TIO_2-PHOTOCATALYZED ARSENIC(III) OXIDATION AND ITS APPLICABILITY TO WATER TREATMENT

Thesis by

Megan Alameda Ferguson

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ABSTRACT

Ingestion of arsenic (As) in drinking water can lead to several chronic illnesses, including bladder, lung, and skin cancers. Due to natural weathering reactions, As is present in many drinking water sources throughout the United States and other countries. The U.S. drinking water standard has recently been revised from 50 μg L^{-1} to 10 μg L^{-1}, thus requiring thousands of water distribution facilities to implement new As removal procedures. However, most As removal technologies treat As(V) much more effectively than As(III), so a pre-oxidation step is recommended for source waters containing As(III) at significant concentrations. The photocatalyzed oxidation of As(III) on titanium dioxide (TiO_2) has been critically evaluated as a potential technology to achieve pre-oxidation.

Batch slurry studies showed that sorption of both As(III) and As(V) to TiO_2 occurs rapidly. Changes in As(III) concentration adsorbed to the TiO_2 surface, whether resulting from varying dissolved As(III) concentration or from the presence of competitive adsorbates, affected the rate of photooxidation. A transition from first-order to zero-order reaction kinetics was observed as the TiO_2 surface became saturated with As(III). Experiments targeting the reaction mechanism (which used hydroxyl radical quenchers, an alternate electron acceptor, and superoxide dismutase) suggested that superoxide plays a major role as an oxidizing agent in this system.

As(III) was rapidly photooxidized in a fixed-bed, flow-through reactor. Catalyst poisoning or severe mass transport limitations were not observed for the conditions studied, although complete As(III) oxidation could not be achieved due to constraints of

reactor geometry. With synthetic groundwater solutions, the reaction appeared to be inhibited by the presence of competitive adsorbates. Use of natural sunlight resulted in more rapid As(III) oxidation than that observed with irradiation from the 365 nm lamp used for other experiments.

As arsenic detection methods improve, reporting levels and perhaps regulatory standards will be lowered, requiring more distribution systems to consider technologies for As treatment. In contrast to methods of pre-oxidation currently in use, TiO_2 photocatalysis involves no hazardous chemicals and generates no toxic reaction byproducts. Based on these findings, TiO_2-photocatalyzed As(III) oxidation could be a viable pre-oxidation technology for certain small water distribution facilities.