**Micromixing efficiency in a rotor-stator Spinning Disc Reactor for liquids with different viscosities**

Arturo Neissen Manzano Martinez1, Melissa Assirelli2, John van der Schaaf\*1

*1 Laboratory of Chemical Reactor Engineering, Department of Chemical Engineering and Chemistry, Eindhoven University of Technology, P.O. Box 513, 5600 MB Eindhoven, The Netherlands
2 Nouryon Specialty Chemicals, Deventer, The Netherlands*

*\* j.vanderschaaf@tue.nl*

**Highlights**

* Micromixing efficiency of three liquids with different viscosities is presented
* Segregation index decreases with increasing rotational speeds in all situations
* Compared to a stirred vessel, rs-SDR enhances mixing for liquids with different viscosities

**1. Introduction**

In the last years, Process Intensification (PI) and the development of novel equipment have become key approaches for engineers and scientist to address the challenges of the modern era, e.g reducing waste generation, emissions, energy consumption, etc. However, for a full implementation of new technology in the chemical industry, sufficient knowledge is needed in order to make it attractive and to guarantee functionality in real situations.

One way of reducing the energy-intensive separation steps in a process is by improving selectivity towards desired products, which may be difficult for fast reactions competing for a limiting reagent. In these cases, micromixing – the homogenization of the system at the smallest scale – plays a crucial role. [1]

Previous results proved that the rotor-stator Spinning Disc Reactor (rs-SDR) can enhance selectivity for fast reactions, with estimated micromixing times ranging between 1×10-4 to 1×10-2 seconds. [2] However, since industrial processes often involve reagents of different properties, the characterization of micromixing efficiency of liquids with different viscosities needs to be investigated.

**2. Methods**

The “Villermaux-Dushman protocol for experimental characterization of micromixers” [3] was performed with two modifications. Instead of Sulfuric Acid, Perchloric acid was chosen for being a strong, monoprotic acid [4]. Since the kinetics of the system have been a great deal of controversy, the iodide-iodate reaction was studied resulting in an empirical equation for the reaction rate [5] that is in agreement with a previous kinetic study [6].

The experimental setup for the rs-SDR was reported previously [2]. In order to compare with traditional equipment, the protocol was performed under the same conditions (temperature, concentrations, etc) in a 5 L tank, stirred with a propeller stirrer set at 900 and 1200 RPM.

To achieve a comparison on micromixing efficiency between an aqueous system and a viscous/non-viscous system, only the viscosity of the acid solution was increased using 10-20%vol of glycerol.

**3. Results and discussion**

The preliminary results are summarized in Figure 1. As expected, segregation Index decreases with an increase in rotational speeds. Furthermore, an increase in viscosity reduces the micromixing efficiency as expected. Surprisingly, at low rotational speeds the effects of an increment in viscosity seem to be less than at high rotational speeds. Further investigation is ongoing to explain these results. When comparing the estimated micromixing times in the rs-SDR with the ones obtained in a stirred vessel for the range of local energy dissipation rates used, the rs-SDR exhibits a better performance, due to the high energy input that can be transferred into a very small volume.

**Figure 1.** (a) The effect of segregation index with varying rotational speeds for two different viscosities of the injected acid in two different reactors and (b) the estimated micromixing times as a function of energy dissipation rate.

**4. Conclusions**

The rs-SDR not only shows better micromixing efficiency when compared to a stirred vessel, but it is also less affected by the addition of a liquid of higher viscosity.

**References**

1. Bourne, J. R. (2003). Mixing and the Selectivity of Chemical Reactions. Organic Process Research & Development, 7(4), 471–508. <https://doi.org/10.1021/op020074q>
2. Manzano Martínez, A. N., Van Eeten, K. M. P., Schouten, J. C., & Van Der Schaaf, J. (2017). Micromixing in a Rotor-Stator Spinning Disc Reactor. Industrial and Engineering Chemistry Research, 56(45), 13454–13460. <https://doi.org/10.1021/acs.iecr.7b01324>
3. Commenge, J. M., & Falk, L. (2011). Villermaux-Dushman protocol for experimental characterization of micromixers. Chemical Engineering and Processing: Process Intensification, 50(10), 979–990. <https://doi.org/10.1016/j.cep.2011.06.006>
4. Baqueiro, C., Ibaseta, N., Guichardon, P., & Falk, L. (2018). Influence of reagents choice (buffer, acid and inert salt) on triiodide production in the Villermaux–Dushman method applied to a stirred vessel. Chemical Engineering Research and Design, 136, 25–31. <https://doi.org/10.1016/J.CHERD.2018.04.017>
5. Kinetic study of the iodide-iodate reaction for micromixing characterization. / Manzano Martinez, A.N.; Haase, Sander; van der Schaaf, J. 2018. Poster session presented at CHAINS 2018 (CHemistry As INnovating Science), Veldhoven, Netherlands.
6. Palmer, D. A., & Lyons, L. J. (1989). Kinetics of iodine hydrolysis in unbuffered solutions. Retrieved from <https://inis.iaea.org/search/search.aspx?orig_q=RN:22075560>