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High-throughput premix membrane emulsification by using metal sieves

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There is a continuing quest for techniques that use less energy and give good control on droplet size (distribution). Here we present results obtained with premix membrane emulsification (Figure 1a-c) using nickel sieves (specifications in table), which have a uniform pore size, and can be used at relatively low transmembrane pressure (Figure 2).

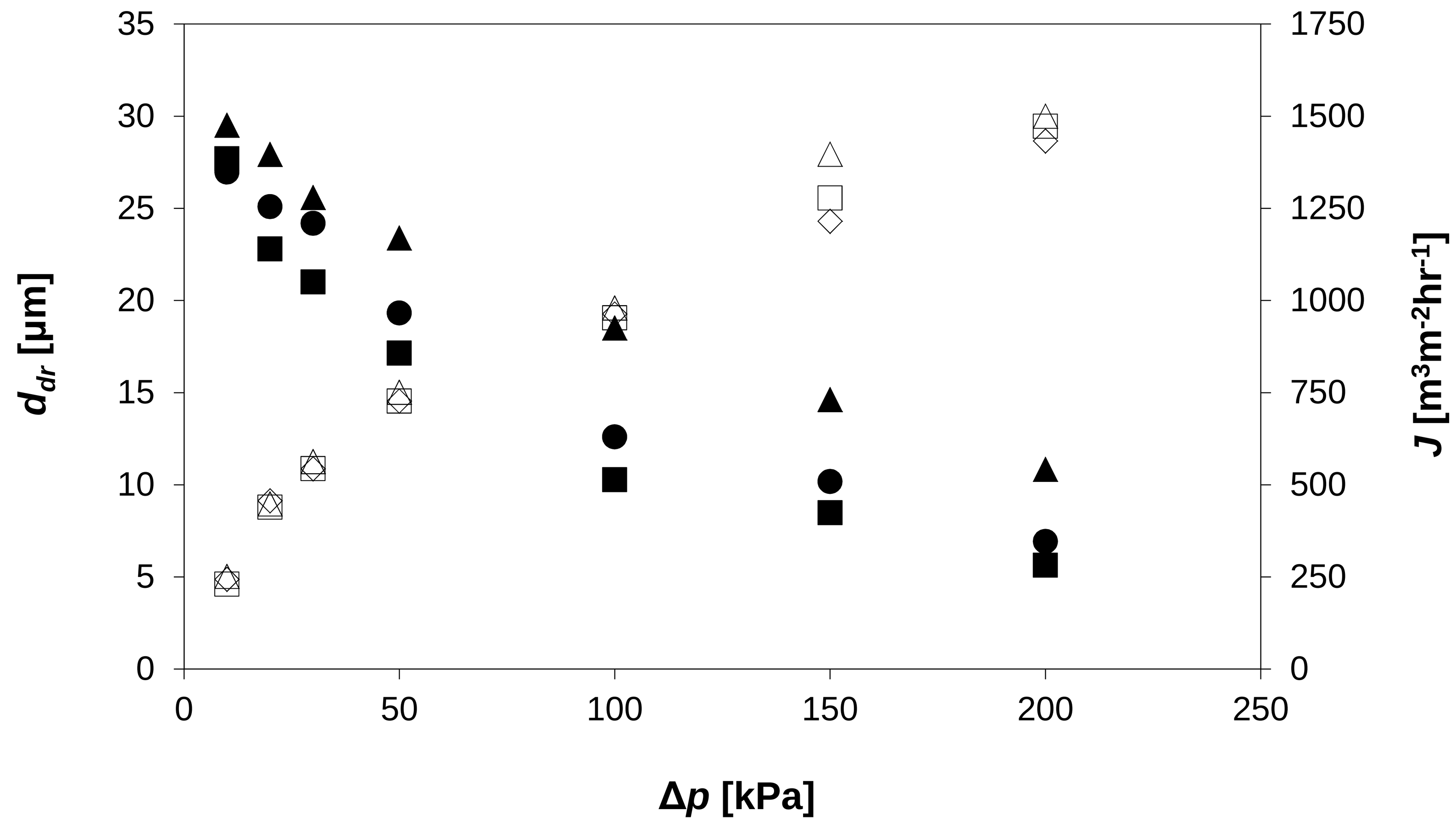


Fig. 2. Droplet diameter, d_{dr}, and transmembrane flux, J, as a function of transmembrane pressure, Δp: (▲) 1st, (●) 3rd, and (■) 5th pass droplet diameter; (△) 1st, (○) 3rd , and (□) 5th pass flux using 13.2µm sieve.

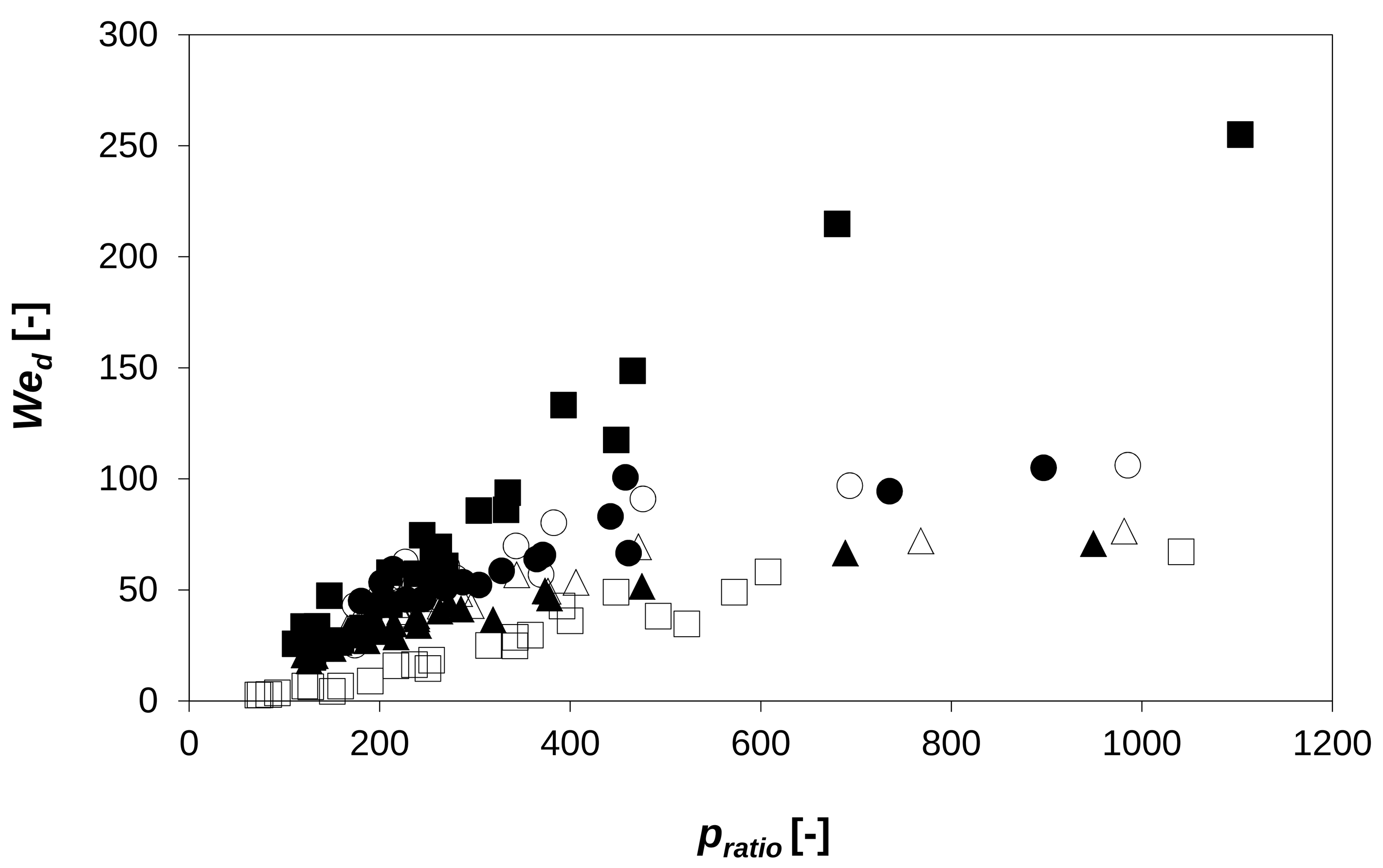


Fig. 3. Droplet Weber number, We_d, as a function of dimensionless pressure, p_{ratio}: (□) 4, (■) 7.1, (○) 10.6, (●) 11.6, (△) 12.8, and (▲) 13.2 µm.

Premix membrane emulsification with nickel sieves was found to be based on elongation and recompression of droplets, which makes it comparable to high-pressure homogenization. The transmembrane flux was rather high (Figure 2), while a reasonable span (~1) of the droplet size was found. There was no indication of fouling in the process, even after five passes, which indicates that the process is tolerant to product and conditions. A scaling relation using droplet Weber number (Figure 3) versus ratio of applied pressure and Laplace pressure described the results per sieve. The droplet Reynolds number versus the droplet Weber number (Figure 4) allows estimation of emulsion droplet size and characterizes flow inside the sieves, with all results for rectangular pores coinciding.

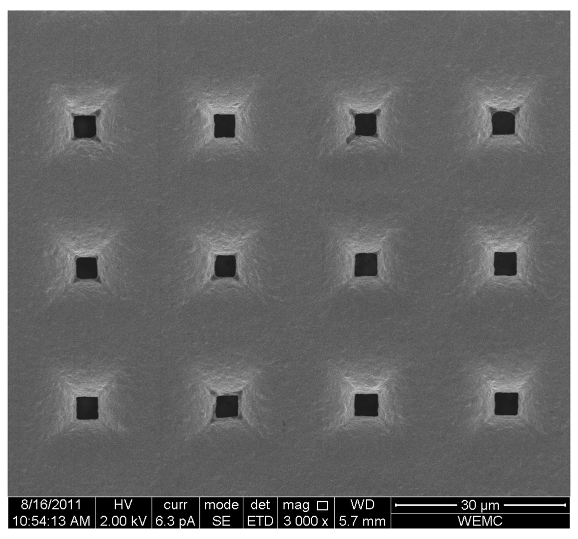


Fig. 1c. Nickel sieve
Pore size = 4 µm × 4 µm

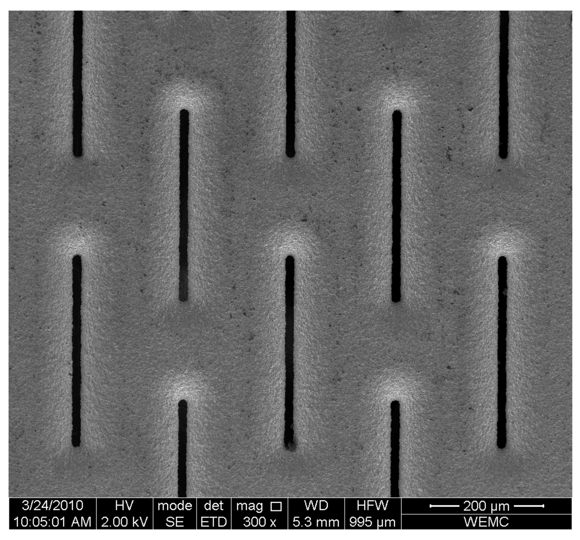
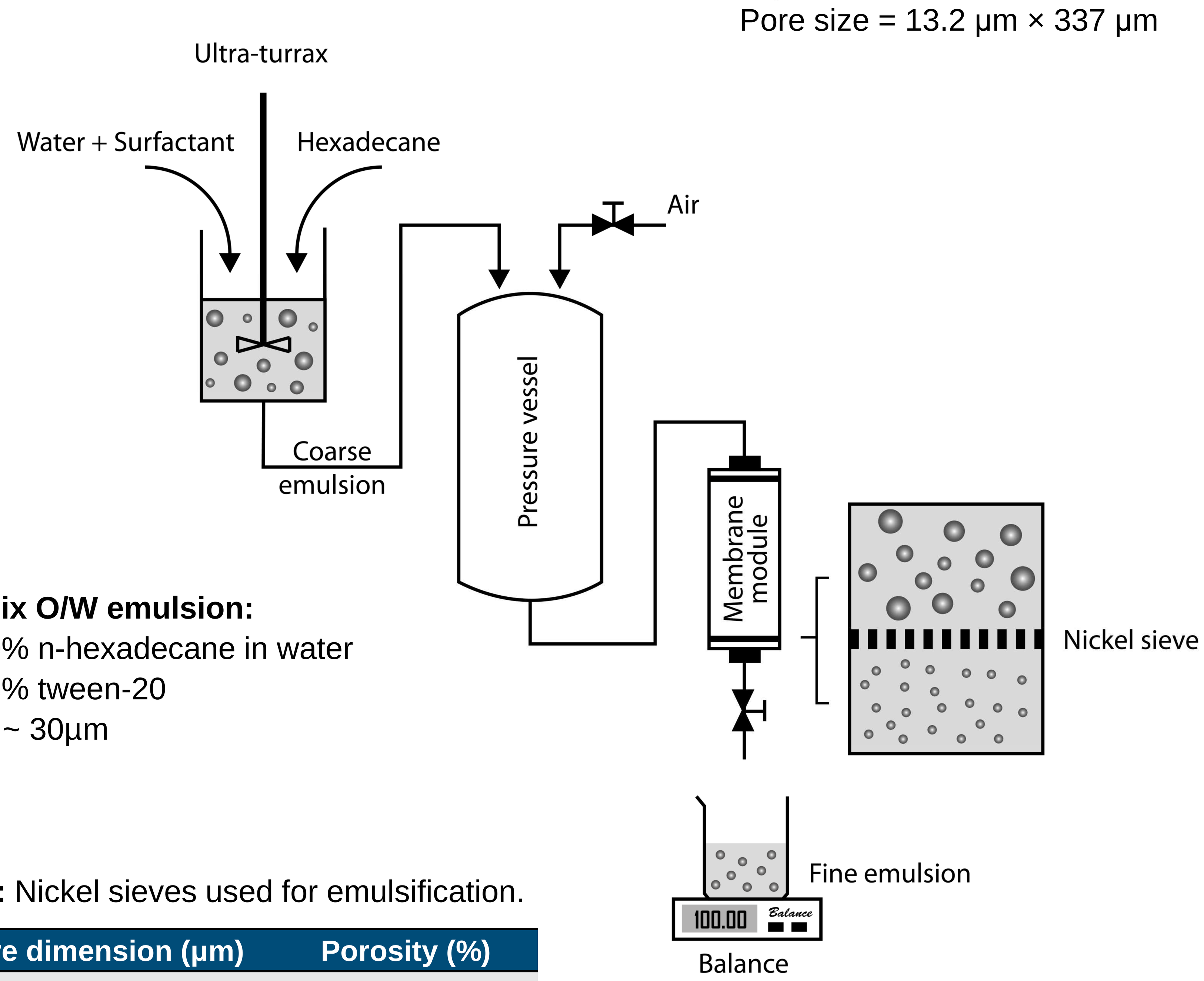


Fig. 1b. Nickel sieve
Pore size = 13.2 µm × 337 µm



Premix O/W emulsion:

- 5.0% n-hexadecane in water
- 0.5% tween-20
- d_{dr} ~ 30µm

Fig. 1a. Experimental setup

Table: Nickel sieves used for emulsification.

Pore dimension (µm)	Porosity (%)
4 × 4	2.7
7.1 × 413	1.5
10.6 × 330	3.6
11.6 × 331	4.0
12.8 × 329	4.4
13.2 × 337	4.8

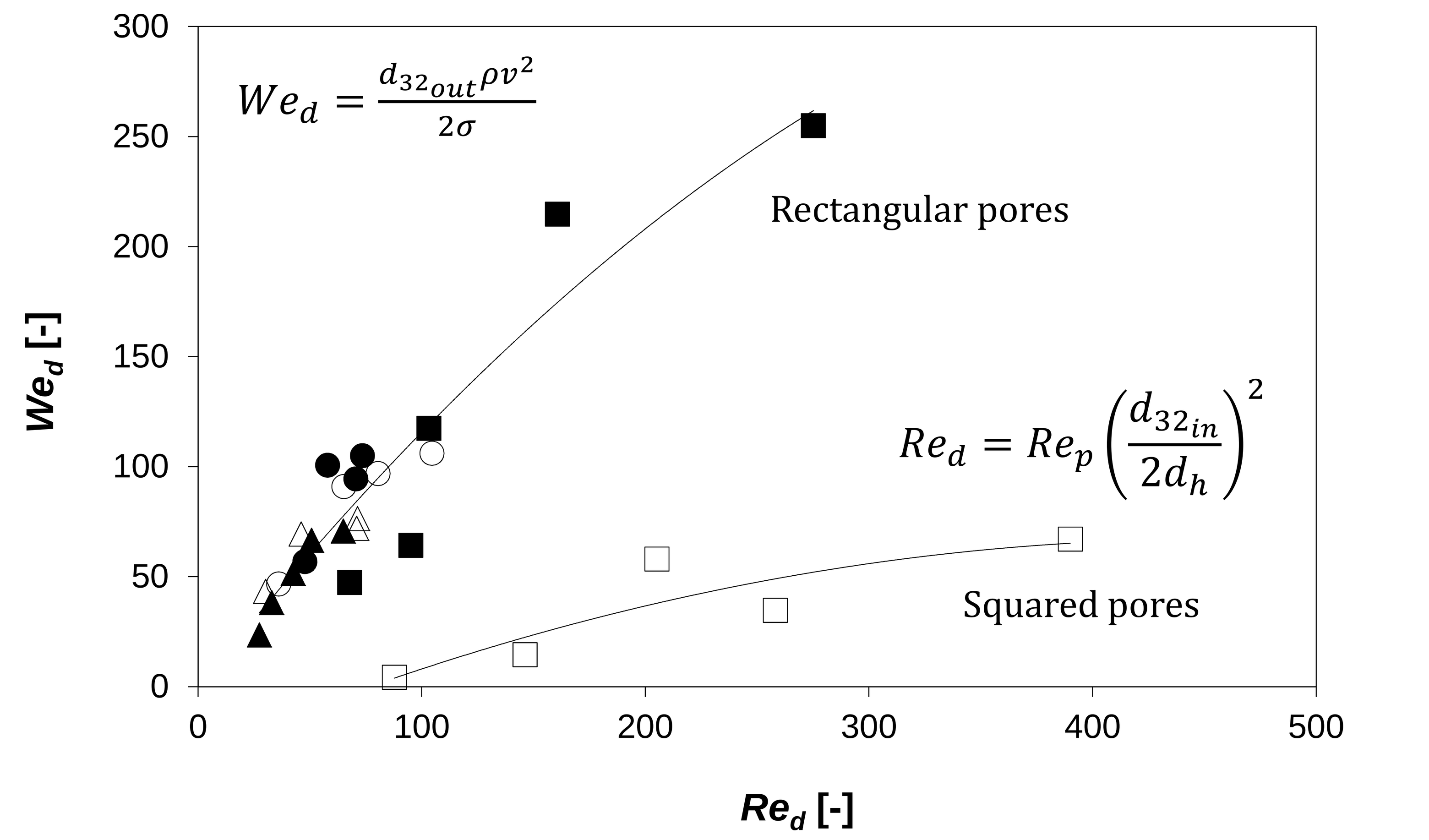
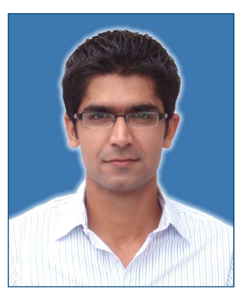


Fig. 4. Relation between droplet Weber number, We_d, and droplet Reynolds number, Re_d, for different sieves: (□) 4, (■) 7.1, (○) 10.6, (●) 11.6, (△) 12.8, and (▲) 13.2 µm.



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