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Removal of fluoride and turbidity from semiconductor industry wastewater by combined coagulation and electroflotation

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ABSTRACT

Reduction of toxic dissolved fluoride and CaF_2 nanoparticle pollution is a critical environmental problem for the semiconductor industry. In this study, suspended matter and fluoride are simultaneously eliminated by combining coagulation and electroflotation. The EF cell was equipped with DSA titanium coated with ruthenium oxide (Ti/RuO_2) as anode and stainless steel as cathode. High turbidity removal efficiency is achieved by using EF as a separation technique. The effect of the following parameters: electrolysis time, coagulant concentration, initial pH, nature of neutralizing salt and current intensity was studied. Removal efficiencies of both fluoride and CaF_2 nanoparticles are satisfactory. Under optimum conditions, the solid–liquid separation efficiency is about 97% in terms of turbidity removal which corresponds to a residual turbidity of 4.4 NTU complying with the standard limit (5 NTU), while fluoride efficiency removal may reach 73% corresponding to 10 mg/L, which is below the environmental recommendations.

Keywords: Semiconductor wastewater; Fluoride; CaF_2 nanoparticles; Coagulation; Electroflotation

1. Introduction

In semiconductor industry units, such as photovoltaic cell manufacturing and electronics plants, a large quantity of hydrofluoric acid is currently used. It is employed for wafer etching and quartz cleaning operations [1]. The generated acid fluoride-containing wastewaters are characterized by low pH and fluoride concentrations more than 1,000 mg/L [1,2]. The direct discharge of such solutions may represent a huge threat for the environment. The World Health Organization recommended 1.5 mg/L as a limit for fluoride concentration in drinking water. In Algeria, the maximum discharge limit is 15 mg/L in industrial effluent.

The most commonly used method for fluoride removal is precipitation using calcium salt, such as lime or calcium chloride. Fluoride reacts with calcium to form calcium fluoride precipitate as follows:

$$Ca^{2+}_{(aq)} + 2F^{-}_{(aq)} \leftrightarrow CaF_{2(s)} \quad (1)$$

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