Removal of Mn ions from synthetic wastewater by a nanocollector of graphene oxide in ion flotation

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Abstract

Removing heavy metals from wastewater has been one of the main challenges in recent decades, and the ion flotation process has been one of the most effective methods for heavy metals removing. The advantages of ion flotation are its simplicity, requiring less energy, having high recovery and selectivity, and by a low concentration of residual metal in the solution. One drawback of ion flotation is the collector's high consumption. The purpose of this study is to enhance the recovery of manganese ions while minimizing the consumption of collectors. In this study, graphene oxide (GO) prepared as a nanocollector was identified by XRD, DLS, FTIR, and SEM analyses. The effective parameters included pH, GO concentration, air flow rate, impeller speed, and SDS concentration as an auxiliary collector. The results indicated that a pH of approximately 10 is the most effective for removing Mn ions from synthetic wastewater using ion flotation. Other optimal parameters of nanocollector concentration, air flow rate, impeller speed, and SDS concentration are equal to 25 ppm, 800 rpm, 2 L/min, and 43 ppm, respectively. Under these conditions, the recovery of Mn ions from synthetic wastewater and water recovery were 82.6% and 45%, respectively. The results of this study demonstrated that utilizing GO as a nanocollector in the ion flotation method for wastewater treatment has significant advantages such as high removal recovery, reduction of collector consumption, reusability of GO.

Keywords

Ion flotation, Mn ion recovery, Water recovery, Graphene oxide, Nanocollector.

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1. Introduction

Sebba initially proposed ion flotation as a method to remove and separate aluminum ions. In ion flotation, the target metal ions (colligends) are absorbed by the hydrophilic functional groups of the collector with the opposite charge, adhere to the dispersed air bubbles, form insoluble sediments (sublates) or soluble complexes, and then are transferred to the foam phase by the air bubbles [1-3].

Manganese is a heavy metal ion that is essential for human health and is considered a pollutant when present in large amounts in the environment. Various industries widely use manganese compounds. Ion flotation has reduced heavy metal concentrations in aqueous solutions in numerous studies, but manganese ion flotation has received relatively little attention [4].

An ascribed drawback of ion flotation is the excessive consumption of the collector, so the ratio of the collector concentration to the ion concentration must be at least a one-to-one stoichiometric ratio, which increases the collector consumption in the process. The advantages of utilizing nanocollector for the removal of ions from wastewater include simple synthesis, low cost, high efficiency, stability in aqueous solutions, and collector consumption. Research indicates that the utilization of graphene oxide (GO) and functionalized GO as nanocollectors has been successful in removing heavy metal ions (lead, nickel, copper, cadmium, and zinc ions) from synthetic wastewater [5, 6].

Peng et al. were able to remove more than 99% of lead ions from synthetic wastewater using GO as a collector [7]. Hosseinian et al. used AFGO as a nanocollector in nickel ion flotation, and they were able to remove almost 100% of nickel ions from synthetic wastewater [5]. Peng et al. removed more than 99% of copper ions from wastewater by ion flotation using AMID@GO as a nanocollector [8]. Peng et al. used IDA@GO as a nanocollector for selective recovery of lead ions from electrolytic effluent via ion flotation [9]. Hosseinian et al. used FGO to remove heavy metal ions such as copper, lead, nickel, cadmium and zinc [10]. Sobouti et al. used GO as a nanocollector to remove Zn ions from synthetic wastewater via ion flotation [11].

The first purpose of this research is to investigate the efficiency of Mn ion removal from synthetic wastewater using GO as a nanocollector in order to reduce collector consumption in ion flotation. Additionally, the effect of various parameters such as pH, nanocollector concentration, air flow rate, impeller speed, and SDS concentration, on the recovery of Mn ions and water recovery has been investigated.

2. Methodology

This study utilized GO as a collector, sodium dodecyl sulfate (SDS) as an auxiliary collector, $Mn(NO_3)_2.2H_2O$ to create synthetic wastewater with a concentration of 25 ppm, and sodium hydroxide (NaOH) and hydrochloric acid (HCl) to regulate the pH.

3. Results and Discussion

3.1. Characterization of GO

The X-ray diffraction pattern of GO before Mn ions adsorption in ion flotation process is shown in Figure 1. The diagram shows that the characteristic peak of GO is at an angle of 2θ=12.3, which indicates the distance between the graphene layers.

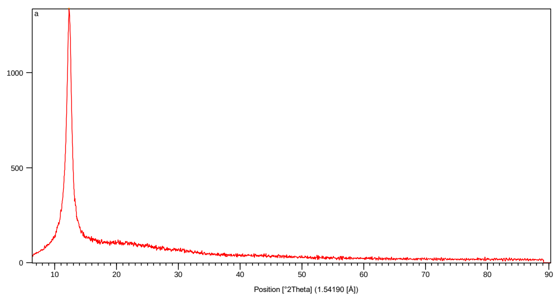

Figure 1. XRD diffraction pattern of GO

Figure 2 shows the zeta potential of GO. According to Figure 2, GO has a negative zeta potential, and the zeta potential exhibited a greater negativity as the pH increased within the tested pH range.

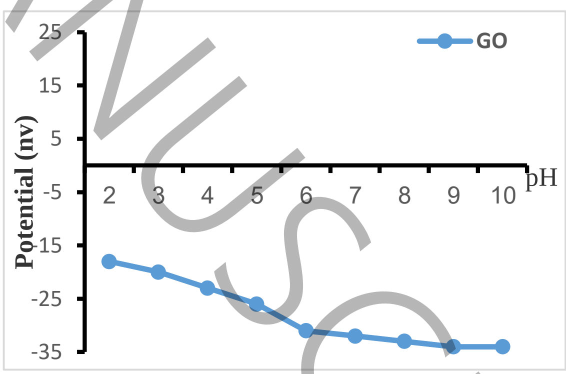

Figure 2. Zeta potential of GO

3.2. Chemical Parameters

Based on the results, the utilization of GO as a nano-collector in the removal of Mn ions from synthetic wastewater in the ion flotation procedure offers. Under optimal conditions, the following conditions were found to be optimal for the recovery of Mn ions from synthetic wastewater: a concentration of GO: 25 ppm as a nanocollector, a pH of 10, a concentration of 43 ppm of

SDS as an auxiliary collector, an impeller speed of 800 rpm, and an air flow rate of 2 L/min. In these conditions, the recovery for Mn ions was 82.6%, and the water recovery rate was 45%.

The scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX) analyses of GO before and after ion flotation are depicted in Figure 3 (a) and (b). The EDX analysis indicates that the GO sample before ion flotation comprises oxygen (O) and carbon (C) atoms, while the GO sample after ion flotation comprises manganese (Mn), oxygen (O), and carbon (C) atoms, confirming the absorption of manganese ions by GO.

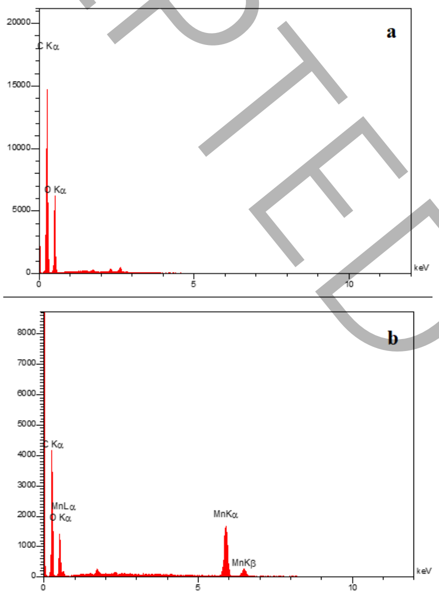

Figure 3. EDX analysis of GO (a) before and, (b) after ion flotation

4. Conclusion

Research results in the field of ion flotation have limited the application of ion flotation on an industrial scale due to the high consumption of the collector. This study used a GO nanocollector to remove manganese ions from synthetic wastewater, overcoming this limitation. The results showed that under the optimal conditions of pH=10, GO nanocollector concentration: 25 ppm, air flow rate: 2 L/min, stirring speed: 800 rpm, and sodium dodecyl sulfonate concentration: 43 ppm, the percentage of manganese ion recovery and water recovery were 82.6 and 45 percent, respectively.

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