Deliverable 3.6 Post-bachelor course in MRT

Introduction

Flow chemistry is an emerging reactor technology to increase the efficiency, safety, environmental impact and reliability of chemical reactions. New process windows are opened to give the chemist the opportunity to explore new chemical possibilities. Starting from lab-on-a-chip application, on mg-scale (produced with nano- and micro-technology), the technology is now capable of scaling-up towards industrial production, which makes it a tool to improve processes in the pharmaceutical and fine chemical industry.

The workshop was set up as “Masterclass: flow chemistry, from lab to industry” during September to October 2013. Topics related to chemical reactions performed in micro and meso continuous flow reactors were presented by both leading academia and industrial experts in the field of microreactor technology. Additionally, general principles illustrated by new developments, latest know-how and new business development activities were shared in order to bridge the gap between academia and industry.

The aim of the post-bachelor course was to provide professionals already working in the field of chemistry with an overview of the possibilities of microreactor technology and developing the practical skills necessary.

While the workshop was launched to professionals during the Masterclass session, an additional course was developed for advanced topics in analytical chemistry for MRT. In this course, detailed information on online reaction monitoring employing analytical tools was presented.

Industrial production with Microreactors

(Dr Peter Poechlauer, Principal scientist, DSM)

This masterclass presents the implementation of microreactor technology from a leading pharmaceutical company point of view. The presentation describes boundary conditions for manufacturers of fine chemicals in Western countries. The exploitation of process intensification and development of flow processes together with examples of recent development in the field are discussed.

Mixing, flow and heat transfer

(Dr Leon Geers, Senior Research Scientist, TNO)

This masterclass explains basic fluid mechanics within microreactors including flow regimes, diffusion and mixing. Passive and active mixing generated in micro- and meso-reactors to reduce mixing time are described. Micro-scale heat transfer and scale-up from microscale are also discussed.

Research overview microreactors

(Professor Volker Hessel, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology)

In this presentation, the current state of microreactor technology and flow chemistry is discussed. Key steps involved in implementation of flow chemistry are explained including:

Step 1: Make hardware working and accessible; different microunits from laboratory and pilot microreactors,
Step 2: Go for systems‘ solution; various commercially flow chemistry equipments available to perform the same reaction,
Step 3: Develop flow chemistry; examples of real-case complex syntheses developed by pharmaceutical companies employing flow chemistry,
Step 4: Get industrial exploitation; implementation of flow chemistry when conventional technology approaches its limits for safety purpose, atom economy, green chemistry, process time reduction.
Step 5: Widening of chemical windows; exploitation of flow chemistry to allow high temperature and high pressure reactions.

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Chemical synthesis in a lab flow reactor
(Dr Charlotte Wiles, CEO, Chemtrix BV)

The course starts with describing the fundamentals regarding mixing and heat transfer of flow chemistry in comparison with batch process. Benefits of flow reactors concerning efficiency, quality and safety are next discussed. Specifications of commercially available micro- and meso- units for lab scale and production scales are summarised. Applications of flow technology for research and development, process development and production are described. Implementation of flow reactors for rapid optimisation, multi-step synthesis, scale-up and industrial examples is finally explained concerning reaction conditions, micro- or meso- reactors employed and process throughputs.

Application systems for laboratory purposes
(Professor Thomas Bayer, School of International Management and Technology, Provadis)

In this masterclass, challenges in process industries in Europe are firstly discussed to highlight the need of process and product development. Secondly, an idea of multi(micro) scale design as a solution for process intensification is introduced to allow chemistry to be the centre of process design with a new approach for scalable technology for production. Example of exploitation of multi(micro) scale design for opening new process windows are explained. Finally, muti(micro) scale design in the area of research and development was discussed with examples of chemical reactions .

Advanced topics in analytical chemistry for microreactor technology

(Dr Bongkot Ngamsom and Professor Nicole Pamme, University of Hull)

This course explains analytical techniques employed for online monitoring of chemical reactions performed in miniaturised flow systems. Spectroscopic detection including fluorescence, UV/Vis, IR, Raman, NMR spectroscopy as well as chromatographic techniques are described concerning the integration of the detection techniques into the microreaction system. Some applications of each technique for online reaction monitoring and catalyst investigation are described. Finally, detection capability and limitation of each technique are summarised.