Turning bio-waste into hydrogen

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Whilst hydrogen cars look set to be the next big thing in an increasingly carbon footprint-aware society, sustainable methods to produce hydrogen are still in their early stages. The HYTIME project is working on a novel production process that will see green hydrogen being produced from grass, straw and food industry residues.

When sustainability and bioeconomy are being discussed, the words 'hydrogen' and 'biomass' are usually not too far away - although rarely mentioned in the same sentence. But what if hydrogen could be produced directly from second generation biomass?

Starting in 2000 with the Dutch project 'Hydrogen from biomass' and followed up with funding under FP5 and 6, Pieternel Claassen's quest for creating an efficient, marketable hydrogen production process from bio-waste has recently reached a new high. HyTIME (Low temperature hydrogen production from second generation biomass), an EU-funded project due to be completed in December, aims to increase the productivity of fermentative hydrogen production, thereby accelerating its implementation in industrial processes.

The stakes are high: in the EU, some 118 to 138 million tons of bio-waste are currently produced every year. With the HYTIME technology, these could be converted into 0.34 million tons of hydrogen and provide a significant contribution to the EU's sustainability targets.

In an exclusive interview with research*eu magazine, Dr Claassen, researcher at Wageningen UR Food & Biobased Research, explains how the combination of the nine participants' expertise in biomass logistics and pretreatment, thermophilic hydrogen production and gas upgrading technologies will enable HYTIME to go beyond the state-of-the-art of current fermentative hydrogen production.

What are the main objectives of the project?

Nowadays 'green' hydrogen can only come from two sources: biomass and electrolysis using 'green' electricity. HYTIME focuses on the former, particularly on biomass resources having a high moisture content where existing technologies such as gasification are less efficient.

We have two main objectives. First, we aim to achieve production of 1 to 10 kg of hydrogen per day from second generation biomass. This is a rather symbolic quantity - which could cover the electricity needs of four households - but we hope this will be enough to convince stakeholders that, on a larger scale, hydrogen production by bacteria is achievable.

Then, we target the reduction of time to market for biohydrogen through the combination of this production process with 'anaerobic digestion' (AD). The latter allows for the conversion of by-products - mainly organic acids - to CH4 (and CO2), which in turn is expected to cover (part of) the energy demand of the hydrogen production process.

What is new or innovative about this approach to hydrogen production?

In natural anaerobic digestion systems, biomass is converted to biogas (CH4 and CO2) by a consortium of micro-organisms working together. Some of these micro-organisms produce organic acids and hydrogen, but the latter is immediately consumed by other, hydrogenotrophic bacteria which convert it into methane or acetic acid. These bacteria are our enemies, and the HYTIME innovation consists in working with extreme thermophilic bacteria - which have superior yield - to make their life so miserable that they can not survive and decrease the hydrogen yield.

How does the hydrogen generation process work?

In anoxic environments, i.e. no oxygen present, bacteria ferment sugars into CO2 and reduced compounds, such as hydrogen, or into organic reduced metabolites, such as ethanol or butanol. In nature however, hydrogen is immediately consumed by methanogenic or hydrogenotrophic organisms, leaving only methane behind. Our aim is to decouple hydrogen production from hydrogen consumption by creating an environment where hydrogen-consuming organisms cannot survive.

What kind of businesses do you see using your technology in the future?

Potential interest may arise from stakeholders involved in electricity production, and chemistry, as well as from biomass owners. The point is that hydrogen's fate in the energy sector is bound to that of fuel cells. As soon as we see a breakthrough in fuel cells, the interest in hydrogen coming from renewable resources will increase.

HYTIME research and development will also deliver spin-off technologies, which have the potential to reach the market quicker than the whole process. These include sensors for gaseous components (H2, H2S, etc.) - which are often observed in the production of biogas - as well as the automation for managing fermentations thanks to our online monitoring and control systems.

We also foresee that biomass owners will be interested in finding new applications for their organic residues. Agro-industrial businesses such as the potato processing industry, the sugar industry and beer producers may find our technology useful either for producing and selling hydrogen or for using it to cover their own electricity needs.

What are the next steps for the project, and after its end?

The next step will be to demonstrate the production process with all operation units being physically connected. This means proceeding to the pretreatment and hydrolysis of biomass to supply the sugars for the hydrogen fermentation on site. During the latter step the gas will be recovered simultaneously with its production and the liquid effluent will be pumped into an anaerobic digester. The sizes of the hydrogen fermenter and the anaerobic digester need to be adjusted to enable a continuous flow of liquids.

What do you expect from the project in terms of market impact?

The market impact is regarded as significant. As I already mentioned, hydrogen is a widely used chemical. The current outlook for society is a move towards a bio-based economy, and hydrogen can be used in numerous businesses aiming to switch to green technologies. Moreover, the project's new monitoring and control devices and systems are applicable in current installations for anaerobic digestion and waste water treatment systems and are expected to increase their efficiency.

The concept for gas upgrading, based on low energy demand, is innovative and will add to the development of more sustainable gas separation processes.