Biological hydrogen production from biomass by thermophilic bacteria

P.A.M. Claassen [a], A. E. Mars [b], M.A.W. Budde [c], M. Lai [a], E.W.J. van Niel[d], and T. de Vrije [e]

[a] Wageningen UR, Agrotechnology and Food Sciences Group (AFSG), Business Unit Biobased Products, P.O. Box 17, 6700 AA Wageningen, The Netherlands; pieternel.claassen@wur.nl;
[b] Wageningen UR, Agrotechnology and Food Sciences Group (AFSG), astrid.mars@wur.nl;
[c] Wageningen UR, Agrotechnology and Food Sciences Group (AFSG), miriam.budde@wur.nl
[d] Lund University, Applied microbiology, P.O. Box 124, 221 000 Lund, Sweden. Ed.van_Niel@tmb.lth.se
[e] Wageningen UR, Agrotechnology and Food Sciences Group (AFSG), truus.devrije@wur.nl;

ABSTRACT:

To meet the reduction of the emission of CO_2 imposed by the Kyoto protocol, hydrogen should be produced from renewable primary energy. Besides the indirect production of hydrogen by electrolysis using electricity from renewable resources, such as sunlight, wind and hydropower, hydrogen can be directly produced from biomass. At present, there are two strategies for the production of hydrogen from biomass: the thermochemical technology, such as gasification, and the biotechnological approach using micro-organisms. Biological hydrogen production delivers clean hydrogen with an environmental-friendly technology and is very suitable for the conversion of wet biomass in small-scale applications, thus having a high chance of becoming an economically feasible technology.

Many micro-organisms are able to produce hydrogen from mono- and disaccharides, starch and (hemi)cellulose under anaerobic conditions. The anaerobic production of hydrogen is a common phenomenon, occurring during the process of anaerobic digestion. Here, hydrogen producing micro-organisms are in syntrophy with methanogenic bacteria which consume the hydrogen as soon as it is produced. In this way, hydrogen production remains obscure and methane is the end-product. By uncoupling hydrogen production from methane production, hydrogen becomes available for recovery and exploitation. This study describes the use of extreme thermophilic bacteria, selected because of a higher hydrogen production efficiency as compared to mesophilic bacteria, for the production of hydrogen from renewable resources. As feedstock energy crops like *Miscanthus* and *Sorghum bicolor* and waste streams like domestic organic waste, paper sludge and potato steam peels were used. The feedstock was pretreated and/or enzymatically hydrolyzed prior to fermentation to make a fermentable substrate. Hydrogen production by *Caldicellulosiruptor saccharolyticus*, *Thermotoga elfii* and *T. neapolitana* on all substrates was observed. Nutrient requirements and inhibitory effects differed depending on the strain and the feedstock applied. Fermentations on a larger scale under controlled conditions allowed accurate determinations of hydrogen yields and hydrogen production rates for these extreme thermophilic microorganisms.

The first results of a new FP 6 Integrated Project “Hyvolution” (start date 01/01/2006; co-ordinated by Agrotechnology and Food Innovations) will be presented. This IP is aimed at the development of a blue-print for an industrial bioprocess for decentral hydrogen production from locally produced biomass.

KEYWORDS : biohydrogen, thermophilic bacteria, biomass, fermentation