Ecole de Chimie de Rennes

POLLUTED EMISSION TREATMENTS FROM INCINERATOR GASES

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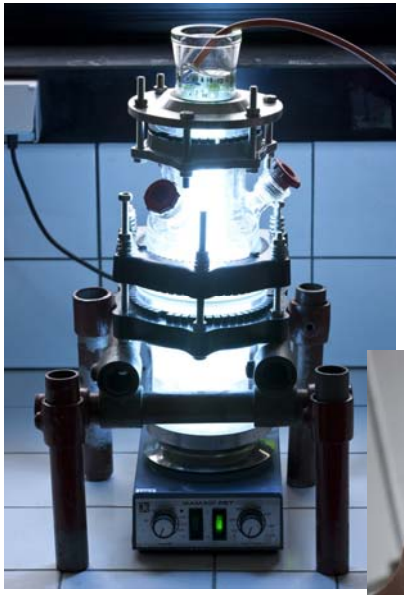

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Flue gas treatment

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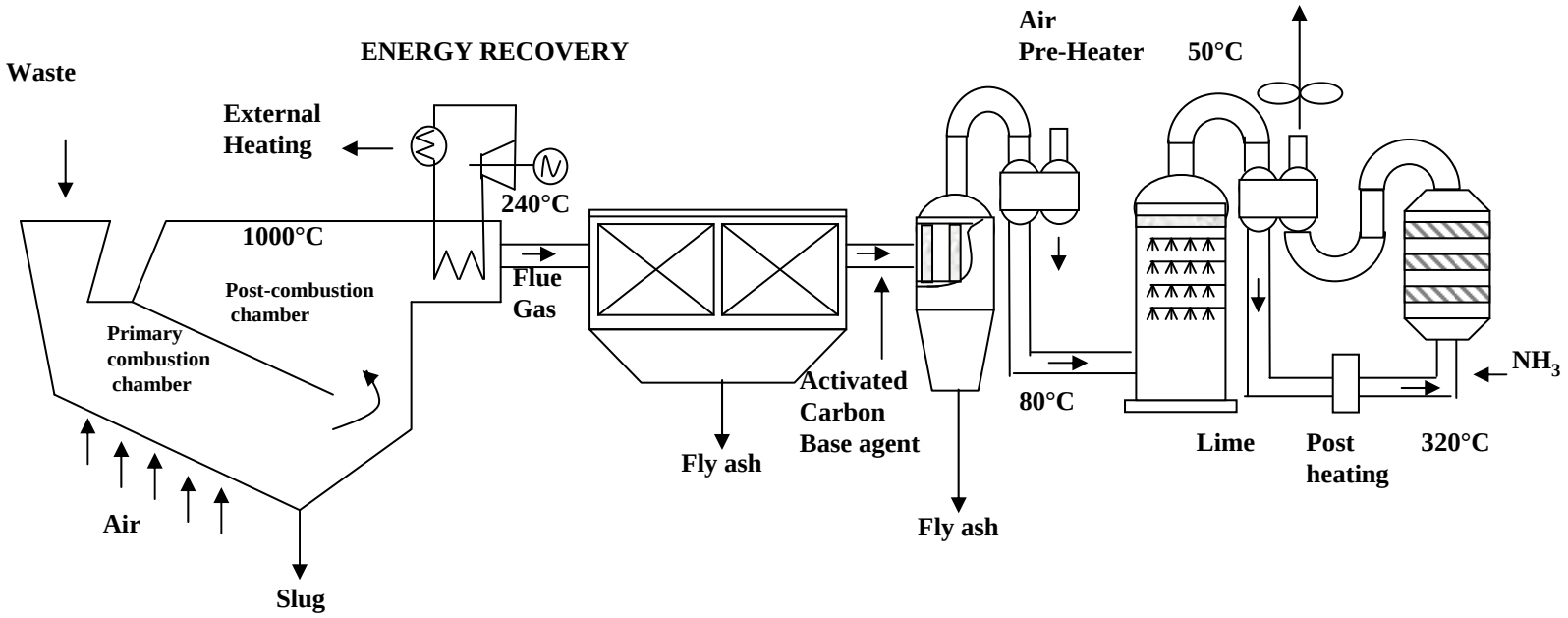

(adapted from Fino *et al.*, 2005)

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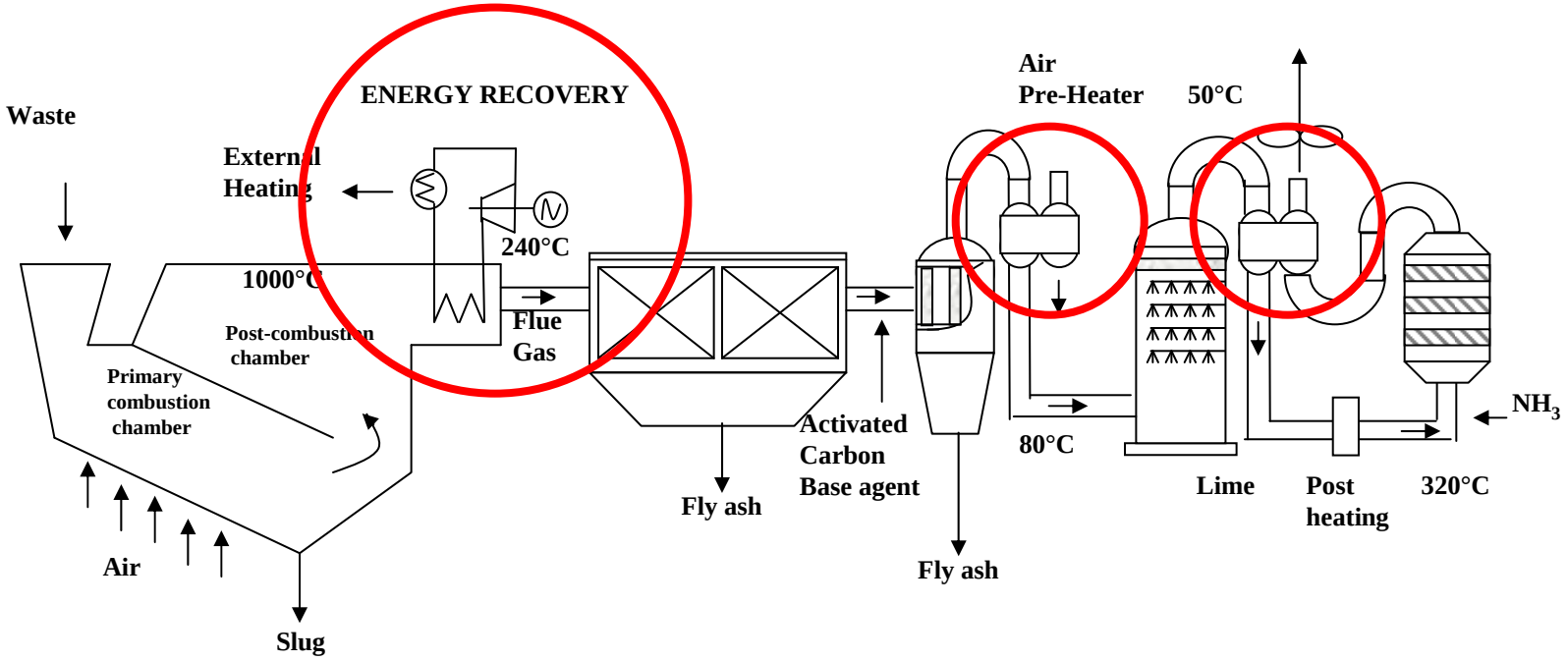

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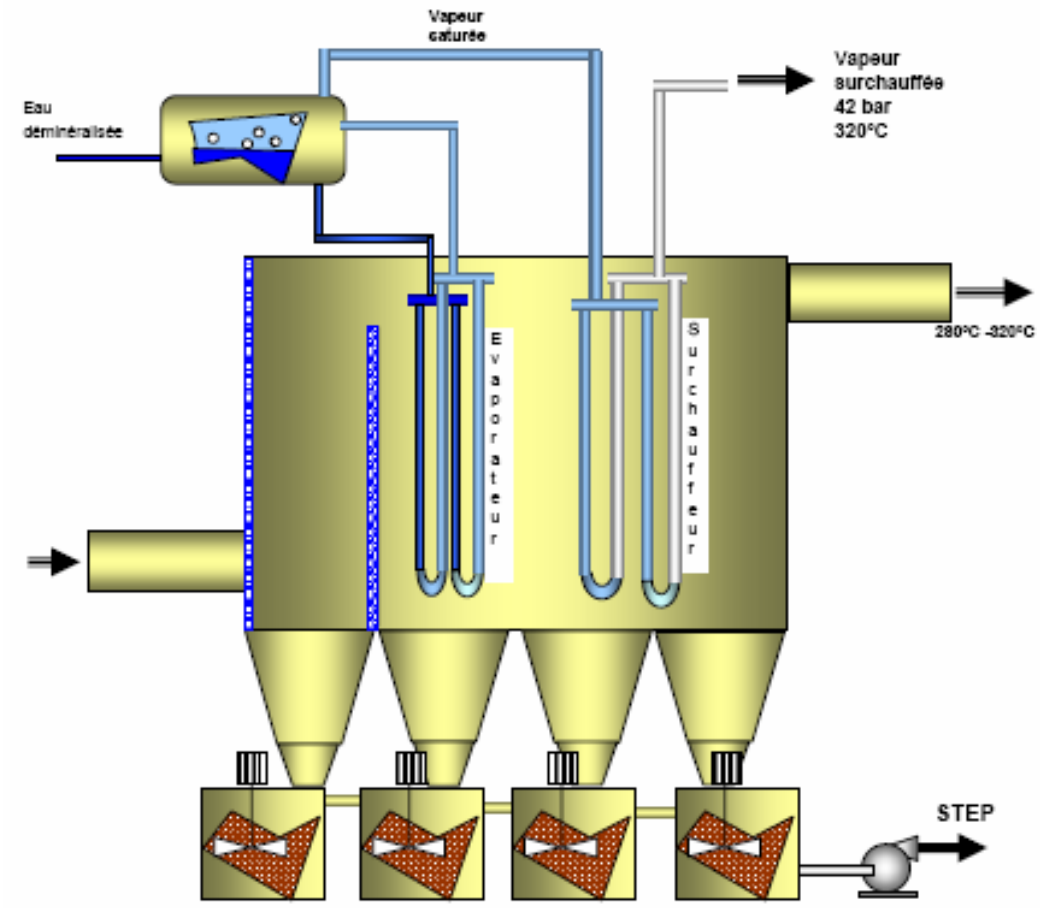
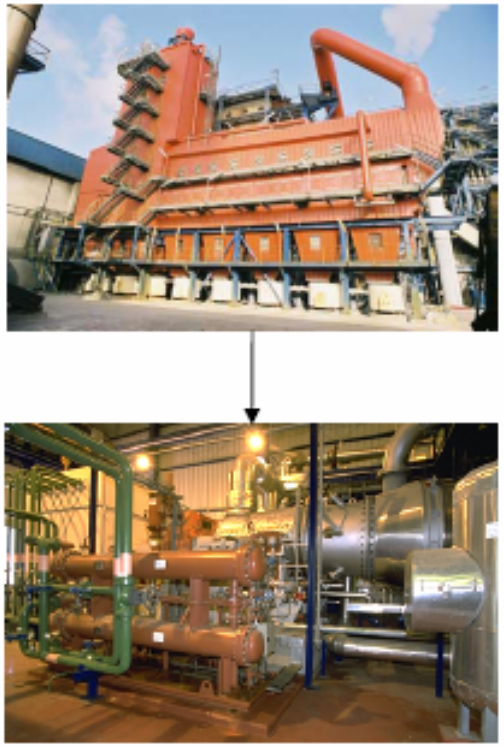
Energy recovery





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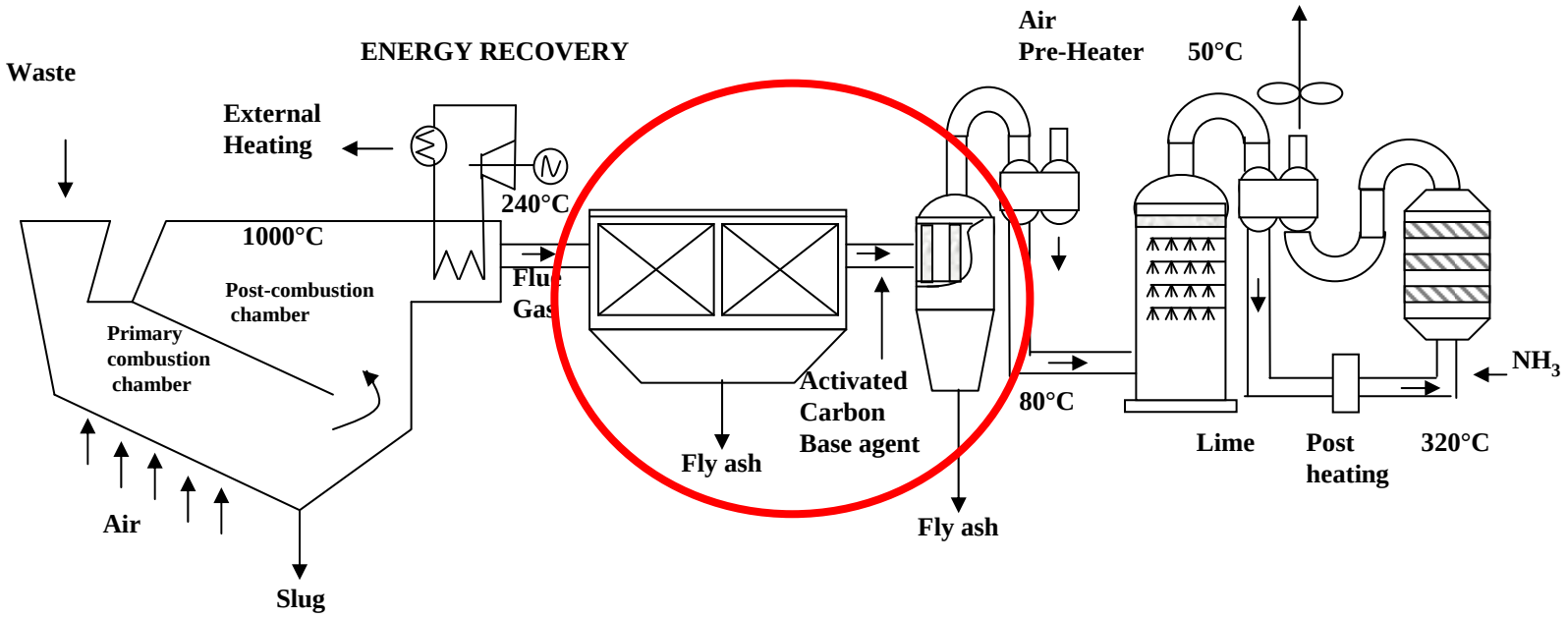
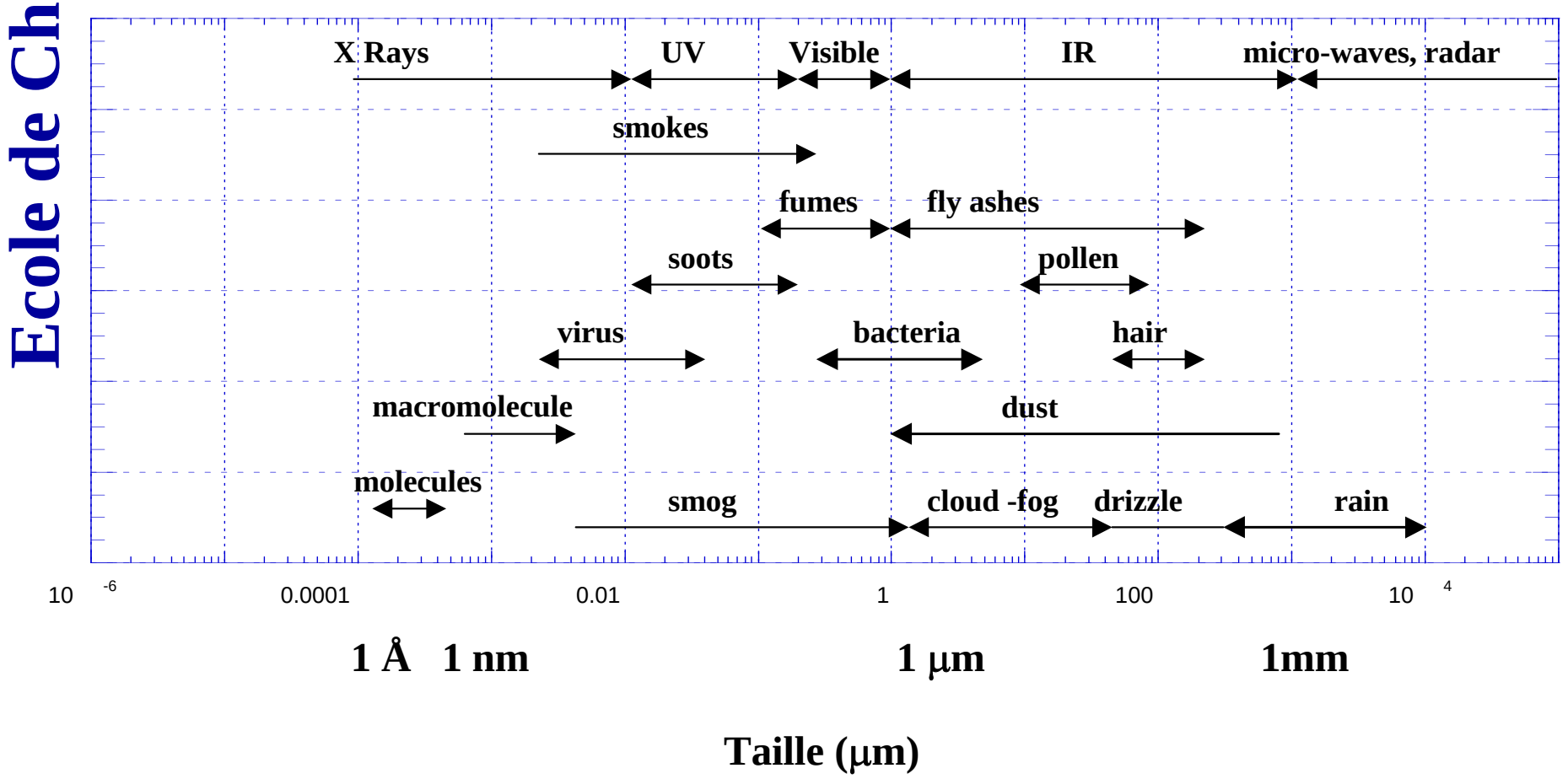
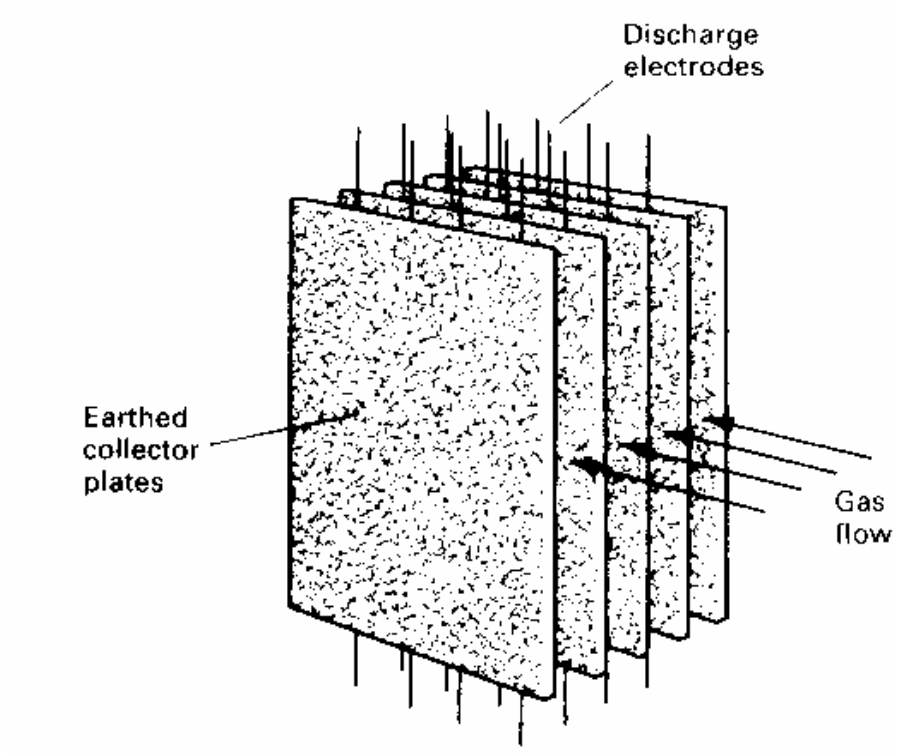


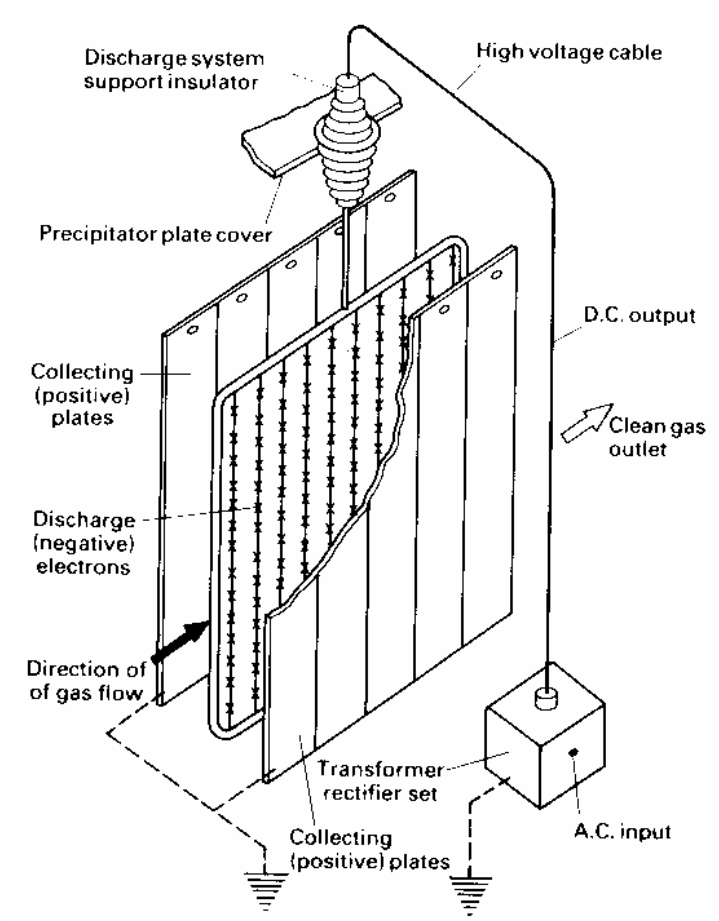
(adapted from Fino *et al.*, 2005)

Particule size



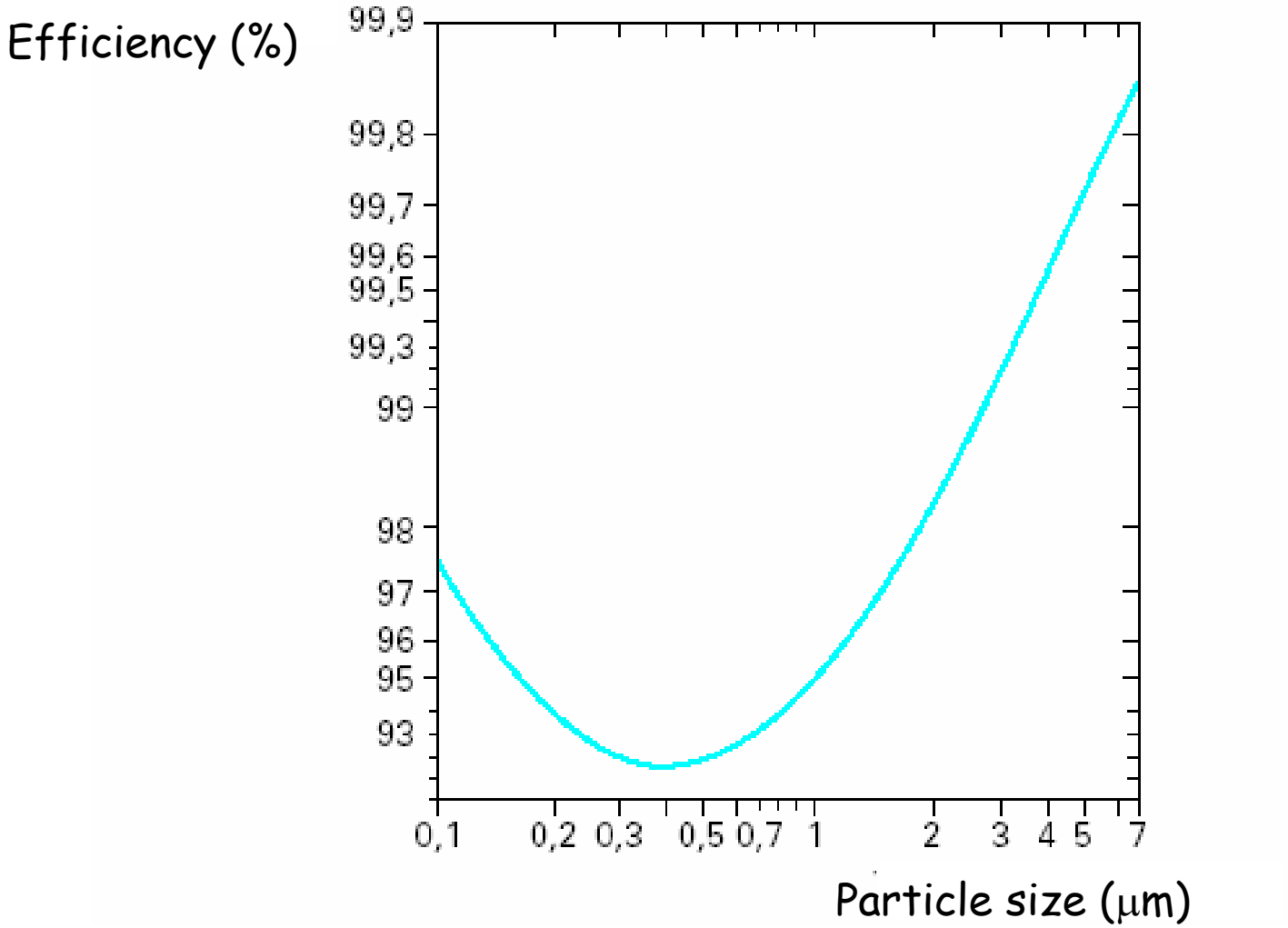
Electrostatic precipitator





Coulson-Richardson, 1997

Electrostatic precipitator



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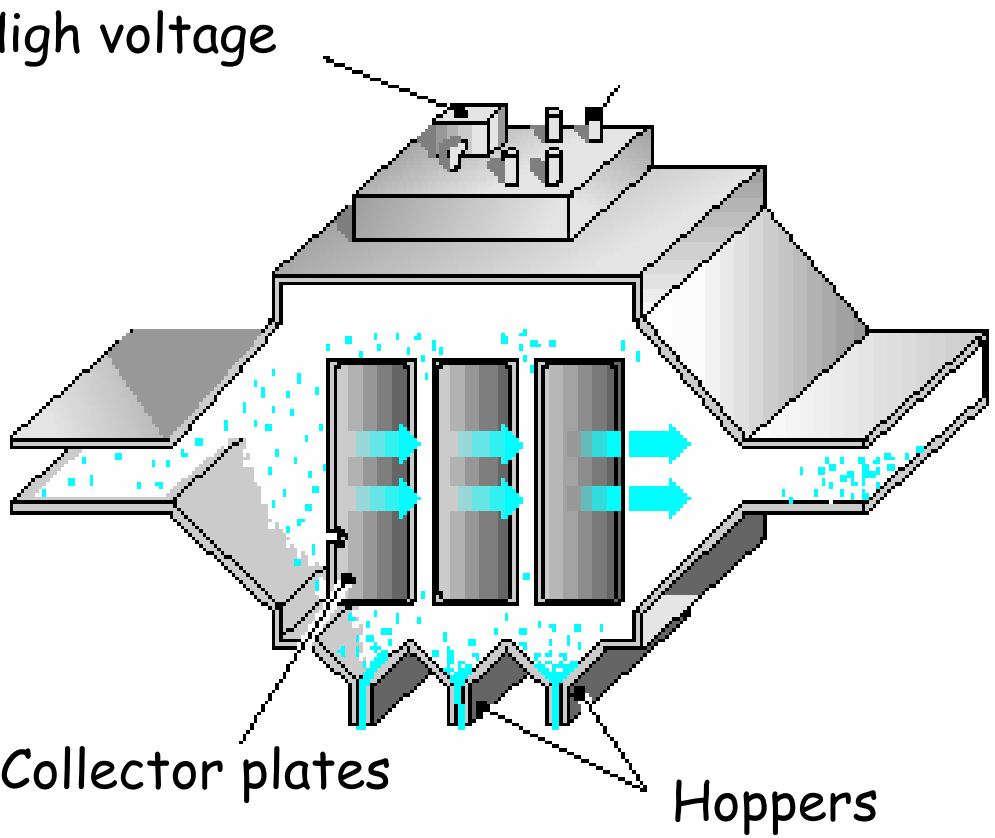
Electrostatic precipitator



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Electrostatic precipitator

Tredi Groupe Séché, France

Filtration mechanisms

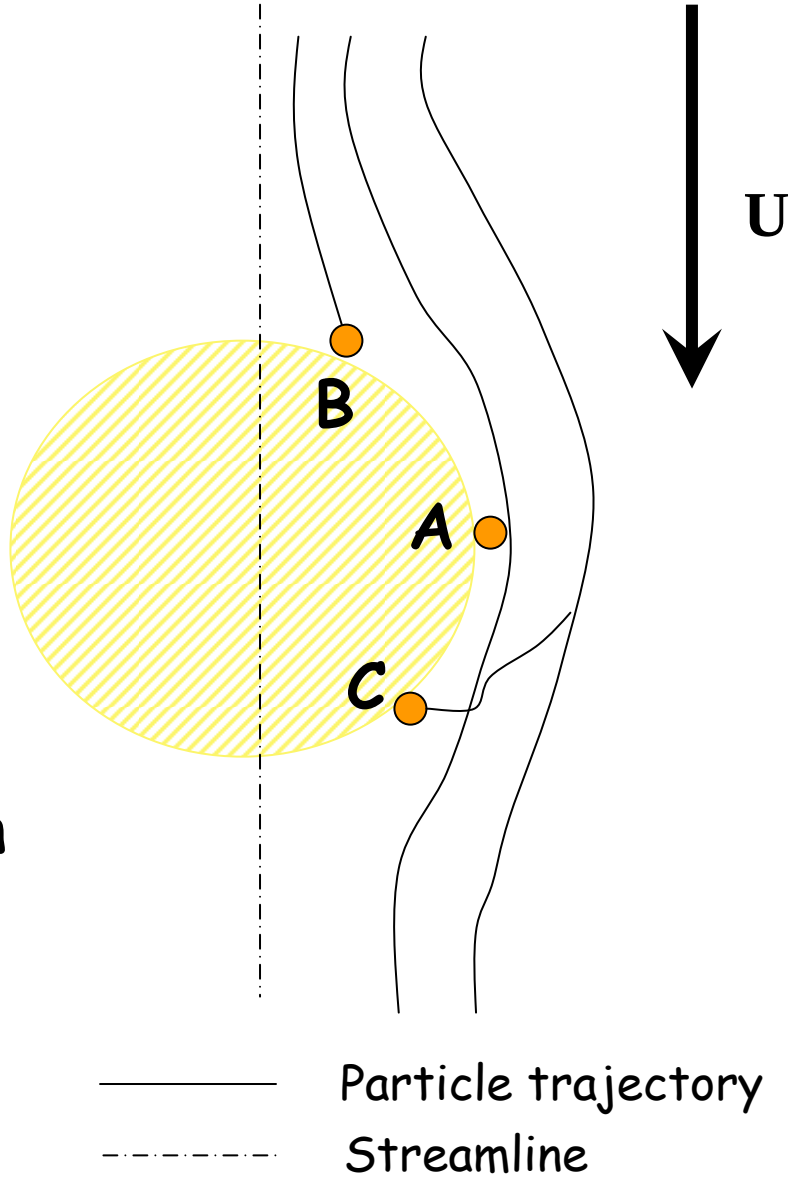
For an isolated single sphere:

Mode of action of the basic mechanisms:

A **Interception**

B **Sedimentation**

C **Diffusion - Adsorption**



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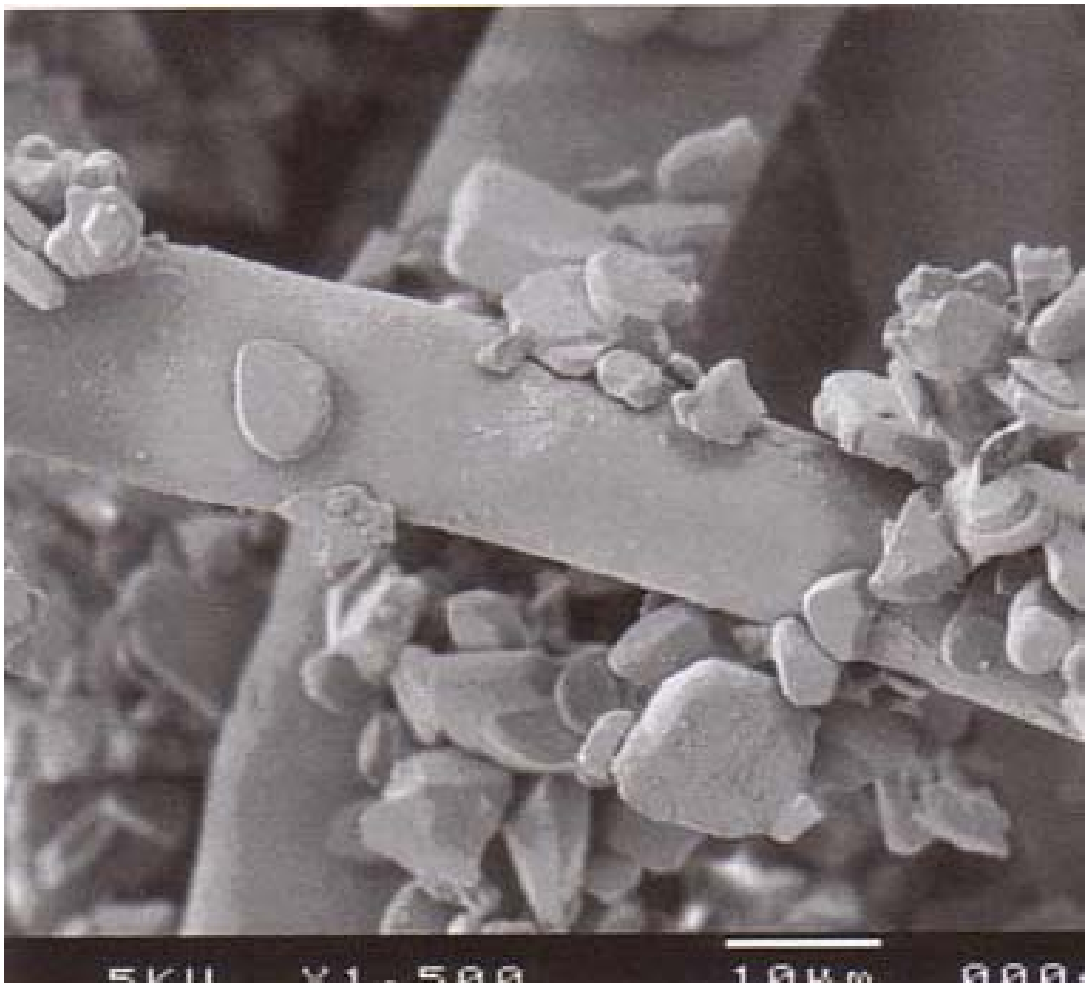
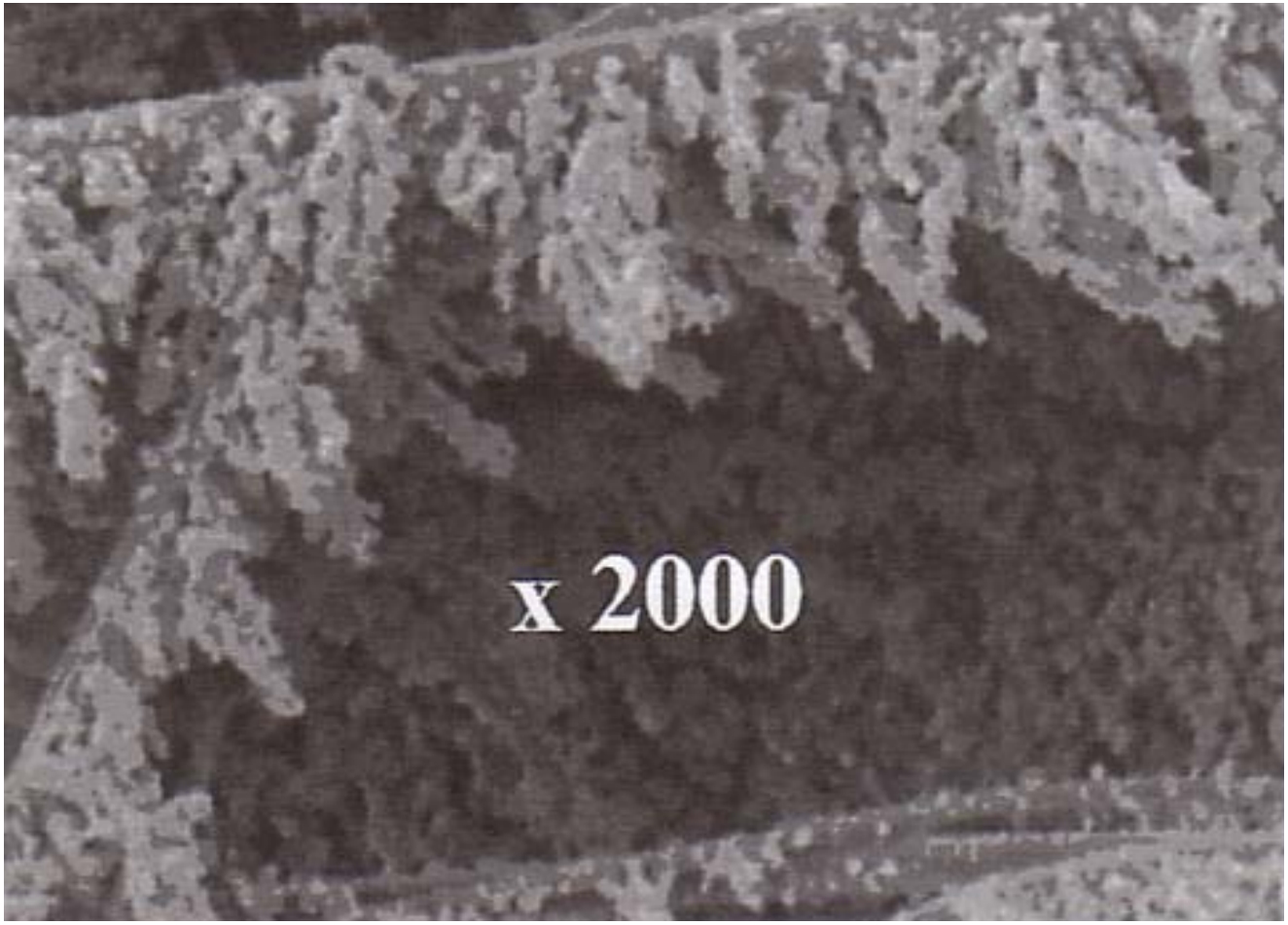


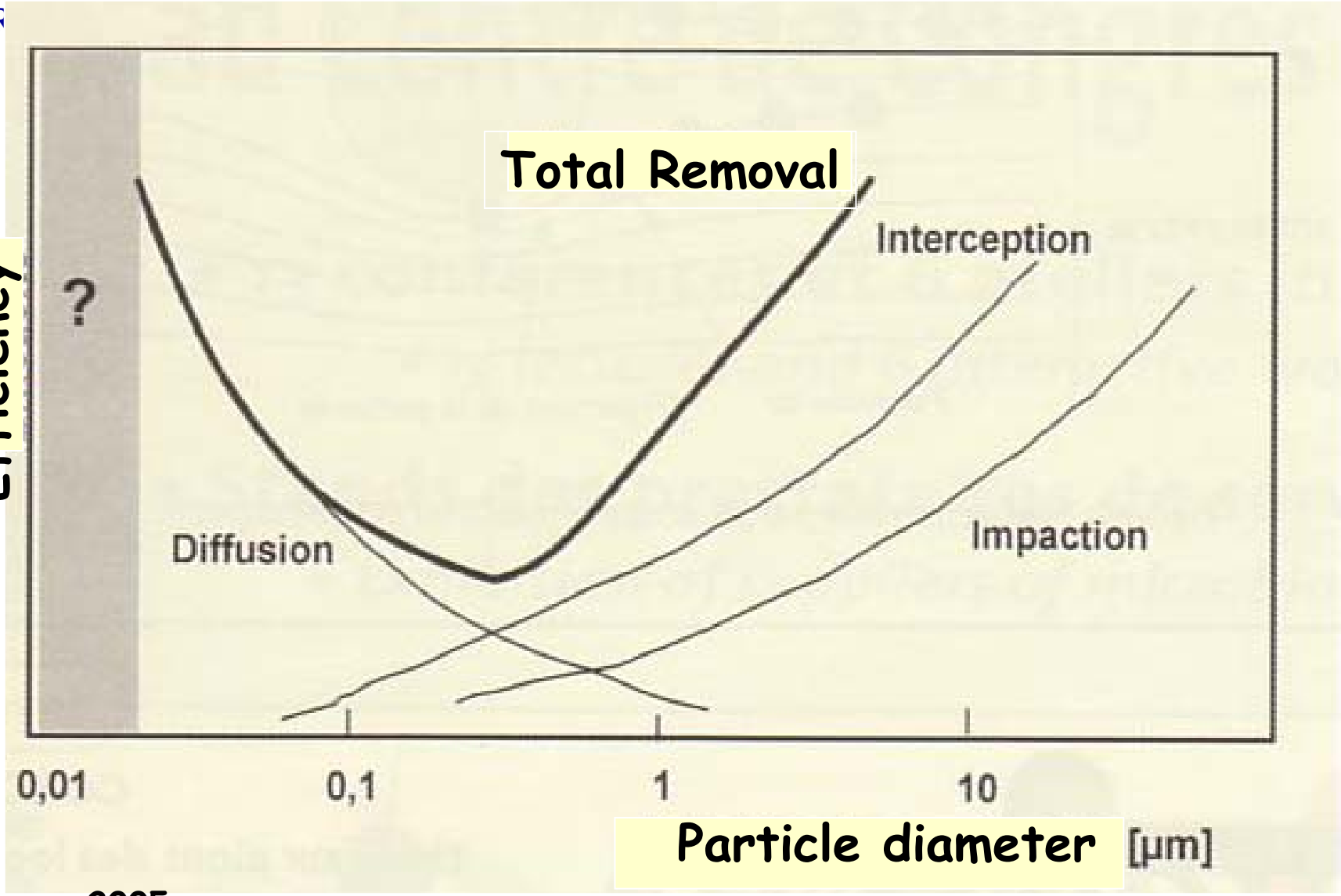
Particle aggregates on fibers
Particle diameter = 2.6 μm

D. Thomas, 2005



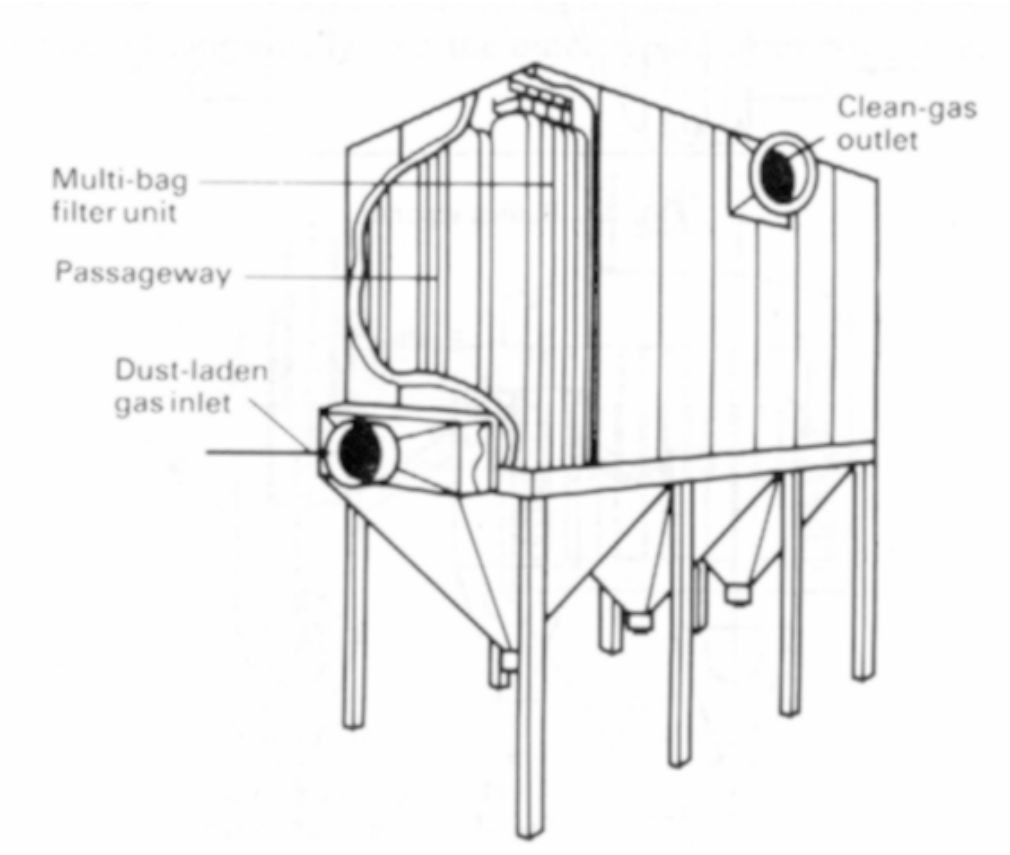
Particle dendrites
Particle diameter = 0.15 μm

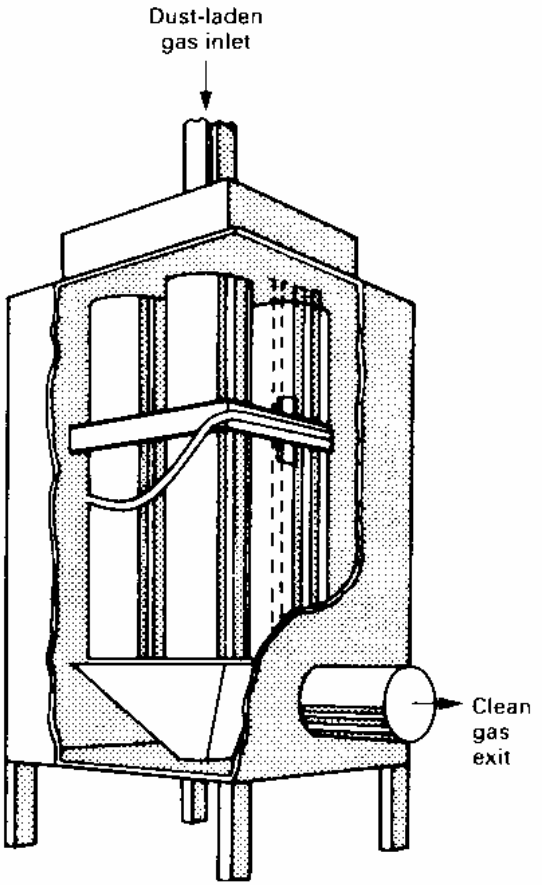
D. Thomas, 2005



D. Thomas, 2005

General view of « Bag House »

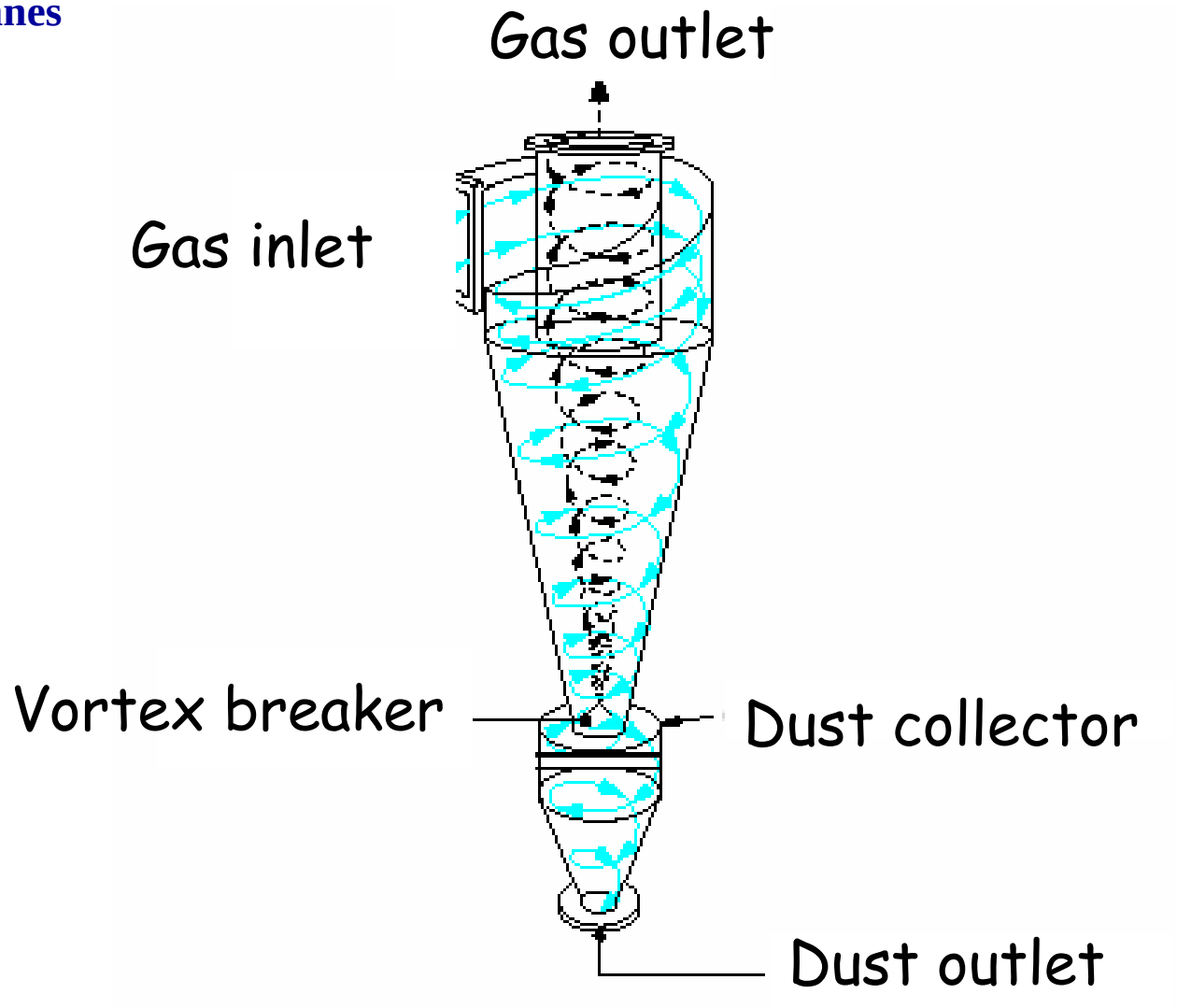




Coulson-Richardson, 1997

Industrial system example

Cyclone



Techniques de l'Ingénieur - Génie des Procédés

Flue gas treatment

Chimie de Rennes

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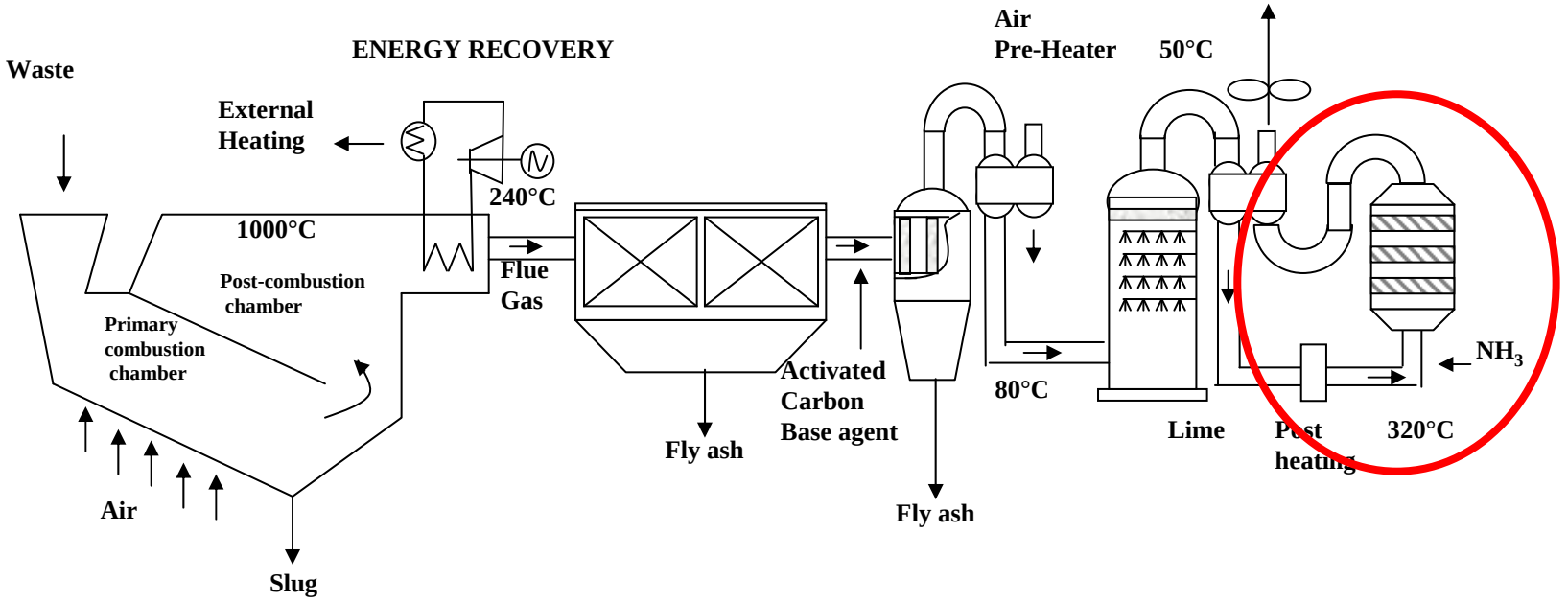
DeNox



(adapted from Fino *et al.*, 2005)

DeNox

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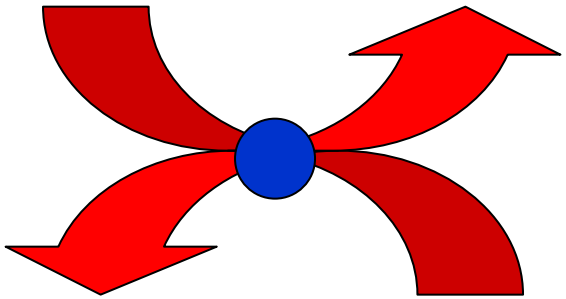
NO_2 or NO

N_2



N_2

NH_3

DeNox

$$4NO + 4NH_3 + O_2 \xrightarrow{Catalyst} 4N_2 + 6H_2O$$

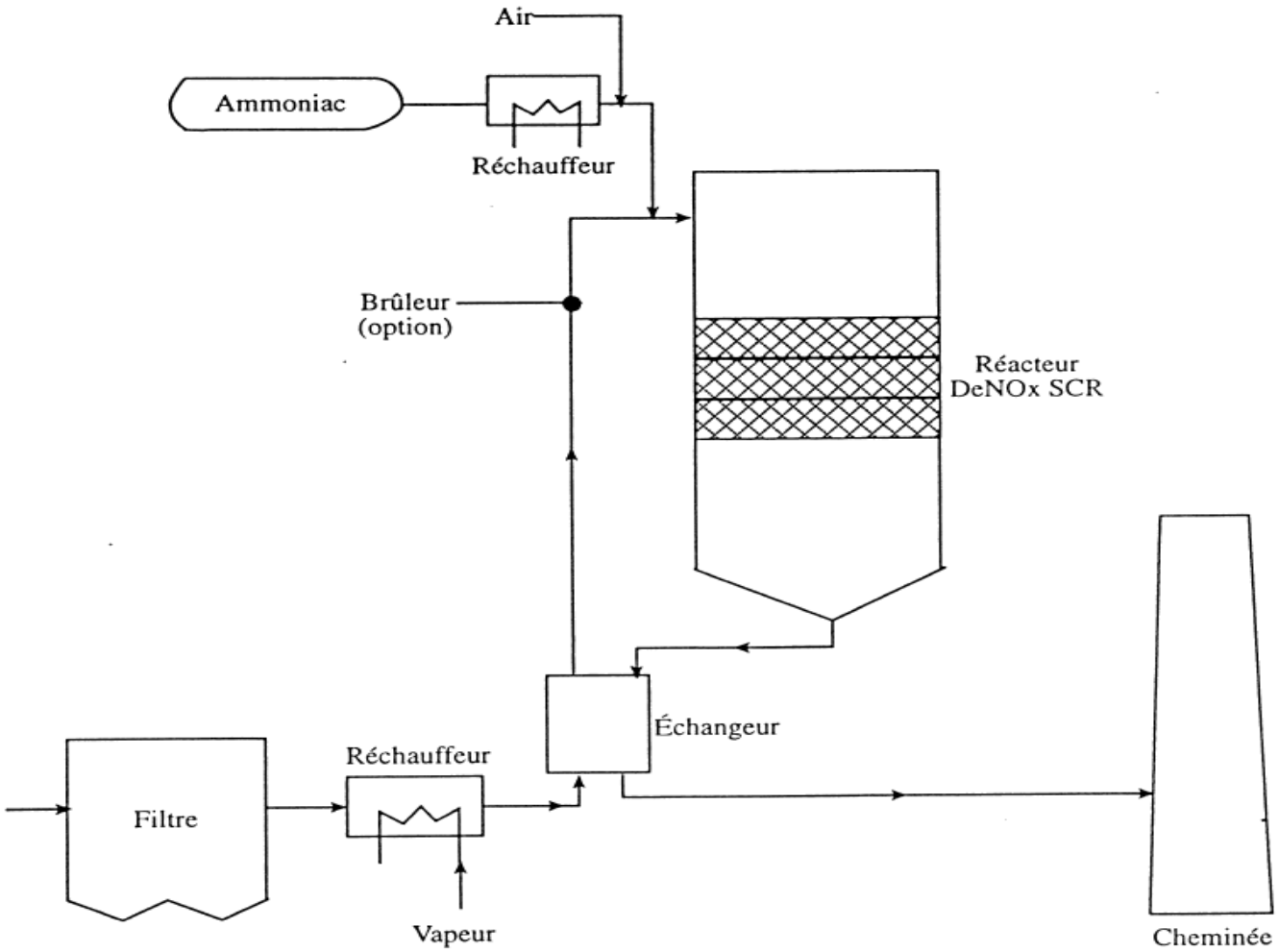
$$2NO_2 + 4NH_3 + O_2 \xrightarrow{Catalyst} 3N_2 + 6H_2O$$

DeNOx

- Inert support
  - Alumino silicate
  - Zeolites

- Metal
  - Pt
  - Pd, V, Zr...

NOx removal


Air
Ammoniac
Réchauffeur
Brûleur
(option)
Réacteur
DeNOx SCR
Échangeur
Réchauffeur
Filtre
Vapeur
Cheminée

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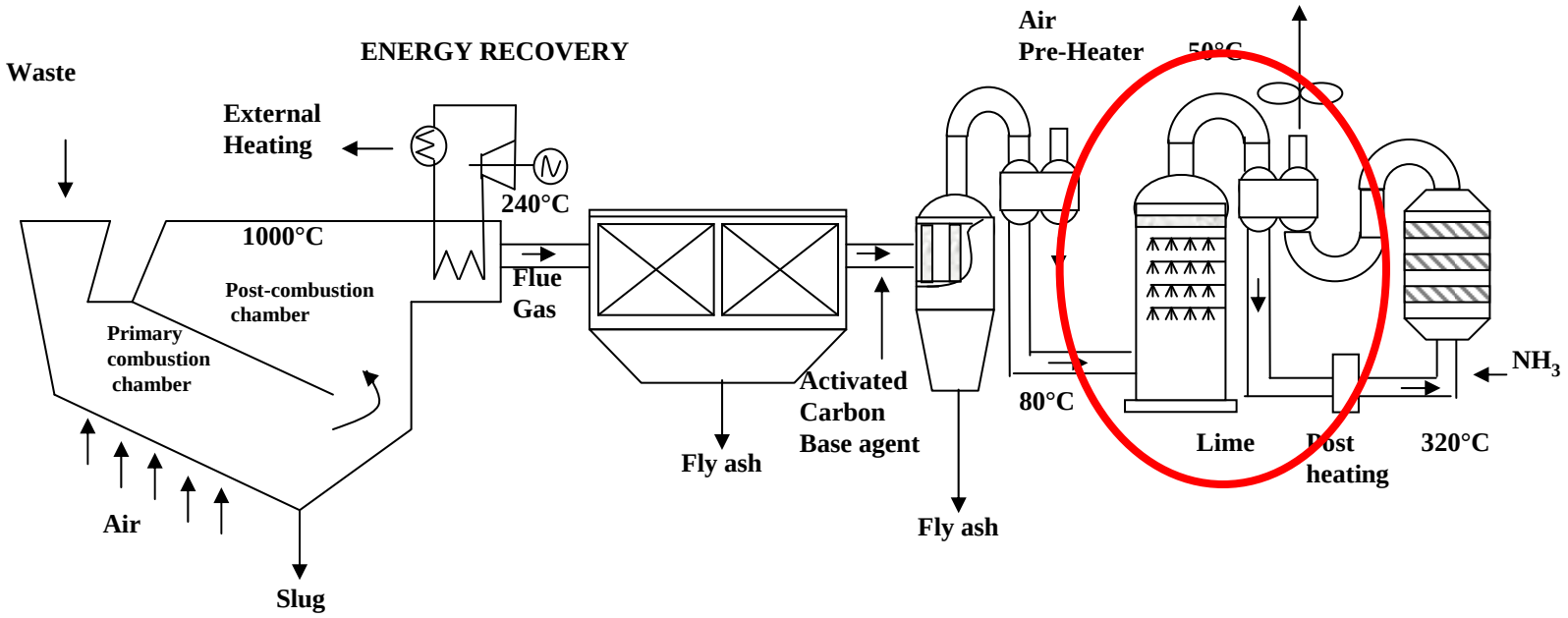
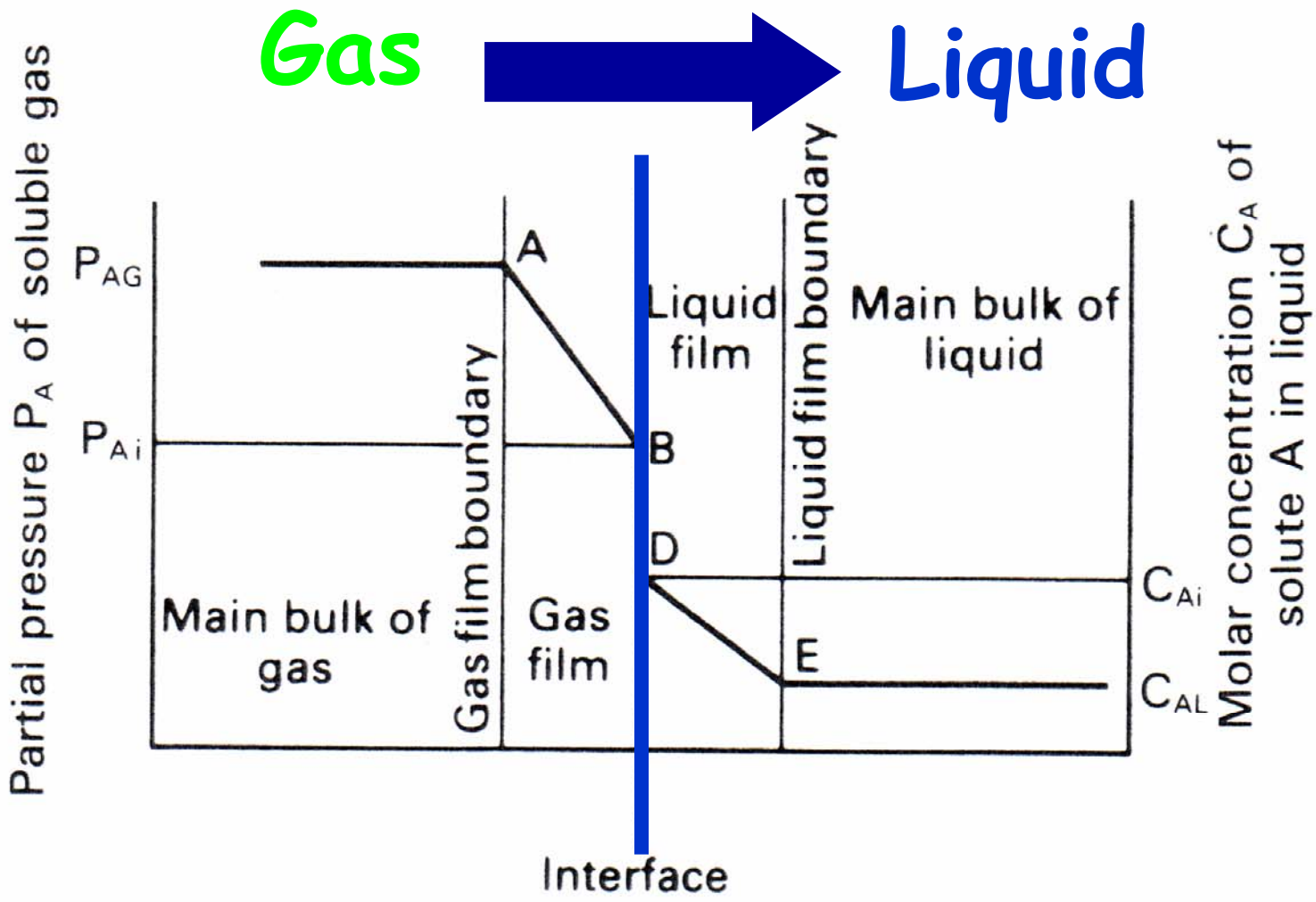


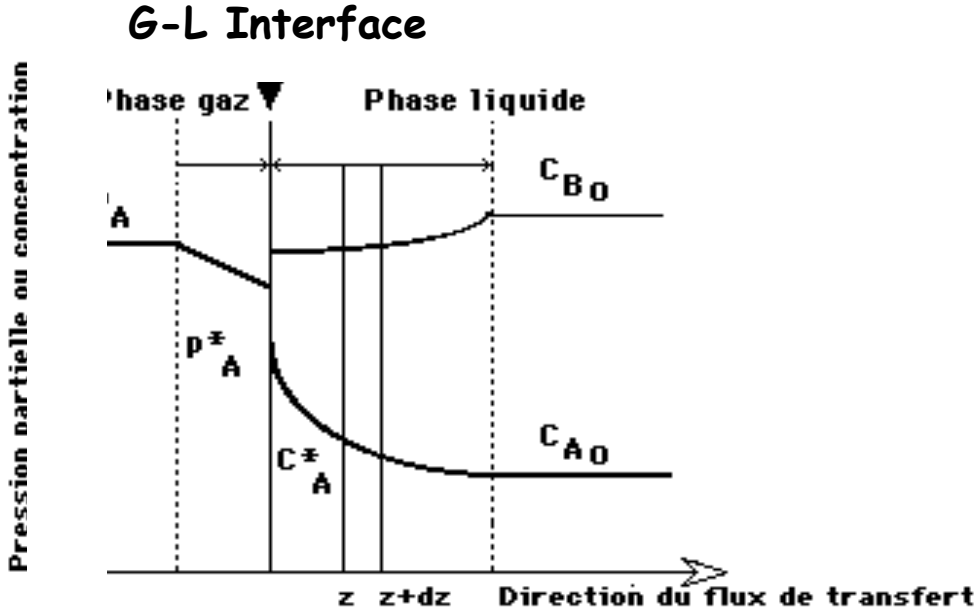
(adapted from Fino *et al.*, 2005)

Gas - Liquid transfer



Absorption with reaction

Gas → Liquid

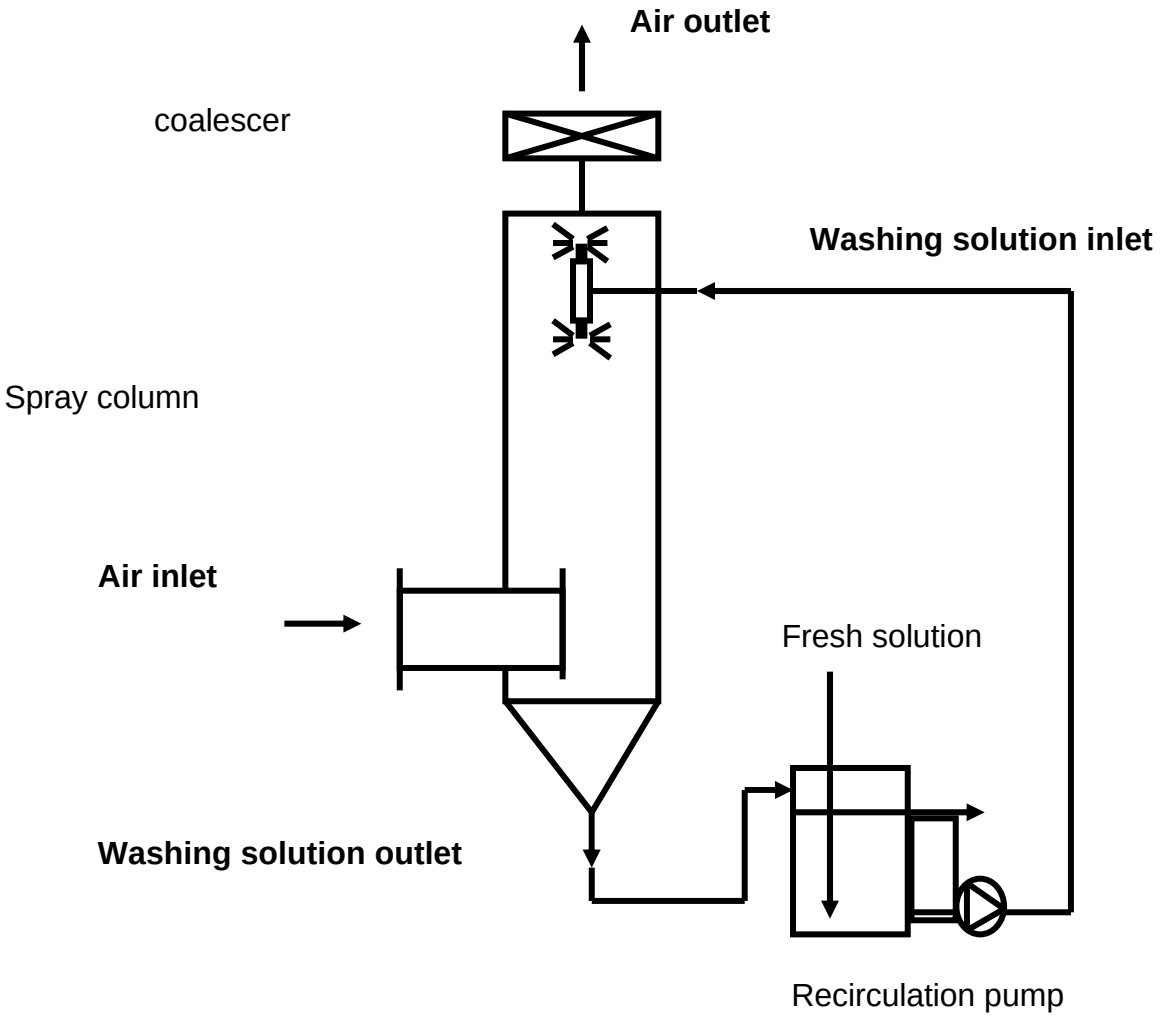


Chemical reaction

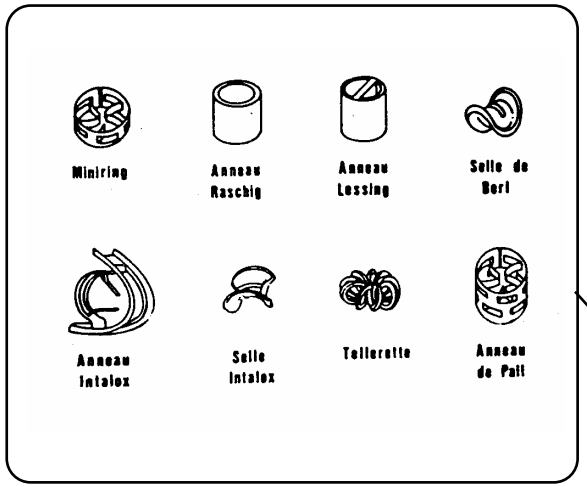
A --> B

- Spray column
- Packed column

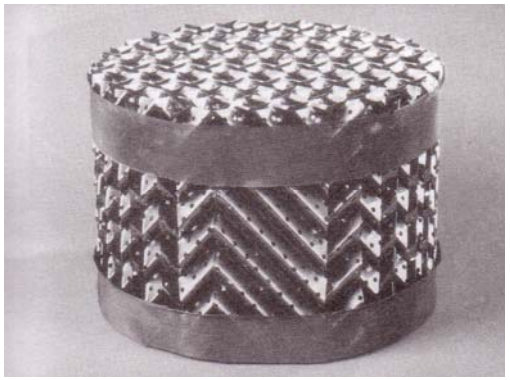
Spray Column

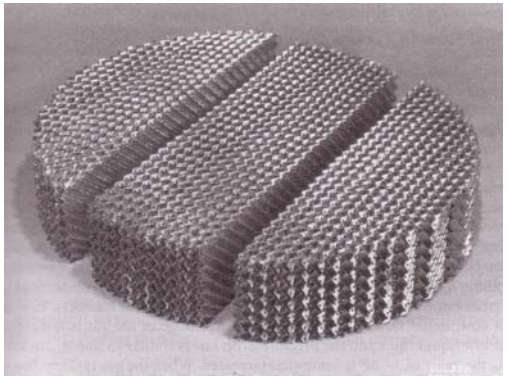


Packed column



Some packing materials





- Acid (H_2SO_4)
- Base (NaOH)
- Oxidant (NaOCl, O_3)

→ CO_2

Liquid solutions treatments

Practical industrial design

- Velocity : 500 - 1000 m/h
- Residence time : 0,1 - 10 s
- Air temperature : 10 - 80 °C
- Concentration : 1 - 50 000 mg/m^3
- Pressure drop : 0,1 - 1 m d 'H$_2$O

An Industrial Example

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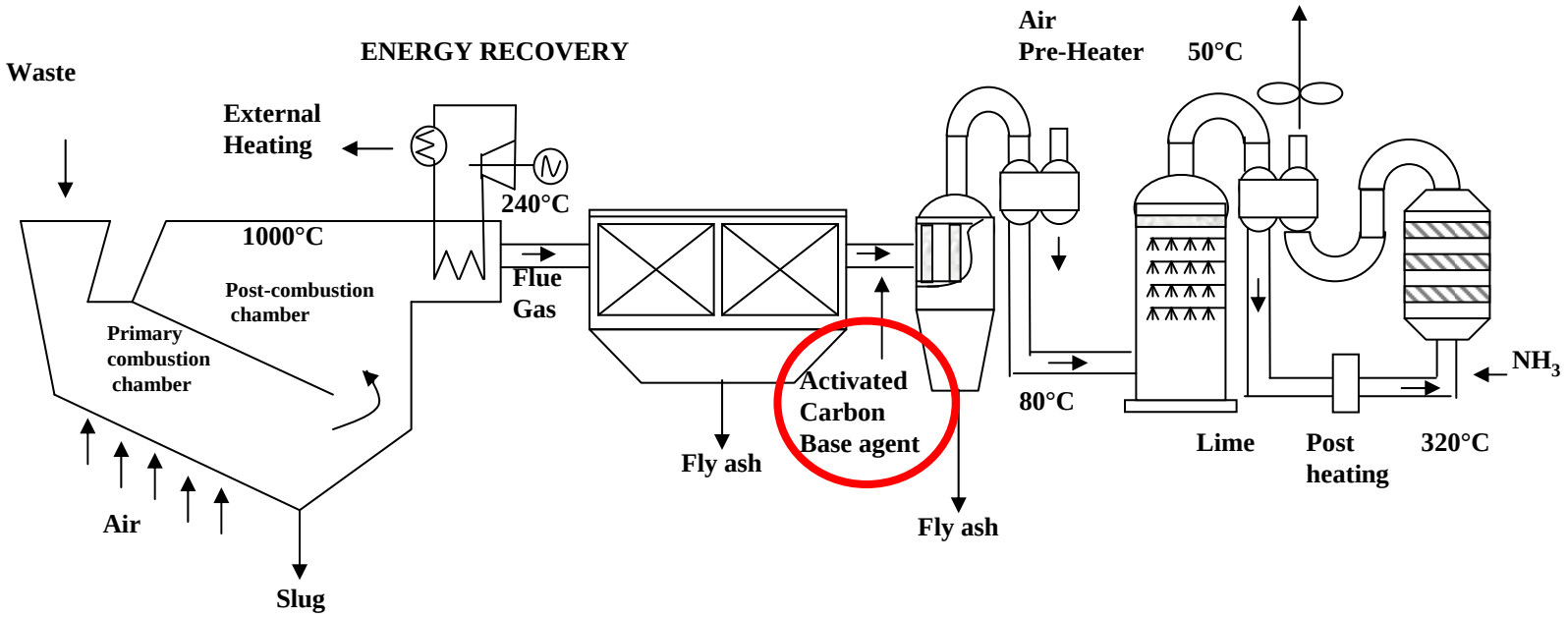
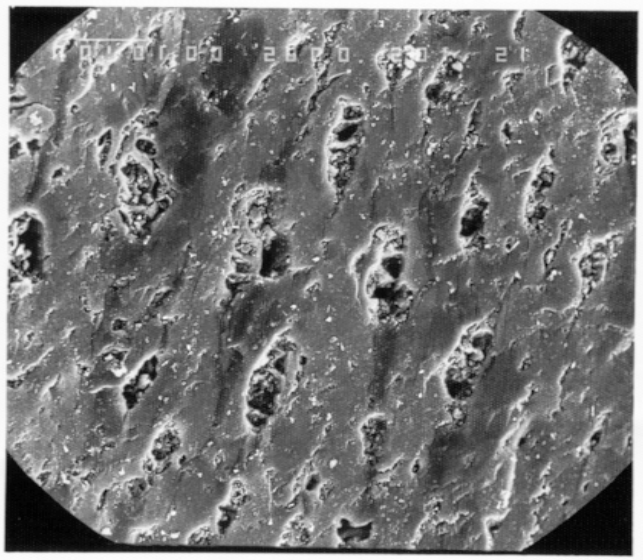
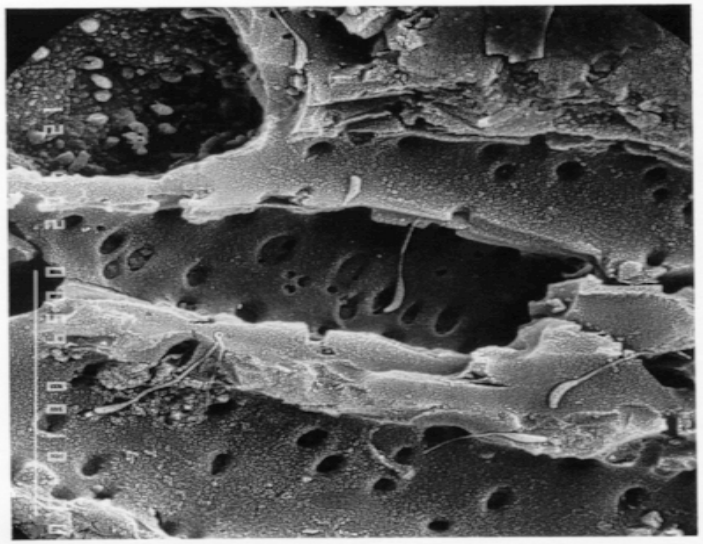


(adapted from Fino *et al.*, 2005)

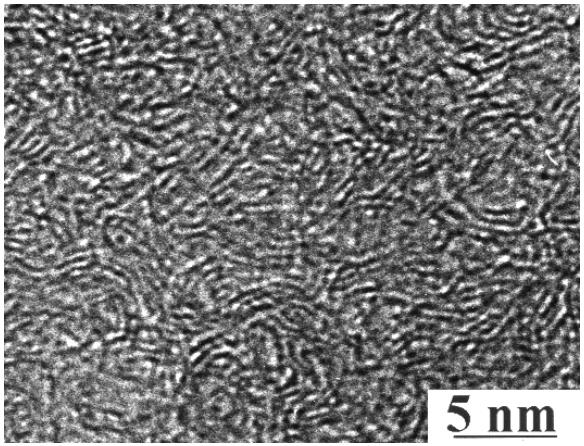
Activated carbon

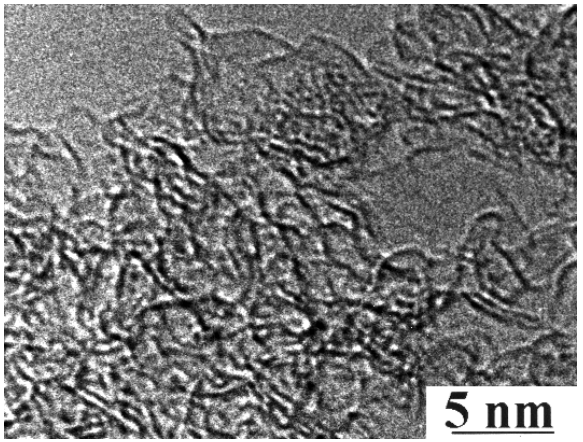




Before activation

Some strongly activated areas



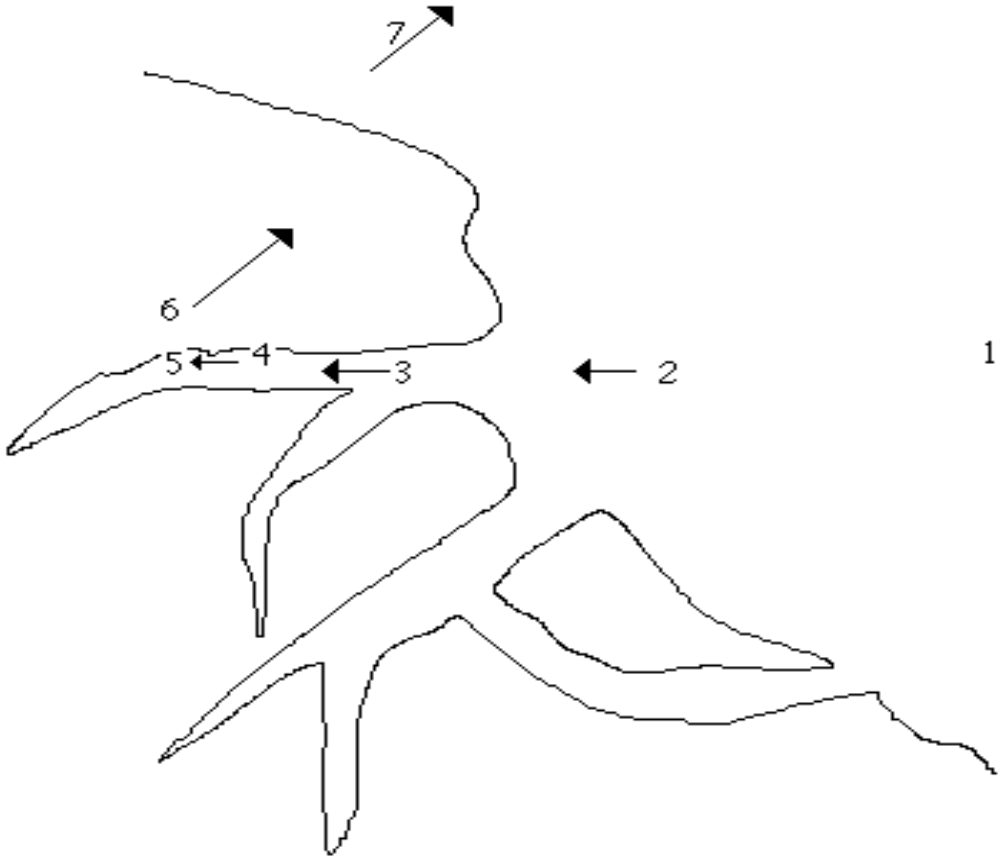


Duber et al, Fuel Proces. Technol 77-78 (2002), 221-227

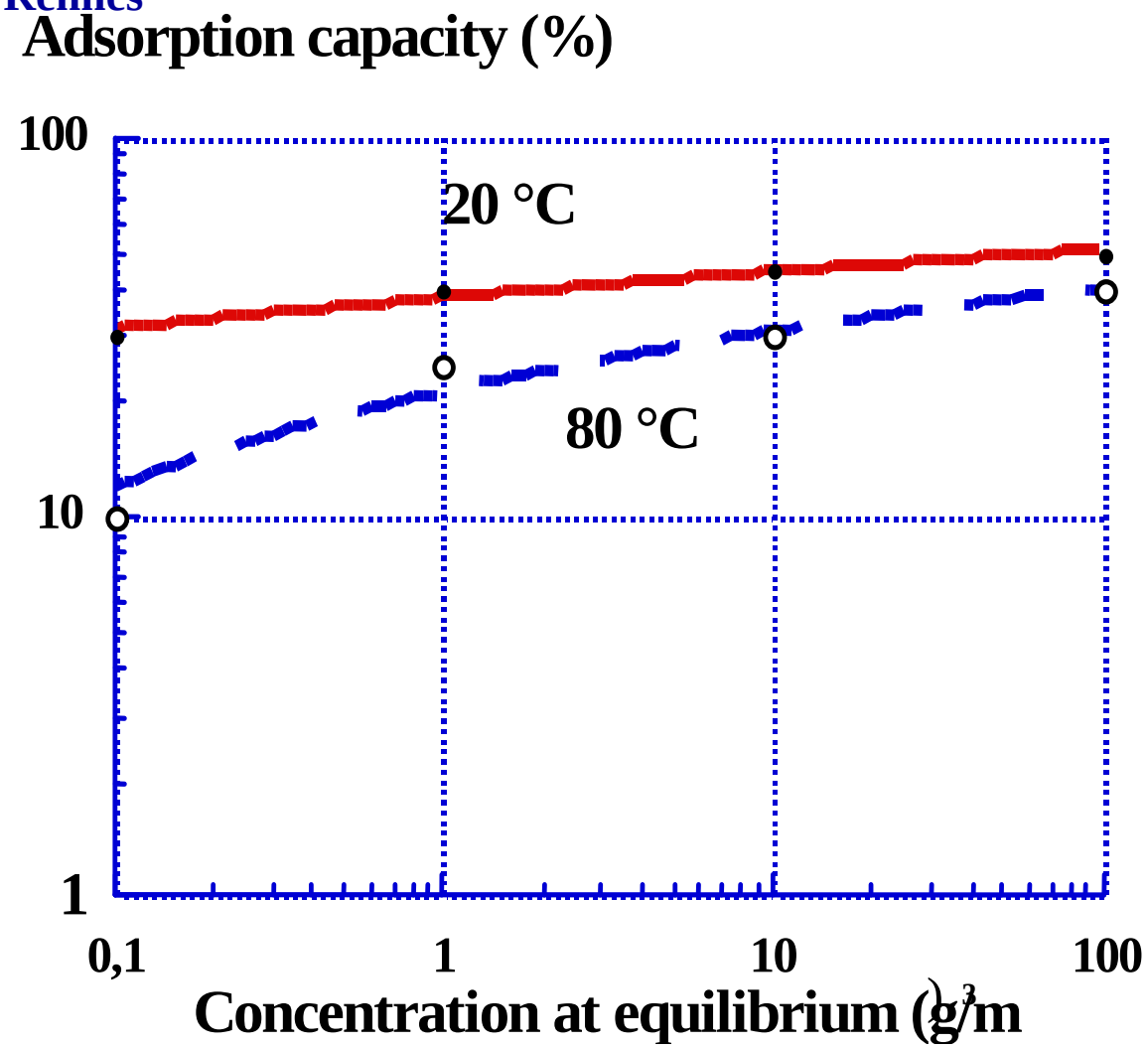
Activated carbon characteristics

Pore diameter	**nm**	**dp**	
- Macropores			**> 50**
- Mesopores			**2 < d < 50**
- Micropores			**< 2**
Porous volume	**cm^3/g**	**Vp**	**0.3 – 0.7**
Specific surface area (BET)	**m^2/g**	**S_{BET}**	
- non activated			**2 - 20**
- activated			**500 - 2000**

Principle of adsorption



Adsorption capacity



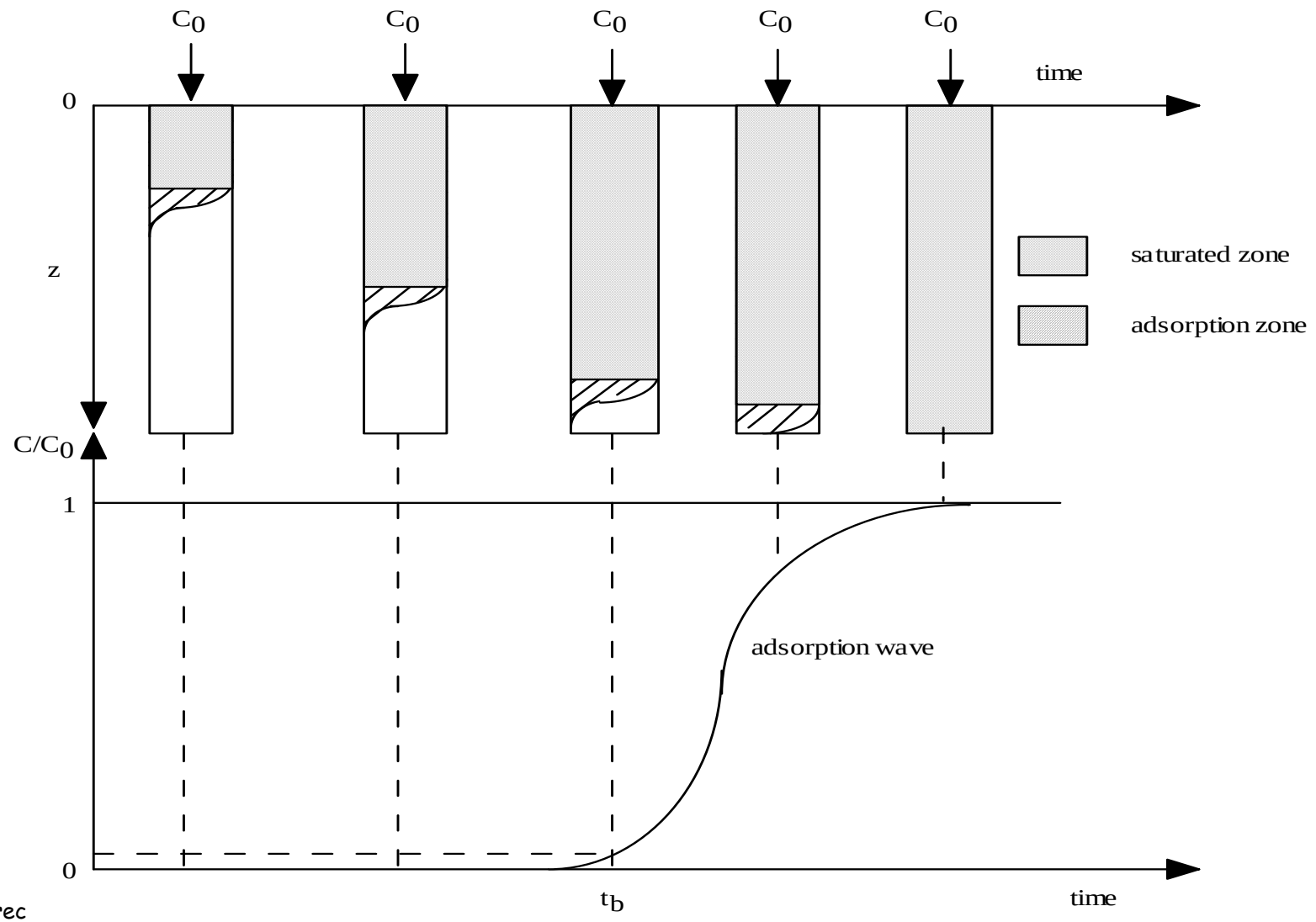
$$q_e = KC_e^{1/n}$$

$$q_e = \frac{bq_m C_e}{1 + bC_e}$$

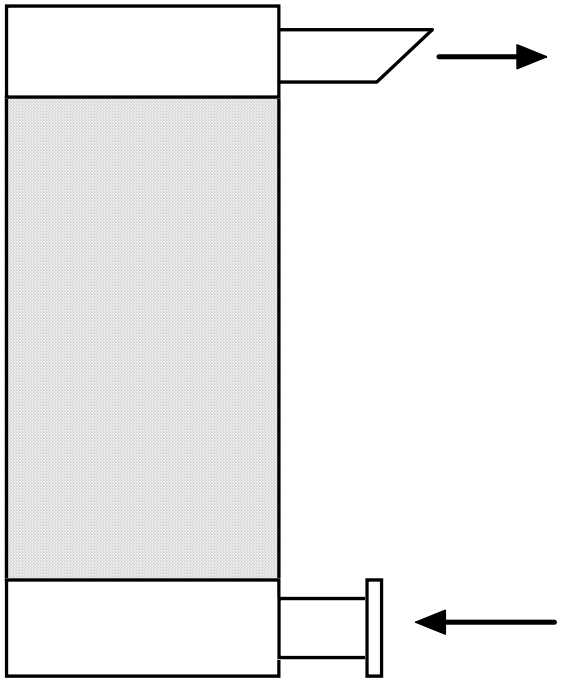
$$q_e = \frac{bq_m C_e^{1/n}}{1 + bC_e^{1/n}}$$

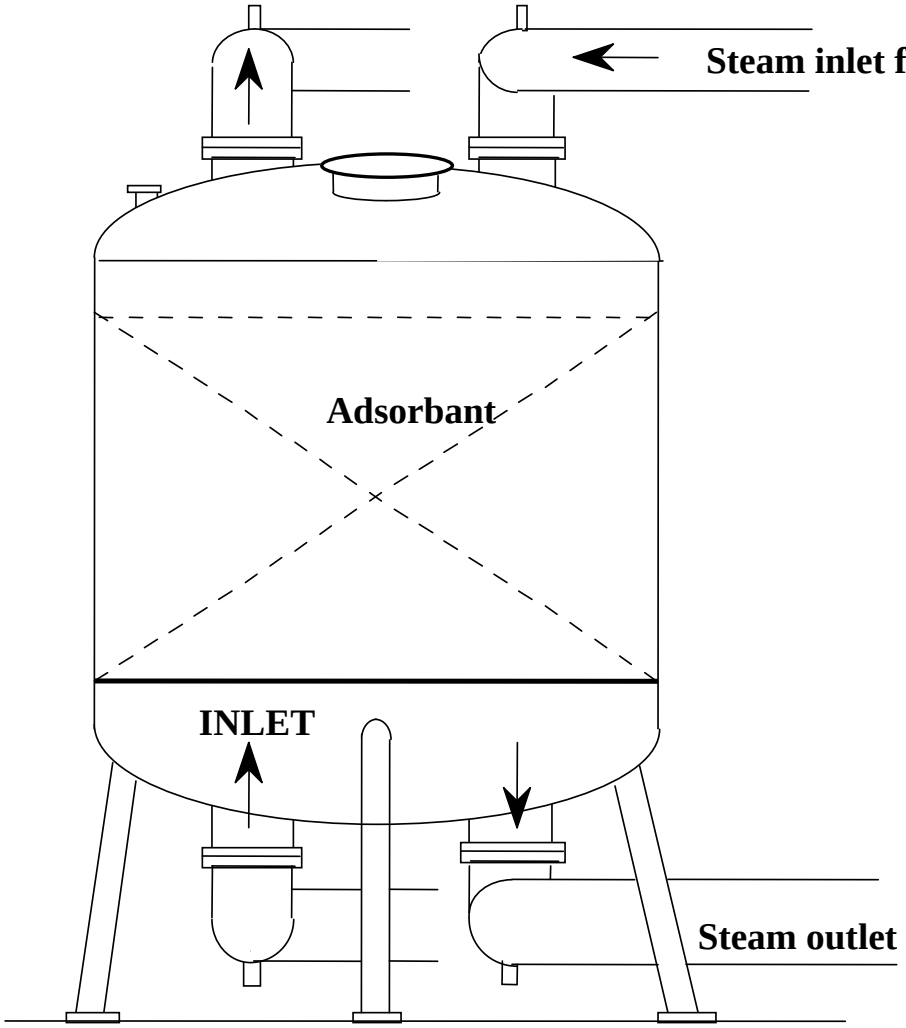
$$q_e = f(C_e)$$

Breakthrough curve



Activated carbon grain filter





Modelling

$$t_b = \frac{N_0}{C_0 U_0}\left(z - z_0\right)$$

$$C(t) = \left[\frac{C_0^{n-1}}{1 + Ae^{-rt}}\right]^{1/n-1}$$

Modeling breakthrough curves
Homogeneous surface diffusion model

Purpose	Equation
Solid phase mass balance	$\frac{\partial q}{\partial t} = \frac{D_s}{r^2}\frac{\partial}{\partial r}\left[r^2\frac{\partial q}{\partial r}\right]$
Initial condition	$q = 0 \quad (0 \geq r \geq R, t = 0)$
Boundary conditions	$\frac{\partial q}{\partial t} = 0 \quad (r = 0, t \geq 0)$
	$\frac{\partial q}{\partial t} = \frac{k_f}{\rho_a D_s \varphi} C(t) - C_s(t) \quad (r = R, t)$
Liquid phase mass balance	$V\frac{\partial C}{\partial z} = \frac{\partial C}{\partial t} + \frac{3k_f(1-\varepsilon)}{R\varphi\varepsilon}(C - C_s)$
Initial condition	$C = 0 \quad (0 \geq z \geq H, t < \tau)$
Boundary condition	$C = C_0(t) \quad (z = 0, t \geq 0)$
Freundlich isotherm equation	$q = K[C_S(t)]^{1/n} \quad (r = R, t)$

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