Electronic Supplementary Information (ESI)

Phosphine-Free Synthesis of ZnSe:Mn$^{2+}$ and ZnSe:Mn$^{2+}$/ZnS Doped Quantum Dots Using New Se and S Precursors

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1. Infrared (IR) spectroscopy of Mn precursor

Fig. S1 IR spectrum of Mn precursor

IR spectrum of the used Mn precursor has been acquired on a Nicolet 360E.FP Fourier transform infrared spectrophotometer and further shown in Fig. S1. There are three strong vibration peaks at 2959, 2924 and 2854 cm$^{-1}$, respectively, from the asymmetry and symmetrical C—H stretching vibration, indicating the presence of CH$_3$ and CH$_2$ group in the Mn precursor. Also the Mn precursor is a carboxylic acid salt, which is indicated by a strong carbonyl vibration absorption peak at the 1546 cm$^{-1}$. So, the above results illustrate the presence of the bonding between nonanoic
acid and Mn\textsuperscript{2+} according to the preparation conditions of Mn precursor.

2. **Elemental analysis of Mn precursor**
   
   Found from Mn precursor: C, 58.34%; H, 9.39%.
   
   Calculated from manganese nonanoate Mn(NA)\textsubscript{2}: C, 58.52%; H, 9.28%.
   
   The measured results from Mn precursor is very close to the calculated value from Mn(NA)\textsubscript{2}.

3. **Thermal gravimetric analysis of Mn precursor**

![Fig. S2](image)

*Fig. S2* Thermal gravimetric curve of Mn precursor

Fig. S2 shows the thermal gravimetric curve of Mn precursor from 25 to 475 °C. There are two obvious weightlessness platform: one in the range of 80-101 °C due to the lost of adsorbed water and then continuous weightlessness from 245 °C to about 350 °C. The final residue was approximately 19%, in good agreement with the theoretical Mn content (19.2 %) based on MnO as the residue of manganese nonanoate.

4. **Conclusion**

According to the above results from infrared spectroscopy, elemental analysis and thermal gravimetric analysis, it is believed that the manganese precursor is manganese nonanoate [Mn(NA)\textsubscript{2}]. In addition, the excess of nonanoic acid relative to Mn\textsuperscript{2+} used in the reaction (the ratio of nonanoic acid to Mn\textsuperscript{2+} is 3) favors the complete replacement of acetate with nonanoate to form Mn(NA)\textsubscript{2}. The preparation reaction of Mn precursor can be represented by the following formula:

\[
\text{MnAc}_2 + 2 \text{CH}_3(\text{CH}_2)_7\text{COOH} \rightarrow (\text{CH}_3(\text{CH}_2)_7\text{COO})_2\text{Mn.}
\]