FACULTY OF ENGINEERING AND ARCHITECTURE

INDUSTRIAL CATALYSIS AND ADSORPTION TECHNOLOGY

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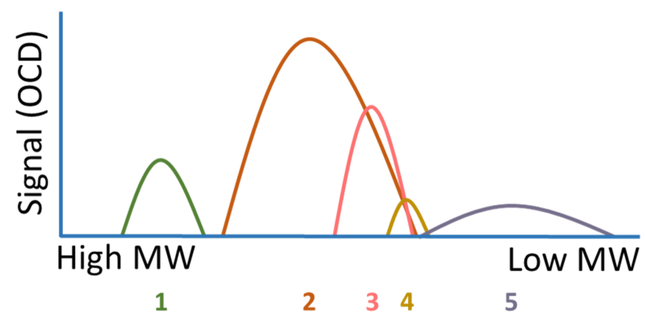
REMOVAL OF NATURAL ORGANIC MATTER BY ANION EXCHANGE RESINS:

EFFECT OF RESIN CONDITIONING ON PH AND REMOVAL MECHANISMS AND EFFICIENCY

Problem Statement

Natural organic matter (NOM)

- Originates from degradation and byproducts of living organisms and plants
- Complex mixture (wide range of MW, hydrophobicity, functionalities)
- Separation via Liquid Chromatograpy – Organic Carbon Detection (LC-OCD) into 5 fractions:
  - **Biopolymers** (1) – **Humic substances** (2) – **Building blocks** (3) – **Low MW acids** (4) – **Low MW neutrals** (5)



Challenges

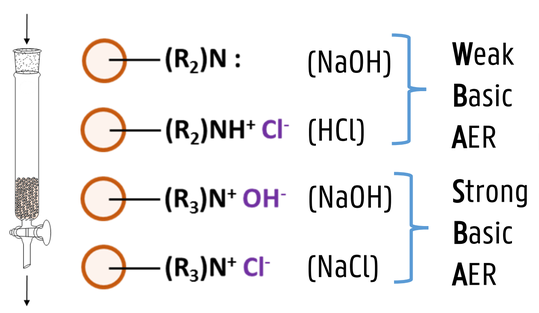
- Complete removal not achieved by classical water treatment processes (*e.g.* demineralisation via ion exchange (IEX) → remaining NOM: biopolymers & low MW neutrals)
  - Increased risk on **corrosion** in steam cycle
  - Formation of **disinfection by-products** during drinking water production
  - **Microbiological growth** in water distribution systems

Strategy

Anion exchange resin (AER) conditioning

Resin	Functionality
MP62[a]	WBA
MP68[a]	W/SBA (3.5/1)
MP64[a]	W/SBA (2.0/1)
MP600[a]	SBA (type II)
MP500[a]	SBA (type I)

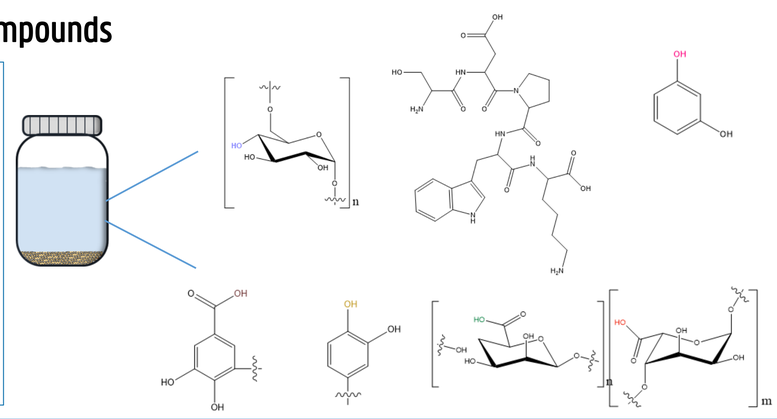
[a] *Lewatit, Lanxess*



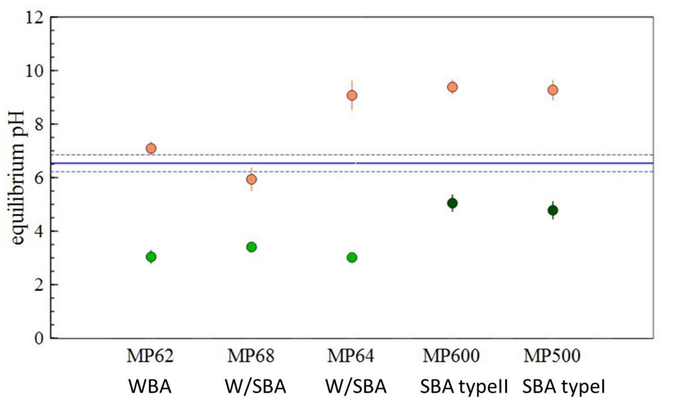
Batch experiments: AER and NOM model compounds

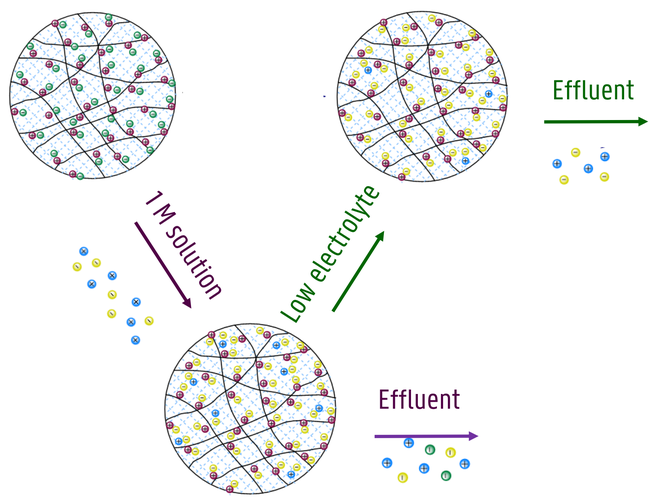
Set-up:
50 ppm model compound
→ BSA / dextran / alginate / HA / resorcinol
2 g resin OH^- form (equivalent capacity Cl^- form)
22h – 200 rpm – 25°C

Analysis:
pH – UV - TOC



pH effects





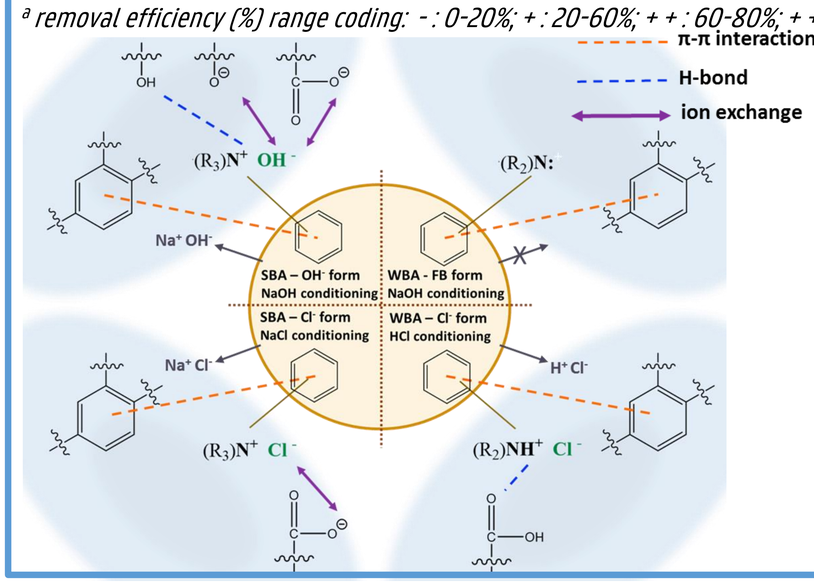
- **Release of ions** in subsequent batch experimtent

  → **ionic strength ↑; pH ↑or ↓**

Removal mechanisms & efficiency

Model compound	**SBA – OH^- form** NaOH conditioning $pH_{eq.}$ 9-10.5		**SBA – Cl^- form** NaCl conditioning $pH_{eq.}$ 4.5-6		**WBA – FB form** NaOH conditioning $pH_{eq.}$ 6.5-8		**WBA – Cl^- form** HCl conditioning $pH_{eq.}$ 3-3.5	
	Removal mechanism	***Removal*** [a]	***Removal mechanism***	***Removal*** [a]	***Removal mechanism***	***Removal*** [a]	***Removal mechanism***	***Removal*** [a]
BSA	IEX	-	IEX	+ + +	H-bond	-	n.a.	-
Dextran	H-bond	+ + +	n.a.	-	n.a.	-	n.a.	-
Alginate	IEX, H-bond	- / +	IEX	+	IEX	+	H-bond, IEX	+
Humic acid	IEX, H-bond, π-π	+	IEX	+ +	H-bond, π-π	+	H-bond, π-π	+
Resorcinol	H-bond, π-π, IEX	+ + +	π-π	+ / + +	π-π	+ + +	π-π	+ +

[a] *removal efficiency (%) range coding: - : 0-20%; + : 20-60%; + + : 60-80%; + + + : 80-100%*



- **Aromatic** NOM: π-π interactions (all counter ion forms)
- **Carboxyl** groups: H-bonding with Cl^- WBA & OH^- SBA
- **Hydroxyl** groups: H-bonding with OH^- SBA
- **Charged** (anionic) NOM: Ion exchange
- **W/SBA** resins: behaviour depends on ratio weak versus strong basic functionalities

Conclusions

- **Conditioning procedure** influences **equilibrium pH and ionic strength**, affecting removal efficiency and mechanisms – especially in batch mode experiments
- **Selection of resin and conditioning procedure** enables optimal **removal of targeted NOM** (fraction)
- Insight in removal mechanisms helps to **optimize regeneration procedures**

- **Future work** on (NOM fractions from) **real surface water** to investigate the effects of this more complex water matrix on NOM removal

References: *Laforce E, et al. Revealing the effect of anion exchange resin conditioning on the pH and natural organic matter model compounds removal mechanisms, Journal of Environmental Chemical Engineering, (2022)*

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