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Removal of Heavy Metals in Effluent by Adsorption and Coagulation

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Abstract: The silicate colloids with an average diameter 100 nm, were prepared by the hydrolysis of tetraethoxysilane (TES), NH_4OH (30%) and then modified by (3-mercaptopropyl) trimethoxysilane (APS). The colloids can adsorb heavy metals such as Pb and Cr in effluent and after adsorption the colloids can be separated by coagulation of aluminum sulfate. The removal of heavy metals is up to 99%.

Keywords: Silicate colloid, modification, adsorption, heavy metals, coagulation.

Due to growing rigorous environmental regulations, limit for heavy metal in drinking water and wastewater becomes more and more strict. The method of ion exchange has been comprehensively employed to remove heavy metals in water bodies currently[1,2], but the cost is high. There are some reports on the removal of heavy metals in effluent by complexation of the dry biomass[3,4]. Unfortunately, these methods are difficult to use on a large scale. Many researches have reported the methods of biosorption or chemical modified solid surface[5], it takes some time for the adsorption of heavy metals in water bodies , especially, at ppm level.

At present, some coagulants have been used to remove the heavy metals in drinking water and effluent. As the flocs formed by the hydrolysis of aluminum salts and ferric salts have no affinity to heavy metals, the research of special coagulants become a hot focus. Many investigators have developed some composite coagulants, but up to now, only limited results were obtained. Water resources available have decreased quickly, people irrigate with sewage in many regions. Heavy metals in water bodies will accumulate in crops and enter into the food chain ultimately. This influence is not observed in a short term, but it may result in irretrievable loss ten or more years later. The occurrence of the same illness in some regions has a close connection with water pollution. Moreover, it will take several decades for the remediation water bodies and soil polluted by heavy metals. During past decades, a newly environmental protection field is the restoration of water bodies and soil pollution.

In the present study, a kind of particles (10~100 nm) were formed in the course of hydrolysis of tetraethoxysilane, and then it was modified by (3-mercaptopropyl) trimethoxysilane (APS). The large specific surface area of these particles provide

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myriad active points of –SH for the adsorption of heavy metal, we first use it for the treatment of effluent contaminated by Pb and Cr.

Experimental

Tetraethoxysilane (TES), aquaous ammonia, alcohol, aluminum sulfate were purchased from Aldrich Company. All reagents were used directly without further purification. 100 mL alcohol was added in 250 mL flask, then 4 mL TES and 6 mL aquaous ammonia (ammonia 27%) were added. The reaction underwent for 24 h at room temperature by magnetic stirring, 300 μL APS was added, the mixture was reacted further for 24 h. A white colloids could be observed. The reactant was seperated by centrifuge. The supernatant was discarded, the sediment was washed with water 2~3 times and transferred to 250 mL flask, the concentration of the solution was 5 mg particles /mL.

Transmission electron microscope, PHLIP100, was used to record the diamter of colloids.

Jar tester by ZhongRun Company was used in the coagulation. The heavy metal effluent was obtained from a plating works. The colloidal solution of silicate was first added in the effluent, and was mixed at 250 rpm/min for 2 min, and the aluminum sulfate solution was fed and mixed at 250 rpm/min for another 2 min, finally, at 50 rpm/min for 20 min. The solution was kept for half an hour and the supernatant was taken to measure the content of heavy metals. The instrument was ICP-AES, Perkin-Elmer Plasma 2000. The original concentration of lead and chromium was 5.0 mg/L or 1.0 mg/L.

Results and Discussion

Sulfides have the strongest affinity to heavy metal ions, the mercaptide can affix on the different carriers, contact with the above heavy metals and remove them by adsorption and coagulation. This modification process can be conducted on the surface of solid or grafted to water soluble macromolecules such as lateral chain of PAM.

Figure 1 displays the appearance of the colloids by hydrolysis of TES. The diameter can be controlled in the range of 20~100 nm by controlling hydrolysis time and reactant concentration. We adjust the diameter of colloids to about 100 nm. These colloids were covered with heavy metals and easily to be coagulated. **Figure 2** shows the scheme of the surface of modified particles.

In the later stage of hydrolysis, silane with mercapto group is added, the surface will be covered with –SH[6]. **Figure 3** indicates the removal effect of adsorption when the dosage of modified colloids is 100 mg/L, the residual concentration depends on the adsorption time.

From the **Figure 3,** we can find the removal of lead is better than of chromium under the same conditions due to the affinity sequence of chromium and lead ions is diffrent[7]. In additon, we can also observe the removal effects of low concentration lead (1 mg/L) are very efficient. We met a tricky problem that mercaptan can be easily oxidized on the suface of silicate colloid and form S-S double bonds, which leads to reduce the adsorption capacity.

Figure 1 Transmission electron microscope photo of silicate colloid

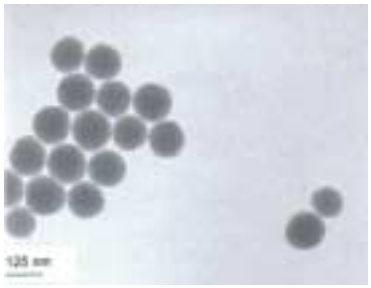
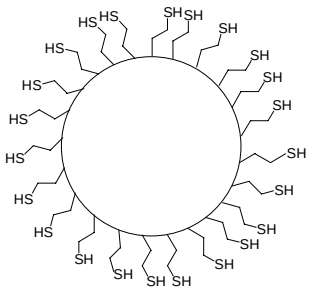


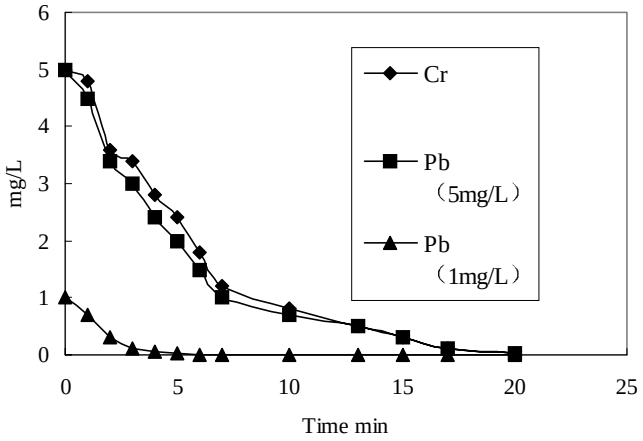
Figure 2 Modified silicon particles surface



Conclusion

Mercapto groups are chemsorbed on the surface of silicon colloid and have very good affinity to heavy metals, such as Pb and Cr. In the result these heavy metal ions can be removed with the removal rate up to 99%. In addition, these colloids can be used as filtering material in closed container[8].

Figure 3 Adsorption effect by the modified silicon colloid



Acknowledgments

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