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Research of novel composite drilling grade bentonite

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Abstract. To improve the performance of sodium-modified bentonite in drilling fluids, the natural Ca-base bentonite (Ca-Bent) was modified by microwave wet, which regarded the anionic surfactant SDBS is compounded with inorganic sodium salt as modifier. The effects of different sodium salts, the volume of modifier, the ratio of SDBS to inorganic sodium salt, temperature and time on the modification of bentonite were studied. Moreover, the applicability of modified bentonite in drilling fluid was also evaluated. The result showed that the optimized experimental parameters are obtained as follows: SDBS to Na_2CO_3 ratio 1:1.5, modified volume 50ml, radiation time 3 mins, and initial temperature 50℃. Under the optimization conditions, the modified bentonite has a swelling volume of 45mL/g. And the pH of 8, the plastic viscosity of 18 mPa·s, yield point and plastic viscosity ratio of 0.25 and sand content less than 0.5% respectively. So, the modified bentonite is regarded as excellent drilling grade bentonite.

Introduction

At present, the rheology and filtration are difficult to controll, so the original drilling fluid additives and drilling fluid system cannot fully meet the deep and ultra-deep well drilling technology development needs. Therefore, the scientists all over the world have been investigating treating agent or drilling fluid system of excellent performance. As an integral part of drilling fluid system, modification and improvement of applicability is very important for bentonite.[1] On that basis, M.Mohammadi et al[2] studied the viscosity of a nanoclay suspension which was produced from bentonite supplied by Kheirabad mine in Kerman (Iran) showed that Kheirabad modified clay had good behavior for drilling purposes at optimum clay concentrations. Luciana Avelino Ratkievicius et al[3] modified bentonite by quaternary cationics showed the method could disperse the bentonite in the organic phase of a vegetable-oil-based drilling fluid.

Materials and methods

Ca-Bent (200 mesh) was obtained from Heishan Wancheng bentonite Co, Ltd of Liaoning Province (China). The swelling volume of the bentonite is about 15mL/g. Na_2CO_3, NaOH, SDBS and absolute ethanol (analytical reagent) from Sinopharm Chemical Reagent Co, Ltd. (Shanghai, China) were used in this study. Besides, the in the experiment included MAS type microwave synthesis/extraction reaction workstation and ZNN-D6B electronic six speed rotary viscometer.

Preparation. The natural Ca-Bent was modified by microwave wet method, firstly, 5g natural Ca-Bent samples and modifier prepared into suspension, next the suspension was poured into a microwave reaction vessel. After keep 30 minutes, the suspension was placed in a microwave device for reaction. In particular, the electromagnetic stirring speed was controlled at 500r/min, and the microwave power is at 400W. Then, the product was placed in drying box, dried at 80℃, milled and screened, and 140 meshes of powder were obtained.

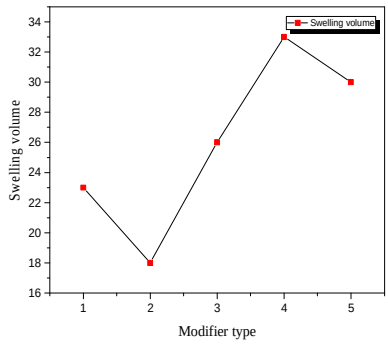
Measurement. The modified bentonite and Na-based bentonite for drilling were measured according to API SPEC 13A-2010 Specification for Drilling Fluid Materials. The test parameters

included viscosity, expansion capacity, sand content and pH, etc.

Result and discussion

Determination of optimal conditions

The Ca-Bent was modified in this experiment by Na_2CO_3, NaOH, SDBS, SDBS+Na_2CO_3 and SDBS+NaOH. As shown in Fig1, modified effect of SDBS+Na_2CO_3 was the best, it is probably because the anionic surfactant improve the surface activity of Ca-Bent. Besides, the modification of bentonite in weak alkaline conditions is easier than others, so it is better than NaOH.



Note:
1-Na_2CO_3; 2-NaOH; 3-SDBS; 4-Na_2CO_3+SDBS; 5-NaOH+SDBS.

Fig 1 Effect of different modifiers on modification

According to modified effect of SDBS+Na_2CO_3 was the best, following work fixed the amount of SDBS and gradually increased the amount of Na_2CO_3. It can be seen from Fig 2 that the swelling volume of bentonite increased gradually with the increase of Na_2CO_3. it is presumed that the special layered structure is enlarged by modified agent. When the ratio of SDBS to Na_2CO_3 was 1:1.5, the swelling volume of bentonite reached the highest value of 36mL/g. And when the amount of Na_2CO_3 increased, the swelling volume of bentonite decreased rapidly. It is probably that there will no more space for inhaled water molecule because sodium ions and organic ions have occupied the interlayer of bentonite, which results in the decrease of the swelling capacity. Finally, the optimum ratio of SDBS to Na_2CO_3 was chose as 1:1.5.

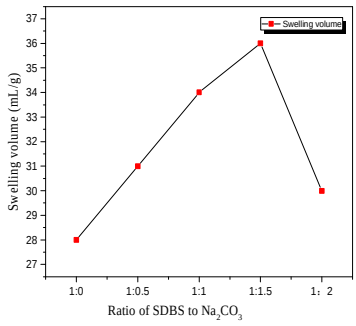


Fig 2 Effect of ratio of SDBS to Na_2CO_3 on modification

As can be seen from Fig 3. At first, the curve showed a quick upward trend, when the modifier volume was 50mL, the maximum swelling volume was 36mL/g, afterwards the curve suddenly dropped, then the downtrend is slow at length. It is probably that too much ion, and the bentonite has no enough ion to exchange.

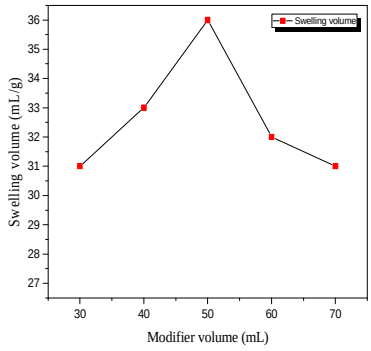


Fig 3 Effect of different modifiers volume on sodium modification

It can be seen from Fig 4, with the increase of temperature, the swelling volume of bentonite slightly increased, then it sharply increased. When the temperature reached 50℃, swelling volume of bentonite had a maximum 36mL/g. Subsequently, the swelling volume of bentonite quickly declined, then the trend was gentle. It is proposed that high temperature will break the balance of Na^{+} (of Na_2CO_3 and SDBS) and Ca^{2+} (of bentonite), so the swelling capacity will decrease.

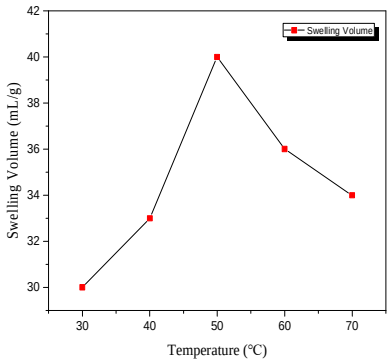


Fig 4 Effect of microwave temperature on modification

As can be seen from Fig 5. At first, the curve showed a slow upward trend, then the rate of rise suddenly accelerated, when the microwave time was 3min, the maximum was 41mL/g, afterwards the curve suddenly dropped, the downtrend is slow at length. It is probably that the surface was modified at the beginning of the process, With the increase of time, temperature of reaction sharply increased, which lead to strong molecular thermal motion. If the time continue to extend, ion exchange equilibrium reaction will be breached.

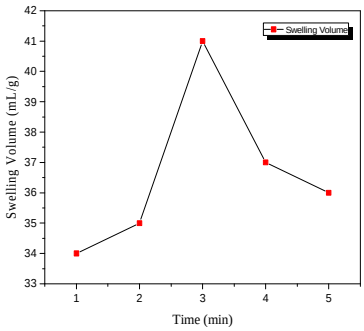


Fig 5 Effect of microwave irradiation time on modification

In summary, the optimal condition of modified Ca-Bent includes the ratio of SDBS to sodium carbonate is 1:1.5, the modifier volume is 50ml, the initial temperature is 50°C, and the modification time is 3min.

Coarse test of drilling grade bentonite

Under the optimization conditions, the modified Ca-Bent has a swelling volume of 45mL/g, PH of 8, the plastic viscosity of 18mPa·s, yield point and plastic viscosity ratio of 0.25 and sand content less than 0.5%, respectively. It can be seen the modified bentonite has well expansibility and rheology. Thus, the drilling fluid system has the best lifting capacity due to the modified bentonite.

Conclusion

(1) Bentonite modified by SDBS and Na_2CO_3 has the best effect.

(2) The optimum conditions are as follows: the ratio of SDBS to Na_2CO_3 is 1:1.5, the modifier volume is 50ml, the initial temperature is 50℃, and the modification time is 3min.

(3) The Ca-Bent was modified by anionic surfactant SDBS and Na_2CO_3 has good tactility and lubrication, and is higher than API drilling grade bentonite standard.

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