POLITECNICO DI MILANO

INNOVATIVE MATERIALS FOR HEAVY METALS REMOVAL FROM WATER

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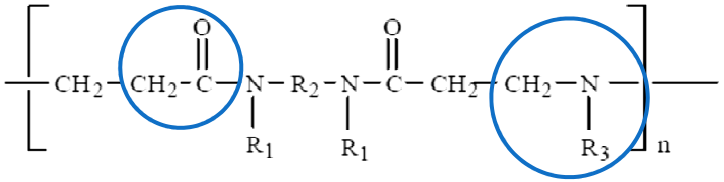
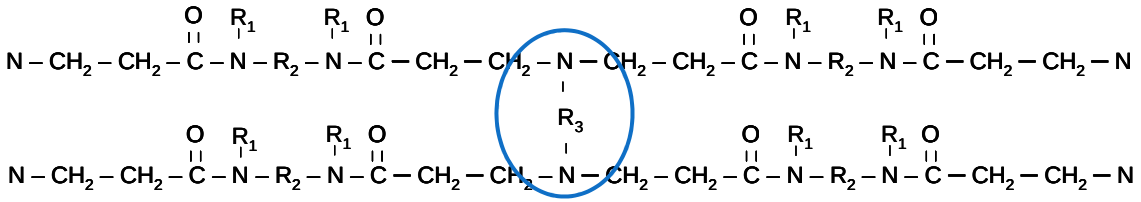
POLYAMIDOAMINE (PAA) HYDROGELS



LINEAR PAA

PAA HYDROGEL



"TARGET ORIENTED" MATERIALS

TO OVERCOME THE LIMITS OF THE EXISTENT TECHNOLOGIES
FOR HEAVY METALS REMOVAL FROM WATER

LOW SELECTIVITY

pH DEPENDANCE

LOW REMOVAL CAPACITY

LONG EQUILIBRIUM TIMES

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AIM OF THE PROJECT

WATER/HYDROGEL INTERACTIONS

stability,
changes in chemical composition of water.

SUITABILITY FOR THE REMOVAL OF INORGANIC POLLUTANTS

kinetics,
maximum complexing capacity,
interferences.

IMPLEMENTATION IN WATER TREATMENT PLANTS

regeneration,
filterability,
breakthrough curves.

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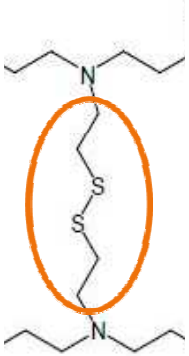
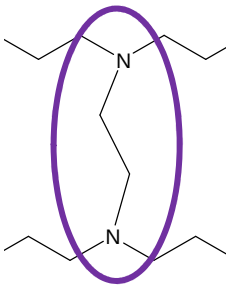
PAA TESTED SAMPLES

MBA/CYS





MBA/EDA

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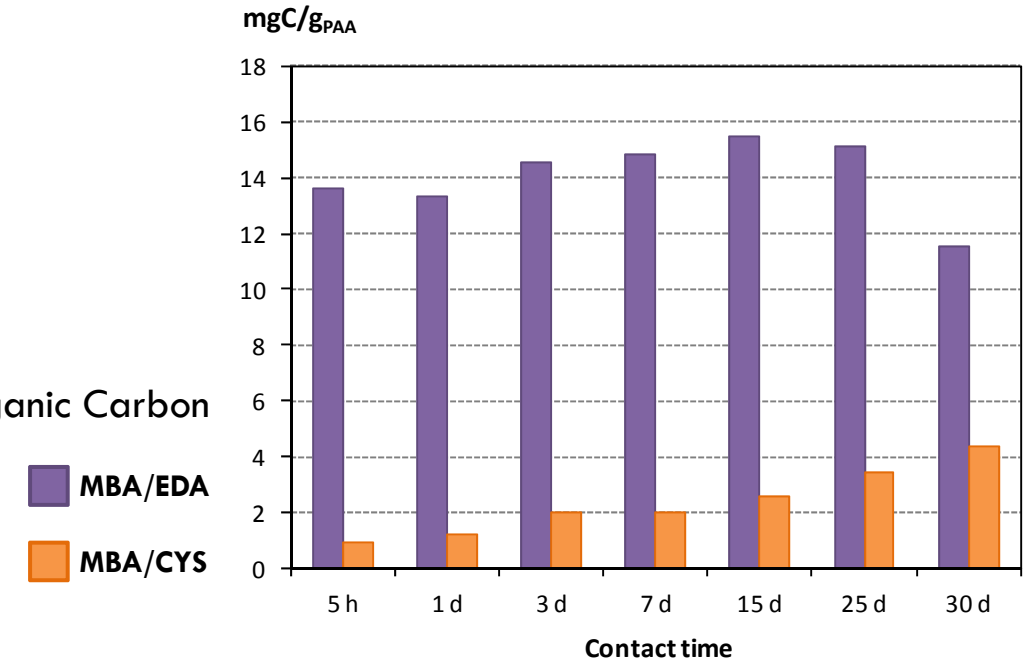
WATER/IDROGEL INTERACTIONS

- Absorption of large amount of water leading to a **VOLUMETRIC EXPANSION**

- **DEGRADATION** over time via hydrolysis

Release of Total Organic Carbon



- **ION EXCHANGE** of anions present in aqueous phase as WBA resin

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REMOVAL OF Cu^{2+}: KINETIC TESTS

COMPLEXATION of HEAVY METALS IONS

due to tertiary aminic, carboxyl groups and disulphide groups

- Batch tests at different contact time
- Tap water with Cu(II) (2 mg/L)
- T ~ 23/24°C
- Contact mode: mechanical mixing
- **S/L ratio = 1/150 – 1/300 – 1/600 g/mL**
- Analyses: pH, CES, C(Cu)

S/L [g/mL]	PARTICLE SIZE	EQUILIBRIUM CONDITIONS					
		MBA/EDA			MBA/CYS		
		Time [h]	Concentration [mgCu/L]	Complexing capacity [$mgCu/g_{RESIN}$]	Time [h]	Concentration [mgCu/L]	Complexing capacity [$mgCu/g_{RESIN}$]
1/150	1mm<d<2mm	16	0.22	0.27	6	0.26	0.26
	d<1mm	2	0.17	0.27	2	0.09	0.29
1/300	1mm<d<2mm	48	0.17	0.55	N.A.	N.A.	N.A.
	d<1mm	16	0.23	0.53	16	0.3	0.51
1/600	1mm<d<2mm	48	0.5	0.9	48	0.32	1.01
	d<1mm	24	0.28	1.03	N.A.	N.A.	N.A.

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REMOVAL OF Cu^{2+}: KINETIC TESTS

COMPLEXING CAPACITY AT THE EQUILIBRIUM ⟷ DEPENDS ON ⟷ **S/L RATIO**
mass of copper provided to the unit mass of hydrogel

S/L [g/mL]	PARTICLE SIZE	EQUILIBRIUM CONDITIONS					
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REMOVAL OF Cu^{2+}: KINETIC TESTS

RESIDUAL CONCENTRATION AT THE EQUILIBRIUM

- not influenced by S/L ratio
- different from zero

DYNAMIC EQUILIBRIUM
established by
$\Delta C = C_{RESIN} - C_{WATER}$

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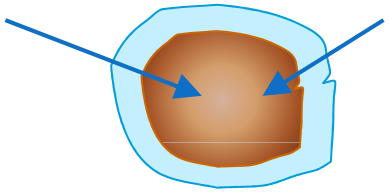
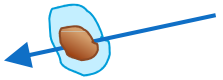
REMOVAL OF Cu^{2+}: KINETIC TESTS

EQUILIBRIUM TIME

PARTICLE SIZE



1 mm < d < 2 mm



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REMOVAL OF Cu^{2+}: KINETIC TESTS

DIFFUSION COEFFICIENTS

INTRAPARTICLE DIFFUSION

$$\frac{\partial q_m}{\partial t} = \left(\frac{D_S}{r^2}\right) \cdot \frac{\partial}{\partial r}\left(r^2 \frac{\partial q_m}{\partial r}\right)$$

D_S: effective surface diffusivity [cm^2/s]

FLUID - FILM DIFFUSION

$$\rho_S \left(\frac{\partial q_t}{\partial t}\right) = k_F \cdot a_P \cdot (c_t - c_s)$$

k_F: fluid film mass transfer coefficient [cm/s]

$$\frac{dC}{dt} = -K_L \cdot C^n - K_P \cdot C^m - K_N \cdot C^p - K_{SS} \cdot C^q$$

INTRAPARTICLE DIFFUSION

FILM DIFFUSION

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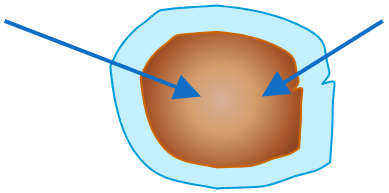
DIFFUSION COEFFICIENTS

$$\frac{dC}{dt} = -k_{MAX} \cdot \frac{C}{K_C + C}$$

$$K_C = K_L + K_P$$

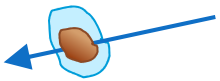
1 mm < d < 2 mm

- FILM DIFFUSION
- INTRAPARTICLE DIFFUSION

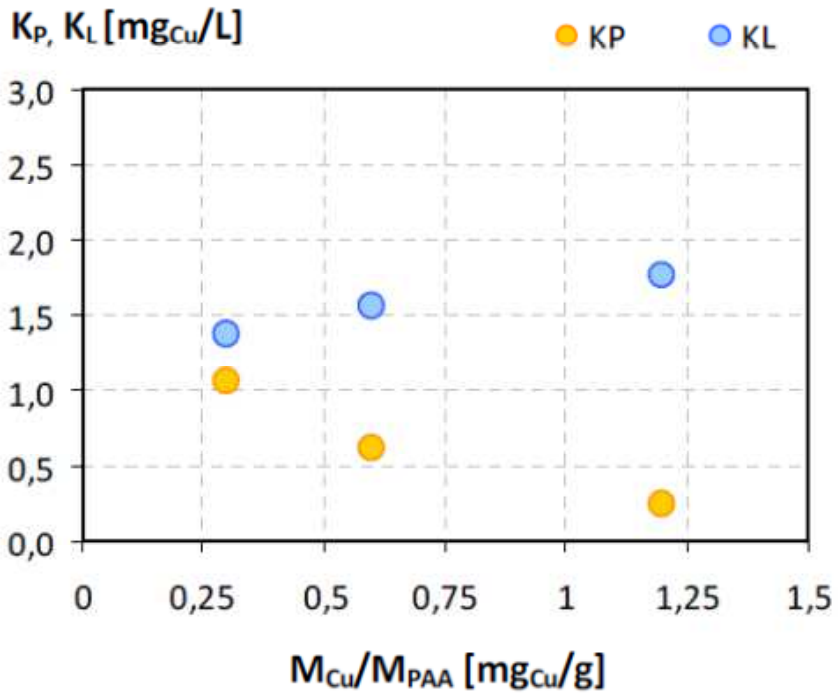


d < 1 mm

- FILM DIFFUSION



MBA/CYS



CONCLUSIONS AND NEXT STEPS

- Influence of liquid-film on contaminant **DIFFUSION** into hydrogels

- Batch isotherm tests to quantify **THE MAXIMUM COMPLEXING CAPACITY** of the hydrogels

- Multistep batch tests compared to RSSCT to simulate **BREAKTHROUGH CURVES** and to obtain design data

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