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Co-sensitization performance of dye sensitized solar cell based on combination of natural dyes extracted from grapes and green tea

Shakya M. D. P. A.[1*], Jayathilaka K. M. D. C.[1], Wanninayake W. T. M. P. K.[1], Kumara R.[2], Siripala W. P.[1] and Wijesundera L. D. B. R. P.[1]

[1]Department of Physics and Electronics, University of Kelaniya, Kelaniya, Sri Lanka.
[2]Japan Synchrotron Radiation Research Institute (JASRI), Kouto 1-1-1, Hyogo 679-5198, Japan.
paramiamashakya1996@gmail.com*

The global energy crisis is a pressing issue that is likely to intensify in the future. Researchers are actively exploring alternative energy sources to create a more sustainable and secure future for the world's energy needs. The advantages of Dye Sensitized Solar Cells (DSSC) include simple, easy and cost-effective manufacturing, the ability to use flexible substrate, and the possibility to attain reasonable conversion efficiency. Their unique properties make them a promising solution for addressing energy shortages and advancing renewable energy technologies. The current efficiency of DSSCs is low, however dye modification can enhance their photoactive performance. Dye modification enhances the dye's optical characteristics and photoconductivity. Co-sensitization is a chemical approach to improve DSSC performance by using two or more dyes with distinct optical absorption properties. This study explores co-sensitized DSSC using natural dyes to enhance photoactive performance. The TiO_2 was prepared by mixing TiO_2 powder (Titanium (IV) dioxide), Acetic acid, and Ethanol. To study the effect of natural dyes on the photoelectric conversion efficiency of DSSCs, extracts of green tea and grapes were used as sensitizers. The photovoltaic characteristics of green tea and grape dyes were studied separately and then blended in a cocktail at four various volume ratios of tea and grapes dyes 1:4, 2:3, 3:2, and 4:1 to determine the best combination. The solar cell devices were characterized using absorbance spectra, electrochemical impedance, and current density-voltage (J-V) curves. UV-visible spectra were taken from the PekinElmer Ultraviolet and Visible Spectroscopy (UV/VIS) Lambda 365. J-V and electrochemical impedance spectroscopy measurements were taken with a Gammy series G 300 potentiostat using ELS300 software. A combination of green tea and grape dyes can increase absorbance and broaden the light absorption spectrum more than a single dye. The 1:4 tea-grape mixed dye demonstrated the best DSSC efficiency value as well as the highest photocurrent value. Co-sensitization resulted in a conversion efficiency of 0.0198%, photocurrent density (J_{SC}) of 230 $\mu A/cm^2$, open circuit voltage (V_{OC}) of 0.28 V, and fill factor of 30% while efficiency also increased from 0.0058% to 0.0198%. The results show that a higher anthocyanin composition relative to chlorophyll can improve DSSC efficiency. The impedance results show that the dye mixture decreases internal resistance, which is consistent with the observed cell efficiencies. Furthermore, the best results were obtained with an acidified cocktail at pH 3 with the same volume ratio of the non-acidified cocktails. Hydrochloric acid was used for acidification. The study reveals that co-sensitization holds significant potential for the future development of DSSCs.

Keywords: Co-sensitization, DSSC, Natural dye