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An integrated biohydrogen refinery: Synergy of photofermentation, extractive fermentation and hydrothermal hydrolysis of food wastes

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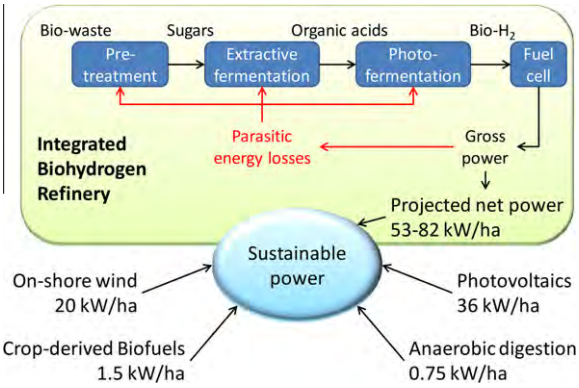
HIGHLIGHTS

- Integrated biohydrogen refinery (IHBR) was evaluated with range of food wastes.
- The IBHR process combines hydrothermal hydrolysis, dark fermentation and photo-fermentation.
- Hydrolysed biomass was suitable for efficient electro-extractive fermentation (EF).
- EF generates an NH_4^+-free liquor suitable for photofermentation (PF) independent of feed N-content.
- On average the IBHR reduced waste by 92% with a net energy ratio of 2.4 producing 67 kW per ha land.

GRAPHICAL ABSTRACT



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ABSTRACT

An *Integrated Biohydrogen Refinery* (IBHR) and experimental net energy analysis are reported. The IBHR converts biomass to electricity using hydrothermal hydrolysis, extractive biohydrogen fermentation and photobiological hydrogen fermentation for electricity generation in a fuel cell. An extractive fermentation, developed previously, is applied to waste-derived substrates following hydrothermal pre-treatment, achieving 83-99% biowaste destruction. The selective separation of organic acids from waste-fed fermentations provided suitable substrate for photofermentative hydrogen production, which enhanced the gross energy generation up to 11-fold. Therefore, electrodialysis provides the key link in an IBHR for 'waste to energy'. The IBHR compares favourably to 'renewables' (photovoltaics, on-shore wind, crop-derived biofuels) and also emerging biotechnological options (microbial electrolysis) and anaerobic digestion.

1. Introduction

Biohydrogen provides opportunities for sustainable energy from biowastes using fermentative and photosynthetic microorganisms. We focus on the synergy of dark fermentation (DF) and photofermentation (PF), with a theoretical yield of 12 mol H_2/mol hexose equivalent. The concept has been advocated by many authors (Redwood et al., 2009 and references therein) and research continues to progress rapidly with at least 10 publications in 2011.

Abbreviations: IBHR, integrated biohydrogen refinery; EF, electro-fermentation; PF, photo-fermentation; DF, dark fermentation; OA, organic acids; PBR, photobioreactor; ASM, anion selective membrane; CSM, cation selective membrane; BPM, bipolar membrane; Ma, wholesaler's mango waste; Ap, wholesaler's asian pear waste; Av, wholesaler's avocado waste; CW1, catering waste 1; CW2, catering waste 2; CW3, catering waste 3; BG, brewers spent grain waste; HCW, hot compressed water; CE_{OAn}, current efficiency based on organic anion; CE_{Tan}, current efficiency based on total anion; HPP, hydrogen production potential; 5-HMF, 5-hydroxymethyfurfural; NER, net energy ratio; GBP, British pounds.

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