

Catalyst Recycling by a Self-Separation of the Product Phase in the Production of Formic Acid from Carbon Dioxide

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Abstract

Climate change is recognized as a global topic since several years. Besides the transition from fossil resources to sustainable energy, the production of chemicals from biomass and carbon dioxide is considered an important pillar to deal with this challenge. Carbon dioxide hydrogenation to formic acid is one possible reaction to introduce carbon dioxide as C₁ building block into the chemical value chain. For homogeneously catalyzed reactions the separation of the product and the catalyst under retention of the catalyst's performance remains a major challenge. One approach towards facile catalyst recycling are liquid-liquid biphasic systems. Using a second solvent for the extraction of the product from the reaction mixture during catalysis, the catalyst and product phase can easily be separated. However, the requirement of a stabilizing amine during the reaction results in the need for the separation of two components (solvent and amine) from the product phase during down-stream processing. Therefore, in the present study, we present a Ru-phosphine catalyzed reaction system comprising only a hydrophobic solvent as the catalyst phase and *N*-methyldiethanolamine as a base. Separation of the reaction mixture into a pure formic acid/amine product and a recyclable catalyst phase occurs in this reaction system spontaneously by the formation of formic acid/formate. The optimization of the reaction conditions enabled a TON of 1590 in a single reaction and a TTON of 5590 after four recycling runs.



Figure 1 Illustration of the reaction system with self-separating product phase