Sustainable Organic Synthesis in Continuous Flow Environments

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Microreactor technology and continuous flow processing in general are key features in making organic synthesis both more economical and environmentally friendly and in the past decade the use of microreactors has opened up new horizons for synthetic organic chemistry and the chemical manufacturing industry in an impressive way.

Microreaction technology is generally defined as the continuous flow processing of reactions within structured channels of 10-500 µm diameter. Because of the high surface-to-volume ratio in microchannels of this type, heat transfer is very efficient and reaction temperatures in microreactors can be changed efficiently by application or removal of heat. In addition, enhanced mass transfer characteristics, safer synthesis of dangerous compounds, isolation of air and moisture sensitive chemistry, and reduction of hazardous waste are all realized using microreactors. The ability to efficiently optimize reaction conditions by control of residence time and rapid experimentation also add value to the technology by shortening production development lifecycles. A particularly attractive feature of microreaction technology is the ease with which reaction conditions can be scaled - without the need for reoptimization - through the operation of multiple systems in parallel (numbering-up, scaling-out), thereby achieving production scale capabilities.

Today, the availability of commercial benchtop-flow reactors entirely based on stainless steel capillaries (Fig. 1) allows to conduct chemistry in a genuine high-temperature/high-pressure regime being more than 100 °C and 100 bar higher than the operational limits of common glass-chip or PTFE-capillary based flow equipment. This extended operating window reaches into the region of near- or supercritical conditions of many organic solvents allowing improved processing characteristics.

Therefore, this high-temperature microreactor approach can also be used to overcome the scale-up limitations inherent to high-speed microwave batch processing in sealed vessels. Vice versa, microwave reactors can be used for rapid method development, since the reaction time at a certain temperature obtained in a microwave reactor can be directly translated to a residence time in a flow reactor.

References