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Short communication

Evaluation of biogasification and energy consumption from food waste using short-term hydrothermal pretreatment coupled with different anaerobic digestion processes

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ABSTRACT

The effect of short-term hydrothermal pretreatment (SHP) before conducting two different anaerobic digestion (AD) processes on the enhancement of biogasification from food waste (FW) was evaluated. Results suggested that the highest biohydrogen and methane production rates were 13.33 mL/h and 15.81 mL/h, respectively, in the two-stage AD process with SHP (SHP-T). The regularity of ethanol and volatile fatty acid yields indicated that the fermentation type changed from a butyric acid-type to an ethanol-type during the SHP-T. Moreover, a combination of fluorescence excitation-emission matrix spectra and parallel factor analysis was used to isolate three fluorescent components. Among which, the major component was protein-like substances. According to energy flow analyses, SHP-T obtained the highest net energy gains among the different AD processes. This phenomenon showed that the new SHP-T technology had remarkable application potential for FW biogasification and complied with criteria relating to green energy concepts and sustainable development.

1. Introduction

Food waste (FW) is a major component of municipal solid waste and brings about critical environmental, economic, and social problems (Mourad, 2016). As FW comprises large proportions of lipid, protein, and carbohydrate, and minor amounts of hemicelluloses and cellulose, as a favourable substrate, it is used to generate biogas in anaerobic digestion (AD) (Kovács et al., 2015). In China, more than 100 pilot projects have been nominated and approximately 80% choose AD as the main disposal technique. However, the high lipid, and salinity, contents with complex components, which are primary characteristics of FW in China, have a negative effect on bacterial activity during AD.

Short-term hydrothermal pretreatment (SHP) is an attractive method, which could cause the degradation of complex molecules and the solubilisation of recalcitrant particles. In our previous study, the effect of the SHP on the biogasification was investigated and it was revealed that SHP could enhance the biohydrogen production potential when used in combination with AD (Li et al., 2014), however, the full potential of biogasification from FW was difficult to unlock due to the complex intermediate metabolites and metabolic pathway in different AD processes. The SHP before the different AD processes may exert a significant effect on the biogasification potential.

The objective of this study was to promote the biogasification potential from FW and evaluate the economic feasibility of incorporating SHP with different AD processes. The regularity of intermediate metabolites, such as ethanol, dissolved organic matter (DOM), and volatile fatty acids (VFA) were investigated. The present work could be used to increase the potential use of biogasification and to enhance energy-producing efficiency for future studies while providing sustainable methods for organic waste energy utilisation.

2. Materials and methods

A fluorescence excitation-emission matrix spectra coupled with

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parallel factor analysis (FEMS-PFA) method was used to assess the effects of different AD processes on DOM utilisation and biogasification potential for FW in China.

2.1. Feedstock preparation

FW was obtained from a dining hall and smashed into 1–3 mm diameter pieces. The raw FW with distilled water (50% m/m) was added to a stirred tank reactor and heated to 90 °C for 30 min. The seed sludge was collected from pig manure disposed of using a full-scale anaerobic reactor located in Beijing, China.

2.2. Experimental design

Four processes were designed for investigating the effect of SHP on single- and two-stage AD processes, including an SHP with a single-stage AD process (SHP-S), a non-SHP with a single-stage AD process (NSHP-S), an SHP with a two-stage AD process (SHP-T), and a non-SHP with a two-stage AD process (NSHP-T). FW inocula of 50 g mass mixed with 350 mL sludge (with a $VS_{food\ waste}/VS_{sludge}$ ratio of 1:2) were added to the reactors, whose total volume were adjusted to 1.6 L and were magnetically stirred at 100 rpm. The pH of both the SHP-S and NSHP-S was controlled to 7.0, while the SHP-T and NSHP-T were self-controlled. The reactors were operated under mesophilic condition (35 ± 1 °C) and samples were taken at intervals of 6 h.

Table 1
Characteristics of untreated FW and inocula. TS is a total solid proportion. VS is a volatile solid proportion. SCOD is a soluble chemical oxygen demand.

	Food waste	Seed sludge
pH	6.3	7.7
TS (%)	21.3	11.45
VS/TS (%)	93.24	49.54
SCOD (g/L)	132.8	1.34
Moisture content (%)	78.7	88.55
Lipid content (%)	27.25	–
Raw protein (%)	19.63	–

2.3. Methods

A gas meter measured the amount of biogas produced. The kinetic reaction governing biogasification was analysed by use of the modified Gompertz model. The composition of the biogas (*i.e.*, H_2, CH_4, and CO_2), and the VFA and ethanol concentrations were assayed by gas chromatography using operational procedures described (Li et al., 2014). An FL-7000 (Hitachi, Japan) fluorescence spectrophotometer was used to carry out excitation-emission matrix (EEM) spectroscopy using the method of Li et al. (2014). The FEMS-PFA was conducted by following the technique proposed by Guo et al. (2012) and by using the DOM Fluor toolbox in MATLAB™ 7.0.

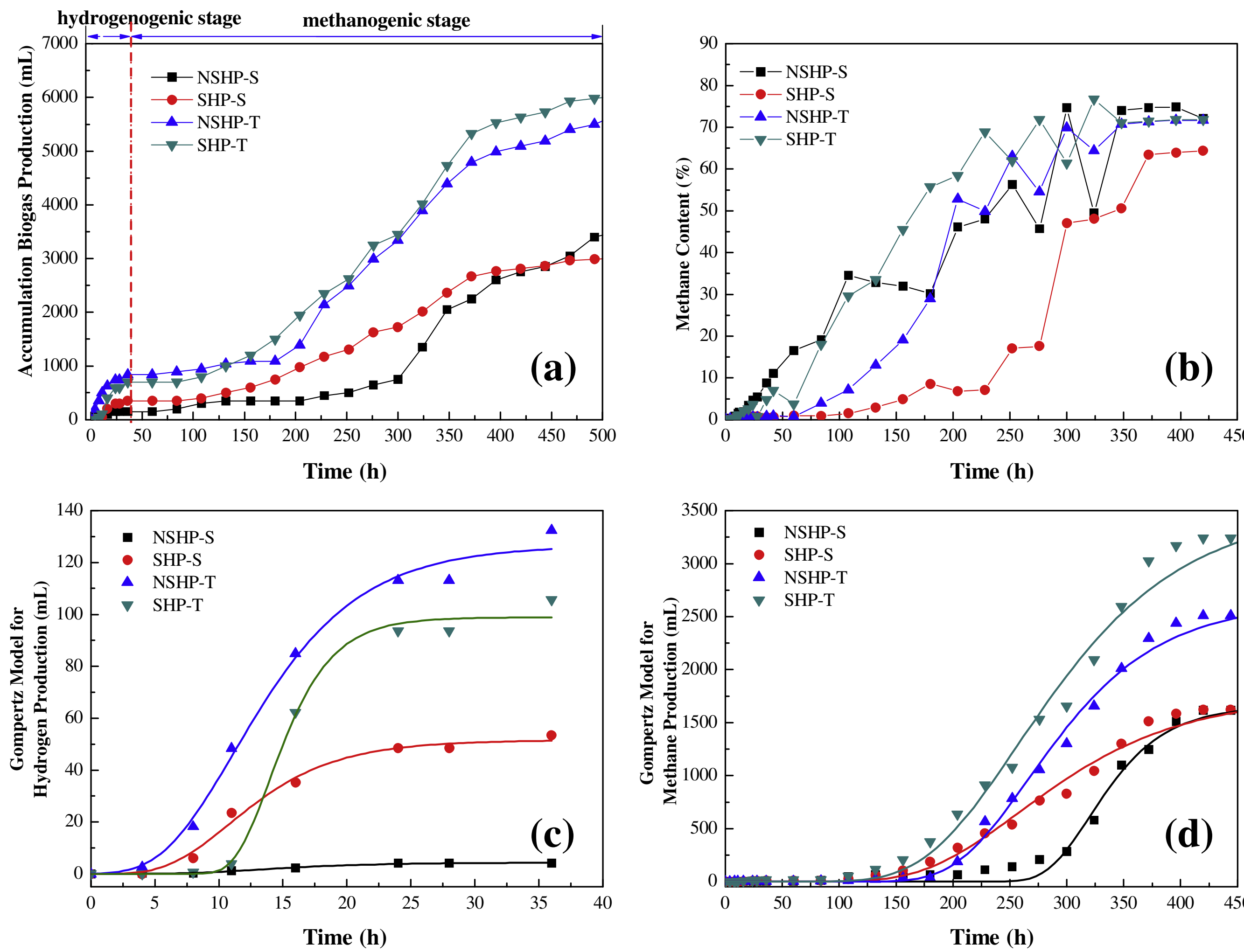

Fig. 1. Biogasification performance and kinetic analysis during the different AD processes. (a) accumulative biogas production; (b) methane proportion; (c) accumulative biohydrogen production; (d) accumulative methane production.