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To cite this article: Karanpreet Kaur *et al* 2022 *IOP Conf. Ser.: Mater. Sci. Eng.* **1225** 012045

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Comparative Study of Chemo- Bio Synthesized MgO Nanoparticle on Maize Seed Germination

Karanpreet Kaur¹, N Jayarambabu² and K Venkateswara Rao²

¹The department of Nanotechnology, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India.

²Department of Physics, National Institute Of Technology, Warangal-500604, India.

²The centre for Nano Science and Technology, Institute of Science and Technology, Jawaharlal Nehru Technological University, Hyderabad, India.

*E-mail: karanpreetbajwa4@gmail.com

Abstract A nanotechnology is expanding area of research is speedily gaining significance and a prominence interest among the farmers. In the present study, the chemical and green synthesize MgO nanoparticles are used for the treatment of maize seeds germination. The green method is a simple, reducing toxic chemical's concentration, an eco-friendly and economically viable. Hence, a locally available plant *Cissus quadrangularis* was selected for MgO nanoparticle's synthesis. The result of XRD, TG/DTA, SEM, TEM, and PSA analysis confirmed formation of MgO nanoparticles. XRD showed the crystalline size of chemical and green synthesized nanoparticles are 25 nm and 24 nm, and the morphology is spherical analysed by SEM. This study is carried out to determine the nanoparticles penetration inside the seed coat, root growth, shoot growth and stimulate the growth hormones. The MgO nanoparticles capability to amplify the dry weight by delivering water to the whole seedling which help to enhance the water nutrient transport and the biomass. The experiment was administered under greenhouse conditions. From the results obtained it is suggested that a green MgO could be used effectively in agricultural fields.

Keywords: A chemo-bio synthesis method, MgO nanoparticle, Maize seed, Seed germination.

1. Introduction

Nanotechnology could come up as a very profound tool for the future. This technology changed the concept of agriculture itself to all the way. Nanomaterials have been increasing attention due to various applications in industries (e.g. electronics, cosmetics, fuel cells, textiles, biosensors), health care, energy.¹ The engineered nanoparticles have unique physio chemical property so, we can expect there are multiplication of applications in global market.² In agriculture food sector, nanotechnology has been used to enhance the food quality and food ingredients.³ Some metal nanoparticles have huge applications in industry such as water treatment and antibacterial properties.⁴

This study reported the novel synthesis of MgO nanoparticles by using magnesium acetate and *Cissus quadrangularis* plant extracted solution in biological method. For a comparative study of maize yield a chemical method has been used to synthesized MgO nanoparticles by using sodium hydroxide as reducing agent. MgO nanoparticles is a non-toxic, odorless, and tasteless white powder. In the biological method for production of MgO nanoparticles we used *Cissus quadrangularis* plant extract as reducing agent instead of chemical compounds. *Cissus quadrangularis* has many applications in ayurvedic medicines. *Cissus quadrangularis* can be found in Rangareddy district of Telangana, India. *Cissus quadrangularis* plant has shown strong anti-



inflammatory, analgesic and antioxidant properties. It has been found to contain carotenoids, triterpenoids and ascorbic acid. The plant contains β -sitosterol, calcium oxalate, ascorbic acid and 3-ketosteroids.⁵ The extract of *Cissus quadrangularis* plant has been used successfully to the synthesized single crystalline triangular MgO nanoparticles and spherical MgO nanoparticles.

Over the past decades, Many metal oxides nanoparticles researched as an antibacterial agent. Zhen-Xing Tang et al. (2014) has been used three methods (sol-gel method, hydrothermal method and micro-emulsion method) to synthesized MgO nanoparticles which shown antibacterial activity and this activity of MgO nanoparticles has been depended upon the concentration and size.⁶ Mei-Rong Song et al. (2007) has been used same nanoparticles by using tetrahydrofuran to provide significance to investigate the sensitivity, catalysis and other properties.⁷ Anagno stakos et al. (2008) described Inorganic nanoparticles has play an important role because its antimicrobial activity has been very productive at high surface area with low concentration which permit a wide range of reactions on this bacterial surface.⁸ Haung et al. (2005)⁹ and Makhulf et al. (2005)¹⁰ investigate the MgO which has been showing activity against gram positive and negative and are safe to use for environment and mammal's cells. The lichens of algae and fungi has been used to synthesized magnesium nanoparticles for many biomedical applications T Devasena et al.(2014).¹¹ Siavash Irvani (2011)¹² shown that the presence of polyphenols and enzymes in plants help to reduce metal ions faster than microorganisms (fungi or bacteria) which play an important role to provide more stable metal nanoparticles. CH. Ashok et al.(2015)¹³ prepared MgO nanoparticles by green synthesis technique using neem extract for the germination of *Ricinus* seeds at different heating temperature of MgO nanoparticles. Environmental friendly technique by using extracts of *Phyllanthus reticulatus* for preparing silver nanoparticles that showed antibacterial activity against the tested microorganisms and can be further analysed for the bacterial growth inhibition (Karunakar Rao Kudle et al. 2013).¹⁴ Anamika Mubayi et al. (2012)¹⁵ the study represents antimicrobial activity of nanoparticles in both gram positive and gram negative bacteria by using extract of *Moringa Oleifera* and silver metal ion. If we embraced the power of nanotechnology to increase our yield, increase our food production, preservation of food grains as well as pest control for the food grains we can make an enormous difference for many masses.

2. Materials and methods

2.1. Experimental details

Green Method: In this experiment *Cissus quadrangularis* plant extract was prepared by boiling the 25gm of plant leaves in 100ml water. The solution was filtered and 30ml of filtered extract was used as reducing agent. 0.1M of magnesium acetate in 200ml distilled water was added separately to plant extract and a vigorous stirring was done at 60°C. The resulted sample was calcinated at 400°C in a muffle furnace for removing the any by products and organic compounds in the sample.

Chemical Method :In a chemical method adds 0.1M of magnesium nitrate in 100ml of distilled water and kept under stirring. 100ml of water of 0.2M NaOH was added a drop wisely into above solution to allow continue reaction for four hours. The supernatant was discarded and remaining the solution was filtered and washed several times with water to remove impurities. Then sample was placed in oven at 80°C for 12 hours and white powder was collected in ceramic crucible. The resulting powder was calcinated for 4 hours in the muffle furnace at 400°C.

3. Characterization techniques

3.1. XRD analysis : As per given XRD pattern in figure 1 showing that the structure of synthesized MgO nanoparticles was cubic. The XRD characterization is employed for the structure and impurities within the sample. According to the reported JCPDS data, all the crystal structure matched to it. The broad peaks indicate synthesized materials are in nanometer range. The peaks were absorbed with 37° , 42° , 62° , 74° and 78° in conjunction with intensities of (111), (210), (220), (311), (222) are comparable JCPDS (01-0420) values.

Scherrer formula ($D = 0.9\lambda/\beta\cos\theta$) was used to calculate the average grain size.

In Scherrer formula, λ , θ , β was represented x-ray wavelength, angle of the bragg diffraction peak And line width at half maximum respectively.

The crystalline size of chemical and green synthesized MgO was calculated around 25 nm and 24 nm by implementation of this formula to major peaks. The XRD patterns were recorded within the range of 30° - 80° with a scan speed of $2/\text{min}$ ¹⁶.

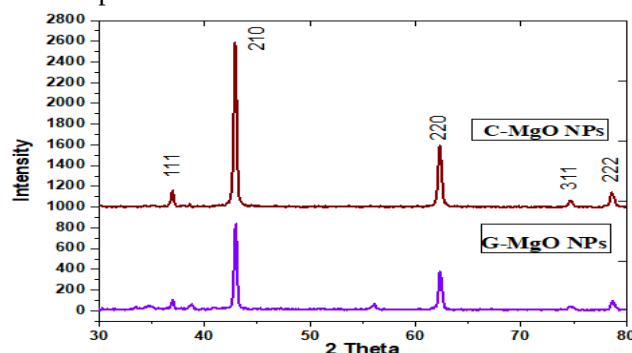


Figure 1. XRD pattern of chemical and green synthesized MgO Nanoparticles.

3.2. Thermo gravimetric analysis : The synthesized MgO nanoparticles are analysed for the thermo gravimetric properties was carried out by the raising temperature gradually and plotting weight against temperature. The temperature of $\text{Mg}(\text{OH})_2$ was an important component at which $\text{Mg}(\text{OH})_2$ has been converted into MgO from its hydroxide precursor. With the help of alumina crucible the precursor was heated at the temperature of $10^\circ\text{C}/\text{min}$ in nitrogen atmosphere and then it started loses its weight in a first step of the process. This process helped to obtain a end product by losing water from $\text{Mg}(\text{OH})_2$ as shown in Fig.2. TGA analysis was observed from room temperature to 800°C in both cases of chemical synthesized MgO nanoparticles and Green synthesized MgO nanoparticles¹⁷.

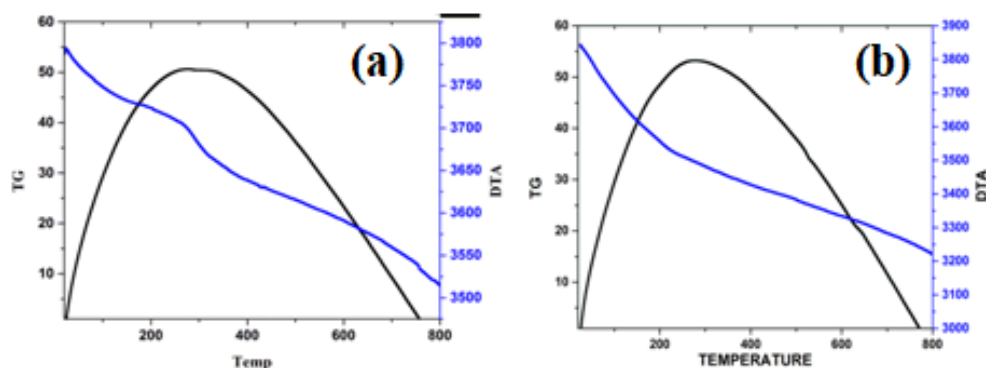


Figure 2. TGA curves of (a) Green and (b) chemical synthesized MgO Nanoparticles.

3.3. Particle size analyser : The prepared Magnesium Oxide nanoparticles were ultra-sonicate by using the distilled water. The sizes of the MgO nanoparticles in the suspensions were determined using a particle size analyser. A fig.3 shows the particle sizes verse undersize percentages in the dispersed distilled water, and the average particle size of chemical synthesized MgO Nanoparticles is 28 nm and Green synthesized MgO Nanoparticles is 26 nm¹⁸.

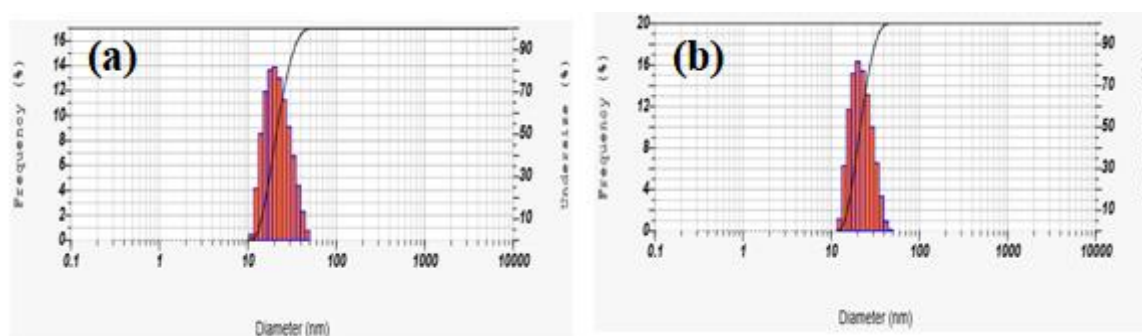


Figure 3. Particle size Analysis of (a) Green and (b) chemical synthesized MgO Nanoparticles.

3.4. SEM analysis and EDS : The shape of chemical and green nanoparticles is spherical and the average size of chemical and green synthesized MgO nanoparticles are 200 nm and 1 μm ¹⁹ which is shown as Fig.4. EDS spectrum shows that the sample primarily contain Mg, O and their respective atomic content of chemical MgO are 55.93%, 44.07% and Green MgO are 62.96%, 37.04%. Magnesium oxides species & residue solvent on the surface of the particles might represent O peak.

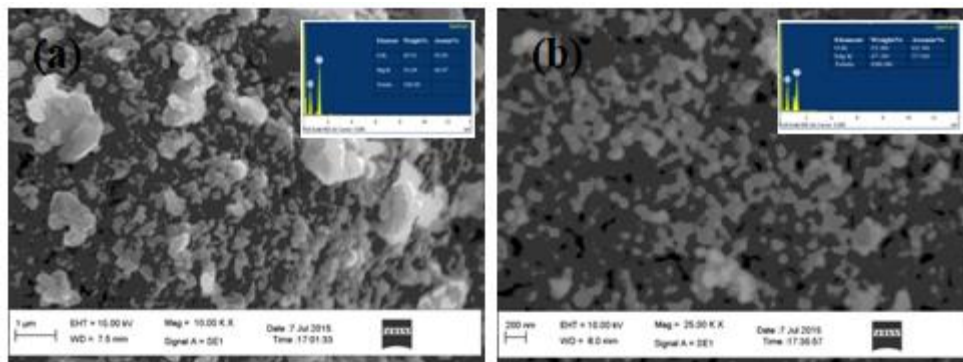


Figure 4. SEM and EDS images of (a) Green and (b) Chemical synthesized MgO Nanoparticles.

3.5.TEM Analysis: TEM is playing important roles for a characterization of grain boundaries, a morphology and crystalline materials. In a Fig.5 the shape of green MgO nanoparticles is spherical and there size measurement dimension is 26.7 nm, 39.3 nm, 49.6 nm where as the chemical MgO nanoparticles has different size measurement which is 17.2 nm, 18.4 nm, 20.5 nm²⁰.

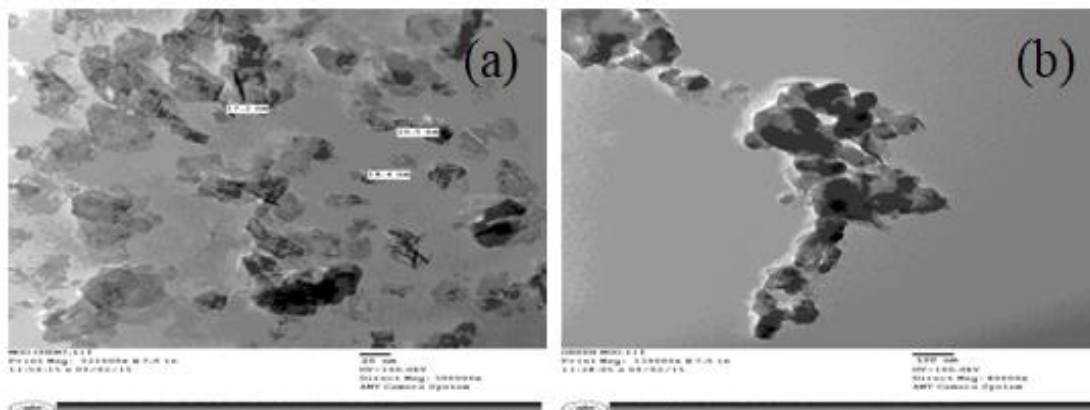


Figure 5. TEM images of (a) Green and (b) Chemical MgO Nanoparticles.

4. Preparation of particle Suspensions and Seed Treatment

The maize seeds were purchased from market kept in the dark and dry place under room temperature before using. For the Green and chemical synthesized MgO Nanoparticles suspensions, maize seeds were surface-sterilized in sodium hypo chloride for 10 minutes, then thoroughly rinsed with distilled water. By using a sonicator instrument the maize seeds were sonicated in prepared nanoparticles suspensions for 2 hours. For the maize seeds growth characterization, the soaked seeds were put in soil pots.

4.1. Seed germination test : After 10 days, we observed the maize seed germination in the presence of the chemical and green synthesized MgO nanoparticles. The green synthesized MgO nanoparticles shown the higher seed germination percentage as compared to the chemical synthesized MgO nanoparticles as shown in Fig.6. By using thread and scale we determined the fresh biomass and the dry biomass of the plant where as digital weighing machine was used to determined the fresh

weight of root and shoot of seedlings. After measuring fresh weight, the seedlings was kept in incubator at 80°C. The fresh and dry biomass of the control plant were 0.1g and 0.09g. The fresh and dry biomass of the chemical Nanoparticle treated plant were 0.2g and 0.18g. The fresh and dry biomass of green Nanoparticles treated plant were 0.22g and 0.19g. The green synthesized Nanoparticles treated plant has more biomass than chemical and the control as shown in Fig.6. The MgO nanoparticles mechanism on maize seed germination is helpful for water and minerals absorption at same time increase the biomass of the plant.

5. Effect of MgO nanoparticles Suspension on maize seed Germination

The interaction of MgO nanoparticles significantly affected the percentage of seed germination. The green method synthesized MgO Nanoparticles suspension shown the higher root growth of the maize seed as compare to the control germination and chemical synthesized MgO Nanoparticles suspension. This treatment also increase the root length and shoot length notably.

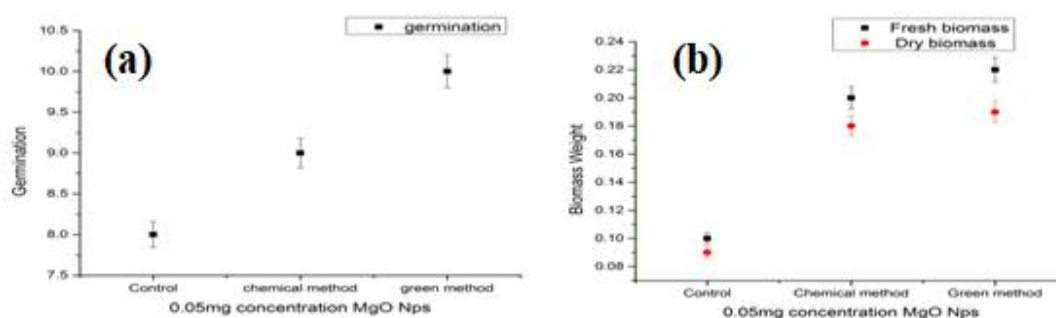


Figure 6. (a) Seed germination of control, chemical, green method nanoparticles and (b) Biomass weight of Control, Chemical, and Green Synthesized maize seed.

5.1. Scanning electron microscopic analysis : We separated the roots of the grown plant of control, chemical and the green nanoparticles and washed with the ethanol solvent. Cut the small pieces of roots and added the glutaraldehyde solution along with roots in test tubes. The surface structure near the roots of the germinated maize seeds in the presence/ absence of the MgO nanoparticles was inspected by the SEM as shown in Fig. 8. In this experiment the MgO nanoparticles capability to amplify the dry weight by delivering water to the whole seedling to enhance the water nutrient transport and the biomass. MgO nanoparticles has faster ability to transported through the plant (including) within the metabolic processes. Based on SEM images of plant root surface analysis the MgO nanoparticles were helpful for absorption of minerals and water at the same time support for the photosynthesis plants.

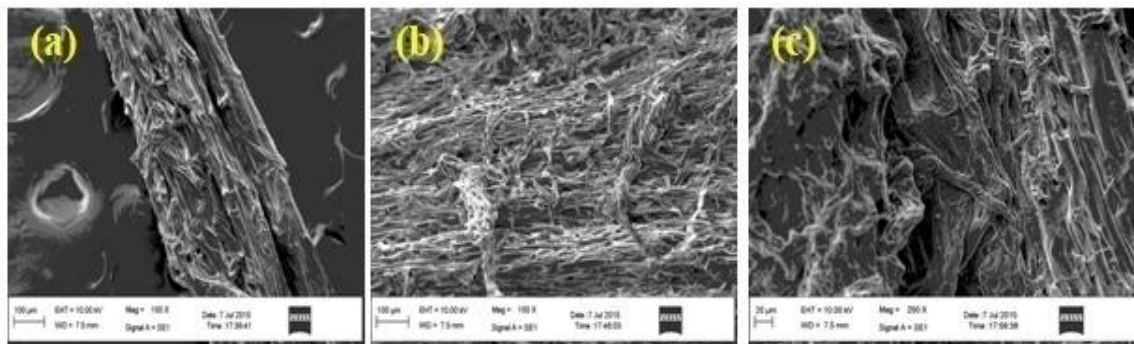


Figure 7. (a), (b) and (c) SEM images of control, Chemical, Green plant germination.

6. Conclusions

The increasing demand for nanoparticles because their wide applications in various areas like seed germination, biosensors, cosmetics etc. Magnesium oxide nanoparticle was synthesized by chemical method from magnesium nitrate and green method from magnesium acetate using plant extract (*Cissus quadrangularis*). Various parameters viz. stirring temperature, concentration of plant extract, calcination temperature were noteworthy effects on the result. The nanoparticles synthesized by using chemical techniques are toxic and flammable in nature while the green method or biological method is an environmentally friendly technique. The structure and morphology of particles were investigated by XRD, TG/DTA, PSA, SEM, EDS and TEM. XRD showed the structure of MgO nanoparticles was cubic and crystalline in nature. The crystalline sizes of chemical and green synthesized nanoparticles are 25 nm and 24 nm. The particle sizes of chemical and green synthesized nanoparticles are 28 nm and 26 nm. SEM was used to characterize the morphology of the MgO nano crystal. The average sizes of the MgO nanoparticles of chemical and green synthesized are 200 nm and 1 µm. EDS pattern infers the presence of elements Mg and O. The chemical and green synthesized MgO nanoparticles are utilized on the maize seed to review its growth characterization and the effect on the bioavailability of seed germination. We observed in maize seed germination, green synthesized MgO nanoparticles showed good shoot, root growth results compared to the chemical and the control during this experiment. The study results also revealed that the germination process was influenced by MgO nanoparticles in maize seed. The nanoparticle exposure involves nutrient transport to support photosynthesis of the plant. In agriculture, the antimicrobial properties of nanoparticles make it more suitable functional to use it as pesticide or herbicide.

Acknowledgement

Our special thanks to Dr. Ashok Chinthakuntla, Senior Scientist, Nanospan India Pvt. Limited and Centre for nanoscience and technology JNTU-Hyderabad, Telangana, India for supporting our work.

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