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## High-efficiency solid-state dye-sensitized solar cells using coupled dye mixtures

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A solid-state dye sensitized solar cell comprising of dye mixtures [Ru(2,2 –bpy-4,4'-dicarboxylic acid)$(NCS)_2$ [dye 1] and [Ru(4,4',4"-tricarboxy-2,2;6,2"-terpy)$(NCS)_3$) [dye 2] on $TiO_2$ thin film was fabricated. The multiple dye system showed the short circuit current ($I_{sc}$) of 10.2 mA/cm$^2$ and cell efficiency ($\eta$) of 2.4 while broadening the spectral sensitivity of the cell. When a single dye is used, $I_{sc}$ of 6 and 5 mA/cm$^2$ and cell efficiency of 1.7 and 1.2 were observed for [Ru(4,4-bis(carboxy)-bpy)$_2$$(NCS)_2$ ] and [Ru(2,2',2"-$(COOH)_3$-terpy)$(NCS)_3$] respectively. Additionally, the resulting IPCE for the solar cell consisting of dye mixture was 50% at wide wavelength range from 530 – 650 nm while for the dye 1, 32% IPCE was observed at 535 nm while for the dye 2, highest IPCE value observed was 20 % at 620 nm. In this research we showed that the $I_{sc}$, $\eta$ and IPCE% values of the DSSC could be increased by using covalently connected dye mixtures with different optical properties. The higher $I_{sc}$ for the cell fabricated with different dye mixtures could be mainly attributed to its extended spectral response. The $\eta$, IPCE% values and $I_{sc}$ values reported in this work are the best-reported values for the DSSC of CuI as a hole collector. The experiments have undertaken to increase the IPCE% further by improving the Voc and the fill factor.

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