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Development of a high velocities co-flowing stratified microfluidic process to obtained kinetic constants for liquid-liquid extraction

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Kinetic constant in liquid-liquid extraction processes are generally determined using constant interfacial area method as the single drop method, Nitsch cell or Lewis cell. Those technics only reach the overall mass transfer constant that can be subdivided on chemical constant and diffusive ones. Molecular diffusive transfer is quite hard to be restrained in a non-stirred device while any phase stirring has to be avoided to determine chemical kinetics. Hence, our microfluidic process carried out high velocities stratified flow in co-flowing configuration to aim chemical kinetics constant determination, thanks to both diffusive length reduction and fine flow control of the microfluidic technology. Moreover, to avoid any Dean vortexes or other convective movements that can be presents at high velocities even at laminar flow, all extraction experiments were realized in a 1.25 cm straight and linear microchannel. Our experimental hypothesis as a centred interface have also been verified tanks to confocal experiments.

This presentation will focus on the extraction experiments of uranium(VI) in nitric acid by the tributylphosphate (TBP) diluted at 30% in TPH as shown on Figure 1.

For example, on a 50.4 g/L uranium(VI) initial aqueous concentration, aqueous and organic residence times are lying between 0.050 s and 0.009 s. Thus, we achieved to reach 12 % extraction yield at low speed and even 4 % at maximum phases velocities.

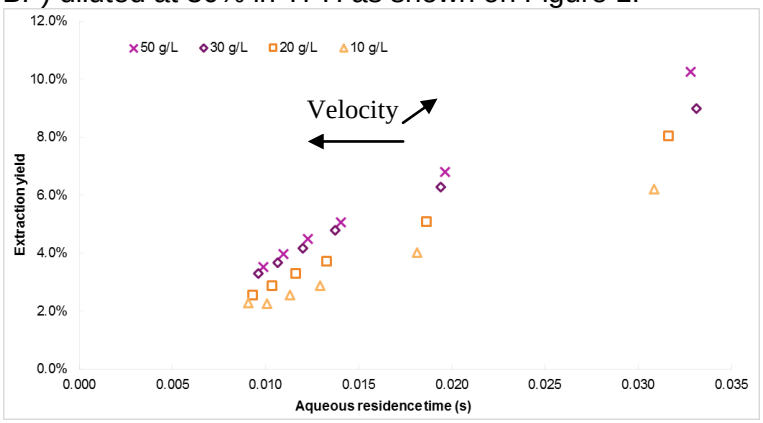

Figure 1. Uranium(VI) extraction yields versus aqueous residence, function of the initial uranium(VI) concentration.

These extraction yields are quite good considering our phases contact time inside the microchip.

To calculate the kinetic constants and especially the chemical one, modelling were run with Scilab and COMSOL Multyphysics software. Neither with Scilab nor COMSOL Multyphysics the chemical kinetic were obtained, all modelling results were way below the experimental data. Hence, we suspect the presence of an acceleration factor enhancing the overall mass transfer.