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The effect of PAX/CMC addition order on chlorite/pyrite separation

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ABSTRACT

Addition order of both PAX (potassium amyl xanthate) and CMC (carboxymethyl cellulose) was investigated to separate pyrite from chlorite. The investigation included both flotation and adsorption tests. The flotation results showed that CMC can depress the flotation of chlorite but was found not to be selective against pyrite. When pyrite was conditioned initially with PAX before CMC it was found that the CMC slightly depressed pyrite flotation. The depression effect of CMC on pyrite was significantly higher when pyrite was conditioned first with CMC before PAX. Flotation of chlorite was not influenced by order of addition of CMC and PAX. Adsorption tests showed that CMC and PAX compete in adsorbing on pyrite and the adsorption density of PAX decreases in the presence of the pre-adsorbed layer of CMC. PAX was found not to adsorb onto chlorite irrespective if chlorite was conditioned initially with or without CMC. Therefore there was no competitive adsorption on chlorite surface between PAX and CMC. PAX can assist to protect the pyrite surface when conditioned initially first and allow the benefits of CMC depression for chlorite.

1. Introduction

Chlorite is a magnesium rich phyllosilicate mineral that occurs as gangue component of many metal sulphide ore deposits around the world. Chlorite may report to the flotation concentrate, thus reducing concentrate grade (Fornasiero and Ralston, 2005). Being a magnesium silicate type gangue mineral, large quantities of chlorite in flotation concentrates can cause problems during smelting. Chlorite depression in oxide and sulphide flotation can be achieved using reagents typically used for the depression of silicate minerals, such as Na_2SiO_3, CMC and fluorocompounds. CMC is a commonly used silicate depressant and not surprisingly has been used in separating sulphide minerals from gangue containing chlorite (Silevster et al., 2011).

In order for CMC to exert its depression effect it must first adsorb on the surface of the mineral. The mechanisms of adsorption of CMC onto minerals have been widely studied and various mechanisms have been proposed. Due to the multitude of binding mechanisms through which CMC can interact and adsorb onto surfaces (Healy, 1974), it is almost inevitable that the depressant will adsorb on the sulphide minerals and affect flotation collection (Bicak et al., 2007; Pugh, 1989). Thus, the investigation of ‘blocking agents’ to protect the sulphide surface and allow the benefits of CMC depression for chlorite without depressing sulphide is imperative. However, little work has been performed to improve depression selectivity when CMC was used as depressant.

Xanthate is a commonly used collector for pyrite flotation and has been found not to interact directly with chlorite (Fornasiero and Ralston, 2005). Several authors proposed that pyrite flotation occurs by a mechanism that involves the oxidation of iron at the surface to ferric and the subsequent adsorption of ferric xanthate at the surface (Leppinen, 1990; Mielczarski, 1986; Sheikh and Leja, 1977; Wang et al., 1989; Wang and Forssberg, 1991). As both the carboxymethyl groups and hydroxyl groups of CMC can also interact with pyrite surface iron sites (Bicak et al., 2007), it is likely that PAX and CMC will compete for the same adsorption sites on pyrite surface.

In the present work, addition order effects between PAX and CMC were investigated to determine if the depression effect of CMC on pyrite was affected by the presence of a pre-adsorbed layer of PAX. The mechanism of addition order effects was also studied providing a reference for further study.

2. Materials and methods

2.1. Samples and reagents

The chlorite used for all experiments was obtained from Haicheng, Liaoning Province, China. Mineralogical and X-ray powder diffraction data confirmed that the chlorite sample was of high purity with trace amounts of talc. Pyrite was obtained from Yunfu, Guangdong Province, China. The result of chemical analysis showed that the composition included Fe 44.96% and S 52.98%. The samples were dry ground and screened through 150, 75 and 37 μm series sieves. The −37 μm size fraction was used for the

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adsorption studies and the −150 + 75 μm fraction was used for the flotation tests. The BET surface areas of the size fraction of −37 μm pyrite and chlorite were 3.34 $m^2\ g^{-1}$ and 7.88 $m^2\ g^{-1}$, respectively. The chlorite sample was stored in an amber bottle over desiccant and the pyrite sample was stored in a vacuum-desiccator. The pyrite was washed in ultrasonic bath for 3 min to remove potential oxidation film before each use.

The sample of CMC used in the study was obtained from Tianjing Kermil Chemical Reagents Development Centre, Tianjing, China. The DS (degree of substituent) of CMC is 0.9 and the molecular weight is 700,000. The CMC solution was prepared by dispersing a known weight of sample in cold distilled water and then dissolved it in boiling distilled water. The solutions were prepared fresh each day. Potassium nitrate was used to maintain the ionic strength and HCl (hydrochloric acid) and KOH (potassium hydroxide) were used as pH regulators. All the reagents used in this study were of analytical grade. Deionized double distilled water was used for all tests.

2.2. Experiments

2.2.1. Flotation tests

Single mineral flotation tests were carried out in an XFG flotation machine with a 40 mL flotation cell, with the impeller set at 1800 rpm. The mineral suspension (either pyrite or chlorite) was prepared by adding 2.0 g of minerals to 40 ml of solutions. The pH of the mineral suspension was adjusted to a desired value by adding KOH or HCl stock solutions. The required volume of CMC was added before conditioning for 10 min for adsorption to occur. The Potassium amyl xanthate (PAX) was added either before or after CMC and conditioned for 3 min. The frother MIBC (Methyl Isobutyl Carbinol) was then added to the slurry and conditioned for 2 min before the commencement of flotation. Flotation was allowed for a total of 4 min. The floated and unfloated particles were collected, filtered and dried. The flotation recovery was calculated based on solid weight distributions between the two products.

For mixed mineral flotation, 2.0 g of pyrite was taken, and the surface was cleaned by using supersonic cleaner. The suspension was then transferred to a conditioning cell and made up to the required volume. 2.0 g of chlorite was then thoroughly mixed into the suspension and the suspension mixed for a total of 3 min. The flotation procedure was the same as the single mineral flotation tests.

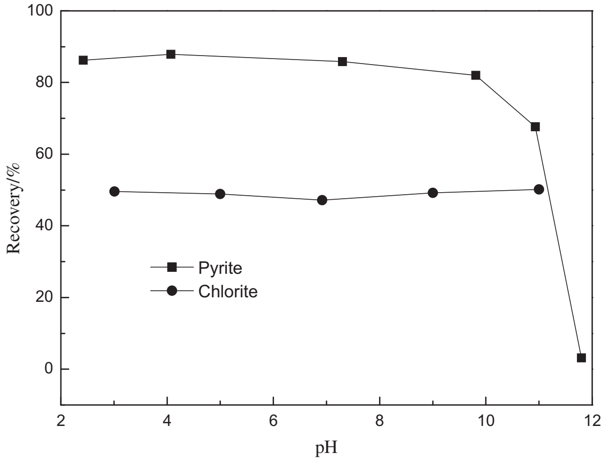

Fig. 1. Effect of pH on the flotation recovery of chlorite and pyrite in the absence of CMC (c(PAX) = 1 × 10^{-4} mol/L and c(MIBC) = 1 × 10^{-4} mol/L).

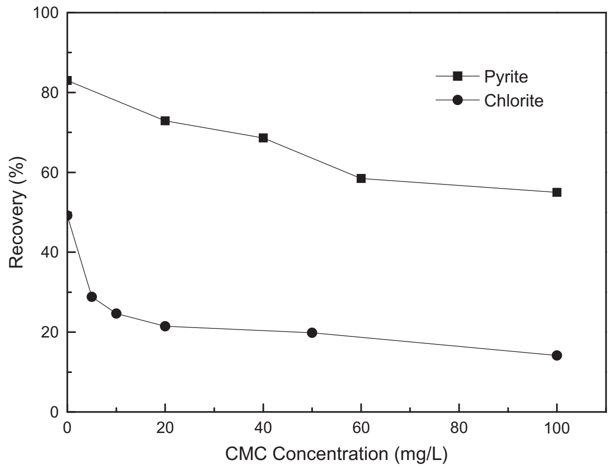

Fig. 2. Effect of CMC concentration on the flotation recovery of chlorite and pyrite (pH = 9.0, c(PAX) = 1 × 10^{-4} mol/L and c(MIBC) = 1 × 10^{-4} mol/L).

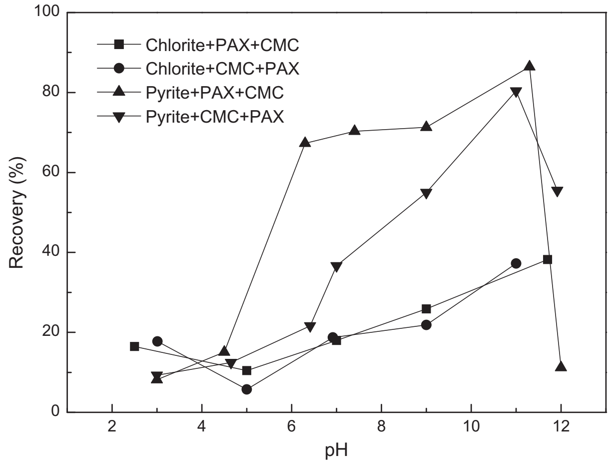

Fig. 3. Effect of the order of reagent addition on the flotation of chlorite and pyrite (c(CMC) = 100 mg/L, c(PAX) = 1 × 10^{-4} mol/L and c(MIBC) = 1 × 10^{-4} mol/L).

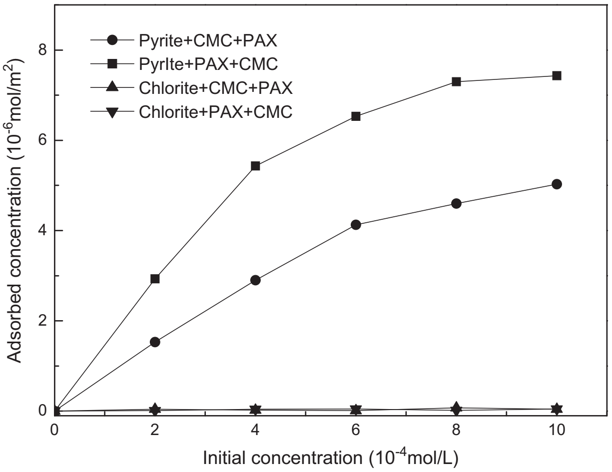

Fig. 4. Adsorption isotherms of PAX on chlorite and pyrite.

2.2.2. Adsorption studies

For the adsorption tests, 1 g of mineral powder was taken and made up to 100 ml after addition of desired concentration of PAX