Isolating Chiral Nanoparticles from Paper: Templates for Chiral Semiconductor Nanoparticles

Sarafina Gutterres, Jeffery L. Coffer
TCU Department of Chemistry and Biochemistry, Texas Christian University , Fort Worth USA

Abstract

Perovskites are a semiconductor nanomaterial with a cubic crystalline unit that has photoluminescent effects under exciting light[1]. Perovskites are a new and emerging field of science with various applications, most notably in optoelectronics. New research in this field includes using chiral silica templates for the synthesis of chiral perovskite films.

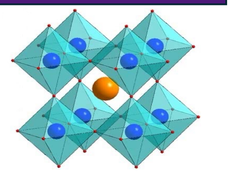


Figure 1: perovskite unit cell structure with cations such as lead (dark blue), halide atoms at the corners (red) and a central cation such as cesium (orange)

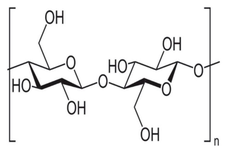


Figure 2: cellulose structure

Introduction

Chirality is an essential property detected throughout nature as well as in synthetic materials with a wide range of applications. At the molecular level, chirality is the ability of two molecules of the same composition to not be structurally superimposable on each other[3]. However, the necessary conditions required to artificially achieve chiral formation are highly specific. his project began by testing cellulose obtained from several different vendors to determine which product has the ideal properties for use in chiral films. The use of cellulose as a porous template provides an environmentally friendly alternative for templating chirality onto materials such as silica and eventually perovskites.

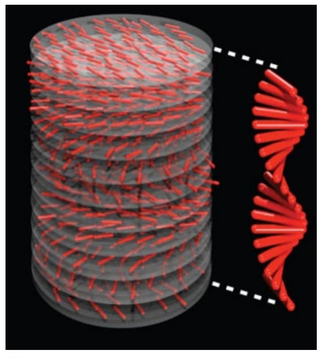


Figure 3: chirality in mesoporous silica templated by chiral cellulose

Characterization

Figure 4: backlit photo of nonchiral cellulose nanocrystals (CNCs) in a separatory funnel at 3 wt%

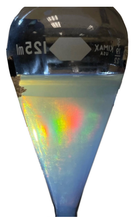


Figure 5: backlit photo of chiral CNCs in a separatory funnel at 3 wt%

Figure 6: nonchiral CNC film 1 week after evaporation at 3 wt%

Figure 7: chiral CNC film 1 week after evaporation at 3 wt%

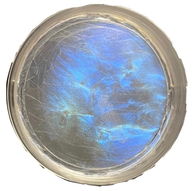


Figure 8: chiral CNC film 1 week after evaporation at 3 wt%

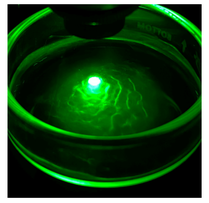


Figure 9: chiral CNC film with perovskite quantum dots on the surface under fluorescent microscope

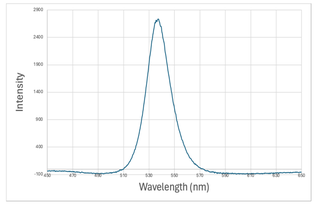
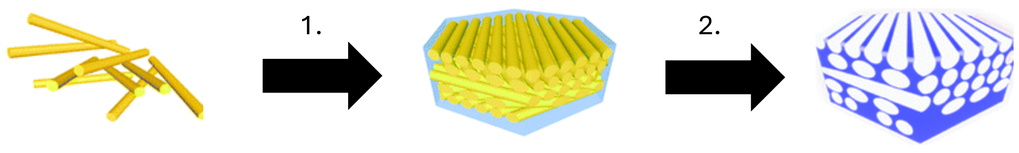
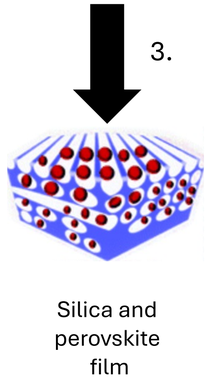


Figure 10: fluorescence spectrum of CNC film with perovskite quantum dots on the surface from **Figure 9**

Procedure



1. Dilute CNC solution to 3 wt%. Acidify using DOWEX ion exchange resin or dilute H_2SO_4 until pH <3. Add tetramethyl orthosilicate (TMOS) and stir at room temperature 1 hour. Pour into polystyrene petri dish and allow slow evaporation.
2. Calcinate films to remove cellulose template. Heat to 100°C (2°C/min) and hold for 2 hours. Heat to 540°C (2°C/min) and hold for 6 hours. Slowly cool to room temperature.
3. Use perovskite material to infiltrate silica films.



Conclusion & Future Work

- Two methods for characterizing chiral CNCs are employed: chiral formation in a separatory funnel or in a dried cellulose film
- Both methods elicit multicolor results indicating the presence of chiral CNCs
- Time for separation or evaporation must be allowed to achieve chiral formation (at least 1 week)
- The conditions for chiral formation in the presence of silica differ from conditions for chiral formation of CNCs only
- Future work includes:
  - Fine tuning conditions for chiral formation in the presence of silica such as acidity and CNC weight percent
  - Testing perovskite materials for infiltration

References

1. Cava Lab: Perovskite Structure and Derivatives. Princeton University https://www.princeton.edu/~cavalab/tutorials/public/structures/perovskites.html
2. Dey, A. Dey, A.K.; Selection of Optimal Processing Conditino during Removal of Methylene Blue Dye Using Treated Betel Nut Fibre Implementing Desirability Based RSM Approach. *Intech Open*. **2021**. DOI: 10.5772/intechopen.98428
3. Shopsowitz, K., Qi, H., Hamad, W. *et al.* Free-standing mesoporous silica films with tunable chiral nematic structures. *Nature* **468**, 422–425 (2010). https://doi.org/10.1038/nature09540
4. Jiang, H. Qu, D. Zou, C. Zheng, H. Xu, Y. Chiral nematic mesoporous silica films enabling multi-colour and on-off switchable circularly polarized luminescence. *New J. Chemistry.* **2019,** 43, 6111. DOI: 10.1039/c9nj00724e