Nanoparticle Coating and Size : Key for optimal magnetic Biosensors

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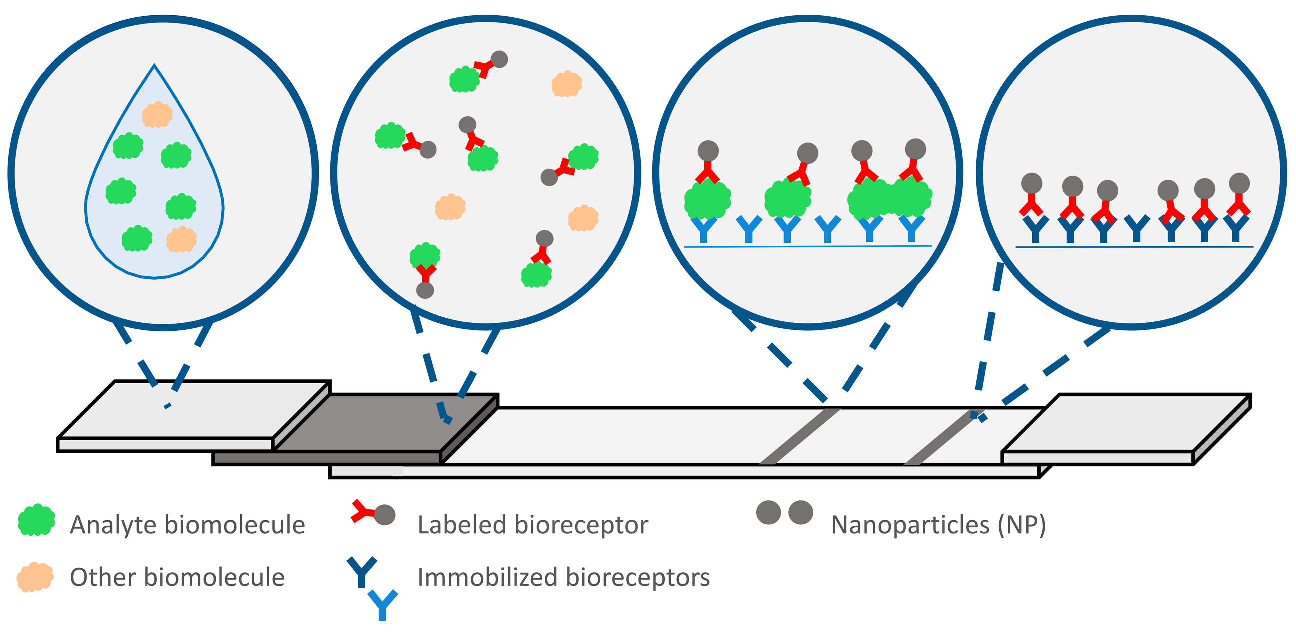
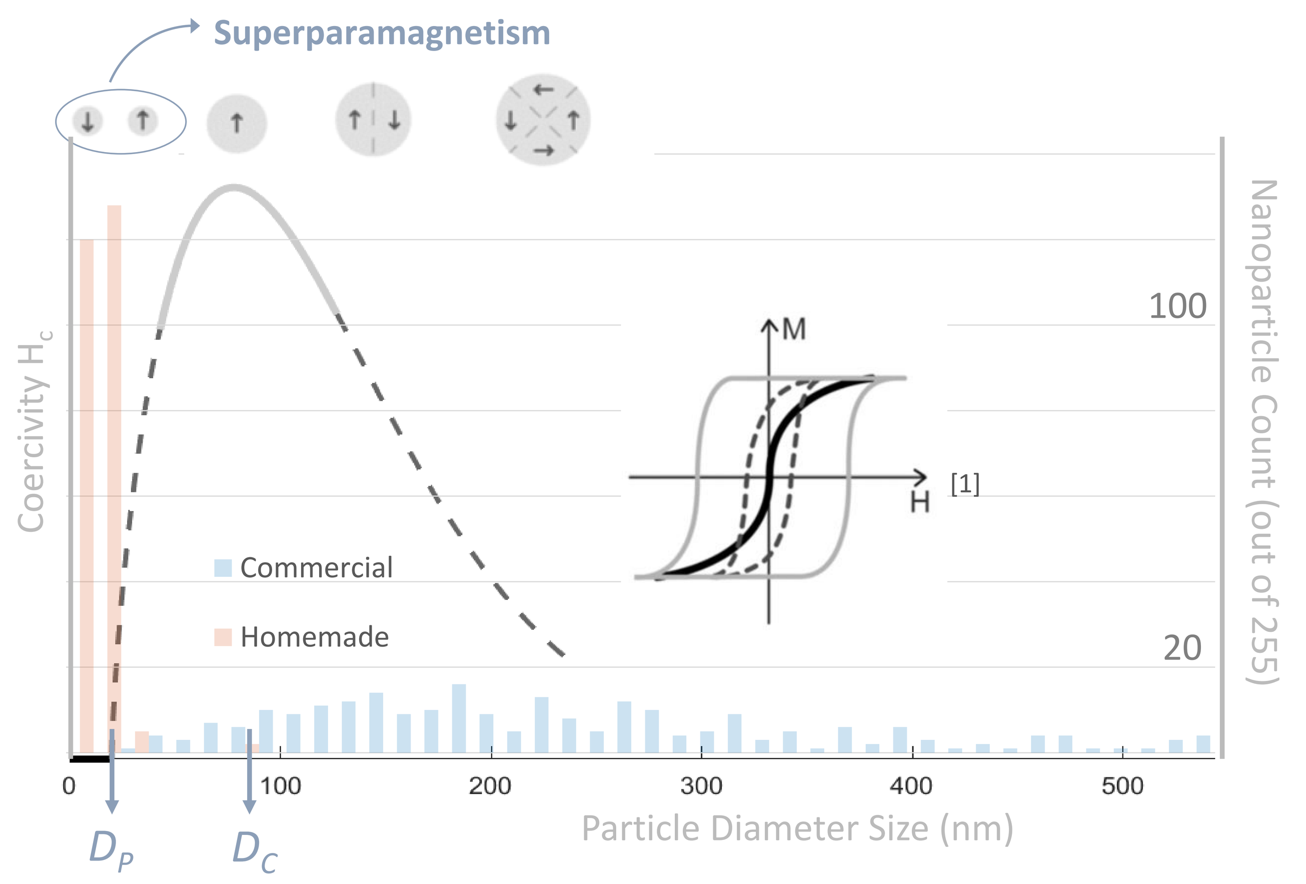
Magnetic Nanoparticles (MNP) in Biosensors



- Increasing use of **magnetic nanoparticles** (MNP)
  - ✓ **Low magnetic background noise** in the aqueous samples
  - ✓ Fast improvement of magnetic sensors

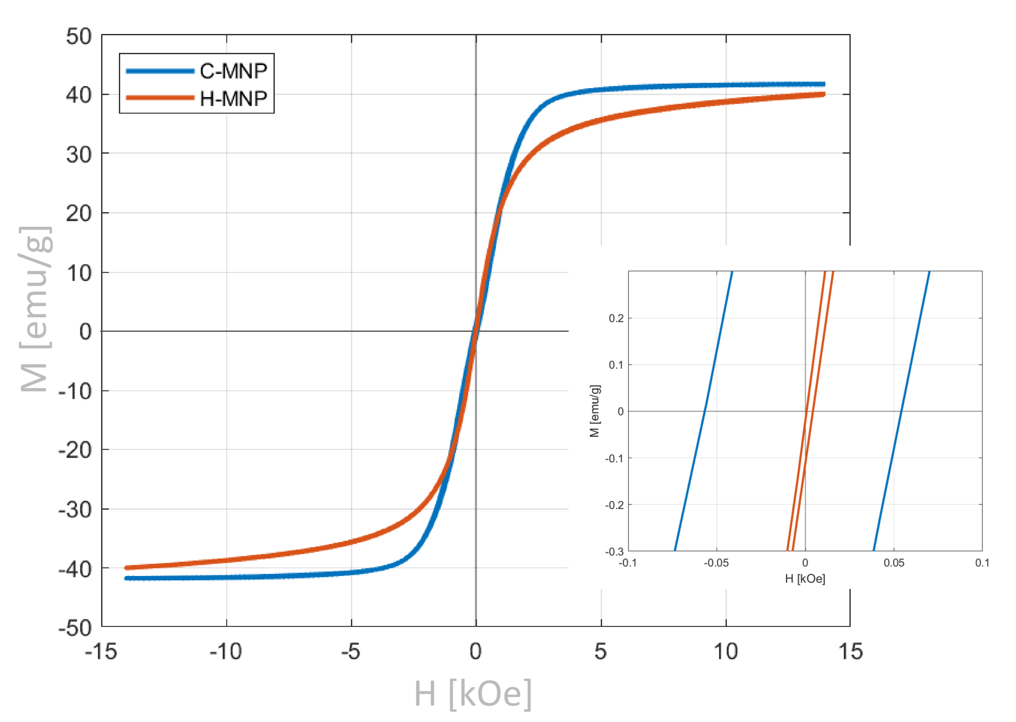
MNP size influences Magnetization

Coercivity variation and NP size distribution



Magnetisation curve of « bare » NP

- Homemade NP *H-MNP* [2]



Superparamagnetism D_p : 18 nm
Maximum Coercivity D_c : 82 nm

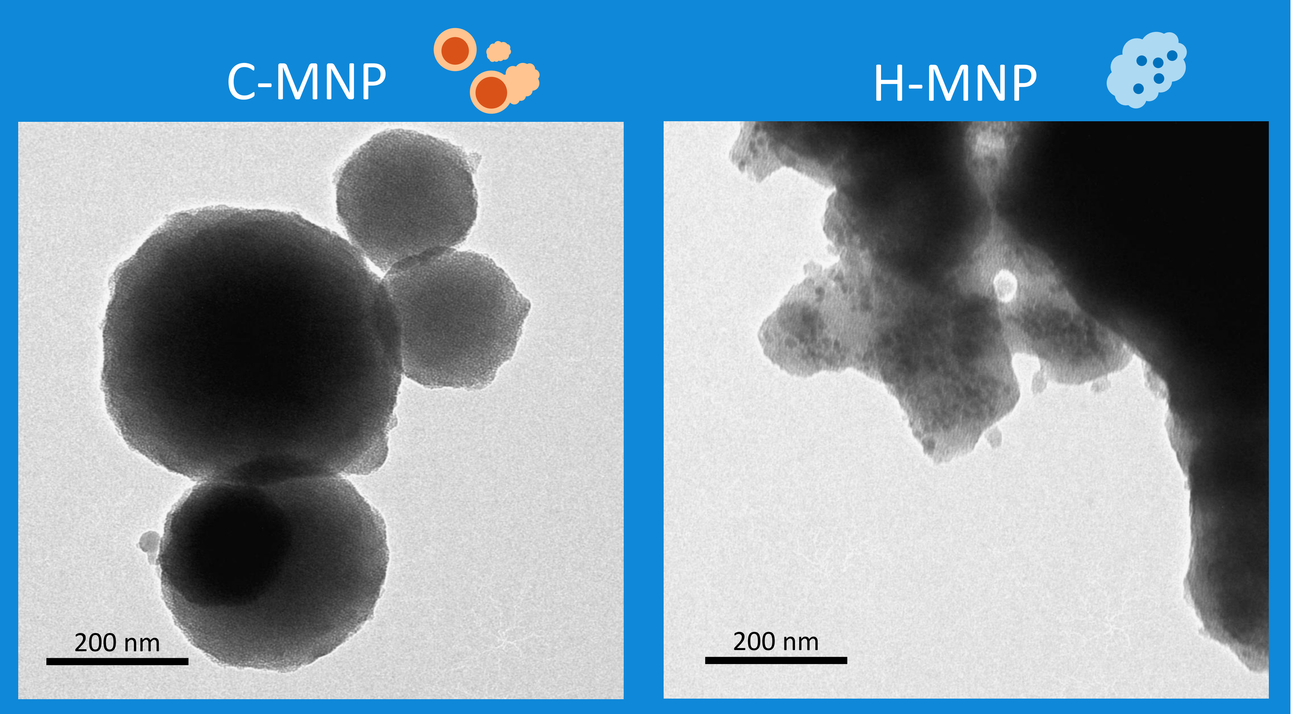
H_c *(H-MNP)* **<<** **H_c** *(C-MNP)*
→ Superparamagnetism

Slower saturation when smaller MNP
→ surface effect (spin canting) [6]

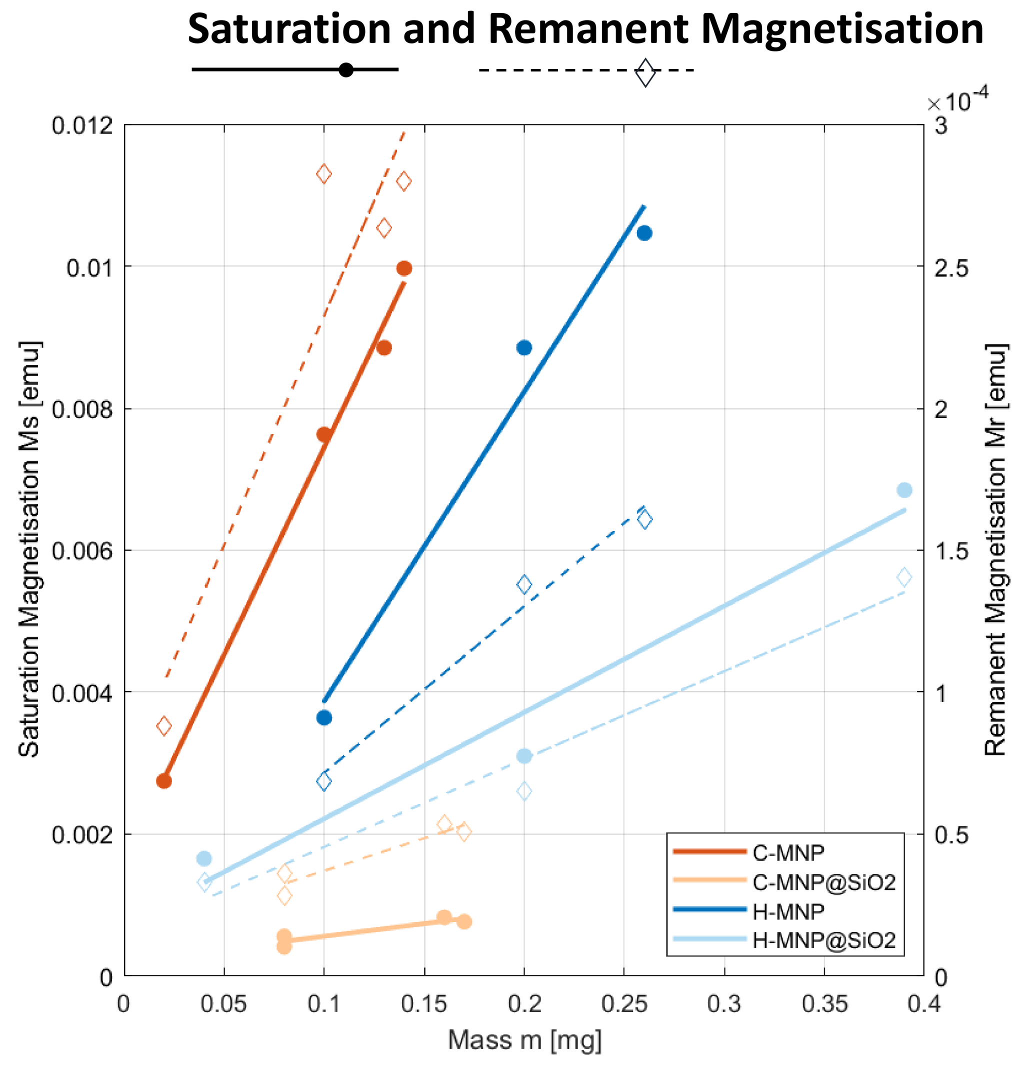
Silica Coating and its diamagnetic Influence

Silica coating [4]
- ✓ Good colloidal stability
- ✓ Functional groups for biomolecules
- ✓ Adaptable porosity

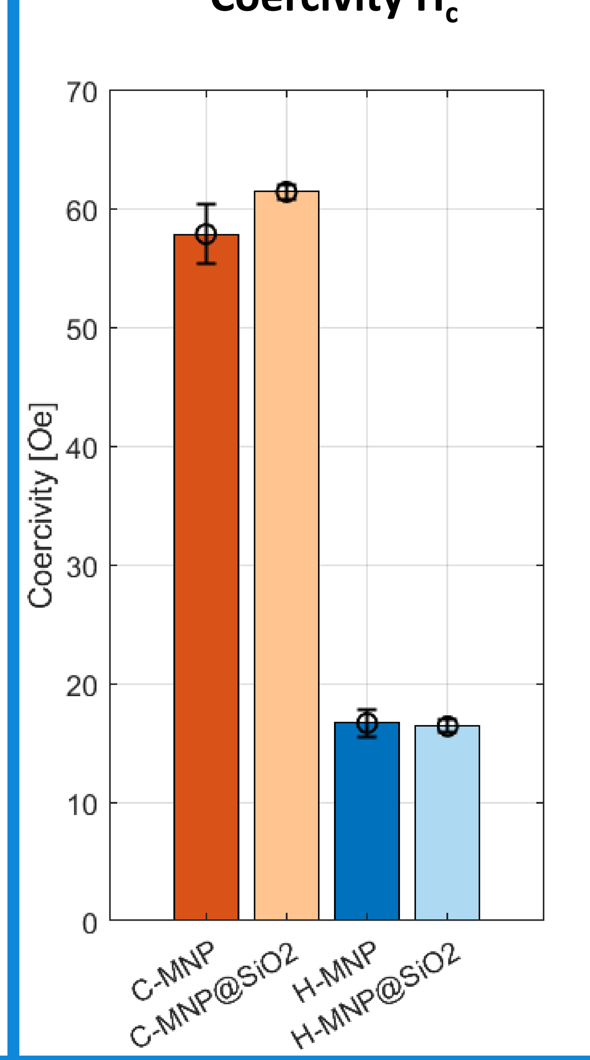
XPS Coating Validation
- ✓ 14% *Si*
- ✓ No bare *Fe* left



Saturation and Remanent Magnetisation



Coercivity H_c



Difference in **susceptibility** χ $[m^3 kg^{-1}]$
- SiO_2: $\chi = -0{,}6 \cdot 10^{-8}$
- Fe_3O_4: $\chi = 50\,000 \cdot 10^{-8}$

Saturation M_s [emu/g] after coating
- C-MNP : 93% decrease (avg)
- H-MNP : 36% decrease (avg)

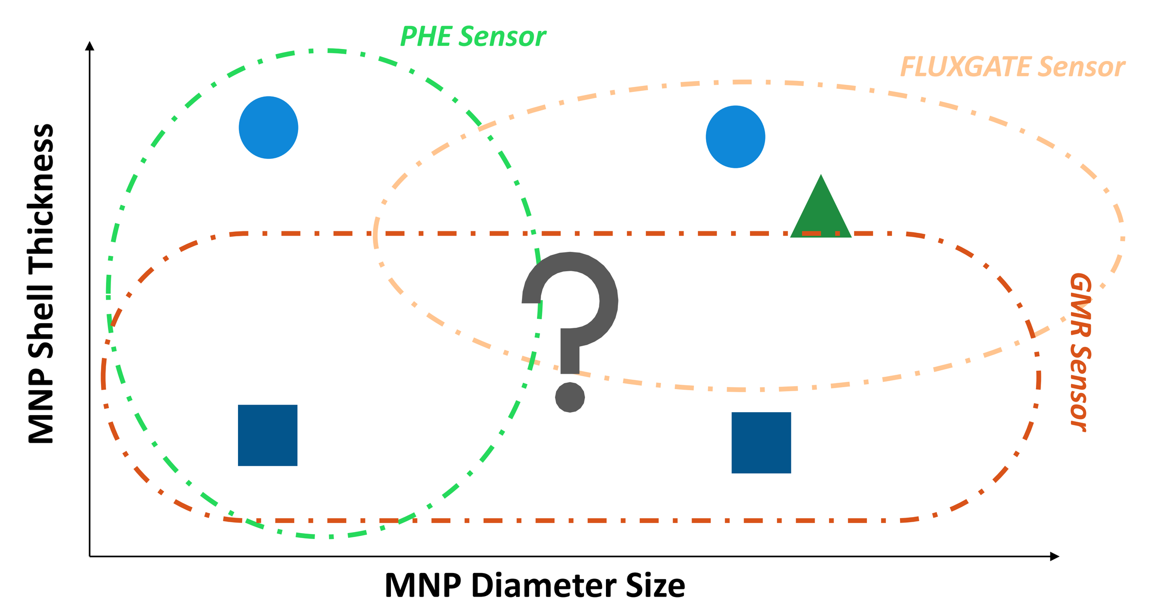
Remanence M_r [emu/g] after coating
- C-MNP : 87% decrease (avg)
- H-MNP : 24% decrease

Coercivity H_c unchanged after coating
- Independent of mass

Less influence on M_s and M_r of **superparamagnetic** nanoparticles

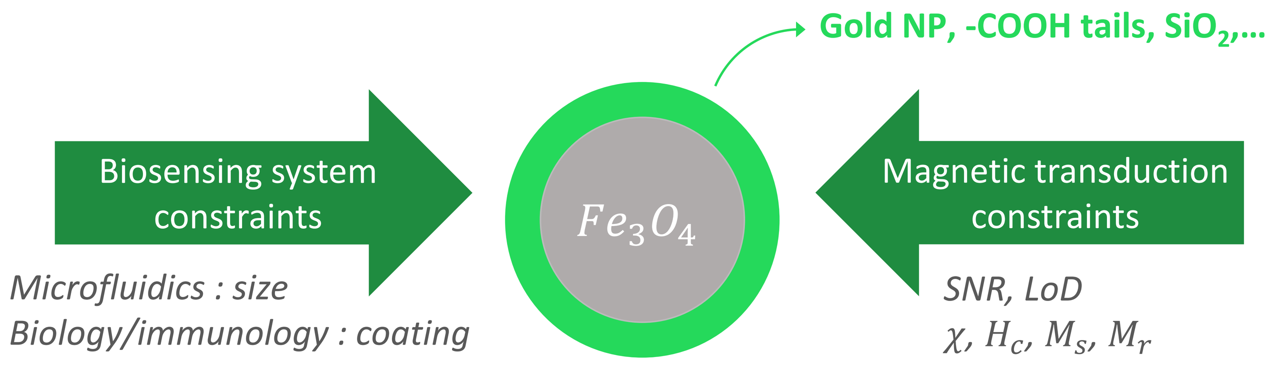
Bulk vs Surface properties ?

System-thinking



MEASURING **DISTANCE**
MNP **ROTATION** [5]
MNP **CONCENTRATION**

Gold NP enrobement
Phosphonates functionalisation
SiO2 coating



Two major parameters for an optimal biosensor system :
SIZE & COATING

Magnetic Characterisation Methodology

Alternating Gradient Force Magnetometer (AGFM)
- MNP powder samples : 0.02mg – 2mg
- Encapsulation in Kapton® Tape

Measurement of magnetic moment
- DC coils -15 → +15 kOe
- AC coils @ 500 Hz

Perspectives for future Works

Magnetic Properties Characterisation
- Gold NP enrobement, Phosphonates with –COOH tails
- Further characterisation with e.g. SQUID
- Measurements in « real conditions » : no MNP powder

Integration of adequate sensor system
- Design of adequate Fluxgate sensor
- Commercial PHE, GMR, Hall Effect sensors
- Interdisciplinary development of biosensor system

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References

[1] Mederos Henry, Francisco. "Decoration of Nanocarbon Supports with Magnetic Nanoparticles for the Control of Electromagnetic Propagation." UCLouvain, 2019.

[2] Pązik, Robert et al. "Energy Conversion and Biocompatibility of Surface Functionalized Magnetite Nanoparticles with Phosphonic Moieties." *The Journal of Physical Chemistry B* 124, no. 24 (June 18, 2020): 4931–48.

[3] *Sigma Aldrich 63710*

[4] Haynes, Tommy, Ovidiu Ersen, Vincent Dubois, Didier Desmecht, Keizo Nakagawa, and Sophie Hermans. "Protecting a Pd/CB Catalyst by a Mesoporous Silica Layer." *Applied Catalysis B: Environmental* 241 (February 2019): 196–204

[5] Gauge icons created by DinosoftLabs - Flaticon

[6] Moriya, Tôru. "Anisotropic Superexchange Interaction and Weak Ferromagnetism." *Physical Review* 120, no. 1 (October 1, 1960): 91–98