Heavy metals removal from wastewater by ferrogels

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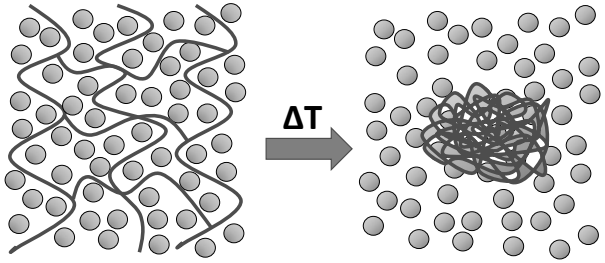
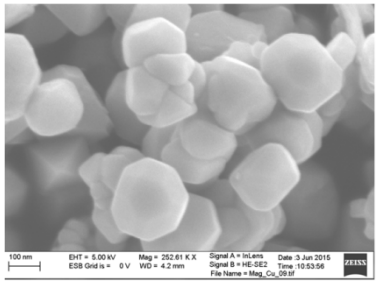
The aim

- **To develop a method for metal removal from waste water samples using thermoresponsive ferrogel sorbents („magnetic sponge”)**

Realization – general scheme

- The synthesis procedure of hydrogel matrix for the implementation of a metal sorbent in aqueous systems with strictly defined composition of the sorption system
  - Gel matrix – thermoresponsive poly(N-isopropylacrylamide) hydrogel
  - Metal sorbent – nanosized magnetite (ferromagnetic properties)





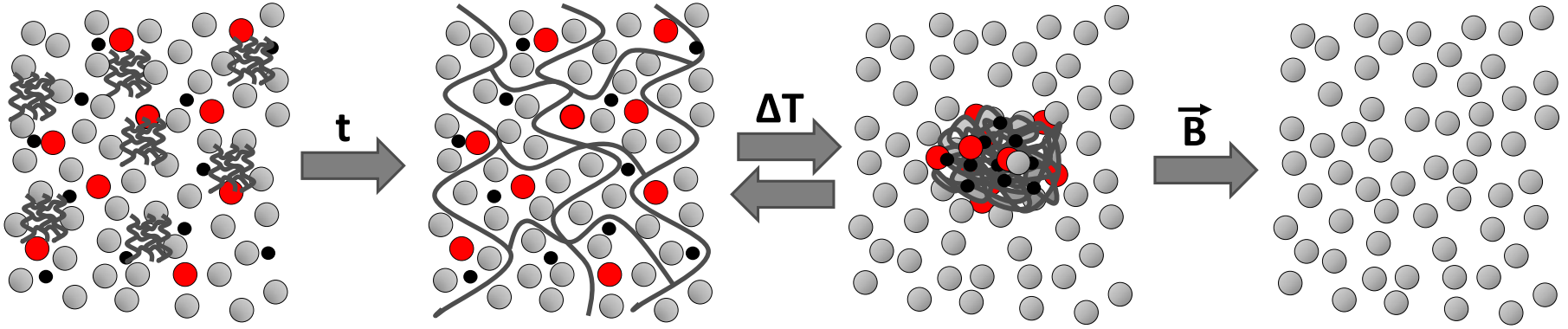
- Examination of the composite material for silver and copper removal from aqueous media

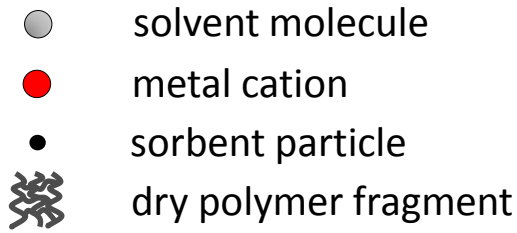
Realization - details

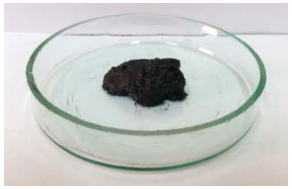
- **Preparation of pNIPA gel swollen by water –** free-radical polymerization of N-isopropylacrylamide (NIPA) using well documented procedures
- **Purification and drying the resulting polymeric material (pNIPA)**
- **Grinding the pNIPA material to a fine powder**
- **Preparation of the ferro-pNIPA system –** mixing the pNIPA powder with known amount of nanosized magnetite
- **Formation of the pNIPA ferrogel swollen by the aqueous solution –** transferring the ferro/pNIPA mixture into the aqueous solution containing heavy metal cations
- **Aqueous solution purification –** inducing volume phase transition of the gel system and removing the collapsed gel by an external magnetic field

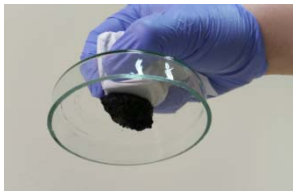
Realization – the idea

- **Water purification using sponge like behaviour of poly(N-isopropylacrylamide) ferrogels**



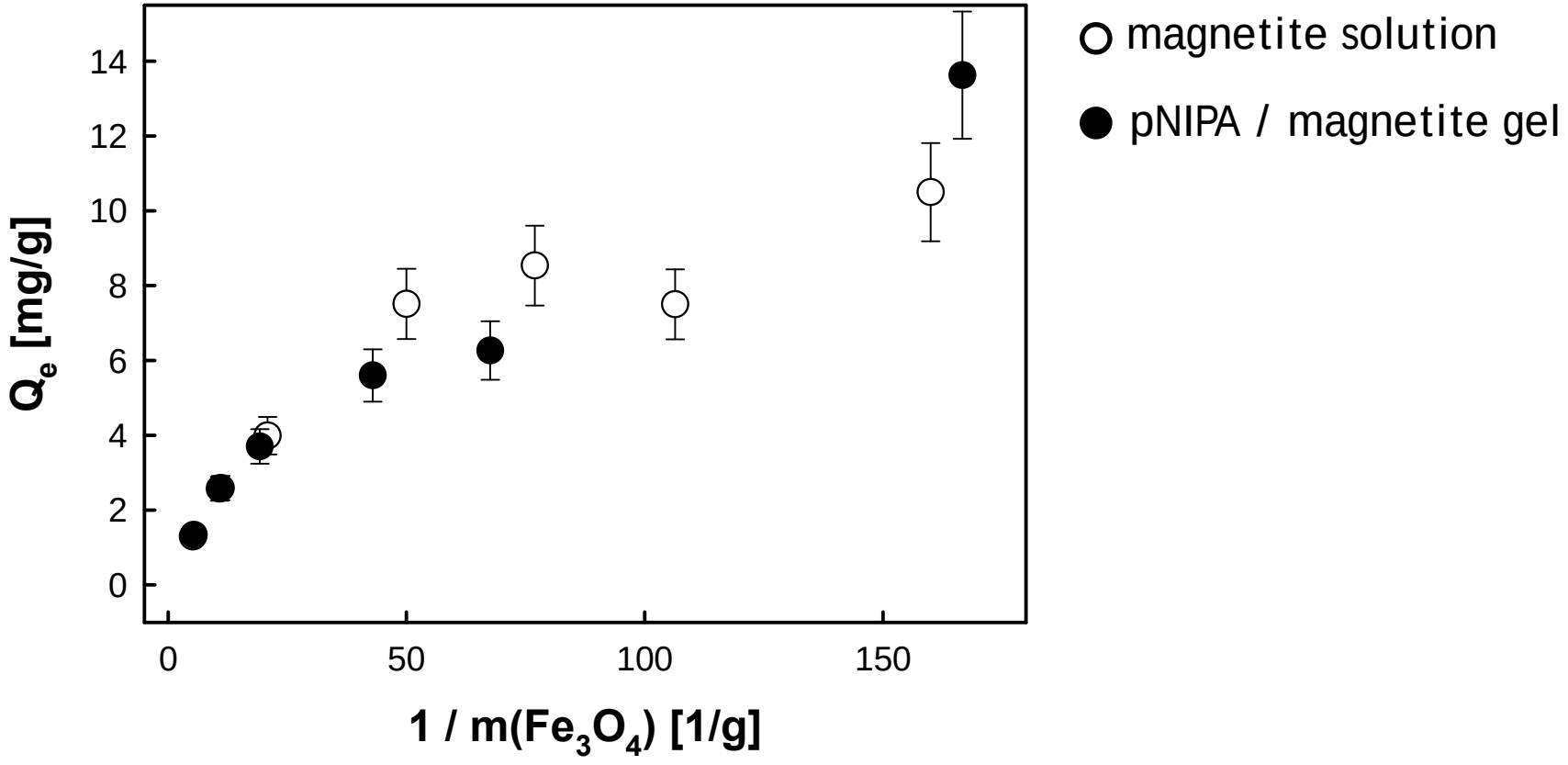






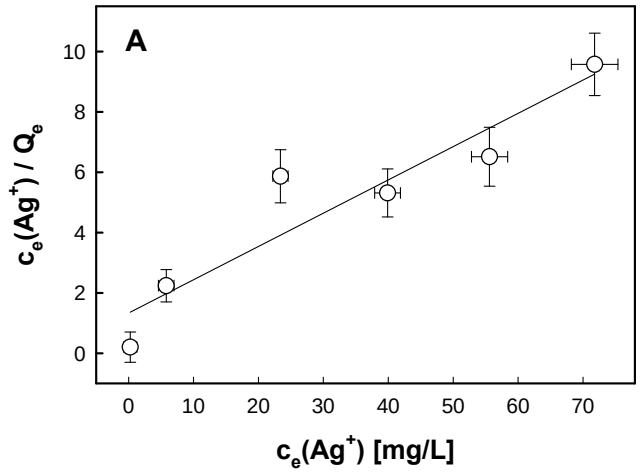
Results – silver removal from water samples

- **Effect of pNIPA matrix on the silver adsorption efficiency**



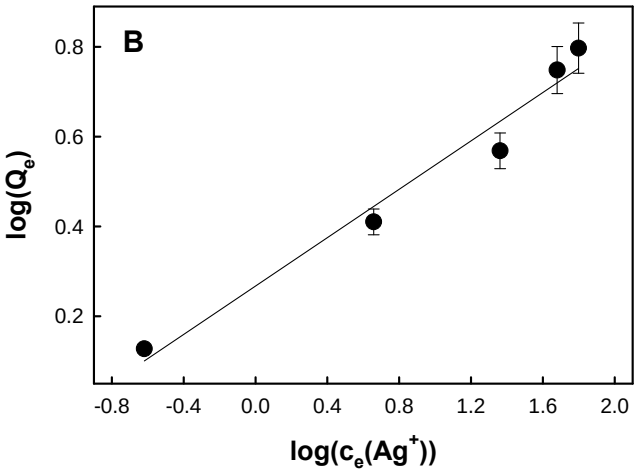
Results – silver removal from water samples

- **Determination of adsorption isotherm**



aqueous solution of magnetite – Langmuir isotherm

Q_{max}: 9.1 ± 3.4 mg / g



pNIPA / magnetite ferrogel – Freundlich isotherm

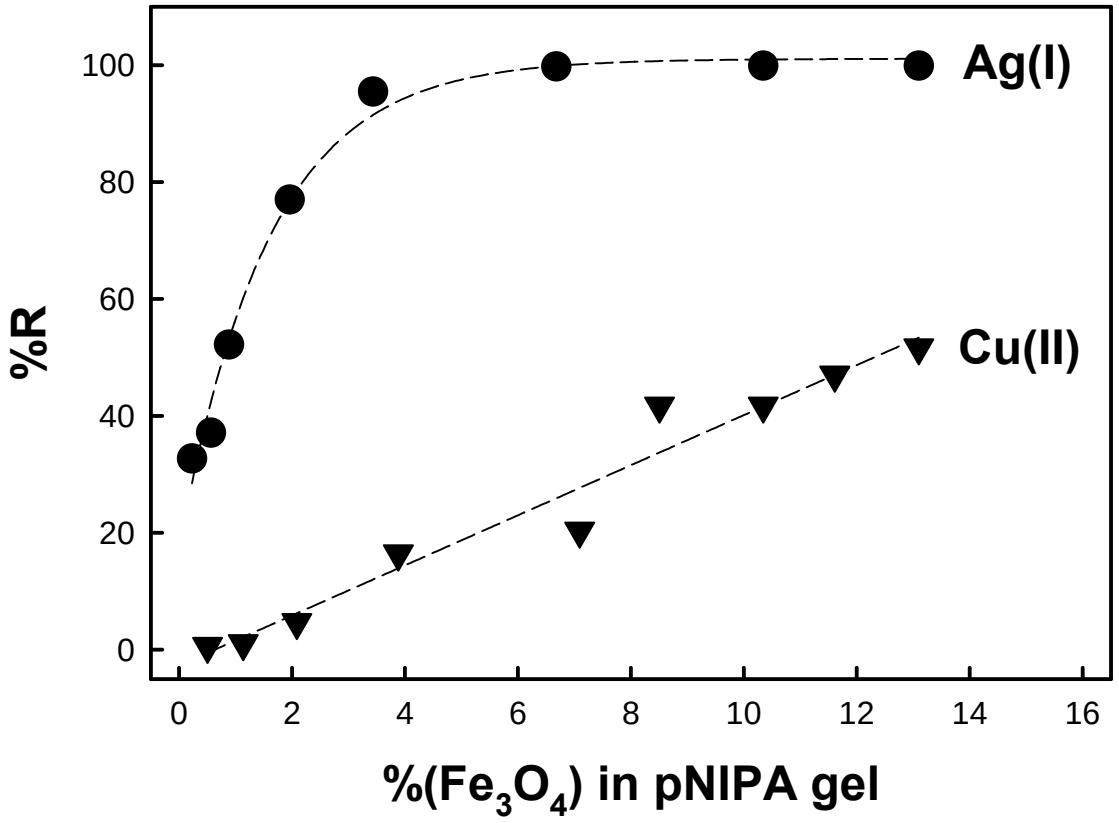
Q_{max}: 13.6 ± 3.8 mg / g

Results – mechanism of silver adsorption on magnetite

- Chemical reduction of silver (I) cations on the surface of magnetite (silver chemical deposition)
- Diffusion of silver (I) cations to iron oxide grains
- $2Fe_3O_4(s) + H_2O + 2Ag^+ \leftrightarrow 3Fe_2O_3(s) + 2H^+ + 2Ag(s)$
- Extraction of silver requires concentrated nitric (V) acid

Method validation for real wastewater samples

- **Sample prepared to mimic copper ore post - flotation waste**



c_{Ag}: 100 mg / L
c_{Cu}: 664 mg / L

Conclusions

- **Synthesis procedure of universal hydrogel matrix for controlled implementation of metal sorbents**
- **Highly efficient silver removal by a “magnetic sponge” (pNIPA / magnetite thermoresponsive ferrogel)**
- **Silver adsorption on magnetite in pNIPA ferrogel is described by the Freundlich model**
- **The presence of gel matrix increases efficiency of silver sorption on magnetite**