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Microwave-Assisted Green Synthesis and Structural Study of V2O5 Nanomaterials Using Mangroves Leaf Extract

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Abstract: *In the present work Vanadium pentoxide (V2O5) nanoparticles were successfully synthesized via an eco-friendly microwave-assisted green synthesis method using mangrove leaf powder as a reducing and stabilizing agent. The XRD analysis confirmed the formation of orthorhombic Vanadium pentoxide with prominent diffraction peaks, indicating good crystallinity with average crystallite size of 35.5 nm, while Williamson–Hall analysis yielded a moderate microstrain. FTIR spectra revealed characteristic bands of bioactive phytochemicals and a distinct V=O stretching vibration, confirming successful formation and stabilization of V2O5 nanoparticles. This study demonstrates a rapid, sustainable, and effective route for synthesizing crystalline V2O5 nanomaterials suitable for energy and sensing applications.*

Keywords: V_2O_5 nanoparticles, Green Synthesis, Mangroves leaf extract, Microwave Synthesis, Structural Properties

I. INTRODUCTION

Green synthesis of nanomaterials has gained significant attention due to the increasing replacement of toxic chemical routes with eco-friendly biological approaches using plant extracts, algae, fungi, bacteria, and agricultural or food waste as reducing and stabilizing agents [1,2]. Extracts obtained from leaves, flowers, fruits, roots, and marine algae contain diverse phytochemicals such as polyphenols, flavonoids, proteins, terpenoids, alkaloids, and polysaccharides, which strongly influence nanoparticle size, shape, stability, and surface chemistry [1,4]. Compared to conventional chemical methods, green-synthesized nanoparticles often exhibit smaller particle sizes, improved stability, and enhanced biocompatibility, leading to strong antimicrobial and antioxidant activities [2,3]. Consequently, these nanomaterials have found extensive biomedical applications, including anticancer drug delivery, antimicrobial coatings, enzyme regulation, wound healing, and biomedical devices [1-3,5]. From an environmental perspective, green-synthesized nanoparticles have demonstrated excellent performance in dye degradation, heavy-metal removal, and wastewater treatment, supporting sustainable environmental remediation technologies [1,2]. Among the biological routes, plant-based synthesis dominates due to its simplicity, scalability, cost-effectiveness, and rich phytochemical content; however, challenges such as lack of extract standardization, seasonal and geographical variability, batch-to-batch inconsistency, and limited industrial-scale protocols persist [3,5]. Mangrove plants have emerged as particularly promising green resources because of their abundant bioactive compounds, rapid synthesis capability, high stability, and excellent biocompatibility, enabling the synthesis of various metal and metal-oxide nanoparticles with significant antimicrobial, antioxidant, anticancer, and environmental applications [6-8]. In parallel, vanadium pentoxide (V2O5) nanomaterials have attracted considerable interest owing to their high theoretical capacity (~437 mAh/g), low cost, abundance, safety, and versatile applications in energy storage, sensing, photocatalysis, and electrochromic devices [9]. Several synthesis techniques such as sol-gel, hydrothermal, electrospinning, combustion, and template-based methods

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have been reported for V_2O_5 nanomaterials; however, microwave-assisted synthesis has emerged as a fast, reliable, and scalable approach for producing V_2O_5 with controlled morphology and improved performance [9,10]. Notably, microwave-synthesized V_2O_5 nanoparticles exhibit excellent room-temperature ammonia sensing ability, high sensitivity, humidity resistance, and low energy consumption, making them promising candidates for next-generation gas sensors in environmental monitoring and health-safety applications [10].

II. SYNTHESIS METHOD

Mangrove leaves were first collected, thoroughly washed with distilled water to remove dust and impurities, and then shade-dried. The dried leaves were ground into a fine powder using a mortar and pestle. The overall green synthesis route followed in this work is schematically illustrated in Fig. 1, which depicts the sequence of leaf collection, powder formation, mixing, microwave treatment, drying, and calcination. For the synthesis process, 5 g of mangrove leaf powder was mixed with 0.1 M ammonium metavanadate (NH_4VO_3, 0.5896 g) in 50 mL of double-distilled water (DW). The resulting mixture was magnetically stirred for 1 hour to ensure homogeneous dispersion and effective interaction between the plant phytochemicals and vanadium precursor.

The prepared solution was then subjected to microwave oven treatment at 540 W, applied in 30-second intervals for a total of 20 cycles, until complete evaporation of water occurred. This microwave-assisted heating facilitated rapid nucleation and growth of vanadium oxide through the reducing and stabilizing action of bioactive compounds present in the mangrove leaf extract. The obtained solid residue was subsequently washed several times with double-distilled water and ethanol to remove unreacted species and organic impurities. The washed product was dried in a hot air oven at 100°C, followed by calcination at 350°C for 2 hours to improve crystallinity and phase formation. The final product was collected as a fine powder for further structural and electrochemical characterization.

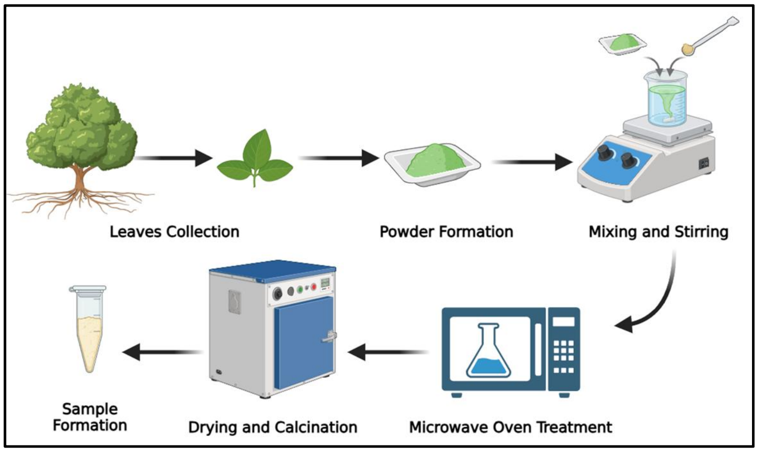

Fig.1 Schematic of Green Synthesis of V_2O_5 Nanoparticles Using Mangroves Leaf Powder

II. RESULTS AND DISCUSSION

X-Ray Diffraction

The X-ray diffraction (XRD) analysis of green synthesized V_2O_5 Nanomaterial using mangrove leaves extract shown in Fig. 2(a) reveals distinct diffraction peaks corresponding to the orthorhombic phase of V_2O_5, as matched with JCPDS card No. 00-003-0206. Prominent peaks observed at 2θ values near 24.38°,29.39°, 32.23°,33.88°, 47.3°, and 55.29°, corresponding to the (210), (101), (310), (111), (600), and (012) planes respectively, confirm the crystalline nature of the material. The sharpness and intensity of the peaks, particularly those of the (101) and (310) planes, indicate a well-developed crystalline structure. Further Debye-Scherrer formula ($D = k\lambda/\beta\cos\theta$) where k (~0.9) represents the Scherrer constant symbols, λ represents the wavelength of X ray source (0.154 nm), β represents FWHM and θ represents Bragg's angle respectively was used to measured average crystallite size (D) of the green synthesized V2O5 Nanomaterial. The value of average crystallite size was found to be 35.5 nm.

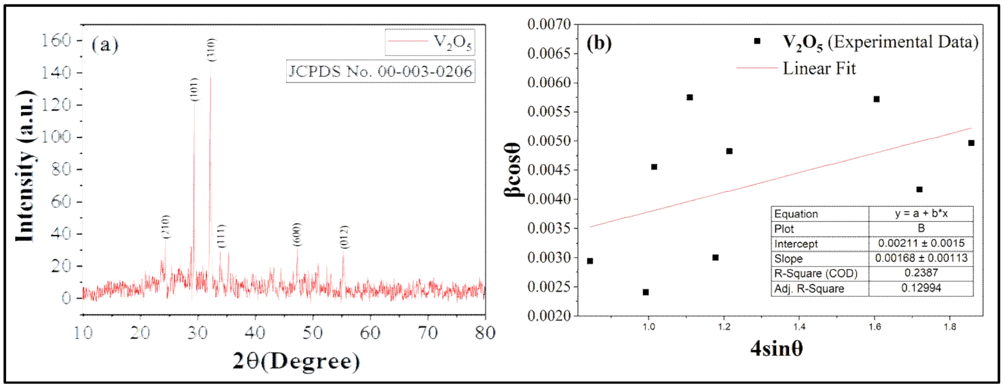

Fig.2 (a) XRD of V2O5 Nanomaterial, (b) W-H Plot of V2O5 Nanomaterial

Further the crystallite size (d) and microstrain (ε) of green synthesized V2O5 Nanomaterial was measured using W-H plot, plotted by using the equation (1):

$$\beta\cos\theta = \varepsilon(4\sin\theta) + K\lambda/D \quad (1)$$

Where microstrain represented by ε (slope) and crystallite size represented by D (y-intercept). Fig. 2(b) represents the W-H plot. By the linear fitting of the graph, the values of crystallite size and microstrain was found to be 65 nm and 1.68×10-3, respectively. Overall the XRD analysis confirms the green synthesis of V2O5 nanomaterial with orthorhombic phase.

FTIR spectroscopy:

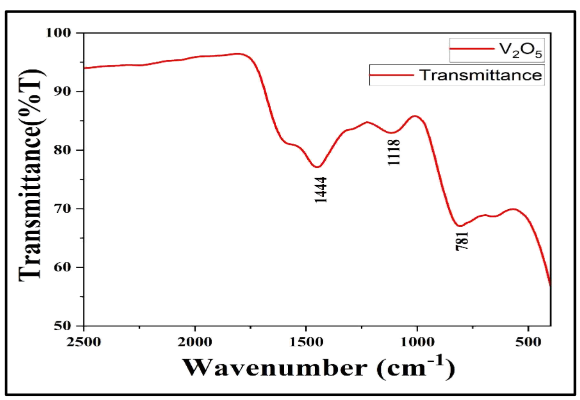

Fig.3 FTIR of V2O5 Nanomaterial

Functional group of green synthesized V2O5 Nanomaterial was studied by using FTIR characterization. The obtained FTIR spectrum of green synthesized V2O5 Nanomaterial shown in Fig. 3. The Peak at 1444 cm^{-1} are attributed to C=C and C–O stretching vibrations of aromatic compounds or carboxylates, indicating the presence of bioactive phytochemicals that act as capping and stabilizing agents. The band observed at 1118 cm^{-1} is likely associated with C–O–C stretching from ethers or polysaccharides present in the extract. Notably, the peak at 781 cm^{-1} corresponds to the stretching vibrations of V=O bonds, confirming the presence of vanadium oxide. These observations validate the successful green synthesis of V2O5 nanoparticles and the role of mangrove leaf biomolecules in the reduction and stabilization process.

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III. CONCLUSION

V2O5 nanoparticles was successfully synthesized using mangrove leaf extract via the microwave synthesis method, and its structural properties were systematically investigated.the structural analysis revealed that the synthesized V2O5 nanoparticles shows an orthorhombic phase with an average crystallite size of 35.5 nm. The Williamson-Hall (W-H) plot analysis indicated the presence of moderate microstarain in the nanomaterial. The FTIR spectroscopy confirmed the formation of vanadium oxide through the characteristic V=O stretching vibrations. This study highlights the significant role of phytochemical constituents present in the mangrove leaf extract in facilitating the green synthesis of V2O5 nanoparticles.

REFERENCES

[1] S. Ying, Z. Guan, P. C. Ofoegbu, and P. Clubb, “Environmental Technology & Innovation Green synthesis of nanoparticles : Current developments and limitations,” Environ. Technol. Innov., vol. 26, p. 102336, 2022, doi: 10.1016/j.eti.2022.102336.

[2] A. Hosseingholian, S. D. Gohari, F. Feirahi, F. Moammeri, and G. Mesbahian, “Materials Today Sustainability Recent advances in green synthesized nanoparticles : from production to application,” Mater. Today Sustain., vol. 24, p. 100500, 2023, doi: 10.1016/j.mtsust.2023.100500.

[3] S. Singaravelu and F. Motsoene, “Green-synthesized metal nanoparticles : a promising approach for accelerated wound healing,” no. July, pp. 1–27, 2025, doi: 10.3389/fbioe.2025.1637589.

[4] T. E. Storage and B. Applications, “Green Synthesis of Nanoparticles and Their Energy Storage, Envronmental, and Biomedical Applications,” 2023.

[5] N. Rabiee, “Green Synthesized Nanomaterials : Principles , Progress , and Perspectives,” Green Nanomater. Sustain. Innov. Divers. Appl. Part 1 - Green Synth. Nanomater. Princ. Progress, Perspect., 2025, doi: 10.1021/bk-2025-1520.ch001.

[6] S. Vaish and B. Pathak, “Environmental Nanotechnology , Monitoring & Management Mangrove synthesized bio-nanomaterial and its applications : A review,” Environ. Nanotechnology, Monit. Manag., vol. 20, no. August, p. 100866, 2023, doi: 10.1016/j.enmm.2023.100866.

[7] N. Willian, A. Labanni, S. Arief, K. L. Manis, and W. Sumatera-indonesia, “Bio-Friendly Synthesis of Silver Nanoparticles Using Mangrove Rhizophora stylosa Leaf Aqueous Extract and Its Antibacterial and Antioxidant Activity,” vol. 13, no. 3, pp. 1478–1485, 2020.

[8] U. Saraswathi, “Green synthesis of silver nanoparticles using a mangrove Excoecaria agallocha,” vol. 3, no. 10, pp. 54–57, 2014.

[9] X. Liu, “V2O5-Based nanomaterials: synthesis and their applications,” pp. 4014–4031, 2018, doi: 10.1039/c7ra12523b.

[10] N. Duc, P. Nam, D. T. Huong, P. H. Anh, B. X. Hoang, and L. H. Phuoc, “Materials Science and Engineering : B Microwave-synthesized V 2 O 5 nanoparticles for ammonia sensing at room temperature,” vol. 307, no. September 2024, pp. 1–6, 2026.