VEINOT Research Group

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# Nanocrystal-Nylon Hybrid Materials for Sensing Nitroaromatic Compounds

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## Introduction

- Silicon nanocrystals (SiNC) have photoluminescent (PL) properties.[1]
- This allows the nanoparticles to be applicable for biological imaging and sensing.[2,3]
- By attaching them to nylon, we are able to make a luminescent polymer that is potentially suitable for wearable sensing devices.
- Previous work has demonstrated that these materials are capable of identifying nitroaromatic compounds.[3]

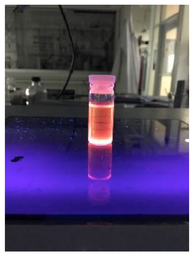

Figure 1: Dodecene-functionalized SiNC under UV light.


Figure 2: SiNC coated filter paper in the presence of nitroaromatic compound trinitrotoluene under UV light. Image from ref. 3.

## Making the Silicon Nanocrystals

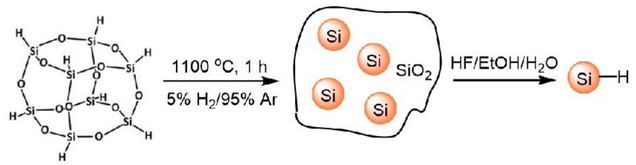


Figure 3: Scheme for making H-SiNCs

- Hydrogen silsesquioxane (HSQ) is heated for 1 hour at 1100°C in a reducing atmosphere.
- This forms 3 nm silicon (Si) nanocrystals within a silicon oxide ($SiO_2$) matrix.
- The composite is then etched with ethanol, deionized water and hydrofluoric acid.
- This process removes the $SiO_2$ and hydride terminated silicon nanocrystals (H-SiNC) remains.

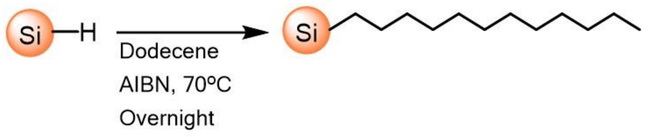


Figure 4: Scheme for functionalization of SiNCs with dodecene

- H-SiNC is placed in solution with 1-dodecene in toluene.
- Azobisisobutyronitrile (AIBN) is then added to the composite and heated at 70°C overnight in an inert atmosphere.
- The alkene is added across the Si-H bond.

## Making Nylon

- 1.5 g of 1,8-diaminooctane (DAO) is dissolved in 35 mL of water.
- 2.5 mL of sebacoyl chloride is dispersed in 35 mL of hexane
- The sebacoyl chloride solution is then poured on top of the DAO solution where a film is formed at the interface.
- Long threads can be pulled from the interface with a pair of tweezers, as shown in Figure 5.

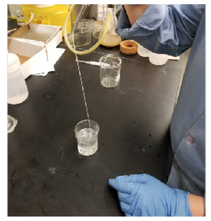

Figure 5: Pulling nylon from the film.

## Making Nylon with Silicon Nanocrystals

- 1.5 g of DAO is dissolved in 35 mL of water.
- 2.5 mL of sebacoyl chloride is dispersed in 35 mL of hexane, which is then added to silicon nanocrystals (SCl-SiNCs).
- The SCl-SiNCs is carefully poured on top of the DAO solution where a film is again formed at the interface.
- Continuous threads can be pulled from the film with a pair of tweezers.

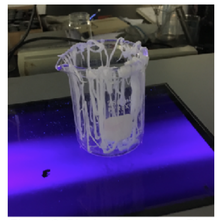

Figure 6: Blank nylon with no PL properties under a UV light.

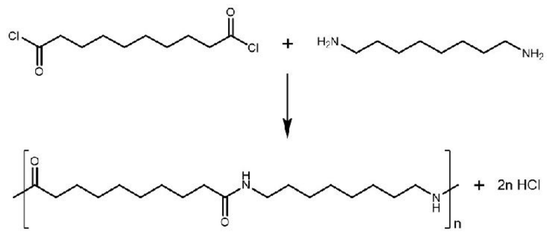


Figure 8: Chemical makeup of 1,8-diaminooctane and sebacoyl chloride to make nylon.

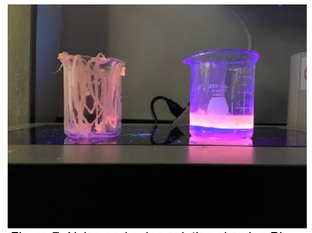

Figure 7: Nylon and nylon solution showing PL properties under UV light.

## Results

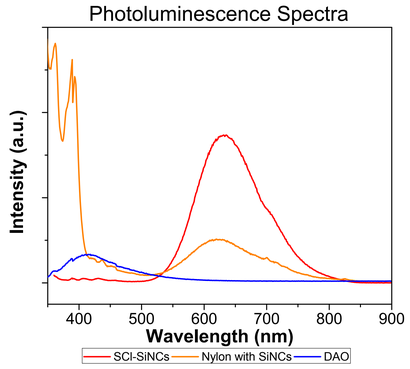


Figure 9: Photoluminescence Spectra of SCl-SiNC, DAO and nylon with SiNC.

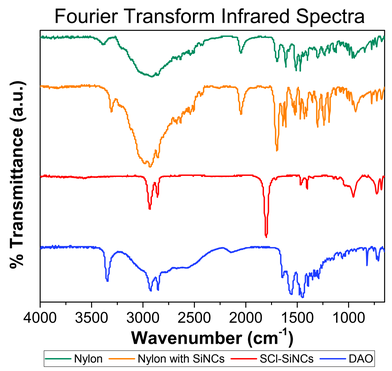


Figure 10: Fourier Transform Infrared Spectra (FTIR) of nylon, nylon with SINC, SCl-SiNCs and DAO.

- When SiNCs were added to the nylon, the top of the interface which contained SCl-SiNCs glowed bright pinkish red under UV light while the bottom as containing DAO glowed purplish blue as shown in Figure 9.
- The threads of nylon glowed orange under UV light.
- Figure 10 shows infrared similarities and differences between nylon, nylon with SiNCs, SCl-SiNCs and DAO.

## Conclusions

- Successfully made nylon containing silicon nanocrystals as characterized by FTIR spectroscopy.
- The SiNCs had photoluminescent properties that were maintained in the SiNC-nylon hybrid
- The material is capable of sensing nitroaromatic compounds such as trinitrotoluene (TNT), dinitrotoluene (DNT) and rohypnol.

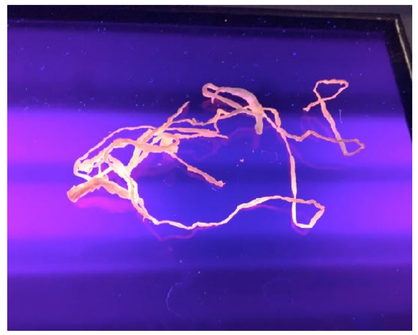

Figure 11: Nylon with SiNC before contacts coming in contact with DNT.

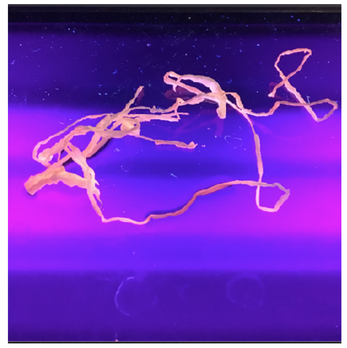

Figure 12: Nylon with SiNC after coming in contact with DNT.

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