Performance Evaluation of Microbe Carrier in Anaerobic Digestion Reactor

GONG Wei-jia[①], LI Wen-zhe[1]
(School of Engineering, Northeast Agriculture University, Harbin 150030, China)

Abstract: The enrichment of microbes in the reactor plays an important role in anaerobic digestion for methane production. The selection of microbe carriers is the key task for improving digestion reactor. Based on the necessity of its selection, the biochemical indices were selected for carriers' evaluation. The amount of aerogenesis, pH and coenzyme F_{420} were measured periodically. Bacterial count by roll tube method was employed for examining the enrichment of microbes. Scanning electron microscopy (SEM) was applied for identifying the bacterias and their adhesion case onto carriers. The results indicated that granular activated carbon was the best selection.

Key words: Anaerobic digestion; methanogen; microbe; carrier
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With the increasing concern of resource lack and environment pollution, anaerobic digestion technique is becoming the perfect choice for its ability of producing energy and cleaning environment. Some of the developed countries are actively put forward methane production into industrialization, which could improve the production from low-level natural process to advanced controllable process. However, the key problem of industrialization is the low efficiency. Based on the reactor's design, the carriers were packed in it, which incorporated into the characteristics of microbe in anaerobic digestion[1-2]. The carrier was expected to increase the density of methanogen in the reactor and ensure the sufficient contacting between materials and methanogen. Also the leaking of methanogen could be reduced and thus the fermentation efficiency could be improved. Based on the comparisons of aerogenesis volume and efficiency, preliminary study was conducted. Further, microscopic factors were evaluated. The mechanisms of microbe holding on the carriers and the beneficiation extent were investigated.

1 Materials and methods

1.1 Experimental materials

Inoculating sludge was fetched from the bottom of fishpond in 168 Middle School, which located at Harbin. Fresh cattle manure used in the experiment was from Wandashan Group Milk Cattle Station.

1.2 Experimental devices and methods

Single-phase anaerobic fermentation process was adopted with batch input and output types in the experiment[3]. Fermentation temperature was controlled at (35±1) ℃ by water-bath. And manually agitation was carried out once a day. The reactor was reformed on the basis of 1 000 mL wild-mouth bottle.

Slurry was prepared by 1 : 3 of inoculated sludge and fresh cattle manure, and the concentration was 6%. The experiment was two-step at the same conditions: first included six carriers and blank, three carriers were optimized and second included three carriers and blank, parallel tests were conducted for the three carriers.

2 Results and discussion

2.1 Preliminary selection

Fig. 1 shows that GAC and bamboo performed dominant, and activated carbon fiber showed similar to the blank. As for the aerogenesis abilities, GAC and bamboo could be the selections as the carrier to improve aerogenesis, and activated carbon fiber was also worth further developing.

It is shown that the tendency of the four aerogenesis volume curves was similar with two fermentation cycle (Fig. 2). Granular activated carbon (GAC) could perform well for its two higher aerogenesis peak, while the long cycle and stable aerogenesis volume for bam-

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作者简介：公维佳（1981年生），女，助教；通讯联系人：李文哲；E-mail: liwenzhe9@163.com; gongweijia@126.com

boo carbon. The aerogenesis effects decided that haydite, glassfiber and polyvinyl formal fiber could be used as carrier in anaerobic digestion.

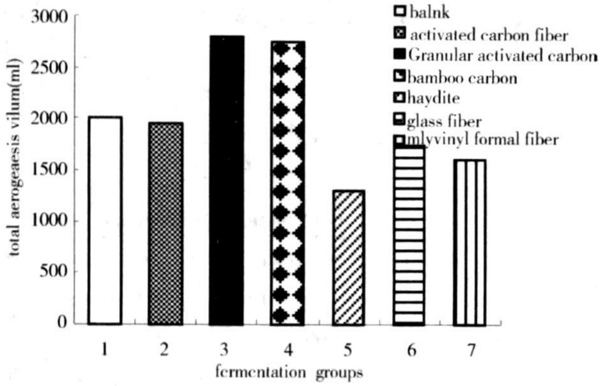


Fig. 1 Total aerogenesis volume of different fermentation groups

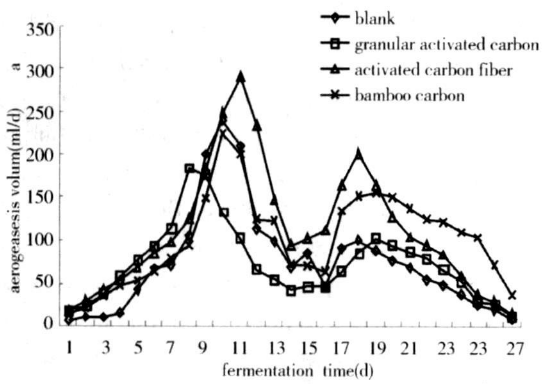


Fig. 2 Variations of aerogenesis volume for partial fermentation groups

2.2 Microscopic characterization of the selected carriers

2.2.1 Methaogen characterization in material recycling

Methanogen can produce blue-green fluorescence at 420 nm ultraviolet light excitation. And the main reason was that coenzyme F_{420} in methanogen[2]. Most methanogen contained high content of coenzyme F_{420}, which was usually above 150 mg/kg wet cells. And there was no other specific anaerobe except methanogen that could contain coenzyme F_{420}[5-6].

Fig. 3 shows that the fermentation groups reached their coenzyme F_{420} peaks at 9 d. At the same time, the coenzyme F_{420} for the fermentation groups with carriers in the fetched slurry was relatively lower compared with the blank. However, the aerogenesis volume was higher than the blank.

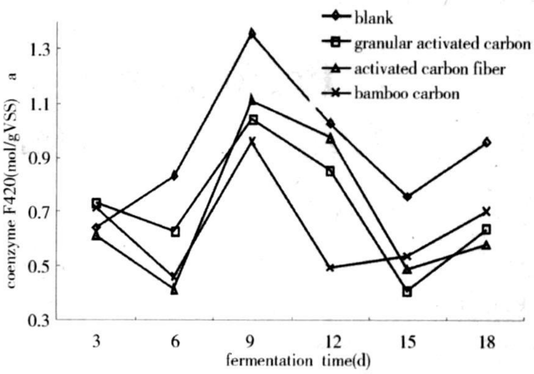


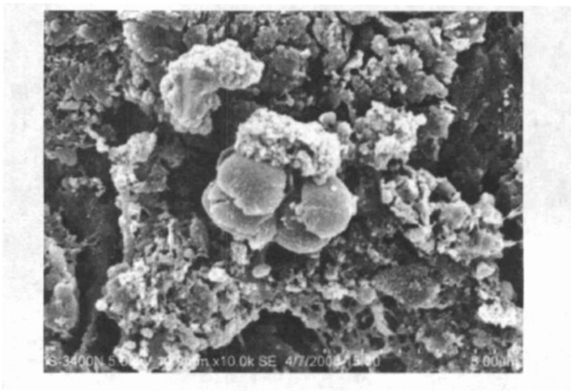
Fig. 3 Variations of coenzyme F_{420} value for different fermentation groups

2.2.2 Analysis of microbe adhering conditions on the surface of carrier

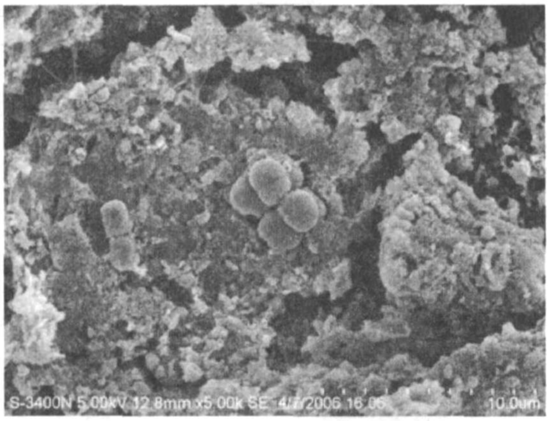
Fig. 4 shows the SEM pictures, which were taken in the aerogenesis peak to provide microscopic observations of carriers. It could be seen that granular sludge appeared on the surface of carriers. And the sludge included different kinds of bacteria. In the experiment, bacillus and coccus were the main forms.

GAC was the best selection for bacteria adhesion. The coarse macropore and mesopore were filled with microbe. And the resident bacteria included bacillus, coccus and also sarcina. The sarcina was an important parameter for improving the aerogenesis. Activated carbon fiber did not show evident beneficiation as GAC, which was related with surface aperture distribution. It was micropore structure, and microbe only existed in the fibre bundle. The bacteria on the surface were mainly short bacillus, also a small amount of sarcina (Fig. 4 (b)). The irregular surface of bamboo carbon changed into membranous layer, though the effect was not as obvious as the other two carriers.

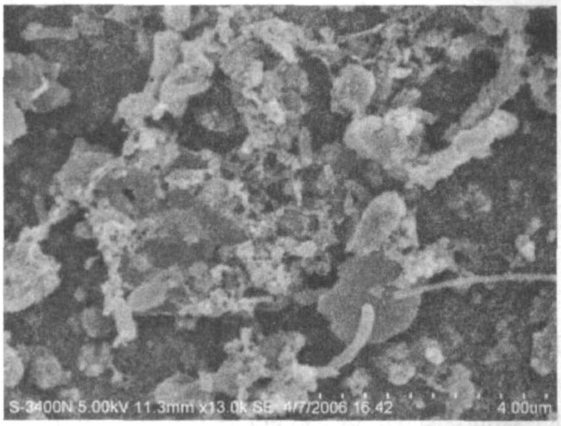
Based on the microscopic results, the surface characteristics of carriers was important for microbe holding. For the carriers with big porosity, microbe could grow on the surface and the carrier could fix microbe.



(a) GAC (×10000)



(b) Activated carbon fiber (×5000)



(c) Bamboo carbon (×13000)

Fig. 4　SEM pictures of activated carbon fibre carrier surfaces with and without membranes

3　Conclusions

The study compared six carriers for improving aerogenesis, and the results showed that:

1. Microbe carrier could improve microbe leaking and increase total aerogenesis efficiency.

2. Aerogenesis volume, coenzyme F_{420} and SEM observations could be used as performance evaluation criteria.

3. Surface characteristics of carriers could affect microbe holding. GAC showed better abilities for microbe residence and microbe diversity, especially for its adsorption of sarcina to enhance aerogenesis.

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厌氧消化反应器中微生物载体效能评价指标

公维佳，李文哲

(东北农业大学 工程学院，黑龙江 哈尔滨 150030)

摘　要：厌氧消化产甲烷过程中反应器内微生物的富集具有重要作用。微生物载体的选择是提高反应器效率的核心所在。产气量、pH和辅酶 F_{420}可作为载体选择评价的指标，并通过扫描电镜对载体微生物附着情况进行微观检测。各评价指标检测结果表明，颗粒活性炭能够更好地提高反应器效率，可作为合适的载体选择材料。

关键词：厌氧消化；产甲烷菌；微生物；载体；指标

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