

Press Information

DSM, Corporate Communications
P.O. Box 6500, 6401 HJ Heerlen
The Netherlands
phone +31 (0) 45 578 2421
fax +31 (0) 045 574 0680

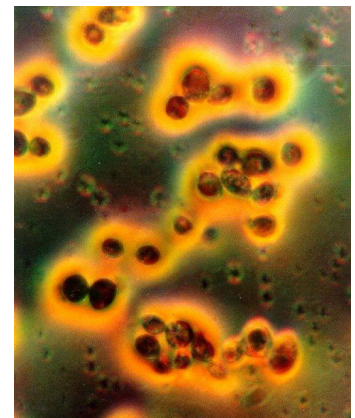
www.dsm.com

All you can eat yeast

A breakthrough in bioconversion technology is bringing second generation bio fuels a major step closer to commercial reality

The challenges posed by resource scarcity, climate change and the growing global population to the environment and our social, economic and political security are well documented. They have also been aptly illustrated by the oil spill in the Gulf of Mexico, which has become the USA's worst ever environmental catastrophe and offers a chilling warning of the risks involved in drilling for oil in difficult locations.

But while a consensus is building around our acceptance of the challenges for sustaining life in a resource-scarce world, the consensus on how mankind will respond is taking longer to develop. With global energy demand set to increase in coming years rather than decrease, the establishment of biological production routes for making fuel offers arguably the most compelling alternative to oil in terms of cost effectiveness and scalability.



This logic of shifting our economic system towards a bio-based economy is undeniable in the long term. However, for bio-based energy - or bio fuels - to reach critical mass as a genuine alternative energy source to oil it must overcome two important challenges associated with first generation technology; namely how to bring production costs into line with oil, and how to enable industrial-scale production without impacting our food supply. Two breakthroughs in bio-conversion technology from DSM offer solutions to both of these problems by bringing us ever closer to commercially viable, second generation bio fuels.

The challenge of second-generation bio fuel

In layman's terms, bio fuel production can be explained in essentially three steps. Firstly, biomass, or substrate - which for first generation fuel tends to be food crops such as corn and sugar cane, is broken down into sugars with the help of enzymes. These sugars are then fed to microorganisms, such as bacteria, fungi and yeasts, which use the sugars to grow and eventually produce substances such as ethanol, or bio-based building block chemicals, such as bio-succinic acid.

However, for bio fuel to become a viable alternative to oil, this production process needs to be made as efficiently as possible. This is not an easy task when one considers that the oil industry has had over 100 years to optimize its processes. To address this, ethanol plants can do two things: firstly, ensure that the biomass is broken down into sugars as efficiently as possible and secondly, optimize the microorganisms' yield. This is typically achieved through a combination of classic strain improvement, in much the same way as a farmer might perfect his herd of cows over time, or by genetically modifying it to produce more ethanol as an end product.

Biomass also needs to be grown without risk to food supplies and biodiversity, hence the importance of second generation technology, which enables the production of bio fuel from wood chips, agricultural residues and energy crops that can be grown on land that is not suitable for food production. Because the sugars contained in these types of biomass are more difficult to access than those from corn or sugar cane, second generation bio fuel to date has not been able to be produced as cost effectively as first generation bio fuel, however new enzyme and yeast technology from DSM promises to change this, and the paradigm of the entire bio fuel industry with it.

Mushrooming potential - DSM's fungus explained

In order to explore how DSM has been able to unlock far greater efficiencies from second generation bio fuel, it is first necessary to examine the process in more detail.

The first step in liberating fermentable sugars from biomass is to subject the material to a high temperature pre-treatment. This serves two purposes in that C5 sugars are immediately liberated and the remaining cellulose, the source of C6 sugars, is made available for enzymatic hydrolysis. Under normal circumstances the pre-treated biomass is then cooled to a much lower temperature in order that the enzymatic hydrolysis to liberate C6 sugars can be carried out.

This cooling phase costs time - by creating a bottle-neck in the process - and money, in terms of the energy that needs to be expended in cooling the material. However, leveraging its 100 year-plus heritage of working with enzymes, as well as world-class research facilities, DSM has discovered and developed a rather special fungus as a source of cellulase enzymes - one that normally lives on fallen trees - with some extraordinary abilities. The first of this fungus' values is the sheer wealth of cellulase enzymes it possesses. Because the fungus sole purpose is to live off trees, these enzymes are extremely well-gearred towards breaking down the most recalcitrant plant matter.

Its benefits are not limited to its extraordinary ability to devour biomass, however. The fungus is also thermophilic, which means that it works at temperatures up to 65 degrees C, meaning less money and time lost on cooling and also less investment in enzymes, as fewer enzymes are required to do the same job at higher temperatures. Finally, their ability to work at 65 degrees C - close to pasteurization temperature - makes the fermentation process less prone to contamination from extraneous organisms, which unchecked can lead to lost production.

DSM's approach towards leveraging this discovery is unique in the bio fuel industry, where the standard approach to improving enzymatic hydrolysis has been to select a single enzyme platform - one originally developed for other applications in, for example, the textile industry - and adapting it to suit each substrate. DSM has instead opted to leverage its unique collection of enzymes by creating a bespoke 'enzyme cocktail' that operates much more effectively on the target substrate for bio fuels, resulting in much higher conversion rates.

Advanced Yeast: up to 100% yield improvement

The second element of DSM's 2G bio fuel breakthrough comes in the form of its Advanced Yeast technology. First generation ethanol yeasts are only able to convert C6 sugars, mainly glucose, into ethanol which, in the case of corn and sugar cane based processes, is perfectly adequate. However for second generation ethanol processes based upon mixed C6 and C5 sugars, new yeast technology is required in order to maximize ethanol yield by using both sugars during fermentation. Through classic strain improvement and genetic modification, DSM's 'all you can eat' Advanced Yeast strain is able to consume both C6 and C5 sugars equally well; in total, glucose, xylose, arabinose, galactose and mannose are all converted to ethanol during fermentation. The result is a fundamental increase in the conversion rate of sugars into ethanol providing maximum efficiency and yield from second generation processes.

The business benefits of using DSM's Advanced Yeast over standard yeasts obviously vary according to the ratio of C6 to C5 sugars that are released from the substrate. However, the company estimates that, taking a mixed sugar fermentation as an example, ethanol yield using Advanced Yeast can be increased compared to the yield of a standard yeast by a factor of two. This productivity boost has massive implications for plant operators' profitability.

Unique business model

DSM's innovation does not stop at technology; the company's business model also changes the economics of the industry. To date, enzyme and yeast manufacturing has been centralized at large hubs and shipped to ethanol plants. This approach, while working adequately for first generation production, is not sustainable for 2G bio fuels, where the complexity of the substrate requires sophisticated enzyme cocktails that are best produced on site and where larger production volumes mean transporting enzymes, even on a regional basis, could be prohibitively expensive.

The logic for on-site production of enzymes is clear: ethanol plants are already built in rural areas, close to the biomass supply, it is therefore an intuitive step to also integrate the production and direct delivery of Bio-Conversion technologies at the same locations. This will result in lower costs, greater efficiency and process compatibility and less waste as compared to remote production.

With DSM now actively marketing both its differentiated enzyme and Advanced Yeast technologies as an integrated Bio-Conversion Solution, the market for second generation (advanced) bio fuels is forecast to grow exponentially over the next decade. This is expected to result in large opportunities for technology providers such as DSM.

As well as the structural shift in the industry brought about by on-site manufacturing, DSM is also developing implementation opportunities for its Bio-Conversion technologies in existing first generation production facilities. DSM's integrated Bio-Conversion solutions enable the conversion of side streams such as corn fibre or wheat bran that otherwise plant operators are not able to convert economically. The advent of these solutions on the market will bring immediate productivity gains and sustainability benefits to the industry by enabling earlier market development of second generation bio fuel.