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Synthesis and Characterization of CTAB Capped Praseodymium Oxide Nanoparticles

Research Article

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Abstract. *Rare-earth-oxides* (REOs) in impressive consideration in view of their potential application in catalyst and optoelectronic gadgets. REOs have promising optical, electrical and chemical properties. They are described by the progressive filling of the 4f level of their electronic arrangement. Among REOs, praseodymium oxide is a significant REO material utilized as catalyst, oxygen storage components and material for higher electrical conductivity. Praseodymium oxide includes unique highlights inside the arrangement of the REOs. It structures homologous a progression of oxides with variable valence states. This has the most astounding oxygen ion mobility inside the arrangement of lanthanide oxides, on account of the assortment of stable phases, which empowers quick changes in the oxidation state of praseodymium. Different methods have been embraced for the synthesis of phase pure praseodymium oxide nanoparticles like solid state synthesis, hydrothermal, microwave assisted synthesis, sol-gel, and so on. Among the above mentioned, the wet chemical approach is a simple, versatile method to prepare phase pure, controllable nanoparticles with high return. The prepared particles are exposed to post synthesis processes and characterized for their basic morphological studies.

Keywords. Nanoparticles; Praseodymium; Solvothermal method

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1. Introduction

Praseodymium oxides involve stoichiometric, Pr_2O_3 and PrO_2, just as non-stoichiometric oxides. Stoichiometric oxides embrace hexagonal, Pr_2O_3, and also fluorite, PrO_2, structures though non-stoichiometric ones are oxygen-inadequate changes of the fluorite structure. As an impetus, Pr_6O_{11}shows great movement execution during the oxidative coupling of methane [1]. Praseodymium oxide (Pr_6O_{11}) is a black colored material, a member of the homologous arrangement $Pr_{(n)}O_{(2n-1)}$ that ranges from Pr_2O_3 to PrO_2 and thermally stable to warming in the air up-to 1000 °C. Pr_6O_{11} is produced via thermal decomposition not just of comparing acetate and oxalate precursor compounds, yet in addition of formate, nitrate, adepate and sebacate, citrate and hydrates of chlorinated acetates. In all cases the observed phase of the oxide was found to rely upon the precursor utilized just as the air and temperature of decay [2]. The stoichiometric Pr_2O_3 and PrO_2 oxides embrace, respectively, the hexagonal and fluorite crystal structures, though the nonstoichiometric ones, for example, PrO_x (where $x =$ 1.833, 1.810, 1.800, 1.78, 1.714 and 1.670), are oxygen insufficient alterations of the fluorite structure [2]. Rare-earth-oxide-supported (promoted) metals establish a moderately new class of multicomponent catalytic frameworks demonstrating rather unconventional behaviors. In specifically, ceria-containing phases have received consideration on account of their utilization as three-way impetuses [3].

When in doubt it was discovered that it is the labile or reactive oxygen's of the catalysts which take an interest in methane enactment [4]. We picked in this manner to test praseodymium oxide, which can exist under an assortment of middle of intermediate oxidation states between Pr_20_3 (Pr^{3+}) and $Pr0_2$(Pr^{4+}). DeBoy and Hicks [5] clarified the higher rate of methane conversion and lower selectivity to C_2 acquired on this oxide contrasted with other rare earth oxides by the nearness of Pr^{4+}. Be that as it may, Gaffney et al. [6] demonstrated that the C_2 selectivity on praseodymium oxide is strikingly expanded when doped with lithium, which likewise decreases its movement toward methane conversion.

One-dimensional (1-D) nanostructures (for example, nanowires, nanorods and nanotubes) have recently incredible consideration attributable to their one of unique physical, chemical and mechanical properties and different potential applications. Rare earth compounds for the most part have extraordinary optical, electrical, magnetic and catalytic properties, and have been broadly utilized in the previous decades because of their unique electronic structures. If the rare earth compounds were created as1-D nanostructures, they would have some new properties because of both their checked shape-specific and quantum-confinement effects [7]. The carboxylates, particularly the acetates and oxalates, of metals are applicable to both adsorption and catalysis. For instance, they can be utilized successfully for the preparation of solids with reactive surfaces. Likewise, their arrangement is engaged with the adsorption processes of some organic compounds on metal oxides. In this manner, a detailed learning of the phases present in these frameworks at different temperatures might be helpful

[8]. Be that as it may, all the above processes for the most part need higher reaction temperature, longer reaction time or extraordinary hardware. Then again, another significant that synthetic trouble experienced around there is poor crystallinity of 1-D nanostructures, and to completely use these 1-D materials, it would likewise be profoundly attractive to prepare single crystalline 1-D nanostructures to exploit their anisotropic properties in many low dimensional applications. In this way, the advancement of easy, quick and productive strategies to synthesize pure praseodymium oxide in 1-D nanostructure with great single crystallinity is still of incredible importance [9].

Recent years have seen extensive enthusiasm for the manufacture and functionalization of low-dimensional nanosized materials, for example nanotubes, nanowires, nanorods, and nanobelts. These frameworks, with at any rate one restricted dimension, may offer opportunities for examining the impact of shape and dimensionality on optical, magnetic, and electronic properties. They may moreover be of extraordinary application esteem for their novel properties instigated by such decreased dimensionalities [10]. Up to now, numerous trial ways to deal with the development of nanorods or nanowires have been accounted including chemical vapor deposition, laser ablation, sol-gel method, solvothermal or hydrothermal route, microwave irradiation, and catalyst-assisted method [11, 12].

In this present work, we report, a simple method the wet chemical approach is a versatile method to prepare phase pure, controllable nanoparticles with high return. The prepared particles are subjected to post synthesis processes and characterized structural morphological studies. Pr III nitrate hexahydrate and some agents were mixed and also alcohol was added. It was thermal treatment with micro-oven assistance until the fluid is completely evaporated. Then the powder sample was thermal treatment with a furnace at various temperatures like 250, 400, 500, 600, 700 °C. The products were portrayed by XRD, Ultraviolet–Visible Spectroscopic Analysis and HRSEM.

2. Results and Discussion

Powder X-Ray Diffraction Studies

Figure 1 shows the XRD patterns of the acquired after calcinations of the as-arranged praseodymium oxide nanoparticles. The XRD patterns of 250 °C, 400 °C and 500 °C calcinated samples can not be listed on account of its amorphous nature and fuzzy diffraction reflections. The 600 °C and 700 °C calcinated Pr_6O_{11} nanoparticles are prepared by calcinations of as dried nanoparticles shows more stronger and narrower diffraction peak intensities than 500 °C and 400 °C calcinated Pr_6O_{11} nanoparticles, which demonstrates that they has larger crystal size and better crystallinities. The fact indicates that the better crystallinity and bigger crystalline size can be accomplished under the high free alkali concentration and long response time.

All detectable diffraction peaks in Figure 2 can be promptly filed to the cubic structure (space group: Fm/3m (225)) of Pr_6O_{11} predictable with the standard powder diffraction record of Pr_6O_{11} with lattice parameter $a = 0.54678$ nm. The high and sharp XRD pinnacles of 600 °C and 700 °C calcinated sample demonstrate that Pr_6O_{11} nanoparticles arranged in this work have perfect crystallinity. No impurity peaks can be detected in XRD analysis, which indicate that Pr_6O_{11} nanoparticles have pure phases.

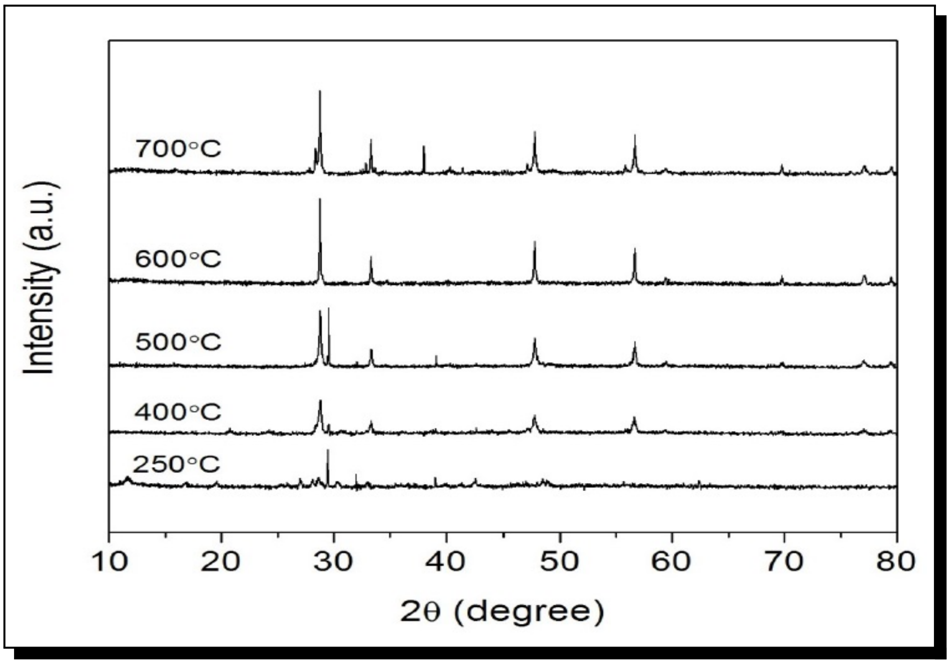

Figure 1. XRD patterns of Pr_6O_{11} calcinated at different temperatures

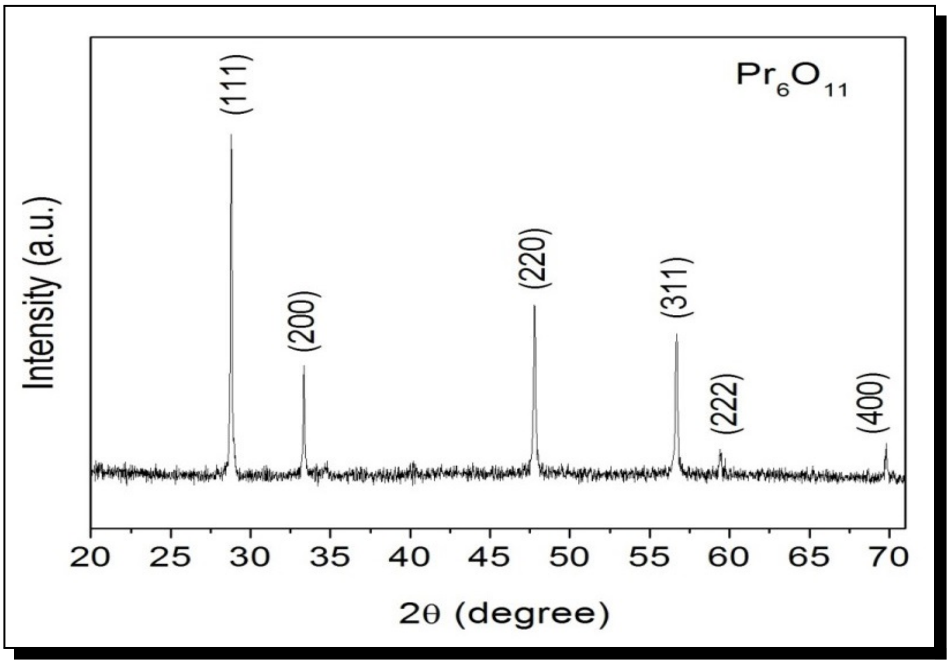

Figure 2. XRD patterns of 600 °C calcinated Pr_6O_{11} nanoparticles

SEM Images of Pr_6O_{11} Nanoparticles

In Figure 3 and 4, the arrangement of Pr_6O_{11} aggregates comprising very tiny three-dimensional dis-ordered primary nanoparticles was visibly observed. The particle size of the 400 °C and 500 °C sample is quite uniform of roughly 20 nm, which is well reliable with the aftereffect of XRD analysis, meaning that each grain can be considered as a single crystal. Furthermore, it is unquestionably significant that Pr_6O_{11} nanoparticle with profoundly mesoporous surface and single crystalline structure can be accomplished by this synthesis technique.

Figure 5 demonstrates the Pr_6O_{11} nanoflakes acquired by calcining the sample at 600 °C. They are sintered a little and appear to be permeable contrasted with the remainder of the calcinated samples. Other than the calcination temperature, response temperature is likewise seen to strongly affect the morphological features of products. As reaction temperature is increased, the edges of these sheets sharpened and lateral size just as thickness increment.

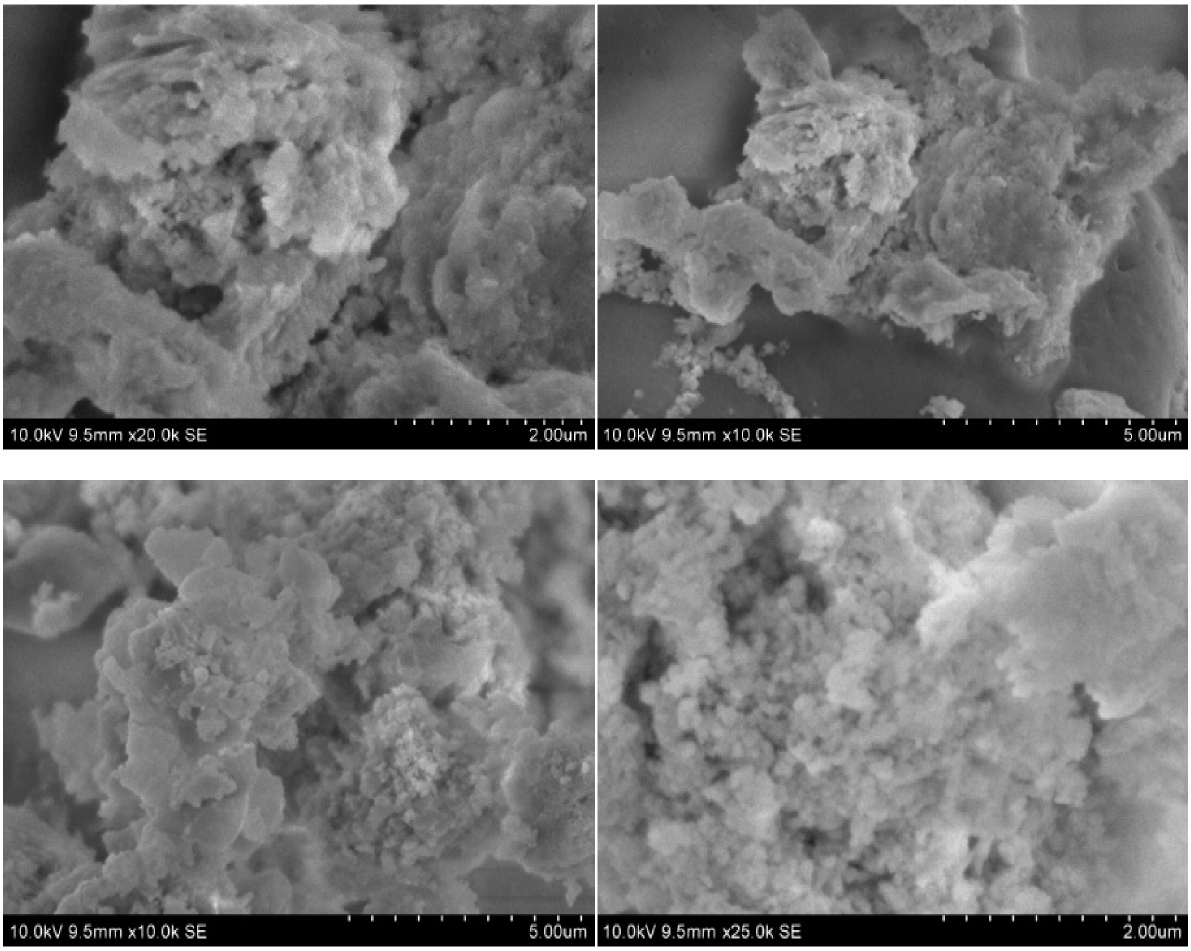

Figure 3. HRSEM images of 400 °C calcinated Pr_6O_{11} nanoparticles

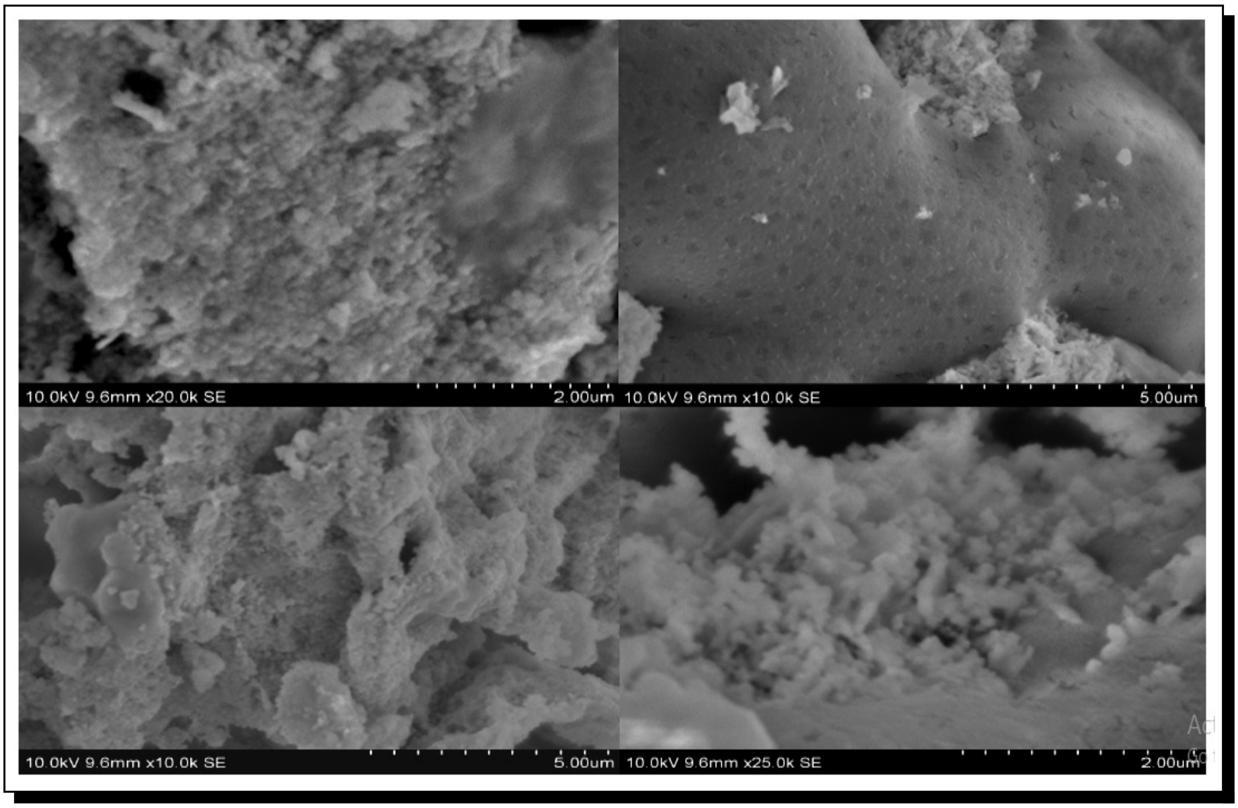

Figure 4. HRSEM images of 500 °C calcinated Pr_6O_{11} nanoparticles

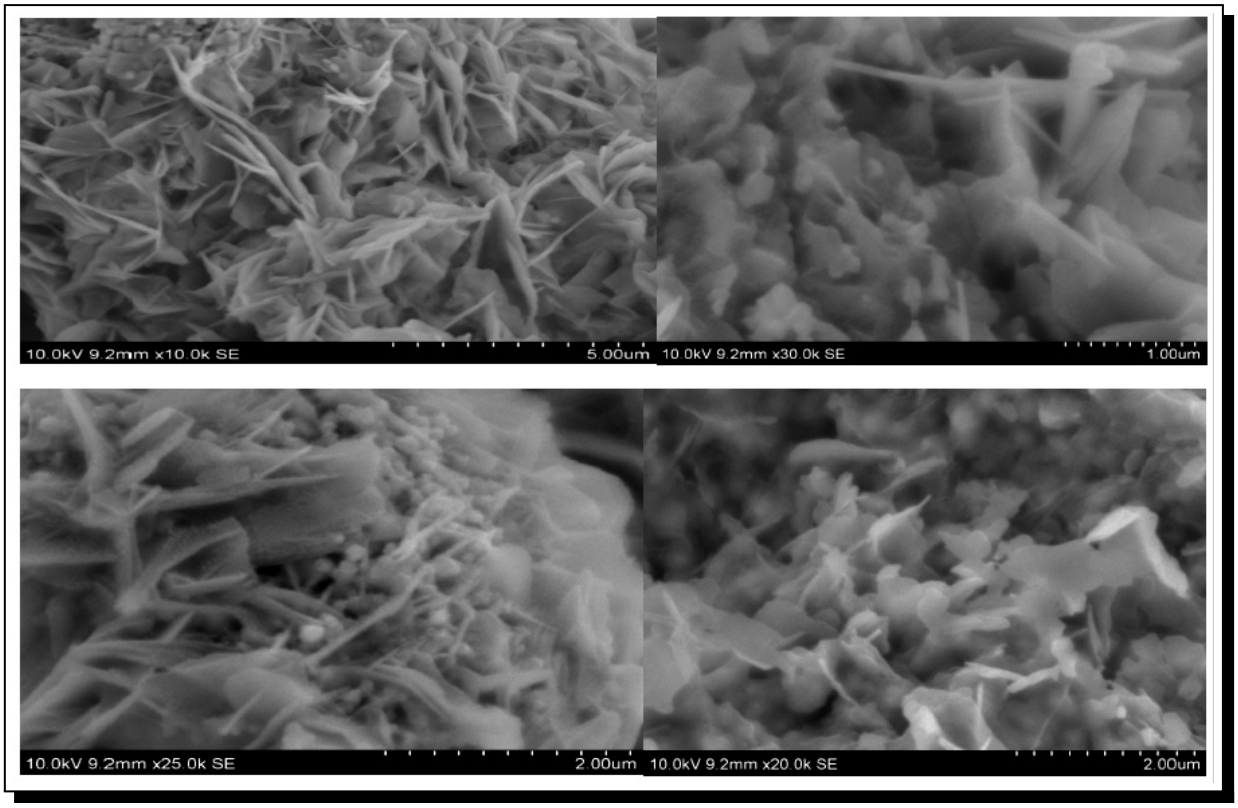

Figure 5. HRSEM images of 600 °C calcinated Pr_6O_{11} nanoflakes

Ultraviolet–Visible Spectroscopic Analysis

The UV–Visible absorption range of a dispersion of praseodymium nanoparticle in ethanol, which would show a blue shift of edge absorption in UV–Visible absorption spectra. The absorption edge clearly moves towards shorter wavelength, the praseodymium oxide demonstrated a strong absorption underneath 290 nm in 250 °C temperature with an absorption peak. This absorbance range prompts apply the readied materials noticeably to optoelectronic application and other biological applications.

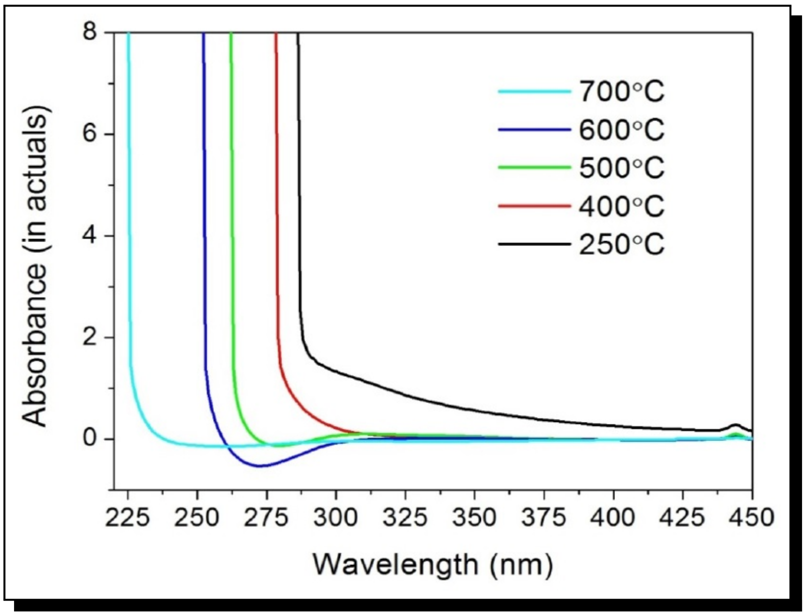

Figure 6. UV–Visible absorption samples of Pr_2O_3 nanoparticles

3. Conclusion

Praseodymium oxide nanoparticles were set up by solvothermal synthesis route. The prepared nanoparticles were exposed to structural and optical property examines. The XRD spectra of as synthesized and annealed sample demonstrated that the particles were amorphous with face centered cubic structure with well-defined dominant peak at 28 °C. No secondary phases were seen in the spectra which revealed that the formed particles were ultra-pure in phase. The UV–Visible spectra of the samples show well confined absorbance from 240 to 270 nm, which is in the ultra violet region. The SEM images shows well-aligned morphology of the synthesized nanoparticle. With promising properties these materials are suitable for optoelectronic application.

Competing Interests

The author declares that he has no competing interests.

Authors' Contributions

The author wrote, read and approved the final manuscript.

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