Emulsion inversion through a controlled process of multiple emulsions

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Stimulable emulsions, which can transit from an oil-in-water (O/W) phase to a water-in-oil (W/O) one are attractive materials for many applications like oil recovery, cosmetic or drug delivery. Such emulsions can be stabilized with emulsifiers like non-ionic surfactants, nanoparticles or polymers.

Recently, we have designed new polymer amphiphilic molecules which are sensitive to pH and temperature. These polymers are able to modify the curvature of the water-toluene interface and promote the phase inversion. They are made of a first block of polystyrene (PS) and a second statistical block of PS and poly-2(dimethyl amino) ethyl methacrylate (PDMAEMA) synthesized by Atom Transfer Radical Polymerization. Composition and length of polymers can be varied with a good precision (PDI<1.3).

At low pH and low temperatures, such polymers stabilize toluene-in-water emulsions while at higher pH and temperatures water-in-toluene emulsions are found. The inversion is directly observable with confocal fluorescent microscopy. Conductivity measurements also show how the emulsion type can be reversibly switched along a temperature scan under stirring.

More recently, we discovered that very stable multiple emulsions are stabilized using a single polymeric surfactant in a definite range of pH dependent on the polymer composition. This is a very interesting phenomenon because usually two types of surfactants are required to form such complex structures. Moreover, we correlated the range of pH where such multiple emulsions appear with the occurrence of a minimum in surface tension between water and toluene phases.

These multiple emulsions can be controlled by the variation of pH, temperature and repartition of hydrophobic PS monomers which control the chain adsorption at the oil-water interface and finely tune the spontaneous curvature of the copolymer. This new system is then an excellent candidate for making noticeable progress on the mastering of multiple emulsions and the physics of inversion by a direct observation of the phases morphology during inversion.