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Fabrication of catalyst from heavy metal containing waste

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Abstract

With the development of modern industrialization, there are increasing amounts of heavy-metal wastes produced every day, such as electroplating sludges, heavy metal slags and tailings. For example, China yearly generates more than 100 000 tons of electroplating sludges, which is featured by high enrichment of metals (Ni, Cu, Zn, Fe, Mn, and Cr etc.) as well as organics. Currently heavy-metal wastes are disposed mainly by landfilling and brick-making. Unfortunately, the former would cause potential pollutions to the eco-environment and occupy the land, and the latter is usually accompanied by high risk of heavy metal volatilization at high temperatures. Thus, it is more desirable to recycle heavy-metal wastes properly so as to reduce the secondary pollution and save the limited metal resource.

To this aim, our group successfully synthesized effective catalysts from heavy-metal wastes, and applied them in NO, H2S and SF6 removals. After various treatments, heavy-metal-waste derived catalyst contained 2~7% of carbon, 30~40% of transition metals. It was characterized by multi-metal supported carbon according to HRTEM. When being used in NO reduction, the catalyst showed great activity towards NO-SCR. The active temperature was 100oC lower than traditional SCR catalyst. NO removal amount per gram of catalyst was also extended for 10 times. The catalyst was also effective for H2S oxidization and SF6 decomposition. Therefore, our works indicated a novel strategy for the high-value-added utilization of heavy-metal wastes and production of effective catalysts at the same time.

Innovative processes for treating industrial wastewater containing heavy metals often involve technologies for reduction of toxicity in order to meet technology-based treatment standards. This article reviews the recent developments and technical applicability of various treatments for the removal of heavy metals from industrial wastewater. A particular focus is given to innovative physico-chemical removal processes such as; adsorption on new adsorbents, membrane filtration, electrodialysis, and photocatalysis. Their advantages and limitations in application are evaluated. The main operating conditions such as pH and treatment performance are presented. Published studies of 94 cited references (1999–2008) are reviewed.

It is evident from survey that new adsorbents and membrane filtration are the most frequently studied and widely applied for the treatment of metal-contaminated wastewater. However, in the near future, the most promising methods to treat such complex systems will be the photocatalytic ones which consume cheap photons from the UV-near visible region. They induce both degradation of organic pollutants and recovery of metals in one-pot systems. On the other hand, from the conventional processes, lime precipitation has been found as one of the most effective means to treat inorganic effluent with a metal concentration of >1000 mg/L. It is important to note that the overall treatment cost of metal-contaminated water varies, depending on the process employed and the local conditions. In general, the technical applicability, plant simplicity and cost-effectiveness are the key factors in selecting the most suitable treatment for inorganic effluent.

Heavy metals are generally considered to be those whose density exceeds 5 g per cubic centimeter. A large number of elements fall into this category, but the ones listed in are those of relevance in the environmental context. Arsenic is usually regarded as a hazardous heavy metal even though it is actually a semi-metal. Heavy metals cause serious health effects, including reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases, death. Exposure to some metals, such as mercury and lead, may also cause development of autoimmunity, in which a person’s immune system attacks its own cells. This can lead to joint diseases such as rheumatoid arthritis, and diseases of the kidneys, circulatory system, nervous system, and damaging of the fetal brain. At higher doses, heavy metals can cause irreversible brain damage. Children may receive higher doses of metals from food than adults, since they consume more food for their body weight than adults. Wastewater regulations were established to minimize human and environmental exposure to hazardous chemicals. This includes limits on the types and concentration of heavy metals that may be present in the discharged wastewater.

Industrial wastewater streams containing heavy metals are produced from different industries. Electroplating and metal surface treatment processes generate significant quantities of wastewaters containing heavy metals (such as cadmium, zinc, lead, chromium, nickel, copper, vanadium, platinum, silver, and titanium) from a variety of applications. These include electroplating, electroless depositions, conversion-coating, anodizing-cleaning, milling, and etching. Another significant source of heavy metals wastes result from printed circuit board (PCB) manufacturing. Tin, lead, and nickel solder plates are the most widely used resistant overplates. Other sources for the metal wastes include; the wood processing industry where a chromated copper-arsenate wood treatment produces arsenic-containing wastes; inorganic pigment manufacturing producing pigments that contain chromium compounds and cadmium sulfide; petroleum refining which generates conversion catalysts contaminated with nickel, vanadium, and chromium; and photographic operations producing film with high concentrations of silver and ferrocyanide. All of these generators produce a large quantity of wastewaters, residues, and sludges that can be categorized as hazardous wastes requiring extensive waste treatment (Sorme and Lagerkvist, 2002).

Sorption is transfer of ions from water to the soil i.e. from solution phase to the solid phase. Sorption actually describes a group of processes, which includes adsorption and precipitation reactions. Recently, adsorption has become one of the alternative treatment techniques for wastewater laden with heavy metals. Basically, adsorption is a mass transfer process by which a substance is transferred from the liquid phase to the surface of a solid, and becomes bound by physical and/or chemical interactions (Kurniawan and Babel, 2003). Various low-cost adsorbents, derived from agricultural waste, industrial by-product, natural material, or modified biopolymers, have been recently developed and applied for the removal of heavy metals from metal-contaminated wastewater. In general, there are three main steps involved in pollutant sorption onto solid sorbent: (i) the transport of the pollutant from the bulk solution to the sorbent surface; (ii) adsorption on the particle surface; and (iii) transport within the sorbent particle. Technical applicability and cost-effectiveness are the key factors that play major roles in the selection of the most suitable adsorbent to treat inorganic effluent.

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