Reducing Quantum Dot Aggregation in Luminescent Solar Concentrators

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Why do we need luminescent solar concentrators (LSCs)?
  • To expand the applications of PV cells

How do LSCs work?
  • Re-direct solar energy by using fluorescence from dyes or quantum dots (QDs)

Advantages of LSCs:
  • Can concentrate diffuse light
  • Down-shift light to better spectrally match PV cells

Wilton, S.R. (2012). MONTE CARLO RAY-TRACING SIMULATION FOR OPTIMIZING LUMINESCENT SOLAR CONCENTRATORS. (Photo by Donna Coveney, MIT)
Luminescent Solar Concentrators (LSCs)

Quantum Dots (QDs) embedded in Acrylic (PMMA) waveguide
How can we reduce QD aggregation in LSCs?

Aim 1:
• Investigate alternate QD surface ligand

Aim 2:
• Investigate and compare different monomers used in fabrication of LSCs

Aim 3:
• Investigate dispersion of QDs after polymerisation
Quantum Dot Properties

Quantum Dots (QD)
• Cadmium selenide – core
• Cadmium sulphide – shell
• Diameter – 12 nm
• Quantum Yield – 35%

Surface Ligands
• Cadmium oleate (Cd-oleate)
• Poly(methyl methacrylate) (PMMA)
Monomers

- Methyl methacrylate (MMA)
- Lauryl methacrylate (LMA)
- Ethylene glycol dimethacrylate (EGDMA)

Processing

- Cast Sheets
- UV Polymerisation

PubChem Identifier: 6658, 8906, 7355
Dynamic Light Scattering (DLS)

- LMA/EGDMA mixture effective for QD dispersion
- LMA addition improved QD dispersion in MMA
- PMMA ligand improved QD dispersion despite DLS result
## Processing - Compositions

<table>
<thead>
<tr>
<th>Polymer</th>
<th>QD Ligand (QD Concentration)</th>
<th>Methyl Methacrylate (MMA) (wt%)</th>
<th>Lauryl Methacrylate (LMA) (wt%)</th>
<th>Ethylene Glycol Dimethacrylate (EGDMA) (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PMMA</td>
<td>PMMA (0.2 wt%)</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>p(MMA-co-LMA)</td>
<td>Cadmium oleate (0.167 wt%)</td>
<td>66.7</td>
<td>33.3</td>
<td>0</td>
</tr>
<tr>
<td>p(LMA-co-EGDMA)</td>
<td>Cadmium oleate (0.2 wt%)</td>
<td>0</td>
<td>80</td>
<td>20</td>
</tr>
</tbody>
</table>
Experimental Design – 3mm LSCs

- PVC Gasket
- Glass Sheets
- Monomer

Excitation Wavelength = 254nm

PMMA

P(MMA-co-LMA)

P(LMA-co-EGDMA)
LSC Optical Properties – 3mm

- Sloped baselines indicated scattering in LSC (solid) and reference (dashed) samples.

- Reference samples (dashed) expected have ~90% transmission.
Experimental Design – 1mm LSCs

Glass Slides

Teflon Gasket

PMMA p(MMA-co-LMA) p(LMA-co-EGDMA)

Excitation Wavelength = 254nm
LSC Optical Properties – 1mm

- No scattering in LSC (solid) and reference (dashed) samples.
- LSC and reference samples have equivalent transmission for longer wavelengths.
Conclusion

Aim 1:
• PMMA ligand resulted in optimal QD dispersion when used in conjunction with a PMMA matrix

Aim 2:
• Addition of LMA improved dispersion of Cd-oleate capped QDs in each matrix tested

Aim 3:
• QDs that were well-dispersed in monomer mixtures showed minimal scattering after polymerisation
Further Research

QD aggregation
• Investigate photoluminescence and quantum yield

Power Conversion Efficiency
• Measurement via attachment of PV cells to LSC edges

LSC Materials
• Experimental design of LSC fabrication with different QD compositions
Acknowledgements

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Appendix

- QD Concentration
  - 0.05 wt%
  - 0.1 wt%
  - 0.2 wt%
  - 0.4 wt%
  - 0.8 wt%
  - 1.6 wt%

- Absorbance
- Wavelength (nm)
- PL Intensity (A.U.)
Appendix

![Graph showing absorbance and PL intensity for different compositions.]

- PMMA
- p(MMA-co-LMA)
- p(LMA-co-EGDMA)
- 100% MMA (PMMA Ligand)
- 66.7% MMA:33.3% LMA
- 80% LMA:20% EGDMA
- CdSe/CdS PL

**Absorbance**

**Wavelength (nm)**

**PL Intensity (A.U.)**