Wigner Emulsions and Crystals:
Electrostatics of Oil/Water/Solid Mixtures

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Abstract:

Oil and water like to separate and it usually takes a surfactant to stabilize droplets of one in the other. However, for several oils with dielectric constant ~5, add a little water and shake and you get stable water droplets, sitting on a BCC lattice as a classical Wigner crystal. Water with dielectric constant ~80, acts as an ion pump reducing the conductivity and electrostatic screening in oils in which it is in contact. Hydration energy differences for the ions leaves the water droplets charged forming surfactant free, charged stabilized emulsions.

The electrostatic repulsion is sufficiently strong that the droplets crystallize with lattice constants ~20 microns and the BCC structure indicating long range repulsive interactions (as opposed to FCC for shrot ragne repulsions). Adding charged particles to the oil phase gives rise to a host of interesting phenomena from image charge effects, colloid armored droplets and 2 and 3 dimensional colloidal Wigner crystallization.

with Mirjam E. Leunissen, Alfons van Blaaderen1, Andrew D. Hollingsworth, Matthew T. Sullivan, NYU, Utrecht, Princeton