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Fabrication, optimization and characterization of natural dye sensitized solar cells using night jasmine flower as a natural sensitizer

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The third generation Dye-sensitized solar cells (DSSCs) have received significant attention as a cost-effective and easily fabricated alternative to traditional photovoltaic technologies. Since the introduction of the DSSCs by Gratzel and his team in 1991, many improvements have been achieved in enhancing the overall performance of the devices. These include introducing new dyes, new electrolytes and various nano-structural modifications to the semiconductor photoanode materials. However, further improvements in efficiency and stability are needed for commercial scale manufacturing. In the DSSC system, a wide band gap oxide semiconductor is placed in contact with a redox electrolyte. These semiconductor oxide films adsorb dye molecules and transport photo generated electrons to the outer circuit. The sensitizer is crucial as it determines the efficiency of light absorption and the overall efficiency of the DSSC. Natural sensitizers are organic compounds extracted from plants and other biological sources. They contain chromophores such as anthocyanins, betalains, chlorophylls and carotenoids that can absorb visible light. This study investigates the impact of dye immersion time on the efficiency of DSSCs using natural dyes derived from carotenoid pigments, extracted from *Nyctanthes arbor-tristis* (night jasmine) flowers. Carotenoids, exhibit strong light absorption in the visible spectrum, making them suitable candidates for DSSCs. Carotenoid dyes were extracted from night jasmine flowers using ethanol as a solvent. The extracted dyes were then used to sensitize titanium dioxide (TiO2) semiconductor based photoanodes. The photoanodes were immersed in the dye solution for varying periods (0.5, 1, 1.5, 2, 3, and 5 minutes) to determine the optimal dye dipping time. Each photoanode was assembled into a DSSC with a platinum counter electrode and an iodide/triiodide based liquid electrolyte. The optical properties of extracted dyes were studied using UV visible spectroscopy. The absorption spectra indicated that carotenoid dyes peaked in the wavelength range of 400-500 nm. The performance of the cells was evaluated by measuring the current density-voltage (J-V) characteristics under simulated sunlight (AM 1.5G, 100 mW/cm²). Results show that optimizing the dye immersion time significantly improves DSSC efficiency, with the highest efficiency of 0.44% achieved at an immersion time of 2 minutes. By systematically analyzing efficiency variations with different immersion times, this research provides valuable insights for optimizing DSSC fabrication using natural dyes. Consequently, this work contributes to the advancement of efficient and environmentally friendly solar energy technologies.

Keywords: Carotenoid dyes, Dye-sensitized solar cells, Efficiency, Natural sensitizers

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