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Effect of hydrogen and carbon dioxide on carboxylic acids patterns in mixed culture fermentation

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HIGHLIGHTS

- This study focuses on the effect of H_2 and CO_2 on the fermentation product spectrum.
- Headspace composition affects the hydrolysis degree rate but not the hydrolysis degree.
- H_2 pressure up to 2 bars does not limit acetate and butyrate production.
- Up to 75% butyrate is selectively produced under a CO_2 headspace.
- Propionate production can be ceased by H_2 or CO_2.

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ABSTRACT

This study investigated the carboxylate spectrum from mixed culture fermentation of three organic waste streams after supplying 2 bar hydrogen and carbon dioxide or a mixture of these two gases to the headspace. Under any modified headspace, propionate production was ceased and butyrate, caproate and the total carboxylate concentrations were higher than in the reactors with N_2 headspace (control). Production of one major compound was achieved under hydrogen and carbon dioxide mixed headspace after 4 weeks of incubation. Both the highest acetate concentration (17.4 g COD/l) and the highest fraction (87%) were observed in reactors with mixed hydrogen and carbon dioxide headspace independent of the substrate used. In the control reactor, acetate made up maximum 67% of the total products. For other products, the highest concentration and fraction were seldom observed together. Selective butyrate production reaching a 75% fraction was found under the carbon dioxide headspace on the carbohydrate rich waste.

1. Introduction

The chemical industry needs to consider alternative, renewable sources to reduce both dependency on oil reserves and to decrease carbon dioxide emission into the environment (Ragauskas et al., 2006). Biomass is an important resource for the production of industrial bulk chemicals. Among the variety of biomass resources, organic waste streams are the most interesting ones because they are abundantly available, cheap and they do not compete with food (Tilman et al., 2009). Organic wastes can be biologically converted into carboxylates, such as acetate, propionate and butyrate under anaerobic conditions without need of costly sterilization operations as in pure culture fermentations. Organic waste materials generally contain a mixture of carbohydrate, protein and lipid polymers. Because of this complexity, organic wastes can only be transformed into the desired products by using a mixed culture.

The first step in a mixed culture anaerobic process of organic wastes is hydrolysis of carbohydrates to monosaccharides, proteins to amino acids and lipids to glycerol and long chain fatty acids. After hydrolysis, these monomers are converted to carboxylates, hydrogen and carbon dioxide during acidogenesis (De Mes et al., 2003). Carboxylates are individually valuable products and they can be used in industry after separation from the fermentation broth and further purification. Carboxylates can however also be used in a secondary fermentation step to generate biofuels and poly-β-hydroxyalkanoates (Agler et al., 2011; Albuquerque et al., 2011; Holtzapple and Granda, 2009).

Because of the diverse polymer composition of organic waste materials and the use of mixed cultures, anaerobic processes generate a mixture of various compounds rather than one single product. Furthermore, because of a high water content of the waste

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