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What is a k’ and what does it tell you?

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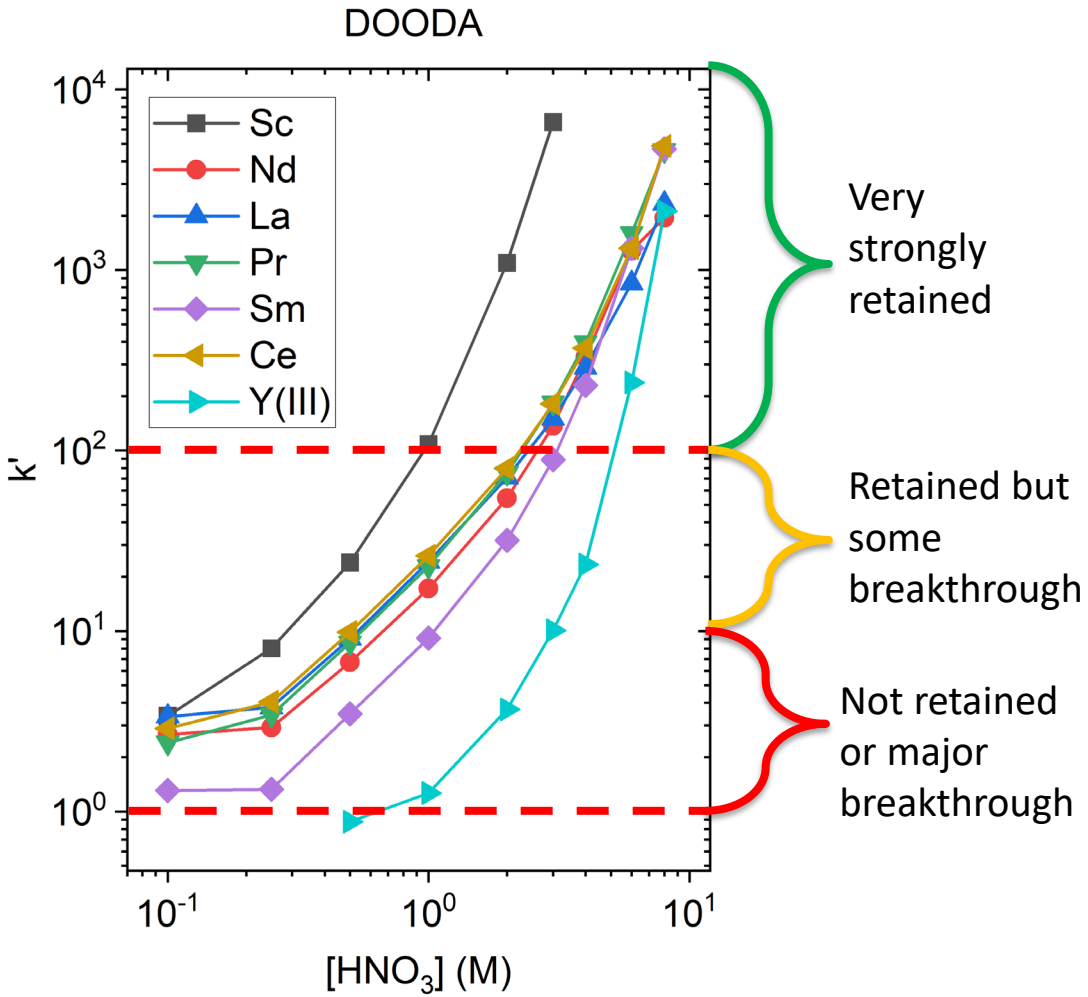
What is a k'?



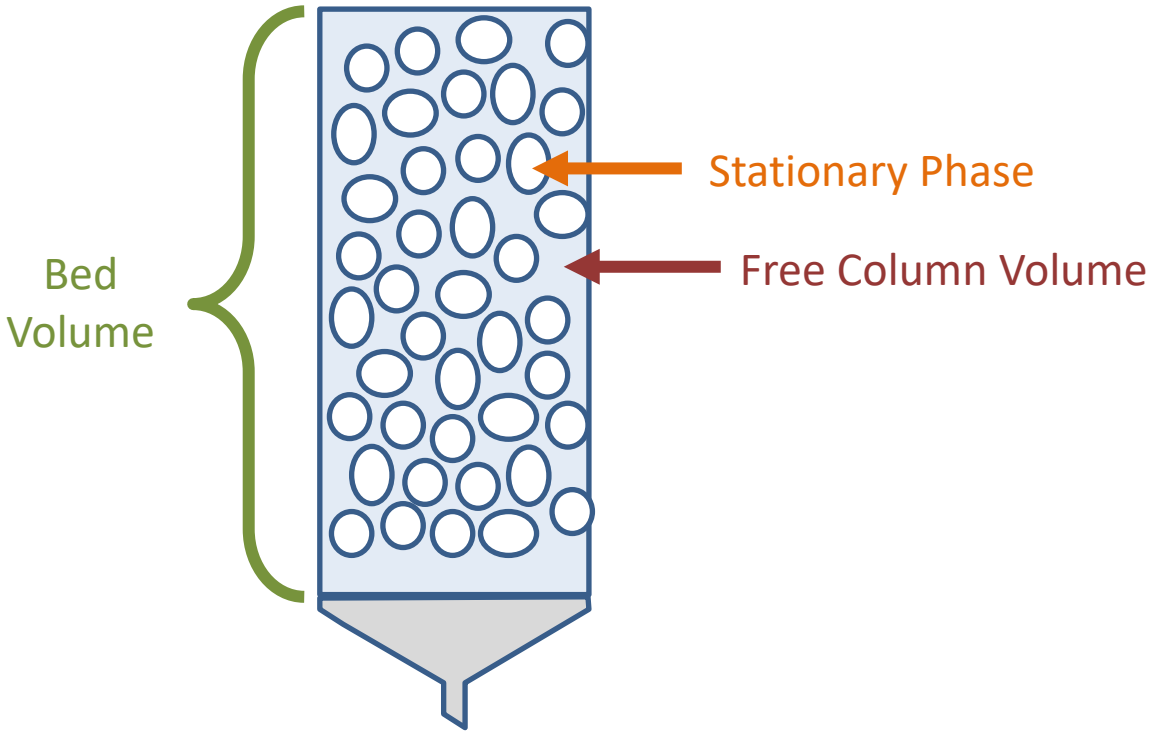
- **k' is a distribution ratio**
- It describes the *distribution* of a metal ion between two immiscible phases at equilibrium
  - It provides insight into where the metal is going to go in a system
  - It is unique for each metal + resin + solution combination
- In batch contact experiments
  - It tells you how much metal is extracted
- In column elution experiments (EXC)
  - It tells you when the metal will be eluted
- It can be reported in many ways

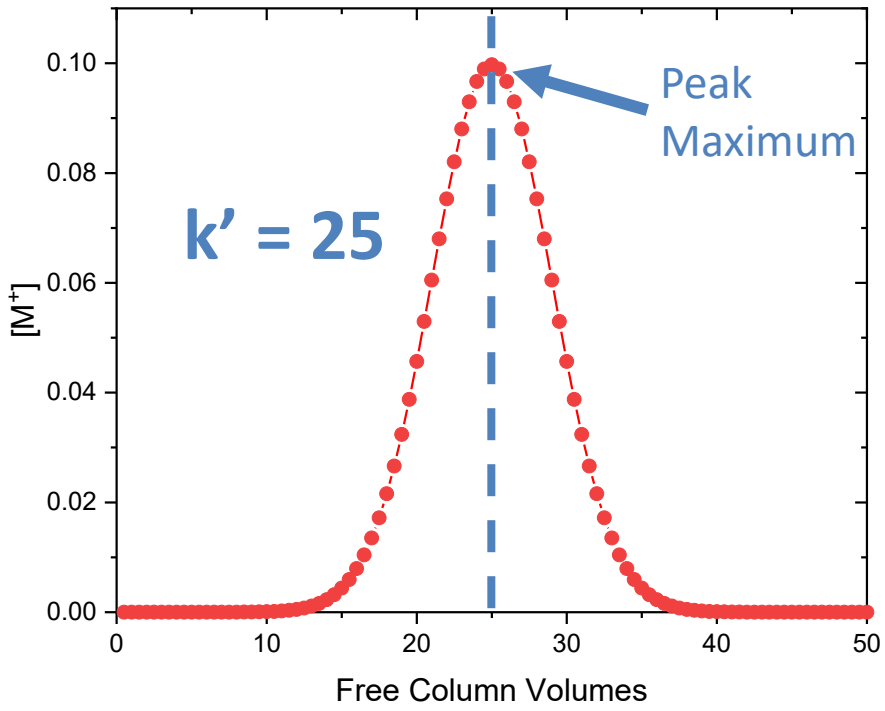
A measurement with an identity crisis

So… what is a k'?

k' defines the number of free column volumes to reach the peak maximum

But… what does this actually mean?





So… what is a k'?

k' defines the number of free column volumes to reach the peak maximum

But… how else can we define it?

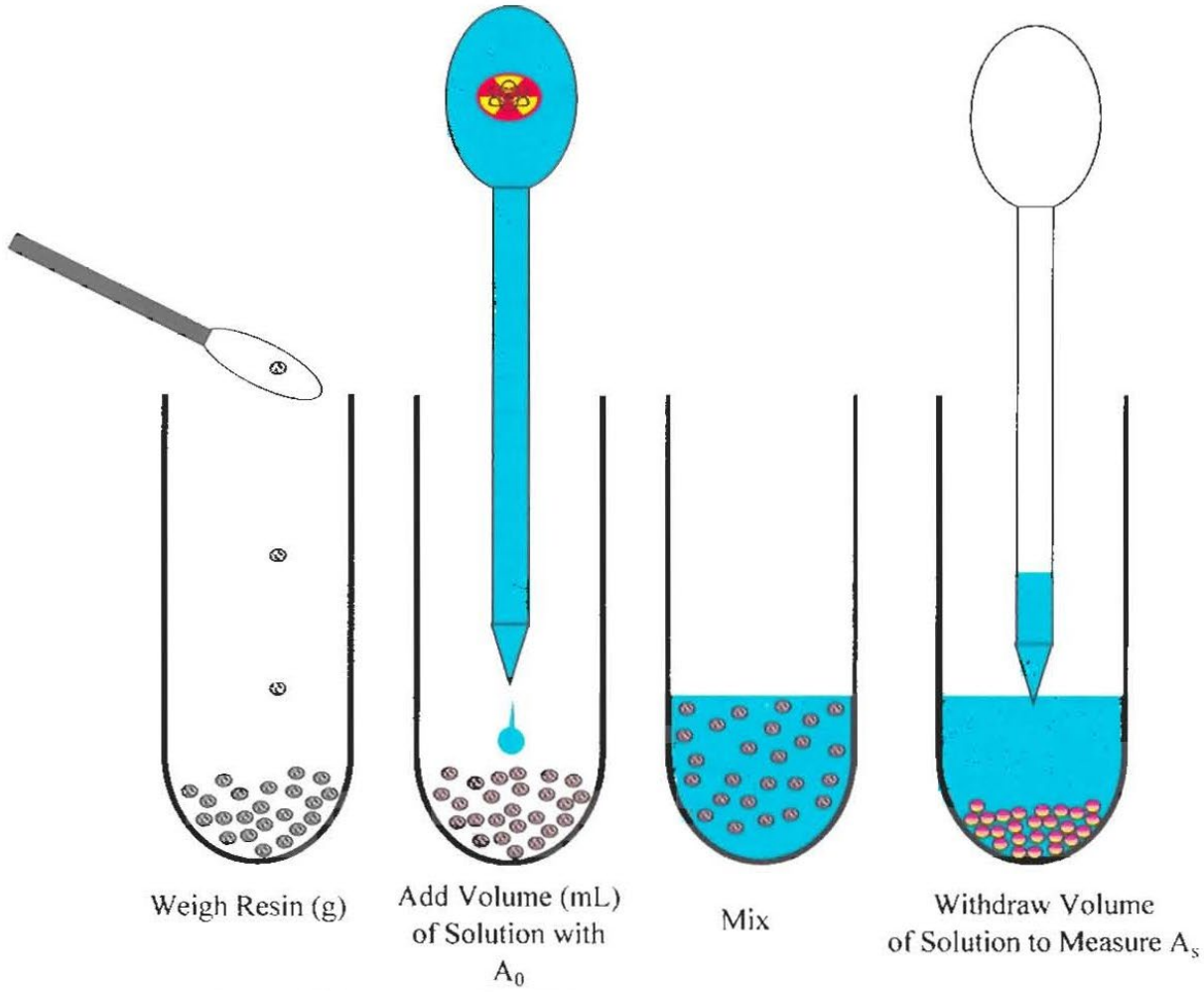
D_w = *mL* solution needed per *g* resin to reach peak max

D_v = *mL* solution needed per *mL* resin to reach peak max

k_d = mol metal per mL resin vs mol metal per mL solution

Measuring a D_w

- Directly measured as D_w
  - Dry weight distribution ratio
- A known mass (g) of resin and a known volume (mL) of solution are contacted
- Measure A_0 vs A_s
- Dw describes the *mL solution per g resin* required reach maximum metal elution



$$D_w = \frac{A_0 - A_s}{w(g)} \Big/ \frac{A_s}{v(mL)}$$

Converting a Dw to a k'

$$D_w = \frac{A_0 - A_s \Big/ Weight\ of\ Resin\ (g)}{A_s \Big/ Volume\ of\ Solution\ (mL)}$$

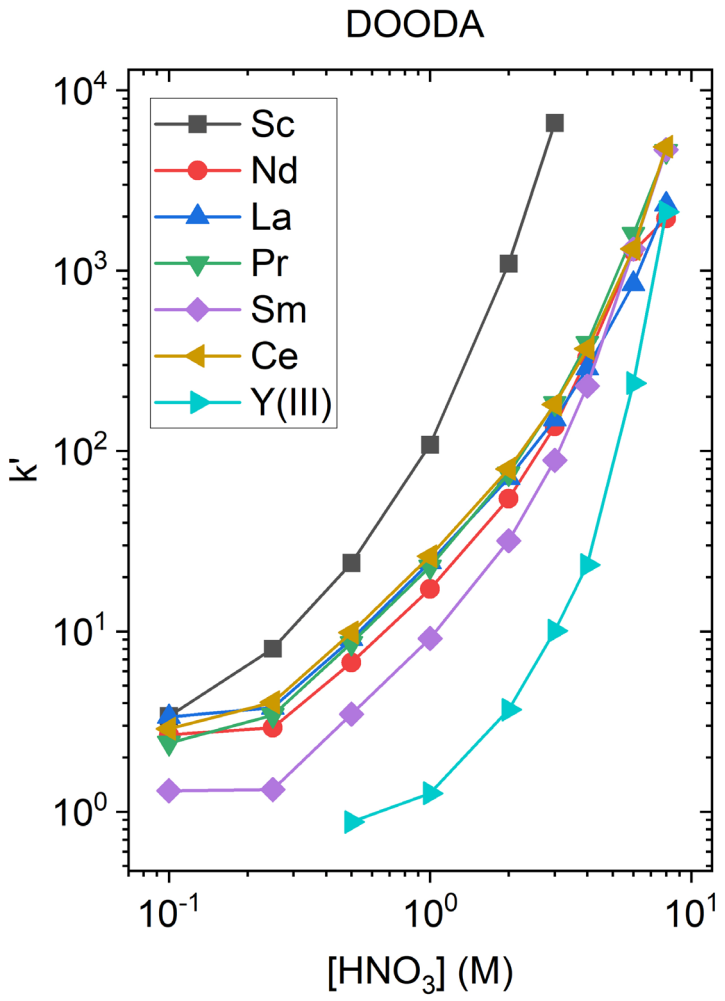
$$D_v = D_w \times \frac{\rho_{extr}}{\%wt_{extr}}$$

$$k' = D_v \times \frac{v_s}{v_m}$$

$$Usually \ldots\ k' \approx 0.5 \times D_w$$

- Variables
  - A_0 = initial [M]
  - A_s = equilibrium [M]
  - ρ_{extr} = extractant density
    - Usually around 1 g/mL
  - $\%wt_{extr}$ = relative % weight extractant on resin
    - Usually 40%
  - v_s = volume of stationary phase
  - v_m = volume of mobile phase
    - Usually $v_s/v_m = 0.2$

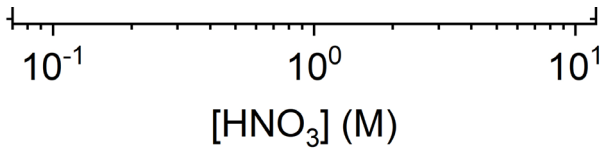
Measuring a k' by batch contact

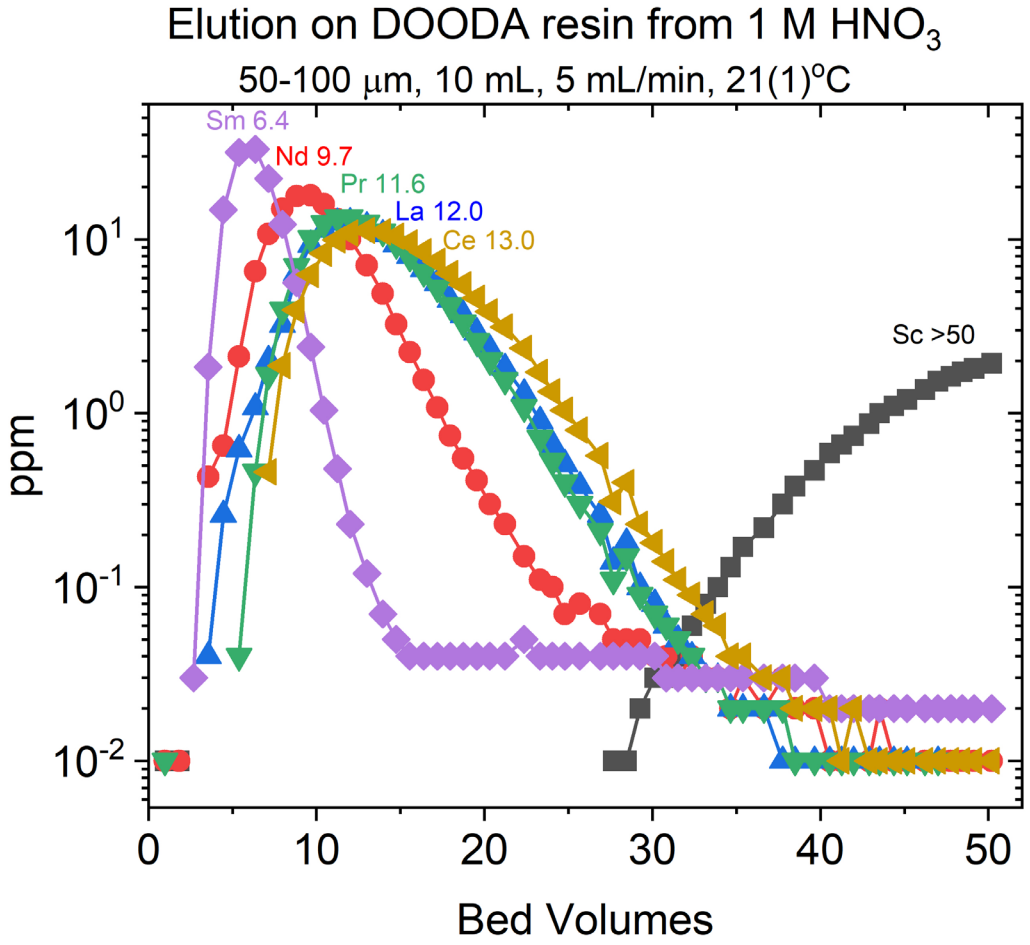


- Fast and convenient
- Can generate the entire graph in nine measurements
- Combine metals of interest
  - Ensure detection will not be compromised (interfering lines on AES)
- Ideal for probing new systems
- Requires minimal resin
- Generates minimal waste

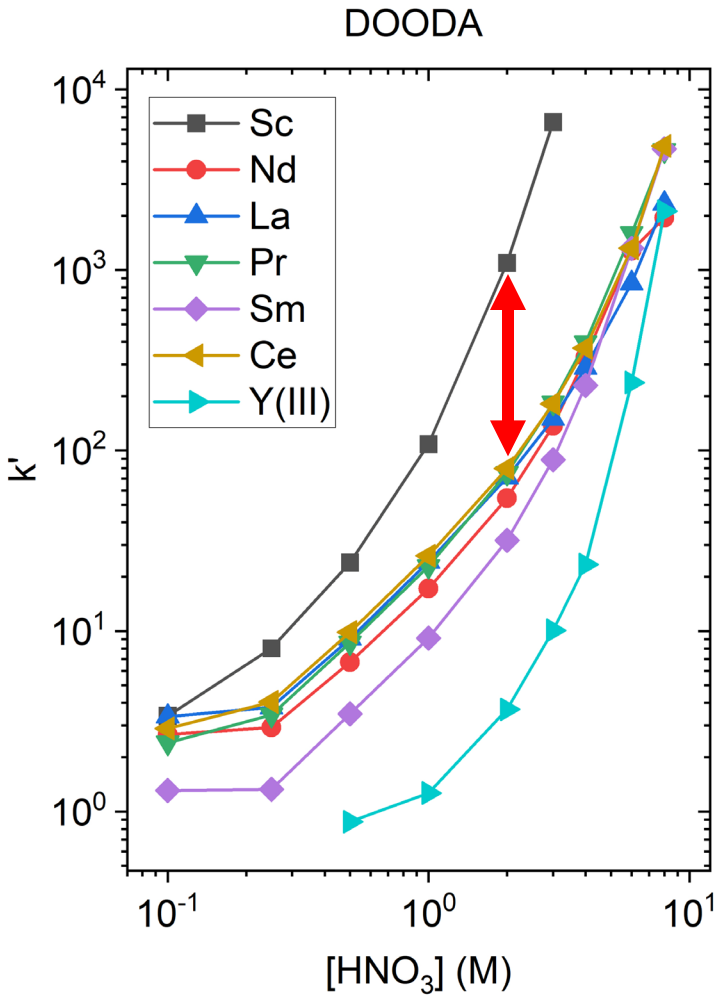
Measuring a k' by column elution

- Uses more time, resin, solution, etc
- Only good form measuring $1 < k' < 50$
- Arguably more accurate measurement
  - Measuring the peak max directly
- Good for measuring small **separation factors** (SF)
- Easy way to validate batch uptake





Separation Factor (SF)



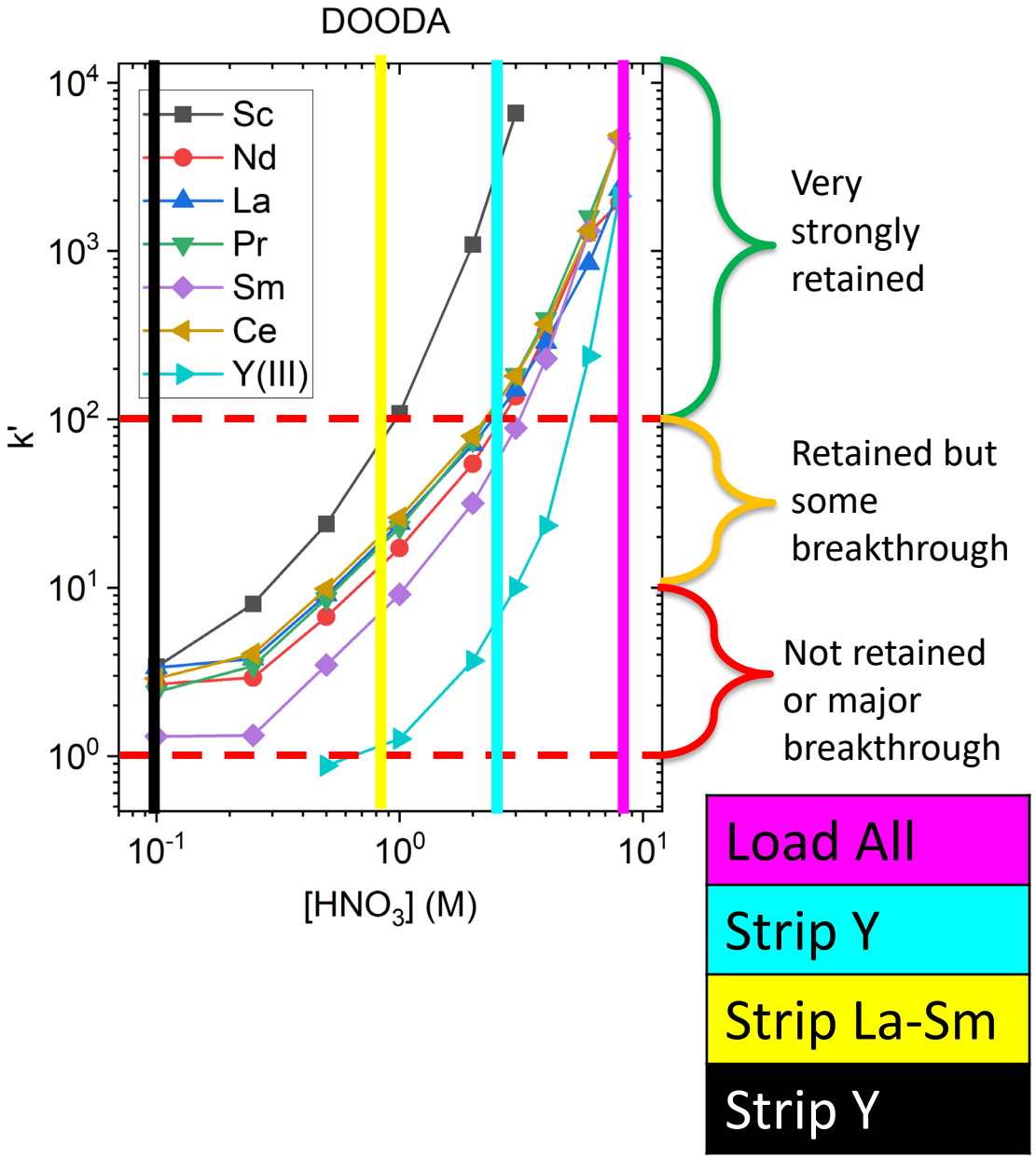
- A separation factor describes the magnitude of separation between two metals

$$SF_{AB} = {k'_A}/{k'_B} = {D_{w,A}}/{D_{w,B}}$$

- The larger the SF, the better the separation.
- But! SF alone can be misleading…

For SF = 20		
k'_A	k'_B	
100	2000	A and B retained
1	20	A and B eluted
10	200	A eluted, B retained

Planning separations



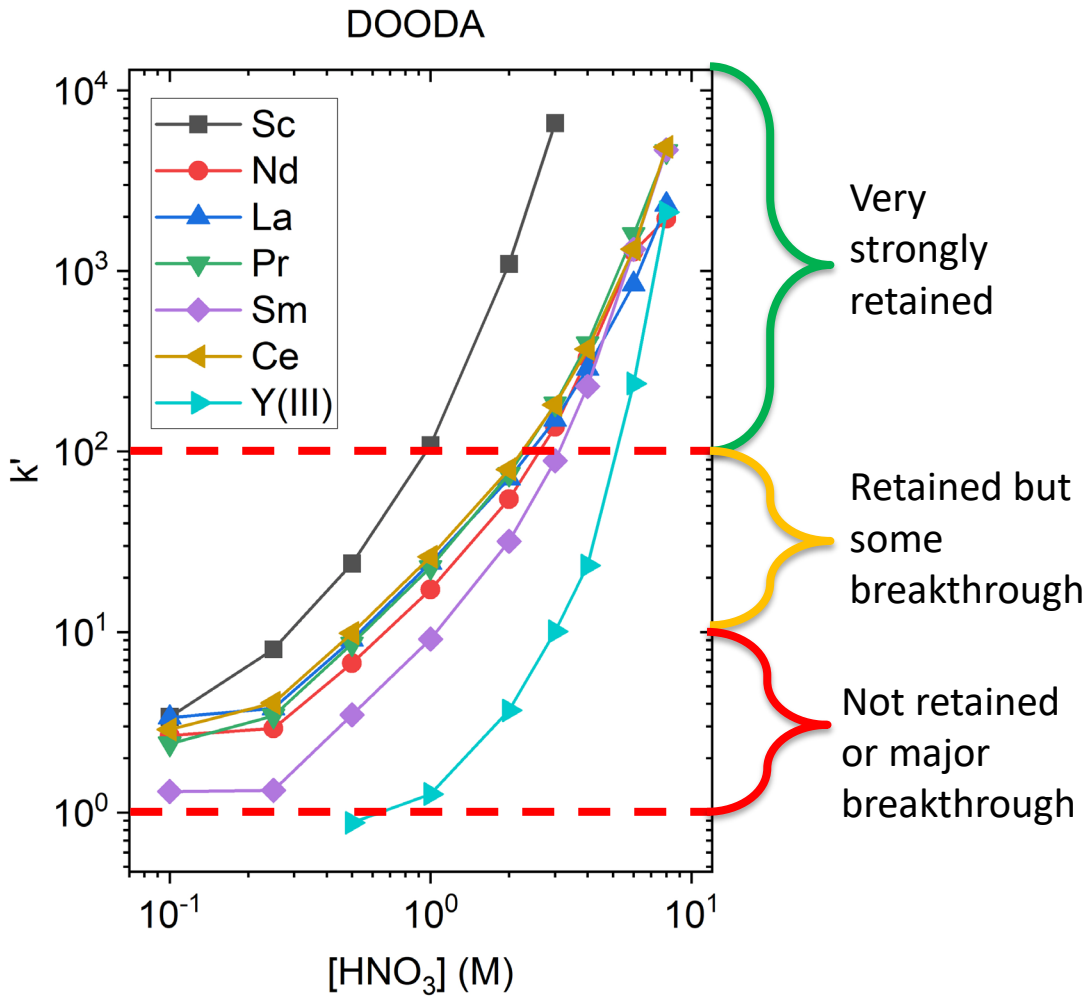
- Use k' vs [acid] curve to identify ideal elution conditions
- Use separation factors to predict quality of decontamination

- For load ensure k' metal > 100
- For strip ensure k' metal < 1
- For contaminants with k' = 1-100 additional rinsing will be required

Summary

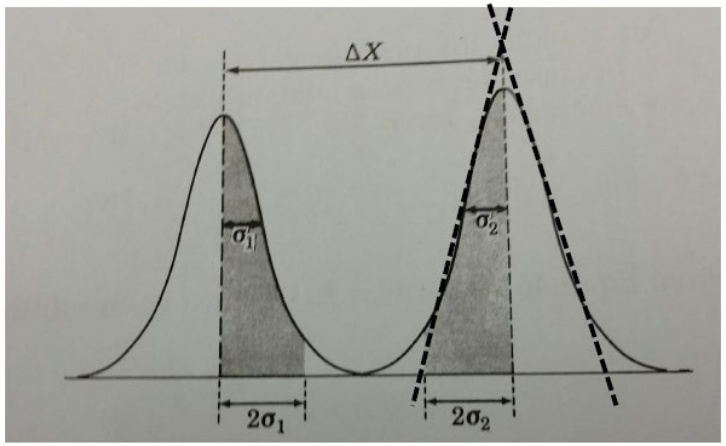
k' defines the number of free column volumes to reach the peak maximum

- k' is a distribution ratio that describes metal partitioning
- Describes how well a metal is extracted
- Measured as D_w and converted using physical properties of the resin
- Separation Factors (SF) describe the difference in extraction for two metals
- When planning separations both SF and k' must be considered

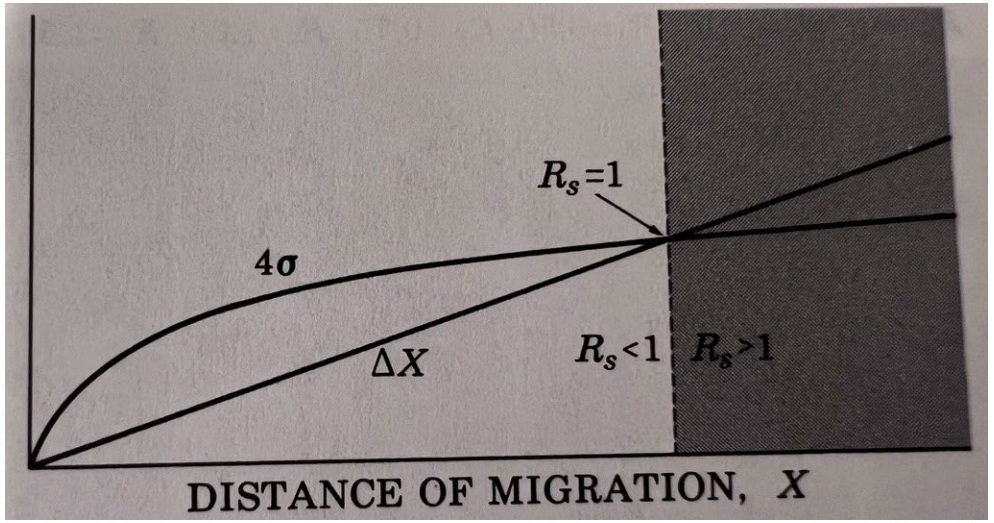


What is a k' not?

- k' describes the chemical behavior of the system
- It is unique for each metal + resin + acid combo
- It does not give any information about peak shape or resolution, only position
- Does not tell you how the physical parameters impact your system
  - Particle size
  - Bed volume
  - Column dimensions
  - Temperature/Pressure
  - Flow Rate



Resolution = $R_s = \Delta X / (2\sigma_1 + 2\sigma_2)$



ΔX increases linearly

$(2\sigma_1 + 2\sigma_2)$ increases as the square root of X

Resolution increases with longer columns!

Giddings, 1991.

Questions?