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Photolytic removal of arsenic and mercury(II) from aqueous solutions

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Due to the pollution of industrial effluents with toxic metals, often in ionic forms, and their spreading to the environment, much work is currently underway to develop the most efficient methods of separation of heavy metals (e.g. mercury, cadmium, chromium or arsenic) from aqueous solutions.

Arsenic is known for its very high toxicity. Its removal by conventional methods, aimed largely at ions removal, is complicated by the predominant non-ionic nature of its more dangerous and mobile trivalent form. This difficulty can be minimized using photochemical techniques. The study focuses especially on the impact various solid modifiers (e.g. aluminum oxide, zinc peroxide) coagulated during UV irradiation on the arsenic removal (1 mmol/L AsO_2^-). The UV irradiation of the systems with aluminum salts, formic anions (HCOONH_4) as scavengers of $\bullet\text{OH}$ radicals and hydrogen peroxide proved to be very effective due to the high rate of arsenic removal after 15 minutes of irradiation: 93% using $\text{Al}(\text{NO}_3)_3$ and 99 % with AlCl_3 . In the case of AlCl_3 , the aluminum oxide precursor, the arsenic was removed also by adsorption on previously photolytically prepared precipitate. After several days, 98 % of As was dissolved out of the aqueous solution. A highly efficient system was a solution containing zinc nitrate, formate, and hydrogen peroxide from which zinc peroxide was precipitated due to UV irradiation. More than 98% of arsenic was then removed. A 92% degree of arsenic removal during photolysis was achieved in the system with nickel, formate and hydrogen peroxide.

Optimal conditions were sought also for the photochemical reduction of mercury(II) at a concentration 1 mmol/L. In the systems containing dissolved mercury acetate, perchlorate or chloride in the presence of scavengers of $\bullet\text{OH}$ radicals (methanol, ethanol, isopropanol activated by acetone, and ammonium formate) the reduction to monovalent or to metallic mercury in the form of a precipitate occurs. In the system containing mercury acetone and isopropanol activated by acetone mercury was reduced to metallic mercury, in the system with mercury chloride with isopropanol and acetone a mixture of metallic mercury and calomel was formed, while other studied scavengers did not have such strong reduction properties and reduced Hg^{2+} only to monovalent mercury. The time course of UV radiation along with changes in pH was also monitored. In most irradiated systems the pH value decreased. The highest degree of mercury removal was achieved in systems containing mercury (II) acetate or chloride, and isopropyl alcohol with acetone, where more than 98% of mercury was removed in the insoluble form.

In UV irradiated (medium-pressure mercury lamp with a maximum operating power of 400 W) solutions containing studied metals their concentration was determined by the AAS method.

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