

BEAMLINE X19A**Funding**

New Jersey Department of Environmental Protection

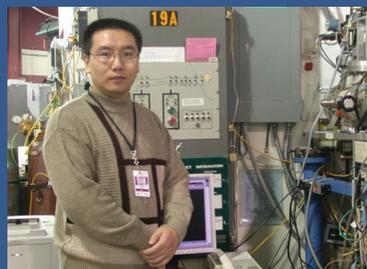
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For More Information

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Arsenic Leachability in Water-Treatment Adsorbents

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At NSLS beamline X19A, we used extended x-ray absorption fine structure (EXAFS) spectroscopy and leaching tests to investigate arsenic (As) leachability in spent water-treatment adsorbents. The EXAFS results indicate that arsenic forms inner-sphere bidentate binuclear surface complexes on the adsorbents, which include granular ferric hydroxide, granular ferric oxide, titanium dioxide, activated alumina, and modified activated alumina. This study improved the understanding of arsenic bonding structures on adsorptive media surfaces and As leaching behavior for different adsorbents.

The U.S. Environmental Protection Agency (EPA) has adopted an arsenic maximum contaminant level (MCL) of 10 $\mu\text{g/L}$, which will be enforceable as of January 23, 2006. This more stringent arsenic drinking water standard requires the installation of new water-treatment systems and the upgrading of existing ones. Filtering arsenic in water using adsorbents is especially suitable for small community systems and individual homes because the filters do not require much effort to operate. Recently, more effective adsorbent media have been developed and used for arsenic removal. As a result of the enhanced removal efficiency, large amounts of spent media with elevated arsenic content will be generated. Accurately determining the leachability of arsenic in this waste is crucial for both economic concerns and the evaluation of environmental impacts.

In this study, EXAFS spectroscopy at NSLS beamline X19A was employed to determine the arsenic local coordination environment of spent adsorbent media. Spent adsorbents were collected from five pilot-scale filters that were tested for their ability to remove arsenic from groundwater in New Jersey. The spent media included granular ferric hydroxide (GFH), granular ferric oxide (GFO), titanium dioxide (TiO_2), activated alumina (AA), and modified activated alumina (MAA).

The As leachability, determined with the Toxicity Characteristic Leaching Procedure (TCLP), was below 180 $\mu\text{g/L}$ for all spent media. The leachate As concentration in the California Waste Extraction Test (WET) was more than 10 times higher than that in the TCLP, and reached as high as 6650 $\mu\text{g/L}$ in the spent GFH sample. The EXAFS analysis shows that the first and strongest peak in the Fourier transform (FT) curve was contributed by four oxygen atoms at an average As-O distance of 1.69 \AA for all five media samples (**Figure 1**). The constant As-O interatomic distance was independent of the media to which the As(V) was adsorbed. The second shell atom (distance) was Fe (3.32 \AA), Fe (3.28 \AA), Ti (3.27 \AA), Al (3.14 \AA), and Al (3.13 \AA) for GFO, GFH, TiO_2 , AA, and MAA, respectively. The EXAFS results show that arsenic formed bidentate binuclear inner-sphere complexes on the surfaces of these five spent adsorbents. This stable structure can be used to explain the high affinity of arsenic for the adsorbent surfaces. The difference in the leachate As concentrations determined with WET and TCLP could be attributed to different acids used in the leaching solutions. An aggressive chelating agent, such as the citric acid used in the WET process, could form soluble complexes with

the adsorbent and release the arsenic. This is especially important for the GFH, which failed in the WET. A moderate organic acid, such as the acetic acid used in the TCLP, could only extract arsenic at a low concentration, less than $180 \mu\text{g L}^{-1}$. However, this kind of organic acid is a relatively stable degradation product of organic matter and is widely available in landfill leachate. Thus, the co-disposal of arsenic containing wastes with municipal solid waste (MSW) may have a potential risk of arsenic re-contamination.

The correlation of the percentage of As leached with the percentage of the adsorbent dissolved for the media is shown in **Figure 2**. The amount of As released was positively related to the amount of adsorbent dissolved in the leachate, which suggests that adsorbent dissolution may be the main mechanism of enhanced As release in the WET.

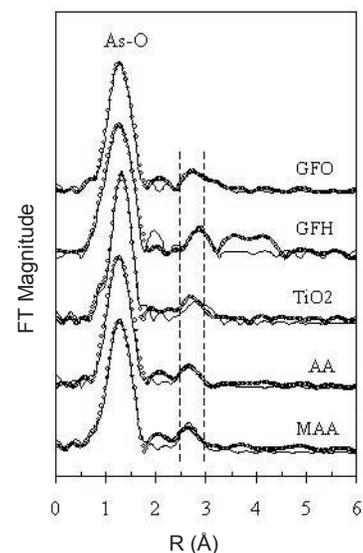


Figure 1. The observed (dotted line) and model calculated (solid line) As K-edge FT EXAFS spectra resulting in a radial distance structure for the spent media. The peak positions are uncorrected for phase shift. Arsenic formed binuclear bidentate surface complexes on the media surface.

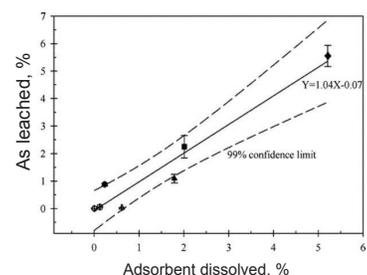


Figure 2. Correlation of percentage As leached and adsorbent dissolution in GFH (\blacklozenge , \blacklozenge), GFO (\bullet , \circ), AA (\blacksquare , \square), and MAA (\blacktriangle , \triangle) for the WET (close) and TCLP (open), respectively. The solid line is the regression and the dashed lines are 99% confidence limits.