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Eliminating Heavy Metals from Water with Nano-Sheet Minerals as Adsorbents

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Heavy metals usually referred to those with atomic weights ranging from 63.5 to 200.6. Because of natural-mineral dissolution and human activities such as mining, pesticides, fertilizer, metal planting and batteries manufacture, etc., these heavy metals, including zinc, copper, mercury, lead, cadmium and chromium have been excessively released into water courses, like underground water, lake and river, etc. The ingestion of the heavy metals-contaminated water would raise serious health problems to human beings even at a low concentration. For instance, lead can bring human beings about barrier to the normal function of kidney, liver and reproductive system, while zinc can cause stomach cramps, skin irritations, vomiting and anemia. Mercury is a horrible neurotoxin that may result in damages to the central nervous system, dysfunction of pulmonary and kidney, chest and dyspnea. Chromium (VI) has been proved can cause many diseases ranging from general skin irritation to severe lung carcinoma. Accordingly, the World Health Organization announced the maximum contaminant levels (MCL) for the heavy metals in drinking water.

There are numerous processes for eliminating heavy metals from water in order to provide citizens safe drinking water, including precipitation, adsorption, ion exchange, membrane separation and biological treatment, etc. Adsorption is considered as a potential process for deeply removing heavy metals, in which the selection of adsorbents plays a predominant role.

Nano-sheet minerals as the adsorbents are currently the hottest researches in the field. They are obtained from layered minerals, such as montmorillonite, graphite and molybdenite, through the processing of intercalation, electrochemical and mechanical exfoliation, etc. Nano-sheet minerals are featured by their large specific surface area, relatively low costs and active adsorbing sites, leading to be effective and potential adsorbents for heavy metals removal from water.

Montmorillonite was usually pre-interacted with organics to increase the interlayer space, and then exfoliated to single or several layers by using ultrasonic. Among the nano-sheets, the surfaces are strongly charged negatively, while the edges are positively charged. This characteristic allows the adsorption of cations or anions, as well as the substances with negative or positive charges.

Graphite can be oxidized and exfoliated into graphene oxide (GO), which has a huge specific surface area and plentiful of functional groups such as carboxyl, epoxy, carbonyl and hydroxyl, leading to high adsorption capacity to heavy metals in water.

Nano-sheet molybdenite is a novel two-dimensional material with single or several layers of MoS_2 sheets. The most common method to prepare nano-sheet molybdenite is exfoliated from bulk molybdenite through chemical method based on ion intercalation process. A large quantity of functional groups and S atom on the sheets are the active sites for adsorbing heavy metals in water.

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Nano-sheet minerals are used as adsorbents in the form of three-dimension hydrogels. They are featured by the huge specific surface area and high adsorption efficiency. In addition, the clean and smooth surfaces allow heavy metals to adsorb directly by film dispersion. Without any barrier of mesopores and micropores, the adsorption rate could be well improved. These characteristics would lead to the extremely large adsorption capacity and high adsorption rate. Currently, nano-sheet minerals as adsorbent is a very hot research topic in the field of heavy metal removal. It is expected that nano-sheet minerals will be promising adsorbents in the removal of heavy metals from water.

About Shaoxian Song

Dr. Song has been a professor in the Universidad Autonoma de San Luis Potosi, Mexico, since July of 1996, and is a national researcher level 3 and the member of the Mexican Academy of Science. Concurrently, he is a chair professor of the school of resources and environmental engineering, Wuhan University of Technology, China. He received his Ph. D. in Mineral Engineering in the Central-South University, China in 1991. His main fields of interests include water treatment, mineral processing and colloidal stability. He is the author or co-author of over 280 journal articles (in which over 200 articles have been indexed by SCI), 3 books, 8 book chapters and over 50 proceedings articles.