

## Studies on Zinc sulfide - Synthesis and Characterization

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**INTRODUCTION:** The poster describes new findings of an investigation of semiconductor nanoparticles for processing size, surface properties, and functionalisation of the surface. It is understood that the control of the surface is the key to highly luminescent nanocrystals. Organic capping yields very high quantum efficiency already at room temperature. The ligands act as passivators and, at the same time, allow functionalisation which turns the nanocrystals into chemical reagents. However, matching extensive ligands with the compact packing of the nanoparticle still remains difficult. Furthermore, for a biomedical application, these quantum dots have to be water-dispersible so as to be compatible with the biological environment. We describe the synthesis of ZnS and manganese doped ZnS nanoparticles by organic and inorganic methods. The two methods are compared here, the development and optimisation of the synthesis is presented on the poster.

**METHODS:** : ZnS and ZnS:Mn nanoparticles have been synthesized in aqueous solution and organic solvent (chloroform).

Inorganic synthesis: relevant synthesis parameters such as pH, concentration, the type of zinc-precursor, temperature, and  $Zn^{2+}/S^{2-}$ -ratio have been investigated and optimised. Furthermore, different stabilizers (e. g. thioglycerol, cellulosederivates, polymers) and their influence on the reaction have been tested. The general synthesis follows a similar route for most inorganic synthesis: a metal salt is dissolved in water in the presence of the stabilizer and the chalcogen source is added.

Organic synthesis: ZnS nanoparticles have been synthesized using bis(trimethylsilyl)sulfide as "sulfide-source" and trialkylphosphine as "stabilizer". Manganese doped ZnS is produced similarly. The properties of the obtained particles have been studied so far by UV-VIS and fluorescence spectra, X-ray diffraction spectra, electron microscopy (TEM) and PCS (Photon Correlation Spectroscopy).

**RESULTS:** The major results can be summarized in the following table:

Table 1. Results

Organic Synthesis	Inorganic Synthesis
Narrow size distribution	Optimisation of existing reaction parameters
Stable over weeks	Improved quantum yield
Efficient doping	No doping possible so far

All samples (organic and inorganic synthesis) show clearly resolved electronic transitions which are blue-shifted compared to the bulk material. Transition metal ion doping works very well for the organic synthesis:

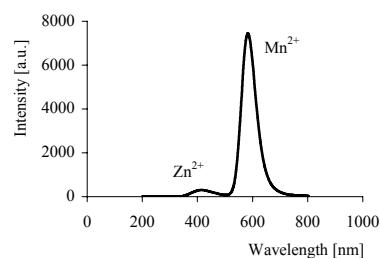


Fig.1:Photoluminescence spectrum of manganese doped zinc sulphide

These powders can be isolated and show an orange fluorescence upon UV-excitation:

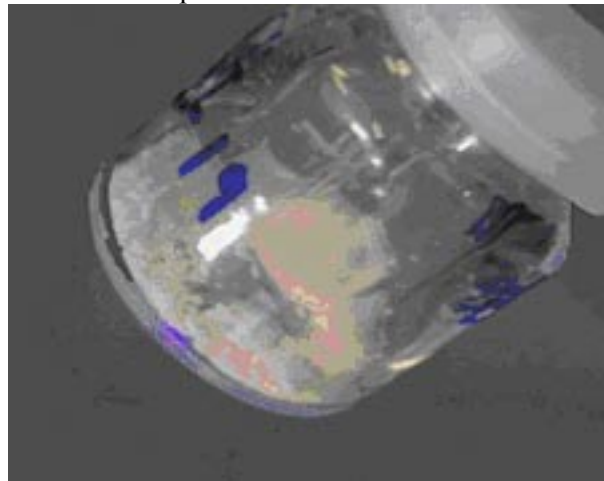


Fig. 2:ZnS:Mn powder

**Recent work:** Instead of removing the organic “shell” and capping the nanoparticles with an inorganic shell and a second layer for solubility and functionalisation, we immediately functionalised the phosphine by an organic synthesis. With this method we are able to obtain water-dispersable highly fluorescent nanoparticles and at the same time provide enough hydrophilic OH-groups for further treatment with biological active molecules.

**DISCUSSION & CONCLUSIONS:** We recently studied various organic and inorganic methods to synthesize ZnS nanoparticles. In particular we focused on the influence of synthesis parameters. Existing methods could be improved leading to systems with reasonable narrow size distribution. Although we started to investigate the system, a detailed characterization has to be carried out. For example the influence of  $Mn^{2+}$  concentration is not yet clear and the concentration and crystallographic environment of the  $Mn^{2+}$  -ion has not yet been determined.

**REFERENCES:** <sup>1</sup>R. Vacassy, S.M. Scholz, H. Hofmann et al. (1998) *J. Am. Chem. Soc.* 81(10): 2699-2704. <sup>2</sup>J. Leeb, V. Gebhardt, G. Müller et al. (1999) *J. Phys. Chem. B* 103: 7839-7846. <sup>3</sup>R. Vacassy, S. M. Scholz, J. Dutta, H. Hofmann (1998) *Mat. Res. Soc. Symp. Proc.* 50: xyz-xyz. <sup>4</sup>K. Sooklal, B. S. Cullum, S. M. Angel, C. J. Murphy (1996) *J. Phys. Chem.* 100: 4551-4555.

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