

Advanced material properties to support (eco)toxicological safety assessment



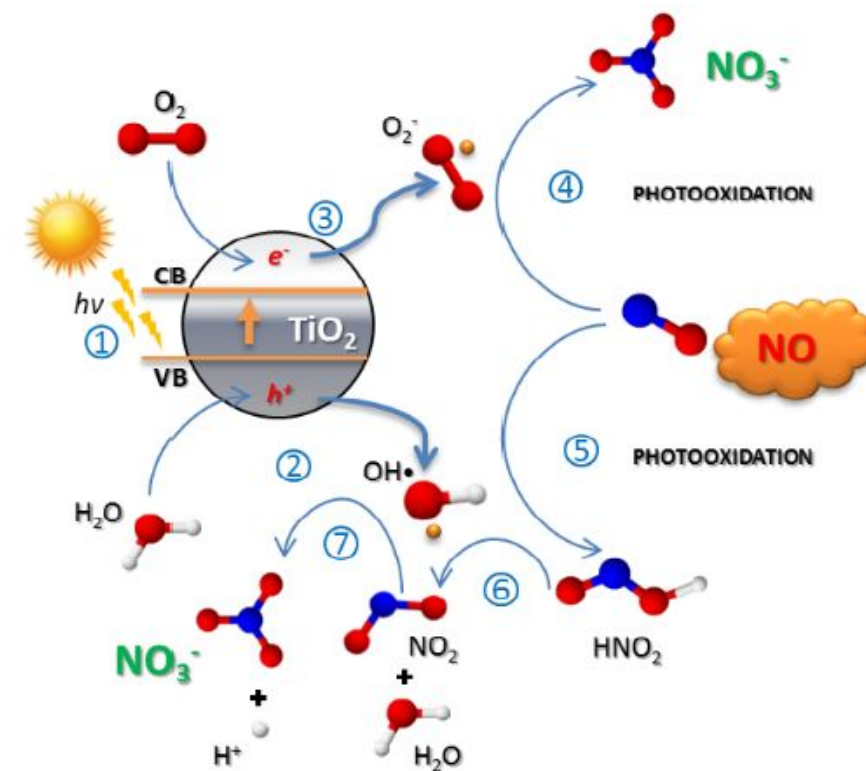
Ca' Foscari
University
of Venice

Dr. Andrea Brunelli



Funded by
the European Union

Case study

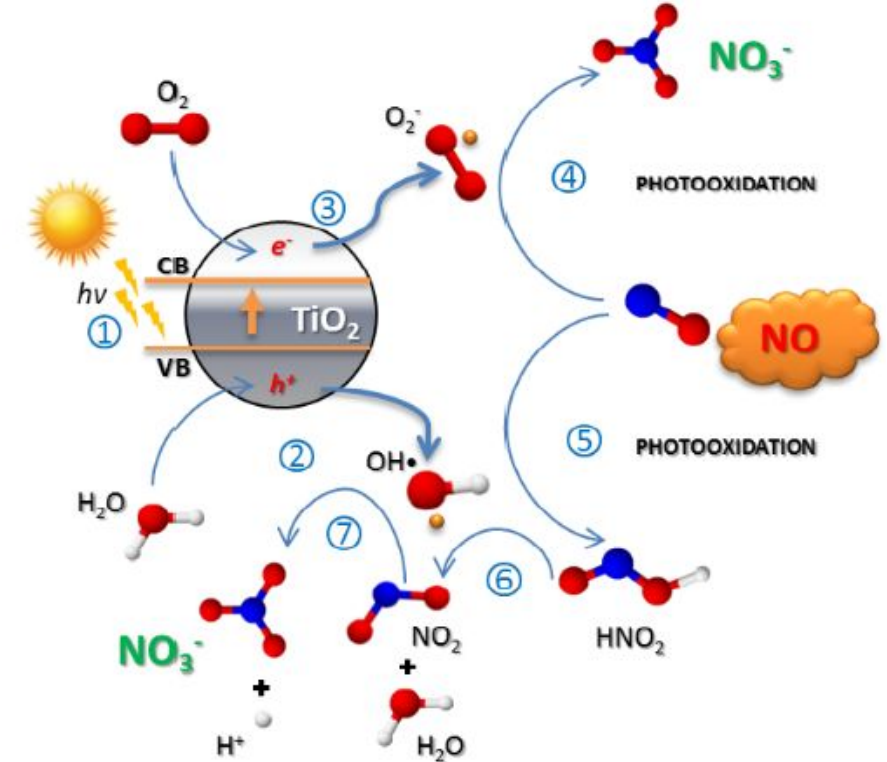


Case study

AdMa



SiO₂@ZnO



- ❖ ZnO was chosen as a safer alternative to TiO₂ NPs
- ❖ SiO₂ NPs has been used as improves performance, compatibility and dispersibility of ZnO in the construction materials

Chemical/Material synthesis

NPs + zinc acetate



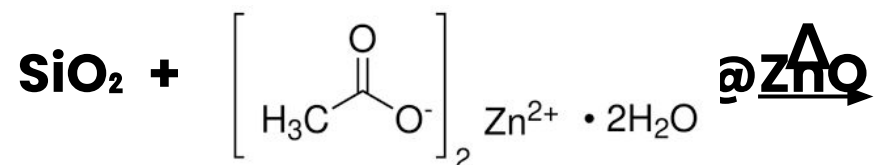
AdMa

Chemical/Material synthesis

NPs + zinc acetate



AdMa

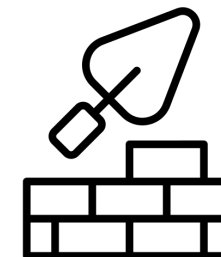
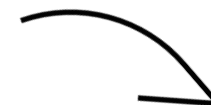
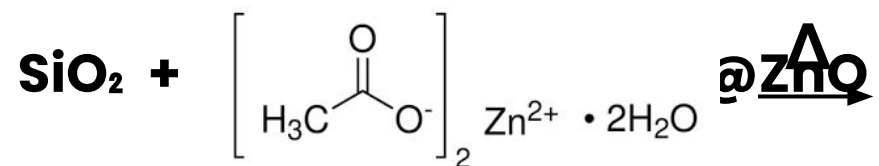


Final product

NPs + zinc acetate



AdMa

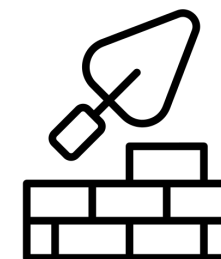
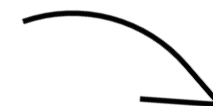
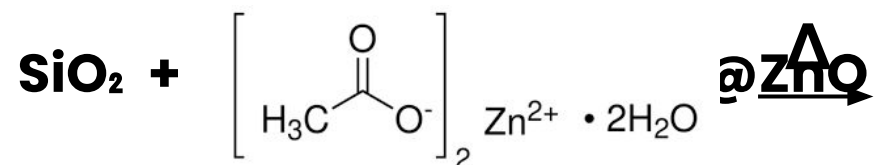


Final product

NPs + zinc acetate



AdMa



Reference materials



ZnO NPs

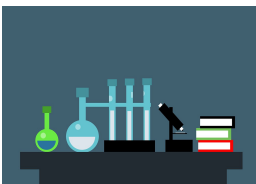


**TiO₂
NPs-based**



**Silica
fume-based**





Characterization

SiO₂

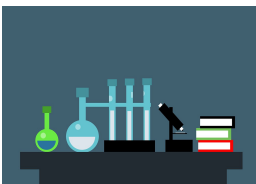


ZnO



SiO₂@ZnO





Characterization

SiO₂



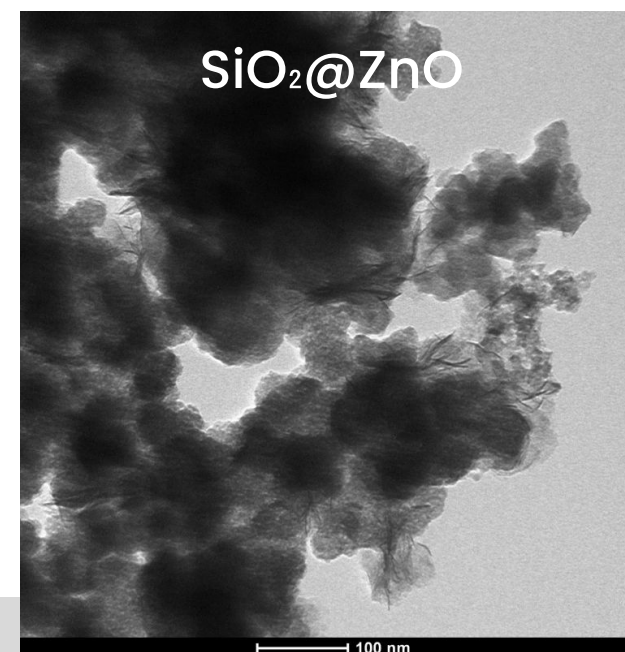
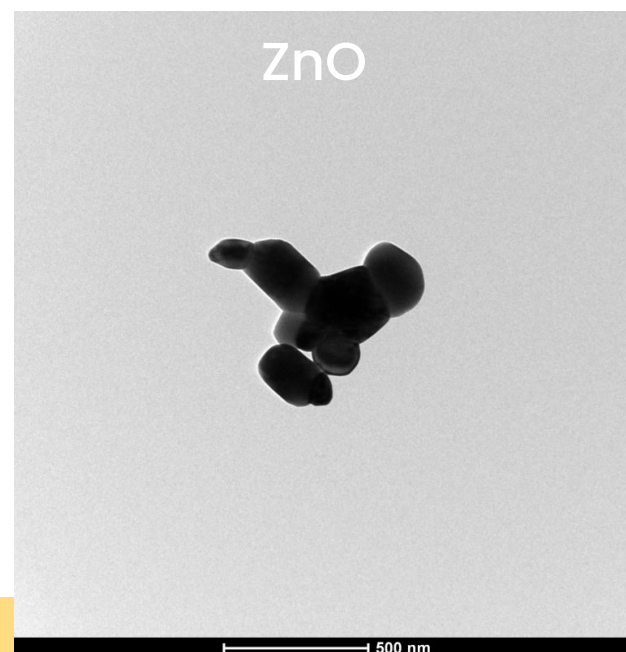
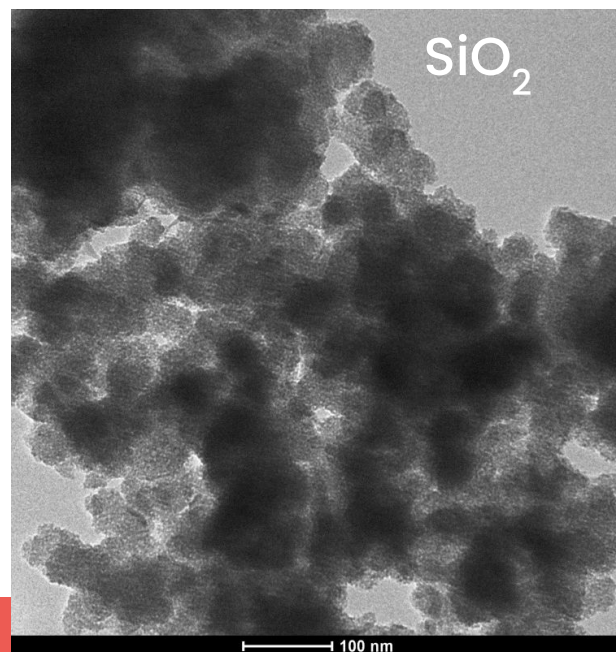
ZnO

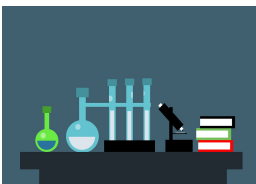


SiO₂@ZnO



Transmission Electron Microscopy (TEM)





Characterization

SiO₂



ZnO



SiO₂@ZnO



Size

- Small particles tend to be more toxic than larger particles from the same material.

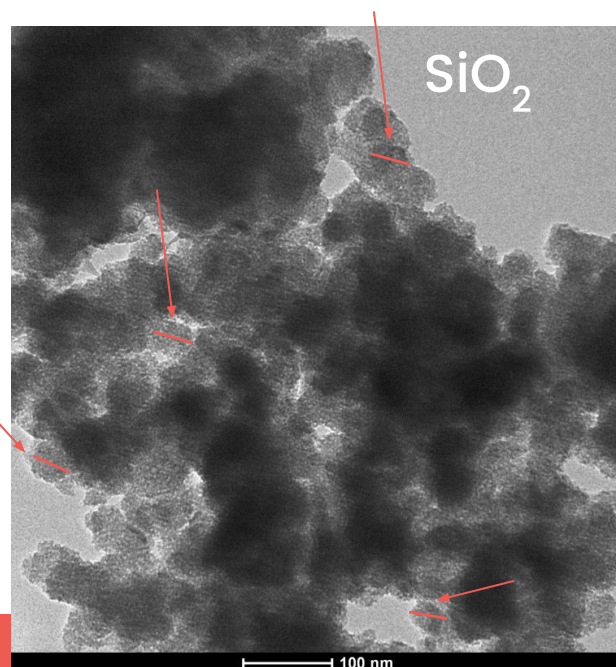
Shape

- Toxic interaction with cells can be enhanced due to the shape of the NMs.

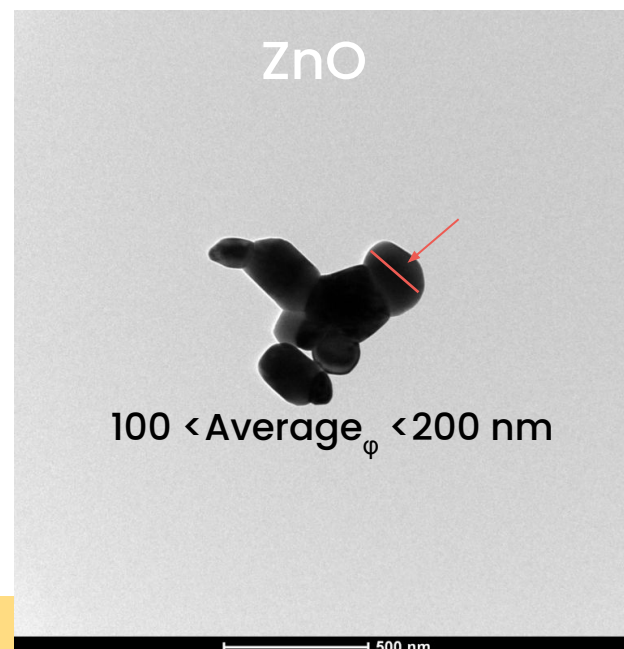
Transmission Electron Microscopy (TEM)



Average_φ
~ 20 nm

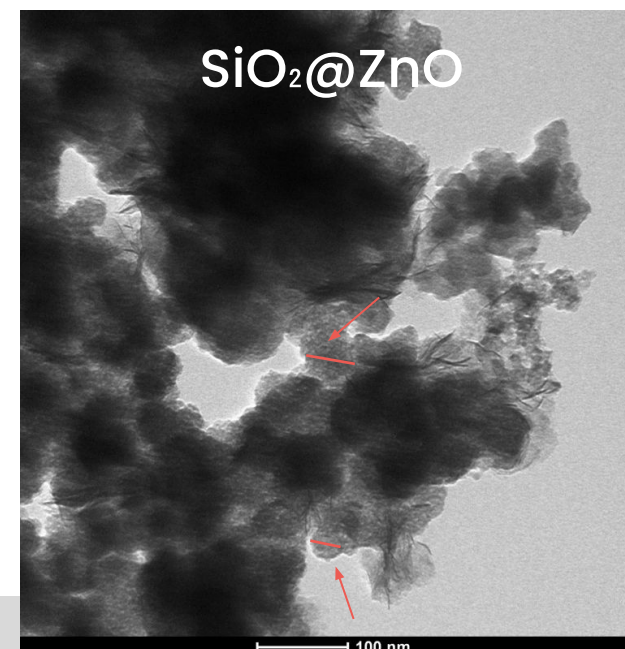


ZnO



100 < Average_φ < 200 nm

SiO₂@ZnO



ZnO

Average_φ
~ 20 nm

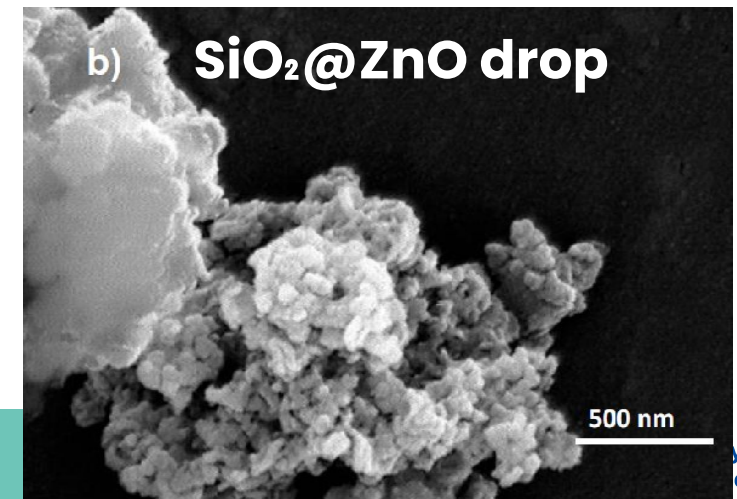
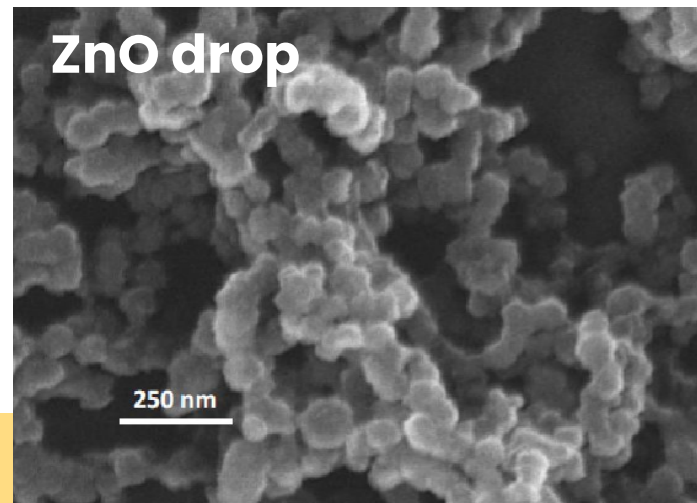
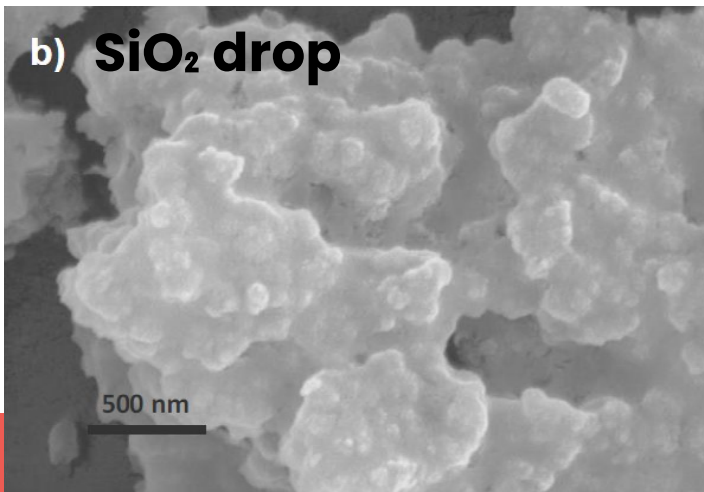
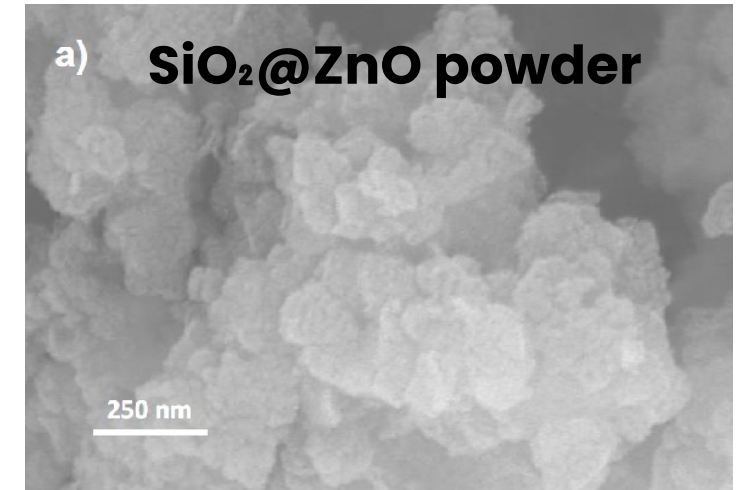
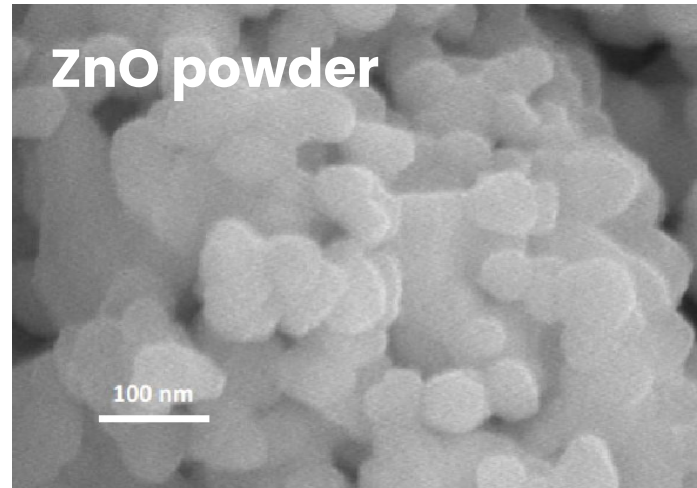
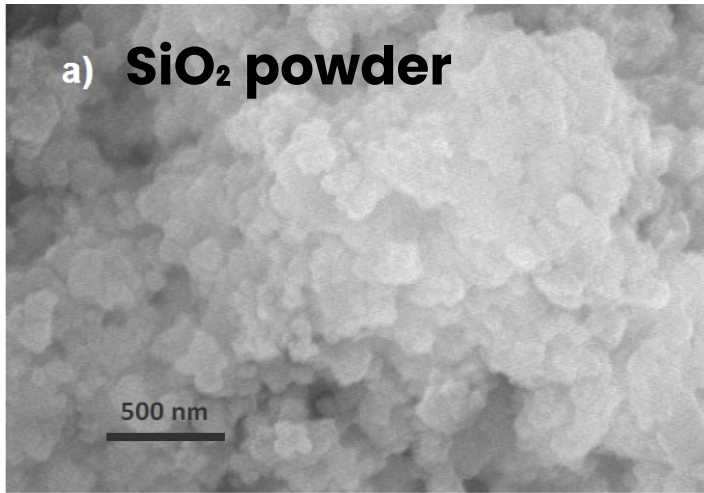


Characterization

Scanning Electron Microscopy (SEM)

Shape

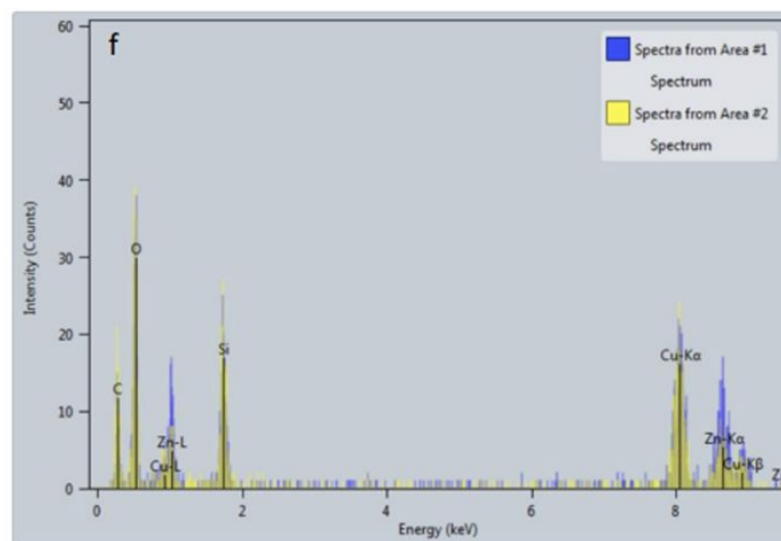
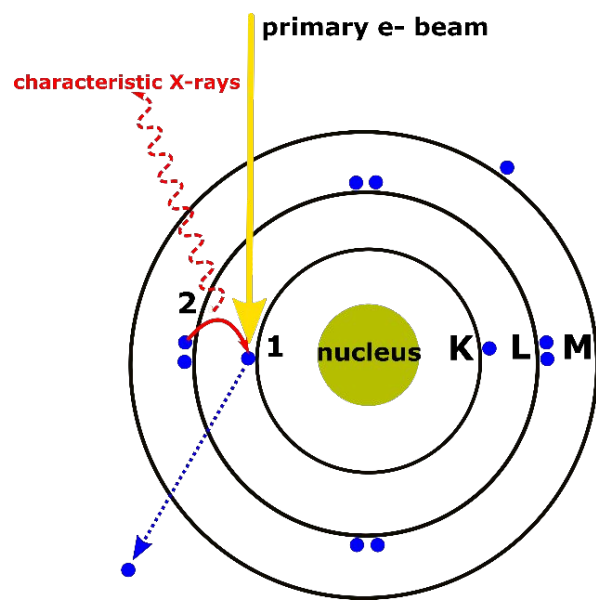
- Toxic interaction with cells can be enhanced due to the shape of the NMs.



Characterization

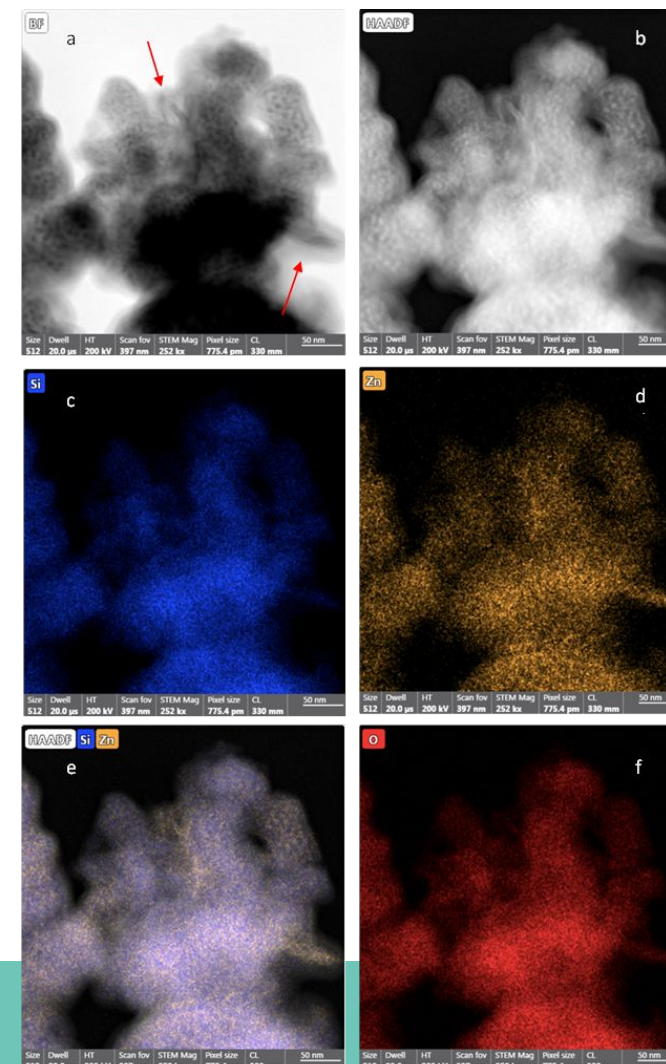


Energy Dispersive X-ray (EDX) mapping



Chemical Composition

- Toxicity depends on the chemistry (e.g., inherent toxicity of metals) of the NMs.





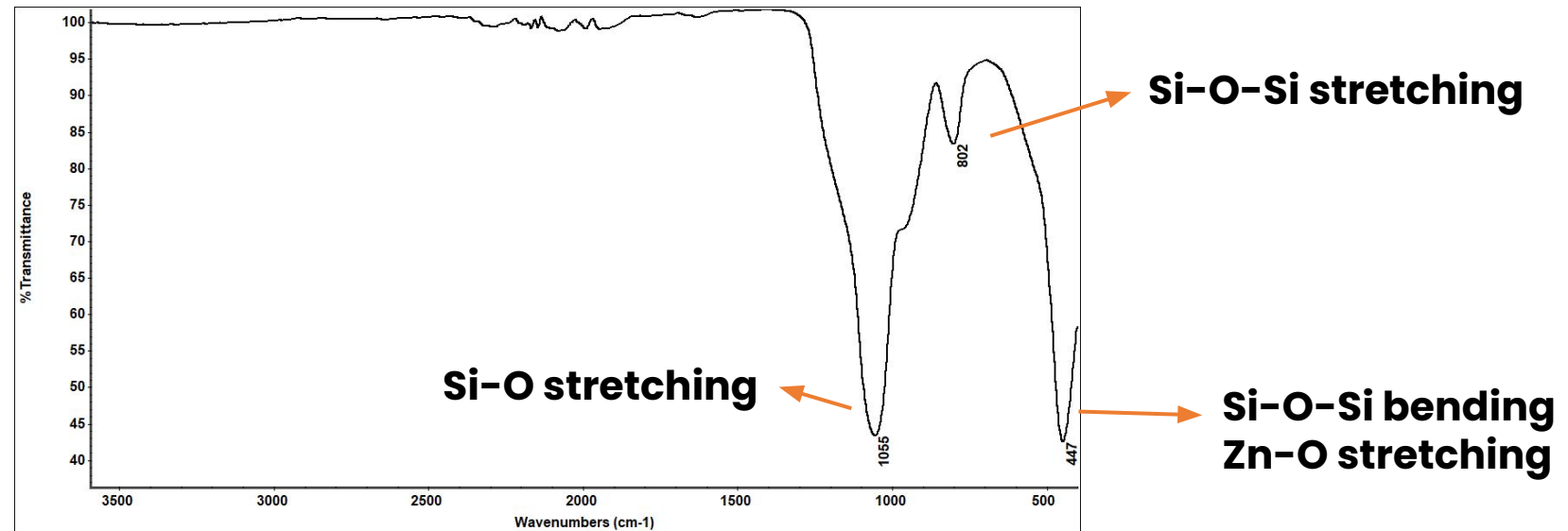
Characterization



Surface chemistry and functionalization

- The chemical composition of the surface and the presence of functional groups may alter NMs i.e., reactivity, solubility, interaction with biological systems, affecting their toxicity.

Fourier Transform Infrared spectroscopy (FTIR)





Characterization

Surface area

- The reactivity of NMs grows with increasing surface area (more sites for chemical reactions/interactions are provided), which influences the toxicity of the materials.



	Specific surface area (m ² /g)	Pore volume (cm ³ /g)	Porosity
SiO ₂	119.2±0.6	0.170±0.008	Mesoporous
SiO ₂ @ZnO	48.7±0.2	0.142±0.007	Mesoporous



Characterization

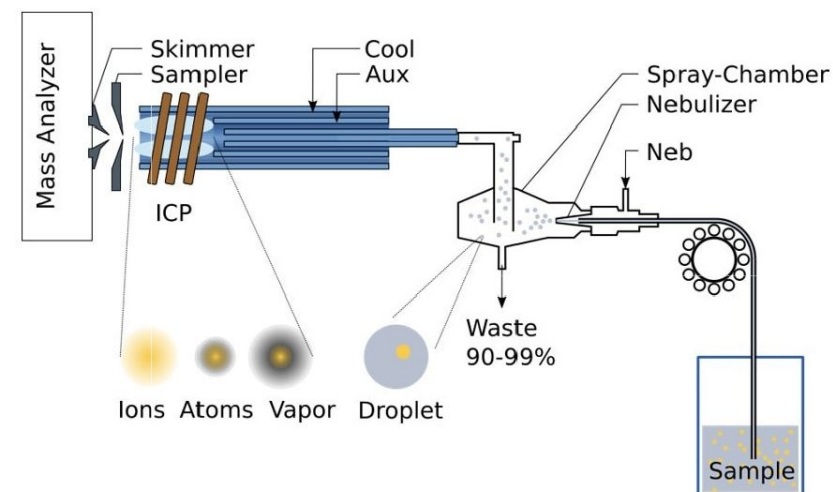
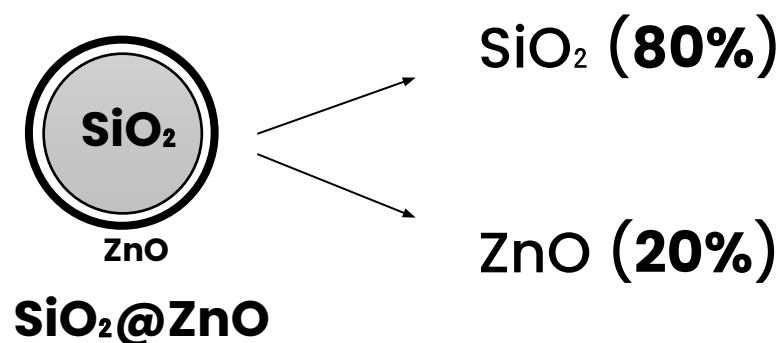
$\text{SiO}_2@\text{ZnO}$



Chemical Composition

- Toxicity depends on the chemistry (e.g., inherent toxicity of metals) of the NMs.

Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES)





Characterization

Dispersion stability

- The ability of NMs to remain dispersed in biological fluids affect their bioavailability, distribution, and potential for accumulation in organs.

Surface charge

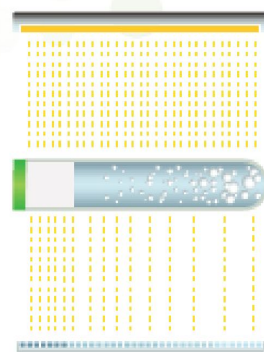
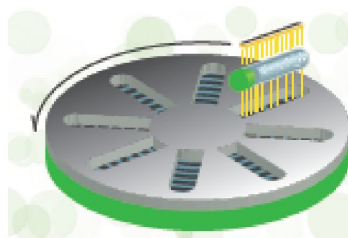
- Surface charge affects the interaction of NMs with cell membranes.

Dispersion stability



Hydrodynamic size

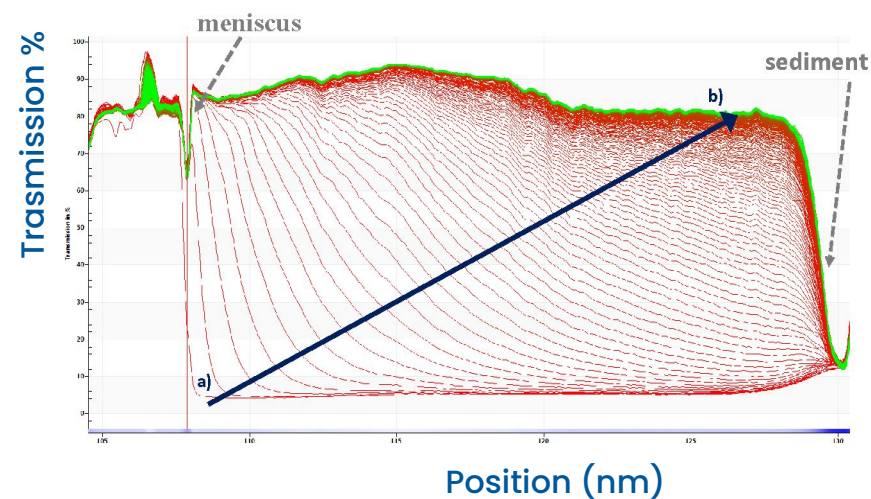
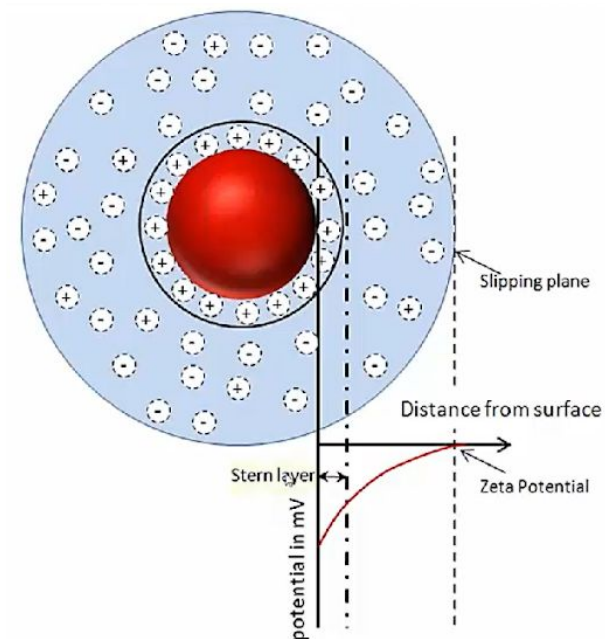
Zeta-potential

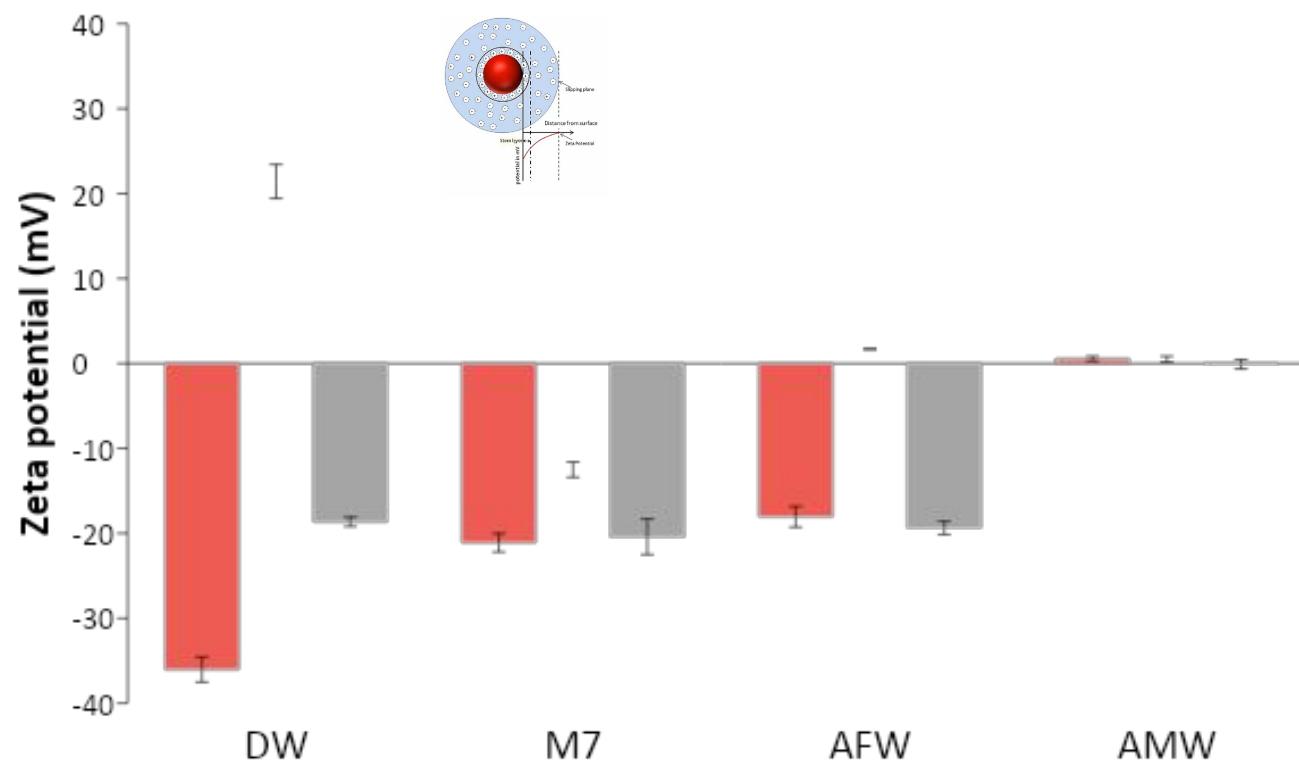
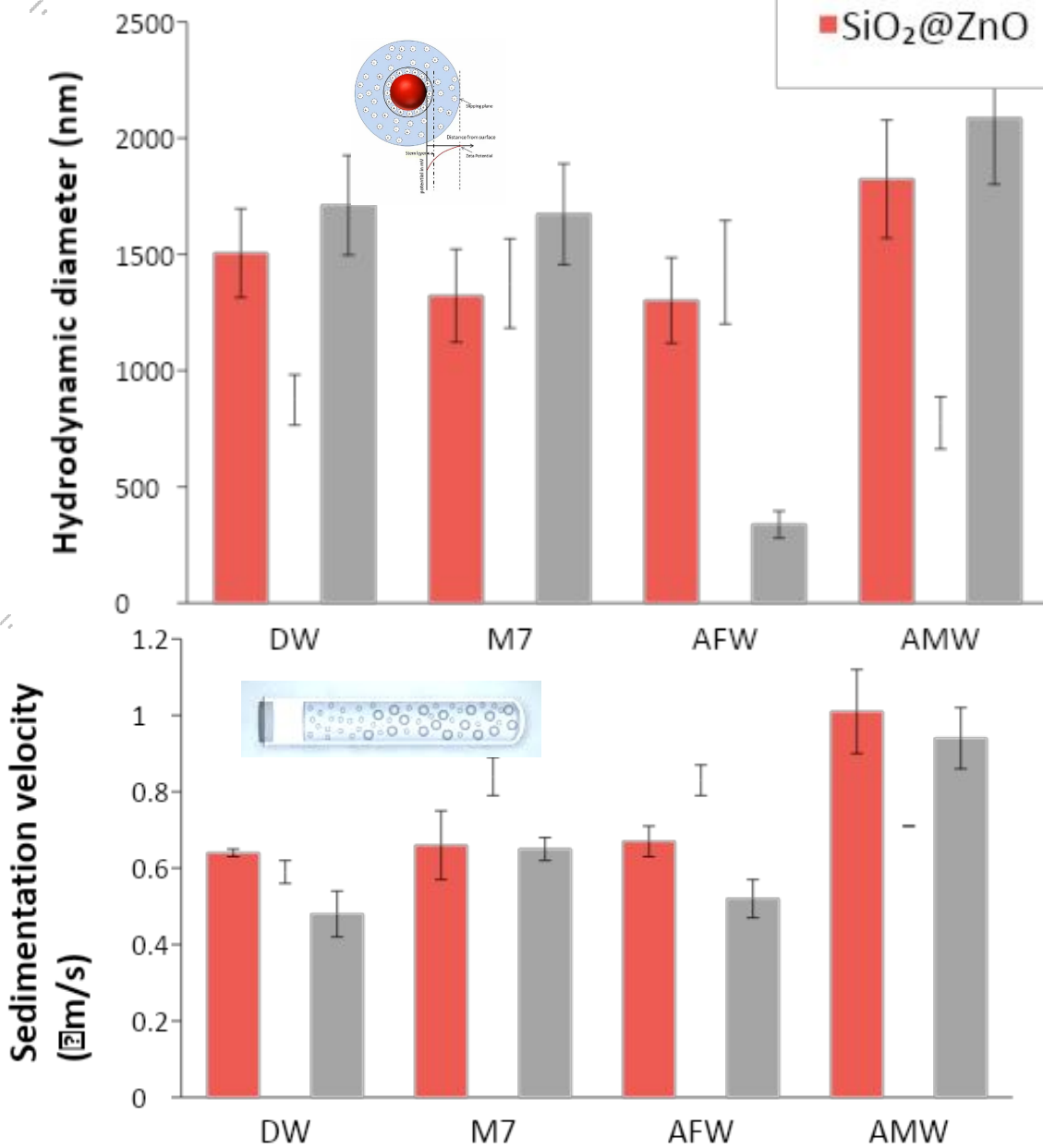


1 Light source
(470 or 865 nm laser)

2 Sample

3 Charge Coupled Device (CCD) Sensor (2500 detectors)





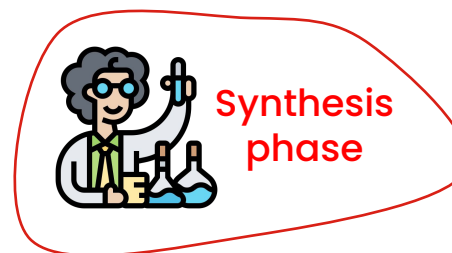
Solubility from powders



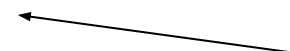
$\text{SiO}_2@\text{ZnO}$



ZnO
(ref material)



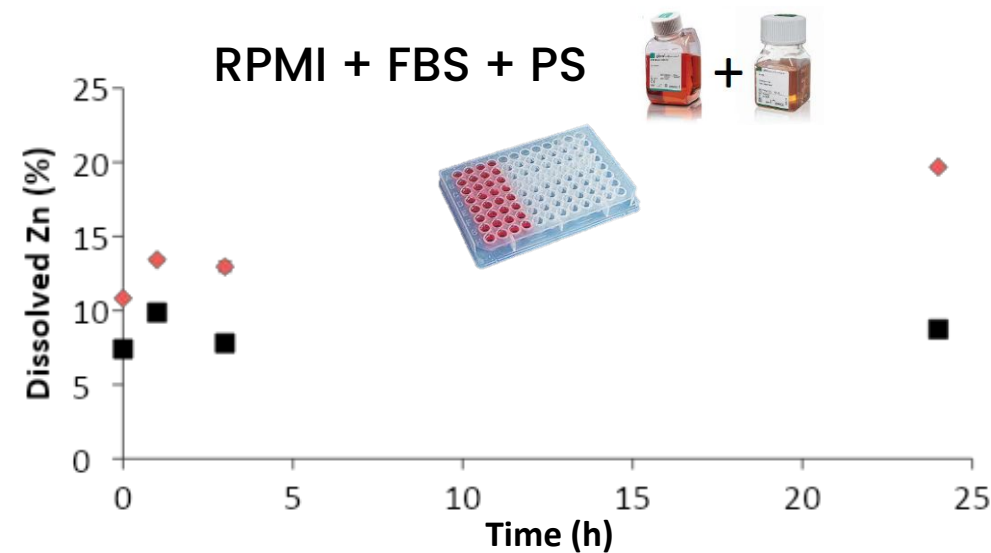
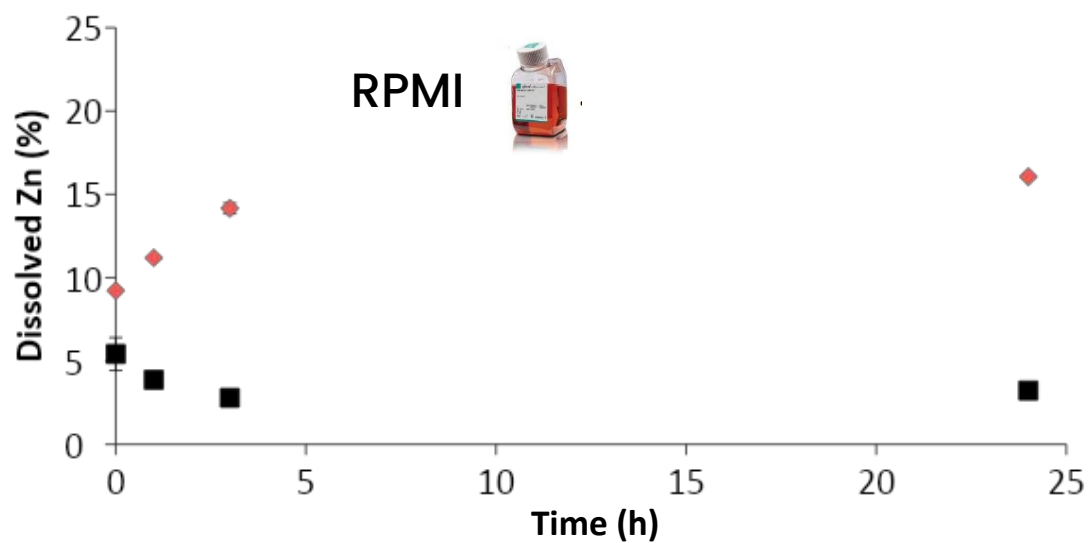
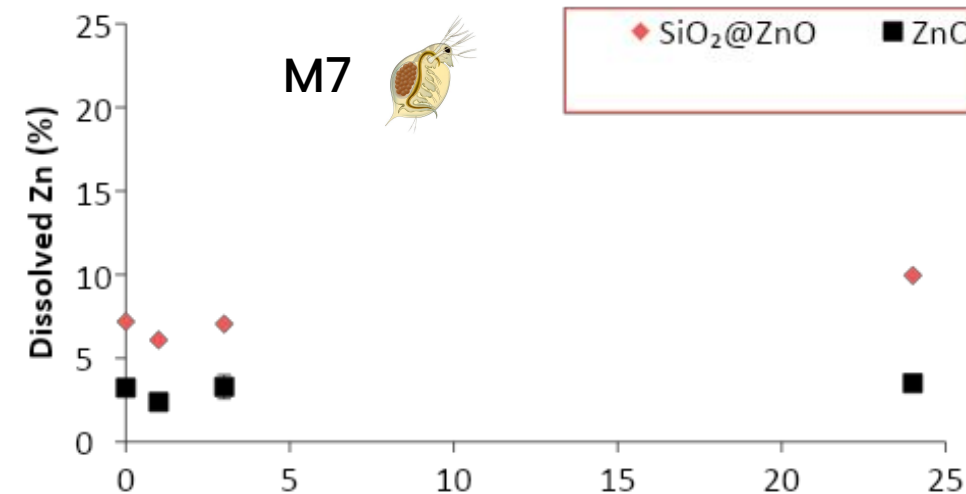
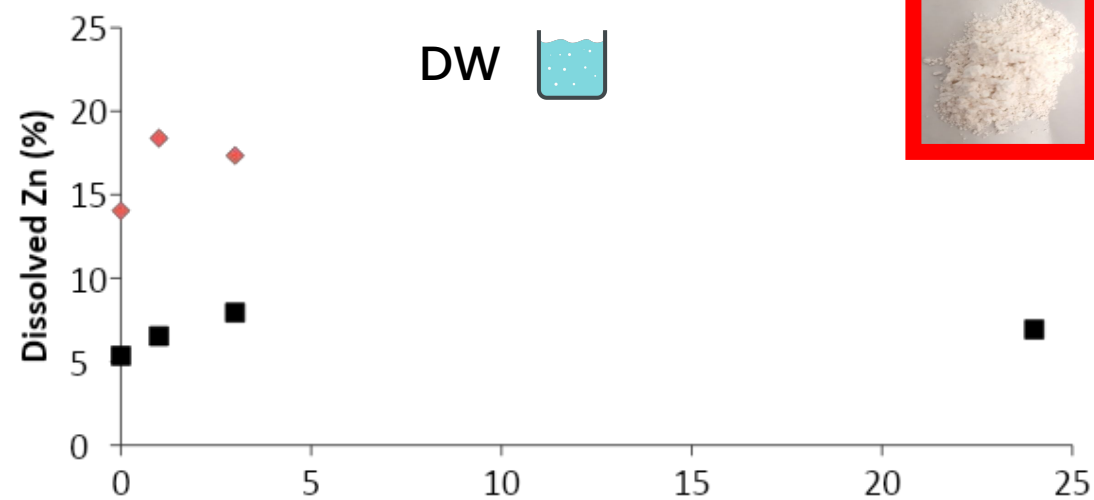
After 0, 1, 3, 24 h



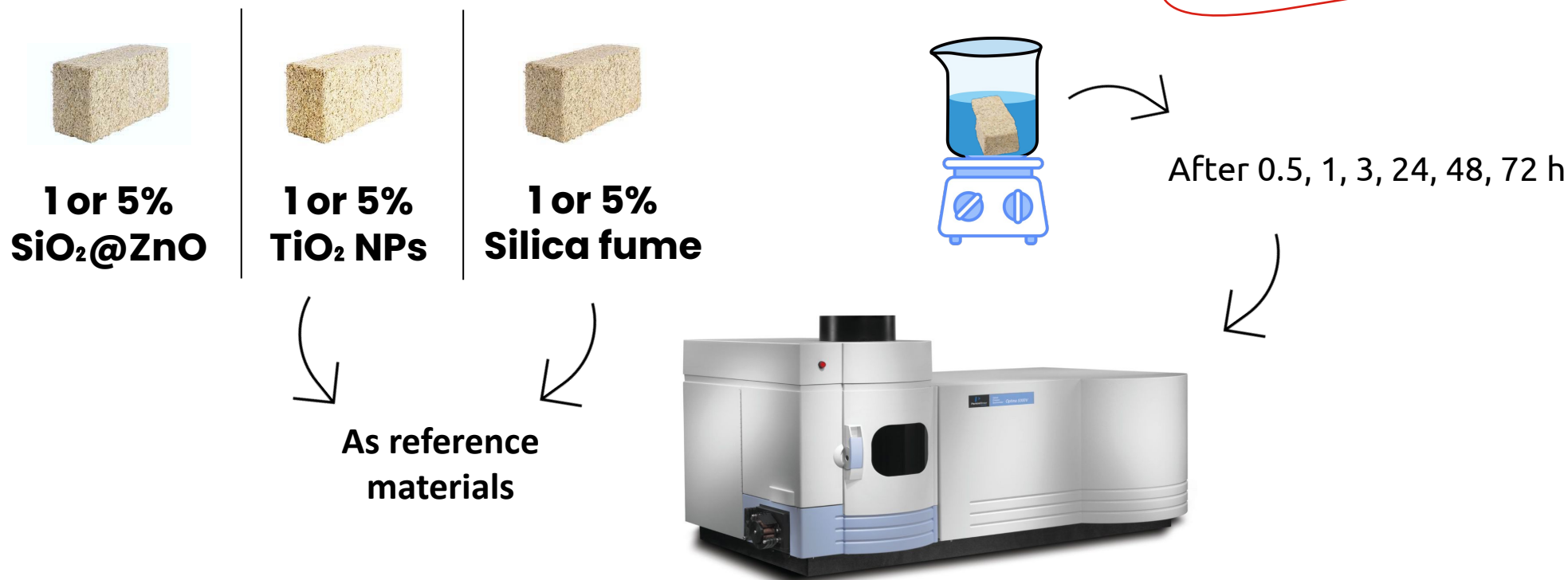
**Inductively Coupled Plasma
Optical Emission Spectroscopy (ICP-OES)**

Solubility and dispersion

- The ability of NMs to dissolve or remain dispersed in biological fluids affect their bioavailability, distribution, and potential for accumulation in organs.

SiO₂@ZnO ZnO

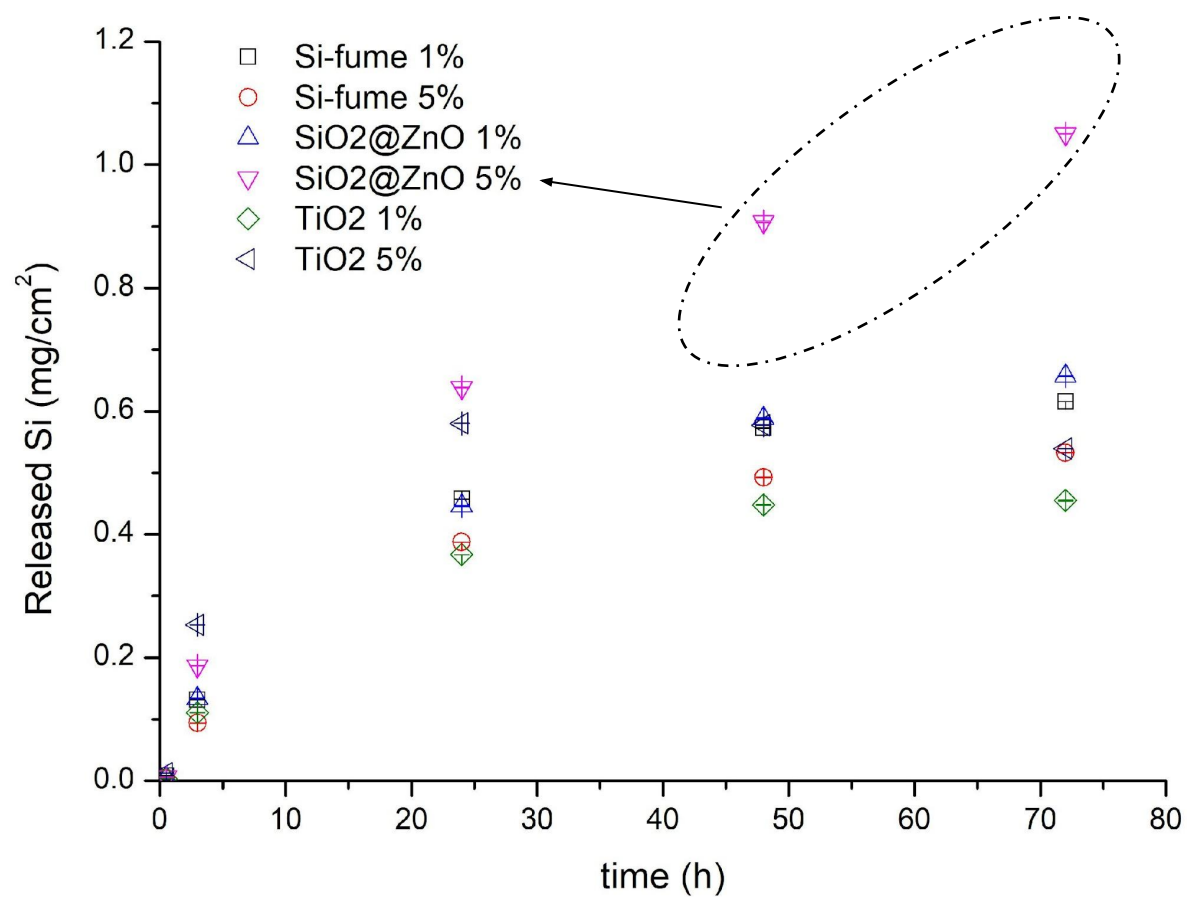
Solubility from the final product



Solubility and dispersion

- The ability of NMs to dissolve or remain dispersed in biological fluids affect their bioavailability, distribution, and potential for accumulation in organs.

**Inductively Coupled Plasma
Optical Emission Spectroscopy (ICP-OES)**



**(no release of Zn & Ti
from the mortars
after 72 h was
detected)**

**Thank you
for your
attention**