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Original Research Article

Synthesis and Characterization of MgO Nanoparticles using Neem Leaves with their Photocatalytic and Antioxidant Properties

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Abstract

Background: Nanoscience and nanotechnology have been established recently a new interdisciplinary science and now a days it is one of the most attractive research area in modern material science. Nanotechnology can be defined as the synthesis, characterization, exploration and application of nanosized materials for the development of science. ***Objective:*** To Synthesis of MgO nanoparticles using Neem leaves extract & characterization of MgO nanoparticles with its antioxidant and photocatalytic effects. ***Methodology:*** *A* Quasi experimental type of study in the Department of Pharmacology and therapeutics, Rajshahi Medical College, Rajshahi from January 2018 to December 2018. Prior commencement of the study, approval was taken from the institutional Review Board of Rajshahi Medical College. ***Results:*** There was no significant difference between Neem extract and Mg $(NO_3)_2$. MgO-NPs vs Mg $(NO_3)_2$ showed Mean difference = -0.19, 95% CI of difference = 0.3434 to – 0.03662, P value = <0.05. So, there was significant difference between MgO-NPs. and Mg $(NO_3)_2$. ***Conclusion:*** Synthesis of nanoparticles were confirmed by changes of colour from yellow to yellowish brown, UV-Vis spectroscopy and also by evaluation of its photocatalytic and antioxidant properties. In the photocatalytic study 88% dye degradation of MgO-NPs was found and antioxidant activity of MgO-NPs was also examined using DPPH assay which showed significant (P< 0.0001) antioxidant properties with 80% DPPH scavenging activity at 100mg/ml concentration.

Keywords: Synthesis, Characterization of MgO, Nanoparticles, Photocatalytic and Antioxidant properties.

INTRODUCTION

Nano science and nanotechnology have been established recently a new interdisciplinary science and now a days it is one of the most attractive research area in modern material science. Nanotechnology can be defined as the synthesis, characterization, exploration and application of Nano sized materials for the development of science [1]. The concept of nanotechnology was first begun with lecture delivered by Richard Feynman in 1959 [2]. The word "Nano" comes from Greek word nanos that means dwarf or extremely small. Nanometer is a unit of length in the metric system, equal to one billionth of a meter. Nanoparticles (NPs) are the particles with a size in the range of 1-100 nm [3]. Due to their smaller size and large surface to volume ratio nanoparticles exhibit remarkable novel properties and methodical applications in the field of biotechnology, medical, catalysis, optical devices, DNA labelling, drug delivery and they are rewardingly treated as a bridge between bulk materials and atomic and molecular structures [4]. Metal oxide nanoparticles have a high specific surface area and a high friction of surface atoms. Because of the unique physiochemical characteristics of nanoparticles, including their catalytic activity, optical properties, electronics properties, antibacterial properties and magnetic properties, synthesis of oxide nanoparticles is an important topic of research in modern science. Metal oxide nanoparticles can be synthesized through three methods like physical, chemical and green methods. Although large quantity of nanoparticles can be synthesized within a short period of time through chemical method, this method requires capping agents for size stabilization of the nanoparticles and the chemicals that are used in this method for nanoparticles synthesis and stabilization are toxic and lead to non-ecofriendly byproduct [5]. Though physical and chemical methods are trendier for nanoparticles synthesis, the biogenic fabrication is better choice for echo-friendliness because green chemistry seeks to reduce pollution at source [6]. Many biological approaches for both extracellular and intracellular nanoparticles synthesis have been reported till date using microorganisms (eg. bacteria, fungi) and plants [7]. Plants provide a better platform for nanoparticles synthesis as they are free from toxic chemicals as well as provide natural capping agents. Moreover, use of plant extract also reduce the cost of micro-organisms isolation and culture media enhancing the cost competitive feasibility over nanoparticles synthesis by microorganisms [5]. So, synthesis of nanoparticles using plant extract is the most adopted method of green, eco-friendly production of nanoparticles and it has also a special advantage that the plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites [8]. Magnesium is an important macro mineral that act as a co factor of several enzymes (eg. kinase enzymes) & constituent for bone & teeth. It has been used in many applications such as catalysis, catalyst supports, toxic waste remediation, refractory materials and adsorbents, etc [9, 10]. In medicine, MgO is used for the relief of heartburn, sore stomach and for bone regeneration [11, 12]. Recently, MgO nanoparticles (MgO-NPs) have shown promise for application in tumor treatment. Moreover, it also shows antioxidant & antibacterial effect. This study presented the synthesis of MgO nanoparticles using Neem (Azadirachta Indica) leaves extract with evaluation of its anti-oxidant and photocatalytic properties. Recently, researchers have tried to find biological methods for the synthesis of nanoparticles that will be alternative to chemical or physical methods. Biological methods for the production of NPs are considered safe and echo-friendly; they are also cost-effective and ensure the complete elimination of toxic chemicals. Neem leaves, which is an important medicinal plant are easily available in our country. This study focused on synthesis of MgO nanoparticles using Neem leaves extract through green method. The anti-oxidant effect & photocatalytic properties of these MgO nanpoparticles were also be evaluated. Though this type of study was performed in abroad but in Bangladesh it had not been done yet. The aim of the study Synthesis of MgO nanoparticles using Neem leaves extract & characterization of MgO nanoparticles with its antioxidant and photocatalytic effects.

METHODOLOGY AND MATERIALS

A Quasi experimental type of study in the Department of Pharmacology and therapeutics, Rajshahi Medical College, Rajshahi from January 2018 to December 2018. Prior commencement of the study, approval was taken from the institutional Review Board of Rajshahi Medical College. In this study, we synthesized Magnesium oxide nanopartcles fourteen times. In the photocatalytic study we took four samples and did the experiment six times. So, total sample size was 24 (4x6=24). In the antioxidant study we took six strength (100mg/ml-1µg/ml) of four solutions and did the experiment six times. So, the sample size was 144 [6x (4x6) =144].

Purposive sampling method

Preparation of Neem leaves extract

5gm of Neem leaves were washed out thoroughly and dried in room temperature for 15-20 minutes. Then it was boiled at 100^0 C with 200 ml of deionized water for 1 hour. Then the solution was filtered. This is Neem leaves extract and it is yellowish in colour. This freshly prepared extract was used throughout the study.

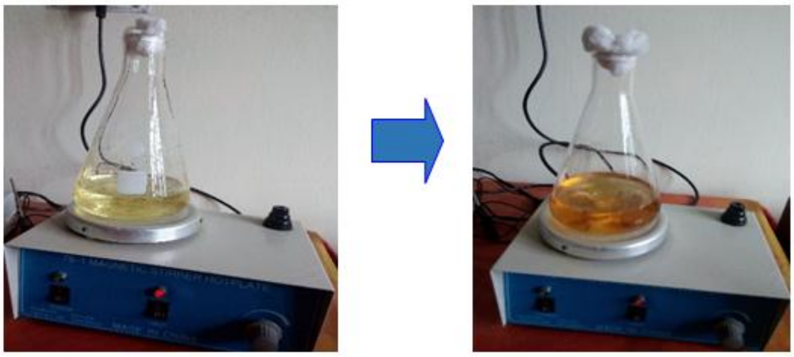

Figure 1: Showing changes of colour during synthesis of nanoparticles

Synthesis of Magnesium Oxide nanoparticles

MgO nanoparticle was synthesized according to the method described by S.K [4]. In this experiment 30 ml of fresh Neem leaves extract and 120 ml of deionized water was added to a 500 ml conical flask and heated at 60^0C for 10 minutes. 30gm of $MgNO_3$ was added to the solution and heated at 80^0C with continuous stirring for 4 hours. Then Magnesium Nitrate ions was reduced to Magnesia or Magnesium Oxide nanoparticles by using Neem leaves extract. The formation of Magnesium Oxide nanoparticles was observed by changing of yellow colour of the solution into yellowish- brown colour [4].

UV-vis spectral analysis

The reduction of $MgNO_3$ was monitored by measuring with the UV-Vis spectroscopy using MODEL U 2940 Spectrophotometer (HITACHI) at BCSIR Laboratories, Rajshahi. Here we followed the scanning range of 220-800 nm. Here scanning speed was 200nm/min, sampling interval was 1.0 nm. Ultraviolet visible spectroscopy (UV-Vis) refers to the absorption spectroscopy or reference spectroscopy in the ultraviolet-visible spectral region. It is the measurement of light passing through a sample (/) and compares it to the intensity of light before it passes through the sample (%). The ratio I/I0 is called the transmittance and usually expressed as percentage (% T). The absorbance A is based on the transmittance: A= -log (%T).

Study of photocatalytic activity of MgO nanoparticles

The photocatalytic activity of these biosynthesized MgO nanoparticles was studied by degradation of methylene blue under sunlight irradiation [13]. At first methylene blue solution was prepared, then around 10 mg of MgO nanoparticle was added to 50 ml of methylene blue dye solution. Then each mixture was stirred magnetically for 45 minute before exposing to sunlight. Controls were prepared using Neem leaves extract and also using Mg $(NO_3)_2$ solution and kept under similar condition for comparing any change in colour of the dye solution.

Figure 2: Methylene blue solution

The colloidal suspension was then put under sunlight irradiation. At frequent intervals (every 1 hour) 2ml suspension was taken from the colloidal mixture and centrifuged for 15 minutes to obtain clean supernatant soup of the tested dye. The soup was then scanned at different wavelength from 350 to 850nm using the spectrophotometer to study the dye degradation in presence of MgO nanoparticles.

Determination of Antioxidant activity of MgO Nanoparticles

The antioxidant activity of MgO-NPs synthesized using the Neem leaves extract will be determined by means of the test using the DPPH (2,2-diphenyl-1 picryl-hydrazil) radicles, which was reflected by the reduction of the absorbance of the DPPH methanol solution during the reaction with the tested solution MgO-NPs. In this study we use the antioxidant method of Reneta[14] with slight modification. At first 0.1 mM solution of DPPH was prepared using 2ml of DPPH dissolved in 50 ml of absolute Methanol and thus prepared the stock solution. Then numerous dilutions of the tested solutions were prepared in the range of 1µg/ml-100mg/ml. Changed in the absorbance intensity were measured using the spectrophotometer (Model 340). In the test tubes (protected from light) 0.3 ml of tested solution and 2ml of the DPPH reagent at the concentration of 0.1 mM were added. The DPPH reagent (Figure-10) was prepared 24hr in advance (protected from light). After shaking the solutions in the test tubes, these were kept in the dark for 30 minutes then the absorbance was read, at the wavelength of 515 nm. Water (0.1ml) and methanol (0.7) ml were used as reference. Before the measurement of the absorbance of samples, the absorbance of DPPH solution was measured. The measurement was made by measuring the absorbance of 0.1 ml of deionized water and 0.7 ml of DPPH solution. The ability to reduce free DPPH radicals was calculated based on the formula: Aa = (Ao– Ai/Ao) x100%, Where Aa means antioxidant activity (%), Ai means average absorbance of the tested solution and Ao means average absorbance of the DPPH solution. As ascorbic acid is a known anti-oxidant, we used ascorbic acid as control in this study. In addition, we also prepared 10 milimolar solution of Ascorbic acid. So, we measured 17.6 mg of ascorbic acid and dissolved in 10 ml of solvent (2ml deionized water and 8ml methanol). Serial dilutions of ascorbic acid were prepared and mixed with DPPH solution in the above-mentioned way and then the absorbance was measured.

Figure 3: DPPH solution in volumetric flask

Collected data were analyzed by using SPSS-16 version software. Ethical consideration. Prior to commencement of the study, the research protocol was approved by the ethical committee (Local Ethical Committee) of Rajshahi Medical College. Proper permission was taken from the department and the institution concerned for the study.

RESULTS

Synthesis of MgO-NPs by biological method Figure-4, showed Neem extract, Magnesium Nitrate solutions and MgO-NPs. When 30 mg of $Mg(NO_3)_2$and 30ml Neem extract was stirred for 4 hour at 80^0C by magnetic stirrer, the colour was turned from yellow to yellowish brown immediately after heating. The appearance of colour is caused by the surface plasmon resonance of reduced magnesium in the visible region. The UV-Vis Absorption spectra of the obtained MgO-NPs was in the range of 200-800 nm. We observed the typical absorption peak at 310nm. The UV-Vis spectroscopy allows high quality characterization of the MgO-NPs. With the technique absorption intensity can be set out against the different wavelengths of light. Photocatalytic activity of the biosynthesized magnesium oxide nanoparticles was observed by degradation of methylene blue under solar irradiation. Dye degradation was visually detected by gradual change in the color of the dye solution from deep blue to colouress which is shown in the figure 6. All dye concentrations were measured by taking the value of absorbance at 660 nm in the spectrophotometer as the concentration is directly proportional to the absorbance value blue solution. The antioxidant activity of synthesized Magnesium oxide nanoparticles using Neem leaves extract was determined by means of test using DPPH radical in Figure 7. Tukey's multiple comparison test among Neem extract, Mg $(NO_3)_2$, MgO-NPs and Methylene blue solution after ANOVA test (F=11.66, P=0.0001). Here, MgO-NPs vs Mg $(NO_3)_2$ showed mean difference=51, 95% CI of difference= 42.77 to 59.23. P value<0.0001. So, there was significant difference between MgO-NPs and Mg $(NO_3)_2$. MgO-NPs vs Neem showed mean difference=43.67, 95% CI of difference=35.43 to 51.90, P value <0.0001. So, there was significant difference between MgO-NPs vs Neem. Again, MgO-NPs vs Methylene blue (MB) solution showed mean difference = 55, 95% CI of difference was 46.77 to 63.23, P value <0.0001. So, there was significant difference between MgO-NPs with Methylene blue solution. Mg $(NO_3)_2$ vs Neem showed mean difference -7, 95% CI difference -15.57 to 0.9012, P value > 0.05. So, there was no significant difference between Mg $(NO_3)_2$ and Neem extract. Between Mg $(NO_3)_2$ and Methylene blue solutions mean difference was 4, 95% CI of difference was -4.235 to 12.23, P value >0.05. There was no significant difference between $Mg(NO_3)_2$ and Methylene blue solutions. Neem vs Methylene blue solutions showed mean difference 11.33, 95% CI of difference was 3.099 to 19.57, P value <0.001. So, there was significant difference between Neem vs Methylene blue solutions Table I shows. Figure-4, shows the colour changes of DPPH solution in presence of MgO-NPs. In this method antioxidant present in the tested sample reduced the stable nitrogen radical of (DPPH), causing decreased in absorbance measured at the wavelength of 515 nm. Table II shows average absorbance of Ascorbic acid, Mg $(NO_3)_2$, MgO-NPs and Neem extract at six different strength. Here, Ascorbic acid at the strength of 100 mg/ml, 10mg/ml. 1 mg/ml, 100µg/ml, 10µg/ml and 1µg/ml showed average absorbances 0.242, 0.182, 0.42, 0.421, 0.459 and 0.46 respectively. Mg $(NO_3)_2$ showed absorbances 0.271, 0.354, 0.420, 0.365, 0.416 and 0.425. MgO-NPs showed average absorbances 0.081, 0.112, 0.367, 0.427, 0.437 and 0.437 and Neem extract showed average absorbances 0.376, 0.198, 0.268, 0.392, 0.397, 0.396 respectively. Table IV shows multiple comparisons test among Ascorbic, Neem, MgO-NPs and Mg $(NO_3)_2$ of 100 mg/ml solutions after ANOVA test (F= 11.66, P= 0.0001). Ascorbic acid vs Neem showed Mean difference=-0.2347, 95% CI of difference= -0.3880 to – 0.08128, P value < 0.001. So, there was significant difference between Ascorbic acid and Neem leaves extract. Ascorbic acid vs MgO-NPs showed Mean difference=0.061, 95% CI of difference=-0.09238 to 0.2144, P value = > 0.05. So, there was no significant difference between Ascorbic acid and MgO-NPs. Ascorbic acid vs Mg $(NO_3)_2$ showed Mean difference = -0.129, 95% CI of difference = -0.2824 to 0.02438, P value = > 0.05. So, there was no significant difference between Ascorbic acid and Mg $(NO_3)_2$. Neem vs MgO-NPs showed Mean difference = 0.2957, 95% CI of difference = 0.1423 to 0.4490, P value = <0.0001. So, there was significant difference between. Neem and MgO-NPs. Neem vs Mg $(NO_3)_2$ showed Mean difference = 0.1057, 95% CI of difference = -0.04772 to 0.2590, P value = > 0.05. So, there was no significant difference between Neem extract and Mg $(NO_3)_2$. MgO-NPs vs Mg $(NO_3)_2$ showed Mean difference = -0.19, 95% CI of difference = 0.3434 to – 0.03662, P value = <0.05. So, there was significant difference between MgO-NPs. and Mg $(NO_3)_{2.}$ Table IV shows So, there was no significant difference between Neem extract and Mg $(NO_3)_2$. MgO-NPs vs Mg $(NO_3)_2$ showed Mean difference = -0.19, 95% CI of difference = 0.3434 to – 0.03662, P value = <0.05. So, there was significant difference between MgO-NPs. and Mg $(NO_3)_{2.}$

Figure-4: Colour of different solutions from left to right, NE for Neem extract, Mg for MgNO3 solution and NP for Nanoparticles

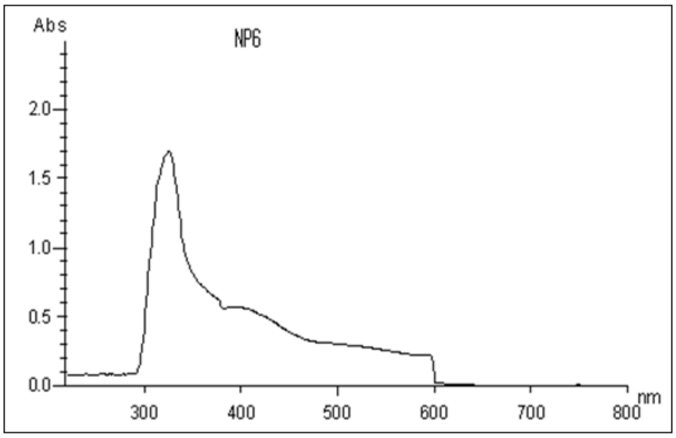

Figure 5: UV-Vis spectroscopy of MgO-NPs

Figure 6: Changes in the color of dye solution from deep blue to colourless

Figure 7: Changes of colour of DPPH solutions after adding MgO-NPs

Figure 9: Neem Leaves **Figure 10: Preparation of Neem extract**

Table-I: Multiple comparisons test among MgO-NPs, Mg $(NO_3)_2$, Neem extract and Methylene blue solutions after ANOVA test (F= 11.66, P= 0.0001)

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	P value	Comment: Significant / not significant
MgO-NPs vs. $Mg(NO_3)_2$	51	42.77 to 59.23	<0.0001	Significant
MgO-NPs vs. Neem	43.67	35.43 to 51.90	<0.0001	Significant
MgO-NPs vs. MB	55	46.77 to 63.23	<0.0001	Significant
$Mg(NO_3)_2$ vs. Neem	-7.333	-15.57 to 0.9012	> 0.05	Not significant
$Mg(NO3)_2$ vs. MB	4	-4.235 to 12.23	> 0.05	Not significant
Neem vs. MB	11.33	3.099 to 19.57	<0.001	Significant

Table-II: Average absorbance of different solutions at different strength

Solutions	100mg/ml	10mg/ml	1mg/ml	100µg/ml	10µg/ml	1µg/ml
Ascorbic acid	0.242	0.182	0.42	0.421	0.459	0.46
$Mg(NO_3)_2$	0.271	0.354	0.420	0.365	0.416	0.425
MgO-NPs	0.081	0.112	0.367	0.427	0.437	0.437
Neem extract	0.376	0.198	0.268	0.392	0.397	0.396

[Here average absorbance of DPPH solution was 0.408]

Table-III: Percentage (%) of Antioxidant activity of different solutions by different strength

Solutions	**100mg/ml**	**10mg/ml**	**1mg/ml**	**100µg/ml**	**10µg/ml**	**1µg/ml**
Ascorbic acid	65%	55%	2.90%	3.10%	12.50%	12%
$Mg(NO_3)_2$	33%	13%	2.90%	10%	1.90%	4%
MgO-NPs	80%	72%	10%	4%	7%	7%
Neem extract	7.80%	51%	34%	3.90%	2.60	2.90%

Table-IV: significant tests for 100 mg/ml of different solutions

Tukey's multiple comparisons test	**Mean Diff.**	**95% CI of diff.**	**P value**	**significant /not significant**
Ascorbic vs. Neem	-0.2347	-0.3880 to -0.08128	<0.001	Significant
Ascorbic vs. MgO-NPs	0.061	-0.09238 to 0.2144	>0.05	Not significant
Ascorbic vs. $Mg(NO_3)_2$	-0.129	-0.2824 to 0.02438	>0.05	Not significant
Neem vs. MgO-NPs	0.2957	0.1423 to 0.4490	<0.0001	Significant
Neem vs. $Mg(NO_3)_2$	0.1057	-0.04772 to 0.2590	>0.05	Not significant
MgO-NPs vs. $Mg(NO_3)_2$	-0.19	-0.3434 to -0.03662	<0.05	Significant

Table-V: Significant tests for 10 mg/ml of different solutions

Tukey's multiple comparisons test	**Mean Diff.**	**95% CI of diff.**	**P value**	**Significant /Not significant**
Ascorbic vs. Neem	-0.016	-0.1750 to 0.1430	> 0.05	Not significant
Ascorbic vs. Nano	0.06967	-0.08936 to 0.2287	> 0.05	Not significant
Ascorbic vs. $Mg(NO_3)_2$	-0.1718	-0.3309 to -0.01280	<0.05	Significant
Neem vs. Nano	0.08567	-0.07336 to 0.2447	> 0.05	Not significant
Neem vs. $Mg(NO_3)_2$	-0.1558	-0.3149 to 0.003197	> 0.05	Not significant
Nano vs. $Mg(NO_3)_2$	-0.2415	-0.4005 to -0.08247	<0.001	Significant

DISCUSSION

Nanotechnology is emerging as a rapidly growing field with its applications in science and technology for the purpose of manufacturing new materials at the nanoscale level (Moron, J. R. *et al*., 2005) [15]. There have been impressive developments in the field of nanotechnology in the recent years with numerous methodologies developed to synthesized nanoparticles of particular shape and size depending on specific requirements. The nanoparticles can be synthesized through physical chemical and biological methods. The current study focused on the biogenic synthesis of magnesium oxide nanoparticals with the use of neem leaves extract and the presence of nanoparticles were confirmed by changes of their colour from yellow to yellowish brown, UV-Vis spectral analysis, photocatalytic and antioxidant properties.In this study we used neem leaves for this MgO-NPs synthesis. (Moorthy, S. K *et al*., 2015) [4] used neem leaves and (Dobrucka, R. 2016) [14] used artemisia abrotanum herba extract for MgO-NPs synthesis. Aloe Vera used for MgO-NPs synthesis, Suresh, J. (2014) [16] used Nephelium lappaceum l., for MgO-NPs synthesis. Jhansi, K. (2017)[17] used Mushroom for MgO-NPs synthesis. Tang, Z. X. and Lv, B.F (2013)[18] synthesized MgO-NPs using sol-gel method, hydrothermal method and micro emulsion method. Munjal, S. (2017) [19] Orange fruit waste used for MgO-NPs synthesis and Raliya, R. (2014) [20]

Aspergillus Tubingensis TFR-3 used for MgO-NPs Synthesis. Sushma, N. J. (2015) [21] Synthesized MgO-NPs using Clitoria Ternatea. Nanoparticles exhibit different colour in aqueous solutions due to excitation of surface plasmon vibration (Rajamanickam, *et al*., 2012 [1]; Saini. *et al*., 2013) [22]. In the metal oxide nanoparticles, electron oscillate collectively. These oscillations effects how light interacts with the nanoparticles. The specific oscillations depend on the particle size and shape. So, particles of different size have different colours in different surface plasmon absorption peak. (Moorthy, S. K *et al*., 2015) [4] Synthesized MgO -NPs which showed similar colour change from yellow to yellowish brown like this study. The UV-Vis absorption spectroscopy is the most widely used method for characterizing the optical properties and electronic structure of nanoparticles, as the absorption bands are related to the diameter and aspect ratio of metal nanoparticles (Philip 2008) [23]. Light wavelengths in the 300-800nm are used for characterizing various metal nanoparticles in the size range 2-100nm Dobrucka, R. (2016) [14]. The MgO -NPs synthesized by (Moorthy, S. K in 2015) [4] the surface plasmon absorption peak at 273.5 nm. Sushma, N. J [21] found peak absorbance in UV-Vis spectroscopy at 280 nm MgO-NPs. Munjal, S. (2017) [19] found surface plasmon resonance of synthesized MgO-NPs at the wavelength of 250 nm found absorption peak at 283 nm of wavelength of synthesized MgO-NPs. Dobrucka, R. (2016) [14] found absorption peak at 300nm of wavelength and confirmed the presence of MgO-NPs and proved the reduction of $Mg(NO_3)_2$. In our study we found surface plasmon absorption peak at 310 nm wavelength. Our observation was nearly similar with the other study reported by Dobrucka, R (2016) [14]. Slight variation in the wave length can be occurred due to lack of calibration of the wavelength of that UV-Vis Spectrophotometer. It may also occured due to changes in the parameter such as environmental temperature, humidity etc. In this observation, narrow sharp double peak was found. According to Pal, Song and Tak (2007) [24] relatively narrow peak indicates that metal oxide nanoparticles were within a narrow size distribution. According to cytodiagnostic (n.d.) as the particle size increased from 10 to 100 nanometer absorbance peak increases from 400-500 nm and broaden in width. Broadening indicated the formation of poly dispersed large nanoparticles. The sharp narrow plasmon peak observed in our study was similar to that reported by Fu, Raveendran & Wallen (2003) [25] who found the surface plasmon absorbance spectrum of SNPs formed in aqueous starch dispersion at 419 nm and 90% of those particles were in the size range from 1 to 8 nm and were confirmed by TEM study. Presence of double peak in our observation was also indicative for MgO-NPs synthesis.

In this study, significant photocatalytic property of synthesized MgO-NP was found. This activity was evaluated by degradation of methylene blue dye under solar irradiation. During exposure in sunlight, when the photons hit the nanoparticles present in the colloidal mixture, the electrons at the particle surface are excited (Yu *et al*., 2012) [26]. The dissolved oxygen molecules in the reacting medium accept the excited electrons from particle surface and are converted into oxygen ion radical. These radical breaks organic dye into simpler organic molecule leading to the rapid degradation of the dye (Houas, *et al*., 2001; Ameta, *et al*., 2013) [27, 28]. Dye degradation was visually detected by gradual change in the colour of the dye solution from deep blue to colourless (shown in Figure-9). The characteristic absorption peak for methylene blue was noticed at 660 nm. The degradation of dye was 88% in presence of MgO nanoparticles and the control exhibited no changes in colour during exposure in sunlight in this study which indicate significant photocatalytic activity. Statistical analysis was done and found significant results. Dobrucka, R. (2016) [14] Conducted the photocatalytic study of synthesized MgO-NPs and found good catalytic activity. In studied the photocatalytic activity of synthesized MgO-NPs and found MgO-NPs as a good adsorbent which also help in removal of effluents from textiles and dying industries. In our study presence of significant photocatalytic activity confirmed the presence of MgO-NPs in the synthesized solution using neem leaves extract. There are a few studies about the antioxidant activity of MgO-NPs. Ilhami Gulcin, *et al*., (2010) [29] also studied on MgO nanoparticles for its antioxidant activity and found positive results. Sushma, N. J. (2015) [21] Found in vitro antioxidant activity of MgO nanoparticles synthesized from Clitoria Ternatea by DPPH study. They found the DPPH activity and reducing power assay of biologically synthesized MgO-NPs could reach 65% at a concentration of 150 mg/ml, respectively. Thus, antioxidant activity of MgO-NPs was found by them. Dobrucka, R. (2016) [14] Also studied the antioxidant activity of synthesized MgO-NPs by DPPH assay and found antioxidant activity. In the DPPH method, Substances that can donate an oxygen atom create the reduced form of DPPH; in consequence the solution losses its violet colour. Antioxidant that present in the tested sample reduce the stable nitrogen radicle 2, 2- diphenyl-1 picryl hydrazil (DPPH), causing the decrease in absorbance measured at the wavelength of 515nm. Then antioxidant activity is calculated from these measurements. In the present study, DPPH method was used to assess the antioxidant activity of the synthesized MgO-NPs and ascorbic acid was taken as a control. Here, six dilutions (100mg/ml-1µg/ml) were prepared of every solutions and experiment was done. It was found that MgO-NPs showed 80% antioxidant activity in the concentration of 100mg/ml and 72% activity in the concentration of 10mg/ml. But below 10mg/ml it did not show any antioxidant effects. So, greater concentration showed greater antioxidant effects. Ascorbic acid showed 65% antioxidant effects in 100mg/ml concentration and 55% effects in 10mg/ml concentration. From the above discussion it could be concluded that due to greater surface to volume ratio the synthesized MgO-NPs have potential antioxidant and photocatalytic activity.

Conclusion and Recommendations

In recent years, nanoscience and nanotechnology have emerged as a new area of fundamental science and are receiving global attention due to their extensive applications in the area of electronics, medicine and agriculture. The synthesis of metal oxide nanoparticles with the use of plant extract is a promising alternative to traditional chemical method. The current study focused on the biogenic synthesis of MgO-NPs in an ecofriendly manner by using Neem (Azadirachta Indica) leaves extract in a simple, easy, rapid and cost-effective way. The obtained MgO-NPs may have potential applications due to their significant photocatalytic activity and antioxidant properties. Neem leaves are available in our country. As the nanoparticles have been biologically synthesized from these leaves in a simple and cost effective way, it will be very helpful to synthesize more nanoparticles for their application in the area of electronics, medicine and agriculture. Besides catalytic and antioxidant properties other potential application of MgO-NPs in medical field should be studied in future.

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