Green Synthesis of Carbon-Based Aerogels for Sustainable Applications

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INTRODUCTION & AIM

Aerogels, characterized by their low density and high porosity, have emerged as promising materials for biomedical, acoustic, food packaging, electrochemical energy storage, thermal insulation, environmental, water treatment [1]. Carbon aerogels are lightweight, porous materials with a huge surface area, making them incredibly versatile. Their unique properties, such as electrical conductivity and chemical stability, have made them promising candidates for a wide range of applications. However, traditional synthesis methods often rely on toxic chemicals and complex processes. This study introduces a sustainable method for producing carbon-based aerogels via hydrothermal carbonization of accessible precursors.

METHOD

Samples with $CaCl_2$ and glucose at different mass ratios were placed in PTFE-lined autoclaves and heated to 220°C. After cooling, the solid products were recovered and analyzed for different using XRD, SEM-EDX,FT-IR and TG.

Reactions:

$C_6H_{12}O_6$ (glucose) → $C_6H_6O_3$ (HMF) + $3H_2O$
$C_6H_{12}O_6$ (glucose) → 6C + $6H_2O$ + gaseous products (CO, CO_2)

RESULTS & DISCUSSION

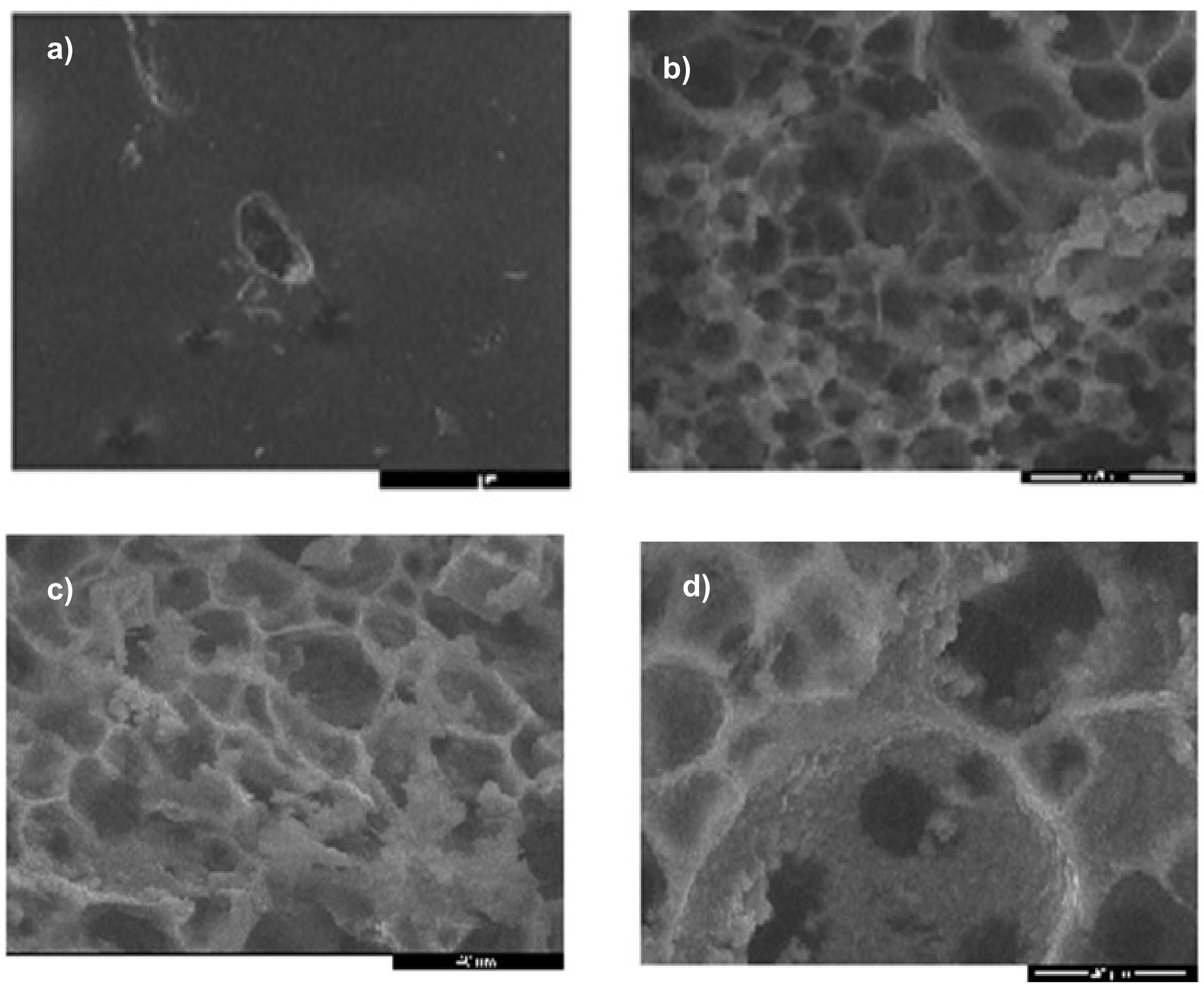

Figure 1. SEM of the aerogels obtained for $CaCl_2$:glucose mass ratios of: a) 0, b) 0.5, c) 1.08, and d) 2.16.

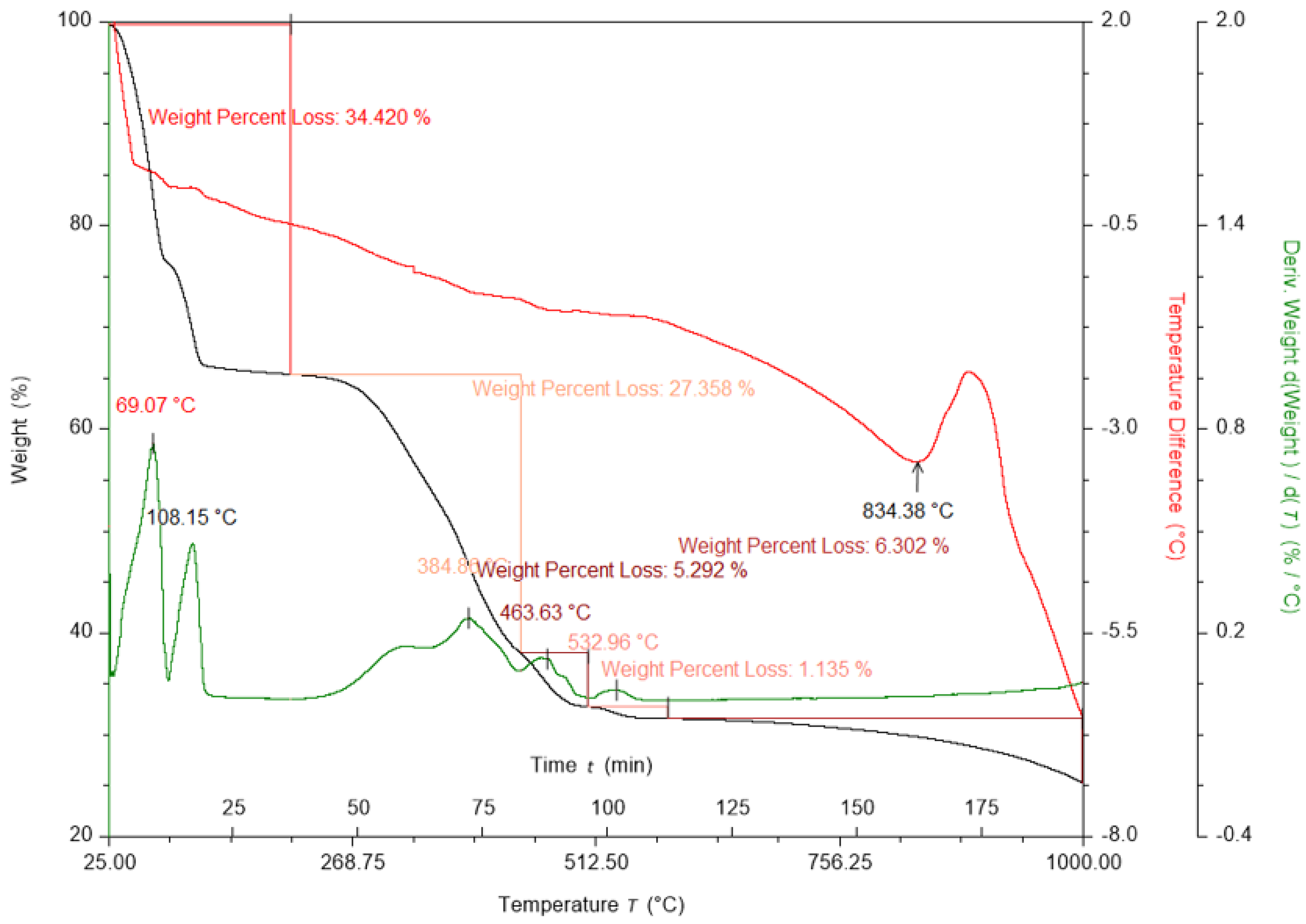

Figure 2. Thermogravimetric analysis in air for the sample with a glucose/$CaCl_2$ mass ratio, R = 4.

The first stage involves water loss through desorption and evaporation from $CaCl_2·6H_2O$. At ~30°C, $CaCl_2·6H_2O$ melts, losing water in four stages until ~260°C, with a total water-related mass loss of 34.4%, indicating dissolution in the aerogel pores. At 260°C, residual glucose begins decomposing, overlapping with carbon oxidation from ~360°C to 550°C, seen as a weakly exothermic hump on the DTA curve. Beyond 550°C, only anhydrous $CaCl_2$ remains. The total mass loss of ~70% at 580°. The endothermic peak with a maximum at 834.4°C is attributed to the melting of $CaCl_2$.

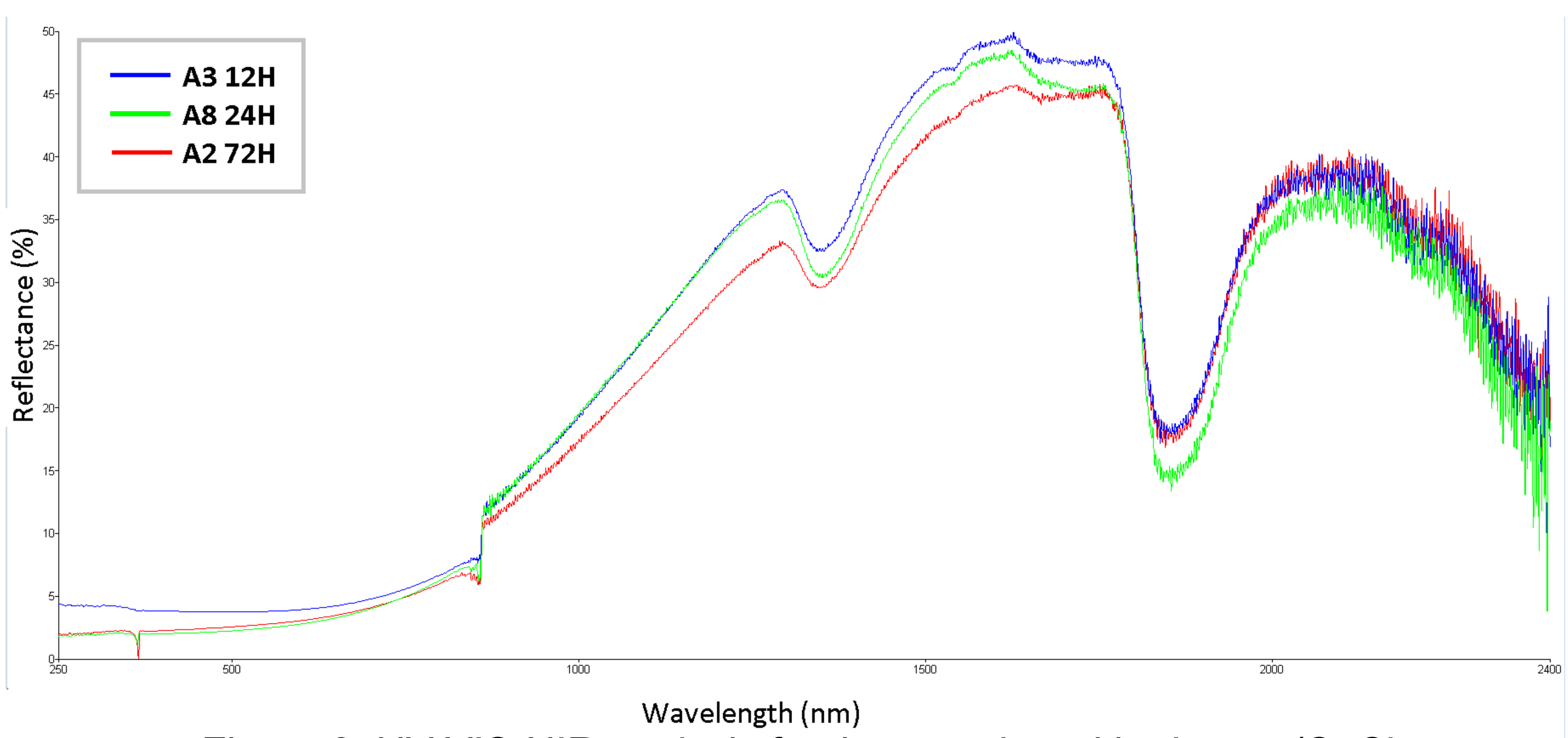

Figure 3. UV-VIS-NIR analysis for the samples with glucose/$CaCl_2$

As evidenced by the UV-VIS spectrum analysis, the specific absorption bands located at 1850 nm and 1348 nm in the near-infrared (NIR) region are distinctly responsible for the characteristic water absorption, highlighting their critical role in the spectral behavior of water.

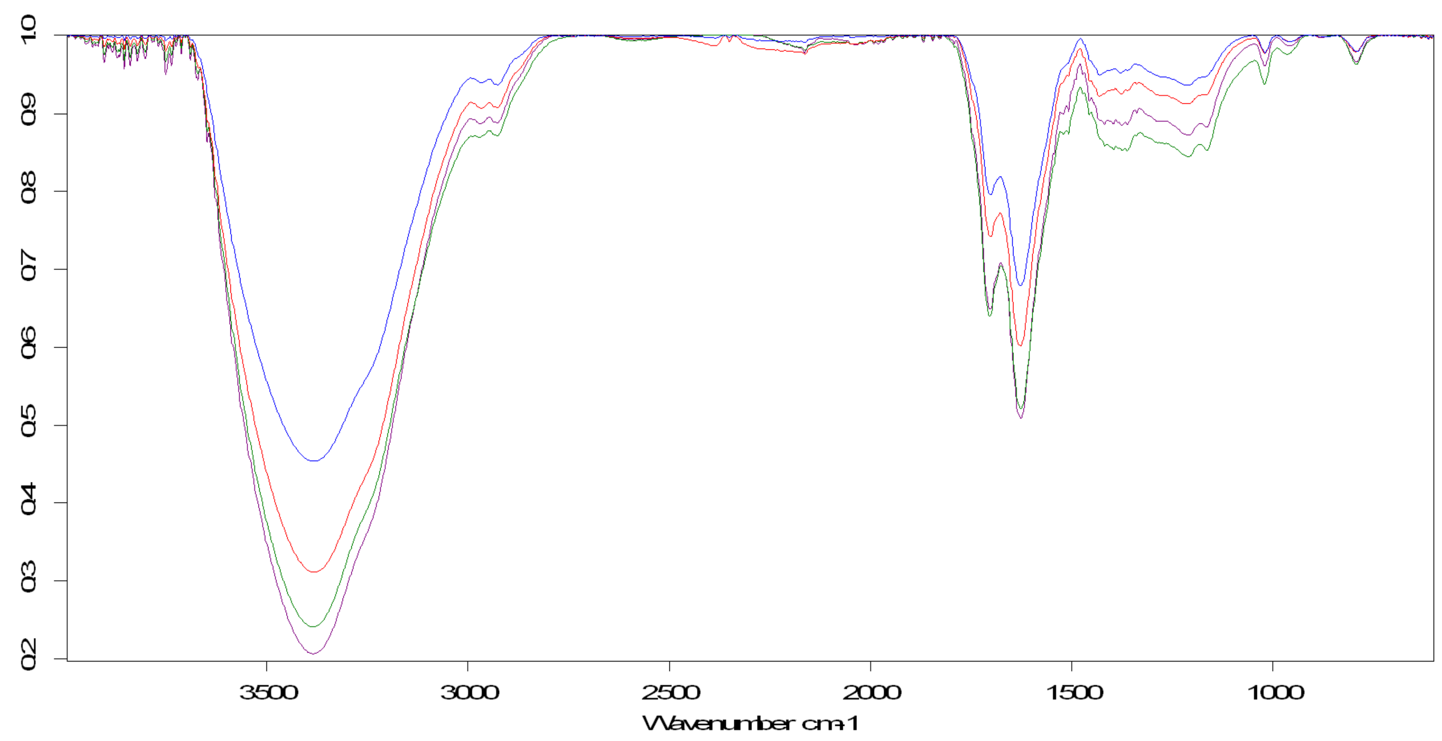

Figure 4. FTIR analysis for the samples with glucose/$CaCl_2$ mass ratio ratios of: 0, 0.5, 1.08, and 2.16.

CONCLUSION

In conclusion, the development of tunable pore-size aerogels through the controlled synthesis of carbon aerogels offers significant potential for a wide range of applications. These materials have the potential to revolutionize fields like energy storage, catalysis, environmental remediation, and biomedical engineering.

Acknowledgment

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FUTURE WORK / REFERENCES

[1] Mosoarca, C.; Hulka, I.; Șchiopu, P.; Rus, F.S.; Bănică, R. CaCO 3 -Infused Carbon Fiber Aerogels: Synthesis and Characterization. Ceramics 2024, 7, 777-795. https://doi.org/10.3390/ceramics7020051