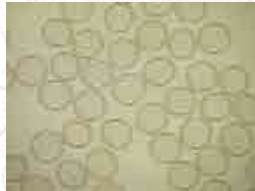




# Microencapsulation ?



Denis Poncelet



ENITIAA, BP82225, F-44322 Nantes - Email : poncelet@enitiaa-nantes.fr



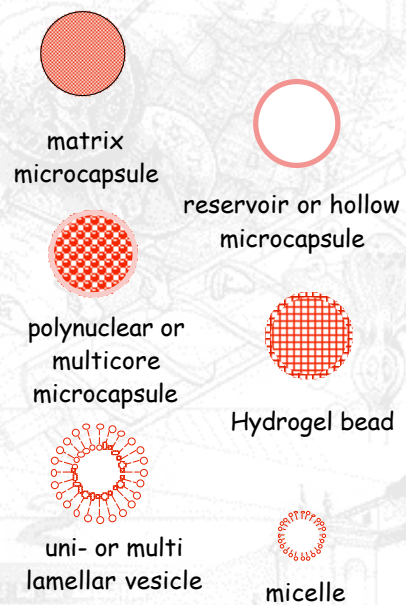
## Introduction : définitions

### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ structure it

- ◇ microcapsules
- ◇ microparticles
- ◇ microspheres
- ◇ nanocapsules
- ◇ nanoparticles
- ◇ nanosphères
- ◇ micelles
- ◇ liposomes
- ◇ (micro)emulsions
- ◇ molecular inclusion



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## Objectives : Immobilization

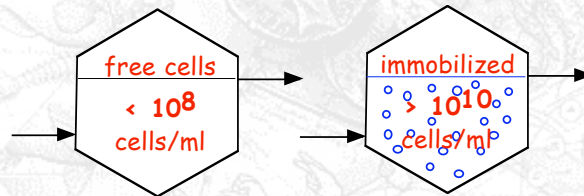
### Microencapsulation

Entrapment of a material inside microparticles for :

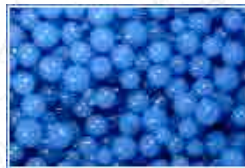
- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ structure it

### Continuous processing (bio-cells & enzymes)

#### Lactic bacteria culture



### Volatile compounds



<http://www.mane.com/>

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## Objectives : Protection

### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ structure it

### About degradation (O<sub>2</sub>, lighth, heat, water)

Vitamin A / monosodium glutamate  
appearance (white)  
protection (water, T, lighth)



[www.encap.com](http://www.encap.com)

### During shell-life, processing and digestion



Meatshure

[www.balchem.com](http://www.balchem.com)



[www.customprobiotics.com](http://www.customprobiotics.com)

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## Objectives : Protection

### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ **protect it**
- ◇ release it
- ◇ structure it

### Taste masking

# BASF

[www.human-nutrition.basf.com](http://www.human-nutrition.basf.com)



### Medium protection

Ferrous fumarate agglomerated and coated with 60% hydrogenated soy oil using the Wurster process. 100-450 µm



### Immunoprotection



<http://www.islet.com>



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## Objectives : Release

### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ **release it**
- ◇ structure it

### Diffusion-rehydration-degradation-rupture



### Chemical - physical - mechanical factors



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## Objectives : Structuration

### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ **structure it**

Liquid or gaz to solid

Dispersibility

Solubility

Flowdability

Tabletisatisable

Hygroscopicity controle

Dust free powder



Spic and Span

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## Objectives : Structuration

### Visual aspect and marketing concept

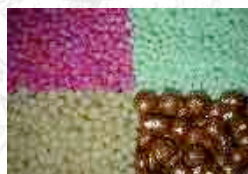
### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ **structure it**



<http://www.coletica.fr>



Colorcon

<http://www.colorcon.com>



EURACLI

<http://euracli.fr/>

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## Objectives : Release

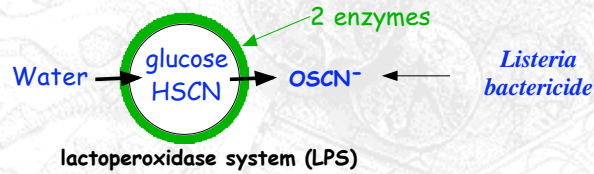


### Microencapsulation

Entrapment of a material inside microparticles for :

- ◇ immobilized it
- ◇ protect it
- ◇ release it
- ◇ structure it

### Release of a by-product

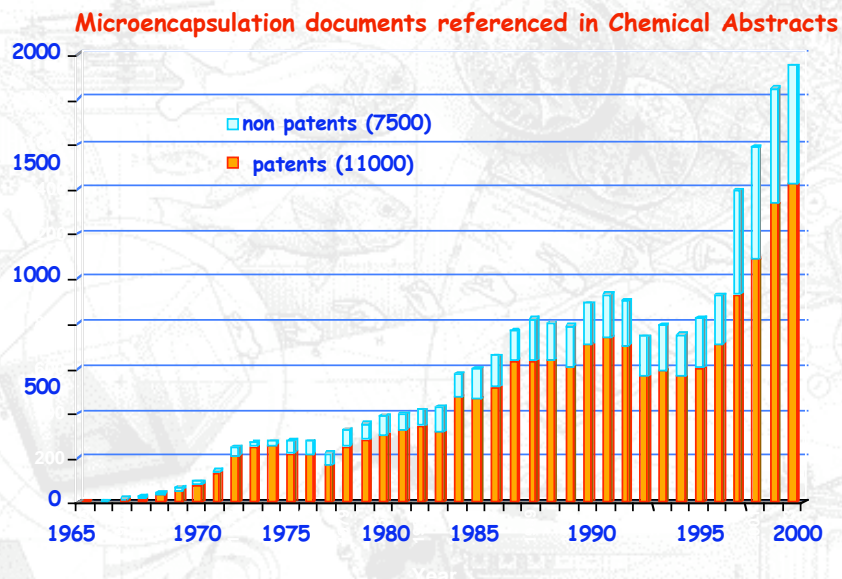


- ◇ material immobilization (enzymes + substrates)
- ◇ enzyme protection (storage)
- ◇ controlled release of end-products
- ◇ control of hygroscopy
- ◇ flowdability & dispersibility
- ◇ high reaction efficiency
- ◇ long term & more efficient action
- ◇ easy to use for underdeveloped countries

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## Microencapsulation : Applications



From Bojana boh (2003) MLL vol. 6, Citus Book, london, UK.

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## Microencapsulation : Applications

### Chemistry

- Printing & recording
- Carbonless paper
- Adhesives
- Pigments and fillers
- Catalysts

### Agriculture

- Fungicide - herbicide
- Insect repellent
- Biopesticide
- Pigments and fillers
- Artificial insemination

### Biotechnology & enviroment

- Continuous reactor
- Shear protection
- Reactor oxygenation
- Bioprobes

### Food & feed

- Aromas
- Probiotics
- Unsaturated oil
- Enzyme food processing
- aminoacid for cows

### Medecine & Pharmacy & veterinary

- Controle release
- Taste masking
- Vectorisation
- Artificial organs
- single dose treatment

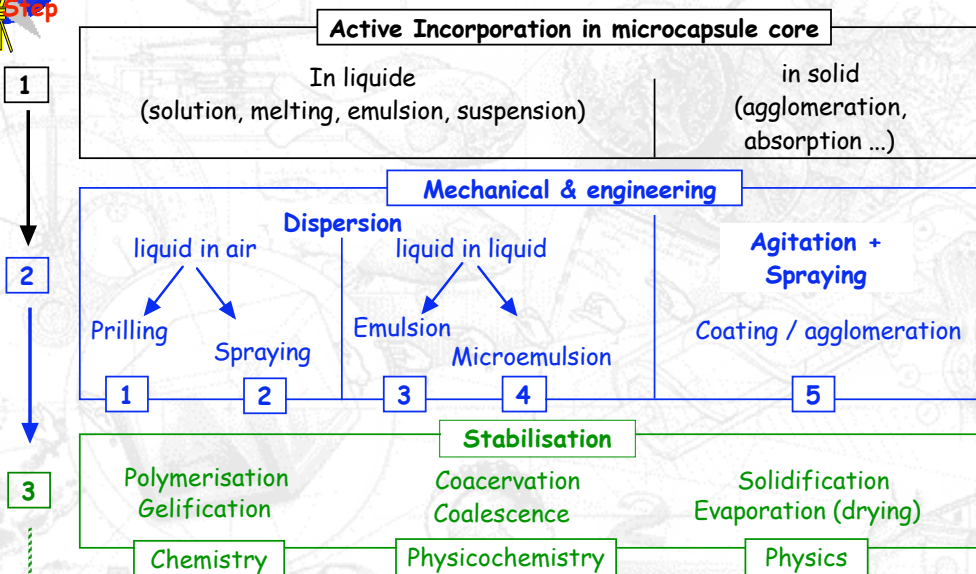
### Consumer & diversified

- cosmetics
- detergents (enzymes)
- sanitary (active, aromas)

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## Encapsulation : methods & technologies

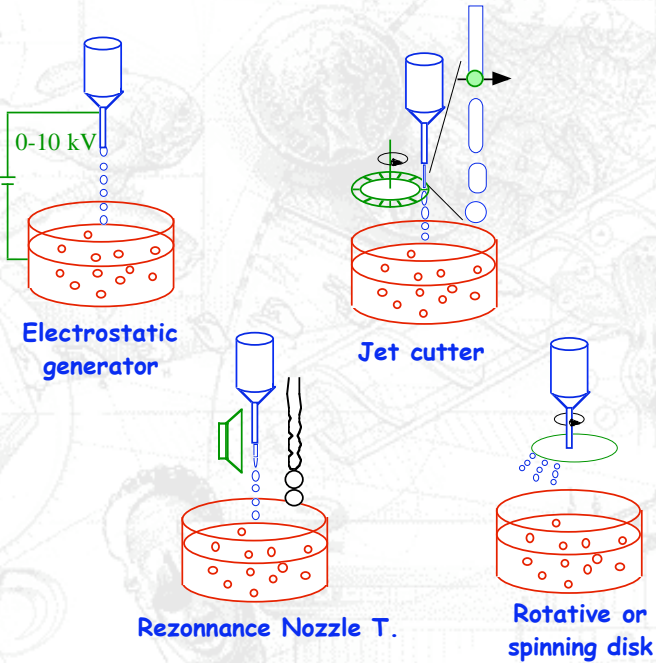
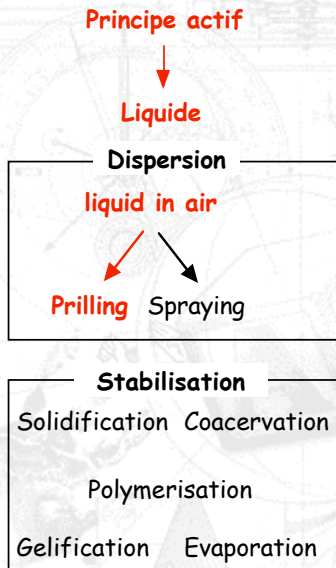


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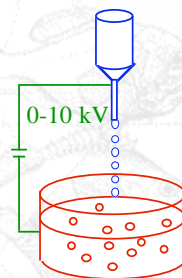
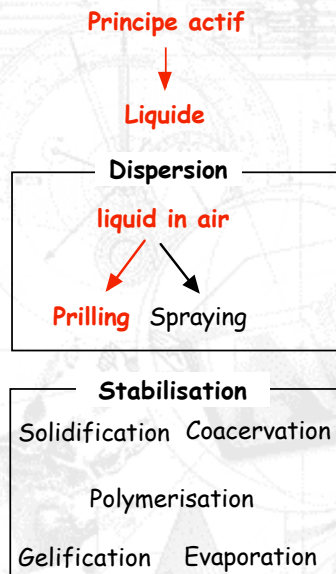
## Prilling / dropping methods



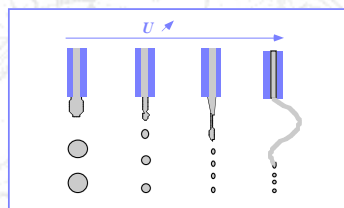
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## Prilling / Electrostatic generator



- ◇ low dispersion (20 %)
- ◇ 50 to 1000 micrometers
- ◇ large range of viscosity
- ◇ low troughput (10 to 100 ml/h)



<http://www.nisco.ch>

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## Prilling / Rezonance Nozzle Technology

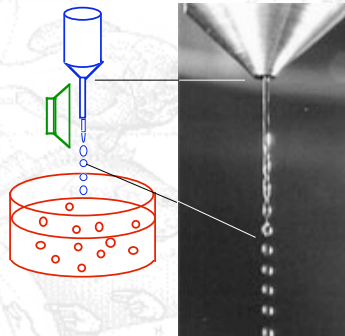
Principe actif

Liquide

Dispersion

liquid in air

Prilling Spraying



**INOTECH**  
<http://www.inotech.ch>

Stabilisation

Solidification Coacervation

Polymerisation

Gelification Evaporation



- ◇ low dispersion (5-10 %)
- ◇ high troughput (0.1 to 2 l/h)
- ◇ 100 to 1000 micrometers
- ◇ including medical applications
- ◇ low viscosity

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## Prilling / Jet cutter

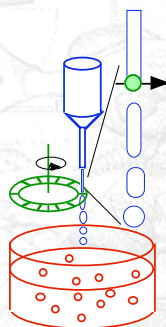
Principe actif

Liquide

Dispersion

liquid in air

Prilling Spraying



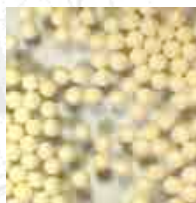
<http://geniaLab.de>

Stabilisation

Solidification Coacervation

Polymerisation

Gelification Evaporation



pectate beads with TiO<sub>2</sub> and vitamine, Ø 500 µm

- ◇ low dispersion (5-10 %)
- ◇ high troughput (0.1 to 5 l/h)
- ◇ 300 to 1000 micrometers
- ◇ high viscosity

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## Prilling / Rotating devices

Principe actif

Liquide

Dispersion

liquid in air

Prilling Spraying



Fig. 1a Prilling Wheel

[www.niro.com](http://www.niro.com)



[www.swri.org](http://www.swri.org)

**Stabilisation**  
 Solidification Coacervation  
 Polymerisation  
 Gelification Evaporation



Particle and coating technology

[www.pctincusa.com](http://www.pctincusa.com)

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## Prilling / Stabilisation



Principe actif

Liquide

Dispersion

liquid in air

Prilling Spraying

Solidification

Melted material



Cold air or water

Gelification

Gel



Gelation bath

Evaporation or drying

polymer + solvent



Hot air

Interfacial Coacervation

Polymer<sup>-</sup>



Polymer<sup>+</sup>

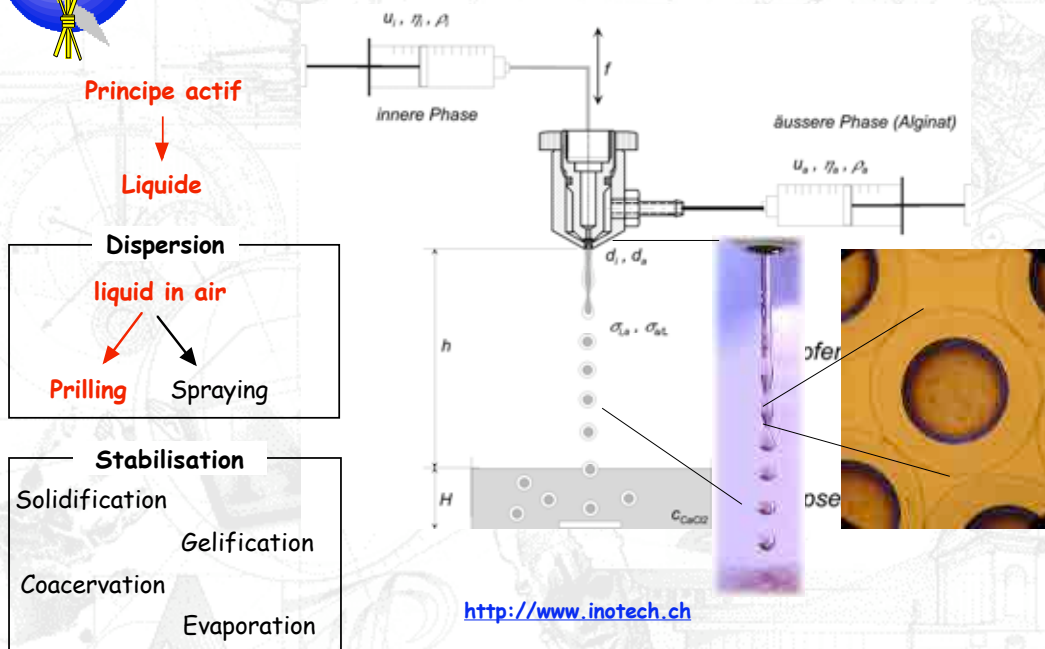
**Stabilisation**  
 Solidification  
 Coacervation  
 Gelification  
 Evaporation

inner core = solution, emulsion, suspension, powder

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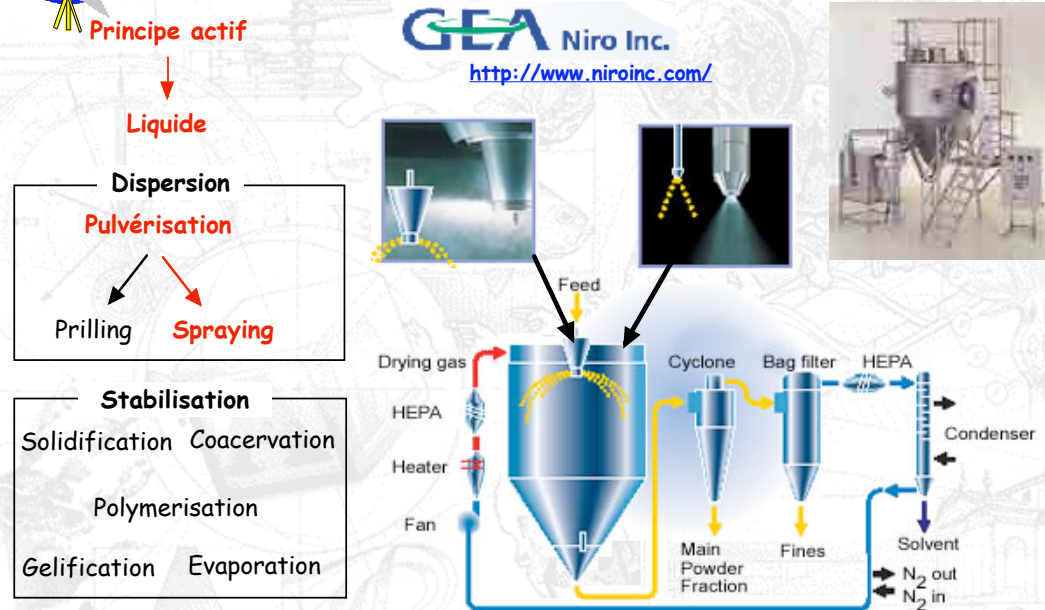
## Prilling / Coextrusion



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## Spraying / Stabilisation

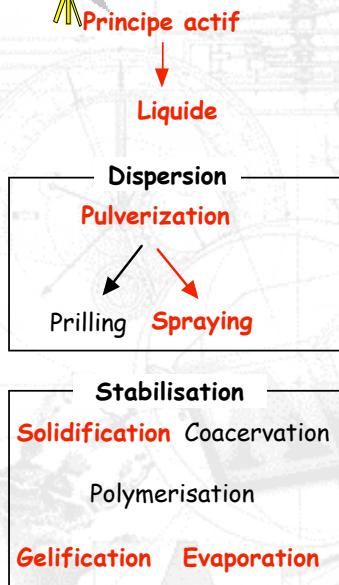


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## Pulverisation / stabilisation



### Spray drying

spray = aqueous solution  
hot air

- ! over heating
- ! low initial dry matter
- ! matrix structuration

### Spray cooling or congealing

spray = hot melt  
cold air  
> high yield, fast process



<http://www.nutriprocess.com/>



### Spray chilling

spray = thermogel  
cold air + drying air



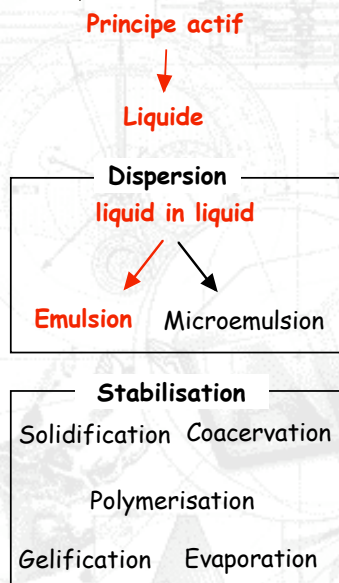
<http://www.innov-ia.com/>

Spray = solution, emulsion, suspension

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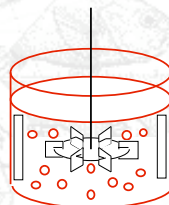


## Emulsion / dispersion



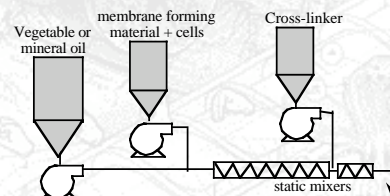
### Batch process

**Turbine reactor**



### Continuous process

**Static mixers**



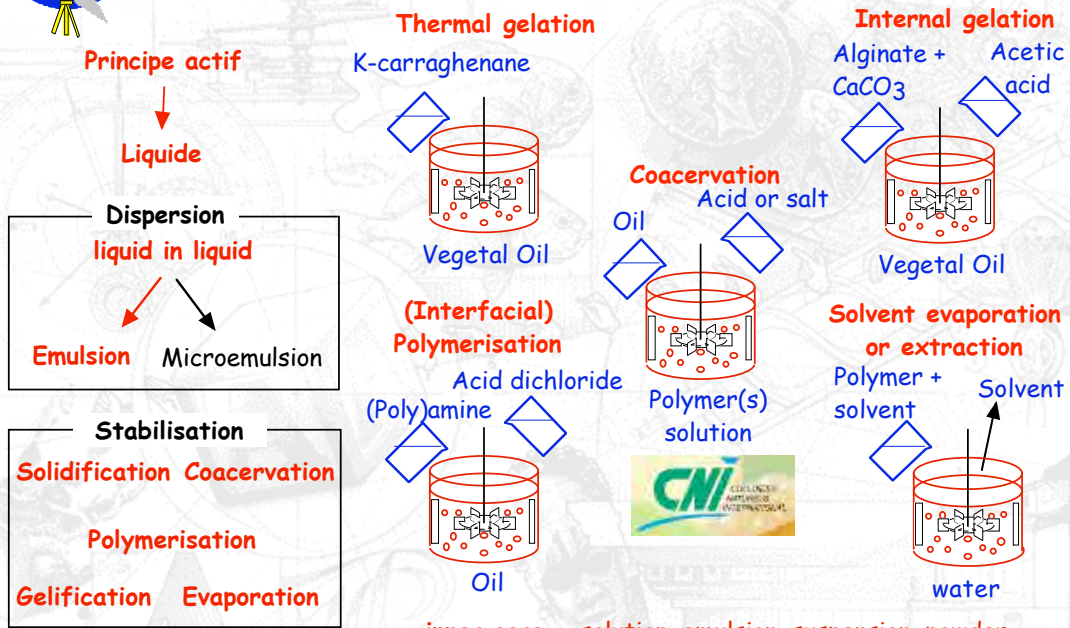
- ◇ fast dispersion (< 1 sec)
- ◇ high throughput (m<sup>3</sup>/h)
- ◇ Cheap, easy



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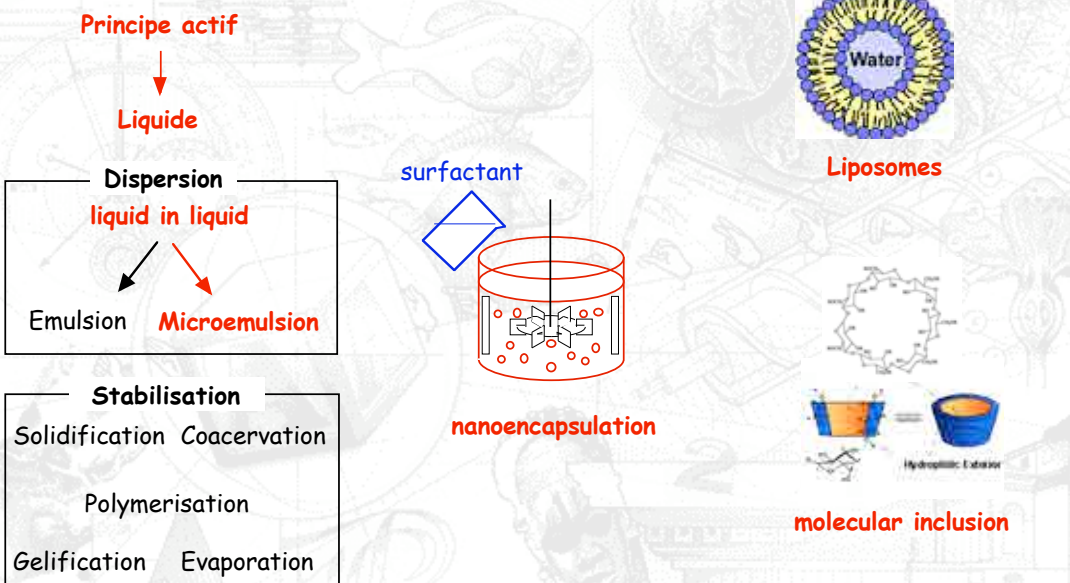
# Emulsion / stabilisation



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# Nanoencapsulation & molecular inclusion



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# Coating - pelletizing - layering

Principe actif

Solide

Technics

Coating / agglomeration

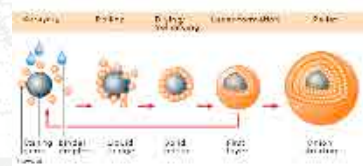
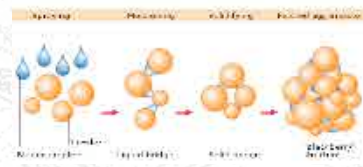
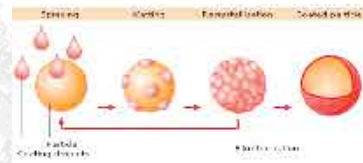
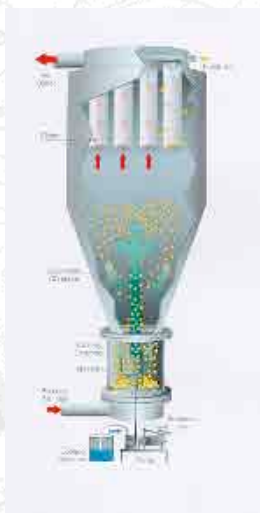
Pan reactor / Fluid bed

Stabilisation

Solidification

Evaporation

Coalescence



[www.encap.com](http://www.encap.com)

<http://www.glatt.de>

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# Fluid bed technologies

Principe actif

Solide

Technics

Coating / agglomeration

Pan reactor / Fluid bed

Stabilisation

Solidification

Evaporation

Coalescence



**Top spray**  
Coating & Drying  
Hot melt coating  
Agglomeration  
High capacity  
poor coating



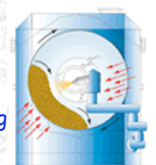
**Wurster**  
Coating & Drying  
lower capacity  
homogeneous coating



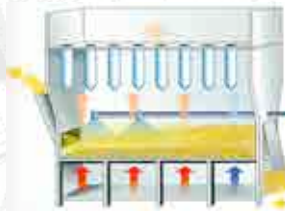
**Rotor spray**  
very dense coating  
spheronisation  
low drying capacity  
lower cooling capacity



**Pan coater**  
Coating & agglomeration  
dry powder coating  
large particles  
lower capacity



**Continuous coater**  
lower cost  
higher capacity



**Spouted bed**  
better circulation  
temperature controle



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# Advances coating technologies

Principe actif

Solide

Technics

Coating / agglomeration

Pan reactor / Fluid bed

Stabilisation

Solidification

Evaporation

Coalescence



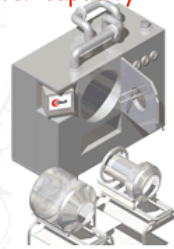
Pan coater

Coating & agglomeration

dry powder coating

large particles

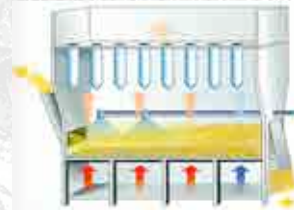
lower capacity



Continuous coater

lower cost

higher capacity



Spouted bed

better particle circulation  
better temperature controle

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# Coating / stabilisation processes

Principe actif

Solide

Technics

Coating / agglomeration

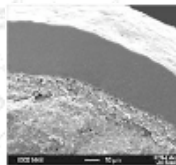
Pan reactor / Fluid bed

Stabilisation

Solidification

Evaporation

Coalescence



Evaporation (spray coating)

spray = solution

hot air

! slow process

! energy demand



<http://mcc-ch.org>

Solidification (hot melt coating)

spray = hot melt

cold air



[www.syntapharm.com](http://www.syntapharm.com)

Coalescence (dry powder coating)

spray = fine powder + plastifiant

air at room temperature

Spray =

◇ solution, emulsion, suspension, powder

◇ polymer, filler, surfactant, active

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## Fluid bed technologies



research coordination  
over 25 (-> 35) countries  
<http://COST865.bioencapsulation.net>

*Evo & micro  
Encapsulation  
Sciences and  
Technologies*



1000 groups  
over 80 countries  
(30 % industrials)  
<http://bioencapsulation.net>



Topical team to develop  
research projects

Marie Curie  
thematic  
network



European platform for promoting  
encapsulation industrial business

UNESCO/  
INTAS  
network

<http://ncapsolutions.net>