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# Optical Properties of Aluminium Oxide Nanoparticles Synthesized by Leaf Extract of *Ocimum sanctum*

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ABSTRACT

In the present work aluminium oxide nanoparticles are synthesized using leaf extract of *Ocimum sanctum*. The synthesized sample was characterized by XRD, HR – TEM, UV – Vis, FTIR and PL. It is found that aluminium oxide nanoparticles synthesized by leaf extract are stable and show good optical properties. This method of synthesis is less toxic and cost of synthesis is low as compared to other chemical and physical methods. By XRD pattern phase of synthesized aluminium oxide nanoparticles is confirmed and the average particle size is found to be 19.43 nm. By HR - TEM analysis, the particle size of synthesized nanoparticles ranges from 18 nm to 25 nm. By UV – visible spectroscopy the energy band gap is found to be 2.55 eV. By FTIR analysis presence of Al–O band and biofunctional group is confirmed. Photoluminescence spectroscopy confirmed the energy band gap of as synthesized alumina nanoparticles is 2.19 eV. Hence, from the present study, it is concluded that aluminium oxide nanoparticles synthesized by plant leaf extract are good semiconductors.

## 1. Introduction

Nanoparticles are of great interest of research in every field due to their very large surface to volume ratio. Aluminium oxide is a compound of Aluminium and oxygen having chemical formula $Al_2O_3$. It is generally known as alumina. It is very hard, chemically inert, has high melting point, non- volatile and it has resistance to oxidation and corrosion [1-5]. There are many physical and chemical methods for the synthesis of Aluminium oxide nanoparticles some of which are ball milling, spray combustion, hydrothermal, sputtering, sol-gel, microwave and laser ablation [5-11].

The nanoparticles of aluminium oxide can be widely used in every field of science and engineering because of their interesting properties such as high stability, hardness, insulation, tunable mechanical properties etc. [6]. These nanoparticles can be used in the form of powder, fluid, films etc. These nanoparticles can be used in the treatment of waste water [9], as organic light emitting devices (OLEDs), solar selective coatings, bar code readers, optical lenses and windows [10].

In the present work aluminium oxide nanoparticles are synthesized using leaf extract of *Ocimum sanctum* and characterized by XRD, HR – TEM, UV – Vis, FTIR and PL.

## 2. Experimental Methods

### *2.1 Synthesis of Aluminum Oxide Nanoparticles*

Plant extract was prepared using leaves of *Ocimum sanctum* (Tulsi). The leaves were first washed with tap water and then with distilled water to remove all the dust and unwanted particles. Then leaves were dried at room temperature. Now, Tulsi leaves are boiled in distilled water at 50 °C for about 12 min. The solution is filtered using filter paper and a pale-yellow clear solution is obtained and stored at about 4 °C. Then, 2 mM solution of aluminium nitrate was prepared by dissolving $AlNO_3$ in distilled water. Tulsi abstract was mixed with this solution and it was kept under constant stirring using a magnetic stirrer for one and half hour. The change in colour from pale yellow to colloidal white indicated the formation of Aluminium oxide nanoparticles.

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### *2.2 Characterization Studies*

The crystalline size, structure, functional groups and energy band gap of sample are determined by XRD analysis, TEM, FTIR analysis, UV – Vis spectroscopy and PL. The XRD analysis was carried out on XPERT – PRO diffractometer operated at voltage 45 KV and current 40 mA. The HR – TEM studies were carried out on model FP 5022/22 – Tecnai G2 20 S – Twin. The FTIR analysis is carried out on PerkinElmer Spectrum Version 10.4.00 in the wavelength range 400 – 4000 cm$^{-1}$. The UV – Vis analysis is carried out on LAMBDA 1050 spectrometer in the wavelength range 200 – 800 nm. Photoluminescence spectroscopy is carried out using 325 nm laser in wavelength range 335 – 807 nm.

## 3. Results and Discussion

XRD diffraction studies are used to determine particle size and crystallinity of sample. The crystallite size is measured using Debey – Scherrer's formula, $D = 0.94\lambda/\beta\cos\theta$, where $\lambda$ is the wavelength of X – rays used which is $CuK_\alpha$ radiation and $\beta$ is full width at half maximum of the diffraction peak corresponding to $2\theta$. The wavelength of $CuK_\alpha$ radiartion used is 1.54060 Å. Fig. 1 XRD patten of aluminium oxide nanoparticles. The average particle size of the nanoparticles calculated by above formula comes out to be 19.43 nm.

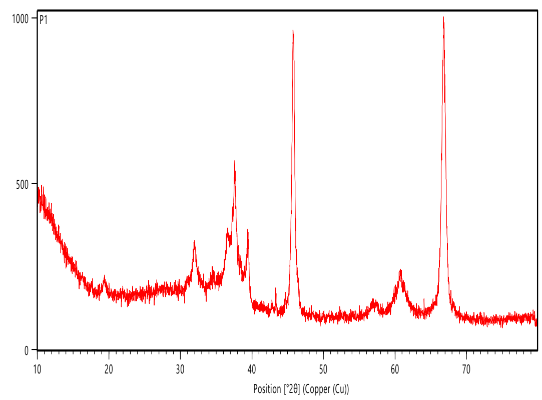


**Fig. 1** XRD patten of aluminium oxide nanoparticles

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The TEM images of aluminium oxide nanoparticles (Fig. 2) revealed that the nanoparticles are nearly spherical in shape and their size ranging from 18 nm to 25 nm.

FTIR spectrum is a useful tool to determine functional groups of the synthesized nanoparticles. The Fig. 3 shows characteristic peaks. The peaks at 796.85, 729.65 and 523.74 cm$^{-1}$ are alumina peaks [12] which confirms formation of $Al_2O_3$ nanoparticles. Two peaks at 3458.58 and 3013.56 cm$^{-1}$ are due to –OH stretching mode [13].

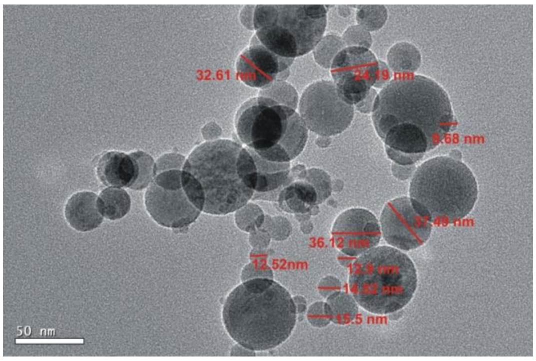


**Fig. 2** TEM images of Aluminium oxide nanoparticles

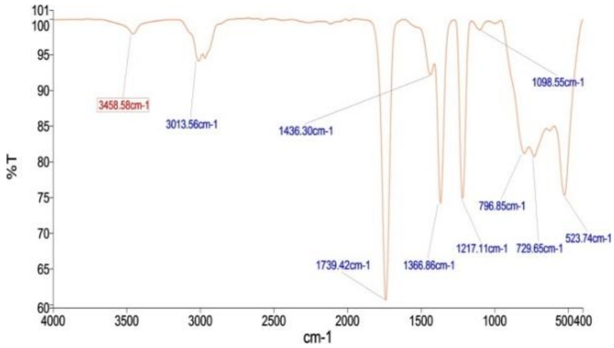


**Fig. 3** FTIR spectrum of aluminium oxide nanoparticles

The UV–Vis spectrum is used to study optical properties of the sample. Light is passed though the sample solution and absorbed light is measured. The absorbance is measured by varying wavelength of light and graph is plotted between absorbance and wavelength of light which is shown in Fig. 4. The sample shows a strong absorption peak ($\lambda_{max}$) at 230 nm in the UV region. This is associated with photo excitation of electrons from valence band to conduction band.

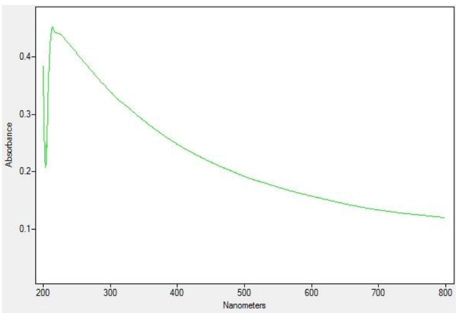


**Fig. 4** UV–Vis absorption spectrum of aluminium oxide nanoparticles

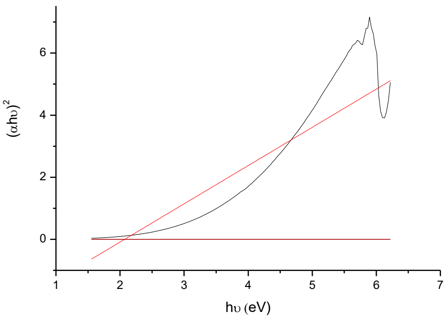


**Fig. 5** Tauc's plot of aluminium oxide nanoparticles

The optical band gap of the aluminum oxide nanoparticles is calculated by Tauc's relation. A graph is plotted between $(\alpha h\nu)^2$ and hν. This is shown in Fig. 5. Here, α is absorbance, h is Planck's constant and ν is the frequency of light. Intercept of straight line at α = 0 gives the value of optical band gap, which is 2.55 eV. This band gap is approximately equal to the band gap [14].

The PL spectrum of the sample is shown in Fig. 6 which shows a broad emission peak in the range 445–625 nm. The broad emission peak is due to oxygen vacancies with three electrons [15]. The optical band gap of the sample can be calculated by peak position of the first peak of PL spectrum. For this sample, it is 2.19 eV, which is approximately equal to the optical band gap calculated by UV–Vis spectrum of the same sample. From PL spectrum it is also clear that there is good emission in green – yellow region.

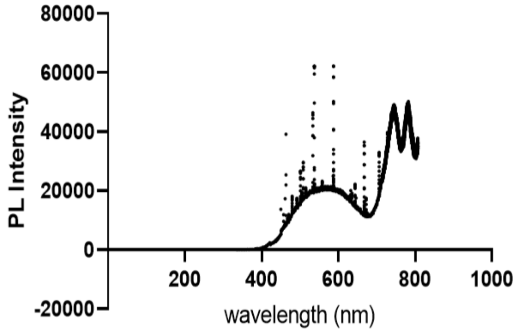


**Fig. 6** PL spectrum of aluminium oxide nanoparticles

## 4. Conclusion

From this work, it is concluded that aluminium oxide nanoparticles are successfully synthesized using leaf extract of *Ocimum sanctum*. XRD analysis revealed that the particle size is in nanometer range which comes out to be 19.43 nm. This is in agreement with the particles size shown in HR - TEM images. FTIR analysis confirms the presence of Al – O functional group. UV – Vis spectroscopy confirms the formation of $Al_2O_3$ nanoparticles. PL suggests that the sample is extremely pure. The energy band gap of these nanoparticles suggests that these are very good semiconductors. PL study revealed that there is good emission in green – yellow region so these nanoparticles can be used as LEDs of green – yellow colour.

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