Fast Analytical Chromatography and the Role of the Design of New Stationary Phases

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Fast chromatography: Monolith vs sub-2 μm particles

- 4.6 mm I.D. Monolithic rod at 300 bar
- 1.7 μm fully porous particles at 1000 bar

\[ \eta = 0.72 \text{ cP} \]

- L = 17.7 cm
- L = 56.1 cm
- L = 79.0 cm
- L = 24.7 cm
- L = 2.5 cm
- L = 7.8 cm

- \( t_0 = 1000 \text{ s} \)
- \( t_0 = 100 \text{ s} \)
- \( t_0 = 1 \text{ s} \)
- \( t_0 = 10 \text{ s} \)
Sub-2 μm particles: limitation

Frictional heating $P_f$

$$P_f = u_s \frac{\Delta P}{L} \pi R^2 < 5 \text{ W/m}$$

Temperature profile

Chromatograms
Impact of the thermal environment

Bath immersion

\( T_{\text{wall}} = \text{Cte} \)

Radial temperature gradients

VS.

Stagnant air-oven

\( Q_{\text{wall}} = 0 \)

Axial temperature gradients

Reduced HETPs

- ★ Bath Immersion
- ● Stagnant still-air condition

Efficiency loss

Reduced velocity \( \nu \)
Fast chromatography: sub-3 µm shell particles

\[ \eta = 0.72 \text{ cP} \]

- 4.6 mm I.D. monolith rod at 300 bar
- 1.7 µm fully porous particles at 1000 bar
- 2.7 µm shell particles at 400 bar
Sub-2 $\mu$m shell vs. Fully porous particles

1.7 $\mu$m fully porous particles
- $\lambda=0.30$ W/m/K
- Smaller radial temperature gradients

1.7 $\mu$m shell particles
- $\lambda=0.53$ W/m/K
- Higher peak capacity (Gradient Elution)
Importance of LC systems

Column

50 x 2.1 mm, shell particles, \( H=3.9 \ \mu \text{m} \), \( V_0=90 \ \mu \text{L} \), \( k=1 \)

\[ \sigma_{v,\text{column}}^2 = 2.5 \ \mu \text{L}^2 \]

HPLC systems

\[ \sigma_{v,\text{ideal}}^2 = 0 \ \mu \text{L}^2 \]

\[ \sigma_{v,y\text{HPLC}}^2 \approx 6 \ \mu \text{L}^2 \]

\[ \sigma_{v,\text{HPLC}}^2 \approx 40 \ \mu \text{L}^2 \]

Apparent efficiencies

\[ N_{v,\text{ideal}} = 12820 \ (100 \%) \]

\[ N_{v,y\text{HPLC}} = 3770 \ (-70 \%) \]

\[ N_{v,\text{HPLC}} = 754 \ (-94 \%) \]