Ligand and Solvent Effects on Hole Transport in PbS Quantum Dot Assemblies

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Semiconductor quantum dots (QDs) in colloidal form have attracted growing interest for their potential applications in solution-processable electronic devices. Controlled electronic doping in QD assemblies is one of the challenges required for advancing the development of novel solar cells [1], photodetectors, and transistors based on this system. While several n-type QD films with excellent conductivity have been successfully demonstrated, in general, p-type QD films have shown poor conductivity. Ligand and solvent engineering were found to permit significant enhancements of hole transport in lead sulfide (PbS) QD films. Capping with a carboxylate ligand generally produces p-type doping of PbS QD films (Figure. 1); furthermore, among various carboxylate ligands, thiophene-2,5-dicarboxylic acid provides PbS QD films with exceptionally high hole mobility values, and solvents with a high solvency power for the ligand are important for enhancing carrier mobility.[2] With an appropriate combination of ligand molecule and solvent, QDs can be packed more closely into films, resulting in orders-of-magnitude enhancement in the field-effect hole mobility, reaching values of 0.20± 0.06 $cm^2 \cdot V^{-1} \cdot s^{-1}$. The new guideline presented in this study will be vital for constructing high-performance QD-based p–n junction-type devices, especially photovoltaics.

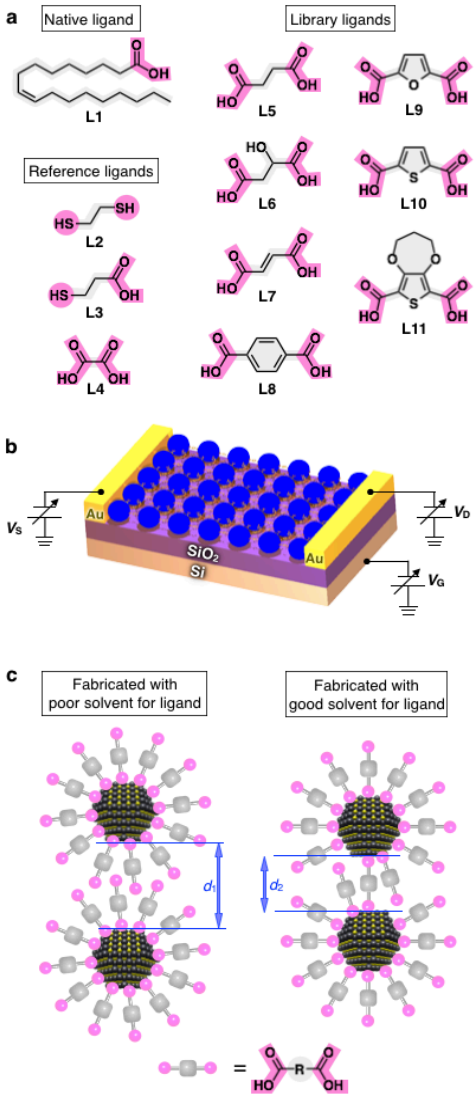

Figure 1. (a) Chemical structures of ligands for capping lead sulfide (PbS) quantum dots (QDs). (b) Schematic illustration of an FET device of a PbS QD film. (c) Effect of the solvent used for fabrication of the FETs on the packing of PbS QDs.

Reference:
[1] Kramer, Illan J., and Edward H. Sargent. *Chemical Reviews* 114.1 (2013): 863-882.
[2] Liu et al. *ACS applies nano material*, submitted.