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Comparative study of nanostructured 3d and 4d transition metal oxides (Mn_2O_3 and TiO_2) for energy, environmental, and biomedical applications: Synthesis, characterization, and future perspectives

Gajendra Singh Lodhi[a], Jyoti Sharma*[b] & Bholey Nath Prasad[c]

[a] Seth Ganga Sagar Jatiya Government Polytechnic, Khurja, 203 131, Bulandshahar, Uttar Pradesh, India

[b] Department of Chemistry, School of Basic and Applied Sciences, Shobhit Institute of Engineering and Technology (Deemed-to-be-University), Meerut 250 110, Uttar Pradesh, India

[c] Government Polytechnic, Ayodhya 224 001, Uttar Pradesh, India

E-mail: lodhigajendra8@gmail.com

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This comparative study investigates the synthesis and characterization of Mn_2O_3 and TiO_2 nanoparticles using auto-combustion and sol-gel methods, respectively. The structural, morphological, and compositional properties of both nanoparticles have been analyzed using X-ray diffraction (XRD), Fourier-transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM), and energy-dispersive X-ray (EDX) spectroscopy. The XRD analysis reveals distinct crystal structures, with Mn_2O_3 exhibiting a cubic structure (space group $Ia\bar{3}$, lattice parameter a = 9.410086 Å) and TiO_2 displaying a tetragonal anatase phase (space group I41/amd, lattice parameters a = b = 3.771 Å and c = 9.43 Å). The average crystallite size of Mn_2O_3 nanoparticles has been estimated to be approximately 30 ± 5 nm using the Debye-Scherrer equation, whereas the Williamson-Hall plot reveals a crystallite size of 75 ± 5 nm and lattice micro-strain of 0.00181. In contrast, TiO_2 nanoparticles exhibit irregular and spherical shapes with clumped distribution, having average grain sizes of 0.54 µm and 0.31 µm under 10,000X and 5,000X magnifications, respectively. EDX analysis has detected the presence of Ti, O, and a small amount of S impurities in TiO_2 nanoparticles. The comparative analysis highlights the differences in structural, morphological, and compositional properties between Mn_2O_3 and TiO_2 nanoparticles, which can significantly impact their potential applications in various fields, including energy storage, catalysis, and biomedicine. This study provides valuable insights into the synthesis and characterization of these nanoparticles, paving the way for further research and development.

Keywords: Mn_2O_3NPs, TiO_2NPs, EDX, XRD, SEM, FTIR, Auto-combustion synthesis, Sol-Gel approach