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Application showcases for a small scale membrane contactor for fine chemical processes.

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The transition from batch to continuous processing in fine-chemicals industries offers many advantages; among these are a high volumetric productivity, improved control over reaction conditions resulting in a higher yield and selectivity, a small footprint and a safer process due to a smaller reaction volume. Pilot studies of continuous micro structured reactors in a production environment have been presented over the last few years by chemicals producers collaborating with equipment developers. It makes, however, little sense to shift only the reactor to continuous operation and not the work-up because this would result in accumulating reaction intermediates and products in storage vessels. The next logical step is the introduction of continuous micro structured separation equipment that has a similar performance with respect to separation efficiency as continuous reactors regarding productivity. Consequently for multistep chemical synthesis a toolbox of separations has to be developed based on the classical operations of evaporation, extraction and crystallization. Potential benefits versus conventionally applied stirred tank vessels include: a small footprint because of high productivity, less product degradation volume and increased safety due to a small because of the lower volume (for example less solvent) and the potential to reduce the number of down stream processing steps. Issues for the development of these separations are multipurpose applicability and scalability by modular design. Membrane contactors are potentially beneficial for small scale separations in fine-chemical applications. Potential benefits of pertraction are: a stable interface and therefore less foam / froth problems, less solvent use because of a asymmetric volume ratio up to 100:1 (for process stream: solvent stream), it allows for streams with small density difference because no gravity based settler is required, a small footprint due to a high specific surface area, flexible with respect to scale-up because a modular construction is possible, multi-applicable by choice of solvent, no moving parts resulting in low maintenance cost and finally proven technology in water applications. Issues that have to be addressed before pertraction can be applied in the core of fine-chemical processes are the use of chemically resistant materials and scale-up at low cost to sufficient large modules. To initiate the development of a pertraction module for fine-chemical processes three showcases for potential chemical applications were demonstrated experimentally. The first application was a solvent switch of a compound from one solvent into another. The second application was an aqueous work-up of a solvent reaction mixture, aiming for removal of spent acids or bases. The aqueous work-up can be carried out without the formation of an emulsion and potentially with a smaller volume of washing water. The third application was the dehydration of a reaction mixture, with the objective of removing both dissolved and dispersed water. In the latter case the test system was an esterification reaction between hexanol and hexanoic acid with lipase as catalyst. For all cases the mass transfer coefficient was determined in order to calculate the surface area of membrane required for a small scale industrial pertraction module. Finally, module design and construction aspects (a.o. stacking) will be considered