Homogenous catalyst recovery by nanofiltration for the production of a potential hydrogen carrier such as formic acid from biomass

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Abstract

Hydrogen is seen as a promising energy carrier of the future that has the potential to reduce dependence on fossil fuels and make a significant contribution to the decarbonization of global energy systems. To increase the efficiency of this concept hydrogen carrier are needed. One potential hydrogen carrier is formic acid (FA). Various integration options of FA have already been investigated like hydrogen fuel cells or direct FA fuel cells.

FA is conventionally produced by carbonylation of syngas-based methanol but can be produced sustainably from biomass via the OxFA-Process. The OxFA-process employs homogeneous polyoxometalate catalysts (POMs) to selectively oxidize biomass to FA. Using biomass as a source for hydrogen could combine utilizing waste streams with the energy system. The OxFA process could therefore be used as an alternative pathway for a future hydrogen economy.

POMs are bifunctional polynuclear metal-oxo-anion cluster characterized by a high proton mobility combined with fast multi-electron transfer and tunable redox potential. Furthermore, POMs are soluble in water, which is the most important green solvent, and exhibit resistance to hydrolytic and oxidative degradation. However, employing POMs as homogeneous catalysts, e.g. to produce FA, comes with the challenge to separate the desired products from the homogeneous POM catalyst in aqueous solution. Efficient catalyst recycling is an essential aspect for cost effective and sustainable implementation of chemical processes. Therefore, we explored the potential of nanofiltration membranes to recover the homogeneous POM catalyst. This technology is particularly promising because of their relative sustainability advantage over thermal separation processes due to their unique properties such as increased selectivity towards polyvalent ions. To establish an efficient downstream process for the recovery of the homogenous catalyst a laboratory-scale membrane system was designed, constructed and tested. Several membranes, such as polymer membranes or ceramic membranes were investigated for the recovery of different POM catalysts. In addition, the separation performance of various system components was determined by varying different process parameters.