



Pore-scale mixing and reactions in porous media

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Even though the basic mechanisms driving mixing in different flow regimes (turbulent, chaotic, laminar) are the same, i.e. creation and destruction of concentration gradients, the differences in the flow kinematics, that stretch the mixing fronts organizing them in elongated lamellae, are fundamental. For continuous Darcy-type flow fields, it has been recently formalized a novel framework for mixing that takes into account the peculiar flow kinematics and it is able to capture the dynamics of statistical distribution (PDF) of a transported scalar field (i.e. Le Borgne et al. *JFM* 2015). The resulting solution is given by a statistical superposition of the spatial distribution of each lamella concentration, which is assumed to have a Gaussian-like shape since it undergoes a simple diffusive process in the direction transverse to the local mixing front. This novel framework for mixing breaks down when the porous structure of the host medium is resolved (at the scale where bio-chemical processes take place) and the confinement condition imposed by the presence of impermeable solid boundaries radically change i) the front concentration profile, ii) the lamellae superposition rules and iii) the flow kinematics (lamellae elongation rules). We present an experimental set-up to visualize and quantify, at the pore scale, the dynamics of reactants mixing and their reaction rate. Conservative mixing of a displacing front is visualized using fluorescent techniques, while to study reactive transport we use a bi-molecular chemiluminescent reaction where the encounter of two solutions in each pore produces light proportionally to the local reaction rate.