Photostimulated nanoparticles for biomedical diagnostics

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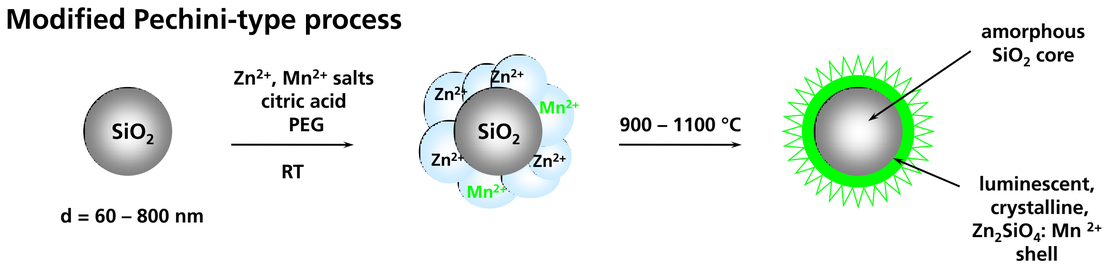
Many analytical methods for tumor marker and gene mutation detection, for the recognition of pathogens or the monitoring of cell related processes are based on the labeling of the investigated object with luminescent nanoparticles (NPs). This technique enables diagnoses to be more sensitive, reliable, and personalized. The photostimulated (PSL) NPs which are in the focus of our research activities show excellent potential for the manufacturing of more efficient and practicable contrast agents for *in vivo* tumor diagnoses.

Here, we present our recent activities for medical diagnostics concerning the synthesis, characterization and surface functionalization of luminescent inorganic NPs based on $Zn_2SiO_4:Mn^{2+}$. Structure, size, and composition of these NPs can easily be controlled to tailor their properties. We have further demonstrated a subsequent surface modification of the resulting NPs with various functionalities for a later attachment of biomolecules to enable their use as luminescent markers in biological or medical diagnostics.

Synthesis

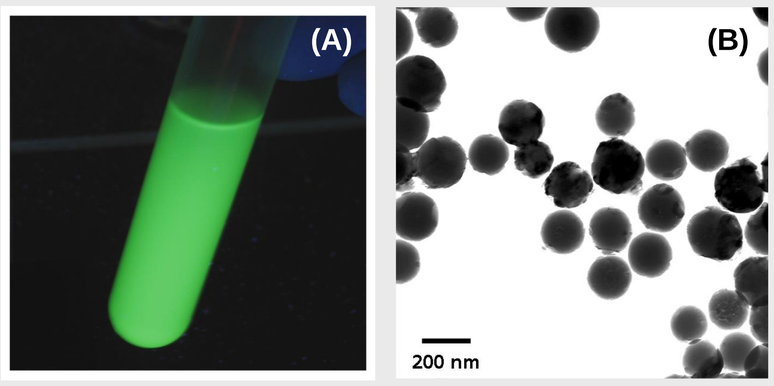
Modified Pechini-type process



An elegant synthesis strategy offers new possibilities to control the nanoparticle properties

Variation of		Adjustment of
core size and shell thickness	→	particle size and morphology
annealing temperature	→	shell crystal structure optical properties
doping ion concentration	→	optical properties

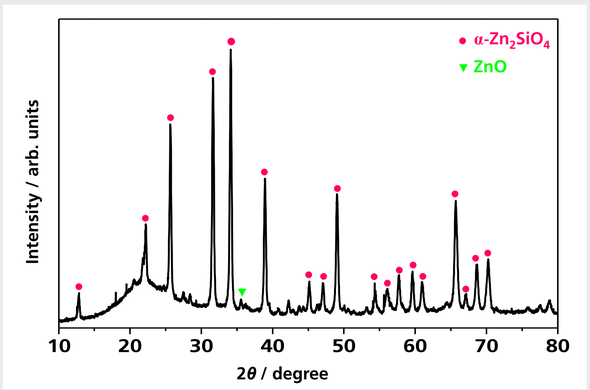
Characterization



(A) Suspension of luminescent $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs under excitation with UV-lamp (λ_{ex} = 254 nm)

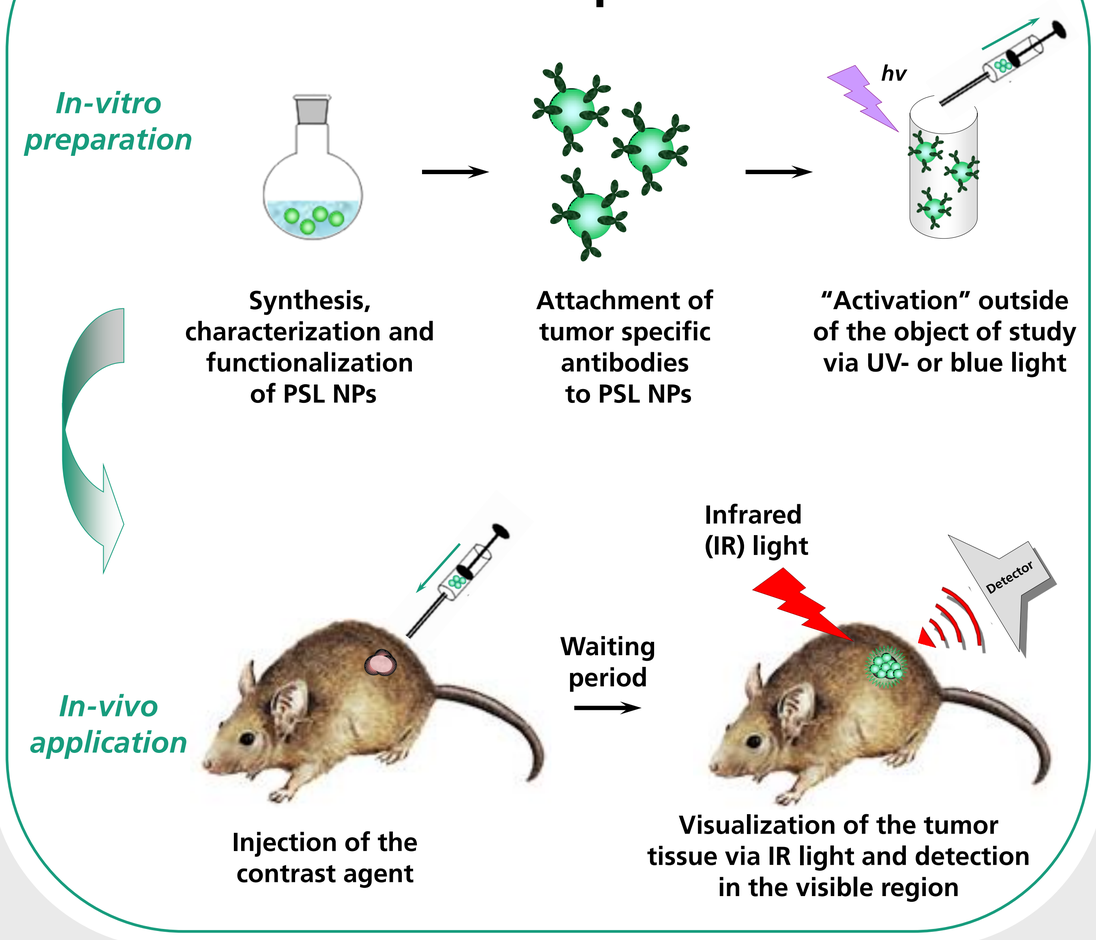
and

(B) TEM micrograph of $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs



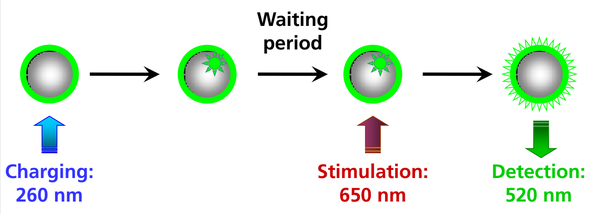
XRD patterns for $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs annealed at 900 ° C (d = 185 nm, doping concentration of Mn^{2+}: 1 mol%)

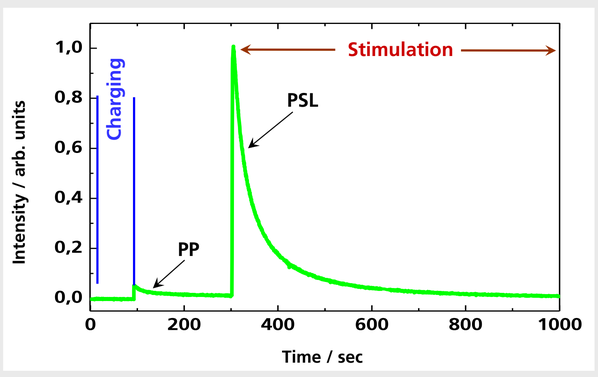
Application Potential of PSL Nanoparticles



Optical properties

Mechanism of photostimulated luminescence (PSL):



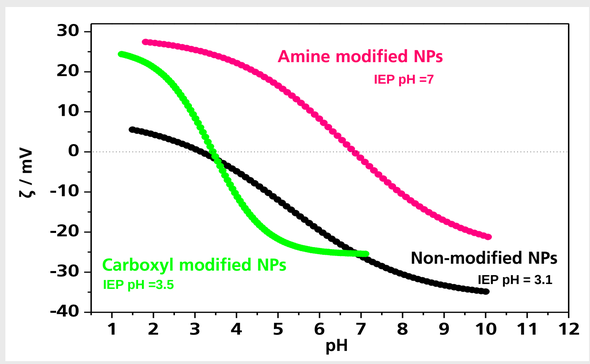


Afterglow (PP) and PSL of the $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs (d = 200 nm). Mn^{2+} concentration 1 mol%. Charging wavelength 260 nm, stimulation at 650 nm, detection at 520 nm, T= 300 K.

$Zn_2SiO_4:Mn^{2+}$ is able to store energy over a long time (from minutes up to hours) once it has been charged through exposure to UV light. A subsequent stimulation of the NPs through exposure to light in the red and IR spectral region results in a release of the stored energy in form of an emission in the visible region.

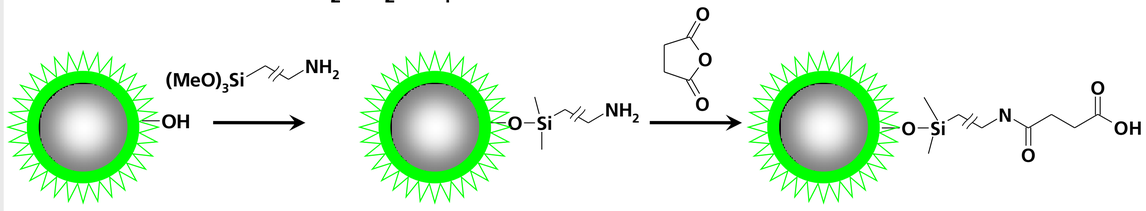
Surface Modification

- Subsequent introduction of reactive functionalities such as amine and carboxyl to the surface of $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs → prerequisite for the attachment of biomolecules
- Qualitative analysis of chemical functions on the NP surface



ζ-potential of non-modified and functionalized $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs as a function of pH

Functionalization of $SiO_2/Zn_2SiO_4:Mn^{2+}$ Core/Shell NP



Summary

- Wet-chemical synthesis of photostimulated $SiO_2/Zn_2SiO_4:Mn^{2+}$ core/shell NPs
- Characterization of structural and optical properties
- Successful surface modification

Outlook

- Attachment of biomolecules such as antibodies
- Analysis of NP cytotoxicity

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