Green chemistry will help reach sustainable ambitions

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The commercialisation of a bio-based succinic acid brand-named Biosuccinium moves up a gear with the completion later this year of the »world's first« large-scale commercial production plant in Italy. Its driving force Reverdia sees packaging materials as one of many diverse sectors that can benefit from the product's sustainable profile.

Reverdia, a joint venture between *Royal DSM* and *Roquette Frères*, is nearing the opening of what it describes as the world's first large-scale facility for the commercial production of bio-based succinic acid. Demand for the substance called *Biosuccinium*, developed for use in the manufacture of polymers and resins, is expected to come from the packaging sector and wherever the need exists to manage the environmental impact of products and production methods.

Due to start-up by the end of Q3 2012, the *Reverdia* plant will have a capacity of about 10,000 tonnes. It shares the site of *Roquette*'s large bio-refinery at Cassano Spinola/I close to the port of Genoa, which will enable efficient global logistics. The scale-up will be fully backward-integrated with onsite production of the starch feedstock. This means that the *Biosuccinium* production plant will be connected to the production plant for starch feedstock that stands on the same site. Agricultural crops, rich in starch, are processed in one production plant to make starch feedstock and this will then go into the production plant for conversion towards making *Biosuccinium*. The advantage of a backward-integrated plant is that it prevents the need for additional transport from one plant location to the next and avoids additional energy use and costs. In addition *Biosuccinium* production will employ co-generation of steam and power and on-site waste water treatment, to help meet ambitions to be low-carbon and resource efficient.

Reverdia claims to be the only company using low pH yeast technology rather than bacteria to produce bio-based succinic acid. It ensures user advantages over bacteria-mediated conversion technologies (*figure 1*). The process converts feedstock directly to acid. Bacteria-based indirect processes require extra chemical processing, additional equipment and more energy to convert intermediate salts into succinic acid (*figure 2* and *3*). The low pH yeast process is also much less vulnerable to infection. So production equipment requires less cleaning and handling which improves the consistency and quality of the end product. Production of acids at low pH is well known, today e.g. citric acid and itaconic acid are commercially produced using similar processes.

The low pH yeast process avoids impurities and undesired by-products. According to *Reverdia* competing processes are liable to produce mono-acids and may cause unwanted polymerisation. The formation of nitrogen containing compounds has been observed to cause unwanted and difficult to remove discoloration.

A demonstration plant on the *Roquette* site in Lestrem/F has been operational since January 2010, producing tonnages sufficient to supply customers for internal testing and application development. »The demonstration plant provided an excellent opportunity to gain technical experience on the production process of *Biosuccinium*. With the expertise we have with the scale-up of processes and installations, we expect a smooth start-up of our commercial plant«, says JEAN-PIERRE VANNIER, Operations Director at *Reverdia*.

A reliable supply of *Biosuccinium* is expected to give an impetus to renewable and sustainable products. On a larger commercial scale, *Biosuccinium* is envisioned to compete with both petrochemical-based succinic acid and petrochemical-based adipic acid. Potentially it could replace chemically produced alternatives used in coating and composite resins and Phtalate-free plasticisers. *Reverdia* believes that

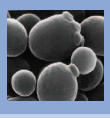
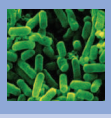
		Yeast	Bacteria
			
Fermentation	Production at pH 3	●	●
	Robustness / phage infection	●	●
Recovery	Product purity	●	●
	No waste salts	●	●
	Simple purification	●	●
Carbon footprint	Compared to petrochemical	●	●

Figure 1:
Low pH yeast technology offers user advantages over bacteria-mediated conversion technologies.

YEAST-BASED

glucose + CO_2 → H_2SA (succinic acid) + ATP (energy)

BACTERIA-BASED

glucose + CO_2 + KOH → K_2SA (succinic salt) + ATP (energy)

K_2SA (succinic salt) + H_2SO_4 (sufuric acid) → K_2SO_4 (salt) + H_2SA (succinic acid)

Figure 2:
Reverdia's yeast-based fermentation process has significant advantages over bacteria-based processes enabling sustainable performance delivering a unique and consistent product quality.

Reverdia facility under construction.

the availability of *Biosuccinium* will help drive the emergence of applications such as bio-based 1.4 Butanediol and Polybutylene succinate (PBS) serving packaging end-markets, in which there is strong and growing need for sustainable solutions.

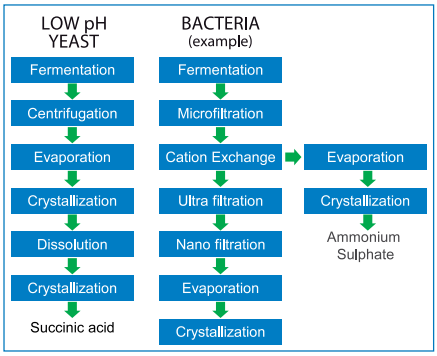
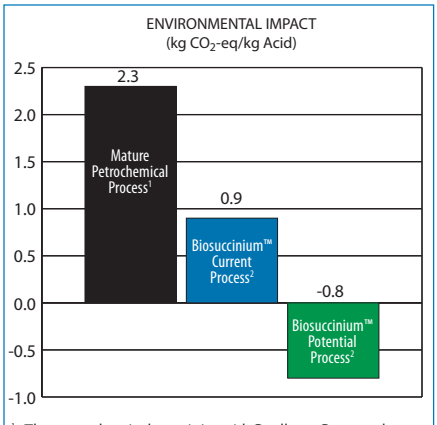


Figure 3: Yeast vs bacteria processes Reverdia's yeast process contains significant fewer steps and requires less energy to produce bio-based succinic acid when compared to competing bacteria-based processes.



[1] The petrochemical succinic acid Cradle-to-Gate study was executed by DSM LCA Group, using SimaPro software with EcoInvent database 2.0 and default allocation for maleic anhydride.
[2] The Biosccinium Cradel-to Gate studay was executed by Dr M.K. Patel, Dr A.L. Roes and B. Cok, MSc at the Copernicus Institute of Sustainable Development at Utrecht University, The Netherlands. Data is pending publication.

Figure 4: LCA comparison between Biosuccinium and petrochemical succinic acid.

According to *Reverdia*, *Biosuccinium* comes with an improved carbon footprint compared with both petrochemical succinic acid and bio-based succinic derived via bacteria process routes. The unique and proprietary technology results in a best-in-class carbon footprint for *Biosuccinium*. A Life Cycle Assessment (LCA) has shown that the carbon footprint is less than half of the carbon footprint of petrochemical succinic acid (*figure 4*).

Biosuccinium-based PBS is partly based on a renewable resource. But with current developments to enable bio-based 1.4 Butanediol, a fully bio-based PBS will be possible to further reduce the dependency on »increasingly scarce and volatile fossil resources«.

Reverdia's spokeperson continues: »Another potential advantage is the material's ability to biodegrade. This means that, depending on conditions, the material breaks down into harmless substances (CO_2, H_2O and compost) within a certain time frame. This time frame for biodegradation depends on conditions – temperature, humidity, thickness, etc – but will always be much shorter than for a similar application made from a non-biodegradable polymer.«

The biodegradable character adds value by helping to reduce littering. In Europe, countries vary in their adoption of biodegradable plastics. *Reverdia* notes that Germany, France and Italy have already released policies related to biodegradable plastics. For example, France and Italy put into effect a ban on the manufacture and distribution of Polyethylene plastic bags that are non-biodegradable from the beginning of 2011. Germany has required conventional plastic bag producers to recycle these bags, while biodegradable plastic bag producers escape that responsibility. And Northern Ireland is to introduce a tax on single-use plastic bags in April 2013.

All of which suggests that market conditions are moving in favour of *Biosuccinium*'s technological proposition, one that gives manufacturers the option to use a »unique and sustainable« building block in the production of sustainable products and packaging.

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