Colloidal Stability of Hydrophilically Modified β-$NaYF_4$ Nanocrystals

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Introduction

Lanthanide doped β-$NaYF_4$ nanocrystals are upconverters that absorb near-infrared radiation and emit visible light. These nanocrystals have a variety of potential applications, such as bioimaging, biosensing, and security printing. These applications and many others, however, require that the nanocrystals be dispersed in water. Since the majority of synthetic procedures use nonpolar capping ligands, the as-synthesized nanocrystals are not dispersible in water and need to have their surfaces modified to form an aqueous colloid. In this study, the colloidal stability of oleic acid-capped β-$NaYF_4$ upconverting nanocrystals (UCNP) that have poly(maleic anhydride-alt-1-octadecene) (PMAO) bilayers, with and without the crosslinker bis(6-aminohexyl)amine (BAHA), are examined.

Experimental

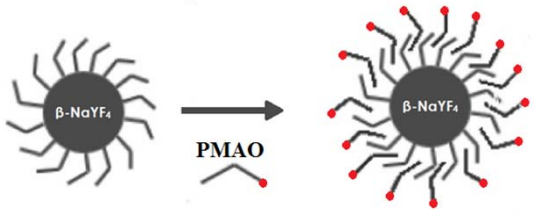
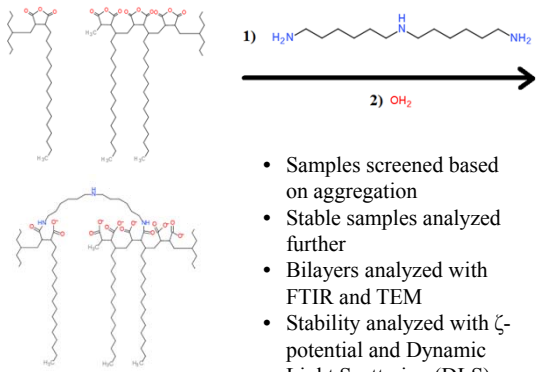


Figure 1. Schematic diagram of the bilayer agent (PMAO) intercalating with the nanocrystal capping ligands (OLA). [3]

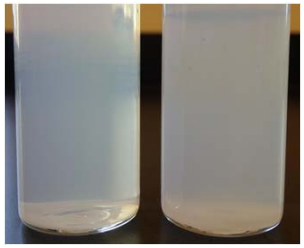


- Samples screened based on aggregation
- Stable samples analyzed further
- Bilayers analyzed with FTIR and TEM
- Stability analyzed with ζ-potential and Dynamic Light Scattering (DLS)

Figure 2. Crosslinking and hydrolysis of PMAO.

Results

Figure 3. Stable aqueous colloids of PMAO-UCNP (left) and PMAO-BAHA-UCNP (right) at approximately 0.3 wt%. The uniform gradient indicates an even dispersion, while the turbidity indicates the presence of fairly large particles.



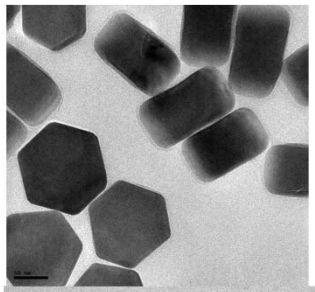
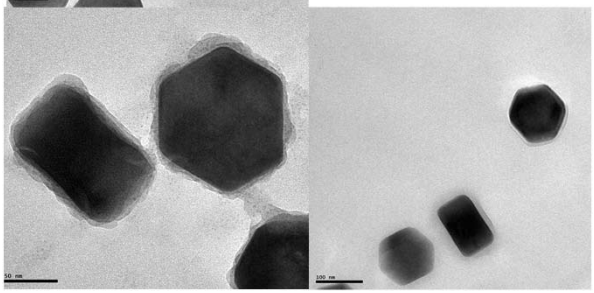


Figure 4. TEM image of non-hydrolyzed PMAO-UCNP (left), hydrolyzed PMAO-UCNP (bottom-left), and hydrolyzed PMAO-BAHA-UCNP (bottom-right). Hydrolysis appears to damage the bilayer if it is not crosslinked.



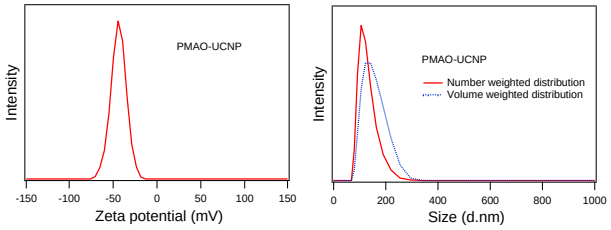


Figure 5. DLS and ζ-potential distributions of PMAO-UCNP. The mean potential is -44±9 mV. The mean size for the Number distribution is 122±32 nm, while that of the Volume distribution is 146±41 nm.

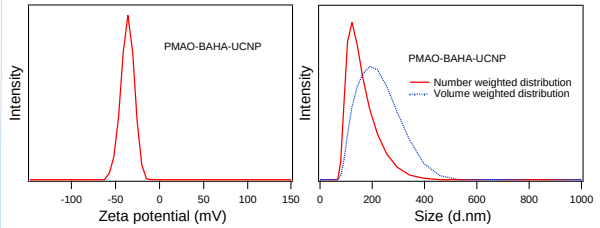


Figure 6. DLS and ζ-potential distributions of PMAO-BAHA-UCNP. The mean potential is -36±8 mV. The mean size for the Number distribution is 145±50 nm, while that of the Volume distribution is 202±74 nm.

Conclusion

The bilayers formed by using PMAO and PMAO-BAHA were uniform, and the resulting aqueous colloids had moderate-to-minimal levels of aggregation after one day at a concentration of 1-0.1 wt%. A significant decrease in aggregation was observed at concentrations of less than 1 wt% in these cases.

Future Work

- Use different crosslinkers such as polyethyleneimine.
- Adopt a quantitative screening procedure based on nanocrystal aggregation.
- Further examine the stability of <1 wt% colloids.

Acknowledgements

This work was made possible by the National Science Foundation REU Security Printing and Anti-Counterfeiting Site EEC-1560323. Special thanks is also given to Dr. Alfred Boysen, who provided support and guidance for the development of this poster.

References

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