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Modified Sol–Gel Synthesis of SiO_2 Nanoparticles

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INTRODUCTION & AIM

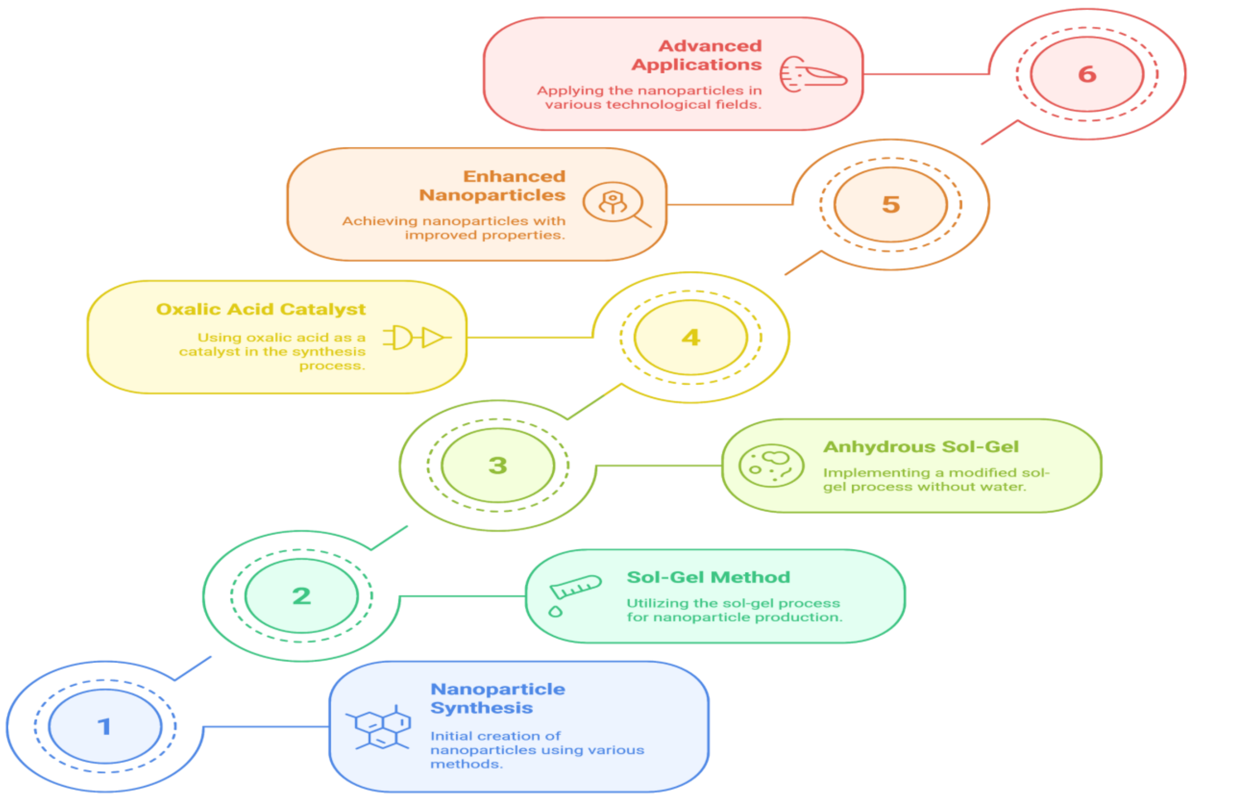

Figure 1: Progressive Development of Carbon-Modified SiO_2 Nanoparticles via Anhydrous Sol-Gel Synthesis and Oxalic Acid Catalysis for Advanced Applications

METHOD

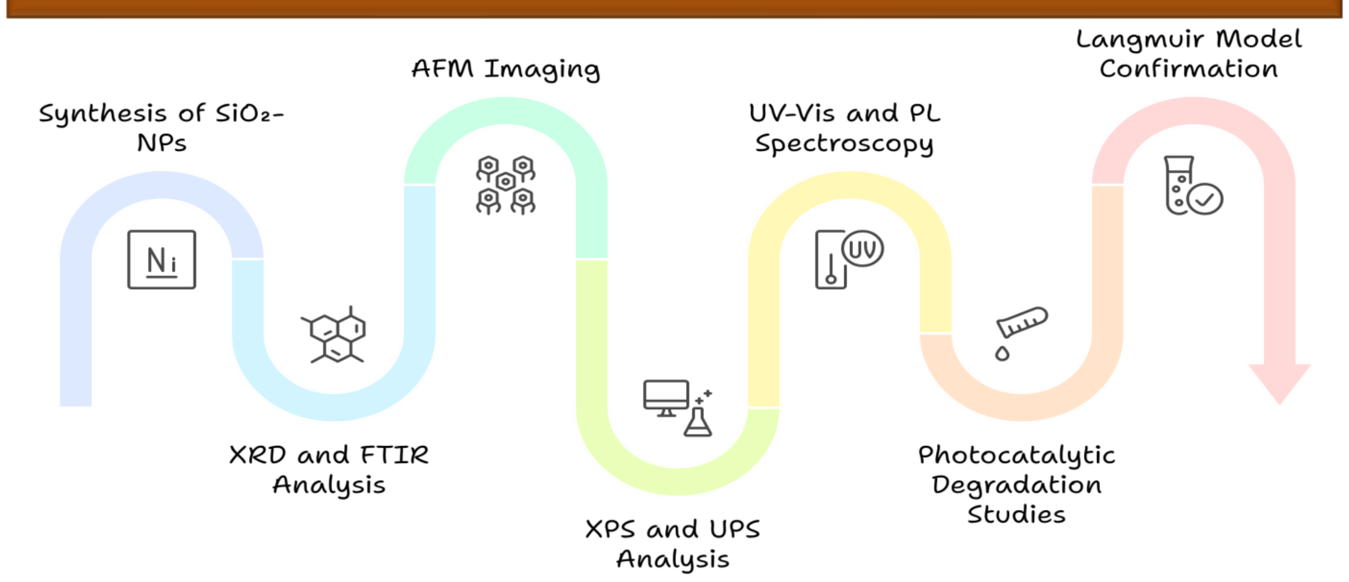

FIGURE 2: Synthesis and Characterization of Carbon-Modified SiO_2 Nanoparticles

RESULTS & DISCUSSION

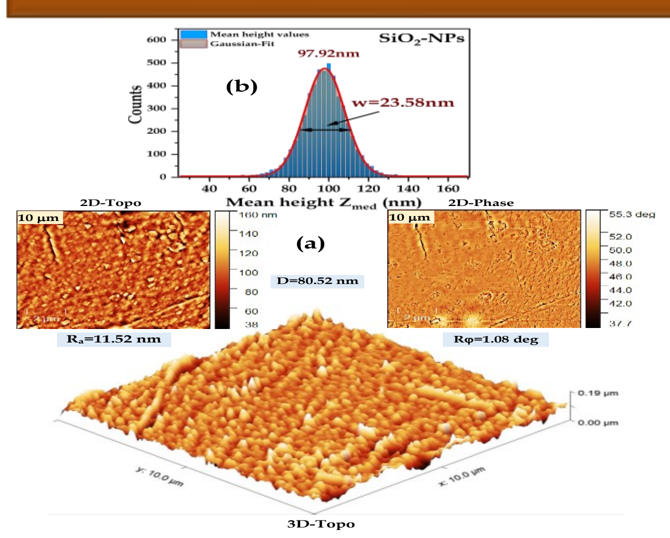

Fig. 3. (a) 2D/3D AFM topography and phase images of SiO_2 NPs (10×10 µm scan; Ra: roughness, ϕa: phase contrast, D: grain size). (b) Height histogram

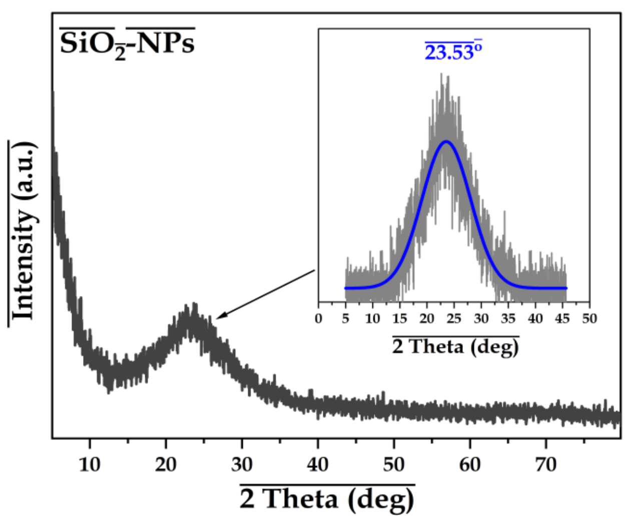

Fig. 4: XRD pattern of SiO_2 nanoparticles.

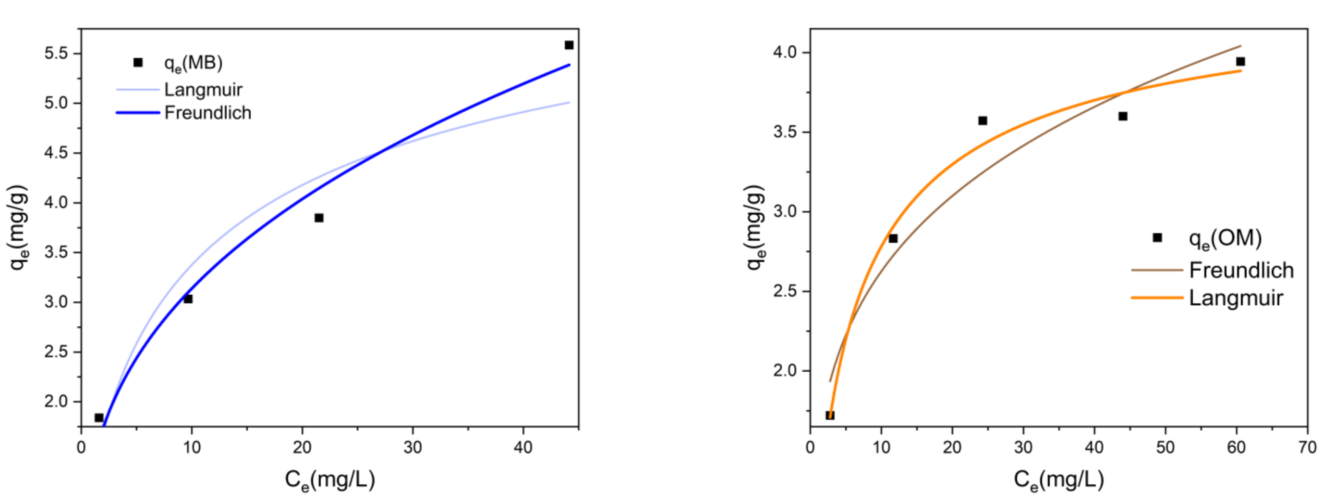

Fig. 5: Freundlich isotherm for Methylene Blue (MB); Langmuir isotherm for Methyl Orange (MO).

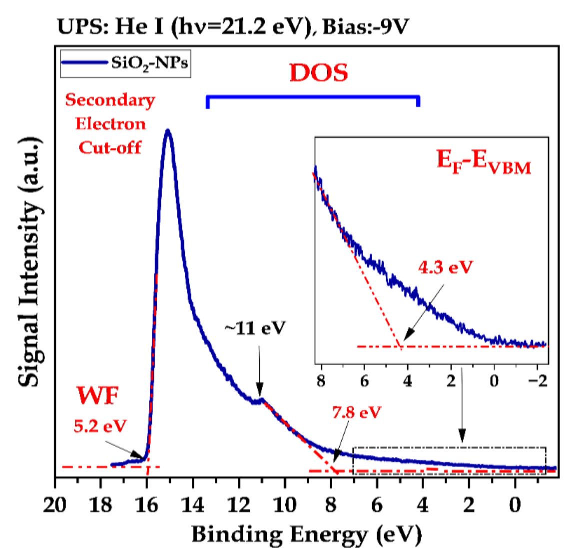

Fig. 6: UPS spectrum of SiO_2-NPs (He I, hν = 21.2 eV); red lines show SE cutoff for work function (WF) and VBM region for EF–EVBM determination.

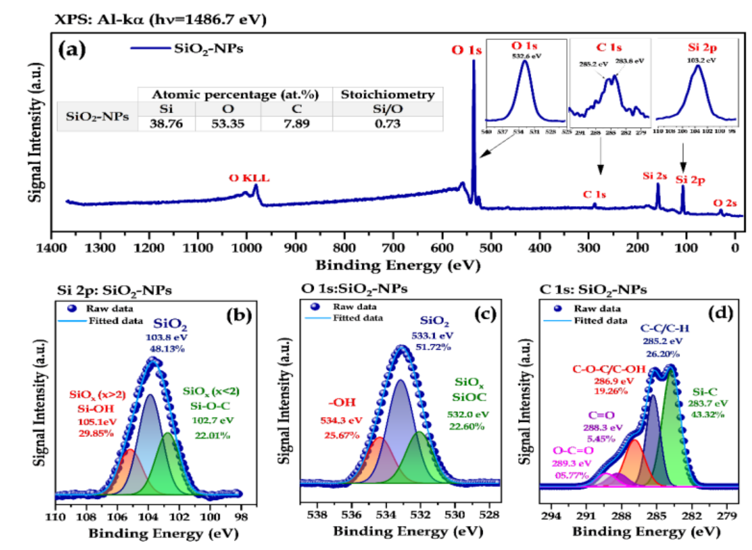

Fig. 7: XPS of SiO_2-NPs: (a) wide scan with atomic %, (b–d) Si 2p, O 1s, C 1s with Gaussian fits.

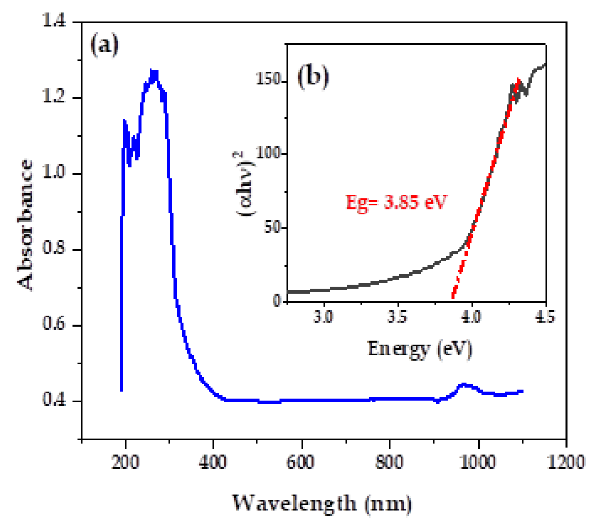

Fig. 7. (a) UV-Vis absorption of SiO_2-NPs (max at 266 nm); (b) Tauc plot for bandgap energy.

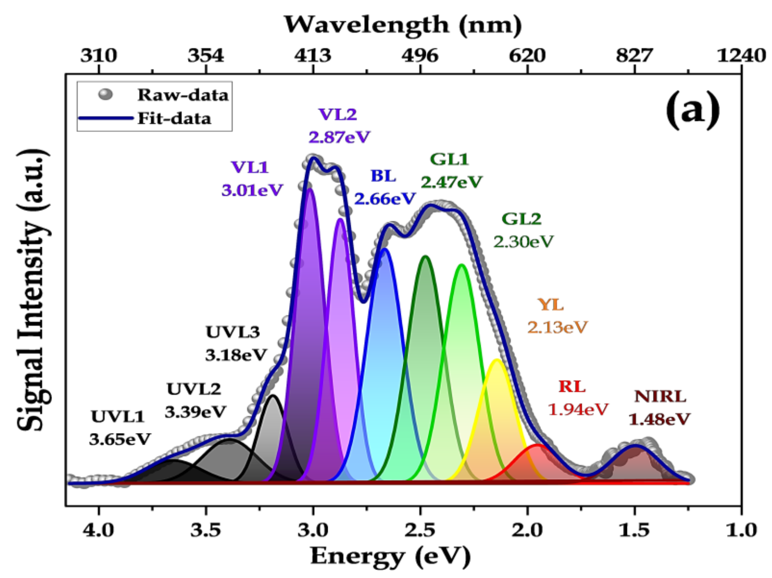

Fig. 8. (a) PL spectrum of SiO_2-NPs with Gaussian fit

Table 1. PL emission peaks and corresponding defect states in SiO_2-NPs.

Emission Peak (eV)	Color	Origin
3.65	Ultraviolet (UV)	Oxygen-deficient centers (ODC I), Singlet-Singlet transition
3.39		
3.18		Oxygen vacancy related states in SiO_2
3.01	Violet	Oxygen deficient centers ODC (II) (≡Si:Si≡)
2.87		
2.66	Blue	Self-Trapped Excitons (STEs)
2.47	Green	Dioxasilirane group (DOSG),
2.30		SiC-related centers
2.13	Yellow	Silanone groups (Si=O double-bond states) The nonbridging oxygen hole centers (NBOHC) ≡Si–O· Hydrogen-related defects (the OH group)
1.94	Red	The quantum confinement effect Defect luminescence fromSilanol groups (Si-OH)
1.48	Near-infrared	Si nanocluster

CONCLUSION

Table 2. Summary of Key Structural, Optical, and Functional Properties of SiO_2-NPs

Parameter	Summary
Crystallite Size	~7.7 nm (short-range order in amorphous matrix)
Synthesis	Sol-gel with oxalic acid, 400°C, low energy
Defects	Oxygen vacancies, Si–O–C bonds, NBOHCs
Surface	Hydroxylated, ~80 nm grains, roughness Sa ~ 11.5 nm
Optical	Bandgap 3.85 eV; PL emissions 1.48–3.65 eV (defects)
Adsorption	MB: Freundlich (R^2 = 0.975); MO: Langmuir (R^2 = 0.983)
Photocatalysis	Defect-enhanced charge separation, visible-light active
Applications	Wastewater treatment, optoelectronics, sensing

Conflict of Interest: The authors declare no conflicts of interest.

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