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How the combination of catalysis and biotechnology can boost CO_2 conversion

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In the recent years, carbon dioxide, a greenhouse gas, has increasingly, been considered a synthon for chemical industry and a source of carbon for fuels. So it results of extreme importance to complement the natural "carbon cycle" by developing man-made industrial processes for "carbon recycling", converting, thus, "spent carbon" as CO_2 into "working carbon", as that present in valuable chemicals or fuels. Different strategies evolved to realize carbon dioxide utilization and conversion to fuels and chemicals. Particularly, biological approaches have drawn attention as natural CO_2 conversion serves as a model for many processes. Microorganisms and enzymes have been studied extensively for redox reactions involving CO_2.

The integration of biotechnology and catalysis can represent a new attitude for an effective CO_2 conversion. Selective catalysts such as enzymes, or even whole microorganisms, can be coupled to chemical technologies for energy supply to enzymes, using perennial sources as sun or wind or geothermal as primary energy. For example electrocatalysis and semiconductors can be coupled to enzymatic catalysis for an efficient conversion of CO_2 in water into methanol at room temperature. [1,2] Alternatively, catalysis can convert biomass into chemicals and fuels.

Biocatalysts, capable of efficiently transforming CO_2 into more reduced forms of carbon, offer sustainable alternatives to current oxidative technologies based on the use of fossil-fuel. Enzymes that catalyse CO_2 fixation steps in carbon assimilation pathways are promising catalysts for the sustainable transformation of this safe and renewable feedstock into central metabolites. The latter may be further converted into a wide range of fuels and commodity chemicals, through the multitude of known enzymatic reactions. The required reducing equivalents for the net carbon reductions may be drawn from solar energy, electricity or chemical oxidation, and delivered in vitro or through cellular mechanisms, while enzyme catalysis lowers the activation barriers of the CO_2 transformations to make them more energy efficient. The development of technologies that treat CO_2-transforming enzymes and other cellular components as modules that may be assembled into synthetic reaction circuits will facilitate the use of CO_2 as a renewable chemical feedstock, greatly enabling a sustainable carbon bio-economy.

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References

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