Transparent lignocellulosic materials functionalized with coumarins for potential applications in the development of luminescent solar concentrators (LSC)

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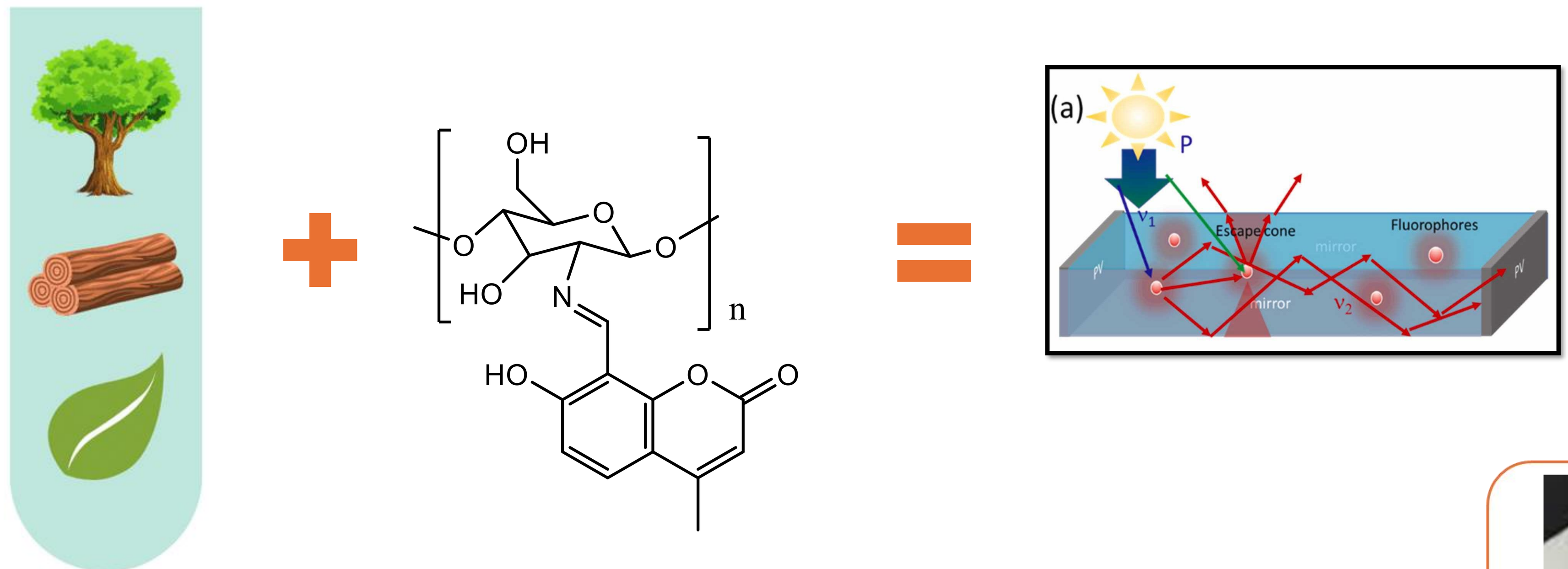
ABSTRACT

In the context of growing concerns about energy sustainability and climate change mitigation, the capture and storage of light energy, particularly solar energy, has become a key research area. This study focuses on the development and optimization of bio-based luminescent solar concentrators (LSCs), using transparent wood as a host matrix and coumarins as luminescent species. Transparent wood, obtained through delignification and chitosan impregnation, exhibits exceptional optical and mechanical properties, with high transparency and enhanced durability due to chitosan, a bio-based polymer [1]. Coumarins were selected for their outstanding photochemical and photophysical properties, including high luminescent emission efficiency and photothermal stability, critical for improving LSC efficiency in solar energy capture and conversion [2].

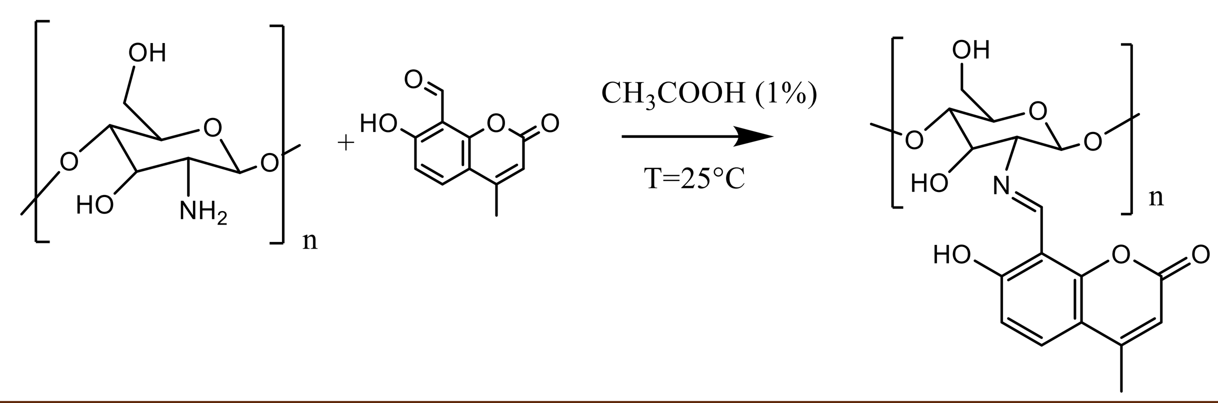
1 Introduction

The purpose of this research is to present an innovative approach to the development of luminescent solar concentrators (LSC) using lignin-free transparent wood and chitosan modified with coumarins. In a global context of increasing interest in sustainability and renewable energy, this research focuses on optimizing the capture and storage of solar energy, addressing current challenges in the efficient conversion of sunlight into usable energy. By utilizing biobased and sustainable materials, we aim to enhance photovoltaic conversion efficiency and contribute to reducing dependence on fossil fuels while minimizing environmental impacts. The characterization of the optical and mechanical properties of the new composites will explore their innovative potential in solar energy applications, thereby promoting a more sustainable future.



2 Methodology

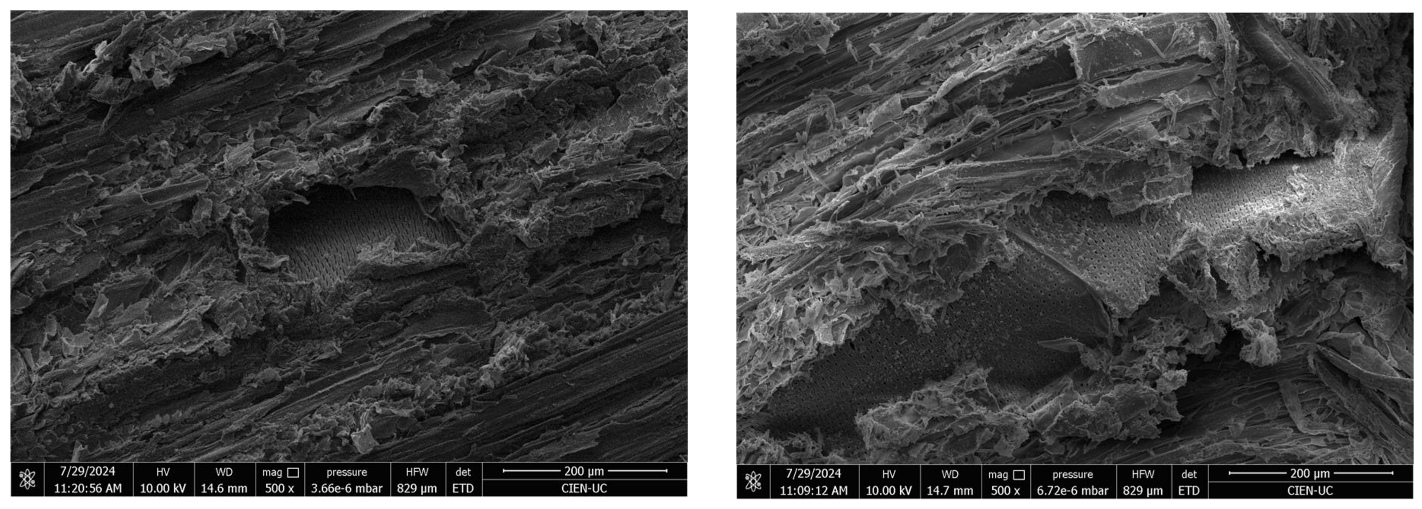
To obtain transparent wood matrices, the delignification of balsa wood (1 cm x 1 cm) is performed using a 1% sodium chlorite (NaClO2) solution in an acetic acid/sodium acetate buffer at pH 4-5. The samples are submerged and pressed to ensure uniformity, then heated at 80°C for 4 hours. The delignified wood retains its porous structure while changing from brown to white, showcasing a greater thermal stability compared to natural wood due to the compact structure provided by lignin and polysaccharides.



A 1% acetic acid solution will be prepared, and reactants will be added and stirred for 1 hour at 25°C. The amino groups of chitosan will react with the aldehyde groups of the coumarin derivative to form Schiff base links. Photochemical properties will be analyzed via UV-Visible absorption and fluorescence spectroscopy.

The polymer matrix will be infiltrated into the delignified wood samples under reduced pressure. The delignified wood slabs will be placed in a Petri dish with a support to keep them submerged in the polymer solution, preventing sample flotation. Reduced pressure will be applied for 1 hour. After this process, the samples will be stored in a Petri dish and dried in an oven at 40°C for 24 hours.

3 Results

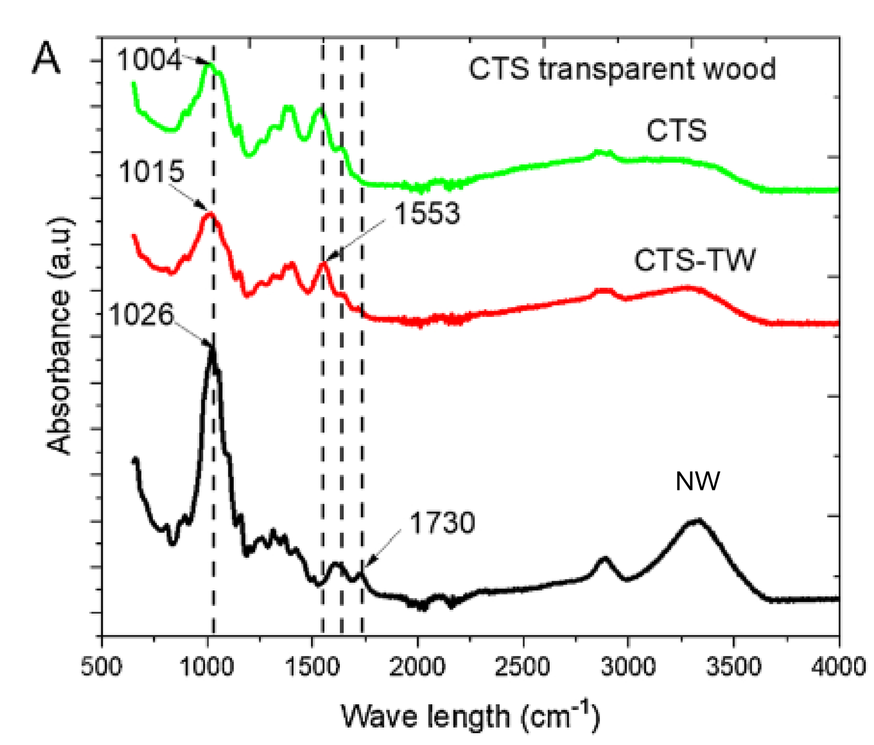


SEM Natural Wood

SEM Deslignified Wood

Water contact angles Natural Wood

Water contact angles Deslignified Wood



FT-IR Natural Wood (NW) Chitosan (CTS) and Transparent Wood with chitosan (CTS-TW)

4 Conclusions

Micrographs reveal the successful removal of lignin and the uniformity of the chitosan treatment, while the reduction in water contact angle confirms the hydrophilicity introduced by the bio-based polymer. The IR spectrum validates the chemical functionalization of the wood with chitosan, highlighting the presence of characteristic functional groups. These findings represent a key step toward the development of efficient bio-based luminescent solar concentrators (LSCs), leveraging the exceptional properties of coumarins as luminescent species for solar energy capture and conversion.

5 References

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