

Laboratory Study on the Oxidation of Arsenic III to Arsenic V

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Foreword

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E. Timothy Oppelt, Director
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Abstract

A one-year laboratory study was performed to determine the ability of seven oxidants to oxidize As(III) to As(V). These included chlorine, permanganate, ozone, chlorine dioxide, monochloramine, a solid-phase oxidizing media, and 254 nm ultraviolet light.

Chlorine and permanganate rapidly oxidized As(III) to As(V) in the pH range of 6.3 to 8.3. Dissolved manganese, dissolved iron, sulfide and TOC slowed the rate of oxidation slightly, but essentially complete oxidation was obtained in less than one minute with chlorine and permanganate under all conditions studied.

In the absence of interfering reductants, ozone rapidly oxidized As(III). Although, dissolved manganese and dissolved iron had no significant effect on As(III) oxidation, the presence of sulfide considerably slowed the oxidation reaction. The presence of TOC had a quenching effect on As(III) oxidation by ozone, producing incomplete oxidation at the higher TOC concentration studied.

Only limited As(III) oxidation was obtained using chlorine dioxide, which was probably due to the presence of chlorine (as a by-product) in the chlorine dioxide stock solutions. The reason for the ineffectiveness of chlorine dioxide was not studied.

Preformed monochloramine was ineffective for As(III) oxidation, whereas limited oxidation was obtained when monochloramine was formed in-situ. This showed that the injected chlorine probably reacted with As(III) before being quenched by ammonia to form monochloramine.

Filox, a manganese dioxide-based media, was effective for As(III) oxidation. When dissolved oxygen (DO) was not limiting, complete oxidation was observed under all conditions studied. However, when DO was reduced, incomplete oxidation was obtained in the presence of interfering reductants. The adverse effect of interfering reductants was completely eliminated by either (a) supplying enough DO or (b) increasing the contact time. In addition to oxidizing As(III), the Filox media also removed some arsenic by adsorption, which diminished greatly as the media came into equilibrium with the As(III)-spiked synthetic water.

UV light alone (254 nm) was not very effective for As(III) oxidation. Significant oxidation was observed only at very low flow rates representing 0.6 - 2.5% of the rated capacities of the two UV sterilizer units tested. However, as reported in a patented process, complete oxidation by UV light was observed when the challenge water was spiked with 1.0 mg/L sulfite.

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Abbreviations and Acronyms

AWWA	American Water Works Association
DO	Dissolved Oxygen, mg/L
DPD	N,N-diethyl-p-phenylenediamine
EBCT	Empty Bed Contact Time (media volume/flow rate), min
EPA	US Environmental Protection Agency
FIAS	Flow Injection Analysis Hydride Generation System
GFAAS	Graphite Furnace Atomic Absorption Spectrophotometer
GPM	Gallons/min
HDPE	High Density Polyethylene
IR	Interfering Reductant
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
NPT	Nominal Pipe Thread
NRMRL	National Risk Management Research Laboratory
PAO	Phenyl Arsenic Oxide
PRV	Pressure Relief Valve
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
SDWA	Safe Drinking Water Act
SM	Standard Methods
SR	Stoichiometric Ratio, μg oxidant/ μg reductant
TOC	Total Organic Carbon
UH	University of Houston
UV	Ultraviolet
WAL	Work Assignment Leader
WAM	Work Assignment Manager

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