Dynamic Adsorbents

Lead Removal from Water by the Use of Activated Alumina

by Gary Witman, MD

Assurance of safe drinking water is essential. Ignoring lead contaminated drinking water can eventually cause irreversible health effects and even death. It has been postulated that the decline of the Roman Empire may have been causally related to the presence of excess lead in the water supply secondary to leakage from piping. One will never know. However, modern science has helped to establish guidelines for acceptable tolerated levels of lead in the water supply, and in the United States these levels are monitored by the Environmental Protection Agency. Lead is a cumulative toxin remaining in the body and concentrating over time. Long term exposure to lead can lead to damage to the gastrointestinal, hematologic and nervous systems and as noted may cause death. Lead contamination in drinking water is usually due to plumbing corrosion in service lines, lead solder and brass fixtures.

There are over 40 million miles of water pipeline infrastructure in the North American aquifier system (United States and Canada). Within this extensive water delivery system more than 34 billion gallons of water daily are purified using industrial scale water purification systems. Over 3 billion of glasses of water are consumed daily in the United States. Within this setting there are more than 170,000 public water authorities. Lead pipes used by older municipal systems are well known to leach lead over time. However, and not recognized by many, even unplasticized poly (vinyl chloride) now used for the transportation and distribution of potable water leaches lead. In the making of PVC piping lead compounds are used as stabilizers and the pipes are produced by extrusion at a temperature of 180 C. The finished pipes contain a lead content of about 1% by weight. This lead may leach out when the pipes are in contact with water. The rate of leaching of UPVC pipe is based on the temperature and the nature of extractants. A report from Virginia Tech illustrated that they may be more susceptible to leaching of lead and copper into drinking water than other types of piping, especially when the PVC systems include brass fixtures and pipe fittings. Brass is composed of copper, zinc and lead.

A particular problem is that water purification plants are using chloramine rather than chloride to disinfect water. At the same time many new homes are constructed using plastic pipe rather than copper in order to cut construction costs. Ammonia formed in chloramine treated water leads to a series of events that corrode brass faucet components and connectors which are commonly used in PVC plumbing systems. Corrosion of brass releases copper, zinc and lead into water pipes.

There is a spectrum of treatment methods employed for removal of heavy metals from water. Commercially available techniques include chemical precipitation, ultrafiltration, membrane separation, solvent extraction, adsorption and ion exchange, reverse osmosis, electrodialysis and alternative biological treatments. One way to minimize the risk of lead being dissolved from lead pipes and lead solder in pipe fittings is to make water slightly alkaline. Treatment methods such as chemical precipitation and ion exchange do not yield sufficient removal of lead and are expensive due to the high cost of chemicals. The two “point of use” technologies which are successful at removing lead from water are reverse osmosis and activated alumina. Metal oxides such as activated alumina may be an ideal sorbent for the removal of heavy metals. Whether in bulk media or as nanoparticles alumina oxide is cost effective and with a demonstrated safety record.

Adsorption results show pH dependency with a Freundlich isotherm fit, which is determined as the percentage of lead removed versus mass of alumina.

Activated alumina is able to sorb lead from aqueous solutions by concentrating lead at the particle surface. Sorption of lead by activated alumina is effected by factors such as pH, alumina surface area (particle size), and presence of background matrices. Particle size and pH plays significant roles in lead sorption.

Activated alumina is a porous granular form of aluminum oxide possessing a large surface area. It is able to sorb lead from aqueous solutions by concentrating lead at the particle surface. Sorption processes can be used effectively when the lead concentration is extremely low.

Furthermore activated alumina can be efficiently regenerated, which significantly reduces treatment costs. Lead adsorption using activated alumina is best explained by the Freundlich isotherm in which q = KFCl/n

Where q is the adsorbate mass per adsorbent unit mass at equilibrium; KF is the adsorbent capacity meaure; C is the aqueous concentration; and n is a measure of how adsorbate affinity changes with adsorption density changes

Experimental data indicates that lead adsorbs to metal oxides in a heterogenous absorbed fashion. While lead is adsorb in a pH dependent fashion, the amphoteric property of activated alumina oxide makes it an excellent agent for the adsorption of heavy metals regardless of the pH. Activated alumina possesses both Lewis and Bronsted acidic and basic sites. While being amphoteric, alumina for lead removal works best under acidic conditions, as in the pH range of 5.5 to 6.0. The surface of compositionally pure activated alumina oxide becomes negatively charged between pH 8 and 10. Because of its acidic pH and low dissolved solid content such as calcium and magnesium soft water tends to be more corrosive than hard water.

Water characteristics promoting the corrosion of water include low pH, low total dissolved solids, high water temperature and high concentrations of dissolved gases such as oxygen or carbon dioxide.

Smaller particles have greater surface area. Surface area as defined by particle size impacts on sorption capacity and rate of lead removal. For this reason it has been suggested that nanoparticles may provide a more cost efficient method for the sorption of lead from the water supply than more bulky conventional media.

One method for using activated alumina for the removal of lead is to add powdered alumina oxide to a batch tank reactor in order to remove lead from solution. The alumina particles with lead ions sorbed to their surface can then be captured by an ultra membrane filtration system.

Another method is to house (contain) the activated alumina inside a cartridge, with a selectively permeable membrane at the end of the cartridge assuring that the alumina and sorbed lead complex remain within the cartridge which can then be easily regenerated.

DAI offers AL 2000, a large particle activate alumina (+200 microns) specifically designed, modified and chemically treated in order to enhance the removal of metal ions from a water stream. It is ideal for point of use applications. This product is specifically designed to remove dissolved lead and other cations from water. It provides a cost efficient, simple and reliable solution for municipal, industrial and home use needs.

Dynamic Adsorbents: P.O. Box 80402 Atlanta, GA 30366-0402
Tel: 770-817-0123 **Toll-Free:** 1-866-314-SORB (7672) **Fax:** 770-455-4380
info@dynamicadsorbents.com