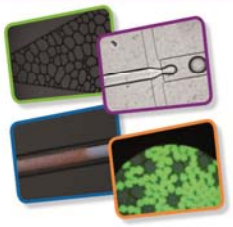
Les Rencontres Scientifiques d'IFP Energies nouvelles



Microfluidics: from laboratory tools to process development

Rueil-Malmaison, France ■ 4 - 5 November 2015

Review

"Microfluidics" refers to the sciences and technologies used to handle fluids from the micron scale to the sub-millimetric scale. Laboratories are increasingly focusing on these technologies, reflecting their potential role in the emergence of radically improved industrial processes.

The program of this scientific conference hinged on four sessions and four keynote lectures.
The major trends and main elements emerging from both the keynote lectures and the presentations are summarized below.

Keynote Lecture 1: Microfluidics and carbon dioxide / Eugenia KUMACHEVA (Toronto University, Canada)
Gas-liquid reactions and physical processes involving carbon dioxide (CO_2) are being studied via a microfluidic platform used for the rapid determination of reaction rates and equilibrium constants, conversion kinetics, the completeness of phase separation and thermodynamic properties, as well as screening of various reagents.

Keynote Lecture 2: Extended-nanofluidics - technology, Science and applications / Takehiko KITAMORI (Tokyo University, Japan)
The (micro) nanofabrication facilities at T. Kitamori's laboratory were presented. The main research avenue concerns the construction of chips and lab-on-a-chip devices, combining individual operations such as confluence, mixing, separation, reaction and extraction. Highly sensitive detection tools are used for single-molecule studies. A solar light-powered micro-fuel cell device has been designed and is currently being used in research work.

Keynote Lecture 3: Synthesis and optimization in segmented flow / Klavs JENSEN (MIT, US)
Jensen group has been working in the field of microfluidics for 20 years, examining reactions and transport in micro-reactors. Solvents are screened and optimized through automated segmented flows (possibly oscillating flows) and can be used at high pressures and high temperatures for high-throughput experimentation (HTE). The synthesis of nanoparticles with a controlled shape was presented. A meter-sized miniaturized autonomous pharmaceutical active principle unit production is also operational.

Keynote Lecture 4: Micro-structured multiphase catalytic reactors for production and screening / Claude DE BELLEFON (CNRS, France)
LGPC has been working on catalytic process engineering since 1994 using microfluidic gas/liquid/solid segmented flows. The kinetics of catalytic reactions were presented, along with screening of catalysts (shape, texture, active phase) and process intensification methodologies.
Sessions were organized to highlight the potential options for transfer of microfluidics from academic laboratories to industrial processes.

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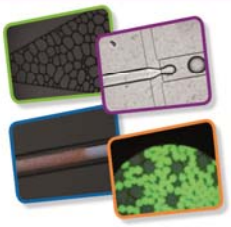

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Session 1. Basic science with microfluidics

Fundamental studies making use of microfluidic or nanofluidic devices where presented in this session. Microfluidic approaches are of particular interest for studying the physical chemistry of complex systems, such as the adsorption kinetics of surfactants at interfaces or the dissolution of spherical bubbles in a solvent. The studies conducted have been based on the production of finely-controlled and reproducible dispersions, as well as space-time equivalency, small Reynolds number flows or the high Surface/Volume ratios that are specific to microfluidics.

Session 2. Analysis and micro-measurement

Innovative analysis techniques have been shown to lead to highly spatially defined measurements or to very small time constants. FLIM (Fluorescence Lifetime Imaging Spectroscopy) must be underlined: focusing on the rate of decrease of the fluorescent signal, this technique can be used to perform fine speciations in real time, down to tens of ms, or to study biomolecular interactions. X-Ray micro-tomography has proven to be a powerful tool to study gas-liquid flows in micro-bead filled reactors. Colorimetric techniques are also under development to measure gas-liquid mass-transfer.

Session 3. New developments for microfluidic devices

Although the majority of microfluidic devices are produced using standard soft lithography involving Polydimethylsiloxane (PDMS), new developments are now emerging to overcome the drawbacks of this material, which is intolerant to pressure, temperature and many solvents. A variety of micro-fabrication solutions are now available (based on glass, silicon-Pyrex, etc.), which can be used to study polymer chemistry or particle synthesis and to handle fluids in harsh conditions (e.g. geological conditions with supercritical CO_2). HTE is another topic covered by a number of presentations: an innovative design already permits a production rate up to 110,000 drops/s. These new developments are likely to be extended soon to include thermodynamic studies as well.

Session 4. Toward industrial applications

As the field of microfluidics is adapted to handle thousands of small objects, such as microorganisms encapsulated in droplets, a number of applications concern biotechnologies. High-throughput sorting with microfluidic droplets of microorganisms based on enzymatic activity, or on other criteria, are now common applications, along with industrial studies. Hazardous conditions or fluids studies are other areas being examined and were illustrated via solvent extraction process cases.

Participation highlights

This Rencontre Scientique d'IFP Energies nouvelles brought together 100 participants from Europe, North America and Asia (14 nationalities were represented), including academics, students, industrial players.

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