ENHANCING ACTIVATED CARBON ADSORPTION OF 2-METHYLISOBORNEOL (MIB)

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Introduction

Taste and odor have long been associated with the "safety" of drinking water. Most people today will reject hygienically suitable water simply because it smells or tastes bad. Two primary causes of disagreeable flavors and odors in surface waters are 2-methylisoborneol (MIB) and geosmin. These musty-smelling compounds are produced by microorganisms and are harmless at naturally occurring concentrations. MIB and geosmin have been linked to taste-and-odor episodes around the world, and are therefore a global concern. Consequently, effective treatment technologies for controlling MIB- and geosmin-related tastes and odors have garnered much attention. Numerous studies of treatment techniques for taste-and-odor control have established that activated carbon adsorption is an effective treatment method for removing MIB and geosmin from water.

This research is aimed at evaluating the effects of high-temperature gas treatments on the MIB adsorption capacity of lignite coal-based activated carbons. Experimental carbons were compared based on batch and fixed-bed, mini-column (RSSCT) adsorption tests. In addition, these carbons are being evaluated in terms of their chemical and physical properties, including surface charge, pore size distribution, and elemental composition. The ultimate goal of this work is to establish a protocol for enhancing the MIB adsorption capacity of lignite coal-based activated carbons and to understand the mechanism(s) responsible for the improvement.

Experimental

A commercial, lignite coal-based activated carbon (HD4000) was employed for the majority of experiments herein. High temperature treatments were performed in either a custom-built fluidized-bed furnace or a Cahn thermogravimetric analyzer (TGA). Batch and fixed-bed MIB adsorption studies were conducted using natural water from the Schuylkill River (PA) that had previously undergone chlorination (and dechlorination), coagulation (with ferric chloride), and clarification through Superpulsators™. This water contained a background TOC concentration of 3.7 mg/L. To date, the research herein has utilized ^{14}C-MIB as a surrogate for MIB and geosmin.

Results and Discussion

It was discovered that heat treatments in mixtures of gases could heighten the MIB adsorption capacity of HD4000. Figure 1 illustrates the improved MIB breakthrough profiles observed following multi-gas treatments at moderate (C1) and moderately high (C2) temperatures. After numerous trials of multi-gas treatment at a high temperature, two of the products (C3, C4) outperformed all other carbons tested herein. In mini-column experiments, these two carbons processed 400% as much water as untreated HD4000 before initial MIB breakthrough occurred (Figure 1).

In earlier tests, it was found that heat treatments in a single gas could also enhance MIB uptake by HD4000. High temperature treatment in this gas increased MIB removal under standard batch conditions from 60% to 75% (see sample C5 in Figure 2). Treatment at an even higher temperature increased MIB removal to 95% under these same conditions (see sample C6 in Figure 2). In fixed-bed adsorption experiments, C6 processed 212% as much water as untreated HD4000.

Heat treatments in another gas environment also improved MIB uptake, though not to the extent observed for the above-mentioned multi-gas or single gas treatments. Treatments in this other gas environment increased MIB removal from 60% to 75% under standard batch conditions (see sample C7 in Figure 2). In mini-column tests, C7

processed 184% as much water as untreated HD4000 before initial MIB breakthrough (Figure 3). Treatments at moderately high temperatures (C8, C9) produced roughly the same results (Figure 3).

Preliminary chemical and physical characterizations of the experimental carbons suggest that changes in pore size distribution may be an important feature responsible for the observed improvements in MIB uptake. Changes in adsorption performance may also be linked to the relative quantity and types of surface oxygen groups in these carbons.

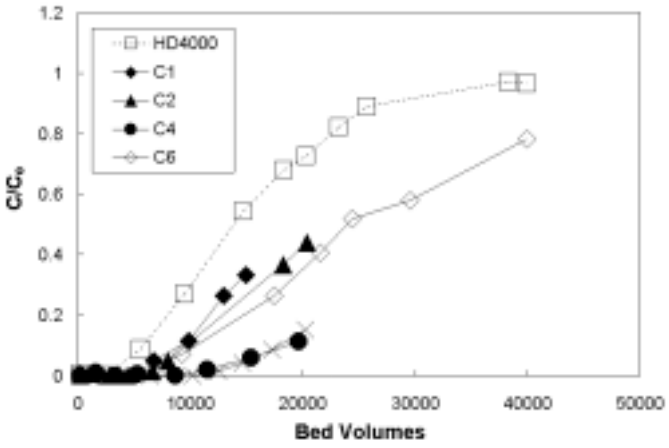

Figure 1. MIB breakthrough profiles (Initial MIB concentration = 135 ng/L; TOC = 3.7 mg/L)

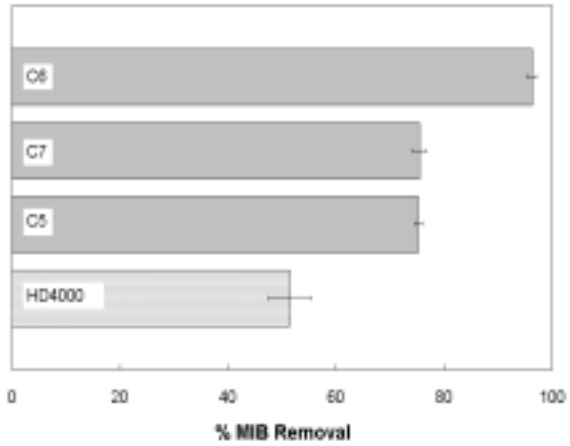

Figure 2. MIB removal in batch adsorption tests (Initial MIB concentration = 135 ng/L; TOC = 3.7 mg/L; 15 mg/L PAC)

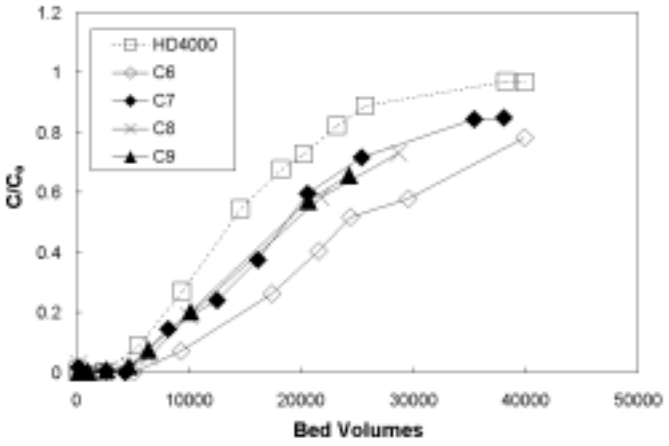

Figure 3. MIB breakthrough profiles (Initial MIB concentration = 135 ng/L; TOC = 3.7 mg/L)