**Nanoemulsions Produced at Large Scale by Premix Membrane Emulsification – Influence of Process Parameters and Formulation.**

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**Highlights**

* Nanoemulsions were produced by premix membrane emulsification
* A high pressure syringe pump controlled the pressure and flowrate
* W/O nanoemulsions with droplet size down to 260 nm were obtained

**1. Introduction**

Nanoemulsions find a wide range of applications in cosmetics, pharmaceuticals or food industry and are defined by their droplet size which is smaller than 1000 nm, 500 nm or 100 nm, depending on the definition used [1]. Generally, nanoemulsions are oil-in water emulsions (O/W) as the oil phase is dispersed into the water continuous phase, but can also be water-in-oil emulsions (W/O) when the water phase is dispersed into the oil continuous phase. W/O and O/W nanoemulsions can be produced by sonication and high pressure homogenization.

Membranes can be used for emulsification either in direct membrane emulsification (DME) or premix membrane emulsification (PME) [2]. DME consists in injecting under mild pressure the dispersed phase through a microporous membrane to the continuous one, whereas PME relies on injecting a coarse emulsion through the membrane. PME produces emulsions of smaller size range and with greater flowrate but DME does not require a premix step.

However, the production of nanoemulsions by membrane emulsification is challenging. Bunjes et al. prepared nanoemulsions by PME with droplet size lower or around 200 nm with narrow size distribution with SPG membranes for volumes up to 10 mL [3]. In previous works, we produced O/W and W/O nanoemulsions by PME and SPG membranes at high flowrate and relatively large volumes up to 500 mL [4, 5]. The aim of this communication is to report the preparation at large scale of O/W and W/O nanoemulsions using PME.

**2. Methods**

The experimental set-up used for the preparation of nanoemulsions by PME is shown in Figure 1. The set-up was composed of a high pressure cylinder pump BTSP 500-5 (Floxlab, Nanterre, France). Hydrophilic and hydrophobic tubular SPG membranes were provided by SPG Technology Co. Ltd (Miyazaki, Japan). Hydrophilic SPG membranes were used for O/W nanoemulsion production and hydrophobic for W/O nanoemulsions. The continuous and dispersed phases were first prepared and then mixed under magnetic stirring for 10 min to produce the premix.



**Figure 1.** Experimental set-up of the high syringe pump with membrane holder and SPG membrane.

**3. Results and discussion**

The effect of several parameters was investigated: process parameters (scalability, cycle number, membrane pore size, flowrate) and formulation (oil and surfactant concentrations). Nanoemulsions were prepared at large scale up to 500 mL at production rate up to 200 mL/min, pressure below 60 bars and one cycle. The droplet size was linearly related to the membrane pore size and highly monodispersed nanoemulsions of around 260 nm in diameter and stable for 9 months at room temperature were achieved with the smallest pore size membrane (0.2 μm).

In addition, the effect of viscosities on pressure and droplet size was investigated: the water phase viscosity by increasing glycerol concentration, the oil phase viscosity with mineral oils of different viscosities and the overall emulsion viscosity by increasing the dispersed phase content of the emulsion. The pressure required to break up the droplets inside the membrane pores did not depend on viscosities, while the pressures generated by the flows through the pipe and the membrane were proportional to the viscosity of the overall emulsion. W/O nanoemulsions were more difficult to produce, they were obtained with mean droplets size around 600 nm and flowrate of 50 mL/min.

**4. Conclusions**

PME with SPG membranes produced O/W monodispersed nanoemulsions down to 260 nm with controlled size and very long stability over time. W/O nanoemulsions were produced with mean droplets size around 600 nm. W/O nanoemulsions were more difficult to produce and to characterize, but the different viscosities had the same influence on the membrane pressure as for O/W nanoemulsions.

**References**

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