Structurally Modified Chlorophyll a as a Natural-Based Pigment for Dye-Sensitized Solar Cells

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Dye-sensitized solar cells (DSSCs) are organic electronic devices which convert solar energy into electrical energy. Unlike the conventional silicon-based solar cell, DSSCs are lightweight and have a lower cost of manufacturing. However, the limitations of DSSCs are still in the spotlight of development, especially the issue from noble metal-based sensitizers: sophisticated and low total yield synthetic pathway, and high cost of production. Natural-based dyes are placing a new opportunity for cutting down the cost of expensive metal complex sensitizers. One of the most promising candidates of natural pigment is chlorophyll a, due to its abundance, ease of extraction, and its high molar coefficient. Nonetheless, chlorophyll a structure is unsuitable for direct implementation as a sensitizer in DSSCs. Therefore, Chlorophyll a extraction and structural improvement were conducted including: (1) chlorophyll a purification using column chromatography, and (2) chlorophyll a modification with transesterification, Knoevenagel's condensation, and hydrolysis reactions to shorten the alkyl group, introduce anchoring group, and carboxylic group respectively for higher adsorption efficiency on TiO2 surface. Both original and modified Chlorophyll a-cored dyes with cyanoacetyl and carboxyl groups were fully characterized with nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry and assessed with a simple DSSC prototype. For the preliminary results, the modified dye exhibited superior adsorption efficiency on TiO2 and showed the power conversion efficiency at 0.042±0.005 percent with the current density of 0.128±0.014 mA/cm2 and the maximum voltage of 0.328±0.010 V.

Awards Won:

American Chemical Society: Third Award of $2,000