Conversion technologies

A large number of different biotechnological and thermochemical conversion processes exist for the recycling of CO₂ to higher-quality products. After considering several advantages and disadvantages of several possible transformation routes, three promising biotechnological value chains were identified and evaluated:

- **PHB value chain**: CO₂ is used for the cultivation of cyanobacteria. After biomass growth, a nutrient limitation is induced which leads to an accumulation of polyhydroxybutyric acid (PHB) within the cells. The biomass rich in PHB is converted into biocrude and propylene in a hydrothermal condensation stage. The remaining aqueous phase contains mineralized nutrients which are recirculated into the cultivation chain.

- **Acetate value chain**: Acetobacterium woodii is used together with CO₂ and H₂ for the production of acetate by acetic acid fermentation. Acetate is an important basic chemical with a wide range of application possibilities. The current microbial production of organic acids is sugar-based, with the system presented in the project, no additional carbon source is necessary, since CO₂ is used as a carbon source.

Fig. 1: Value chains for industrial CO₂ (copyright BIOENERGY 2020+)
• **Biomass value chain:** This system uses a biorefinery approach. CO₂, light and nutrients are required for microalgae cultivation. The non-specific biomass produced is further processed into organic acids (such as acetic acid or propionic acid) in an acidification step and then converted into polyhydroxybutyric acid in a heterotrophic fermentation process. This is used for the production of biodegradable plastics. The fermentation residue is used for biogas and biomethane production.

The market potential for market volumes, applications, market sectors and market players was examined for the selected products diethyl carbonate (DEC), acetic acid / acetate and polyhydroxybutyric acid (PHB).

For example, DEC will be used as an electrolyte for lithium batteries in the course of future enhanced electromobility. In the case of acetic acid, a very sharp fall in prices has been registered in Europe over the last ten years. PHB prices currently depend strongly on the price development of conventional plastics.

**Impact and effects**

Some of the defined and considered value chains can generate higher-quality products for the industry through biobased processes, thereby promoting the replacement of fossil by biobased materials. The interesting utilization paths stand out with certain advantages. These are processes that use industrial CO₂ directly and as the only source of carbon and whose generated products have high market potential and growing markets.

The UseCO₂ project shows interesting fields of interest and promising value chains, which still pose further research requirements in the field of the use of industrial CO₂.

For the value chain via acetate, a follow-up COMET project could already be initiated with new company partners.

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