Application And Prospect Of Talc As Heavy Metal Passivation Agent

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Abstract. Heavy metal pollution in water and soil has been widely concerned by all sides. Heavy Metal passivation agents can change the presence of heavy metals in water and soil, thus reducing mobility, toxicity and bioavailability. In this paper, the application, effect and prospect of using talc to repair heavy metal pollution are introduced, and some problems and prospects of remediation method of heavy metal pollution are prospected.

1. Introduction

Water and soil are important natural resources for human survival. Since the rapid development of science and technology since the 20th century, although the economic development has been promoted and people's living standards have been improved, people have also paid a heavy price. At present, the heavy metal pollution in China is mainly caused by the heavy metals such as cadmium, lead and chromium that are caused by water, soil and atmosphere during mining, smelting and processing. The sources of heavy metal pollution are also reflected in exhaust emissions from motor vehicles, sewage irrigation and the unreasonable use of pesticides and fertilizers, and inadequate combustion of fossil fuels.

The heavy metal pollution in water and soil can affect the environment itself and the damage to animals and plants as well as the harm to human survival. Because the physical and chemical properties of heavy metals are relatively stable, they cannot be degraded by microorganisms, they are easy to accumulate, and they are converted into more toxic hydrocarbon compounds. Progressive bioaccumulation through various food chains harms human health. This requires the restoration of water or soil contaminated with heavy metals to reduce the effective concentration of heavy metals.

Heavy metal pollution generally adopts three kinds of physical, chemical and biological remediation technologies. Stabilization technology is the main technology for remediation of heavy metal pollution in soil, and stabilization of materials is a key factor influencing the treatment effect. Adsorption is widely used to repair heavy metals in wastewater because of its mature technology and simple operation. Activated carbon, clay materials, nanomaterials, and talc materials can be used as stabilizing materials for soil heavy metal remediation, and can also be used as adsorption materials for...
heavy metal remediation of wastewater. Talc has many advantages. It has the advantages of low cost, high quality, simple operation, high efficiency and reusability. Talc is rich in silicon, which is a plant nutrient element. Through the absorption of silicon, plants can not only increase biomass, but also promote the secretion of oxidases in plants and reduce the toxic effects of heavy metals. Therefore, this method is of great significance for reducing the bioavailability of heavy metals in soil [9-10]. At the same time, there is a general shortage of silicon in China’s soil, and rational use of silicate passivating agents will have a significant effect on supplementing silicon sources and increasing crop yield. In this paper, through the review of the characteristics of talc, the application and effect of talc inactivators, it provides new ideas for the performance improvement and application of talc as a passivating agent for heavy metals.

2. The characteristics of talc

The talc, also known as drawing stone, living stone, brittle stone and Liu Shi, is a layered silicate mineral with large specific surface area and no charge [11]. Its chemical formula is Mg₃Si₄O₁₀(OH)₂.

China’s talc resources are abundant, mainly produced in China’s Guangxi, Yunnan, Sichuan, Jiangxi, Jiangsu, Shaanxi, Shandong, Hebei, Liaoning and other places, with associated minerals mainly carbonate minerals, such as calcite, dolomite, magnesite, followed by chlorite, Serpentine and flash stone, etc [12]. There are three main genetic types of talc: (1) The silicon-rich hydrothermal fluid represents talc minerals formed by rich magnesium carbonates, clay rocks, etc.; (2) The basalt-ultrabasic talc ore formed by silicon-rich hydrothermal alteration metamorphism; (3) Deposited talc [13]. The dissociation between talc layers is very complete. After disintegrating the crystals, there are two surfaces with different properties. The hydrophobicity of the base surface is better, and the hydrophobicity of the end surface is slightly worse. The talc minerals have very good natural hydrophobicity [14]. The special layered structure of talc and its large specific surface area determine its strong adsorption and ion exchange properties [15]. Therefore, talc can be used to repair heavy metals in wastewater and soil.

Talc powder has physicochemical properties such as lubrication, softness, anti-adhesion, good gloss, flow aid, hydrophobicity, good hiding power, strong adsorption force, fire resistance, insulation, acid resistance, etc. Widely used in cosmetics, pharmaceuticals, food, coatings, paper, plastics, rubber, cables, ceramics, textiles and other manufacturing industries; At the same time, talcum powder has the characteristics of heat removal, moisture permeability, and phlegm, and is often used to treat diseases such as heat and polydipsia, urination, water diarrhea, phlegm, gonorrhea, jaundice, edema, blood stasis, beriberi, and wet skin [16].

3. Application and effect of talc passivator

At present, some studies have been done on the properties of talc in China, but little research has been done on it as a passivator for heavy metals. The application of talc in foreign countries has been studied in the restoration of heavy metal pollution.

Talc powder is formed by crushing and grinding talc. Since the surface of talc powder has a large number of Mg-O- and OH- bonds, when talcum powder is in full contact with heavy metal ions in water or soil, the heavy metal ions will cooperate with Mg-O- and OH- to immobilize heavy metal ions on the surface of talc powder, thereby realizing the separation of heavy metal ions from water or soil. It can be seen that surface adsorption plays a major role. In addition, special groups such as Si-O-Si and O-Si-O on the surface of talc can also complex with heavy metal ions and play a role in removing heavy metal ions from talc.

3.1 Research applications and effects of Unmodified Talc

Some domestic researches show that talcum powder [8,15,17] by using an adsorption method [18], an aqueous solution contaminated with heavy metals (such as mercury, lead, and nickel) can be repaired. Yunfeng Xu and others [8] also used talc in the study of the adsorption of nickel-containing wastewater in water, and discussed the effects of talc dosage, reaction time, and the pH of the solution on the treatment effect, orthogonal experiments were used to study the effect of comprehensive factors on the
treatment effect, and the optimum conditions for the determination of talc was 7.0 g/L, the reaction time was 5 h, and the pH was 8.0. Yunfeng Xu et al. [15] studied the adsorption performance and mechanism of mercury divalent mercury in talc in water, the results show that the talcum powder is mainly adsorbed on the surface, and the complexation reaction also plays a certain role. The strong acid and alkali conditions are not conducive to the removal of divalent mercury ions.

Yunfeng Xu [17] used talc to study the adsorption of divalent lead ions in water. Research shows that talc has a rapid adsorption rate for Pb\(^{2+}\) in lead-containing wastewater. The adsorption type is physical adsorption, and surface adsorption is the main factor. Among the three factors of talc dosage, adsorption reaction time and solution pH value, pH value had the most significant effect on the treatment effect. From the correlation coefficient value, the adsorption of Pb\(^{2+}\) by talc is more consistent with the Langmuir isotherm model, and the correlation coefficient is 0.9924.

Abroad, Myroslav Sprynskyy et al. [19] studied the adsorption of uranium in aqueous solution by talc, and studied the adsorption of uranyl ion from aqueous solution to talc in batch adsorption experiments. The results show that uranium adsorbs on talc in many molecules or clusters. In addition, the detected talc surface area of 3.5 m\(^2\)/g is too small for the uranium adsorption monolayer. The maximum uranium adsorption capacity (41.6 mg/g) occupies a surface area of 58.3 m\(^2\)/g as a monolayer.

### 3.2 Application and Effect of Research on Modified Talc

Due to the special characteristics of talc, when the talc is modified, its specific surface area can be increased to increase the active functional group, and some properties can be added, so that the modified talc can not only be used for the repair of heavy metal pollution, but also can be used for other purposes.

Domestic Haiyan Wu et al. [11] used microwave-assisted talc modified by hydrochloric acid as oil absorption agent, studied its oil absorption performance, isothermal adsorption model and adsorption kinetics of simulated vegetable oil wastewater solution. The modified talc was characterized by X-ray diffraction (XRD) and Fourier infrared (IR) spectroscopy. The results showed that the talc modified by microwave-assisted hydrochloric acid increased the specific surface area, dissolved impurities in the pores, increased the number of active functional groups, and enhanced the ability to adsorb vegetable oils. It can be used as a natural mineral absorbent to treat simulated vegetable oil wastewater solutions. Adsorption equilibration time was 30min, dosage of modified talc was 7g/L, and oil absorption effect was best under neutral conditions. At 25°C, the adsorption of the modified talc to the simulated vegetable oil wastewater solution conformed to the Langmuir isotherm adsorption model and the pseudo-second-order kinetics equation. The maximum adsorption capacity was 3.92 mg/g.

In foreign countries, Hannatu Abubakar Sani et al. [20] used ZnO nanoparticles to modify talc to form ZnO/talc nanocomposites to study the adsorption efficiency of Pb(II) in aqueous solution. The results showed that ZnO/talc nanocomposites have high adsorption capacity. Its largest lead adsorption capacity adsorbent was determined to be 48.3 mg x g\(^{-1}\). It was also found that the adsorption mechanism is controlled by the electrostatic attraction of nanocomposites. The overall results show that the prepared nanocomposite can be used as a substitute for removing Pb(II) from wastewater. Katayoon Kalantari et al. [21] used Fe3O4/talc nanocomposites to remove Cu(II), Ni(II) and Pb(II) ions from aqueous solutions. The results showed that the initial concentrations of heavy metal ions Cu (II), Ni (II) and Pb (II) were 100, 92 and 270 mg/L, respectively. The optimum removal conditions were 120s and the adsorption dose was 0.12g. The removal efficiencies of Cu (II), Ni (II) and Pb (II) were 72.15%, 50.23% and 91.35%, respectively. The prediction of this model is in good agreement with the experimental results. Fe3O4/talc nanocomposites have been successfully used to remove heavy metals from aqueous solutions.

Pourya Moradihamedani et al. [22] used a novel polysulfone/Fe3O4-talc nanocomposite hybrid matrix membrane to efficiently remove lead (II) and nickel (II) from aqueous solutions. It is shown that the higher surface area of talc in Fe3O4-talc nanocomposites can be considered as the main reason for the higher removal rate of heavy metals in PSf/Fe3O4-talc film.

As talc is an inexpensive and readily available ore, it is used as a substrate for modification, and there is a promising prospect for the recovery of soil and water contaminated by heavy metals.
3.3 Other studies on talc

Artificial neural networks because of its capture reliability, robustness and outstanding characteristics of non-linear relationship between the variables in complex systems are widely used to solve the problem. In the study of the optimization of the wavelet neural network process parameters for the rapid adsorption of Pb(II), Ni(II) and Cu(II) by magnetic talc nanocomposites by Negisa Darajeh et al [23]. From the process modeling, the high correlation of the model shows that the wavelet neural network can be used to optimize the removal of heavy metal ions. The response from the model assessment shows very good agreement with the observations. Entire approach has proven sufficient for removal of Pb (II), Ni (II) and Cu (II) design and optimization.

Two researchers at the Institute of Chemistry at the University of Campinas, Syed Badshah and Claudio Airoldi [24], synthesized a new methyilsilylation reagent and magnesium salt hydrolysis condensation reaction under certain environmental conditions. A talc-like self-assembled organoclay layered structure was synthesized by condensation reaction. According to the sulfur element analysis data, the maximum binding amount of the organic part in the clay layer space was 3.87 mmol×g⁻¹, which confirmed the talc-like structure from the peak of 60° in the X-ray diffraction pattern. Organic chain in the clay layer comprising a plurality of coordination sites, which can be used for the organic portion contains nitrogen, oxygen and sulfur substantially central divalent lead, copper and cadmium cations is removed, for the removal of divalent lead, copper and cadmium from aqueous solutions. Langmuir model based at ambient conditions, the maximum adsorption capacity of mixed cation these are 7.08,4.01 and 1.86 mmol×g⁻¹, compared with the cadmium and copper cations, hybrid showed higher adsorption of lead cations.

Under José A.A. Sales et al [25] also mild temperature conditions, by using a sol-gel matrix process successfully synthesized two new layered inorganic-organic magnesium silicate. Two silylating agents are obtained as the silicon source talc-organosilicate, (1) 3- chloropropyl trimethoxysilane and (2) from 5-amino-1,3,4-thiadiazole-2-thiol molecules are attached to the precursor agent, to give PhMg-Cl and PhMg-Tz layered silicate. The novel compounds PhMg-Tz potential as a multi-material properties has been enhanced, which is used to adsorb cations from aqueous solutions. Such functional organoclay materials exhibit the potential to remove heavy cations from ecosystems.

4. Conclusions

Heavy metal pollution has become increasingly severe and there are more and more methods of repair. At present, the main research is on the remediation of cadmium, lead, and copper heavy metals. The selection of substrates mainly tends to be cheap, readily available, recyclable, and highly efficient materials. Heavy metal pollution in Guangxi is relatively severe, and Guilin Longsheng has a relatively rich talc resource. Studies have been carried out on talc in the repair of heavy metal pollution.

In the repair of heavy metal pollution in China, there is little research on the modification of heavy metal pollution by modified talc, and more in-depth research is needed on the application of talc as a high-quality substrate. However, foreign researchers have relatively more researches on the modification of talc, and also study the synthesis of a self-assembled layered organoclay with a talc-like structure for the removal of divalent lead, copper and cadmium from aqueous solutions.

Because talc is a layered silicate mineral and it is inexpensive and has good adsorption properties, it can undergo in-depth modification studies to repair heavy metal contamination in soil or water. In the repair of heavy metal pollution, talc can be modified by substances containing favorable elements such as carbonates. By applying such modified talc in soil or water, the plant or aquatic plant grown on the surface of the soil absorbs those beneficial elements through a period of growth. With the enrichment of the biological chain and the transfer of elements, the beneficial elements of the human body are naturally fully supplemented when ingested by the human body.
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