Formation of nanocapsules by emulsion-diffusion : prediction of the emulsion size

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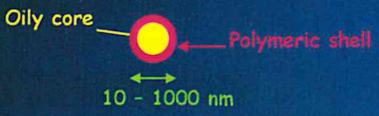
Nanocapsules

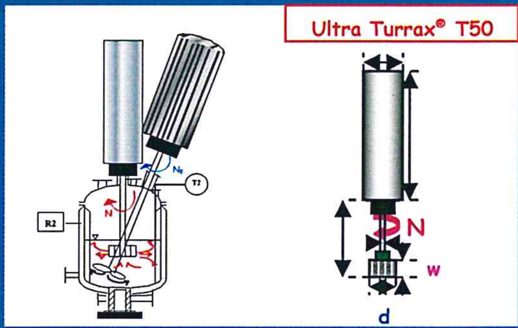


Drug Delivery Systems:

- ✓ Drug protection - stability
- ✓ Controlled release - targeting

Emulsion – Diffusion

Method : ★ o/w émulsion
★ dilution of the emulsion ⇨ solvent diffusion ⇨ nanocapsules formation



Reactor and rotor - stator used for the emulsion preparation

Emulsion				Agitation	
Oil		Water		Rotor Stator	Impeller
Solvent saturated with water (Ethyl acetate)	: 32,4%	Water saturated with solvent	: 64,8%	N = 5200 - 8800 - 10000 rpm	N_2 = 600 - 800 rpm
Polymer (Eudragit® E100, Poly-ε-caprolactone)	: 0,3%	Surfactant (Mowiol®4-86)	: 1,6%		
Oil (Miglyol®812)	: 0,8%				

Droplets size distribution

❶ Estimation

Costaz, 1996 :

$$\frac{d_{32}}{D_i} = 0.02\,(We)^{-0.6}\left(\frac{\mu_c}{\mu_d}\right)^{0.5}$$

★turbulent regime ⇨ Re : $5{,}4.10^4 - 1.10^5$

★$L_{macro} >> l_{micro} >> d_{32}$
⇨ L_{macro} : rotor blades size ≈ 2.10^{-3} m
⇨ l_{micro} : $(\mu_c{}^3/\rho_c{}^3.\varepsilon)^{1/4}$: 7,2 - 11,7 .10^{-6} m
⇨ d_{32} : droplets Sauter diameter ≈ $0{,}5.10^{-6}$ m

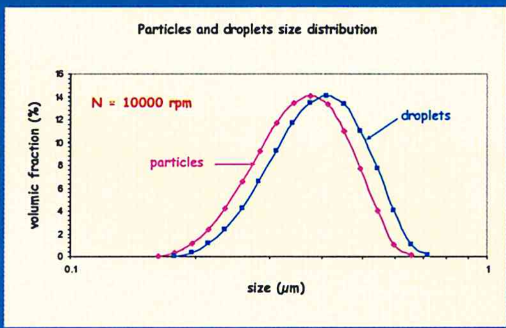
- ★ d_{32} : Droplets Sauter diameter (m)
- ★ D_i : Rotor diameter (4.10^{-2} m)
- ★ μ_c, μ_d : Dynamic viscosity of the continuous and dispersed phases (10^{-3} Pa.s)
- ★ We : Weber number = $\rho_c.N^2.\ D_i{}^3/\sigma$ (-)
- ★ ρ_c : Volumic mass of the continuous phase (10^3 kg.m^{-3})
- ★ σ : Interfacial tension (6.10^{-3} N.m^{-1})

❷ Calculation

- Particles size distribution measurement (Laser granulometer Coulter® LS200)
- Assumptions ✓ one droplet ⇨ one particle
  ✓ particles and droplets are not porous
- Droplets size distribution calculated from the particles size distribution

$$\frac{d_{drop}}{d_{part}} = \left[\frac{\rho_{part}}{\rho_{drop}}\frac{m_{drop}}{m_{part}}\right]^{1/3} \quad \text{and} \quad \frac{1}{\rho_{drop}} = \frac{x_{polymer}}{\rho_{polymer}} + \frac{x_{ethylacetate}}{\rho_{ethylacetate}} + \frac{x_{oil}}{\rho_{oil}}$$

Results



Calculation of the droplets size distribution from the particles one

N rotor stator rpm	Particles d_{32part} (measurement) µm	D_{32} droplets µm: calculated from the particle size distribution ❷	D_{32} droplets µm: Calculated from the correlation ❶	Correlation / distribution (-)
5200	0,925	1,016	1,300	1.28
8800	0,365 0,294	0.400 0,322	0,710	1.78 2.20
10000	0,345	0.378	0,610	1.61

Comparison of d_{32} estimated from the correlation and calculated from the particles size distribution

Conclusions

- D_{32} correlation ≈ (1,5 - 2) d_{32} distribution
- Correlation established for micrometric emulsions (≈ 3µm)
- one droplet ⇨ one particle ⇨ OK (solvent = only 25% volume)
- Very low interfacial tension (6.10^{-3} N.m^{-1}) - Accuracy ?
  If σ = 3.10^{-3} N.m^{-1} ➲ D_{32} correlation = 0,47 µm for N = 8800 rpm

REFERENCES

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