Using wetting, capillary forces, and ultrasonic waves to extract oil from a drop containing oil/water mixtures

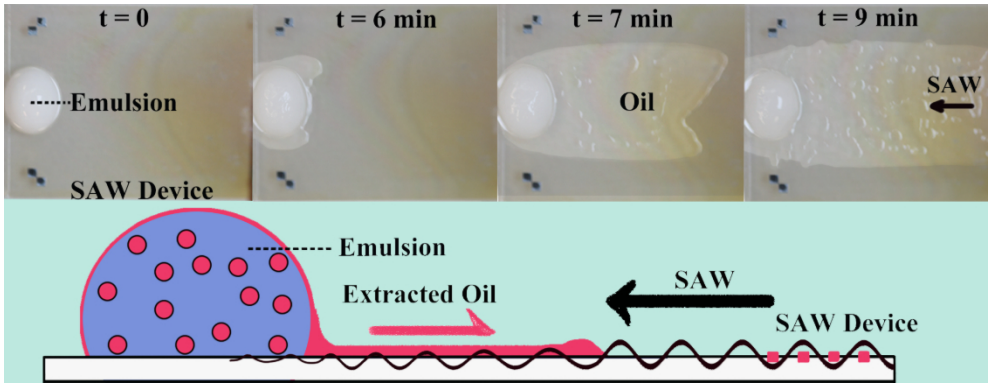
Yifan Li [a], Jesús Marcos [b], Mark Fasano [c], Javier Diez [d], Linda Cummings [c], Lou Kondic [c], and Ofer Manor [a]

[a] Technion — Israel Institute of Technology, Haifa, Israel
[b] Universidad de Extremadura, Badajoz, Spain
[c] New Jersey Institute of Technology, Newark, New Jersey , USA
[d] Universidad Nacional del Centro de la Provincia de Buenos Aires, Tandil, Argentina

manoro@technion.ac.il

Oil and water placed atop of a solid surface respond differently to a MHz-level surface acoustic wave (SAW) propagating in the solid due to their different surface wetting properties. We observe that, under SAW excitation, non-organic silicon oil and organic sunflower oil are extracted continuously from sessile drops that are comprised from emulsions of the oil in a solution of water and surfactants. The mechanism responsible for the extraction of oil from the mixtures is the *acoustowetting* phenomenon: Under acoustic stress the low surface tension oil phase leaves the mixture in the form of 'fingers' that, away from the drop, spread opposite the path of the SAW. The high surface tension water phase remains at rest. Increasing either the SAW intensity or the oil content in the mixture enhances the rate at which oil leaves the emulsion. We further observe acoustic-capillary flow instabilities at the free surface of the oil film and the formation of spatial gradients in the emulsion oil-concentrations in the presence of SAW. Our study suggests the potential for using SAW for heterogeneous removal of oil from oil-in-water mixtures to complement current phase separation methods.

Keywords:
Dynamic wetting, capillary stress, emulsion, phase separation, liquid film, surface acoustic wave



Time lapse and an illustration of an experiment where oil leaves a drop containing an emulsion of oil in water in the presence of a MHz-level surface acoustic wave

References:

[1] Yifan Li, Jesús. M. Marcos, Mark Fasano, Javier Diez, Linda J. Cummings, Lou Kondic, and Ofer Manor, J. Colloid Interface Sci., volume **700** , part 2, p. 138442 (2025)
[2] Jesús Marcos, Yifan Li, Mark Fasano, Javier Diez, Linda J. Cummings, Ofer Manor, and Lou Kondic, Phys. Rev. E, volume **112** , p. 025502 (2025)

Acknowledgements:
This work was supported by US-Israel Binational Science Foundation (BSF) under grant No. 2020174 and by the donors of ACS Petroleum Research Fund under Grant PRF# 62062-ND9. J.M.M. is grateful to the Spanish Ministerio de Universidades for a predoctoral fellowship No. FPU2021-01334. J.A.D. acknowledges support from Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET, Argentina) with Grant PIP 02114-CO/2021 and Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT, Argentina) with Grant PICT 02119/2020.