Synthesis and Application of Manganese Dioxide Coated Magnetite for Removal of Trace Contaminants from Water

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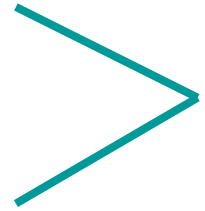
Outline

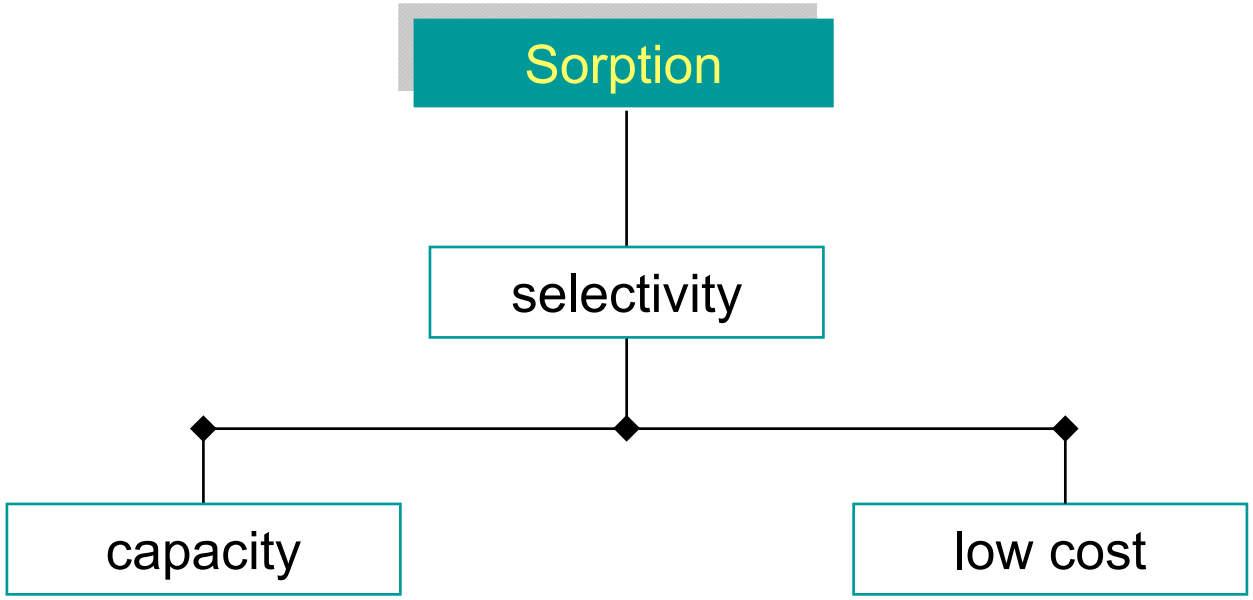
- Introduction
  - Sorbents
  - Hydrous manganese dioxide
  - Magnetic Micro Sorbents
- Magnetic Micro Sorbent MMS
  - Preparation
  - Characterization
  - Magnetic separation
- Adsorption performance
  - Kinetics
  - Equilibrium
- Conclusions

ntroduction

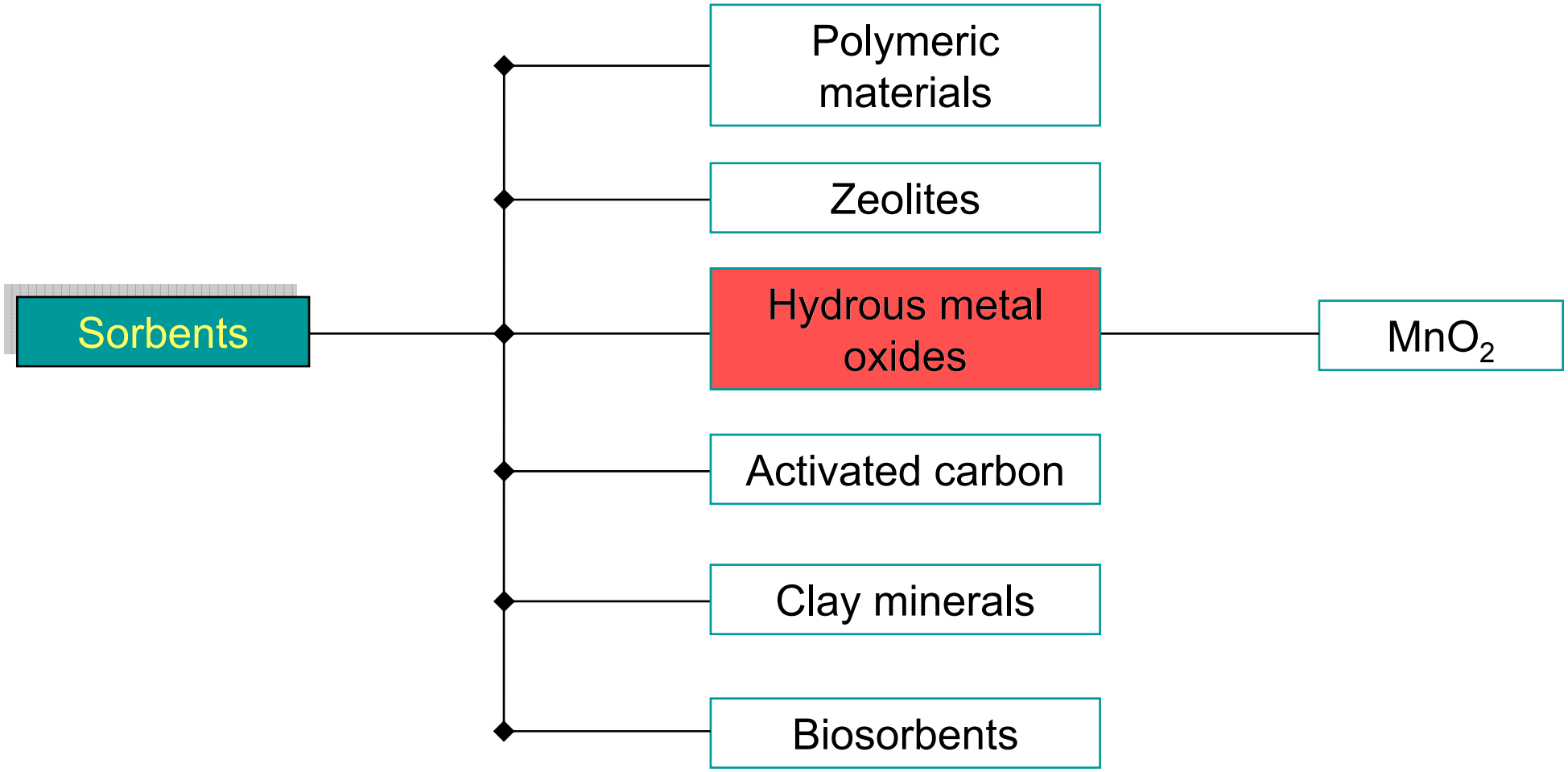
- Ground Waters
- Surface Waters
- Processes Waters
- Wastewaters



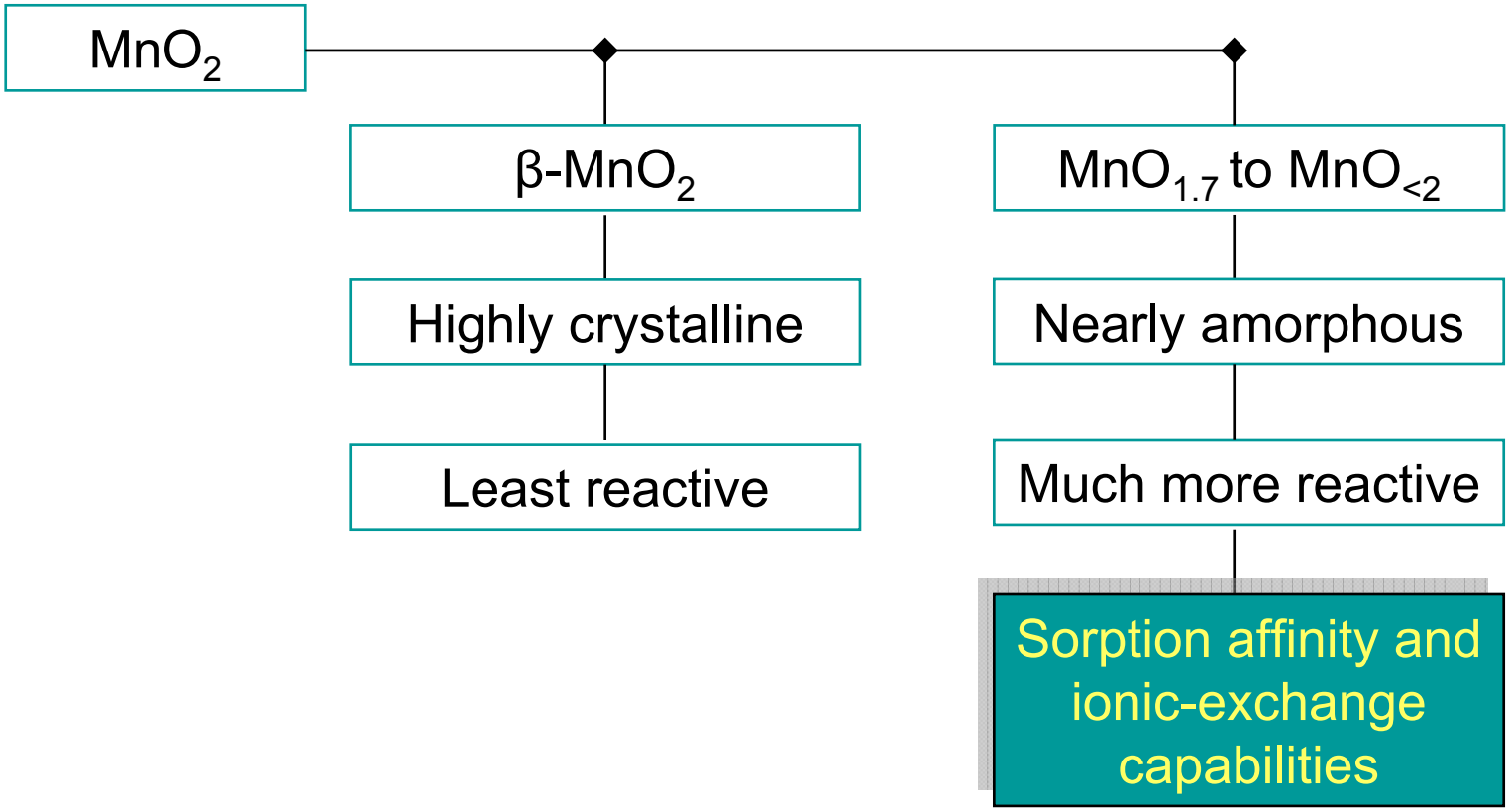
Hazardous inorganic trace components



ntroduction - Sorbents



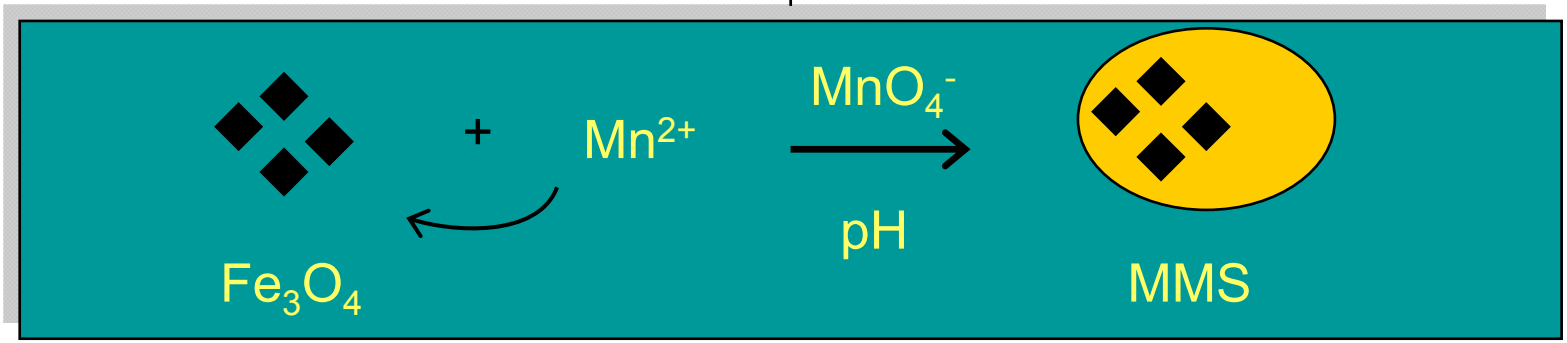
ntroduction – Hydrous manganese dioxide



ntroduction – MnO_2 and MMS

Manganese dioxide

Magnetic Micro Sorbent



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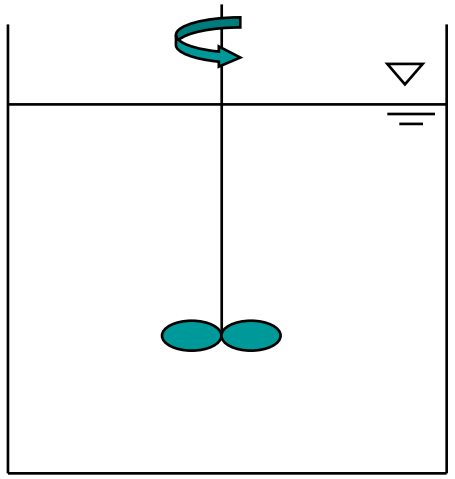
Magnetic Micro Sorbent – preparation

SET UP

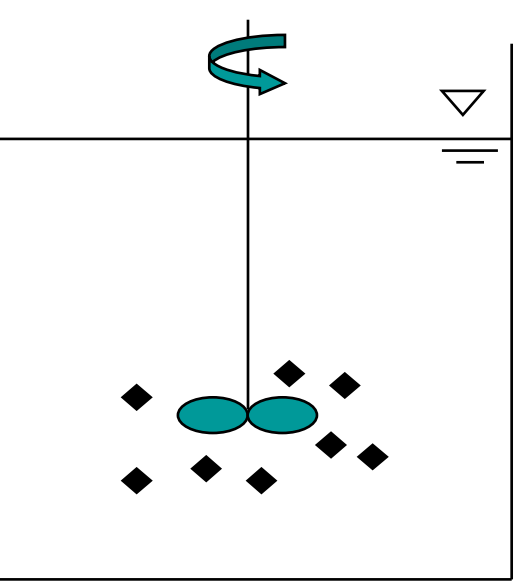


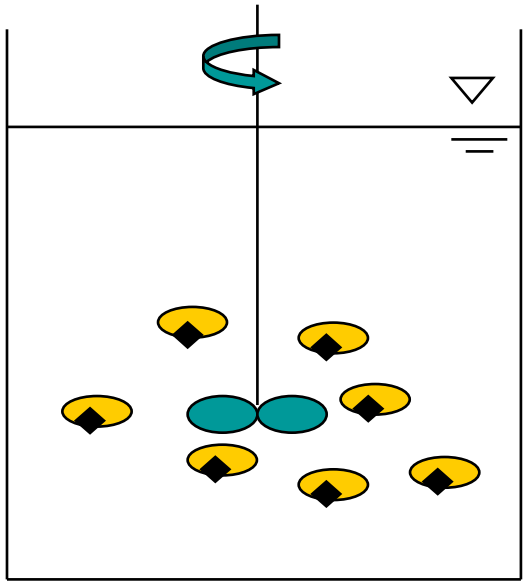
- $MnCl_2$ 1mol/L = 7 mL
- $KMnO_4$ 0.2 mol/L = 23 mL
- KOH 1 mol/L = 14 mL

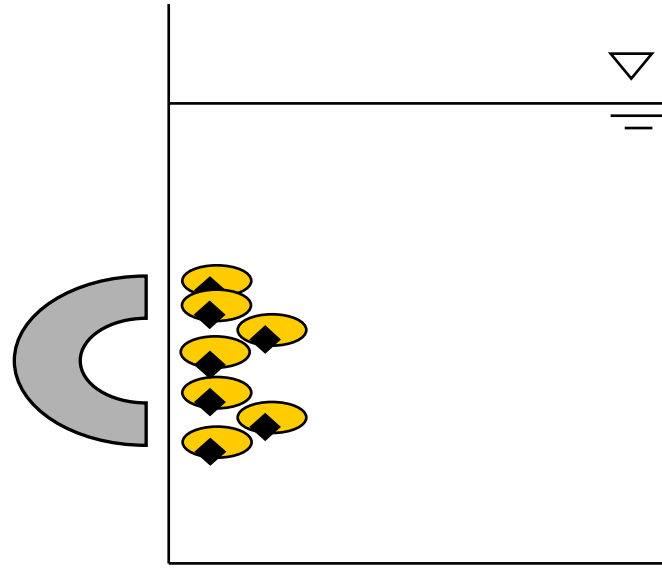
- Fe_3O_4 Bayoxide®
  m = 1g
- V_{H2O} = 500 mL

$$3MnCl_2 + 2KMnO_4 + 4OH^- \rightleftharpoons 5MnO_2 + 2H_2O + 2K^+ 6Cl^-$$

Magnetic Micro Sorbent – preparation







- Magnetite suspended in alkaline solution of $KMnO_4$

- Addition of $MnCl_2$
- Precipitation of MnO_2

- Solid/ Liquid separation by means of a magnet

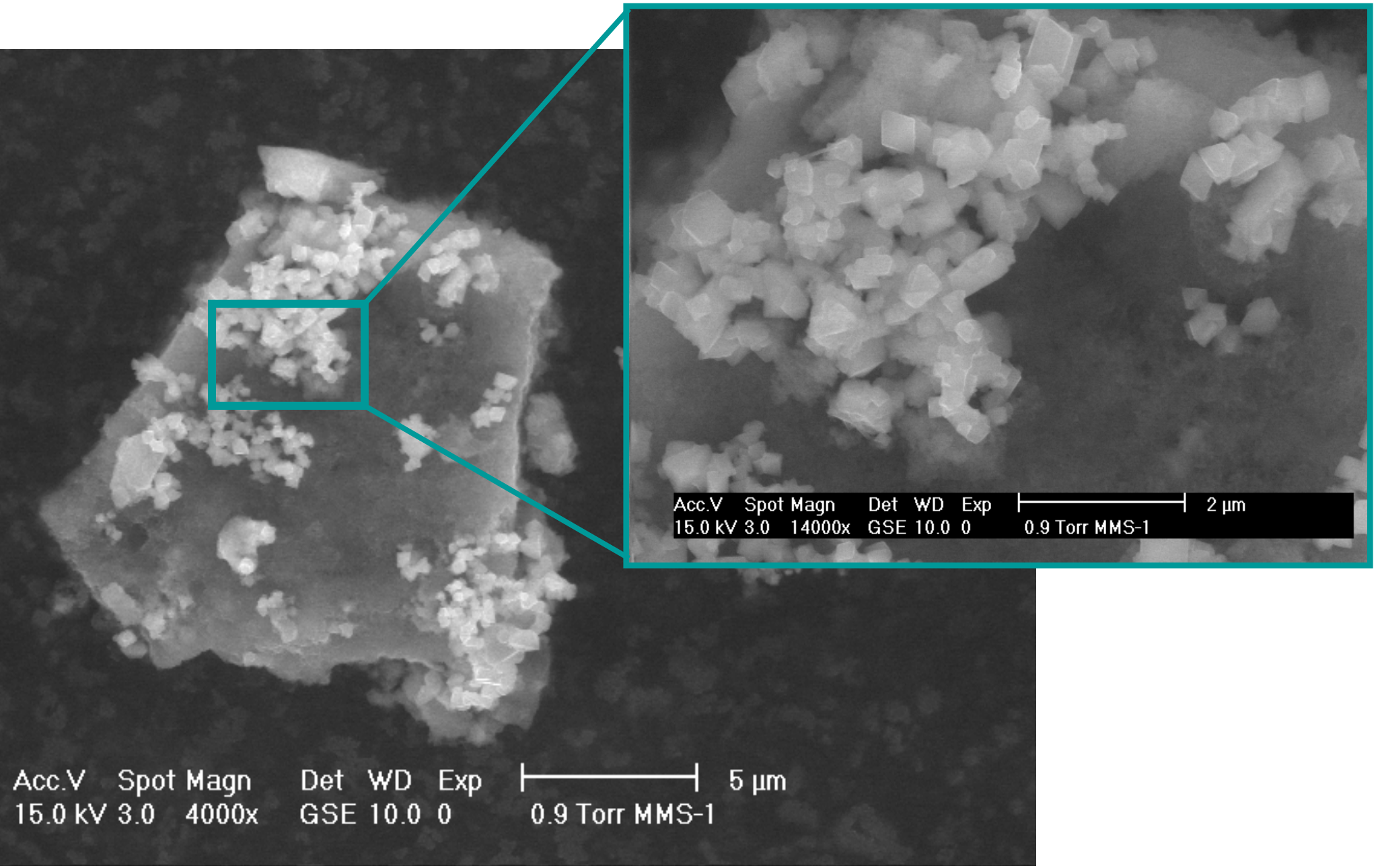
Magnetic Micro Sorbent– characterization

	Fe_3O_4	MnO_2	MMS
Mn^{2+} (g/g MMS)	-	-	0.47
BET Surface area ($m^2\ g^{-1}$)	5	240*	92
Magnetic saturation (Am^2/kg)	90-95	0.3 – 0.4	36 - 40
$pH_{(PZC)}$	6.5	2.1	3.5

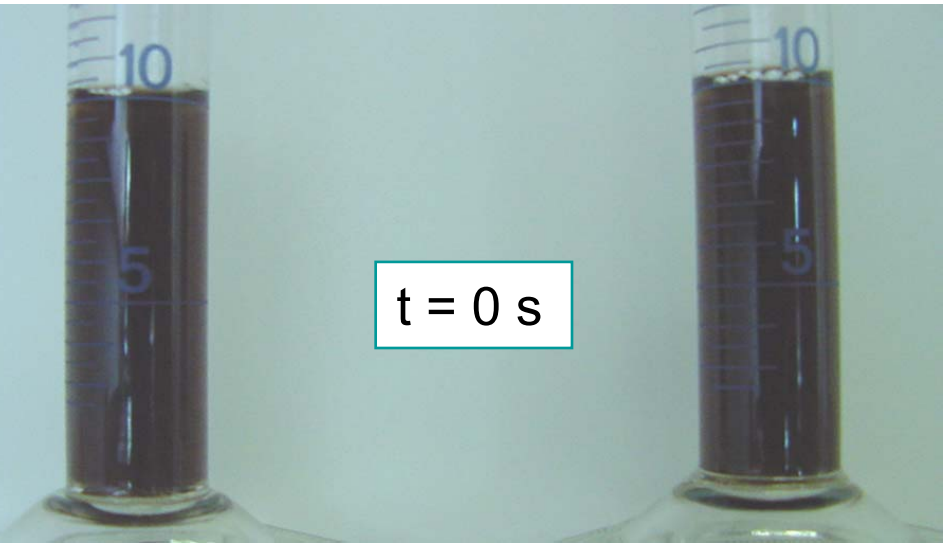
content, Magnetization, $pH_{(PZC)}$ and BET surface area measurements.

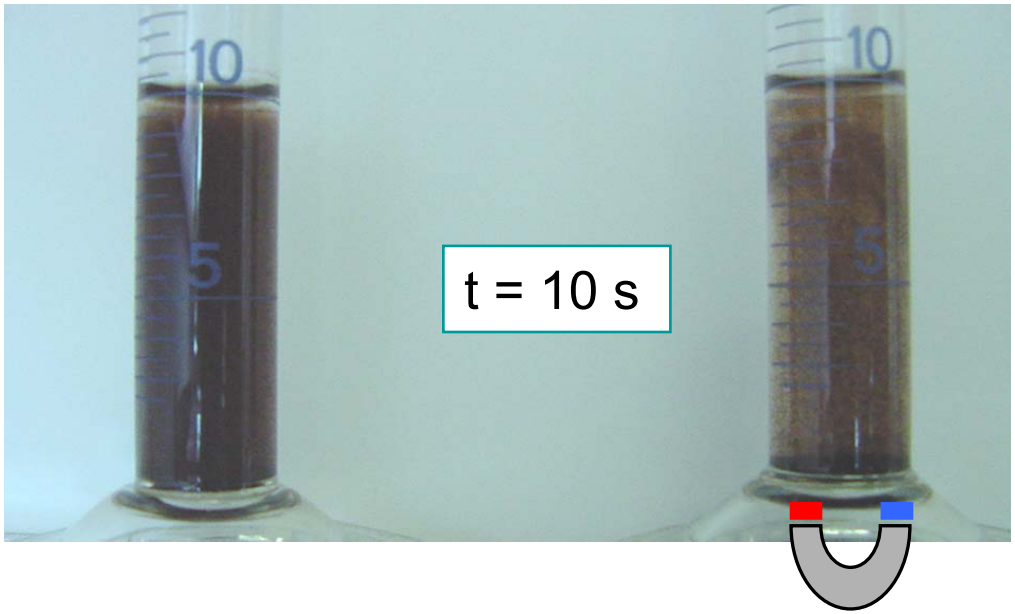
Driehaus, Arsenentfernung mit Mangandioxid und Eisenhydroxid in der Trinkwasseraufbereitung

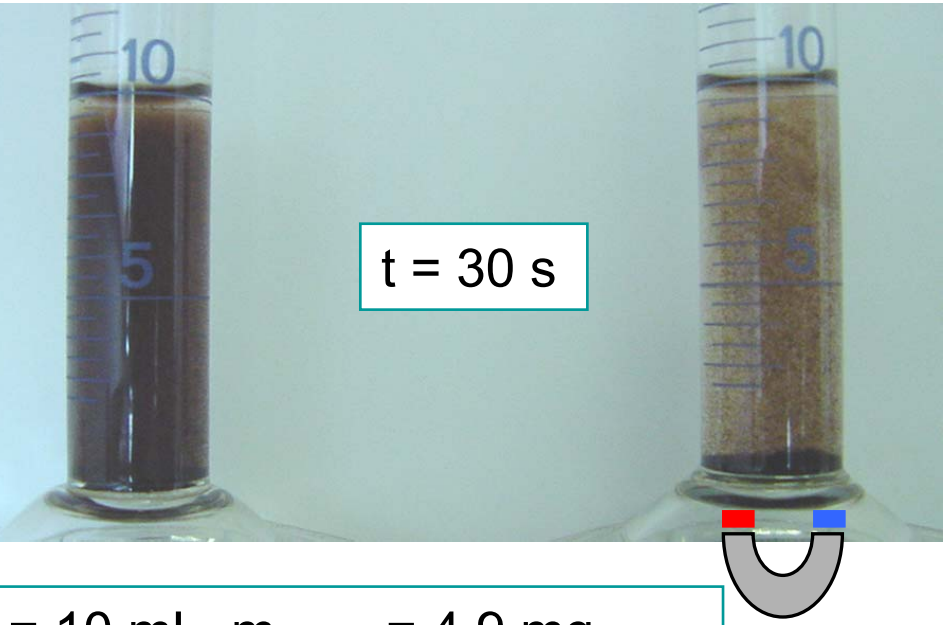
Magnetic Micro Sorbent– characterization

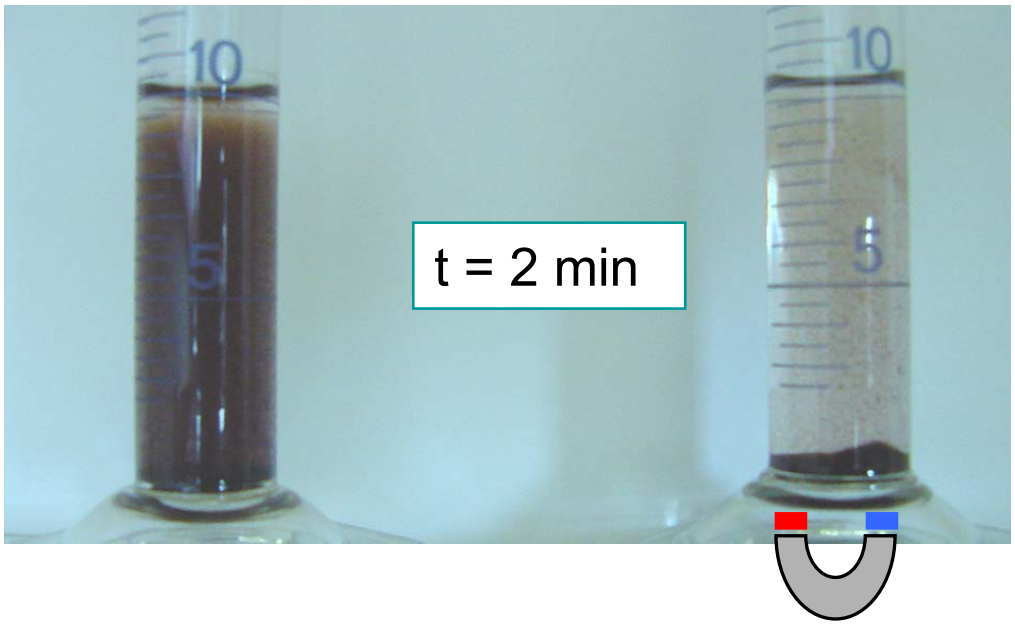


Magnetic Micro Sorbent – separation









= 10 mL, m_{MMS} = 4.9 mg

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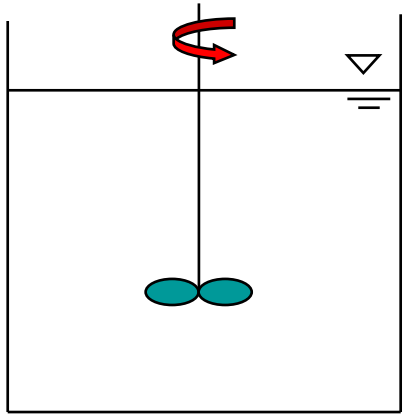
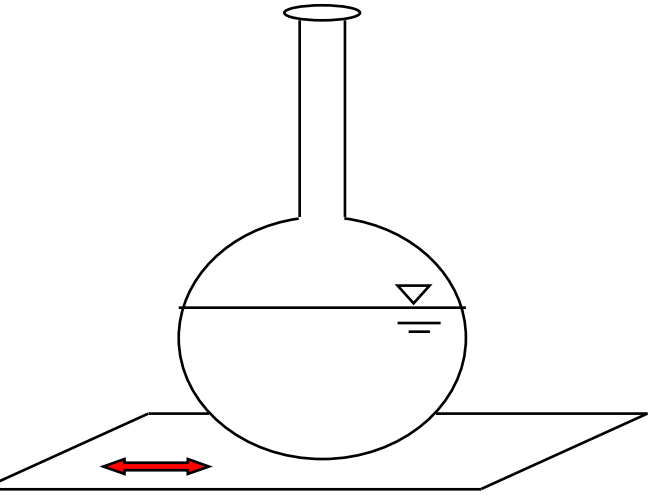
dsorption performance

SET UP Kinetics



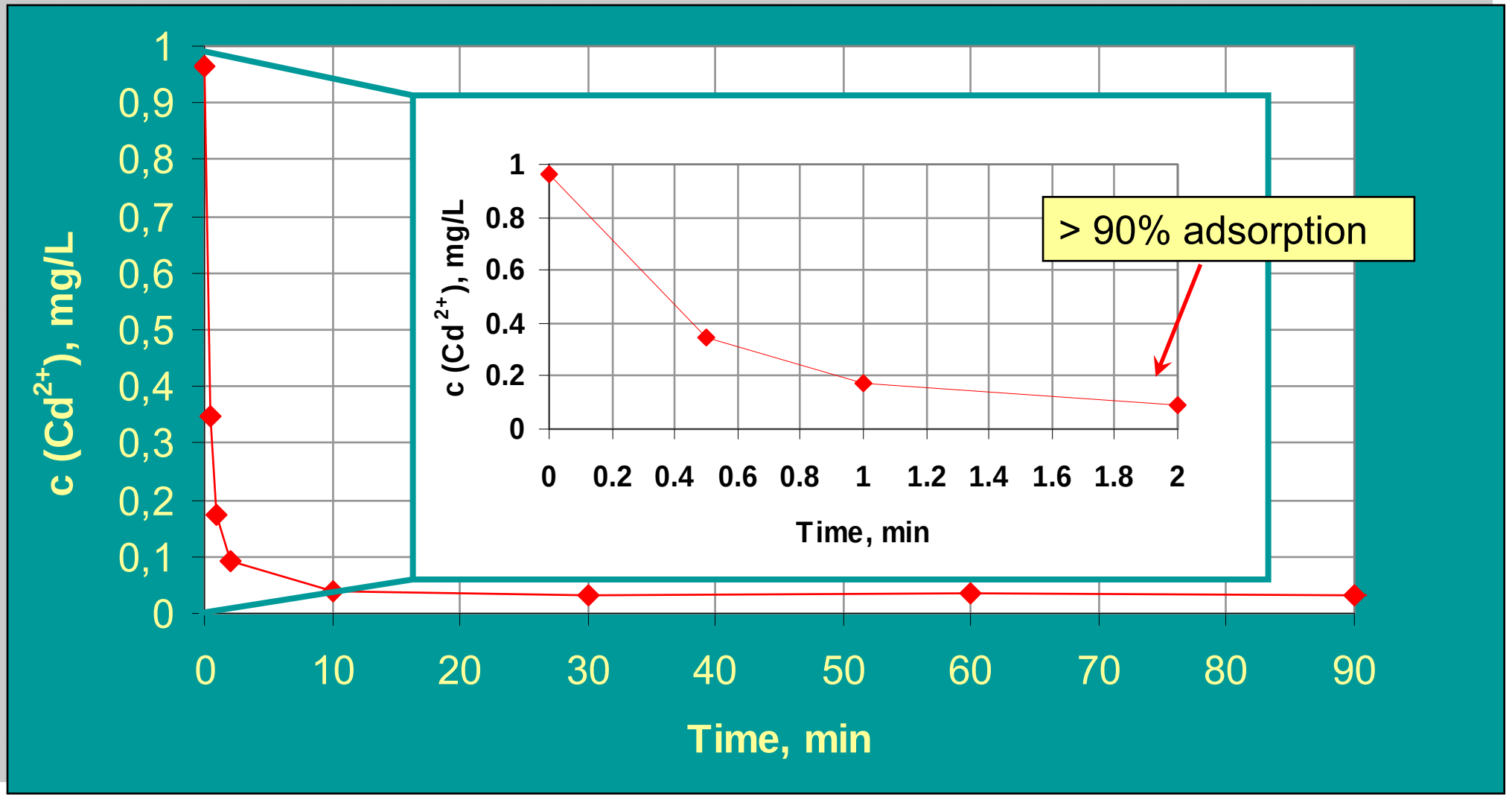
- $C_{i,\,Cd}$ = 1 mg/L
- m_{MSS} = 92 mg
- V_o = 1 L
- r.p.m. = 300
- t =0 ⟶ t = 90 min

SET UP Equilibrium Study



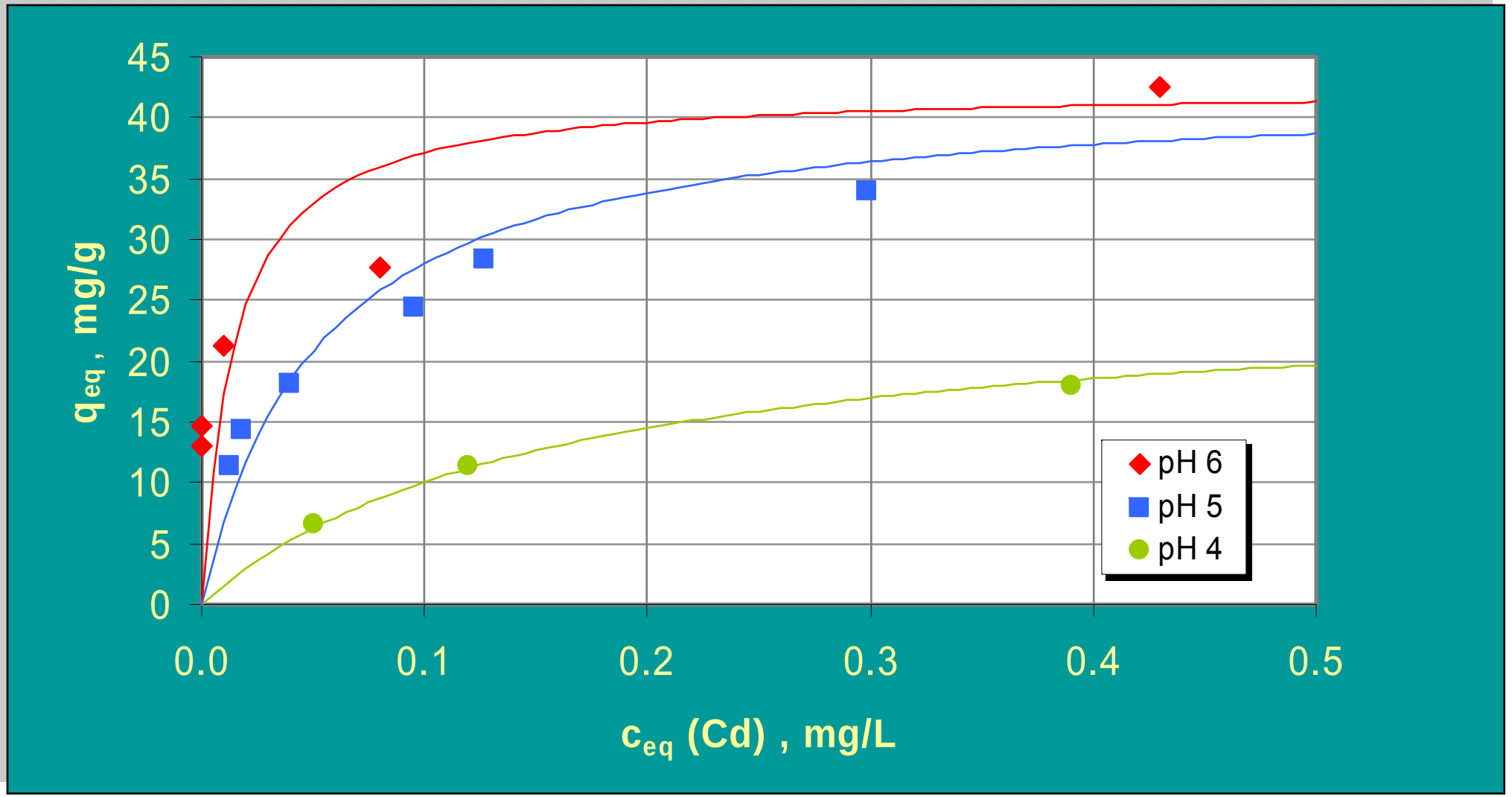
- $C_{i,\,Cd}$ = 0.08 – 0.5 mg/L
- V_o = 500 mL
- m_{MSS} = 3 mg
- r.p.m. = 250
- t = 90 min
- CH_3COONa = 0.01 mol/L

Adsorption performance - Kinetics



Adsorption performance – equilibrium study

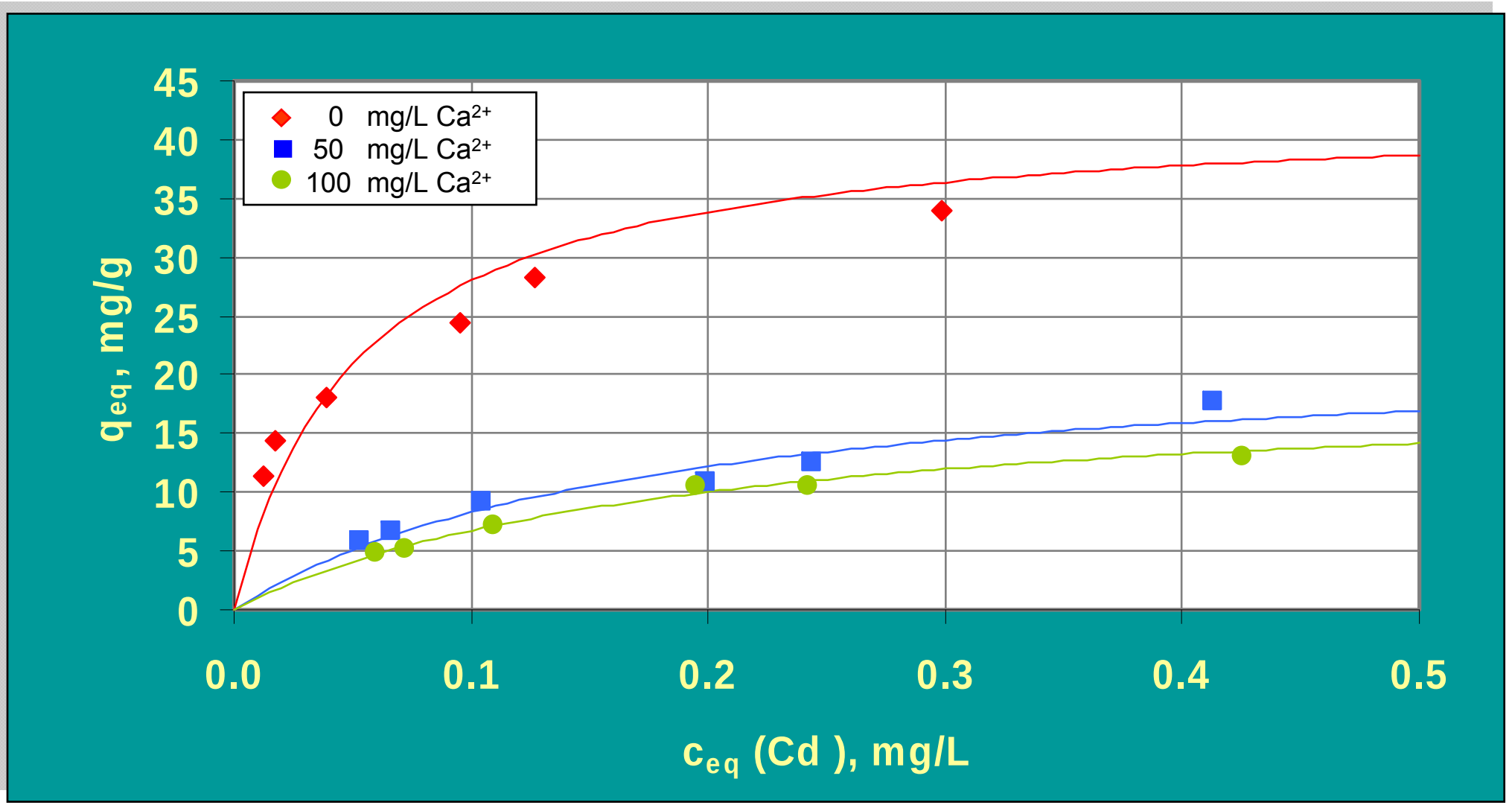
pH effect



V = 500 mL, m_{MMS} = 3 mg, $C_{i, Cd}$ = 0.08 to 0.5 mg/L

dsorption performance – equilibrium study

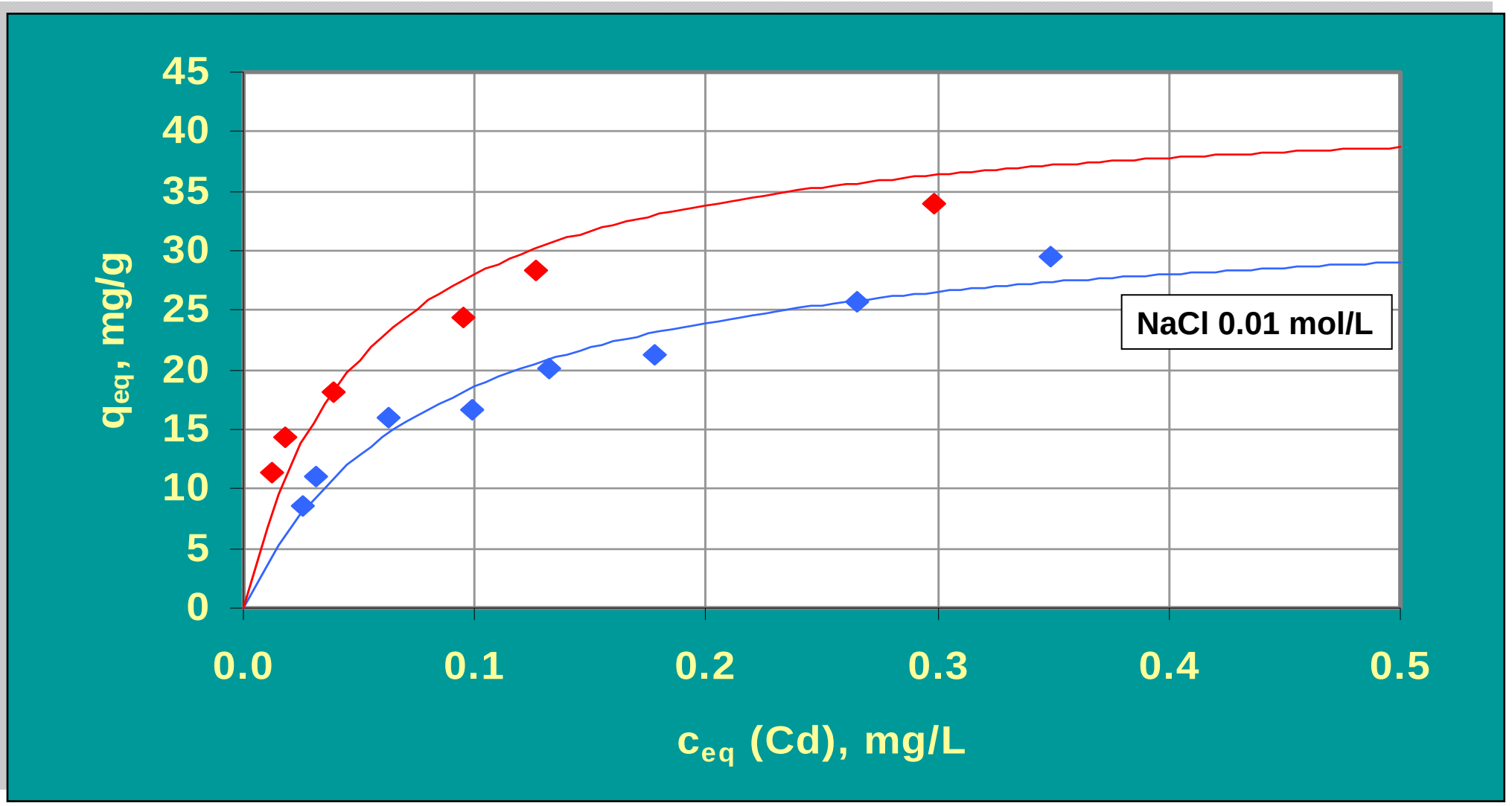
Competition: Addition of $CaCl_2$



V = 500 mL, m_{MMS} = 3 mg, $C_{i,\,Cd}$= 0.08 to 0.5 mg/L

dsorption performance – equilibrium study

Ionic strength : Addition of NaCl 0.01 mol/L



V = 500 mL, m_{MMS} = 3 mg, $C_{i,\,Cd}$ = 0.08 to 0.5 mg/L

dsorption performance – Cd speciation

	Cd^{2+} , %	$CdCl^{+}$, %
$CdCl_2$	100	-
50 mg/L $CaCl_2$	80	20
100 mg/L $CaCl_2$	67	33
0.01M NaCl, 50 mg/L $CaCl_2$	45	53
0.01M NaCl, 100 mg/L $CaCl_2$	40	58

lodelling with MINEQL©, C_{Cd} = 0.08 mg/L

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Conclusions

Magnetic manganese oxide adsorbents can easily be produced from magnetite and manganese salts.

Magnetic properties of magnetic micro sorbents allow simple solid-liquid separation applying a magnetic field.

Divalent heavy metals like cadmium can be well adsorbed.

Fast adjustment of sorption equilibria is obtained by using MMS in the conditions applied.

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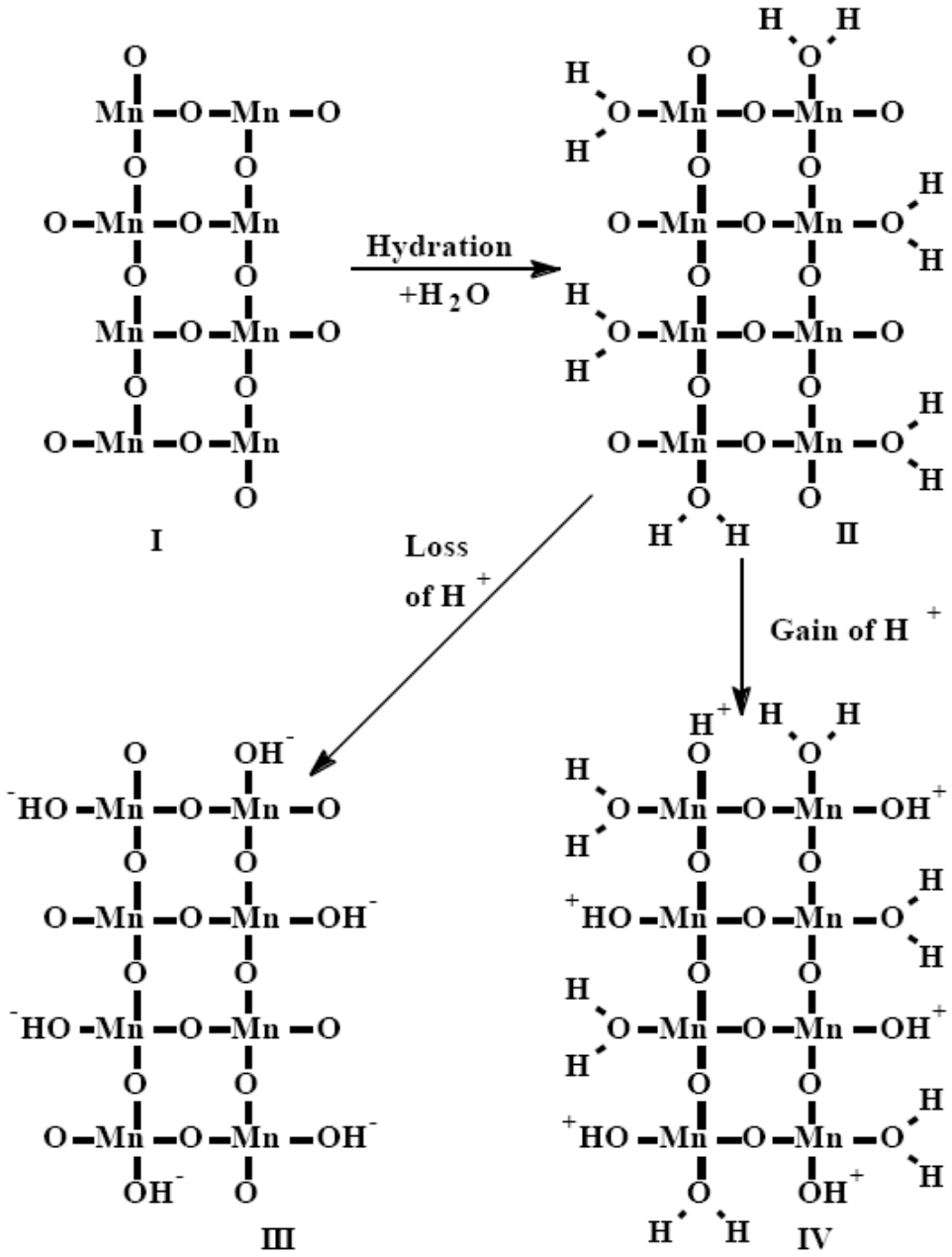
Hydration
+H2O
I
II
III
IV
Loss
of H+
Gain of H+