Assessment of thermophilic acidogenic fermentation of hydrolyzed urban solid waste

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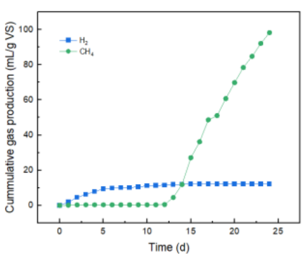
The management of urban solid waste (USW) remains a significant global challenge, driven by accelerated urbanization, increasing consumerism, and insufficient waste separation. The "residual" fraction of USW, characterized by a high moisture content and a predominance of biodegradable organics, presents major obstacles to material and energy recovery. Commonly managed through landfilling or incinerationdirected todisposed of in landfills or used in incineration facilities, this waste stream contributes to air pollution, liquid effluents, and leads to the irreversible loss of valuable resources. In response, European Union directives aligned with recycling targets and low-carbon strategies have progressively restricted the landfilling of biodegradable waste, while fostering resource recovery and biological energy conversion alternatives. Acidogenic fermentation (AF) stands out as a promising biotechnological pathway among these alternatives, converting organic residues into hydrogen gas and volatile fatty acids (VFAs). Hydrogen represents a clean and versatile energy vector for low-emission systems, whereas VFAs serve as key precursors for bioplastics, renewable fuels, and co-substrates in biogas production. This study evaluated AF of hydrolyzed USW under semi-continuous thermophilic operation (55 °C), assessing its potential for hydrogen and VFA generation.

The feedstock consisted of hydrolyzed USW with 7.6% total solids and a chemical oxygen demand (COD) of 88.5 g/kg, including 23% as soluble COD. The experimental setup utilized a 1.5 L semi-continuous reactor operating under semi-continuous mode at a hydraulic retention time (HRT) of 8 days and an organic loading rate (OLR) of 4.5 g VS/L·d. The trial lasted 24 days without active pH control. The inoculum was an adapted mixed sludge, preconditioned at 55 °C and heat-treated at 105 °C for two hours to suppress methanogens and favor hydrogen-producing microbes.

Biogas cumulative production composition and composition cumulative production are presented in Figure 1. During the initial phase (days 0–5), fermentative activity prevailed, with a hydrogen-specific rate of 1.9 mL H_2/g VS·d at an average pH of 6.4, favorable for hydrogenogenesis. In contrast, fFrom day 13 onward, methane dominated the output, reaching a specific production rate of 8.5 mL CH_4/g VS·d, which suggests the reestablishment of methanogenic populations—likely hydrogenotrophic archaea—despite the thermal pretreatment. In contrast, during the initial phase (days 0–5), fermentative activity prevailed, with a hydrogen-specific rate of 1.9 mL H_2/g VS·d at an average pH of 6.4, favorable for hydrogenogenesis. As shown in Figure 2, the total VFAs concentration stabilized at around 8.4 g CH_3COOH eq./L, indicating a balance between acid formation and conversionsumption, potentially through methanogenic pathways that couple hydrogen and acetate to methane. The rapid onset of methanogenesis following the short hydrogenogenic phase underscores the need for improved strategies to sustain acidogenesis. Potential measures strategies include shorter reducing HRTs, recirculatingon of acidified digestate, applying targeted methanogen inhibitors, or implementing continuous pH regulation control to maintain conditions favoring acidogenic microbial communitiespopulations.



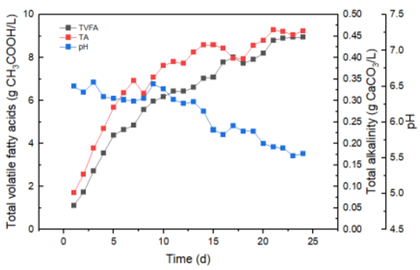


Figure 1. Cummulative gas yields

Figure 2. Stability assessment of acidogenic fermentation

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