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Biocatalytic enzyme processes for CO2 conversion and lignin modification

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Global anthropogenic carbon dioxide (CO2) emissions recently reached a record high level of 35.7 billion tons per year. An agreement to achieve zero net greenhouse gas emissions and pursue efforts to limit the temperature increase to 1.5 ℃ during the 21st century was negotiated recently at the 2015 United Nations Climate Change Conference, COP 21, in Paris, France. Enzyme catalysis (biocatalysis) may offer new solutions to help lower CO2 emissions by removing the CO2 and actually use CO2 as a carbon substrate for production of chemicals: A designed biocatalytic cascade system based on reverse enzymatic catalysis by formate dehydrogenase (EC 1.2.1.2), formaldehyde dehydrogenase (EC 1.2.1.46), and alcohol dehydrogenase (EC 1.1.1.1) can convert CO2 to methanol (CH3OH) via formation of formic acid (HCOOH) and formaldehyde (HCHO) during equimolar cofactor oxidation of NADH to NAD+. This reaction is appealing because it represents a double gain: 1. Reduction of CO2 and 2. An alternative production route to fossil oil derived chemicals. The talk will present the efficiency of different immobilized enzyme systems and reaction designs that have been explored for optimizing this sequential enzymatic conversion of CO2 to CH3OH, and present data we have obtained at DTU from enzymes immobilized in membranes [1]. The talk will also highlight some recent important learnings we have achieved in relation to enzymatic modification of lignin, a lignocellulosic biomass conversion residue, and notably address how laccase enzymes (EC 1.10.3.2) work to oxidize phenolic substrates using oxygen and whether laccases can really act upon lignin [2].

References
1) Luo et al. Cascade catalysis in membranes with enzyme immobilization for multi-enzymatic conversion of CO2 to methanol, New Biotechnol. 2015, 32, 319–327.
2) Munk et al. Can laccases catalyze bond cleavage in lignin? Biotechnol Adv 2015, 33, 13–24.

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