Development of continuous processes for vegetable oil alcoholysis in microfluidic devices

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The vegetable oil alcoholysis system is complex due in particular to phase equilibrium changes as well as simultaneous presence of various phenomena (mixing, heat and mass transfers, principal and competitive reactions) which have to be precisely controlled. According to the reaction scheme and the thermokinetic properties, the limits of current batch or semi-batch processes can be overcome by carrying out continuous processes. Therefore, for transposition to a continuous process, microreactors which enable to acquire numerous data, appear as the appropriate tool. Moreover, the scale-up of this technology from laboratory to industrial scale can be rapidly implemented by just numbering up these microreactors. Recently, many studies examining the continuous methanolysis of vegetable oil in the presence of homogeneous catalysts to produce biodiesel were reported in literature.

In our work, we were interested in the transesterification reaction of sunflower oil with ethanol, which leads to ethyl esters, used to date for applications principally in food and cosmetic industry. To open the application field to biofuels (to substitute current fuels resulting from fossil resources), the process efficiency has to be developed to be economically profitable.

The batch reaction of vegetable oil ethanolysis was transposed to a micro-scaled continuous device (PFA tube of 508 μm internal diameter), inducing better heat and mass transfer. Study of the influence of the operational conditions (reactants flow, initial ethanol to oil molar ratio, temperature...) revealed the favourable reaction parameters necessary to reach high conversions and yields. In these conditions, we showed the possibility of acquiring kinetic data at the first seconds of the reaction, which was not feasible in a conventional batch process. To acquire data in batch and microreactors, an on-line analysis method by Near InfraRed (NIR) spectroscopy was developed by using gas chromatography as a reference method. PLS models were then set up to quantify the major compounds contents on-line during the transesterification reaction of high oleic sunflower oil with ethanol. These data were used to model occurring phenomena and to determine kinetic constants and transfer coefficients. The model was subsequently used to simulate reactions with other operational conditions and enabled to work on the reaction products separation.