Introduction

Until today, lots of microfluidic reaction systems have to be performed manually and contain several enclosed devices, which are physically connectable but not centrally controllable. The so-called Internet of Lab (IoL) gives the opportunity to steer all parts electronically within a mesh, managed by a common PC, a so-called main controller. Such a controller acts as smart as an autopilot for chemical reactions. With the gained data from the different sensors all over the system, e.g. flow-meter, pressure sensor, droplet detector and of course analytic devices like in-line Raman or in-line IR, the smart controller is able to drive all necessary actuators (pumps, electrochemical cell, phase separator, sample collector, analytic devices, etc.). The controller intelligence can be used for screening of reaction parameter and to optimize the reaction on-the-fly and without human interaction. Especially for droplet-based systems the integration into the Internet of Lab will simplify optimizing chemical reactions.

Supply chain

- Pump programming to control
  - HPLC pumps
  - Syringe pumps
- All flow parameters dynamically calculated from different sensors all over the system like
  - Flow controllers
  - Pressure sensors
  - Thermometers
- User-defined pump sequences e.g. for purging

Flow preparation

- Reactant mixing
- Droplet generation
- Segment generation
- Emulsion generation
- Droplet counting
- Droplet manipulation

Reactor

- Inline-measurement of all reaction-parameters (e.g. temperature, pressure, flowrate)
- Determination of droplet position, e.g. for electrochemical, photochemical or other reactions where knowledge about the exact droplet position is important
- Voltage and current control for electrochemical reactions managed by the Internet-of-Lab (IoL) controller
- Droplet detection inside a PTFE-capillary using a light barrier managed by a microcontroller connected to the Internet-of-Lab (IoL) system

Sample collection

- Sample collection with a modified conventional fraction collector controlled by an Arduino Nano®[4]
- Turning an existing device into an Internet of Lab device
- Fluid splitting using turnouts
- Preparation
- Easy waste management

Phase separator

- WLAN or LAN
- Electrically steered valves
- Phase boundary
- Multiple optic control unit
- Glass frame triangular phase separator[2]
- Four UV-light barriers measuring the light-transmission
- Two electronically steered valves on each output
- Light barriers and valves controlled by an Arduino UNO®[4]

Summary

- A fully autonomous reaction parameter screening system
- All sensors and actuators meshed through the Internet of Lab (IoL) and centrally controlled
- Novel process making use of meshed microcontroller technology for sensing and actuating
- Not restricted to reaction parameter screening, also continuous and smart reaction controlling possible
- Variable setup of all components which is easily expandable at low costs

References