

The Dispersion Stability of Upconverting Nanoparticle Inks

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Introduction

- Upconverting nanoparticle (UCNPs) inks were created for security applications
- Upconversion: light that is emitted at lower wavelengths than the exciting light's wavelength.
- The inks must undergo quality control tests: The goal is to create a testing procedure to determine the shelf life of UCNPs inks
- Size-dependent factors of UCNPs affect the stability of UCNPs ink
 - Dispersion

Procedure

- The stability of the UCNP ink was tested using a mass drying test which resulted in measuring the mass of nanoparticles. 2 wt% red NaYF₄ nanoparticle ink was made.
- This ink was placed into five different vials label A,B,C,D,E. Vial labeled A was used for the control and testing real-time exposure, vial B was shaken by hand for 30 seconds, vial C was shaken by vortexer for 30 seconds at 1000 rpm, vial D was heated at 60°C for the regular time period and vial E was cooled at 11°C for the regular time period.
- A fixed volume of 400 uL of ink was placed onto a glass slide for each test respectively and left to dry for about 30 minutes.
- The mass of the dried UCNPs was calculated by measuring the mass of glass slide before testing and after testing. The typical time period was approximately 2-4 days.

Results

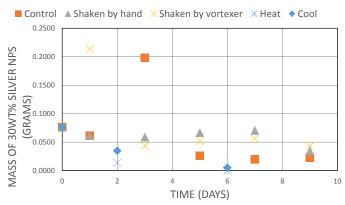


Figure 1: Mass of 30 wt% silver NPs in ink as a function of time for various testing conditions

Nanoparticle sedimentation is observed over time. There is an observed mass drop over time but due to some systematic errors there can be a large deviation in mass. (See Figure 1)



Silver NPs inks were used to create and test the procedure. "Shaking" seems to have a positive effect on redistribution of silver NPs. (see Figure 2)

Figure 2 : After testing silver NPs after five days testing the control, shaking by hand, and shaking by vortexer (from left to right)

Toluene was found to dissolve parafilm. The parafilm test sample had less strength in terms of stretching the material than another that had no toluene evaporated on the parafilm. (see Figure 3 & 4)



Figure 3: Toluene placed on parafilm test sample



Figure 4: Parafilm test sample after stretching

Heating the upconverting red nanoparticle ink eliminated the "coffee ring" effect



(see second sample from the right in **Figure 5**) **Figure 5**: After testing red UCNPs after five days under various testing condition

the right in **Figure 5**) days under various testing condition The red UCNP inks remain stable throughout the testing of four weeks. There was no large drop in mass. The heated experiment had an increase of mass after parafilm was reinforced to prevent leaks. (see **Figure 6**)

■ Control ▲ Shaken by hand × Shaken by vortexer × Heated ◆ Cooled

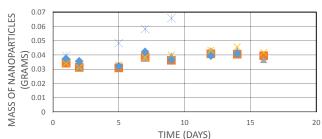


Figure 6: Mass of 2 wt% red UCNPs in ink as a function of time for various testing conditions

Conclusion

The dispersion of upconverting nanoparticles remain stable up to four weeks. Nanoparticles stability is likely to be driven by concentration gradients. Higher concentrations of NP ink have a larger effect by shaking. Stability of NPs in ink remain throughout the various testing conditions.

Future Work

For future work on this research, a different sealant instead of parafilm should be used due to its incompatibility with toluene.

The experiment should be repeated to test UCNPs stability over longer times. Reproduction of this experiment is important for finding all the errors, testing validity of data and shelf life of ink.

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