

Study on Influencing Factors of Sodium Modification of Bentonite

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Abstract. Bentonite, a new class of layered compounds, displayed a broad application prospects in catalyst supports. The influencing factors of sodium modification on bentonite were studied in this paper. The bentonite obtained the best charater after the 10% bentonite slurry was treated by 3% Na₂CO₃ at 60°C for 1.5h. It can be seen that the swellvalue increased from 19.7 ml/g to 86.2 ml/g, the blue absorption power from 28.8 g/100g to 43.6 g/100g and the cationic exchange capacity from 0.384 mmol/g to 1.026 mmol/g. The X-ray Diffraction showed the interlayer space changed from 1.4321 nm to 1.229 nm. All the results meant that the Ca-bentonite had been modified into Na-bentonite and obtained good expansibility and dispersibility.

1. Introduction

With the progress of science and technology, the requirements of bentonite are getting higher and higher. In China, bentonite reserve ranked first in the world. But most of them was Ca-bentonite^[1]. It contained some non-montmorillonit components such as quartz, feldspar, cristobalite and other impurities, resulting that further purification was needed for bentonite to make better use^[2]. The Na-bentonite, having larger specific surface area, higher cationic exchange properties, better physical properties, had broader market prospects. Ca-Bentonite could be modified by ion exchange to prepare Na-bentonite^[3]. The Na-bentonite has better water absorption and expansibility in an aqueous medium dispersion. And also its colloidal suspensions thixotropic and thermal stability were better than Ca-bentonite^[4]. The application of Na-bentonite was more widely Ca-bentonite. The study on sodium modification of bentonite was of great significance for the preparation of Na-bentonite with high performance.

In this paper, the influencing factors of sodium modification were studied. The obtained Na-bentonite was characterized by X-ray diffraction (XRD) and scanning electronic microscopy (SEM).

2. Experimental

2.1 Materials

Na₂CO₃, HCl, Na₄P₂O₇, MgO, Methylene blue, NH₄Cl, NH₃.H₂O, ethanol absolute, formalin, CaCl₂ and phenolphthalein were supplied by Tianjin Kemiou Chemical Reagent Co. Ltd. All chemicals were of analytical reagent grade and used without further purification.

Bentonite was obtained commercially and was used without any further purification.

2.2 Influencing factors of sodium modification

The experiments for the influencing factors of sodium modification were as follows. Firstly, the bentonite was added into a certain amount of water and stirred for 2hr at 60°C. Secondly, amount of Na₂CO₃ was added into the slurry in an Erlenmeyer flask and shaken for some hour at some temperature. Lastly, the slurry was filtered by filter paper after standing for 20 minutes and washed with distilled water and dried at 85°C for 16hr. Finally, the dried solid was ground and sieved to obtain a fraction passing through 200 mash screen.

In this paper, the dosage of sodium agent, reaction time, slurry concentration and reaction temperature were studied.

2.3 Characterization

The swellvalue, the blue absorption power and the cationic exchange capacity (CEC) were examined by GB/T 20973-2007, which was published on June 22, 2007 in China. The XRD was done in a 'Bruker D8 Advance' device, which operates with Cu K α radiation that ranged between 5° and 40°. The SEM was done in a 'FEI Quanta 200' device, which delivered with a 50 mm (2 inch) motorized stage (X/Y travel), with a motorized z-range of 25 mm.

3. Result and Discussion

3.1 Effect of the dosage of sodium agent

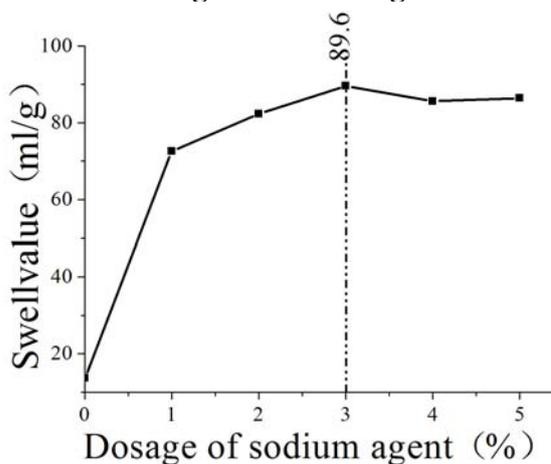


Fig.1. Effect dosage of sodium agent on the quality of Na-bentonite

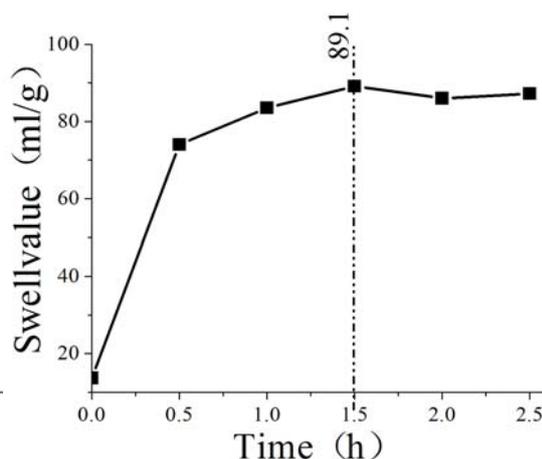


Fig.2. Effect of the reaction time on the quality of Na-bentonite

The influence of the dosage of sodium agent in sodium modification was illustrated in Fig.1. The swellvalue increased as the amount of Na₂CO₃ increased, when the dosage of sodium agent was less than 3%. The reaction was driven by the difference of ions concentrations. Only if the concentration of Na⁺ was greater than the amount of Ca²⁺ and Mg²⁺, could the sodium modification react completely. The swellvalue decreased slightly, when the dosage of sodium agent was more than 3%. Because the equilibrium of ion exchange between Ca²⁺ and Na⁺ was destroyed, the effect of more sodium agent on the sodium modification was poor. Therefore, the best dosage of Na₂CO₃ was determined to be 3%.

3.2 Effect of the reaction time

Enough time was important to complete the sodium reaction. The swellvalue increased quickly, when the time was less than 0.5hr (Fig.2). It reached the highest value, when the time was 1.5hr. When the slurry was treated for more than 1.5hr, the swellvalue began to decrease. It could be seen 1.5hr was the best time for sodium modification. More time would destroy the equilibrium of ion exchange. In addition, the sample would become worse dispersibility and more difficult to dewater if the slurry was treated for a longer time.

3.3 Effect of the slurry concentration

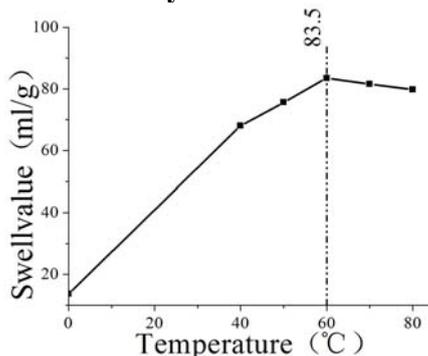


Fig.3. Effect of the slurry concentration on the swellvalue of Na-bentonite

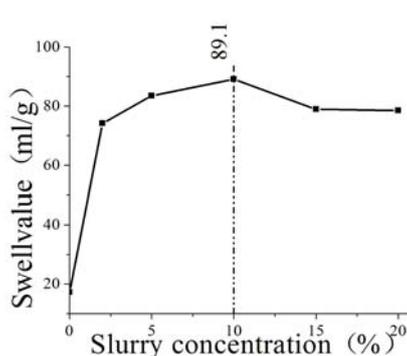


Fig.4. Effect of the reaction temperature on the swellvalue of Na-bentonite

The effect of slurry concentration on the swellvalue was shown in Fig.3. The highest swellvalue was obtained when the slurry concentration was 10%. The low concentration would increase the load during the subsequent dehydration process. When the slurry concentration was more than 10%, the liquidity of the slurry would become poor and it was hard for the slurry and ion Na^+ to contact effectively. In consequence, the most suitable slurry concentration was chosen to be 10%.

3.4 Effect of the reaction temperature

The temperature had a vital affect on the ions' movements. The higher was the temperature, the active was the ion. If the temperature began to increase from a low temperature, the moving rate of the ions increased quickly and also the viscosity decreased rapidly. The equilibrium between Ca^{2+} and Na^+ required short time, helping the sodium modification to complete in a short time. It could be seen in Fig.4 that the swellvalue increased when the reaction temperature was lower than 60°C . At the same time, the higher was the temperature, the greater the ionization of Ca^{2+} was. If the temperature was higher than 60°C , the ionization Ca^{2+} would become a key factor and the ion equilibrium between Ca^{2+} and Na^+ moved to Na^+ . More Na^+ desorbed from the bentonite, resulting in the decrease of the swellvalue. As a consequence, the best reaction temperature was determined to be 60°C .

3.5 Characterization

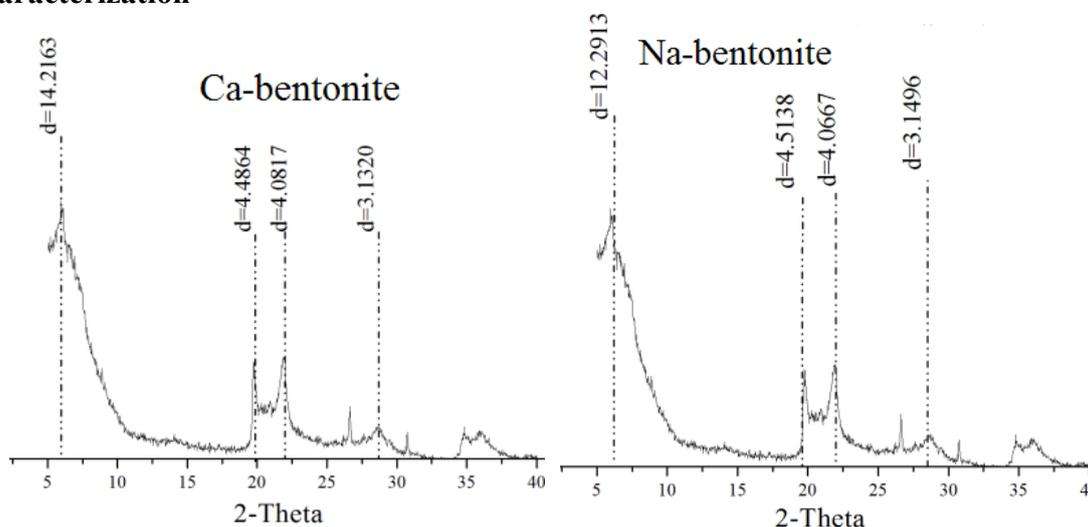
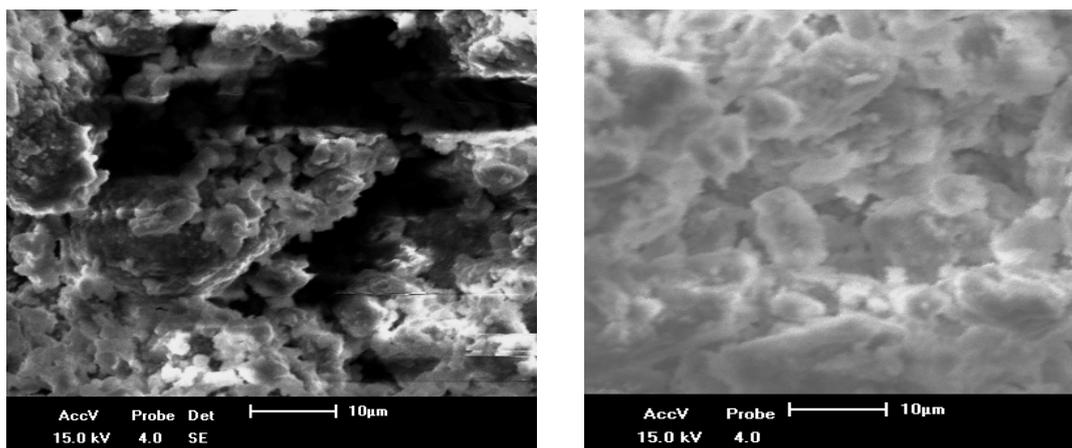


Fig.5. XRD patterns of Ca-bentonite and Na-bentonite

The raw bentonite was modified under the determined conditions. The character of Na-bentonite was shown in Table 1. The XRD (Fig.5) patterns shown that $d_{(001)}$ had changed from 1.421nm to 1.229nm, showing that Na-bentonite was obtained by the modification of the Ca-bentonite. Fig.6 was the SEM photos of bentonite. It could be seen that Na-bentonite had better expansibility and high dispersibility than Ca-bentonite. The particles were decomposed into thin wafers, showing an aggregate of petals and had obvious characteristics of layer and flake on the edge. Some part of the edge showed serration. Conclusion could be drawn that the bentonite obtained high purity and good performance after sodium modification. The content of montmorillonite increased from 65.1% to 98.6%.



Ca-Bentonite

Na-bentonite

Fig.6. SEM photos of bentonite

Table.1 Character of bentonite

Character	Ca-bentonite	Na-bentonite
Swellvalue (ml/g)	19.7	86.2
Blue absorption power (g/100g)	28.8	43.6
CEC (mmol/g)	0.384	1.026

4. Conclusions

Na-bentonite was obtained by the modification of commercial Ca-bentonite. Na_2CO_3 was chosen as the sodium agent and its dosage was determined to be 3%. The 10% slurry was treated at 60°C for 1.5h, resulting that the swellvalue increased from 19.7 ml/g to 86.2 ml/g, the blue absorption power from 28.8 g/100 g to 43.6 g/100 g and the CEC from 0.384 mmol/g to 1.026 mmol/g. The XRD showed the interlayer space changed from 1.4321 nm to 1.229 nm. The SEM photos showed the Na-bentonite could obtain good expansibility and dispersibility. This experiment laid a good foundation for the preparation of pillaring bentonite.

Acknowledgements

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