

Research on the effect of drilling fluid's pH value on the coal's wettability

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Abstract Drilling fluid contacts with the surface of coal and fractures fully during the drilling process for CBM, its pH value has direct impact on the wettability of coal, affecting the seepage of CBM further. Therefore, the research about the effect of drilling fluid's pH value on the coal's wettability has important practical significance. The influence law of drilling fluid's pH value on the coal's wettability was studied through lots of experiments, the results showed that the wettability was related to the pH value of drilling fluid, decreases firstly, increases secondly and decreases at last, the coal's hydrophilicity was the weakest at the pH value of 9, and the hydrophilicity of coal was weaken further after the addition of surfactants. The conclusions provide strong technical guidance for selecting drilling fluid and optimizing fluid performance, and it helps to protect the reservoir and increase CBM production.

Keywords pH value · Wetting height · Hydrophilicity · Surfactant

Introduction

Drilling fluid contacts with the surface of coal and fractures fully during the drilling process for CBM, its pH has direct impact on the wettability of coal, affecting the seepage of CBM further (Zhang and Wang 2000). Therefore, the

drilling fluid's pH value is an important performance index, and it is an important subject to do research about the effect of drilling fluid's pH value on the wettability of coal, to design the scientific scheme for protecting CBM reservoir effectively and to obtain the maximum of production. In order to solve this problem, the paper discusses the change law of coal's wettability changing with the drilling fluid's pH value combined with the experiments of pulverized coal's self-priming, which has important practical significance for selecting drilling fluid and optimizing fluid performance, and it contributes to protect the CBM reservoir and increase the production of CBM.

The effect of drilling fluid's pH value on the coal's wettability

Experimental principle

In this experiment, we use the method of pulverized coal's self-priming speed and capillary action principle (Li et al. 2014), and the experimental flowchart is shown in Fig. 1.

Experimental process

Experimental method

In order to verify the effect of drilling fluid's pH value on the coal's wettability and the effect of different surfactants on the self-priming velocity of pulverized coal, the wetting solution is prepared with different pH values. In order to eliminate the influence of component and rank on the self-priming velocity of coal sample, each kind of coal sample is derived from the same area with the same work surface, also with the same bedding direction and the same or

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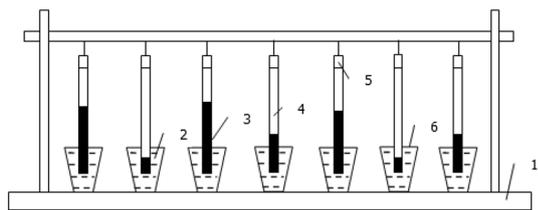


Fig. 1 Flowchart of self-priming speed method. 1 Bracket, 2 wetting solution, 3 wetting pulverized coal, 4 dry pulverized coal, 5 glass, 6 beaker

similar structure, and the coals are ground through the 100-mesh sieve. Put the ground pulverized coal in the glass tube with the same degree of compaction, suspend the glass

tube in the beakers which are filled with solutions of different pH values, and then, record the pulverized coal's wetting height at different times (Wang 2015).

Experimental procedure

1. Weigh several pulverized coals of 8 g and 100-mesh sieve.
2. Wrap the end of glass tube with filter paper, put the pulverized coal in the glass tube and compress it, ensuring the consistency of the degree of compaction of pulverized coal in each glass tube, and record the height of pulverized coal at this time.

Table 1 Experimental results of pulverized coal's self-priming in solutions with different pH values (first group)

Coal no.	pH value	Powder pillar height (cm)	Wetting height (cm)							
			1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	20	2.7	3.9	5.3	6.5	18.3	18.7	19.3	19.5
2	8	20	3.1	4.6	6.0	7.2	17.1	17.5	18.1	18.3
3	9	20	3.1	4.4	5.0	6.4	14.1	14.1	14.0	14.3
4	10	20	2.7	4.2	5.3	6.7	17.4	17.6	17.7	18.7
5	11	20	3.3	5.0	6.4	8.0	20.1	20.1	20.4	20.7
6	12	20	3.0	4.4	5.3	7.9	20.5	20.9	21.6	22.2
7	13	20	3.4	4.8	5.8	7.6	15.8	16.0	16.4	17.0

Table 2 Experimental results of pulverized coal's self-priming in solutions with different pH values (second group)

Coal No.	pH value	Powder pillar height (cm)	Wetting height (cm)							
			1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	20	3.8	5.7	7.0	8.2	16.1	16.7	17.0	17.8
2	8	20	3.7	5.3	6.7	7.9	14.5	14.0	14.2	15.0
3	9	20	3.6	4.9	5.3	6.2	12.0	11.7	11.9	13.0
4	10	20	3.5	4.7	5.9	6.8	15.0	14.6	14.3	14.8
5	11	20	3.1	4.8	6.4	7.5	11.2	12.4	12.5	13.0
6	12	20	3.0	4.6	5.2	6.6	9.9	10.3	10.4	11.3
7	13	20	3.2	4.6	5.5	6.4	11.1	11.8	12.0	13.0

Table 3 Pulverized coal's average wetting height in solutions with different pH values

Coal No.	pH value	Average wetting height(cm)							
		1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	3.3	4.8	6.2	7.4	17.2	17.7	18.2	18.7
2	8.5	3.4	5	6.4	7.6	16.6	16.9	17.3	17.6
3	9	3.4	4.7	5.6	6.3	13.1	13.8	14.2	14.8
4	10	3.1	4.5	5.6	6.8	16.2	16.4	17.1	17.3
5	11	3.2	4.9	6.4	7.8	15.7	16.3	16.9	17.4
6	12	3.0	4.5	5.8	7.3	15.6	16.0	16.8	17.1
7	13	3.3	4.7	5.7	7.0	13.5	14.2	14.6	15.0

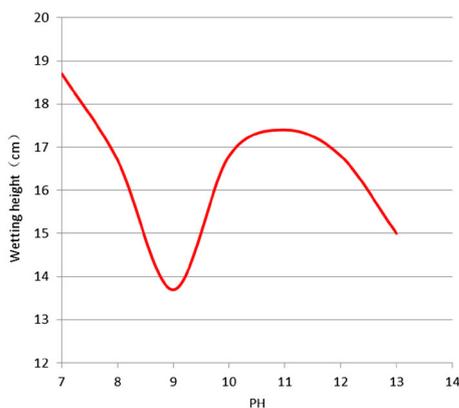


Fig. 2 Curve of pulverized coal’s average wetting height varying with the change of pH values in different solutions

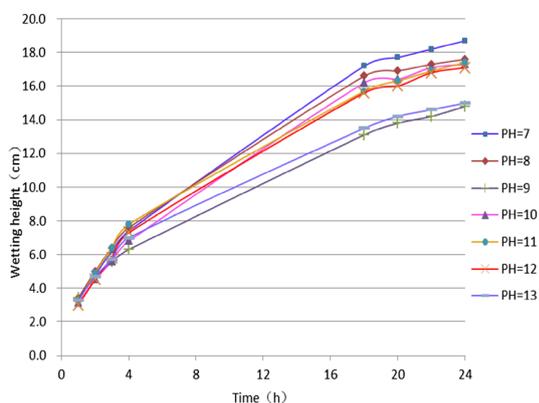


Fig. 3 Pulverized coal’s average wetting height varying with the change of time in the solutions with different pH values

- Suspend the glass tube in the beaker filled with wetting solution to keep the glass tube perpendicular to the liquid surface, and the bottom of glass tube is below the liquid level 0.5 cm. When the solid and liquid phase begins to contact, record the time and height of liquid level rising in the glass tube at different times.

Experimental results and analysis

In the experiments, in order to eliminate the effects of accidental errors, two parallel experiments were carried out, and the experimental results are shown in Table 1, 2. The average results are shown in Table 3.

The results above show that the drilling fluid’s pH value affects coal’s wettability, and different pH values change differently. Because the change of pH value affects the ionization behavior of coal surface carboxyl and phenolic hydroxyl, thus affecting the coal surface potentially further, and affecting the coal’s wettability ultimately (Yang 2012; Li et al. 2013). As shown in Fig. 2, self-priming height decreases with the pH rising firstly and then increases and decreases finally. When the pH value is 9, the height of pulverized coal is the minimum, indicating that the solution has the weakest hydrophilicity at this time, so the attention should be paid to adjust its pH when preparing the drilling fluid (Fig. 3).

Interaction effect of surfactant and pH value on the coal’s wettability

Experimental methods

We use the same method of self-priming speed to carry out the experiments. In the experiments, grind the coal into pulverized coal to 100 mesh, and put in the glass tube. Prepare two solutions with different pH values: and one is added surfactants and the other without surfactants to make a comparison, to analyze the interaction effect of surfactant and pH value on the coal’s wettability.

Experimental results and analysis

In the experiments, in order to eliminate the effects of accidental errors, two parallel experiments were carried out, and the experimental results are shown in Table 4, 5. The average results are shown in Table 6.

Table 4 Experimental results of pulverized coal’s self-priming in different solutions (the first group)

Coal no.	pH value	Surfactant (sodium dodecyl benzene sulfonate)	Powder pillar height (cm)	Wetting height (cm)							
				1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	×	20	6.8	9.6	11.1	11.6	24.3	24.3	24.5	24.6
2	7	✓	20	5.2	6.8	7.3	8.6	18.8	19.3	20.1	21.6
3	12	×	20	4.3	6.6	7.1	8.9	19.7	21.6	21.9	22.3
4	12	✓	20	3.8	5.6	6.4	7.4	19.3	21.1	21.4	21.9

Table 5 Experimental results of pulverized coal’s self-priming in different solutions (the second group)

Coal no.	pH value	Surfactant (sodium dodecyl benzene sulfonate)	Powder pillar height (cm)	Wetting height (cm)							
				1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	×	20	4.9	7.6	9.8	11.4	19.8	20.4	20.7	21.3
2	7	✓	20	4.4	6.8	9.3	11.1	20.5	21.8	22.1	22.3
3	12	×	20	4.1	6.2	7.5	9.2	19.3	21.5	21.8	22.1
4	12	✓	20	3.8	5.7	7.1	8.6	15.4	17.6	18.1	18.3

Table 6 Pulverized coal’s average wetting height in different solutions

Coal no.	pH value	Surfactant (sodium dodecyl benzene sulfonate)	Powder pillar height (cm)	Average wetting height (cm)							
				1 h	2 h	3 h	4 h	18 h	20 h	22 h	24 h
1	7	×	20	5.9	8.6	10.5	11.5	22.1	22.4	22.6	23.0
2	7	✓	20	4.8	6.8	8.3	9.9	19.7	20.6	21.1	22.0
3	12	×	20	4.2	6.4	7.3	9.1	19.5	20.1	20.3	20.5
4	12	✓	20	3.8	5.7	6.8	8.0	17.4	18.3	18.8	19.6

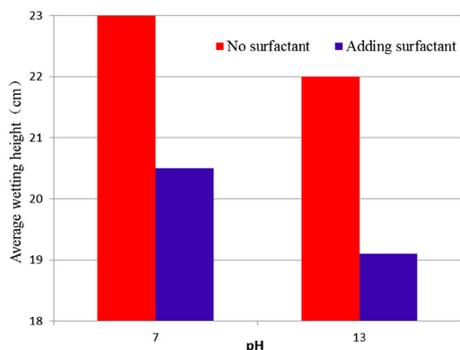
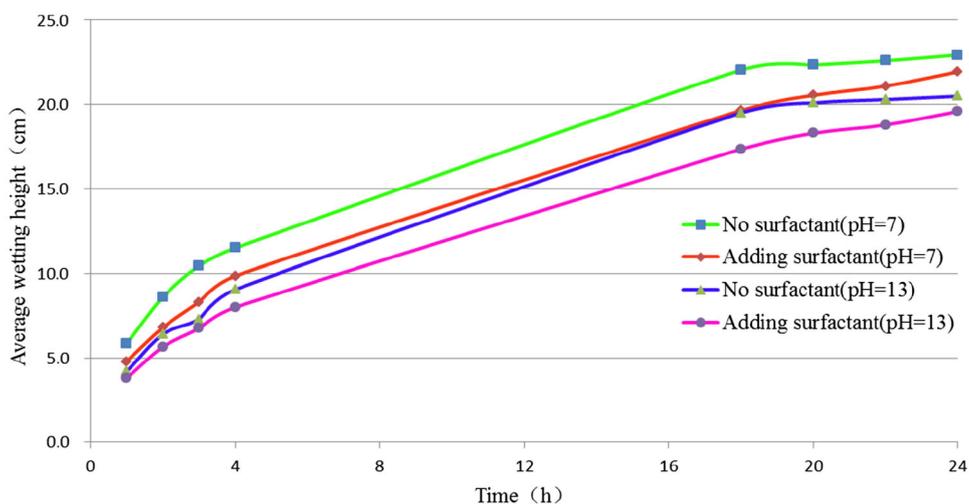


Fig. 4 Pulverized coal’s average wetting height in different solutions

Through the experiments above, we can draw the following conclusions:

1. For the same pH value, the self-priming height decreases significantly after the addition of surfactants, indicating that the joint action of surfactants and pH value will weaken the hydrophilicity of coal (Fig. 4).
2. Figure 5 shows that after the addition of surfactants to the solution with pH value of 12, the self-priming height of pulverized coal decreases to 5.47%, while the pH value of 7 decreases to 2.77%, and the decreased magnitude of self-priming height is greater after the addition of surfactants, indicating that adding

Fig. 5 Pulverized coal’s average wetting height varying with the time in different solutions



surfactants into the solution with pH value of 12 will greatly weaken the hydrophilicity of coal. Accordingly, adding surfactants into the solution with pH value of 12 should be avoided in the preparation of drilling fluid (Fig. 5).

Conclusions

1. Drilling fluid's pH value directly affects the coal's wettability, and different wettability is relative to the different pH values. The pulverized coal's self-priming height decreases firstly and then increases and increases finally, the solution with pH value of 9 makes the coal's hydrophilicity weakest, so pH value should be adjusted properly when preparing the drilling fluid.
2. For the solution with the same pH value, after the addition of surfactants, the coal self-priming height decreases significantly, indicating that the pH value and the surfactants combine together to make the coal's hydrophilicity weakened.
3. The solution with pH value of 12 makes the coal's hydrophilicity weakened significantly after the

surfactants are added. Thus, adding surfactants into the solution with pH value of 12 should be avoided in the preparation for drilling fluid.

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