HYDRODYNAMIC-COLLOIDAL INTERACTIONS OF AN OIL DROPLET AND A MEMBRANE SURFACE

M. Galvagno[1,a] and G. Z. Ramon[1,b]

[1]Faculty of Civil and Environmetal Engineering, Technion Israel Institute of Technology, Haifa, Israel

(a) *mgalvagno@technion.ac.il* (b) *ramong@technion.ac.il*

Membranes offer a superior separation capacity for stable emulsions, which are otherwise difficult to process. However, membrane fouling is always prevalent and requires extensive backwashing and cleaning as part of the operating regime. Oil droplets deform when in close proximity to a membrane, primarily due to permeation drag, which can lead to irreversible deposition on the membrane. Understanding the influence of hydrodynamic stresses and colloidal interactions between droplets and membranes will allow for better engineered membrane surfaces and process conditions. Using a long-wave hydrodynamic description that incorporates wettability via a Derjaguin (disjoining) pressure and electrostatic repulsion via electric double layer (EDL) contributions, we derive a set of equations for the thickness and pressure in the liquid film separating the droplet and the permeable membrane.

Numerical simulations are used to analyse equilibrium states where a zero net force acts on the droplet, to investigate the influence of droplet shape, distance from the membrane, membrane permeability and characteristic parameters of the colloidal interactions on the overall repulsion / attraction towards the membrane surface. A stability phase diagram is constructed in terms of the modified capillary number - accounting for the ratio of the viscous and surface tension forces - and a parameter representing the ratio of the hydrodynamic pressure scale over the electrostatic interaction intensity.

These calculations are used to classify stable (upward deflection, increasing distance from the membrane) vs. unstable drop shapes (downward deflection bringing the droplet closer to the membrane), and investigate conditions leading to irreversible deposition onto the membrane. In particular, the model can describe how membrane properties and emulsion characteristics dictate a 'critical' flux.

ACKNOWLEDGEMENTS: The authors thank the support at the Technion by a fellowship from the Lady Davis Foundation.

REFERENCES:

1. Fux G. and Ramon G. Z. ‘Microscale dynamics of oil droplets at a membrane surface: Deformation, reversibility, and implications for fouling ’ *Environmental Science & Technology*, **2017**, *51 (23)*, 13842.

2. Ramon G.Z., Huppert H. E., Lister J. R. and Stone H. A. ‘On the hydrodynamic interaction between a particle and a permeable surface’ *Physics of Fluids*, **2013**, *25*, 073103.

3. Ramon G.Z. and Hoek E.M.V. ‘On the enhanced drag force induced by permeation through a filtration membrane’ *Journal of Membrane Science*, **2012**, *392-393*, 1.