**TITLE:** **SYNTHESIS OF SULFUR-BASED WATER TREATMENT AGENT FROM SULFUR DIOXIDE WASTE STREAM**

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## ABSTRACT

OBJECTIVE

We propose the synthesis of polymeric ferric sulfate (PFS) from sulfur dioxide. Polymeric ferric sulfate is a flocculating agent that has been widely adopted for water treatment in some parts of the world because of public health concerns about aluminum-based flocculating agents. Several medical studies implicate aluminum as an agent in the development of Alzheimer's disease. The prospect for addressing both air pollution and water pollution problems in the United States through the synthesis and application of PFS is an exciting one. However, several issues must be resolved before this technology becomes a reality. Specific research objectives include:

- Optimize *synthesis* of polymeric ferric sulfate from the sulfur dioxide by-product of coal-based power systems. As part of this objective, a reaction mechanism for PFS synthesis will be developed.
- Improve *characterization* of polymeric ferric sulfate product. Quality indices currently used to characterize PFS synthesis will be related to the structure of these inorganic polymers. The role of product drying will be related to the amorphous structure of PFS and its ultimate flocculation performance.
- Optimize *application* of polymeric ferric sulfate to different kinds of drinking water and wastewater. The market for PFS would be greatly expanded if its efficacy in removing heavy metals could be explicitly demonstrated.

ACCOMPLISHMENTS TO DATE

Absorption of sulfur dioxide from a mixed gas stream was investigated by sparging it into a stirred reactor of volume 4 $dm^3$ containing a solution of ferrous sulfate with sodium chlorate added as an oxidant. The reaction product was a solution containing approximately 50 wt-% polymeric ferric sulfate (PFS). The reaction took place near atmospheric pressure and at temperatures of 30-80°C. $SO_2$ removal efficiencies greater than 90% were achieved, with ferrous iron in the product at concentrations less than 0.1%. Other PFS quality parameters were also monitored, including total iron content, basicity, and pH. A factorial analysis of the effect of temperature, oxidant dosage, $SO_2$ concentration, and gas flow rate on $SO_2$ removal

efficiency was carried out, and a statistical analysis has been conducted. The PFS product was used in pilot-scale tests at a municipal water treatment facility, and gave good results in the removal of turbidity and superior results in the removal of organic materials when compared with equal doses of ferric chloride.

The corrosion behavior of two coagulants used in water treatment, ferric chloride (FC) and polymeric ferric sulfate (PFS) has been conducted. Corrosion tests were performed to compare the corrosiveness of these two coagulants on aluminum 6061 and steel 4140 specimens. Results showed that both temperature and concentration of the coagulants substantially impact corrosion rates. The corrosion rates increased with the increase of temperature and concentration. The results from scanning electron microscopy (SEM) showed that chloride caused more serious pitting than sulfate anion on both aluminum and steel specimens. Although SEM confirmed the existence of pitting corrosion, the results of weight loss indicated that uniform corrosion predominates the corrosion mechanism, and pitting corrosion played a less important role. The test proved that PFS was less corrosive than FC, which makes attractive large-scale application of PFS in wastewater treatment.

## SIGNIFICANCE TO COAL RESEARCH PROGRAMS

The U.S. Department of Energy's Vision 21 is a plan to deploy high efficiency, ultra-clean integrated energy plants in the twenty-first century. These systems will produce concentrated streams of byproduct $SO_2$. Economic utilization of these byproduct streams is one of the goals of the DOE.

This research uses $SO_2$ to product an inorganic polymer, which can be used in drinking water and wastewater treatment. Integration of polymer synthesis with air pollution from an electric power plant would be an important step toward realizing a coal refinery, a concept in which every waste stream becomes a feedstock for another process.

## PLANS FOR THE COMING YEAR

Evaluate the performance of PFS in wastewater treatment.

## JOURNAL ARTICLES


1. Maohong Fan, Robert C Brown, Shih Wu Sung and Yahui Zhuang, A Process for Synthesizing Polymeric Ferric Sulfate Using Sulfur Dioxide from Coal Combustion", *International Journal of Environment and Pollution.* **17**(1/2)*,* 102-109, 2002.

2. Maohong Fan, Shih-Wu Sung, Robert C. Brown, Thomas D. Wheelock and Fran C. Laabs, Synthesis, Characterization and Coagulation Performance of Polymeric Ferric Sulfate, *Journal of Environmental Engineering*. **128**(6) 483-490, 2002

3. Maohong Fan, Robert C. Brown, Shihwu Sung, C. P. Huang, Say K Ong, and J(Hans) Van Leeuwen, (2003). Comparison of polymeric and conventional coagulants in arsenic (V) removal, *Water Environment Research,* 75(4), (308-313).

4. Yonghui Shi, Maohong Fan and Robert. C. Brown, Comparison of Corrosivity of Polymeric Sulfate Ferric and Ferric Chloride as Coagulants in Water Treatment, *Chemical Engineering and Processing,* (submitted).

5. Aron D. Butler, Maohong Fan, Robert. C. Brown, Hans. Van. Leeuwen, Shihwu. Sung, and Barbara Duff, Pilot scale water treatment study of poly ferric sulfate synthesized using $SO_2$, *Journal of Environmental Engineering*, (submitted).

6. Aron D. Butler, Maohong Fan, Robert. C. Brown, Hans. VAN. Leeuwen and Shihwu. Sung, (2002). Factorial analysis of producing polymeric ferric sulfate from $SO_2$, (in preparation).