Development of Methane Fermentor for Restraining Ammonia Inhibition

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Abstract

Anaerobic digestion of swine wastes is an attractive practice in which both pollution control and energy recovery can be achieved. Nowadays, anaerobic digestion becomes a promising process due to its beneficial output including renewable energy production and mitigation of pollutant emissions. However, the high concentration of ammonium in manure and the produced ammonia as a common metabolic end product during the anaerobic digestion of protein-containing substrates often cause the inhibition of anaerobic digestion process, because it is toxic to anaerobes.

Several methods are available for eliminating ammonium inhibition in the anaerobic digestion process including adding adsorption materials, chemical precipitation, ammonia stripping, and biological ammonium removal. Given its advantages and limitations, adding adsorption materials has been recognized as a favorable technology with the advantages of convenient and economic. Furthermore, the ammonium saturated material can be recycled as fertilizer which fulfills the requirements of sustainable development. Therefore, the aim of this study is to develop an anaerobic bioreactor integrated with adding adsorption materials for eliminating ammonium inhibition and improving anaerobic digestion efficiency.

Firstly, a zeolite fixed bioreactor was developed for anaerobic digestion of ammonium-rich swine waste. This section was mainly focus on the configuration of the bioreactor by comparing the performance of anaerobic digestion in the zeolite sunken bioreactor and without zeolite bioreactor. The new bioreactor exhibited good performance, with startup time on the 14th day and methane production of 178.5 ml/g-VS during all 32 days of the experiment at 35 ºC. This bioreactor significantly

shortened startup time, enhanced methane gas yield more than two fold and made COD removal more efficient than under the other models.

After that, a porphyritic andesite (WRS) was tried to use as an ammonia adsorbent and bed material for the anaerobic digestion process. To improve its ammonia adsorption capacity, a calcium salt treated and calcination method was developed. Scanning electron microscope (SEM) and Brunauer–Emmett–Teller (BET) surface area analyses were performed to characterize the Ca-modified WRS, and adsorption isotherms and kinetics were investigated to clarify the adsorption mechanism. The ammonium adsorption process was explained well with a pseudo-second-order kinetic model. The specific surface area of the Ca-modified WRS was determined to be 4.56 sq. m/g, and the maximum NH_4^+-N adsorption capacity was determined to be 45.45 mg/g. These values are improvements over those of natural WRS. The ammonium adsorption capacity remained constant at a pH range from 5.0 to 9.0, which indicates that Ca-modified WRS is a promising material for various applications. Then the modified WRS fixed bioreactor was set up and the anaerobic digestion of ammonium-rich swine wastes in bioreactors with modified WRS, natural WRS, calcium chloride and no additives was investigated. The modified porphyritic andesite bioreactor exhibited the best performance, with start-up time on the 7th day, methane yield of 359.71 ml/g-VS, and COD removal of 67.99% during all 44 days of the experiment at 35 ℃. The effective ammonium adsorption and essential ions dissociation for microorganisms by modified WRS, as well as the immobilization of microbial on the surface of the modified WRS play a great role on the high efficiency anaerobic digestion of ammonium-rich swine waste.