Select Publications from Dr. Joseph Calo

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Electrosorption/Electrodesorption of Arsenic on a Granular Activated Carbon in the Presence of Other Heavy Metals

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Abstract:
The adsorption, electrosorption, and electrodesorption of aqueous, inorganic arsenic on the granular activated carbon (GAC), DARCO 12 × 20 (Darco 1220) GAC, were investigated in solutions containing arsenic as the only contaminant, as well as with chromium, nickel, and iron. Darco 1220 was selected for these investigations primarily because it is relatively ineffective as a normal (unassisted) arsenic adsorbent in the chosen electrolytes at the low loadings used. It is shown that the application of anodic potentials in the 1.0−1.5 V range, however, result in enhanced uptake, most likely because of charging of the electrochemical double layer at the electrode surface. Regeneration (100%) of electrosorbed arsenic was achieved via electrodesorption at a cathodic potential of 1.50 V. The presence of metal ad ions was observed to have a significant and complex effect on arsenic adsorption, electrosorption, and electrodesorption. In particular, the Cr/As ratio was shown to have complex effects, decreasing adsorption uptake when present as 3:2 but enhancing adsorption when present as 5:1. Nickel was found to have less of an effect than chromium, except at the highest anodic potential used of 1.50 V, where it exhibited better performance than chromium. The presence of iron significantly enhanced uptake. With a 1.50 V anodic potential, the bulk arsenic concentration was reduced to less than detectable limits, well below the United States Environmental Protection Agency (U.S. EPA) maximum contaminant level (MCL) for drinking water. Regeneration efficiency by electrodesorption for the As−Fe system was greater than about 90%.

Arsenic species interactions with a porous carbon electrode as determined with an electrochemical quartz crystal microbalance

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10.1016/j.electacta.2009.02.023

Abstract:
The interactions of arsenic species with platinum and porous carbon electrodes were investigated with an electrochemical quartz crystal microbalance (EQCM) and cyclic voltammetry in alkaline solutions. It is shown that the redox reactions in arsenic-containing solutions, due to arsenic reduction/deposition, oxidation/desorption, and electrocatalyzed oxidation by Pt can be readily distinguished with the EQCM. This approach was used to show that the arsenic redox reactions on the carbon electrode are mechanistically similar to that on the bare Pt electrode. This could not be concluded with just classical cyclic voltammetry alone due to the obfuscation of the faradaic features by the large capacitative effects of the carbon double layer.

For the porous carbon electrode, a continual mass loss was always observed during potential cycling, with or without arsenic in the solution. This was attributed to electrogasification of the carbon. The apparent mass loss per cycle was observed to decrease with increasing arsenic concentration due to a net mass increase in adsorbed arsenic per cycle that increased with arsenic concentration, offsetting the carbon mass loss. Additional carbon adsorption sites involved in arsenic species interactions are created during electrogasification, thereby augmenting the net uptake of arsenic per cycle.

It is demonstrated that EQCM, and in particular the information given by the behavior of the time derivative of the mass vs. potential, or massogram, is very useful for distinguishing arsenic species interactions with carbon electrodes. It may also prove to be effective for investigating redox/adsorption/desorption behavior of other species in solution with carbon materials as well.

Arsenic removal via ZVI in a hybrid spouted vessel/fixed bed filter system

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Abstract:
The description and operation of a novel, hybrid spouted vessel/fixed bed filter system for the removal of arsenic from water are presented. The system utilizes zero-valent iron (ZVI) particles circulating in a spouted vessel that continuously generates active colloidal iron corrosion products via the "self-polishing" action between ZVI source particles rolling in the moving bed that forms on the conical bottom of the spouted vessel. This action also serves as a "surface renewal" mechanism for the particles that provides for maximum utilization of the ZVI material. (Results of batch experiments conducted to

examine this mechanism are also presented.) The colloidal material produced in this fashion is continuously captured and concentrated in a fixed bed filter located within the spouted vessel reservoir wherein arsenic complexation occurs. It is demonstrated that this system is very effective for arsenic removal in the microgram per liter arsenic concentration (i.e., drinking water treatment) range, reducing 100 μg/L of arsenic to below detectable levels ($\ll$10 μg/L) in less than an hour.A mechanistic analysis of arsenic behavior in the system is presented, identifying the principal components of the population of active colloidal material for arsenic removal that explains the experimental observations and working principles of the system. It is concluded that the apparent kinetic behavior of arsenic in systems where colloidal (i.e., micro/nano) iron corrosion products are dominant can be complex and may not be explained by simple first or zeroth order kinetics.

Cyclic electrowinning/precipitation (CEP) system for the removal of heavy metal mixtures from aqueous solutions

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http://www.ncbi.nlm.nih.gov/pubmed/22102792

Abstract:
The description and operation of a novel cyclic electrowinning/precipitation (CEP) system for the simultaneous removal of mixtures of heavy metals from aqueous solutions are presented. CEP combines the advantages of electrowinning in a spouted particulate electrode (SPE) with that of chemical precipitation and redissolution, to remove heavy metals at low concentrations as solid metal deposits on particulate cathode particles without exporting toxic metal precipitate sludges from the process. The overall result is very large volume reduction of the heavy metal contaminants as a solid metal deposit on particles that can either be safely discarded as such, or further processed to recover particular metals. The performance of this system is demonstrated with data on the removal of mixtures of copper, nickel, and cadmium from aqueous solutions.