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Research Article

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Experimental Study on the Inhibition of Gas Desorption in Coal by Mucilage

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Abstract The aim of this study was to investigate the law of influence of viscosity of water injection additives on gas desorption characteristics. For this purpose, the inorganic salt NaCl was used to increase the viscosity of the surfactant AES, and the coal was treated by spraying pure water and mucilage of different viscosities respectively, and the gas desorption characteristics of the different solutions after treatment were analysed by plotting the corresponding gas desorption curves. The experimental results showed that the greater the viscosity of the mucilage, the more obvious the initial decrease in gas desorption rate in the treated coal samples, and the gas desorption rate decayed exponentially in the first 30 min, and then the desorption rate and desorption rate decreased slowly. At the same time, the addition of mucilage can effectively reduce the amount of gas desorption in coal samples, and the greater the viscosity of the mucilage, the more significant the inhibitory effect on coal desorption.

Keywords Mucilage; Viscosity; Gas desorption characteristics; Inhibition effect

1. Introduction

Coal is the basis of China's industry and occupies an important position in China's energy structure [1]. As the most common kind of geological disaster in coal mine safety production, gas disaster seriously restricts the sustainable and healthy and stable development of coal mines, coal mining workings are the main source of gas gushing out from mines, and with the increasing degree of coal mining mechanisation and the continuous improvement of mine production capacity, especially in comprehensive mining workings, during the process of mining down coal The rapid desorption of gas from the coal seam causes the gas concentration in the tunnel to exceed the limit, which can easily lead to a reduction in oxygen concentration and asphyxiation of personnel due to lack of oxygen [2]. Therefore, it is very urgent to carry out technical research on the management of gas gushing out from the high intensity mining of comprehensive mining faces.

Practice has proven that spraying liquids (water) on the coal seam being mined is an effective gas management measure at the working face. The spraying of water on the coal wall not only wets the coal, but also improves the gas adsorption and desorption characteristics of the coal, and the retention of water in the micro-pores of the coal can play a role in slowing down the rate of gas dispersion [3-5]. However, the wetting effect of pure water is limited, and many scholars have proposed that surfactants can be added to water to reduce the surface tension of water to enhance the wetting ability of water, and for water injection additives containing surfactants to affect gas desorption, some scholars have carried out a large number of experimental studies, Liu Dan [6] used four kinds of surfactants containing SDBS, AEC, PPG400, APG0810 and other water injection By analysing the amount and rate of gas desorption under different liquid treatments, it was concluded that the surfactants could effectively slow down the rate of gas desorption, and the inhibition effect was more obvious as the surfactant concentration increased; Yan Min [7] used two surfactants, SDBS and APG0810, to compare the surface tension and viscosity of the solutions, as well as the foaming and stability of the solutions after acting on the coal body. Jiang Li [8] used three natural non-ionic biotype surfactants tea saponin, saprophytic, sucrose ester and a natural anionic biotype surfactant lipopeptide, by comparing the wetting performance of each solution at different concentrations, screened out several solutions with the best wetting performance concentration and compounded according to different volume ratios, compared with a single surfactant to inhibit gas dispersion rate, the study concluded that the compounded solution inhibited gas desorption better than a single surfactant.

The above studies have been carried out by wetting the coal body, using water to invade the fine pores in the coal and blocking the gas transport channels in order to inhibit gas desorption. Although the effect of gas inhibition is relatively significant, the coal body has complex conditions of distribution, and as the degree of coal deterioration increases, the wetting of the coal becomes worse, so more perspectives are needed to find ways to inhibit gas desorption in the coal. Therefore, this study is intended to increase the viscosity of the solution so that the sprayed solution can wrap around the coal body, thereby slowing down the rate of gas dispersion. As inorganic electrolytes compress the double electric layer of the ionic surfactant colloids in the solution [9], thus enhancing the viscosity of the solution, it is proposed to use the inorganic salt NaCl to enhance the viscosity of the anionic surfactant Sodium Alcohol Ether Sulphate (AES) to investigate the effect of the viscous solution on gas desorption at different viscosities, with a view to preventing gas concentration exceedance or coal and gas protrusion at the working face. Theoretical and data references were provided.

2 Test Methods

2.1 Test sample preparation

1) Coal sample preparation. The coal samples were taken from the No. 3 coal seam of Changping Mine, Jincheng, Shanxi Province. The coal samples were collected from the coal wall at the fresh exposure of the excavation face, sealed and sent to the laboratory, and the pulverized coal samples were screened by using 60 mesh-80 mesh standard sieve, followed by putting the screened pulverized coal samples into a vacuum drying oven and dried at a constant temperature of 60°C for 8 hours, and finally the samples were collected in sealed sample bags for maintenance. The coal samples were analysed industrially according to the industrial analysis method for coal (GB/T212-2008) and the results are shown in Table 1.

Table 1: Industrial analysis results of coal samples

M_{ad}（%）	A_{ad}（%）	V_{ad}（%）
0.94	9.16	7.97

2) Preparation of compounding solution. According to the test requirements, NaCl solutions with mass concentrations of 0.1%, 0.5%, 1.0%, 2.0%, 3.0%, 4.0%, 5.0%, 6.0%, 6.5%, 7.0%, 7.5% and 8.0% and AES solutions with mass concentrations of 10% were prepared. The NaCl solutions of different mass concentrations and AES solutions of 10% mass concentration were compounded in equal volumes, and the viscosity of the compounded solutions was measured using NDJ-1 mechanical pointer viscometer, and according to the viscosity of each compounded solution, two types of compounded solutions with low viscosity of 1000mPa.s-1500mPa.s and high viscosity of 10000mPa.s-15000mPa.s were preferably selected for The subsequent spraying of the coal body affected the gas desorption experiment. The viscosities of the different blends were measured in Table 2.

Table 2: The solution viscosity of 10%AES after adding different concentrations of NaCl (1:1)

NaCl 浓度（%）	0.1	0.5	1.0	2.0	3.0	4.0	5.0	6.5	6.5	7.0	7.5	8.0
混合溶液粘度（mPa/s）	2.7	2.7	3.0	6.7	18.2	25.9	1200	4200	7000	12500	620	79

Based on the results of the viscosity measurement experiments, NaCl solutions of 5% and 7% mass concentration were preferably combined with AES solutions of 10% mass concentration in equal volumes respectively for subsequent experiments.

2.2 Test content

In order to study the effect of different viscosity compounding liquids on the gas desorption inhibition characteristics of the coal body, the test compared dry coal samples, sprayed water, low and high viscosity mucilage at 0.4 MPa, affecting the gas desorption inhibition test within the coal, the test is shown in Table 3.

Tab.3：Experimental scheme

Type of coal sample	**Proportioning**	**Temperature**	**Pressure**	**Test parameters**
Drying	—	30℃	0.4MPa	Desorption volume, desorption rate
Pure water spraying	—			
5% NaCl + 10% AES surfactant	1：1			
5% NaCl + 10% AES surfactant	1：1			

2.3 Test procedure

The test was conducted using a coal seam gas thermostatic desorption test bench at the College of Safety Science and Engineering, Henan University of Technology, with the test temperature maintained at 30°C at all times.

1) The raw coal was made into 0.18mm-0.25mm coal sample particles, and 70g of each group of test coal samples.

2) Prepare equal volume compound solutions of low viscosity 5% NaCl + 10% AES surfactant and high viscosity 7% NaCl + 10% AES surfactant respectively.

3）Dry the soft and hard coal, spray water, low and high viscosity viscous liquid respectively, and put the treated coal samples into the coal sample tank, connect the system with the vacuum pump after gas tightness check, turn on the vacuum pump into for vacuum degassing, observe the vacuum degree shown by the dial is less than 10 Pa and then continuously degas for 2h.

4) Coal sample inflation and adsorption equilibrium. Open the methane gas cylinder, set the test temperature to 30°C and isothermal adsorption at 0.4MPa for 8 hours.

5）Open the valve to start desorption until desorption equilibrium and the test is completed.

3 Test results and analysis

The gas desorption process was measured under the same temperature and the same adsorption equilibrium pressure for the experimental coal samples from Changping coal mine to investigate the effect of different viscosity of the mixed solutions on the gas desorption pattern, and the adsorption equilibrium pressure was selected as 0.4 MPa. After 240 min of desorption, the accumulated gas desorption in the dry coal samples and the coal treated with each mucilage are shown in Table 4. and the total gas desorption and desorption rate versus time for the coal samples treated with low and high viscosity mucilage, respectively.

Table 4: Table of the first 240 min desorption of sample coal with different viscosity content

Mucus viscosity（mPa/s）	**0（Dried coal samples）**	**0.8937（water）**	**1200**	**12500**
Q_{240min}（mL）	76	72	64	6

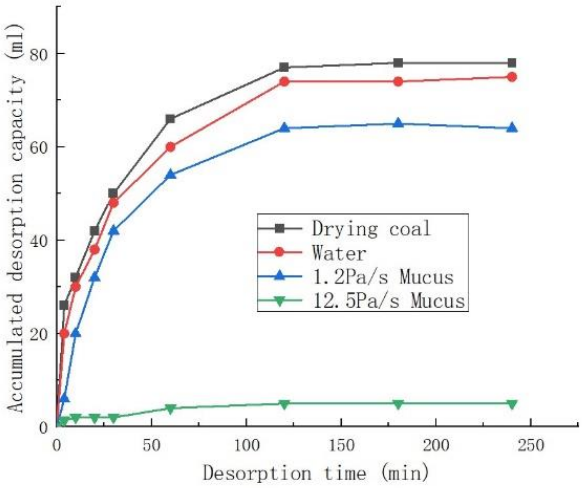

Figure a: Plot of coal desorption with time for different solution treatments

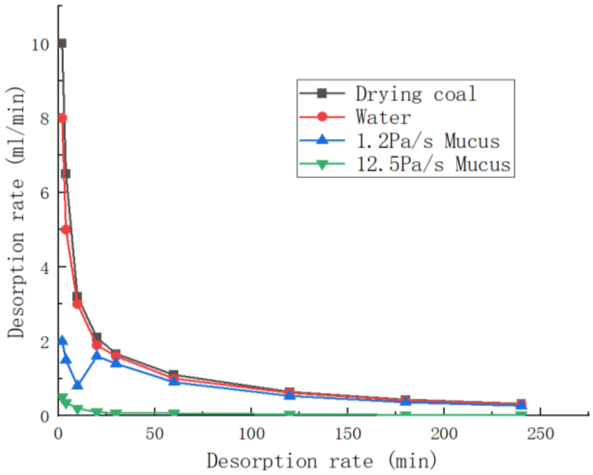

Figure b: Plot of coal desorption rate with time for different solution treatments

1) Analysis from Table 4 and Figure a shows that: the desorption volume of coal sample under dry condition is 76ml in 240min; under the condition of spraying water, the desorption volume of gas in the same time is 72ml; under the condition of spraying low and high viscosity mucus, the desorption volume of gas in the same time is 64ml and 6ml respectively, and the total amount of desorption decreases with the increase of viscosity of mucus, so it can be obviously concluded that mucus can effectively Therefore, it is obvious that mucus can effectively inhibit the desorption of gas in coal, and as the viscosity of mucus increases, the inhibiting effect becomes more obvious.

2) From the analysis of figure b, it can be seen that the desorption rate decreases rapidly within 30 min before desorption, after which the desorption rate still decreases, but the trend becomes slower and slower. The higher the viscosity, the faster the decay of gas desorption rate. Within 5 min, the desorption rate of coal samples treated with low viscosity decreased by 87%, and that of coal samples treated with high viscosity decreased by 96%.

4 Conclusion

- Under the action of different viscosity mucilage, the desorption amount of coal samples decreased significantly, compared with the desorption amount of dry and water sprayed treated coal samples, the gas desorption amount and desorption rate of coal body sprayed with mucilage decreased significantly.
- Under certain conditions of adsorption equilibrium pressure, the greater the viscosity of the mucilage, the smaller the gas desorption rate of the treated coal samples at the beginning, and the gas desorption rate

decays exponentially in the first 30 min, and then the desorption rate and the change in desorption rate decrease slowly in the subsequent time.

- The total amount of gas desorption decreases as the viscosity of the treated coal samples increases, and the mucus has a significant inhibitory effect on gas desorption in coal, and the greater the viscosity of the mucus, the more obvious the inhibitory effect.

References

[1]. WANG Guofa, LI Shijun, ZHANG jinhu, et al. Ensuring the safety of coal industry to lay the cornerstone of energy security [J]. CHINA COAL, 2022, 48(07): 1-9.

[2]. QIU Yonggang, XU Yanpeng. Application of comprehensive measures to eliminate protrusions at protruding working faces in medium-thick coal seams [J]. Coal Engineering, 2010, No. 374(01): 56-57.

[3]. CHEN Jinsheng, WANG Zhaofeng, YUE Jiwei, et al. Experiments on gas desorption from coal during moisture wetting [J]. Journal of Safety and Environment, 2017, 17(04): 1309-1313.

[4]. CHEN Haidong, CHEN Menglei, XIAO Zhiguo, AN Fenghua, et al. Research on influence of external moisture on gas desorption characteristics of soft and hard coal [J]. Industrty and Mine Automation, 2020, 46(11): 28-33+40.

[5]. CHEN Xiang-jun, CHENG Yuan-ping, et al. Experiment Study on Water Injection Affected to Desorption of Coal Adsorption Gas [J]. Coal Science and Technology, 2014, 42(06): 96-99.

[6]. Liu Dan. Experimental study on the effect of surfactant on the gas desorption of coal [D]. Xi'an-University-of-Science-and-Technology, 2019.

[7]. YAN Min, YANG Ting, LIN Haifei, YAN Dongjie, LI Yong, HUO Shihao, et al Experimental study on the influence of surfactant foam properties on coal gas slow release [J/OL]. Coal Science and Technology:1-11 [2023-05-27].

[8]. JIANG Li. Study on the Influence of Bio-type Surfactants on the Adsorption and Desorption of Coal Gas [D]. Anhui University of Science and Technology,2020.

[9]. LI H L, QU R H, HAN X M, et al. Surfactant-enhanced washing of aged PAH contaminated soils: Comparison between nonionic surfactant and anionic surfactant [J]. Applied Mechanics and Materials Vols,2014,522/524:316-321.