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Effect of methanogenesis of residue from thermal pre-treatment sludge by anaerobic fermentative hydrogen production

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Abstract

The municipal sludge of Wastewater treatment plants generate a mass of municipal sludge is becoming an extremely environment issue. Effective utilization of the sludge to generate benefits concern many scholars. This research worked systematically to study the condition of gas production of sludge by thermal pre-treatment and compared a large differance among the maximum cumulative methane production in the sludge of high temperature thermal treatment. The inoculum via 75°C thermal pretreatment for 10 min mixed sludge substrates by different temperature pre-treatment for 30 min. The optimum methane production was obtained from 160°C, and the 120°C was worse in the methane produciton. The max accumulated hydrogen and methane production were 3.57 mL and 235.97 mL respectively of 160°C; the max accumulated methane production was 193.24 mL of 120°C. Compared the metabolic process of anaerobic fermentation of methane, the degradation of organic matter in the sludge substrate by 160°C for heat treatment was better than that of 120°C.

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Keywords: Thermal pre-treatment, Sludge, Methanogenesis of residue of hydrogen production;

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1. Introduction

With the improvement of China's urban sewage treatment rate, there is a sharp increasing of sludge in municipal wastewater treatment plants, which means that we need to treat more sewage sludge. From 2007 to 2013, the amount of sludge grew 13% every year. In 2013, 6.25 million tons dry solids (DS) was produced[1]. This situation is in urgent need of changing. Many scholars and engineers focus the attention on how to treat and utilized the sludge effectively. According with the literature in the field of sludge anaerobic digestion (AD), there are two aspects catching a hot. On the one hand, improve the degradation efficiency of organic dry solids. On the other hand, enhance the methane production in anaerobic digestion[2-3]. AD is the common way to treat sludge in the WWTPs, which is economic feasibility and environmental friendly. Meanwhile, the biogas and organic acid that are produced in the AD process can be reused. Biogas has a power potential (1 m^3 CH_4=10 kWh), but the traditional organic digestion process in normal temperature is weakness in gas production[2,4]. The Bryant presented that the organic anaerobic fermentation was separated into four stages in 1979, they were hydrolysis, acidification, acetogenesis and methanogenesis respectively. The organics hydrolysis process is considered the main reason of affecting the gas product rate. Many scholars in order to solve this problem have taken a lot of work, most of the studies focused on the methods to accelerate the organics hydrolysis process, including thermal hydrolysis, chemical, mechanical disruption, ultrasonication and enzyme hydrolysis[5].

The thermal hydrolysis was used to sludge dewatered at the beginning, based on the degradation of gel structure so that the combined water was separated from sludge, meanwhile, the organic dissolved from the sludge cells. The sludge thermal hydrolysis is universally accepted in the way of sludge AD. Thermal treatment can be classified into two on the basis of treatment temperature, which one is high temperature thermal hydrolysis (above 100°C, the other one is low temperature thermal hydrolysis (under 100°C). Without considering the energy consumed, the high temperature thermal treatment is widely adopted[6]. The thermal pretreatment is aimed to search the optimum treatment temperature in facilitating the biogas volume, most of studies of the temperature range from 160 to 180°C, and the treatment time for 30-60 min. P.J. Strong[7] et al. treated the sludge by thermal hydrolysis (165°C). The thermal hydrolysis at 165°C destroyed 20% of the VSS, and the ultimate methane potential of the combined the thermal hydrolysis and anaerobic digestion improved by 12-13% relative to the untreated control sample. Mavi Climent[8] et al. obtained a 50% increment in biogas production for low temperature (70°C) thermally treated sludge.

This study will focus on municipal sludge under different temperature of thermal treatment, and adjust the initial pH value of the reaction system. After a period of time to produce hydrogen, then the residue from the anaerobic fermentation hydrogen production inoculated the new sludge, further study on the gas generation, and the thermal treatment of sludge anaerobic fermentation mechanism was discussed.

2. Materials and methods

2.1 Inoculum and substrate pretreatment

The sludge was the aerobic sludge that was collected from the thickening tank of the WWTPs in Fuzhou, China. Taking a certain amount of sludge to be treated at 75°C for 10 min and then stored at 4°C until its utilization, which was used as the inoculum furthermore, the substrate sludge was treated at different temperature. For the low temperature thermal pretreatment, the sludge was treated at 75°C, 90°C in the water-bath; for the high temperature, the sludge was treated at 120°C, 140°C, 160°C and 180°C in the high temperature and high pressure reaction kettle. The substrate was treated for 30 min at different temperature. The substrate cooled down naturally, then stored at 4°C for using.

The inoculum was pretreated at 75°C then inoculated the substrates which were pretreated at different temperature, The fermentation reactors were the 250 mL serum bottle. Afer 90h hydrogen production process, the residue sludge from the hydrogen production was mixed well, inoculating 60 g new sludge then adjusting pH value by 7.0, fetching the mixture into the 250 mL serum bottle. The anaerobic atmosphere of the system was maintained by nitrogen blow off, after that all reactors were maintain at 35 ± 1°C.

2.2 Analytical methods