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$K_2Ti_4O_9$ Whisker adsorbent investigation and utilization of it in Heavy Metal Ions elimination

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ABSTRACT

This study's purpose is investigating about adsorption of heavy ions of Pb2+, Cd2+ in water on potassium tetratitanate whisker. The impact of the Potassium tetratitanate whisker quantity, time, and pH amount on adsorption is investigated. The examination outcomes indicate that the adsorption proficiency of Potassium tetratitanate whisker improves by the adsorbtion quantity, time, and PH amount. The adsorption of Pb2+ and Cd2+ ions on Potassium tetratitanate whisker follows Freundlich's Equation. The Potassium tetratitanate whisker regeneration feature is as well as analyzed in this study. The utilization of Potassium tetratitanate whisker possibility for treating industrial sewage including heavy metal ions is considered.

Introduction

Potassium tetratitanate whisker is a white or yellowish needle such as a crystal (Wei et al., 2004). Potassium tetratitanate whisker study in environment conservation utilization formed from treatment nuclear wastes. The ion exchange behavior and Potassium tetratitanate whisker adsorption has been firstly investigated in the United States. The exchange and adsorbtion capacity of radioactive Ba2+ ions on Potassium tetratitanate whisker stays permanent even under the neutron radiation by strength about 3.85×106 $n/cm^2 \cdot s$ and γ-ray of1.72Gy/h.

Investigators in Japan composite K2Ti4O9 whiskers adsorbed heavy metal ions by oxides and clays for producing ceramics by not considering radioactivity. So far, for the radioactive heavy ions' exchange treatment, Potassium tetratitanate whisker is the most suitable choice.

Empirical method

Adsorption features of Potassium tetratitanate whisker is specified by estimating the quantity of Pb^{2+}or Cd^{2+} ions adsorbed on Potassium tetratitanate whisker. In the examination, Potassium tetratitanate whisker of various quantity is set in a 250 ml cone bottle, water including different Pb^{2+}or Cd^{2+} amount (100ml) is counted to the bottle, orderly. The bottle with Potassium tetratitanate whisker and water including Pb^{2+}or

Cd^{2+} is shaken at 140 r/m for specific time. After shaking, the water on top of the bottle is divided and amount of Pb^{2+} and Cd^{2+} ions are investigated utilizing Atomic Adsorption Spectrophotometer.

Discussion and Results

Adsorption behavior of Potassium tetratitanate whisker

The relation of the Potassium tetratitanate whisker quantity and the absorption proficiency of Pb^{2+} and Cd^{2+} in water is demonstrated in Fig. 1. According to this figure, by increasing the quantity, the Potassium tetratitanate whisker's absorption proficiency rises.

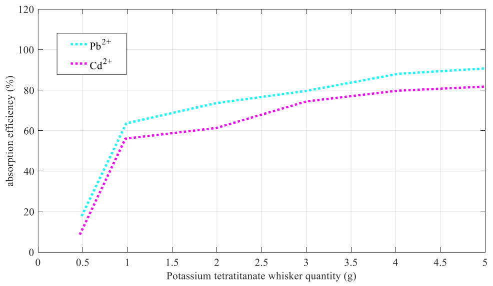

Fig. 1. The influence of Potassium tetratitanate

whisker's quantity on the absorption efficacy.

In China, studies on Potassium tetratitanate whisker as an economical reinforcement material in high-efficiency compound have been performed (Meng et al., 2002). Nevertheless, Potassium tetratitanate whisker study for removing heavy metal ions in industrial sewage by adsorption hasn't been presented. This study is the initial report of the examination outcome of Potassium tetratitanate whisker as an adsorbent for removing Pb^{2+} and Cd^{2+} in water.

The impacts of Potassium tetratitanate whisker quantity on the absorption capacity is demonstrated in Fig. 2. in accordance with the experiment comes, while Potassium tetratitanate whisker is utilized for treating sewage including Pb^{2+} and Cd2+, its adsorption rate growths with quantity, then the elimination of $Pb^{2+}$and Cd^{2+} rises, when the adsorption capacity of Potassium tetratitanate whisker diminishes. The reason for this is that a given amount of the metallic ions in water, as the adsorbent quantity of Potassium tetratitanate whisker rises, the active areas of the adsorbent rise that results in more metallic ions adsorbed and less ions stay in water in equilibrium, demonstrating as the elimination of metallic more ions.

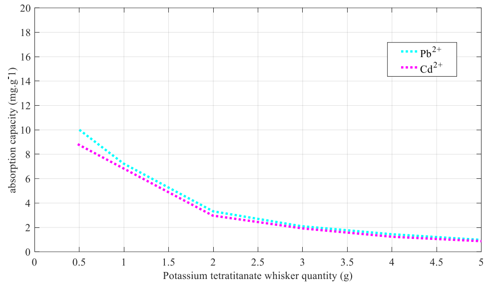

Fig. 2. The influence of Potassium tetratitanate

whisker's quantity on the absorption capacity Also as the ion amount in water reductions, the adsorption potential of Potassium tetratitanate whisker reduces. The elimination and absorption rate of Pb^{2+} is more than of Cd2+. This is maybe because of the various in the ion size and the segregation coefficient of Potassium tetratitanate whisker on these 2 ions (Chen et al., 2004).

The time impact on the adsorption of Pb^{2+} and Cd^{2+} on Potassium tetratitanate whisker is illustrated in Fig. 3. According to this figure, the adsorption of Pb^{2+} and Cd^{2+} on Potassium tetratitanate whisker improves with time. The absorption capability of Potassium tetratitanate whisker grows fast in the beginning and reduces speed slowly, and gets stable at balance. in the beginning, Potassium tetratitanate whisker is fresh and the metallic ion amount is high therefore the adsorption possibility is high. As time rise, the adsorption potential reductions, and the adsorption capability closes to a stable. in accordance with the experiment outcomes, fifty minutes from the beginning, the adsorption rate of Cd^{2+} is scarcely high in comparison with Pb^{2+}, while over fifty minutes, the adsorption capability of Potassium tetratitanate whisker for Cd^{2+} is low in comparison with Pb^{2+}. Adsorption of Pb^{2+} and Cd^{2+} on Potassium tetratitanate whisker reaches balance in 120 minutes.

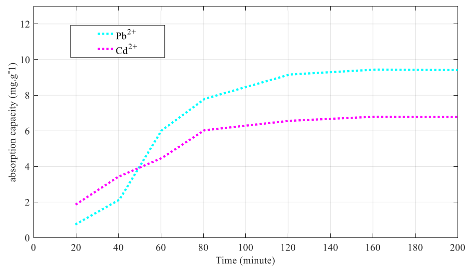

Fig. 3 The time influence on the absorption capacity

The influence of pH amount on the adsorption capability of Potassium tetratitanate whisker is demonstrated in Fig. 4. It could be noticed that the adsorption capability of Pb^{2+} and Cd^{2+} on Potassium tetratitanate whisker rises by PH amount. It indicates Pb^{2+} and Cd^{2+} adsorption would choose the high PH amount. Nevertheless, if the PH amount is so high, it might result in precipitating metallic hydroxides. Therefore, PH amount must be controlled during the procedure. Generally, an appropriate PH amount is 6 to 8.

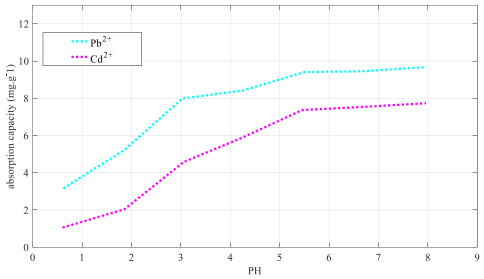

Fig. 4. The influence of PH amount on the absorption capacity

Saturated Potassium tetratitanate whisker's regeneration

The saturated Potassium tetratitanate whisker could be regenerated. The regeneration is accomplished by washing by 5 percent HNO_3, then by filtered water thoroughly (until the solution becomes neutral) and drying. The regenerated Potassium tetratitanate whisker is experimented in the identical situation as earlier. The adsorption experiment outcomes are shown in Table 1. It could be noticed that the adsorption capability of regenerated Potassium tetratitanate whisker is analogous to fresh Potassium tetratitanate whisker.

Table. 1. The absorption capacity of regenerated Potassium tetratitanate whisker

	Main value	Adsorption on fresh Potassium tetratitanate whisker (mg/g)	Adsorption quantity on regenerated Potassium tetratitanate whisker (mg/g)
	60	7	6.9
Pb^{2+}	80	8.5	8.5
	100	10	9.8
	60	7.5	7.5
Cd^{2+}s	80	8.3	8.2
	100	9	8.8

Mechanism of adsorption (IHSC, 1986)

Potassium tetratitanate whisker is comprised of titanium oxide and potassium oxide. It is constructed by combining titanium oxides and potassium oxides in a specific ratio, by a proper calcination flux, and by calcining at 900 – 1100°C. The reaction in calcination is as follows:

$$4TiO_2 + K_2O \rightarrow K_2O \cdot 4TiO_2 \ (In\ terms\ of\ stoichiometry\ K_2Ti_4O_9)$$

Potassium tetratitanate whisker contains a monoclinic system. The Potassium tetratitanate whisker crystal has lattice constants a = 1.825 nm, b = 0.3791 nm and c = 1.201 nm, β = 106.4º, space group C2/m, molecular weight of Potassium tetratitanate whisker is 413.72. In the crystal, titanium has a complicated number of 6 and every titanium atom is covered by 6 oxygen atoms. TiO_6 structures octahedrons and the octahedrons comprise a layer structure with connections every other at apexes or edges, parallel to the crystal whisker axis. The space between every layer is 0.85 nm and K^+ ions remain among the layers.

The ion diameters of some heavy metal ions are demonstrated in Table 2. According to this table, the metal ions are so small in comparison with the layer space of the Potassium tetratitanate whisker crystal (EGIC, 2002). Such that the metal ions can preferably easily interpenetrate to the crystal layer and substitution K^+ ions to form constant metallic/potassium tetratitanates. The metal ions could be eliminated from the water.

Table2. Some factor's diameters

Factor	Control	Diameter of ion (nm)
Ac	+3	0.222
Cd	+1	0.228
	+2	0.194
Ag	+1	0.252
	+2	0.194
Tc	+1	0.288
	+3	0.190
Tl	+1	0.288
	+3	0.190
Pb	+2	0.24
Sc	+3	0.161
Ba	+2	0.27
Co	+2	0.148
	+3	0.126
Ra	+2	0.28
U	+3	0.206
	+4	0.188
	+5	0.174
	+6	0.166
Th	+3	0.216
	+4	0.198
Sr	+2	0.226

The curves of the isotherm adsorption of Pb^{2+} and Cd^{2+} on Potassium tetratitanate whisker is presented in Fig. 6. It demonstrates that $Pb^{2+}$and Cd^{2+} adsorption on Potassium tetratitanate whisker related to an L_2 kind of Gibbs adsorption isotherm curve. Regression of the isotherm adsorption curves of the Following figure utilizing Freundlich logarithm regression forms the linear logarithm equations, just when presented in Table 3. It could be noticed that the Freudlich logarithm regression and the experiment outcome relate remarkably good. The isotherm adsorption constant 1/n of Pb^{2+} and Cd^{2+} are in the range of 0.1 to 0.5, demonstrating the ions absorbent on Potassium tetratitanate whisker is remarkably good (Chen et al, 1990).

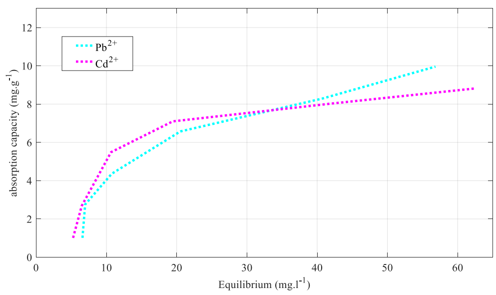

Fig. 6. The absorption isotherm curves of Pd^{2+} and Cd^{2+} on Potassium tetratitanate whisker.

Table. 3. Freundlich logarithm regression of the isotherm adsorption curves.

z	Regressed equation	k	$\frac{1}{n}$	correlative constant
Pd^{2+}	$logq_e = 0.1919 + 0.4809\ \mathrm{logc_e}$	1.5556	0.4809	0.9705
Cd^{2+}	$logq_e = 0.4050 + 0.3010\ \mathrm{logc_e}$	2.5409	0.3010	0.9600

Conclusion

Potassium tetratitanate whisker contains a high adsorption capacity for Pb^{2+} and Cd2+. The adsorption proficiency rises by the amount of Potassium tetratitanate whisker, time, and PH amount. The isotherm adsorption of Pb^{2+} and Cd^{2+} could be forecasted remarkably well by Freundlich logarithm linear Equation. The saturated Potassium tetratitanate whisker could be regenerated. If it could be instantly utilized in sewage treatment, since of the Potassium tetratitanate whisker's small size, it is feasible for causing secondary pollution of the water, and it is hard to be assembled. For avoiding this issue, a potential method is fabricating aggregated granules, like spherule or honeycomb, of Potassium tetratitanate whisker with integrating and calcining by a proper binder material. Study in this field is performed in Shandong University.

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Conflict of interest

The authors declare that they have no conflict of interest.

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