International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 3 | Mar -2017 www.irjet.net p-ISSN: 2395-0072

Green Synthesis of TiO_2 Nanoparticle Using Moringa Oleifera Leaf Extract

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Abstract: *The present work describes synthesis and characterization of Titanium dioxide (TiO_2) nanoparticles. TiO_2 nanoparticles prepared by eco-friendly green synthesis method using Moringa oleifera leaves extract. The synthesized TiO_2 nanoparticles were characterized by X-ray diffraction (XRD). Anatase phase TiO_2 nanoparticles with mean crystalline size 12.22 nm and Band gap of 3.9 eV was obtained by UV-Visible spectroscopy.*

Keywords: TiO_2, XRD, Moringa oleifera, Band gap, Crystalline size.

1. INTRODUCTION

Nanotechnology is a branch of science which deals with matter having at least one dimension sized from 1-100 nm. Nanomaterials are classified into organic and inorganic material. The synthesis of inorganic metal oxide nanoparticles has attracted considerable attention in physical, chemical, biological, medical, optical, mechanical and engineering sciences where novel techniques are being developed to probe and manipulate single atom and molecules [5]. Metal and metal oxide nanoparticles have high surface to volume ratio which is responsible for their fascinating properties such as antimicrobial, magnetic, electronic and catalytic activity. Generally properties of nanoparticles depend on size, shape, composition, morphology and crystalline phase. Among the various metal oxide nanoparticles, TiO_2 nanoparticles have wide applications in air and water purification, Dye sensitized solar cell (DSSC) due to their potential oxidation strength, high photo stability and non-toxicity.

Traditionally metal oxide nanoparticles were synthesized by various physical and chemical methods. Some commonly used synthetic methods are non-sputtering, Solvothermal, reduction, sol-gel technique and electrochemical technique. But these methods are costly, toxic, high pressure, high energy requirement and potentially hazardous [2]. Hence developing of reliable biosynthetic and environment friendly approach has added much importance because of its eco-friendly products, biocompatibility and economic viability in the long run and also to avoid adverse effects during their application especially in medical field.

Biosynthesis of nanoparticles is a bottom up approach where the main reaction occurring is reduction/oxidation. The plant phytochemicals with antioxidant or reducing properties are usually responsible for the preparation of metal and metal oxide nanoparticles [4]. The three eco-friendly and green chemistry perspective for the nanoparticle synthesis are the choice of the solvent medium, reducing agent and non-toxic material for the stabilization of nanoparticles.

Recently nanoparticle synthesis were achieved using plant extract such as azadirachta indica, camellia sinensis, Nyctanthes arbor-tristis, coriandrum, nelumbo nucifera, ocimum sanctum and several others which is compatible with the green chemistry principles. Among the various biosynthetic approaches, the use of plant extract has advantages such as easily available, safe to handle and possess a broad viability of metabolites. The main phytochemicals responsible for the synthesis of nanoparticles are terpenoids, flavones, ketones, aldehydes, amides [1]. In this paper we have reported green synthesis using Moringa oleifera leaves. Moringa has chosen because of its antibacterial, anti-septic, antifungal and anti-inflammatory activities.

2. EXPERIMENT DETAILS

The healthy leaves of Moringa oleifera were collected from Agar District, Madhya Pradesh, India. The collected leaves were washed to remove dust. Leaves were shade dried at room temperature for about 7 days in normal atmosphere. Dried leaves were cut into fine pieces, grinded to get the finest powder. Ten gram of the dried leaves were mixed with 100 mL of ethanol and extracted under reflux condition at 50^{o}C. After one hour, the ethanolic leaf extract

was obtained by filtering the mixture through Whatman No.1 filter paper.

For the synthesis of titanium dioxide nanoparticles, the Erlenmeyer flask containing 0.5M of titanium tetraisopropoxide in ethanolic leaf extract was reacted under stirring at 50°C. After four hours of continuous stirring, the formed titanium dioxide nanoparticles was acquired by centrifugation at 5000 rpm for 15 minutes. Then the centrifuged particles were washed with ethanol and again subjected to centrifugation at 3000 rpm for 10 minutes. Separated titanium dioxide nanoparticles were dried and grinded to calcinated at 500°C in muffle furnace for about 5 hours. The calcinated titanium dioxide nano powder was used for further analytical techniques.

Fig-1: Sample preparation

3. RESULT AND DISCUSSION

3.1 XRD Characterization

The formation of titanium dioxide nanoparticles synthesized using Moringa oleifera leaves extract was analysed by X-ray diffraction measurements. In the XRD analysis, five diffraction peaks at 25.3°, 37.7° 48.1°, 54.0°, 62.7° have obtained, which having planes 101, 004, 200, 105 and 204 respectively of the tetragonal body-centred titanium dioxide (JCPDS No.86-1156). The average crystalline size was estimated 12nm which was calculated by Scherrer's formula,

$$D = \frac{K\lambda}{\beta \cos\theta}$$

Where D is crystalline size, λ is wavelength of X-ray (1.54 Å), β is full width half maxima, θ is Bragg angle, K is shape factor (0.9).

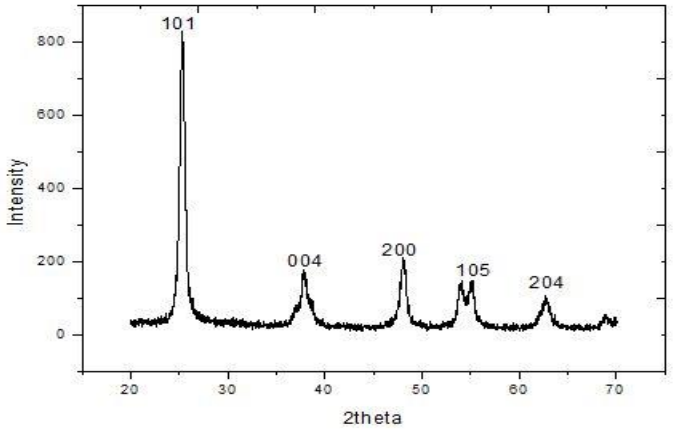

Fig. -2: XRD pattern of TiO_2 nanoparticles

3.2 UV-Vis Spectroscopy

UV-Vis spectroscopy is used to determine particle size and band gap of prepared tio2 nanoparticles. The energy band gap of TiO_2 nanoparticles was calculated using the equation:

$$E_g = \frac{hc}{\lambda}$$

Where h is Planck's constant (4.135 x 10^{-15} eV.s); c is velocity of light (3 x 10^8 m s^{-1}) and λ is wavelength (in nm). The band gap was calculated 3.9 eV at wavelength 318 nm corresponds to absorption peak.

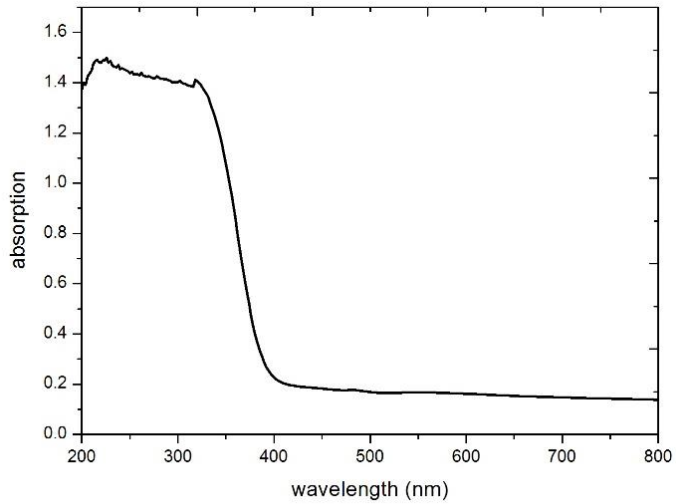

Fig-3: UV-Vis Spectroscopy of synthesized TiO_2 nanoparticles

4. CONCLUSION

The synthesis of titanium dioxide nanoparticles using Moringa oleifera leaves extract solution has been demonstrated. Structural properties of synthesized nanoparticles were characterized. XRD analysis showed that the anatase TiO_2 sample having tetragonal structure. The energy band gap of synthesized TiO_2 nanoparticles was calculated 3.9 eV which was greater than bulk TiO_2 having band gap of 3.2 eV. The present work proves that biosynthesis of TiO_2 nanoparticles using Moring oleifera leaves extract is a new technique using cheap precursors. This simple, cost effective, time saving and environmental friendly synthesis technique used in various applications.

ACKNOWLEDGEMENTS

Author wish to thank Medi-Caps Institute of Science and Technology and UGC-DAE consortium for scientific research, Indore, Madhya Pradesh

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