

## Status of anaerobic digestion pretreatment of high solid waste\*

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Compared with low-solid state, high-solid anaerobic digestion has the advantages of requiring less reactor volume, less energy input for heating and mixing and producing nutrient-rich fertilizer. Besides, it also has a higher net energy yield. It is urgently necessary to pay attention to the resource of solid waste. However, it is considered that the hydrolysis stage is a rate-limited step in the anaerobic digestion. Therefore, various pretreatments have been applied to improve the hydrolysis process. In this paper, three pretreatment methods which can be used in engineering were reviewed.

*Keywords:* High-solid; Anaerobic Digestion; Pretreatment; Thermal; NaOH; Ultrasonic.

### 1. Introduction

In recent years, with the development of China's economy, the level of urbanization and the improvement of people's living standards, the city's biomass waste showed a significant growth trend. The annual growth rate of solid waste from 2010 to 2014 was 3%. In 2014, the quantity of municipal solid waste was 178.602 million tons[1].

Anaerobic digestion (AD) is a biological process in which organic matter is degraded and converted to clean biogas under anaerobic conditions. Traditional anaerobic digestion is normally carried out at low-solid state. When compared to low-solid anaerobic digestion, high-solid anaerobic digestion requires less reactor volume, requires less energy input for heating and mixing, produces nutrient-rich fertilizer, and has a higher net energy yield[2].

Hydrolysis is the rate-limiting step of the overall processes which release the intracellular and extracellular matters. Pretreatment have been studied to promote hydrolysis.

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## 2. Thermal Pretreatment

Thermal pretreatment has been suggested as an effective method by which to accelerate hydrolysis during conventional anaerobic digestion of low-solids sludge, and thereby shorten digestion time and enhance biogas production[3].

Applying thermal pretreatment to high-solid sludge anaerobic digestion is reasonable considering that conventional anaerobic digestion and high-solid sludge anaerobic digestion are based on the same fundamental biochemical processes. Previous research on thermal pretreatment of high-solid sludge anaerobic digestion divided into high temperatures(120-180 °C) and low temperatures(50-90 °C) pretreatment. After thermal hydrolysis pretreatment, which reduces sludge viscosity and increases the fraction of soluble COD, high-solids anaerobic digestion is stable, produces highly stabilized biosolids, and greatly increases biogas generation[4].

Liao et al. [3] found that after low temperature thermal treatment, a large amount of organic matter in sludge solids was dissolved, and sludge flow ability was enhanced significantly. Xue et al. [5] found that both the low temperature thermal pretreatment and high temperature thermal pretreatment positively affected the solubilization of organics in sludge. In the biodegradability batch experiments, the low temperature thermal pretreatment did not improve the total gas volume, while the high temperature thermal pretreatment did. Zhu et al. [6] found that the oil extraction amount of kitchen waste after thermal hydrolysis pretreatment was increased significantly. the highest (67.7 ml/kg) was achieved under the conditions of 150 °C, 40% water added and 60 min thermal hydrolysis, which was 2.65 times higher than the control group.

## 3. NaOH Pretreatment

Alkaline pretreatment can effectively dissolve the cellulose into dissolved organic carbon compounds, so it is easy to be used by microorganisms. The effect is related to the type and dosage of alkaline [7]. NaOH pretreatment is usually used in sewage sludge and straw anaerobic digestion.

Some researchers proposed that NaOH pretreatment can enhance sludge solubilisation and methane yields. Zhang et al. [8] thought the reason was mainly due to the increasing pH value. The increasing pH value changed cell osmotic pressure in dewatered activated sludge resulting in extracellular polymeric substances solubilisation and cell lysis. Cho et al. [9] found the solubilisation efficiency and methane yield of the sludge increased significantly. The SCOD, soluble protein and carbohydrate concentration increased with the increase of the NaOH dosage. During high solid anaerobic digestion process, although high

NaOH does inhibited methanogenic activity, moderate NaOH does was able to improve cumulative methane yield[8].

The straw contains a high content of lignin, which cannot be well utilized by anaerobic bacteria in high solid anaerobic digestion process. NaOH pretreatment can destroy the complex structure of the lignin to enhance its high solid anaerobic digestion. Chen et al. [10] thought that not only lignocellulose but also some nitrogenous materials were destroyed or broken down by alkaline treatment. The lignin structure was destroyed through alkaline treatment that caused the decreased lignin, but the crystallinity index of cellulose increased. Pang et al. [11] investigated the effect of temperature and chemical pretreatment on anaerobic biogasification of corn stalk. The result showed that NaOH was the optimal reagent for pretreatment to increase the yield of biogas at 35°C by 77.0% than that of anaerobic digestion without pretreatment at the same temperature.

#### **4. Ultrasonic Pretreatment**

As a new pretreatment method, ultrasonic technology is mainly used in the anaerobic digestion of sludge. Meanwhile it is used in the anaerobic digestion of kitchen waste and cow-dung.

Ultrasound could destroy the sludge flocs and the cytoderm through the shear force caused by Cavitation bubble breakup, so that the EPS and intracellular substances, such as protein, nucleic acid, sugar and other substances release into the solution. As a consequence, the sludge anaerobic digestion improved and the value of COD increased. The main influence factors of ultrasonic pretreatment are ultrasonic time, power density and pH of sludge. Vlyssides et al. [12] studied the effect of ultrasonic pretreatment on the solubilization of sludge. The results showed that the increase of total solid solubility increased with the energy input increment.

Appropriate intensity of ultrasound can effectively improve the activity of the enzyme and promote cell growth. Some researchers studied the effect of ultrasound pretreatment on cow-dung anaerobic digestion. Results showed that the ultrasound pretreatment with proper intensity was benefited to cow-dung anaerobic digestion.

#### **5. Conclusion**

Pretreatment is an effect way to improve the performance of high solid anaerobic digestion. The main effect is to improve the solubilisation of the solid waste in the hydrolysis process. At the same time, some pretreatment methods can effectively improve the yield of gas and acid production. Taking into

account the actual industrial applications, the study should focus on the relatively low energy consumption.

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