An Ecotechnological Removal System for Fluorine in Water by Using Activated Alumina

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In this study, a novel system of fluoride removal from wastewater was assessed from the viewpoint of "Ecotechnology". The equipment with activated alumina in a column can remove fluoride without increment of any chemical components in treated water. However, this system must be regenerated after activated alumina saturating, in order to minimize the emission derived from it. Then, we proposed an ecotechnological fluoride treatment system, which is composed to combine the adsorption and co-precipitation with aluminum hydroxide, and fluoride was removed as calcium fluoride from the system. As a result, the system is suggested to be very promising because of it's possibility of energy saving and resources saving.

**Key Words**: ecotechnological removal system, fluoride-containing wastewater, activated alumina, minimum emission, chemical equilibrium

1. Introduction

Wastewater containing fluoride is released from various industries, such as metal plating, soldering, semiconductor, glass and fine chemicals industries. Large amounts of Hydrogen fluoride also come from industrial boilers that burn coal, facilities that fabricate aluminum and stainless steel, and agricultural use of phosphate fertilizers1).

In 1999, water environmental quality standards for fluorine was established as 0.8 mg/dm3 in Japan. The effluent standard was also reformed from 15 to 8 mg/dm3 in 2001.

On the other hand, the latest information shows that fluorosis is endemic in at least 25 countries across the globe. The total number of people affected is not known, but a conservative estimate would number in the tens of millions. In 1993, 15 of India's 32 states were identified as endemic for fluorosis. In Mexico, 5 million people are affected by fluoride in groundwater. Fluorosis is prevalent in some parts of central and western China, and caused not only by drinking fluoride in groundwater but also by breathing airborne fluoride released from the burning of fluoride-laden coal. Fluorine problems are very serious in the world.

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2. Materials and Methods

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2.1 Materials and Reagents

Several grades of activated alumina with different particle sizes and different makers were first taken up for the study. After trial and error experiments, taking into consideration the defluoridation capacity of the material and the rate of flow of water through the bed of activated alumina, Activated Alumina KHD-12 (Sumitomo Chemical Co., Ltd.) was selected for further investigation with the experiments. Some characteristics of the activated alumina are shown in **Table 1**.

Total ion strength adjusting buffer solution was prepared by dissolving 11.6 g of sodium chloride and 0.06 g trisodium citrate dihydrate in distilled water, adding 11.4 ml of acetic acid, adjusting pH to 5.2 by sodium hydroxide solution, and diluting to 200 ml by distilled water. Fluoride ion standard solution was prepared by dissolving sodium fluoride with distilled water.

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**Table 1** Characteristics of used activated alumina

Contents of Al2O3 > 99.7 %

Contents of Na2O < 0.26 %

Particle size 1 – 2 mm

Specific surface area 270 m2/g

3. Results and Discussion

Equilibrium relationships for the above equations are:

[Al3+][OH-]3 = Ksp = 1.92×10-32 (8)

[AlOH2+]/[Al3+][OH-] = 9.77×108 (9)

[Al(OH)2+]/[Al3+][OH-]2 = 2.00×1019 (10)

[Al(OH)30]/[Al3+][OH-]3 = 6.31×1026 (11)

[Al(OH)4-]/[Al3+][OH-]4 = 5.01×1032 (12)

[Al(OH)52-]/[Al3+][OH-]5 = 5.62×1035 (13)

[H+][OH-] = KW = 1.01×10-14 (14)

In addition, a mass balance for aluminum in solution must be maintained: The total values so calculated were plotted as a function of pH and are represented by the solid line in **Fig. 2**.



**Fig. 2** Dependency of the total concentration of aluminum on pH at the presence of various amounts of fluoride

4. Conclusion

A novel system for treating fluorine- containing water has been developed in order to minimize the emission from it. The proposed system is expected to be very promising because it is recognized from above results that it is energy saving, resources saving and environmental protection. The system will make a significant contribution to environmental preservation for our country, and to public health for developing countries where drinking water is polluted by fluorine.

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