Comparison between automated anaerobic digestion test systems for determination of biochemical methane potential of cellulose

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1. Introduction

Biochemical methane potential (BMP) tests are used to determine methane yields and the biodegradability of the organic substances under anaerobic conditions [1]. The values obtained are also useful for determination of operating conditions such as the hydraulic retention time in anaerobic digestion (AD) plants [1].

Due to human errors that can result from 'one-off' experimental set-ups, automated systems have been developed to simplifying experimental set-up and give consistent results [2]. This study investigated the use of two automated systems, the Automatic Methane Potential Test System II (AMPTS II) and the CJC lab system, a newly developed system, to measure BMP of cellulose. The differences in system operation are also highlighted.

2. Method

Inoculum

The inoculum was collected from an anaerobic digester treating paper making waste at Smurfit Kappa Townsend Hook Paper Makers, Kent, United Kingdom. It was incubated at 35℃ for three days so that the microbes could use up any remaining substrate.

Experimental Set-up

Both systems consist of 4 main units: the digesters within water baths, the CO_2-fixing unit, the gas volume measuring device (GMD), and the data acquisition system (DAS) (Figure 1).
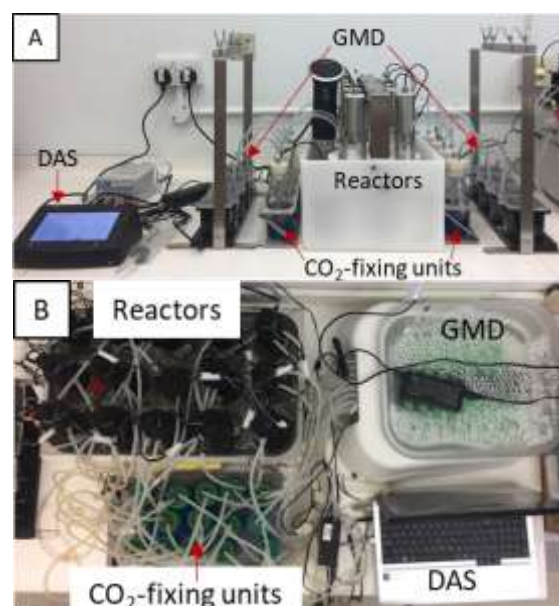

Figure 1: A) CJC system set-up (front view), B) AMPTS II set-up (top view).

The experiment in both systems were set up with three controls, containing 140ml (5.76% volatile solids (VS)) inoculum and 260ml deionised water. The remaining reactor bottles had an inoculum-substrate ratio of 8.06, using 1g of $20\mu m$ cellulose powder (100% VS) (Sigma-Aldrich). For both systems, the reactors were incubated in a water bath set to $35\pm0.5℃$ over 28 days. The headspace of the bottles was flushed with 100% nitrogen gas to create an anaerobic environment. The gas produced from each reactor passed into an individual CO_2-fixing bottle of the unit consisting of 80ml 3M NaOH solution and

0.4% Thymolphthalein pH-indicator solution before passing to the GMD.

Operational Differences

Operational differences existed between the two systems. Examples of differences are shown in Table 1.

Table 1: Differences in operation for CJC and AMPTS II

	AMPTS II	CJC
Number of digesters	15	8
Stirring unit	Bent Stirring rod Controllable speed + period	Paddle-like
Water Bath	Thermo-static	Separate heating device
Temperature and pressure correction	0°C, 101.325kpa	0°C, 100kpa
Flush gas correction	Yes	None
Powering motor units	'Daisy-chain' spade connections	Cables connect to power rails

4. Results and Discussion

The BMP values were significantly different between the test systems (*p-value < 0.05*) (Table 2).

Table 2: BMP results

Theoretical yield (ml g^{-1})	AMPTS II (ml g^{-1} VS)	CJC (ml g^{-1} VS)
415	174 $\pm$ 22	427 $\pm$ 38

The theoretical yield for CH_4 production of cellulose was calculated using the 'Buswell' equation. Both values were adjusted to STP (0°C, 100kPa), inoculum gas production, and flush gas overestimation.

The CJC produced a CH_4 yield closer to the theoretical value for the biodegradable cellulose substrate compared to the AMPTS II. Although the value is slightly higher, the results indicate that the inoculum is efficient at degrading cellulose and is not the reason for low CH_4 yields produced by the AMPTS II.

The differences in BMP values for different methods using the same substrates have also been found by other authors [3]. The higher CH_4 yield using the CJC system could be due to greater mixing intensity. Mixing energy is required to bring the fresh material for fermentation into contact with the fermenting microorganisms and to prevent the settling out of denser materials, within the feed stock, in the digester [4].

5. Conclusions

The results indicate that for cellulose, the CJC system achieves a BMP value closer to the theoretical value compared to the AMPTS II. Therefore, it may be a better determinant of BMP. Tests using cellulose and other substrates will be required to validate the results.

6. References

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