Gels, Xerogels and Aerogels from PbS and PbSe Quantum Dots

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Semiconductor quantum dots attract enormous attention in the scientific world today. The synthesis of highly monodisperse nanoparticles with unique properties can provide a wide range of new materials whose potential uses range from fundamental studies to incorporation into presently existing or newly designed device architectures. The lead chalcogenides are especially interesting due to their large exciton Bohr radii leading to strong quantum confinement.

Possible applications for devices based on individual quantum dots are limited due to their small size. Most techniques are not single-particle based and do not operate in solution environments. Therefore it is imperative to be able to build 2D and 3D architectures without losing the unique characteristics inherent in these nanoscale building blocks that make nanoparticles so unique.[1]

A gel is a solid three-dimensional porous network formed through the interconnection of the primary particles. Depending on the media that fills the pores there are different terms used to describe them. For dried gels the terms aerogel and xerogel are commonly used. An aerogel is a gel that does not change its structure or volume during the drying whilst xerogels undergo shrinkage during the drying process.[2] The resulting properties depend not only on the properties of the building blocks, but are also influenced by the different steps in the gel preparation. Because of the highly porous nature of gels one can achieve very light structures which possess a very high surface area.
We have, from previous studies, gained a great deal of experience in the field of aerogel preparation using CdTe quantum dots[3] and noble metal nanoparticles[4] as building blocks and we have been able to extend these approachs successfully to the lead chalcogenides.
Combining the properties of lead sulfide and lead selenide quantum dots with the unique properties of gel structures will offer a wide market for further applications such as thermoelectric devices.

In this work we will describe the formation of lead sulfide, lead selenide and mixed lead sulfide lead selenide gel structures and their different dried equivalents. Starting from quantum dots prepared by hot injection into organic media, gels are formed from between two hours to four days depending on the chosen conditions. These three dimensional gels are supercritically dried or dried under ambient pressure to achieve aerogels and xerogels, respectively. The resulting structures are characterized with respect to their optical and electrical properties, their structure and their composition.

References

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[3] N. Gaponik *et al*., Adv. Mater. **40** (2008) 4257.
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Figures

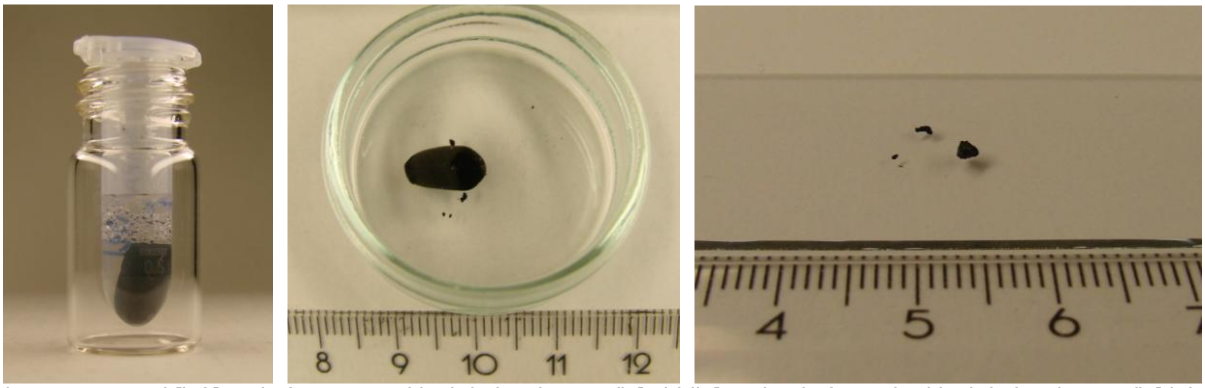

Figure 1: wet gel [left], gel after supercritical drying (aerogel) [middle] and gel after subcritical drying (xerogel) [right]

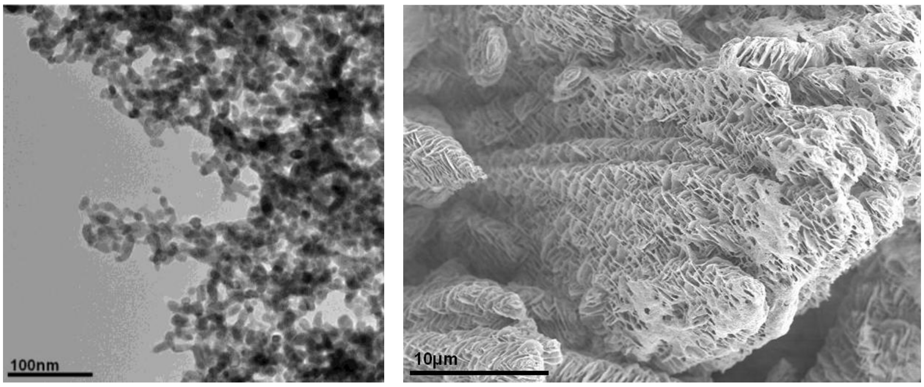

Figure 2: TEM image of a mixed PbS/PbSe aerogel [left] and SEM image of a PbS xerogel [right]