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Physical Properties of Carbazole-Based Hole Transport Layers Thin films

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INTRODUCTION & AIM

Organic–inorganic halide perovskite solar cells (PSCs) have emerged as promising candidates for next-generation photovoltaic technologies, owing to their remarkable optoelectronic properties and ease of fabrication. Among these, lead-based PSCs have demonstrated impressive power conversion efficiencies. However, their commercial viability remains hindered by critical issues such as intrinsic instability, lead toxicity, and the high cost of conventional hole transport layers (HTLs)[1].

The objective of this study is to identify and develop low-cost, easily processable hole-transporting materials (HTMs) as alternatives to standard HTLs in PSCs. In this work, we report the fabrication of thin films of 9-(4-fluorophenyl)-N²,N²,N⁷,N⁷-tetrakis(4-methoxyphenyl)-9H-carbazole-2,7-diamine (Cz-1) via a sol–gel spin coating technique on glass substrates. The optical properties of Cz-1 were thoroughly characterized using UV–Visible absorption spectroscopy and photoluminescence.

METHOD

Before the deposition, Glass substrates were sequentially cleaned in an ultrasonic bath using ethanol and acetone for 15 minutes each to eliminate organic and particulate contaminants. This was followed by an isopropanol rinse and a high-temperature treatment at 150 °C using a flux synthesis approach to ensure optimal surface (as illustrated in Figure 1). Cz-1 thin films were then deposited via the sol–gel spin coating technique, utilizing a low-concentration solution (~10^{-5}M) of the compound dissolved in chlorobenzene. The optical characteristics of the resulting films were systematically analyzed using UV–Visible absorption spectroscopy and photoluminescence (PL) spectroscopy [2] to assess their suitability as hole-transporting materials in perovskite solar cell architectures.

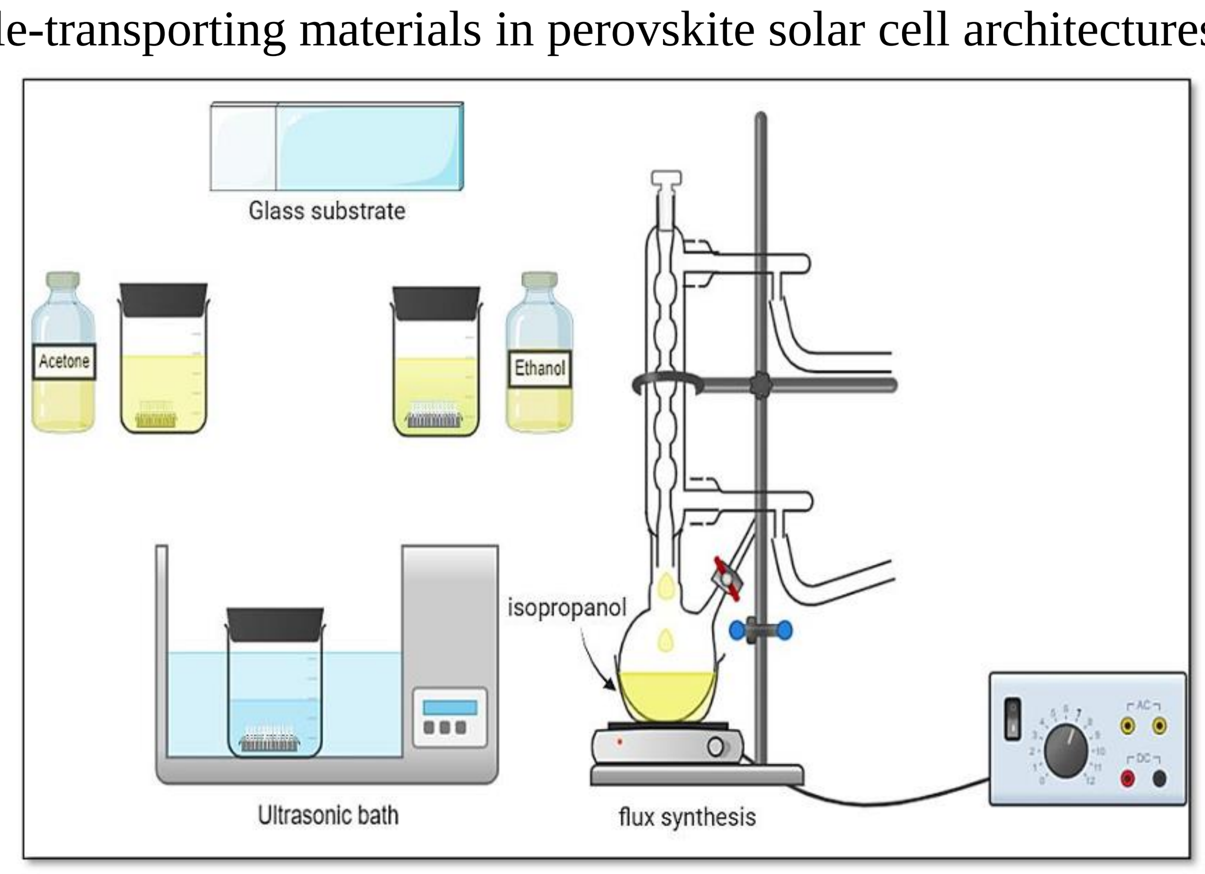

Figure 1: cleaning the substrate before the deposition process.

RESULTS & DISCUSSION

The transmittance T(k) of the film was measured at normal incidence in the spectral range 190–1100 nm. Figure 2 shows the transmittance spectra of the Cz-1 thin films deposited using sol-gel spin coating. The spectrum demonstrates the impressive absorption in the UV region.

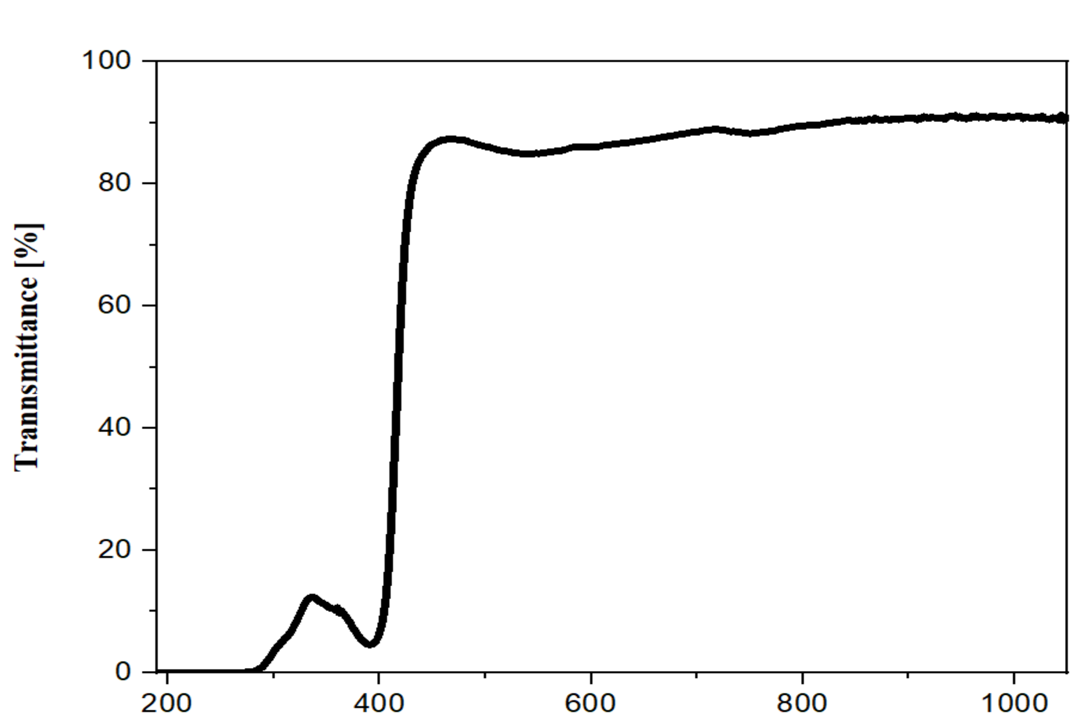

Figure 2 : Transmittance spectra of Cz-1 thin films.

Using the Tauc plot, the optical bandgap was determined from the transmittance spectrum by fitting the following formula :

$$\alpha E = B(E - E_g)^r$$

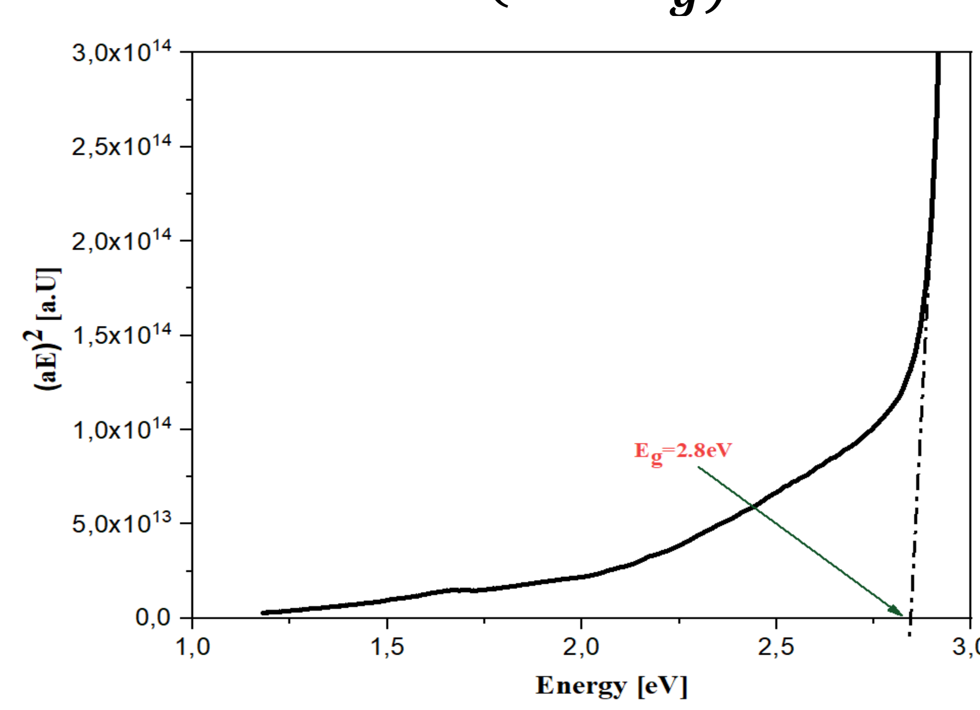

Figure 3 : Tauc plots and corresponding optical band gap of Cz-1 thin films.

The emission spectra of Cz-1 thin films recorded at room temperature exhibit a dual emission. These two bands result in the intense green-yellow luminescence.

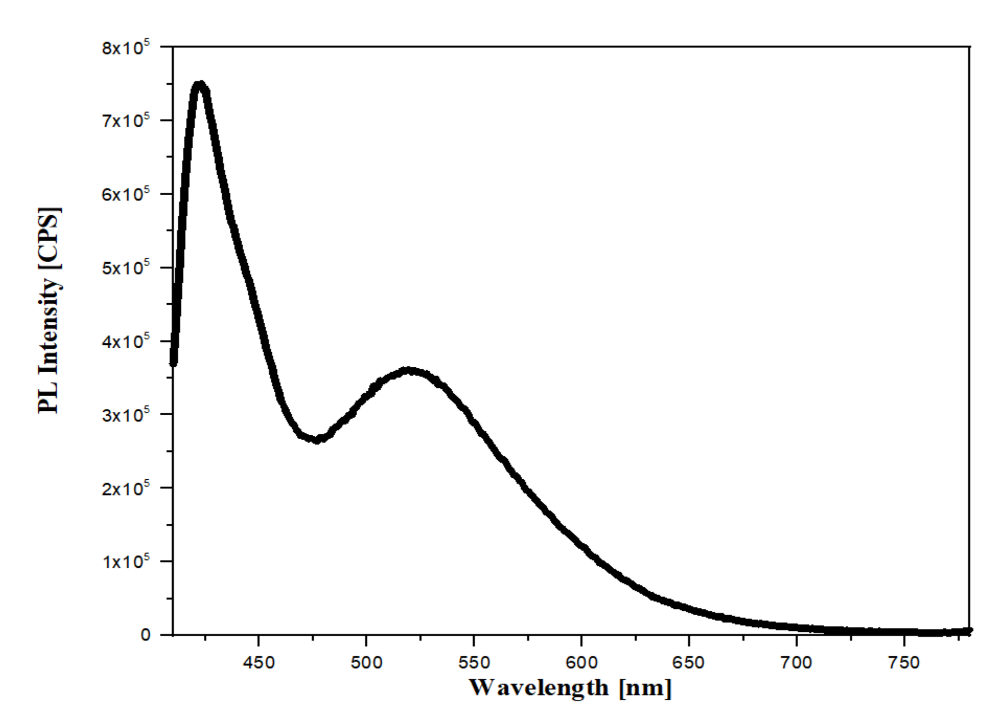

Figure 4: the emission spectra of Cz-1 thin films on a glass substrate (λex = 395 nm).

CONCLUSION

- The Cz-1 thin films were deposited by the sol-gel spin coating technique.
- The optical band gap was calculated from the transmittance spectra using the Tauc plot method (Eg=2.8eV)
- The absorbance spectra show strong absorption in the UV region, which is favorable for photovoltaic applications.
- A strong green yellow emission of Cz-1 was detected.

FUTURE WORK / REFERENCES

- **Integration of Cz-1 into a complete perovskite solar cell** to evaluate its impact on device performance parameters such as power conversion efficiency, open-circuit voltage, and stability.
- **Comparative studies** with standard hole-transporting materials (e.g., Spiro-OMeTAD) to benchmark the performance and cost-effectiveness of Cz-1.

[1] N. El, B. Oukarfi, M. Zazoui, and P. Plociennik, "Physica B : Condensed Matter Simple hole transporting material based 2 , 7- carbazole for perovskite solar cells : Structural , photophysical , and theoretical studies," vol. 682, no. December 2023, 2024.

[2] N. El, B. Oukarfi, M. Zazoui, and P. Plociennik, "Exploring the structural , photophysical , and electrical properties of Dopant-Free hole transporting material based on 2 , 7-carbazole from experimental to simulation," *J. Mol. Struct.*, vol. 1318, no. P2, p. 139091, 2024, doi: 10.1016/j.molstruc.2024.139091.