

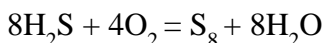
## **Midas OCM versus Water Regenerable Carbons – What are the Facts?**

### **What is Midas OCM?**

Midas OCM is a Siemens proprietary odor control carbon that is manufactured from a selected grade of bituminous coal. Before the bituminous coal is converted to an activated carbon, the active ingredients are added so that are uniformly dispersed and thus become a part of the activated carbon itself. These active ingredients become an integral part of the carbon's matrix and therefore don't decrease its overall pore volume. Midas OCM is **not impregnated** and removes H<sub>2</sub>S from an air stream by **catalytically** oxidizing the H<sub>2</sub>S to elemental sulfur. Being catalysts, the active ingredients in Midas OCM are not consumed during the oxidation of H<sub>2</sub>S.

Most odor control carbons remove H<sub>2</sub>S from a gas stream by converting the H<sub>2</sub>S to either sulfuric acid (i.e. Water Regenerable Carbons) or a mixture of sulfur and sulfuric acid (i.e. both impregnated and non-impregnated carbons). What makes Midas OCM unique is a way has been found to manufacture a carbon matrix that selectively converts H<sub>2</sub>S to elemental sulfur. In that the molecular size of the sulfur atom is less than 1/3 the molecular size of the sulfuric acid molecule, this discovery means it is possible in the same pore volume to store 3.5 times more sulfur molecules than you could store sulfuric acid molecules. Compared with odor control carbons having the same pore volume, this selectivity to sulfur gives Midas OCM at least 3.5 times the H<sub>2</sub>S breakthrough capacity.

Midas OCM by not being impregnated has an exceptionally high total pore volume and surface area, giving it a high capacity for the adsorption of VOCs. The following equation summarizes the H<sub>2</sub>S oxidation reaction that is catalyzed by Midas OCM:

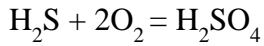


### **What are Water Regenerable Carbons?**

Water Regenerable Carbons are proprietary products manufactured from coal. Based on information disclosed in issued patents, apparently during the last stages of the activation process where the coal char is converted to an activated carbon, a nitrogen containing gas (such as ammonia, urea, etc.) is introduced into the activation furnace. This nitrogen containing gas reacts at high temperatures with the carbon surface leaving nitrogen containing functional groups dispersed on its surface. These functional groups are responsible for giving Water Regenerable Carbons their catalytic properties. In order for the concentration of these surface functional groups to be maximized, complete activation of the coal does not take place and the resulting

carbon's pore structure is not fully developed. This under activation results in a product that has a lower overall pore volume and surface area and a significantly higher density when compared to Midas OCM and non-impregnated coal based carbons. This lower surface area of Water Regenerable Carbons gives them a lower capacity for the adsorption of VOCs that may be present in the gas stream being treated. Water

Regenerable Carbons remove H<sub>2</sub>S from a gas stream by almost exclusively oxidizing the H<sub>2</sub>S to sulfuric acid. Under most conditions, little or no sulfur is formed. The overall chemistry is summarized by the following equation:



Because Water Regenerable Carbons converts the H<sub>2</sub>S to the larger sulfuric acid molecule, they have a more limited H<sub>2</sub>S capacity in that the oxidation process stops when the available pore structure is filled. When tested in accordance to ASTM test procedure D-6646, it has a breakthrough capacity of only 0.09 gH<sub>2</sub>S/ccC. Once Water Regenerable Carbons reach their maximum H<sub>2</sub>S capacity, they need to be water washed in order to restore some of that capacity.

The restoration of the H<sub>2</sub>S capacity of Water Regenerable Carbons through water washing is problematic at best. The following are issues that affect its water washability:

- When used in an air stream containing only moderate (<50 ppmv) to low concentrations of H<sub>2</sub>S, Water Regenerable Carbons essentially produces only sulfuric acid that can theoretically be washed from the carbon's pore structure using water. The washing process is slow due to the slow rate at which the sulfuric acid molecules diffuse from the carbon's micropore structure and if not continued for sufficient time, residual sulfuric acid will remain decreasing the subsequent capacity of the carbon.
- At moderate (>50 ppmv) and higher H<sub>2</sub>S concentrations, the selectivity of Water Regenerable Carbons for producing only sulfuric acid changes and significant amounts of elemental sulfur begin to form. This sulfur is insoluble in water and stays in the carbon's pore structure after water washing, significantly decreasing its subsequent capacity for H<sub>2</sub>S.
- The presence of VOCs (volatile organic compounds) in the stream being treated will be adsorbed in the pore structure of the odor control carbon and compete for space that is needed to store the products resulting from the oxidation of H<sub>2</sub>S. This competition for pore space will shorten the adsorption cycle and increase the need for water washing. Most of these VOCs however are insoluble in water and are not readily removed by water washing. They can remain in the pore structure, greatly decreasing the capacity of the water washed carbon in the next adsorption cycle.
- Water Regenerable Carbons rely on the catalytic activity of the nitrogen containing functional groups on their surface for high activity and their ability to convert H<sub>2</sub>S to H<sub>2</sub>SO<sub>4</sub>. These sites are sensitive to being lost through physical blockage by the presence of adsorbed VOCs. These adsorbed VOCs often aren't removed by water washing. The active sites can also be irreversibly poisoned by the presence of reduced sulfur compounds such as organic sulfides and ringed sulfur compounds. This poisoning process can slowly deteriorate the performance of the Water Regenerable Carbons and make subsequent washing cycles less successful.

## **What is Required for Odor Control Carbons to Work Successfully?**

All odor control carbons, be it Midas OCM, Water Regenerable Carbons, impregnated carbons or virgin carbons, to one degree or another catalytically oxidize  $H_2S$  to either elemental sulfur and/or sulfuric acid. In order for these odor control carbons to work successfully in this oxidation process, in addition to the reduced sulfur compound two other components must be present. These are oxygen (typically >0.5 vol.%) and moisture (water vapor). A number of researchers have conclusively shown (for example Bagreev and Bandosz,  $H_2S$  Adsorption/Oxidation on Unmodified Activated Carbons: Importance of Prehumidification, Carbon 39 (2001, pgs. 2303 – 2311.) that water plays an essential role in the  $H_2S$  oxidation reaction and is required to be present independent of what reaction products are formed. In that this oxidation process involves chemical reactions whose rates are controlled by such things as temperature and reactant concentrations, sufficient contact time must be built into the system to allow these reactions to go to completion. With this in mind, many odor control systems are therefore designed to operate at a superficial velocity of about 60 fpm.

## **How Are Odor Control Carbons Evaluated?**

A test method that allows the comparison of different odor control carbons under the same conditions is described in detail in the ASTM standard test method D-6646. This test method calls for a humidified air stream (85% RH) containing 1.0 vol.%  $H_2S$  to be passed through a specified column of the odor control carbon at a specified flow rate until an  $H_2S$  breakthrough concentration of 50 ppmv is reached. The results from this test are expressed in  $gH_2S/ccC$ . The gas flow rate and column size are selected based on the mean particle diameter of the odor control carbon being tested. Most testing is done using a 1-inch diameter by 9-inches long column at a flow rate of 1450 cc/min. However when testing larger particles as the 4 mm Midas OCM, a larger tube diameter and higher gas flow rates are recommended.

The test procedure recommends the odor control carbons be tested as received (not dried) or if they are non-impregnated virgin carbons like Midas OCM that they should be humidified with the 85% air only for several hours prior to starting the test. This humidification allows the carbon to come into equilibrium with the moisture in the air stream and allows more consistent results to be obtained.

When tested in a manner as described in ASTM test method D-6646, Midas OCM has a breakthrough capacity that ranges from a low of 0.26 to a high of 0.34  $gH_2S/ccC$ . This breakthrough capacity is approximately 3.5 times the capacity measured for Water Regenerable Carbons of 0.09  $gH_2S/ccC$ .

## **How Does the Presence of Volatile Organics Affect the Performance of Midas OCM?**

Midas OCM possesses a fully developed pore structure and therefore has a surface area and pore volume that is similar to other high quality gas phase carbons. In that Midas isn't impregnated, all of its surface area and pore volume are available for the adsorption of VOCs and the storage of elemental sulfur resulting from the oxidation of  $H_2S$ . Based on field studies, Midas has been found to be capable of adsorbing between 50 and 100% of its weight in volatile matter. This volatile matter is comprised of both elemental sulfur and adsorbed VOCs. During initial use, Midas will load sulfur and VOCs in the quantities they are present in the gas stream. As Midas reaches the point at which it is saturated with VOCs, the elemental sulfur forming in the carbon's pore structure will tend to push the VOCs deeper into the bed where they are re-adsorbed. Therefore the presence of high levels of VOCs in the stream being treated will reduce the capacity of Midas for  $H_2S$  but by a degree significantly less than that experienced by Water Regenerable Carbons being used in the same situation.

## **What Hazards Are Associated With the Production of Sulfuric Acid?**

When  $H_2S$  is controlled using Midas OCM, >92% of the  $H_2S$  is converted to elemental sulfur. Very little of the  $H_2S$  is converted to sulfuric acid. Therefore when Midas OCM is fully spent, it will have either a neutral pH or only be slightly acidic. Midas OCM will be non-hazardous when initially placed in the odor control unit and will be non-hazardous when removed.

Water Regenerable Carbons controls  $H_2S$  by oxidizing it to sulfuric acid. The pH of the Water Regenerable Carbons carbon becomes very acidic, usually dropping to a pH of about 2 before a water washing cycle is initiated. Considerable water washing is required before the pH of the carbon is raised to the point where it is no longer considered hazardous (pH ~4). Some applications where Water Regenerable Carbons have been used have experienced corrosion problems from the sulfuric acid. In these applications, the sulfuric acid appears to be carried out of the bed as an aerosol or mist with the gas stream being treated causing down stream system corrosion.