Outline of presentation

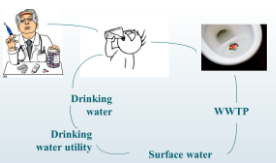
- Introduction
- Principle of affinity adsorption
- Results; proof of principle
- Conclusions

Introduction
Pharmaceuticals in the watercycle

Many organic micropollutants in water cycle

Pharmaceuticals are found in sources of drinking water:
- Groundwater
- Surface water
- Bank filtrate

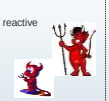
Origin:
- Human
- Veterinarian



Introduction
Pharmaceuticals in the watercycle

Concern:
- Designed to affect organisms
- Metabolites may be at least as reactive

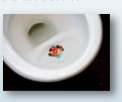
Problems:
- "small" molecules
- Hydrophilic/charged
- Difficult to remove by common treatment methods



Adsorption:	too small
	break through
Filtration:	too small
	charge
	formation of concentrate
	Large energy demand
(Advanced) oxidation:	not always sensitive
	formation of byproducts
	large energy demand

Introduction
Pharmaceuticals in the watercycle

Two possible strategies:
1. Polishing step in drinking water production process
2. Removal at the source



Advantages:
- Limited amount of different pharmaceuticals
- "high" concentrations

Principle of affinity adsorption

Adsorption depends on:
- Properties adsorbate
- Surface properties adsorbent
- Presence of compounds/groups on surface
- Presence of competitors (other compounds, NOM, salts, etc.)
- pH

Affinity adsorption depends on:
Specific interactions between adsorbent surface groups and functional groups within molecule.

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Principle of affinity adsorption

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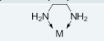
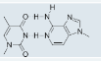
Principle of affinity adsorption

Interaction	example
Van der Waals	(Induced) dipole interactions
Dative bond	
Coulomb forces	NaCl
Hydrogen bonding	
Base pairing (special case of hydrogen bonding)	
Acid – base reaction	
π – stacking	

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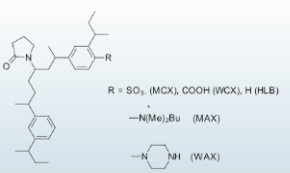
Results
Polymer adsorbents

Oasis materials:

Polymer backbone
Different functional groups



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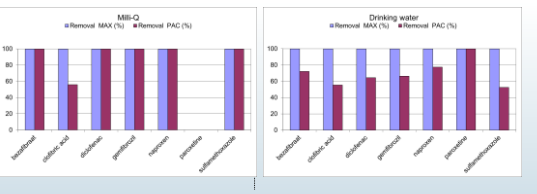
Results
Polymer adsorbents: effect of competition



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Results
Polymer adsorbents

Affinity adsorption: proof of principle

Disadvantages of adsorbents:

- Limited availability
- Expensive
- Difficult to remove in e.g. WTTP (density ≈ 1)

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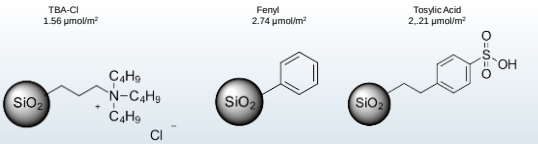
Results
Silica modified with silanes

TBA-Cl
1.56 µmol/m²

Fenyl
2.74 µmol/m²

Tosylic Acid
2,.21 µmol/m²



Particle size ca. 50 µm

Specific surface area ca. 500 m²/g

Density ca. 2,65 g/cm³

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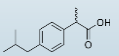
Results
Silica

Benzoic acid

Carbamazepine

Diclofenac

Ibuprofen

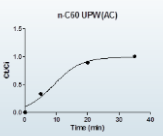


Results
Silica

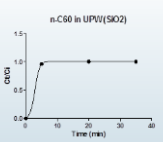
compound	Bmax (g/kg)	Mol/mol TBA or fenyl
Diclofenac	12	0,062
Benzoic acid	24	0,313
Ibuprofen	30	0,225
carbamazepine	12	0,042

Results
Column experiments for removal of fullerene n-C60; break through curves

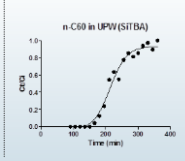
Activated Carbon



Bare SiO_2



SiO_2/TBA



Effect of charge interactions: surface n-C60 is negatively charged.

Conclusions

Proof of principle:
- Affinity adsorption effective method to deal with specific contaminants
- Extra filtration step in drinking water process
- Removal at source (high density → removal together with sludge)

Further research required:
- Optimization of adsorbents
- Adsorption kinetics: is adsorption fast enough for removal at source?
- Influence water matrix
- Economical aspects

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