TECHNICAL BRIEF (UST-003)

Omega-3 fatty acid rich algae oil nanoemulsions produced by Ultra Shear Technology

Summary: Ultra Shear Technology™ (UST™) produced algae oil nanoemulsions comprised of small monodisperse oil droplets of minimum 34 nm mean hydrodynamic diameter, nearly three orders of magnitude smaller than self-assembling emulsions produced by conventional homogenization.

Background: Docosahexaenoic acid (DHA) is a polyunsaturated fatty acid (PUFA) that comprises 97% of all omega-3 fats in the brain and 93% of all omega-3 fats in the retina [1]. Omega-3 fatty acids have a carbon-carbon double bond located three carbons from the methyl end of the chain. Since the human body can only form carbon-carbon double bonds after the ninth carbon from the methyl end of a fatty acid [2], these essential fatty acids must be obtained from a dietary source.

Over the last decade, the transitioning to non-pelagic feed sources has significantly reduced the omega-3 fatty acid content of farmed salmon, hence reducing its nutritional value [3]. Marine microalgae are a rich cholesterol-free source of these polyunsaturated fatty acids. Algae oil can provide over 30 times more DHA than farmed salmon [4] and has a DHA content similar to fish oil, but without the malodorous taste and smell [5]. Moreover, it avoids methyl mercury that bioaccumulates in the food chain.

Methods: Algae oil nanoemulsions were produced by UST in which coarse emulsions were cycled ten times through a self-throttling nanoscale annular valve. The coarse emulsion was prepared by rotor-stator homogenization at 35,000 rpm. Algae oil (Jedwards International, Braintree, MA, USA) was oil phase and constituted 10% w/w of the final formulation. Surfactant phase was Phospholipon 85G (American Lecithin Company, Oxford, CT, USA) in which the hydrophilic-liphobilic balance (HLB) was adjusted with a polyoxyethylene sorbitan series cosurfactant. The total surfactant to oil ratio was 0.9. Mean oil droplet size was measured after each UST cycle by dynamic light scattering (DLS), except for the coarse emulsions in which the large, polydisperse oil droplets were characterized microscopically. Clarification of nanoemulsions commensurate with decreased particle size was quantified by UV-Vis spectrophotometry.

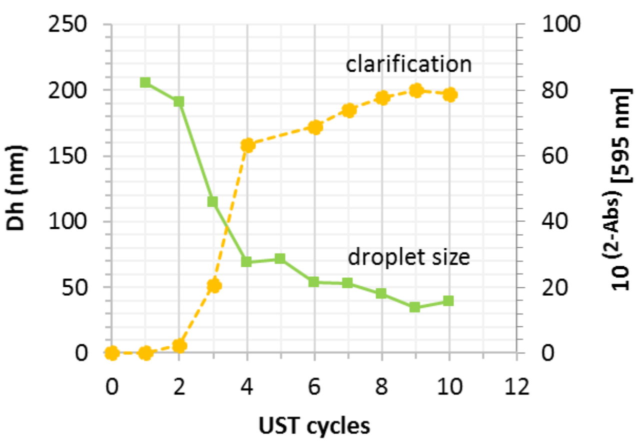

Figure 1. DHA-enriched algae oil nanoemulsions. Oil droplet size reduction as a function of the number of UST cycles at 45,000 psi (green) and corresponding clarification of nanoemulsions (yellow dashed). A minimum particle size of 34 nm was observed after nine UST passes Clarity was quantified from turbidity measurements at 595 nm and expressed as transmittance.

Results: Course emulsions were milky suspensions of large polydisperse oil droplets in which phase separation occurred within hours. From microscopy, mean hydrodynamic diameter (Dh) of oil droplets in the course emulsion was estimated to be 4,300 ± 3,000 nm (n = 447, median = 3,300). Oil droplet size reduction over two orders of magnitude was observed after just one pass through the UST NanoGap™ valve. Particle size was approximately 200 nm following one UST cycle, and was further reduced in half after three UST cycles. An inflection in the rate of particle size reduction was typically observed after four UST cycles. A minimum particle size of 34 nm was observed after nine UST passes (**Figure 1**). The transitioning of unstable, crude emulsions to form stable, optically clear nanoemulsions was marked by decreased Rayleigh light scattering corresponding to smaller particle size. No phase separation was observed in filter sterilized algae nanoemulsions stored at room temperature for several weeks.

References:

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