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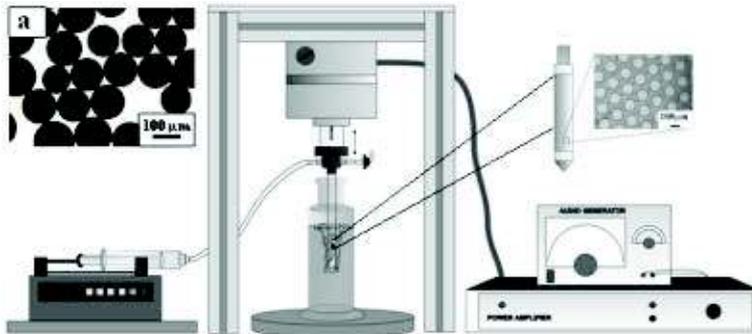
## Novel oscillating membrane for production of W/O/W emulsions

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Conventional devices for preparing emulsions (high pressure, ultrasonic homogenisers, colloid mills, rotor–stator systems, microfluidisers) apply more energy than needed for the production of monosized droplets, leading to droplets with a wide size distribution. Membrane emulsification is a dispersion process to produce a monosized emulsion of one liquid phase (e.g. oil) in a second immiscible liquid phase (e.g. water) using low energy per unit volume where the shear stress applied on the membrane surface mainly influences the droplet size [1]. Production of larger oil droplets of controlled diameter is becoming increasingly popular. Those droplets after additional treatment may be applied in industries such as food and flavour encapsulation, controlled release depots under the skin, medical diagnostic particles, high value fillers, electronic ink capsules, ion exchange resins. A new technique supplied by Micropore Technologies Ltd. UK was introduced for generating the shear on the membrane surface providing the possibility to generate larger droplets without risk of breakage [2].

In this work oscillating membrane emulsification was used to produce water in oil in water emulsion (W/O/W). Such emulsions can be used for encapsulation of water soluble compounds and their controlled release.



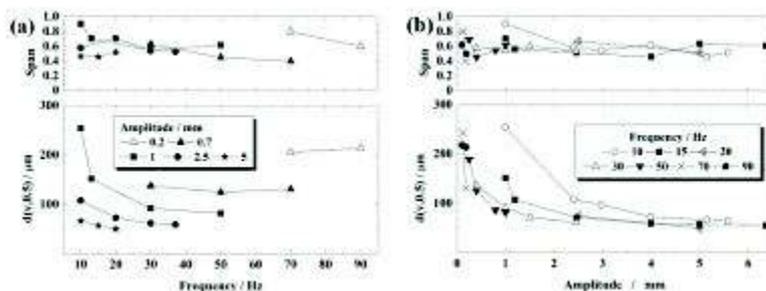
**Fig. 1** Image of produced droplets for condition  $f=70$  Hz,  $A=0.4$  mm corresponding to the maximal shear stress of 3 Pa, oscillating membrane system, tubular membrane and surface of used membrane.

The shear stress required for droplet detachment from the tubular membrane in the oscillating membrane emulsification (Fig. 1) can be altered by varying the frequency, or the amplitude of oscillation. The maximal shear stress is related to the frequency  $f$  and amplitude  $A$  of the oscillation by the equation [2]:

(1)

The oil phase in W/O/W emulsions was sunflower oil containing 10 wt% PGPR (polyglycerol polyricinoleate). The inner aqueous phase was pure water and the continuous phase was 2 wt% Tween 20 (polyoxyethylene sorbitan monolaurate). Low dispersed phase flux of  $30 \text{ L m}^{-2} \text{ h}^{-1}$  was maintained, in order to minimise any push-off force [3].

In Fig. 2 influence of frequency and amplitude on median droplet size and droplet uniformity is presented (span was used as a measure of droplets uniformity).



**Fig. 2** Influence of frequency and amplitude on median droplet diameter and span.

The results shown here indicate that an oscillating membrane system is applicable for generating larger droplets of W/O/W emulsion. Changing frequency or amplitude it is possible to produce droplets in the range between 50 and 280  $\mu\text{m}$ .

An important advantage of the oscillating membrane technique is that it can easily be scaled up by providing a larger membrane area in the oscillating membrane assembly.