**Effect of the addition of oak wood biochar and hydrochar in anaerobic digestion**

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**Highlights**

* Anaerobic Digestion
* Hydrothermal Carbonisation
* Pyrolysis

**1. Introduction**

Anaerobic digestion (AD) is a technology highly used for the sustainable management of a wide variety of waste while producing energy. The main product of AD is biogas, an alternative gaseous biofuel, composed principally of CH4 [1]. Nevertheless, AD presents a major problem regarding inhibitory compounds from the organic feedstocks or produced during their hydrolysis, which detriment the CH4 final yields [2]. Among the reported approaches for improving the CH4 yields is the addition of adsorbent materials. It has been suggested that the addition of carbon materials for their role in the mitigation of the NH4+ inhibition, increasing CH4 metabolism, reducing lag time, and facilitating the syntrophic metabolism between the different microorganisms involved [3].

Therefore, the integration of carbon materials, such as char products from the thermochemical treatment of biomass with AD has a growing interest. The thermochemical products of interest are biochar (BC) and hydrochar (HC). The former is produced by pyrolysis in non-oxidative conditions, whereas the latter is produced by hydrothermal carbonisation (HTC) in water at sub-critical conditions [4]. For the purposes of this work, the term ‘char’ is used to refer to both BC and HC. Particularly, the interest on the chars is due to certain characteristics, such as inertness, porosity, high surface area, and high surface functionality [5]. Even though there are indications of their positive effect on the stability of the AD process and higher quality of the digestate, their full potential as adsorbent materials in AD has not been properly assessed [2].

**2. Methods**

Oak wood was employed for the production of the chars. Firstly, the BC450 and BC650 was obtained by pyrolysis in a mono retort reactor at 450 and 650 °C for 1 hour, respectively. Secondly, the HC250 was produced by HTC in a non-stirred 2 L stainless steel batch Parr reactor at 250 °C, for 1 hour at 40 bar. Subsequently, the two biochars (BC450 and BC650) and the hydrochar (HC250) were used for AD. The anaerobic sludge inoculum was collected at Esholt Wastewater Treatment Plant, West Yorkshire, UK. The AD was performed in 500 mL reactors coupled to a BioprocessTM Automatic Methane Potential Test System (AMPTIIS) system with daily online Biochemical Methane Potential (BMP) measurement. The reactors were supplemented with inoculum 5 g VS/L, cellulose 5 g/L, and 15 g of the corresponding char, whereas the control contained only the inoculum and the cellulose. At the end of the AD the volatile fatty acids (VFA) content were measured by gas chromatography with an Agilent 7890A GC System, a DB-FFAP column, and a flame ionisation detector (FID).

**3. Results and discussion**

The effect on the CH4 production largely differed between the systems with HC and BC (**Fig 1**). Firstly, the addition of HC250 lead to a BMP significantly lower than the control. This inhibitory effect could be related to the VFA accumulation (**Fig 2**) and the acidic nature of hydrochar, since the optimal pH for AD is around neutrality. Secondly, the addition of BC450 lead to a BMP 22% higher than the control. Thirdly, in comparison to the control, the BC650 system presented a similar BMP but a shorter lag phase. The variations on the effect of the chars could also be related to the differences between BC and HC, since their surface functionality and structure are dependent of the pyrolysis and HTC process conditions and the nature of the feedstock employed. For instance, in contrast to the HC, the BC presents a higher porosity and surface area that could promote the immobilisation of cells, and an alkaline nature that could provide a buffering effect. Although while comparing both BCs is worth considering the different temperatures employed for their production, since higher temperatures lead to lower O/H ratios and surface functionality. Thus, the different effect of the chars in AD could be related to their functional and physicochemical properties.

 

**Figure 1.** Production of biomethane during AD. **Figure 2.** Production of volatile fatty acids during AD.

**4. Conclusions**

The addition of oak wood BC and HC had a different effect on AD. The HC250 presented an inhibitory effect on the production of CH4 and a higher accumulation of VFAs. On the other hand, the BCs presented no inhibition on the anaerobic digestion. In consequence, the addition of BC450 improved the BMP and reduced the lag phase, whereas the addition of BC650 presented no significant effect. Therefore, given the BMP values obtained, it could be stated that the oak wood BC could have a beneficial effect on AD, whereas the oak wood HC presented a detrimental effect.

**References**

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