

QUANTITATIVE MULTIPLEX CARS SPECTRO-MICROSCOPY TO MONITOR *IN SITU* CHEMICAL PROCESSES IN MICROREACTORS

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Coherent anti-Stokes Raman Scattering (CARS) microscopy is a third order non-linear optical process, ideal for non-invasively and label-free imaging of complex, e.g. biological, systems. CARS spectroscopy allows label-free, chemically specific, quantitative determination of the local concentration of the various species in a sample [1], with 3D submicron spatial resolution. We here demonstrate the application of multiplex CARS microscopy for monitoring chemical processes in a microreactor, where, at any given position within the device, a full spectrum across 400 cm^{-1} is acquired in 20 ms, from which the Raman peaks can be retrieved directly by using an algorithm based on the maximum entropy method [2], allowing local concentrations to be determined with 10 mM accuracy. As a proof-of-principle experiment, we investigated an acid-base reaction where the two reactants are brought into contact behind a horizontal Y junction, and employed the capability of CARS to monitor the chemical conversion and flow profile in the microreactor [3].

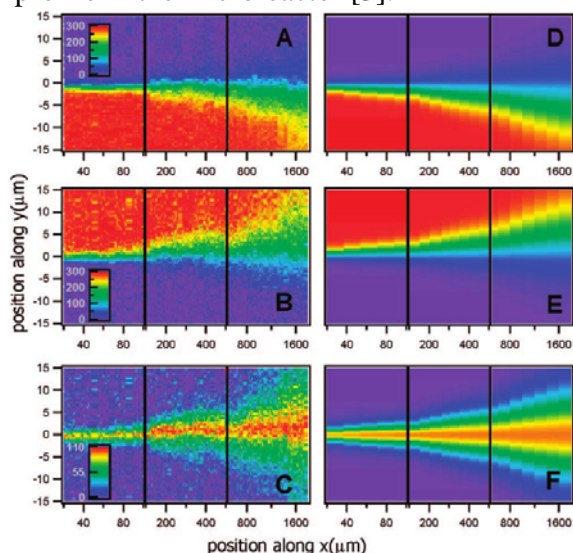


Figure 1: concentration profiles of pyrrolidine (A), acetic acid (B) and the reaction product within the mfd device

Solutions of acetic acid and pyrrolidine in deuterated 1,4-dioxane transform into their conjugate acid and base inside a microfluidic device (Fig. 1 A-C). The vibrations of the C-H groups around 2900 cm^{-1} are used to determine the concentration profiles of the two reactants, as well as of the reaction product (salt) within the microfluidic device, which are in very good agreement with numerical simulations obtained using a reaction-diffusion model (Fig. 1 D-F).

We will also discuss work in progress on other, more complex reactions where this approach allows us to quantify (otherwise difficult to determine) reaction parameters and investigate different flow cell geometries, e.g. the reaction between octene and Me_2Ph silane in presence of a Pt catalyst in a three ways junction.

[1] M. Muller, and A. Zumbusch, *ChemPhysChem* 8, 2156 (2007).

[2] E.M. Vertiainen; H.A. Rinia; M. Muller, and M. Bonn, *Optics Express* 14 (8), 3622 (2006).

[3] D. Schafer, J. Squier, J. Maarseveen, D. Bonn, M. Bonn, and M. Muller, *J. Am. Chem. Soc.* 130, 115932 (2008).