A chemical shift selective rheo-MRI method to investigate time-dependent dense emulsions

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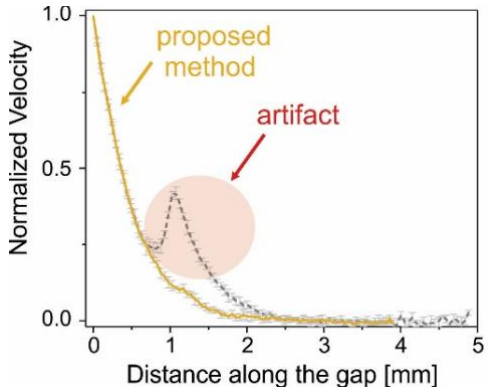
Emulsions are important in nature and industrial processing, founding applications in diverse areas such as food technology, pharmacy, cosmetics and refineries, among others. An important class of these systems are food products, such as mayonnaise, which exist as dense oil/water emulsions. The flow properties of these colloidal dispersions are of special interest, since its many industrial applications relay on the ability to measure and optimize the rheological response of the material under deformation.

In the past years, rheo-MRI has been successfully applied to the characterization of diluted and dense emulsions [1], identification of non-local effects [2] and shear induced migration of droplets [3]. However, the deep understanding of the complex rheological behavior present in dense emulsions depends on the accurate determination of droplet's phase concentration and velocity under shear.

In this work, we proposed to exploit the chemical shift difference between water and oil protons present in oil/water emulsions, clearly observed at high magnetic fields. In order to map oil droplets phase during rheo-MRI experiments, we implemented a chemical shift selective method that suppresses water phase NMR signal and uses the remaining magnetization to acquire a flow encoded image. The method was validated with respect to quantification of oil concentration and velocity under industrial relevant conditions, showing a good agreement with expected concentration values [4].

Since this method allowed for real-time assessment of both local shear rate and stress, as well as local oil concentration, we employed the chemically selective method to investigate the time-dependent rheological behavior of dense oil/water emulsions upon constant shearing, varying the nature of the employed emulsifier. Reliable and accurate characterization of time-dependent behavior of these systems, are of especial importance for quality control and shelf-life optimization. The obtained results showed that chemically selective rheo-MRI method coupled with torque measurements, allowed to characterize the deformation of dense oil/water emulsions as a function of shearing time, being able to discriminate heterogeneous flow behavior, such as yield stress and wall slip variation.



[1] D. W. de Kort, T. Nikolaeva, J. A. Dijksman, in Rheo-NMR: Applications to Food, in Modern Magnetic Resonance, (Ed: G.A. Webb), Springer International Publishing, Cham 2017 1.
[2] J. Goyon, A. Colin, G. Ovarlez, A. Ajdari, L. Bocquet, Nature 2008, 454(7200), 84.
[3] K. Hollingsworth, M. Johns, *J. Colloid Interface Sci.* 2006, *296*(2), 700.
[4] Serial, M.R., Nikolaeva, T., Vergeldt, F.J, van Duynhoven, J., van As, H. *Magn. Reson. Chem.* 2019, No. November, 1–5