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The influence of volatile fatty acid (VFA) on anaerobic system and its control countermeasures

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Abstract: This paper studies the characteristics of volatile fatty acids (VFA), the reasons for their formation, and their harm to the anaerobic system, and summarizes the methods and means to effectively regulate VFA during the operation of the anaerobic system to ensure the stable and normal operation of the anaerobic system.
Keywords: Volatile Fatty Acid(VFA); Anaerobic system; Organic load; pH; degradation.

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1. INTRODUCTION

Volatile Fatty Acid (VFA), abbreviated as VFA, is a type of fatty acid, generally an organic acid with a carbon chain of 1 to 6 carbon atoms, including acetic acid, propionic acid, isobutyric acid, valeric acid, isovaleric acid, Butyric acid, etc., their common feature is strong volatility, so they are called volatile fatty acids.

Volatile fatty acids are an important intermediate product in the anaerobic digestion process. Methanogens mainly use VFA to form methane, and only a small part of methane is produced by CO2 and H2. However, the production of CO2 and H2 also goes through the intermediate process of polymer organic matter to form VFA. From this point of view, the process of forming methane is inseparable from the formation of VFA, but the accumulation of VFA in the anaerobic reactor can reflect the inactive state of methane bacteria or the deterioration of reactor operating conditions. Higher VFA (such as acetic acid)) Concentration has an inhibitory effect on methanogens. Therefore, in the operation of the reactor, the effluent VFA is used as an important control index.

2. THE INFLUENCE OF VFA ON ANAEROBIC REACTOR

The principle of anaerobic production of volatile fatty acids is in the middle stage of anaerobic fermentation, by adding methanogenic inhibitors to block the methanogenesis step, so that the anaerobic fermentation stays in the acid production stage to obtain high concentrations of acetic acid and propionic acid. , Butyric acid and other mixed volatile fatty acids[1]. VFA is mainly formed through the steps of hydrolysis and acid production and is the precursor matrix for the next step of methane production[2]. If the methanogens cannot use VFA in time during the fermentation process, the pH of the system will decrease, which will cause VFA to accumulate. Too high VFA will cause acidification of the system and inhibit the growth of microorganisms. When the system is in an acidic state, it will affect the stability of the anaerobic reactor, which can easily lead to acidification and operational breakdown of the reactor.

3. CAUSES AND HARMS OF VFA ACCUMULATION

Generally, high organic load and complex raw materials in the anaerobic digestion system will lead to the accumulation of VFA in the system, especially fur wastewater with high VFA content. The anaerobic digestion should pay close attention to this indicator. In addition, since the degradation of fatty acids such as propionic acid and butyric acid into acetic acid, carbon dioxide and hydrogen requires high free energy, it cannot proceed spontaneously. Therefore, the degradation of VFA is considered to be the rate-limiting step of the anaerobic digestion process. In the initial stage of anaerobic digestion, the hydrolysis of the substrate will produce a large amount of VFA. If it is not properly controlled, it will easily cause the accumulation of VFA and decrease the pH value. The toxicity of VFA will increase at low pH, which will destroy the entire reaction system[3].

4. VFA CONTROL COUNTERMEASURES

(1) The anaerobic reaction of the control system is carried out under neutral conditions

Zhang Xuecai[4] and others found that acid-base has a greater impact on the gas production effect when conducting anaerobic digestion of organic waste. When the pH is between 7.0 and 8.0, the gas production is in good condition. Affect normal gas production. Wu Yun[5] et al. found in the study of anaerobic digestion of food waste that under neutral conditions (pH=7.5), the chemical oxygen demand (CODcr) and the cumulative dissolution of VFA both increased significantly. Through the adjustment system The pH value can relieve the acidification of the system, ensure the stability and processing capacity of the system, and improve the methane production capacity. A study by Muhammad[6] et al. in 2017 found that when the pH value decreased from 7.0 to 5.5, the VFA concentration in the anaerobic digestion system increased from 40 mg/L to 504 mg/L. Ye Ningfang[7] studied the influence of pH value on the diversity of flora in the process of anaerobic fermentation, and the results showed that the microbial diversity is higher when the pH value is between 7.0 and 8.0, and the species diversity changes with time under the pH value in this range. There is a similar change rule, the species diversity at pH 5.0 is low, and the higher species diversity is conducive to the production and degradation of volatile acids. Therefore, anaerobic digestion should be controlled under neutral conditions.

(2) Properly control the organic load of influent water

In addition, excessive organic load will also stimulate the rapid growth of acid-producing fermentation bacteria in the system with strong adaptability and short generation time, while the growth of methanogenic bacteria is slow, and the metabolic balance between the two is disrupted, causing a large amount of fatty acid and other metabolites to accumulate. Inhibiting the activity of methanogens even leads to acidification of the reactor. Xia Yuanliang[8] et al. used a single-phase anaerobic digestion system to treat kitchen waste under moderate temperature conditions and found that when the organic load was 2.5-3.0 kg/(m3 d), the overall effect of anaerobic digestion was better. Continue to increase the organic load, and the accumulation of VFA will cause the pH in the system to drop rapidly, and the gas production rate and organic matter degradation rate will decrease significantly, which is not conducive to the progress of anaerobic digestion. Shi Xiankui[9] and other studies have shown that after increasing the feed concentration and organic load, the pH value rapidly decreases from 6.7 to 5.5. Because the reproduction rate of acid-producing bacteria is faster than that of methanogens, when the organic load is high, acid-producing bacteria decompose. The organic matter produces a large amount of VFA, which exceeds the utilization capacity of methanogens, which leads to the accumulation of VFA in the system and the acidification of the reactor. Therefore, the organic load is too high will also cause the accumulation of VFA, the most intuitive phenomenon is the decrease of pH. In order to ensure the stable operation of anaerobic digestion, the organic load of influent water should be properly controlled.

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