Study on the Performance of Sulfite Reduction by SRB Isolated from Landfill Leachate

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Abstract: SO_2 emission may cause acid rain leading to environmental pollution and living-life threats. Sulfite reduction as the most important step during biological fume gas desulfurization and sulfur resources cyclic utilization has been concerned widely. Conditions of low pH, carbon desire, and temperature were investigated in this paper to reveal the characteristics of sulfite reduction by such a sort of SRB. The results show that such a sort of SRB is much sensitive to the acidic condition and could be effective to reduce sulfite within 4 days. At least C/S should reach the value 0.275 of carbon resource (calculated as COD) to keep sulfite reduced efficiently. Sulfite could be reduced at room temperature by the SRB with only 3 days delay than at 35 ℃. It cloud apply some preliminary study for biological fume gas desulfurization and recycling of sulfur resources.

1. Introduction

The emission of SO_2 is the main cause of the formation of acid rain, which is harmful for living things such as plant, aquatic organism, insect and so on. The traditional desulfurization technology refers that SO_2 is chemically or physically absorbed by alkaline substance from fume gas. C. Li [1] pointed out that the wet limestone flue gas desulfurization system, circulating fluidized bed flue gas desulfurization, Ammonia - fertilizer flue gas desulphurization, regenerated amine desulfurization, etc. was the most representative FGD technology. According to the investigation of Y. Wang’s research [2], wet limestone flue gas desulfurization system was popularly used all over the world. However the efficiency of the desulfurization only reached as much as 60%-80%. Too much amount of gypsum as the coproduct is not only easy to scale leading to form blockage in pipelines easily, but also causes secondary pollution. Meanwhile, coal is the main primary energy in our country, the consumption of which takes up around 70% of the depletion of the whole energy resources, pointed out by G. Wu [3]. As a result, the amount of gypsum waste would be produced too much to be treated easily and it would be more and more in the future until the new energy resource not containing sulfur instead in some time. So transforming the fume gas SO_2 to resource element S would be a best way to control the emission of the SO_2.

Biological gas desulfurization as the most potential way to FGD is concerned by many researchers for its low-cost and no secondary pollution generation. Nowadays there are two biological ways to turn the H_2S or SO_2 to element sulfur [4]. One was that sulfide could be catalyzed by Fe^{3+} to form element sulfur while the remains Fe^{2+} could be oxidized by some bacteria to be transferred to Fe^{3+} in order to make it used cyclically. The equations are as follow (1) and (2).

$$2FeSO_4 + \frac{1}{2}O_2 + H_2SO_4 \xrightarrow{bacteria} Fe_2(SO_4)_3 + H_2O \quad (1)$$

$$H_2S + Fe_2(SO_4)_3 \longrightarrow 2FeSO_4 + H_2SO_4 + S\downarrow \quad (2)$$

The other way was that SO_2, sulfite or sulfate were firstly reduced by SRB to form sulfite, and then it was oxidized to element sulfur by some sulfur-oxidizing bacteria (SOB). The reaction equations are as follow (3) and (4).

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$$SO_3^{2-} / HSO_3^{2-} / SO_4^{2-} + C_xH_yO_z \xrightarrow{SRB} H_2S / HS^- / S^{2-} \quad (3)$$

$$H_2S / HS^- / S^{2-} + O_2 \xrightarrow{SOB} S\downarrow + OH^- \quad (4)$$

No matter how to form element sulfur, the formation of sulfide must be the initial step. In this case, as for turning fume gas SO_2 to element S, how to produce sulfide more is the key point. Hence, SRB would be a most promising bacteria to reduce SO_2 to sulfide in the technology of biological fume gas desulfurization. Here we report some characteristics about sulfite reduced by a sort of SRB isolated from landfill leachate to give some theoretic basis for fume gas SO_2 desulfurization and its reclamation as element sulfur.

2. Methods and Materials

2.1 Culture Medium.

As SO_2 was easily dissolved under biological desulfurization process and form sulfite. So Postgate's C medium [5] was used and the sulfate was chanced to sulfite to fit the condition. It contains 0.5 $g\cdot L^{-1}$ KH_2PO_4, 1.0 $g\cdot L^{-1}$ NH_4Cl, 0.06 $g\cdot L^{-1}$ $MgSO_4\cdot 7H_2O$, 0.01 $g\cdot L^{-1}$ $FeSO_4\cdot 7H_2O$, 0.87 $g\cdot L^{-1}$ $CaCl_2$, 5 $g\cdot L^{-1}$ Na_2SO_3, 3.5 $g\cdot L^{-1}$ sodium lactate, 1.0 $g\cdot L^{-1}$ yeast extract, 0.3 $g\cdot L^{-1}$ sodium citrate, which was prepared with distilled water. The Na_2SO_3, sodium citrate and $FeSO_4\cdot 7H_2O$ were added later, after other matters dissolved into the distilled water bottled in 250 mL anaerobic bottle with aerating N_2 for 5-10 min. Then they were added in and adjusted to pH=7 by a pH meter (PHS-3C, INESA, Shanghai, China) with HCl (1:1, v/v). Finally, it was aerating N_2 for 5-10 min again and sealed and put into the shaking table (HNY-2102C, Honour, Tianjin, China) at 35 ℃ to preheating.

2.2 SRB material.

The SRB was selected from the mud at the bottom of a ditch beside a refuse transfer station nearby Anju Road in Wuhan, China. Then it was inoculated into the culture medium as much as 3.0 g. After that, it was aerating N_2 for 5-10 min, sealed then put into the shaking table at 35 ℃ to grow at the first time of cultivation. As for the later time cultivations, 20 mL bacteria solution was directly taken out by dry clear injection syringe with 12 cm 12# needle. Then it was quickly injected into the new prepared medium culture to grow in the shaking table at 35 ℃. The SRB used for experiments was enriched at least 3 times after black circle was formed.

2.3 Analytical method.

Various initial condition of pH from 4 to 7, C (sodium lactate calculated as COD) :S from 0.55:1 to 0.1375:1 and temperature from room temperature to optimum one was set to investigate the characteristics of sulfite reduced by SRB. When C:S was set to be reduced, other nutrient substances in the medium were also reduced in proportion. Certain bacteria solution mixture was taken out to test its pH and concentration of SO_3^{2-} after centrifuged (TDZ4A-WS, Xiangli, Hunan, China) every day. If negative pressure was formed in the bottle as a result of sampling, N_2 should be made up to keep its pressure balancing with atmosphere. Sulfite was determined by pararosaniline hydrochloride spectrophotometric methods at 550 nm [6].

3. Results and discussion

3.1 Features in low pH condition.

As to biological fume gas desulfurization, SO_2 was dissolved into liquid and its pH may decline. So some acidic conditions were simulated to investigate the adaptation of SRB. As shown in Fig. 1, no obvious changes of pH during the whole process at the initial pH condition 4, 5, 6, which indicates there is nearly no vital movement of SRB. As for sulfite shown in Fig. 2 at range of neutral pH, 4 days were enough to transfer almost all the sulfite. However, at the other acidic condition sulfite reduced little, the variation of which may due to adsorption or desorption by SRB.

That is to say such a sort of SRB is much sensitive to the acidic condition.

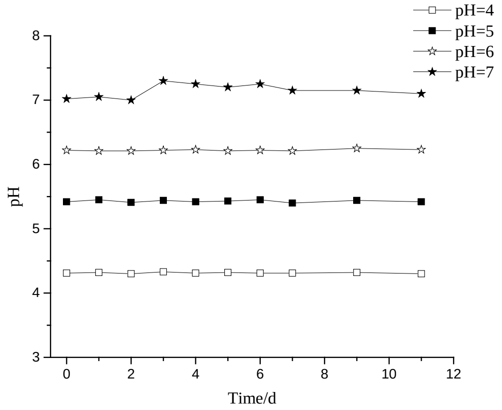

Fig. 1 Features of pH under acidic condition effected by SRB

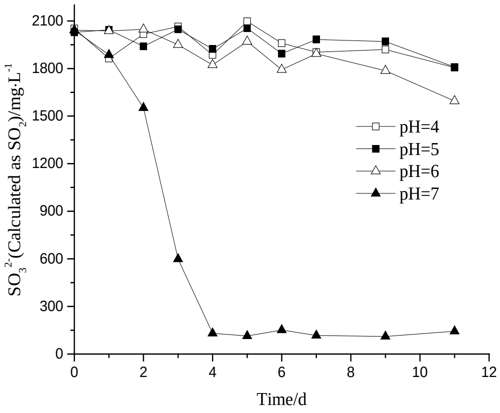

Fig. 2 Features of SO_3^{2-} under condition acidic condition effected by SRB

3.2 Carbon desire to reduce sulfite by SRB.

1/4, 1/2, 3/4 and 1 of carbon resource (sodium lactate calculated as COD) in the Postgate' C medium, which equals C(COD)/S is 0.1375, 0.275, 0.4125 and 0.55, was set to investigate what extent sulfite could be reduced in the low concentration of carbon resource. It seems that the lower the C/S was, the higher the pH reached at the end shown in Fig. 1. While sulfite should be reduced to sulfide by SRB, and the more C/S was the swifter the sulfite reduced. It indicates that the swifter the sulfite reduced, the High the pH reached at the end. However Larry L. Barton [7] referred that if the electron (carbon resource) concentration is high, sulfide was form probably. As common sense, the more sulfide produces, the higher the pH of liquid reaches. But in the Anaerobic bottle, which couldn't keep air out, sulfide couldn't disperse to atmosphere as H_2S, the only way of which was to be dissolved into the bacteria solution. As more and more sulfide produced leading to the pH decline after its initial rising.

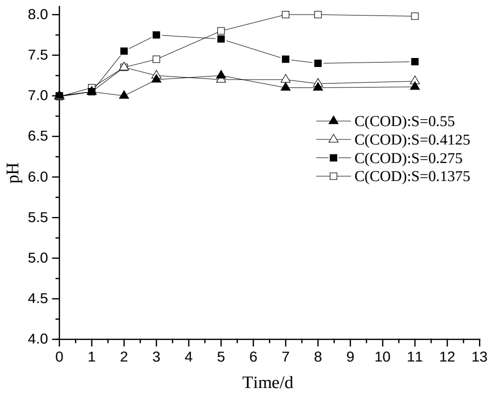

Fig. 3 Features of pH in various C/S SRB

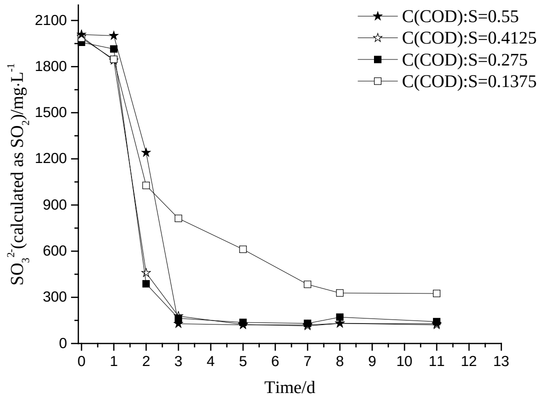

Fig. 4 Features of SO_3^{2-} in various C/S effected by effected by SRB

Although sulfite was reduced more slowly than others in the case of 1/4 of C (COD)/S, still most of the sulfite disappeared. And the least C (COD)/S SRB needed to keep its high efficiency to reduce sulfite was 0.275.

3.3 Temperature effect on SRB growing.

As is known to all that the most appropriate temperature for SRB growing was 35℃, while room temperature or even lower takes up most of time every year in our country. So room temperature condition was set to investigate how well sulfite was reduced by such sort of SRB. About 3 days later when sulfite disappeared at room temperature than 35 ℃, but the amount of sulfite reduction in both condition were almost the same shown in Fig. 5, which indicates that lower temperature could only decline the speed of sulfite reduction and couldn't change its reduction amounts.

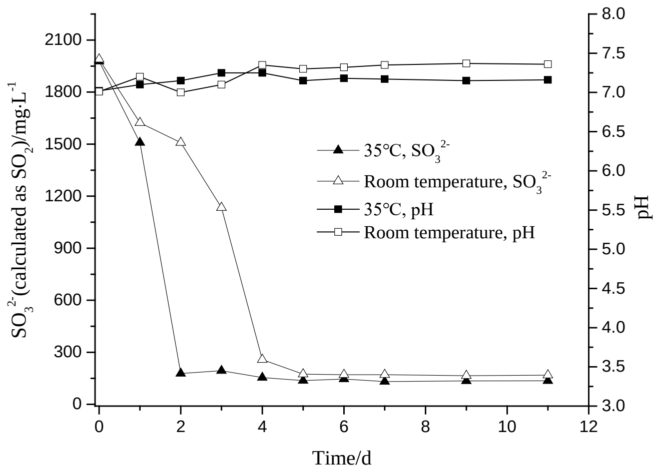

Fig. 5 Features of pH and SO_3^{2-} with C(COD)/S=0.275 effected by SRB both at room temperature and 35 ℃

4. Conclusion

A sort of SRB was successfully isolated, cultured and enriched from the mud at the bottom of landfill leachate. It is much sensitive to the acidic condition but effective to reduce sulfite within 4 days. When SRB cultivation in anaerobic bottle, H_2S would be dissolved into bacteria solution leading to its pH rise firstly and decline later. And at least C/S should reach the value 0.275 of carbon resource (calculated as COD) to keep sulfite reduced efficiently by such sort of SRB. Besides, sulfite could be reduced at room temperature by the SRB with only 3 days delay than at 35 ℃, but the reduction amounts are the same.

Acknowledgements

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