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Original Article

The settling behavior of quartz using chitosan as flocculant

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ABSTRACT

The settling behavior of quartz using chitosan as flocculant has been studied and the mechanism has been discussed. The sedimentation results show that pH has an influence on the settling behavior of quartz particles and the sedimentation velocity is more quickly at acidic pH range. Chitosan is a useful flocculant for the settling of quartz but its flocculation effect is influenced greatly by pH. The sedimentation velocity of quartz is quickly and the volume of sediment is large when chitosan was added at pH 9. The reason is that chitosan is only sparingly soluble in water at pH 9, thus the adsorption amount is large and produce strongly flocculation effect. However, when the pH was changed from 9 to 3, the adsorbed chitosan desorption from quartz surface and the flocculation effect disappeared. The flocs were disorganized to the particles and the sediment can be consolidated to significantly higher densities.

1. Introduction

Because of the very slow settling of fine solids in the tailing ponds, it is necessary to flocculate fine particles to produce more rapid settling and easy removal of the solids by gravity in the tailings treatment process [1]. Over the last several years, many attempts have been made to realize the fast solid liquid separation. This includes the addition of excess electrolyte (coagulation), the addition of a high molecular weight polymer (bridging flocculation) and change of pH [2–5]. Bridging flocculation is extremely important in mineral tailings disposal. However, polymeric flocculants, which are widely used in the flocculation of tailings have the drawback that the flocs contain large amounts of water which cannot be easily removed. To solve this problem, stimuli-responsive polymers were used in the solid liquid separation process [6–10].

In recent years, much interest has been focused on polymer systems that show a phase transition in response to external stimuli such as temperature, pH, ionic strength, and electric potential because of their scientific or technological importance [11–14]. A temperature-sensitive polymer, poly(N-isopropylacrylamide) has been widely used in settlement process and improved dewatering efficiency by producing

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both fast sedimentation of fine particles (by aggregation) and dense (low moisture) sediment beds and filter cakes [15–17]. However, it is necessary to heat the slurry above the critical solution temperature to achieve fast sedimentation of fine particles, which will waste a lot of energy [18].

The settling behavior of quartz using chitosan as flocculant has been studied and the mechanism has been discussed in this paper. The aim of this paper is to provide a novel solid/liquid separation reagent, which is sensitive to the change of pH.

2. Materials and methods

2.1. Pure minerals and reagents

Pure quartz was sourced from Jiangxi, China. X-ray powder diffraction data confirmed that the quartz was 99% pure (Fig. 1). The sample was dry ground and screened. The −20 μm fraction was used in the settling tests and adsorption tests. Samples further ground to −2 μm in an agate mortar were used for zeta potential measurements.

The sample of chitosan (molecular weight is 250,000 mol/l and degree of deacetylation ≥95%) used in this study was obtained from Shanghai Civi Chemical Technology Co., Ltd. Hydrochloric acid (HCL) and sodium hydroxide (NaOH) were used as pH regulators. Deionized water was used for all tests.

2.2. Sedimentation tests

For the sedimentation tests, 1 g of sample was taken and made up to 100 ml after addition of distilled water in a beaker. Then desired amount of chitosan was added to the suspensions and agitated for half an hour using a magnetic stirrer at different pH, and then transferred to 100 ml graduated cylinders. As soon as the cylinder was placed on a flat solid surface, the settling test began and no further disturbances were allowed. The descent of the solids/liquid interface (mud line) was carefully observed and recorded as a function of settling time. Photographs were also taken of the settling suspensions periodically, initially every few min, then every few hours.

2.3. Adsorption tests

For the adsorption tests, 1 g of mineral powder was taken and made up to 50 ml after addition of desired concentration of chitosan solution in 250 ml Erlenmeyer flasks. The suspensions were mixed and placed on a rotator for 1 h, ensuring that the adsorption process had reached equilibrium. Each sample was then centrifuged and the concentration of chitosan remaining in the supernatant is measured by determining the total organic carbon (TOC) in the supernatant and comparing the value to a known calibration standard.

2.4. Zeta potential measurements

For these measurements, a mineral suspension was prepared by adding 1 g mineral to 50 ml of 10^{-3} M potassium nitrate solution and magnetically stirred for 10 min and the pH adjusted using HCl or NaOH. The zeta potential of samples was then measured using a zeta potential meter.

3. Results and discussion

3.1. The settling behavior of quartz at different pH

The effect of pH on the settling behavior of quartz was studied and the results are shown in Fig. 2. It is evident from Fig. 2 that pH has influence on the sedimentation velocity of quartz and the quartz particles settling more quickly at pH 3. The reason is that the surface charge of quartz increased with the increase of pH, and so is the electrostatic repulsion force between quartz particles.

Fig. 3 shows the effect of chitosan amount on the settling behavior of quartz at pH 3. It is evident from Fig. 3 that the addition of chitosan increased the sedimentation velocity of quartz, but the sedimentation velocity is still slow. A large number of fine particles are still suspended when the settling time is 30 min. The results also show that when the chitosan amount increased from 300 mg/L to 600 mg/L, the sedimentation velocity of quartz decreased. This is due to the fact that adsorption of chitosan makes the quartz particles have more

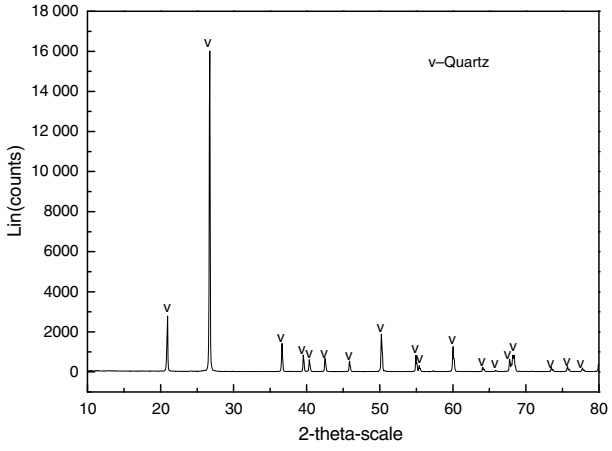

Fig. 1 – XRD diagram of quartz.

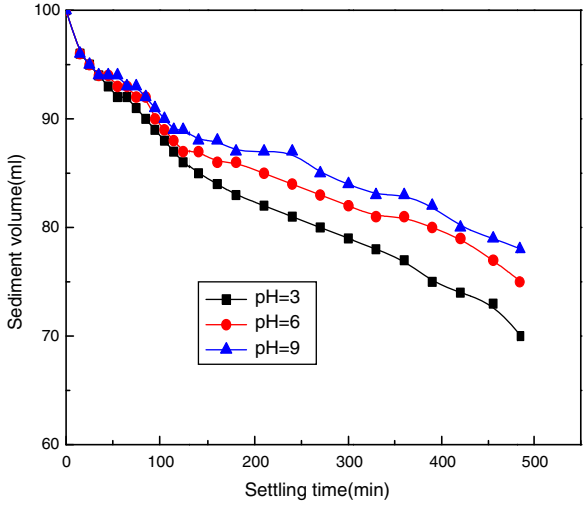

Fig. 2 – Effect of pH on the settling behavior of quartz.

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