Magnetic ionogels for fluid handling in microfluidic devices

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Outline

1. The need for stimuli responsive materials in microfluidics

2. Ionogels

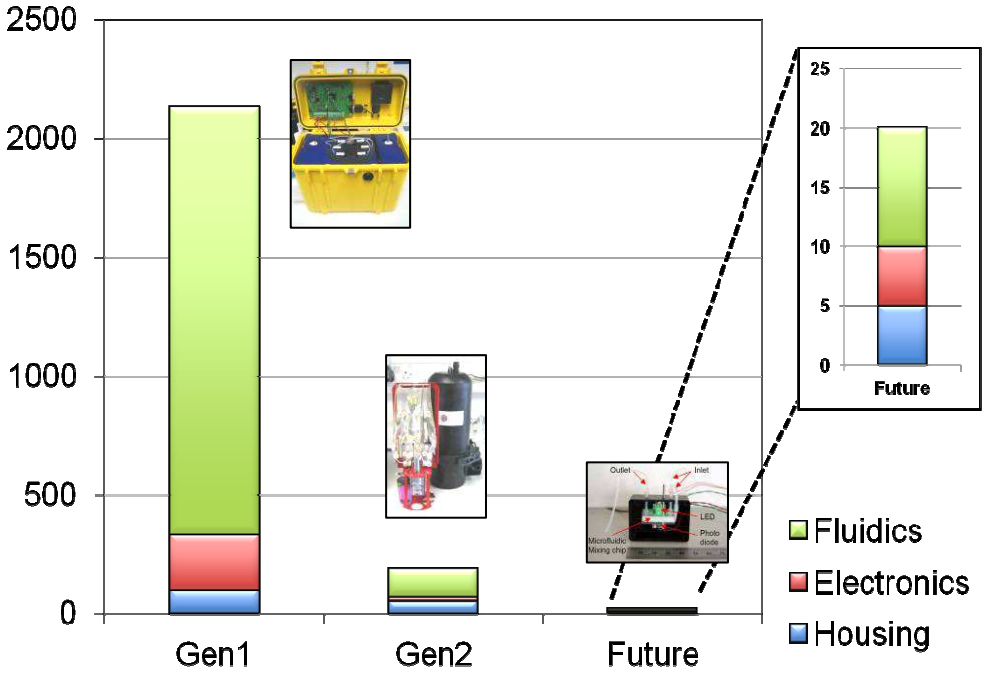
3. Magnetic ionogels

4. Future work

5. Conclusions

1. The need for stimuli responsive materials in microfluidics

- Autonomous sensor platforms for water quality are available
- High cost, high maintenance, high power usage
- Evolutionary engineering approach
- Revolutionary materials reserach



2. Ionogels

What are ILs?:

- **Organic salts**
- **Negligible vapour pressure**
- **High thermal stability**
- **Tunable properties**
- **Some are liquid at room temperature**
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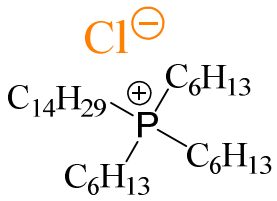
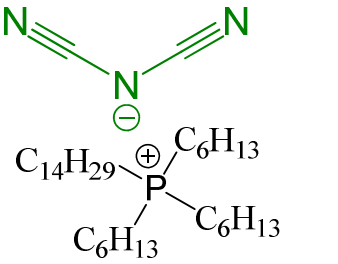
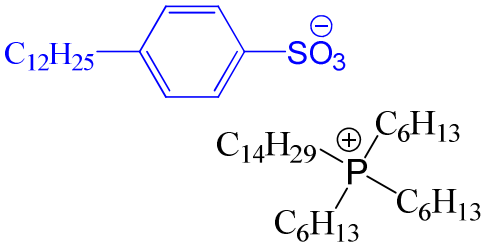


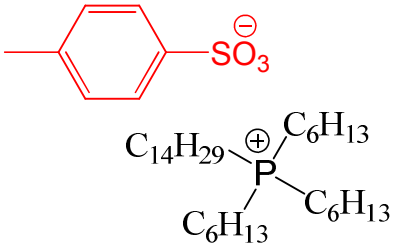
[$P_{6,6,6,14}$][Cl]



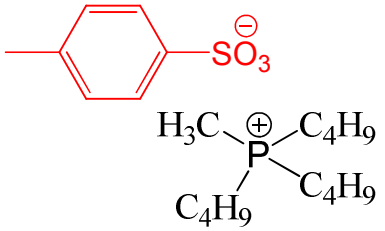
[$P_{6,6,6,14}$][DCA]



[$P_{6,6,6,14}$][dbsa]



[$P_{6,6,6,14}$][Tos]



[$P_{1,4,4,4}$][Tos]

2. Ionogels

Recipe for

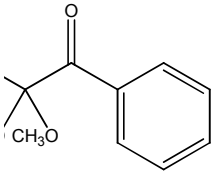
1 mole of

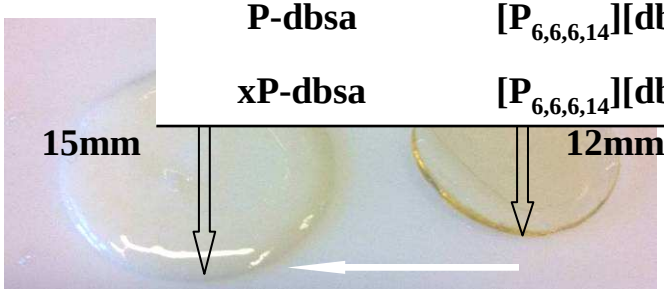
0.05 mole

0.02 mole

Stir togeth

Sample abbreviation	IL (1.2 mL)	NIPAM [mmol]	MBIS [mmol]	DMPA [mmol]
P-Cl	$[P_{6,6,6,14}][Cl]$	3.53	-	0.07
xP-Cl	$[P_{6,6,6,14}][Cl]$	3.53	0.18	0.07
P-DCA	$[P_{6,6,6,14}][DCA]$	3.53	-	0.07
xP-DCA	$[P_{6,6,6,14}][DCA]$	3.53	0.18	0.07
P-Tos	$[P_{6,6,6,14}][Tos]$	3.53	-	0.07
xP-Tos	$[P_{6,6,6,14}][Tos]$	3.53	0.18	0.07
P_i-Tos	$[P_{1,4,4,4}][Tos]$	3.53	-	0.07
xP_i-Tos	$[P_{1,4,4,4}][Tos]$	3.53	0.18	0.07
P-dbsa	$[P_{6,6,6,14}][dbsa]$	3.53	-	0.07
xP-dbsa	$[P_{6,6,6,14}][dbsa]$	3.53	0.18	0.07





Soaking (H_2O)

2. Ionogels

Methods used:

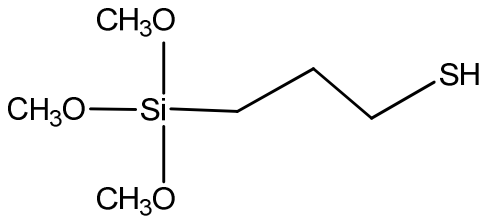
UV- curing rheometry

Custom made DSC chamber and UV-LED array

3. Magnetic ionogels:

Particle preparation

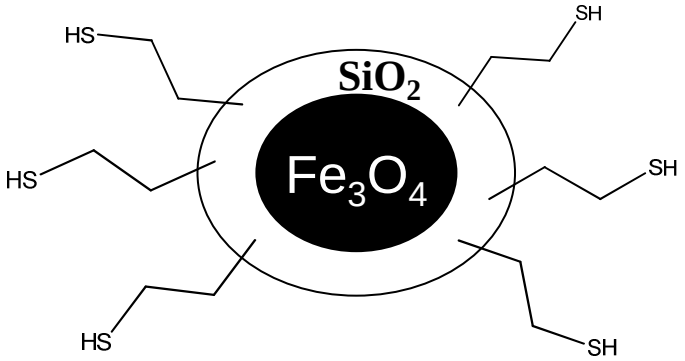
(3-mercaptopropyl)trimethoxysilane



OR

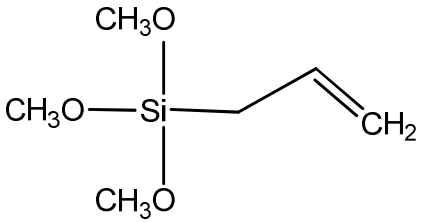
+

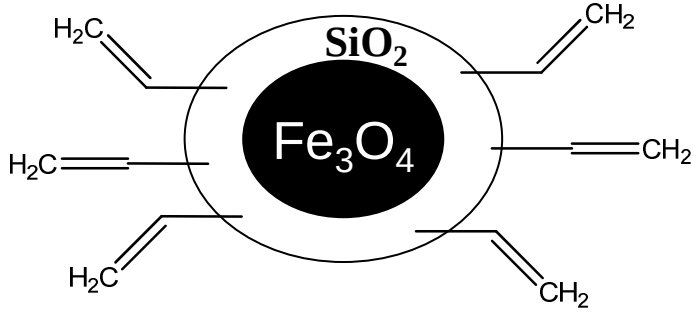
Fe_3O_4



OR

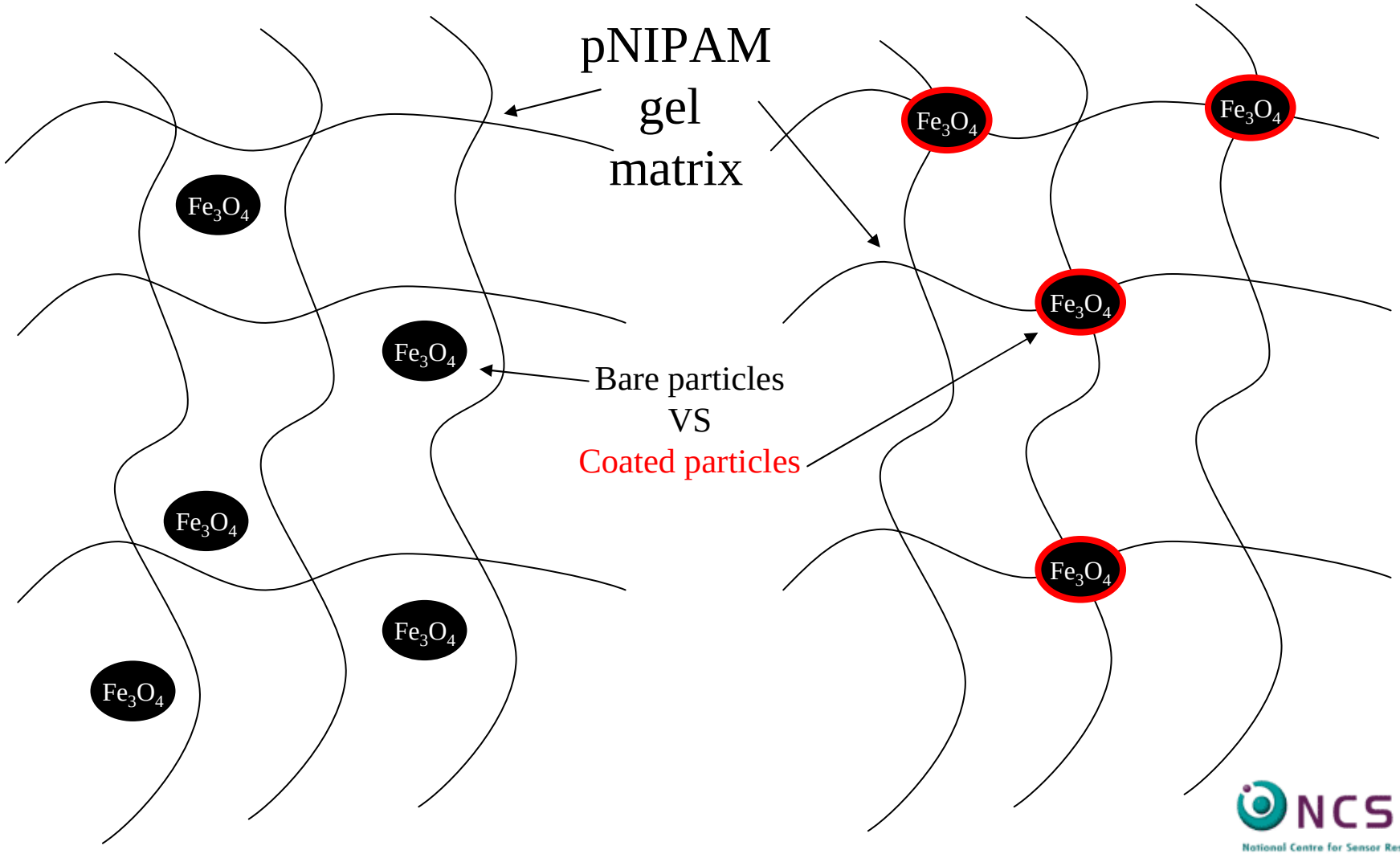
Allyltrimethoxysilane





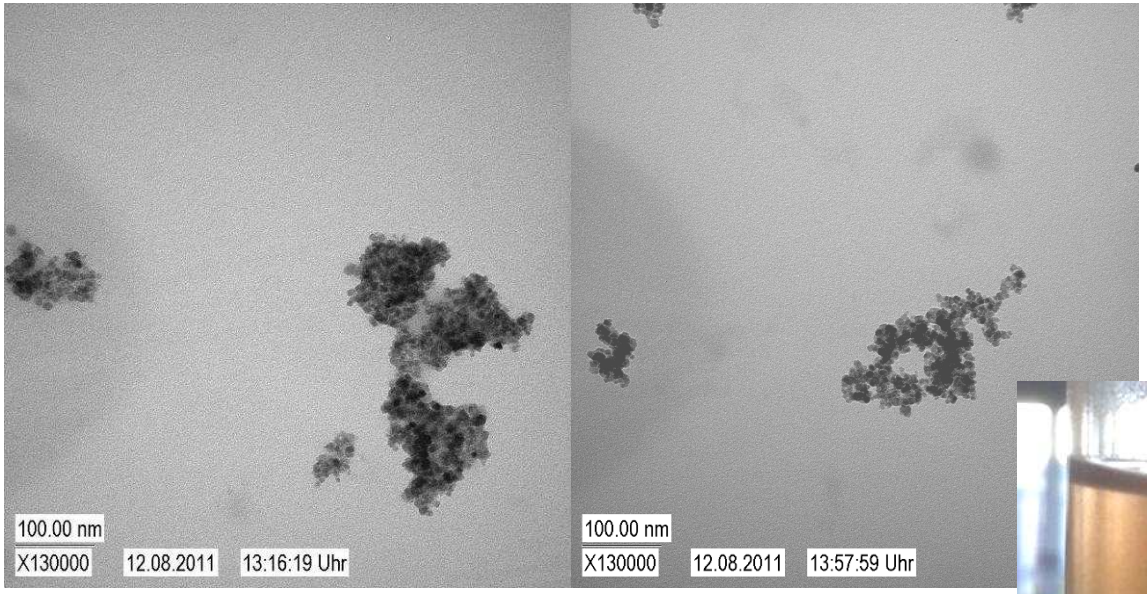
3. Magnetic ionogels:

Particle preparation



3. Magnetic ionogels: Particle preparation

TEM picture of the magnetic nanoparticles coated with MPTMS (left) & ATMS (right)



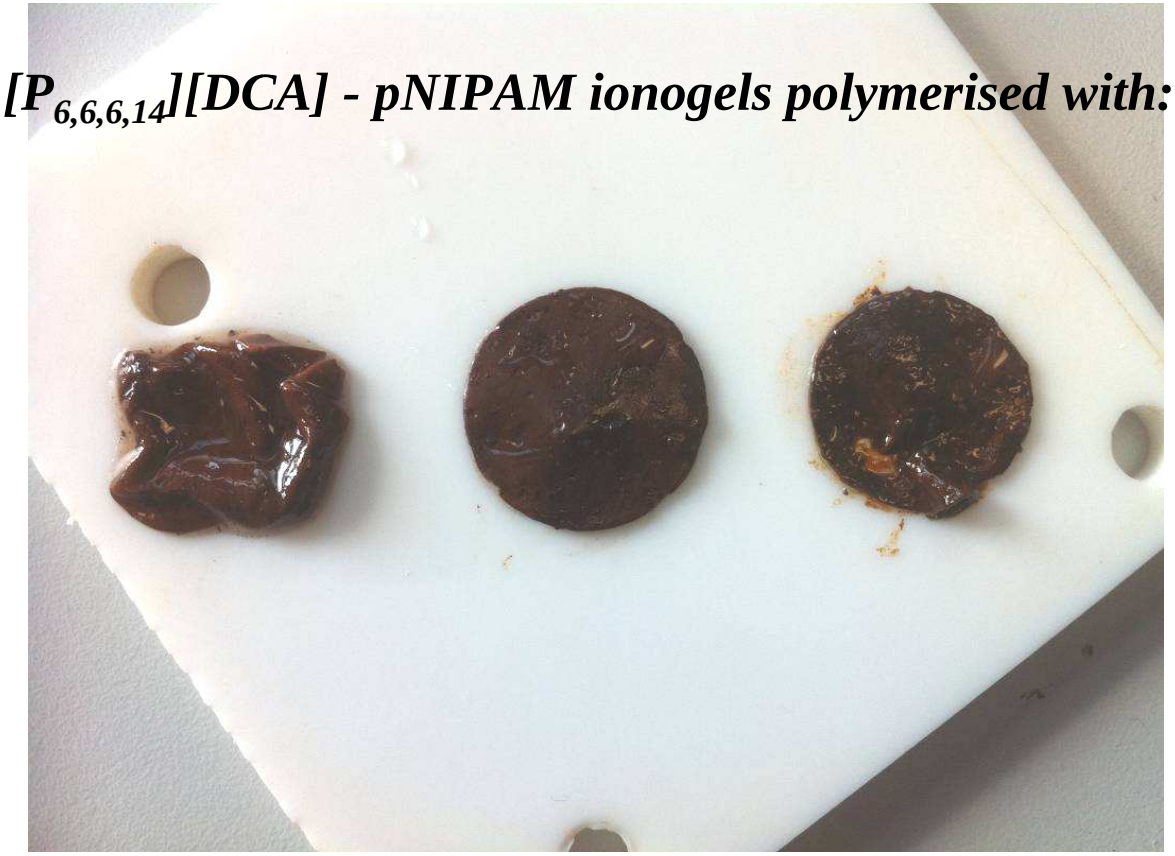
Left: bare Fe_3O_4 in acetone
Right: MPTMS coated Fe_3O_4 in acetone

Table 1. Dynamic light scattering analysis of functionalised nanoparticles. Their sizes and size distributions.

	MPTMS@F_3O_4	ATMS@Fe_3O_4
DLS intensity peak [nm]	261	172
PDI [nm]	108	70

3. Magnetic ionogels:
Analysis of ionogels

[$P_{6,6,6,14}$][DCA] - pNIPAM ionogels polymerised with:

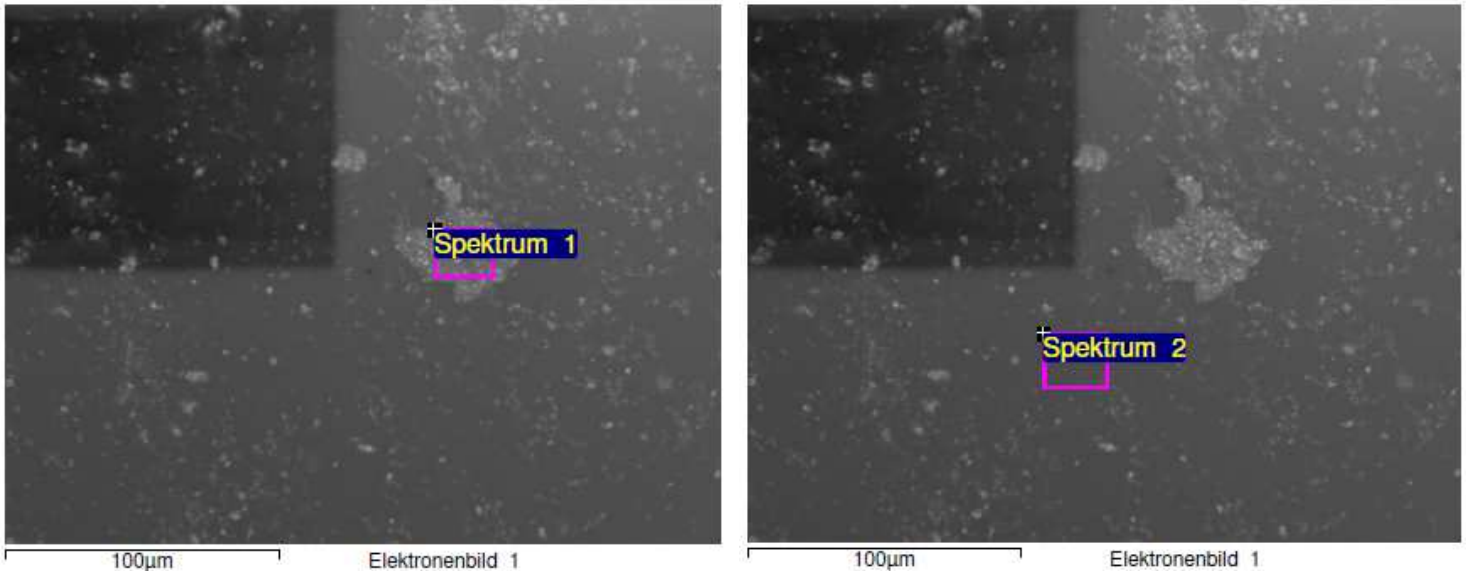


Left: bare Fe_3O_4 Middle: MPTMS coated Fe_3O_4 Right: ATMS coated Fe_3O_4

(20%wt in all)

3. Magnetic ionogels:

Analysis of ionogels

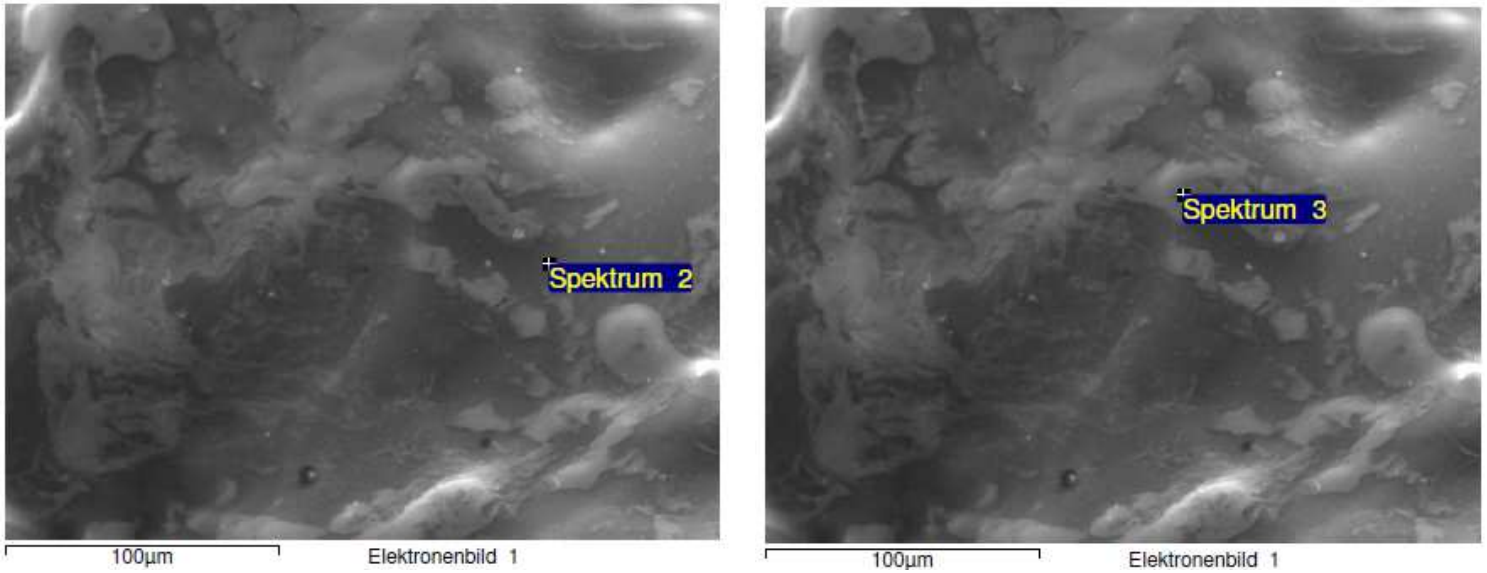


$[P_{6,6,6,14}][DCA]$ - pNIPAM ionogel polymerised with bare Fe_3O_4
Left: 25%Fe, 14%P
Right: 1%Fe, 27%P

Bare particles phase-separate in the final material

3. Magnetic ionogels:

Analysis of ionogels



[$P_{6,6,6,14}$][DCA] - pNIPAM ionogel polymerised with ATMS coated Fe_3O_4
Left: 25%Fe, 14%P
Right: 36%Fe, 6%P

Coated particles do not phase separate

3. Magnetic ionogels:

Actuation

4. Future work

- Spectroscopic analysis of IL-polymer and IL-monomer interactions

- Optimisation of the organosilicon coating process of magnetite

- Magnetic analysis of ionogels to determine their susceptibility to magnetic fields

- Integrating this composite material into microfluidic manifolds and demonstrating a working valve and/or a working pump
    - Oscillating magnetic field actuation
    - Permanent magnet actuation

5. Conclusions

- Stimulus responsive materials can revolutionise autonomous sensor platforms
- Ionogels – functional polymeric sponges filled with a non-volatile IL
- ILs significantly impact the ionogel's curing speed and stiffness
- Magnetic particles provide an attractive, non-invasive actuation method
- Magnetic nanoparticles can be coated with polymer linker organosilicon groups
  - Increased ionogel durability
  - Increased compatibility between the polymer and the particles
  - Reversible bending in non-uniform magnetic fields achieved

Acknowledgements

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Dr.

Dr.

Pro

Kat

Dr.

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• Germ
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• FP7 A
ITN, N