Ligand Exchange on Semiconductor Nanocrystals

Enhancement of the Charge-Transfer Process in Photoconductive and Photorefractive Nanocomposites

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Introduction

Advancements in semiconductor nanocrystal synthesis allow for their use in as photosensitizers in a variety of applications. However, traditional syntheses render the nanocrystals passivated with electrically insulative molecules such as trioctylphosphine. We speculate that here the charge-transfer process will be enhanced by replacing the native ligands with ones more conducive to the charge-transfer process.

Colloidal Synthesis of QCdSe

CT Molecules Studied

PVK  ECZ  TPD

Ligand Exchange on QCdSe

CdSe + PVK or ECZ or TPD

\[ \text{CdSe} + \text{PVK or ECZ or TPD} \rightarrow \text{CdSe} \]

Device Compositions

PVK: 33 wt%  
ECZ: 33 wt%  
TPD: 33 wt%  
QCdSe: 1 wt%  

Absorbance, \( \alpha \) [A.U.]

Wavelength, \( \lambda \) [nm]

Absorbance, \( \alpha \) [A.U.]

Device Absorbenes

\[ d = 6.4 \text{ nm} \]  
\[ 3.0 \times 10^{-7} \text{ M} \]  
\[ 0.15 \text{ mg/mL} \]

\[ \text{Control} \]  
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[ ]  

\[ \text{TPD90} \]  
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\[ \text{TPD70} \]  
[ ]  
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\[ \text{PVK90} \]  
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\[ \text{PVK70} \]  
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\[ \text{ECZ70} \]  
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\[ \Phi = \frac{N_{cc}}{N_{ph}} = \frac{\sigma_{ph} h e E}{\lambda \alpha d^2} \]

Photo/Dark Conductivity, \( \sigma_{ph}/\sigma_d \) vs External Field

\( \sigma = \frac{V}{CRE} \)

Quantum Efficiency vs External Field

\[ \text{Control} \]  
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\[ \text{TPD90} \]  
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\[ \text{PVK90} \]  
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\[ \text{PVK70} \]  
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\[ \text{ECZ70} \]  
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Conclusion

An enhancement in PC was not observed, however, a substantial decrease in DC was. While not anticipated, this approach may be useful for applications where the PC/DC is the relevant figure of merit, such as in photorefractive applications. Future studies will focus on determining the underlying reason for this behavior, which is likely rooted in a modification of the QCdSe surface characteristics, as well as the exploration of this approach in photorefractive composites.