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# Removal of elemental mercury from Bayer stack gases using sulfur-impregnated activated carbons

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## HIGHLIGHTS

- Vapor mixtures were tested for adsorption by carbon and sulfur-impregnated carbons.
- Equilibrium Hg adsorption complements column adsorption analyses.
- Adsorbents tested met or exceeded supplier's specifications.
- VOC addition to Hg vapor had negligible effect adsorbent Hg capacity or efficiency.
- Rapid VOC breakthrough in packed beds indicated weak interaction with sulfur.

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## ABSTRACT

The Bayer refining process can generate flue gases that contain elemental mercury, volatile organic carbons (VOCs) and water vapor creating a unique and challenging environment for the development of mercury adsorption technologies. Three sulfur impregnated activated carbons (SIACs) were tested under a range of conditions to assess each as a potential candidate for use in pilot scale fixed bed adsorber trials.

All materials tested met or exceeded the mercury loading capacities specified by the respective suppliers and were therefore not significantly impeded by the addition of toluene into the gas phase. Of the SIACs, Pica/Alcoa Selexorb HG showed the lowest affinity to adsorption of organic vapors (toluene) and the highest affinity to the adsorption of mercury vapors (over a wide range of operating temperatures). Alcoa/Pica Selexorb HG is the preferable sulfur impregnated carbon for the removal of mercury vapors and is recommended for use in pilot trials.



## 1. Introduction

Mercury emission from various industrial sources is a global problem. The total global mercury emissions from all sources is estimated between 4400 and 7500 tons [1]. The USA accounts for ≈3% of the global annual anthropogenic mercury emissions (≈150 tons), with major contributors such as coal-fired utilities (≈48 tons), municipal waste combustors (≈30 tons), medical waste incinerators (≈15 tons) [1] and cement kilns (≈2.4 tons) [2]. The United States Environmental Protection Authority (US EPA) adopts several serious measures targeting mercury emission reduction to the environment. The Clean Air Mercury Rule [1] introduced by the US EPA in 2005 presents methods for permanently capping and reducing mercury emissions from coal-fired power plants by ≈70%. The US "EPA's Roadmap for Mercury" [3] suggests six areas where health risks arising from mercury exposure need to be reduced. Three of these include "mercury releases into the environment, managing mercury uses in products and processes, and conducting mercury research and monitoring" [3].

The Bayer process involves alumina extraction via treatment of bauxite with sodium hydroxide solution to dissolve the aluminum hydroxides and oxyhydroxides with the production of a sodium aluminate solution, leaving the iron oxides and other insoluble species as gangue material. In the modern Bayer process, a hot, high-pressure alkaline solution digests controlled particle size bauxite with the solid phase of the post-digested slurry split into sand and mud fractions for disposal. Crystallization of aluminum trihydroxide from aluminate-rich digestion liquor is followed by calcination to dehydrate the former for alumina production. Recycling of alkaline liquor is carried out via its evaporation for removal of water previously introduced into the production cycle.

Mercury emissions control practices in the Bayer process employs one or a combination of three methods: firstly, sulfide additions to the process stream prior to aluminum hydroxide

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