VOCS

A monolithic form of activated carbon developed by MAST Carbon Ltd. (Guildford, U.K.) and the University of Bath (Bath, U.K.) offers low pressure drop and favorable economics thanks to short regeneration times, which in turn allow the use of much smaller bed volumes than for conventional forms of activated carbon. And because the regeneration uses electric resistance heating instead of steam, the recovered VOCs are dry and so are easy to re-use without further treatment (*CE*, August 2003, pp. 15, 16).

"With low capital and operating costs, and no need for steam, the technology should be attractive to small operations such as dry-cleaning firms and printers, as well as larger companies that already use activated carbon to recover VOCs," says Dr. Edwin Crezee of MAST Carbon. "We are now carrying out trials at two pharmaceutical companies in the U.K. and we plan to have a fully commercial product by early 2006."

The monolithic material developed by MAST Carbon, known as Novacarb, is made from phenolic resin that is milled and sintered before being carbonized. No binder is used, and the result is a very pure carbon containing a large number of macroscopic pores whose size can be closely controlled within the size range 2–20 μm. Within these macropores are micropores with a mean pore size of around 0.8 nm.

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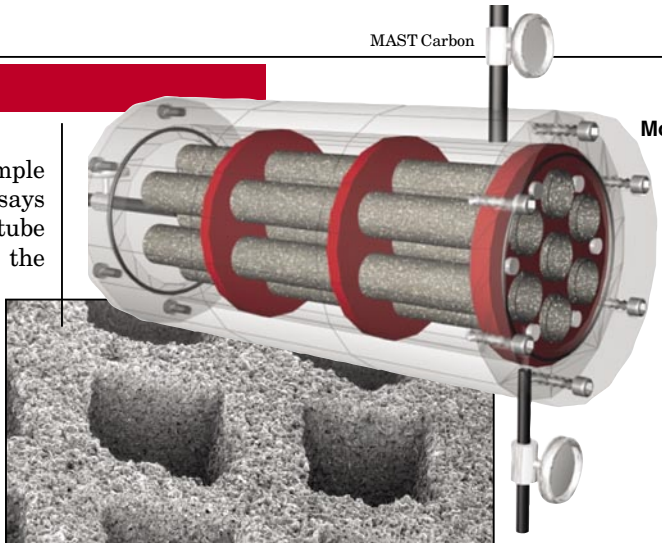

Monolithic forms of activated carbon developed by MAST Carbon combine high specific surface area with low pressure drop, and can be rapidly regenerated using electric resistance heating. In this arrangement, carbon monoliths bearing tubular channels are assembled into a device resembling a shell-and-tube heat exchanger

A microscopic view of Novacarb shows the macroporous structure of the channel walls. The macropores, in turn, carry micropores less than 1 nm in diameter

The sintering process can yield simple granules, but more commonly, says Crezee, it is used to create multi-tube monolithic structures similar to the ceramic supports used for automotive exhaust catalysts.

The tubular channels are typically 1 mm in diameter, with a wall thickness of 0.5–1 mm. "Wall thickness is a compromise," says Crezee. "Thinner walls mean shorter distances for diffusion, but thicker walls give you more carbon." The microporous nature of the structure gives a very high surface area, he says, while the straight channels ensure that pressure drops are much lower than for packed beds. As a result, Novacarb avoids the need for extra blowers or compressors, and makes it easier to position adsorbers close to the points at which VOCs are produced.

Thanks to the intrinsic electrical conductivity of carbon, the monolithic structure can be regenerated at temperatures of 150–200°C by passing an electric current through it. Because it heats the entire mass of carbon directly, resistance heating can regenerate the adsorber in around 30 minutes, compared to the 8 hours or so typically needed for regeneration with steam.

Regeneration time generally dictates the volume of an activated-carbon adsorber, says Crezee. The rapid regeneration of Novacarb means that the bed size can be around one-sixteenth of that needed for an equivalent adsorber based on granular carbon, and energy use around one-tenth. Both the capital and operating costs are correspondingly smaller. Although this will be appreciated by all users of activated carbon adsorbers, he believes it will be particularly useful for small companies that are being caught by new emissions legislation for the first time.

As well as avoiding the need for a boiler, regeneration without steam eliminates problems caused by condensate. Keeping the adsorber dry increases adsorption capacity and does away with a bed-drying step, while the fact that recovered VOCs are not contaminated with water can allow them to be directly re-used in the process. "That can provide a payback right from the start compared to conventional activated carbon systems and also thermal oxidizers," says Crezee.

Controlling H_2S

Another innovative form of activated carbon, developed by USFilter Westates Carbon (Irvine, Calif.), shows excellent performance in removing hydrogen sulfide (H_2S) and other malodorous compounds from air. According to Technical Director James R. Graham, the patented pelletized material, known as Midas OCM, incorporates oxides of magnesium, calcium and barium to catalyze the oxidation of contaminants.

Where other odor-removal adsorbents oxidize H_2S to sulfuric acid, says Graham, Midas converts most of the H_2S directly to elemental sulfur. The relatively small size of sulfur atoms compared to H_2SO_4 molecules helps to give the material a high sulfur capacity. "We can typically achieve a capacity of 30 lb of sulfur and 30 lb of VOCs per 100 lb of carbon, and in some cases more than 100 lb of total contaminants per 100 lb of carbon," says Graham. "The VOCs tend to load up first, but as the sulfur is formed it pushes the VOCs deeper into the bed."

The metal oxides are distributed uniformly through the raw material (bituminous coal) before extrusion and final carbonization, says Graham. The result is a material whose capacity for H_2S is three to six times that of other odor-control media. Midas was developed for odor control in wastewater treatment, but has many other potential applications, he adds. Most inlet H_2S concentrations will be in the range 1–25 ppm, but Midas can easily handle both average and spike concentrations of hundreds of ppm. The high capacity means that in most cases the fully-loaded material will be sent for disposal rather than regenerated.

H_2S removal is above 99%, and the material also copes well with mercaptans and other malodorous compounds, VOCs and carbon dioxide. The relative absence of sulfuric acid means that the pH of the spent carbon remains above 4, so the material can be treated as non-hazardous waste and there are no problems with acidic wash water, as can be the case with conventional activated carbon. Midas is safe to handle and use, with no alkali impregnation and good fire resistance, and its pelletized form keeps pressure drops low.

Keeping down the NOx

Alzeta Corporation (Santa Clara and Sacramento, Calif.) faces some of the world's tightest environmental standards in its home area, but its ultra-low-NOx gas burners comfortably meet even the most stringent Californian legislation.

"NOx limits range from 9 ppm to 30 ppm depending on the municipality," says Andy Minden, Vice President, Business Development with Alzeta. "Our burners can achieve 5–7 ppm, and as a result, they have a 100% record of compliance with the 9 ppm limit. Some of our competitors' burners are not so consistent in their performance."

The keys to the low NOx levels achieved by Alzeta's burners are good pre-mixing of the gas and air, followed by combustion on the outer surface of a cylindrical burner tube made from ce-

ramic or metal fiber. Pre-mixing keeps emissions of hydrocarbons and carbon monoxide low, while surface-stabilized combustion ensures reliable operation of the ultra-lean mixtures required to keep within stringent NOx limits.

The company's CSB and other burners for boilers and process heaters cover the input range 2–130 million BTU/h, using natural gas, LPG or digester methane from wastewater treatment as fuel. Flue gas recirculation is avoided, says Minden, because it can cause corrosion problems, especially when burning digester methane containing sulfur compounds.

Alzeta's sales of large low-NOx burners are taking off along the U.S. Gulf coast and elsewhere as emission regulations tighten, says Minden. The company also has technology licensing partnerships, for example with Power Flame Inc. (Parsons, Kan.), a leading manufacturer of burners for utility boilers, and BOC Edwards (Crawley, U.K.) for the supply of EDGE low-NOx thermal oxidation systems to treat waste gases in the electronics and other industries.

PureAire Monitoring Systems

The Air Check √EX is a selective, rapid-response way to measure benzene concentrations over the range 0–300 ppm in hazardous areas

Modeling and measuring

Good control of air pollution, of course, requires accurate measurements, and sometimes modeling too. Trinity Consultants (Dallas, Tex.) has released Version 5.0 of its Breeze Aermod/ISC air quality modeling software, used to estimate pollutant concentrations at ground level. The new version helps users visualize their model results more effectively in relation to the surrounding terrain, with features such as the ability to "drape" maps or aerial photos over relief surfaces. The software incorporates the Aermod model, proposed by the U.S. Environmental Protection Agency (EPA) as the standard for future regulatory applications, as well as the current ISC model.

An economical monitoring system that detects parts-per-million concentrations of benzene is now available from PureAire Monitoring Systems, Inc. (Lake Zurich, Ill.). Designed for use in Class I, Division 1, Group B, C and D hazardous areas, the Air Check √EX Benzene Monitor has a response time of less than 30 seconds and is unaffected by humidity or other environmental conditions. A renewable electrochemical sensor and long-life pyrolyzer provide reliable and highly-specific benzene measurement in the range 0–300 ppm, with low operating costs.

GrayWolf Sensing Solutions (Trumbull, Conn.) has launched the DirectSense TVOC system, which uses a 10.6 eV photoionization detector (PID) to measure total VOCs in the ppb and ppm ranges. The system uses a PDA to record measured data, field notes and photographs. It includes relative humidity and temperature sensors as standard, and can also accommodate up to three electrochemical sensors for specific gases.

Similar functionality in a robust and compact package is provided by the Sirius multi-gas detector from Mine Safety Appliances Co. (MSA; Pittsburgh, Penn.) The Sirius includes a PID detector, for VOCs with low vapor pressures, and up to four single-gas sensors. Visible and audible alarms make the unit especially suitable for emergency use and confined spaces.

GrayWolf Sensing Solutions

The DirectSense TVOC system uses a photo-ionization detector (PID) to measure total VOCs

For out-of-the-way locations, remote sensors can be valuable tools to track and reduce emissions. A prime example is pressure relief valves, says Cliff Lewis, Vice President of Accutech (Hudson, Mass.), a company that is accumulating considerable experience in wireless instrumentation. Relief valves are designed to vent process gases or vapors to the atmosphere, but quantifying releases is difficult when relief valves are hard to reach and poorly instrumented. Accutech's wireless technology allows instrumentation such as valve position switches and ultrasound flow monitors to be added to relief valves at reasonable cost. Knowledge of valve opening times, upstream pressures, fluid properties and valve characteristics then allows discharge quantities to be calculated, sometimes to an accuracy of ±1%, says Lewis. ■

Charles Butcher

SOURCES FOR AIR POLLUTION SOLUTIONS

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Alzeta Corp.	edlinks.che.com/4819-562
GrayWolf Sensing Solutions	edlinks.che.com/4819-563
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MSA Instrument Div.	edlinks.che.com/4819-565
Omega Engineering, Inc.	edlinks.che.com/4819-566
PureAire Monitoring Systems, Inc.	edlinks.che.com/4819-567
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University of Bath	edlinks.che.com/4819-569
USFilter Westates Carbon	edlinks.che.com/4819-570

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