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Investigation of the Magnesium Oxide Nanoparticles Effect on Thyroid (T3, T4) Thyroid Stimulating Hormones (TSH) in Rat

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Abstract

Nanoparticles (NPs) are used in industrial and biomedical fields, such as cosmetics, food additives and biosensors. One of the most important of these particles is magnesium oxide nanoparticles. The nanoparticles of magnesium oxide are diagnosed through several techniques, including the Atomic Force Microscope (AFM) and (XRD). Analyzing the structure of studied nano materials is useful to investigate their medical applications by influencing thyroid hormones such as thyroxine (T4), triiodothyronine (T3), and thyroid-stimulating hormone (TSH) in rat. A total of 15 Sprague-Dawley adult female rats were split into three groups, each group injected daily intraperitoneally of MgONPs at one dose (80 mg/kg). In different periods (14 and 28 days), as follows; The first group: is the control group without injections. The second group: injected intraperitoneally with MgONPs (80 ppm) for 14 days. The third group: was injected intraperitoneally with MgO NPs (80 ppm) for 28 days. The findings of this study revealed a highly significant reduction ($p < 0.01$) in T3, T4 and Thyroid stimulating hormones (TSH) levels increased high significantly ($p < 0.01$).

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1. Introduction

The concept of nanotechnology is one of the modern concepts from which many applications and medical and industrial devices have been developed [1], which give new characteristics to the material whenever its nanosize varies [2]. The characteristics of nanoparticles are of high economic advantages and also have good results in several journals, the most important of which in medicine [3]. computing [4]. energy materials [5]. sensing and detection [6], and catalysis [7]. MgO is an important inorganic material with a wide band-gap [8]. In medicine, MgO is used for the relief of heartburn, sore stomach, and bone regeneration, Recently, MgO nanoparticles have shown promise for application in tumor treatment MgO nanoparticles also have considerable potential as an antibacterial agent [9]. The thyroid gland is brownish-red in color and consisted of left and right lobes connected by a midline isthmus. It is located anteriorly in the neck and attaches to the trachea and larynx [10]. The Thyroid gland is a secretes two major hormones that control metabolic processes in the body, including Thyroxine (3,5,3',5'-tetraiodothyronine T4) and Triiodothyronin (3,5′,3′-triiodothyronine, T3) [11]

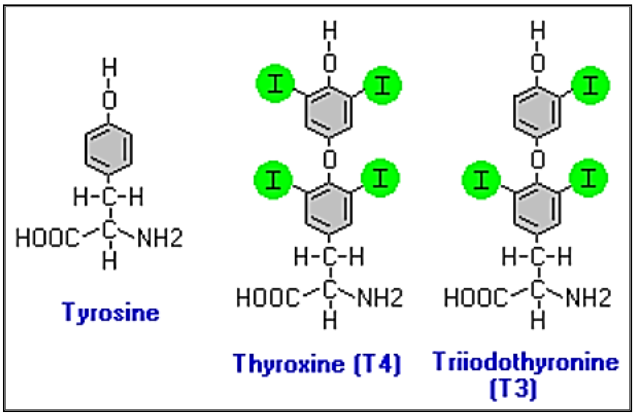

Figure 1. Structure of Thyroid Hormone) [105].

The total molar concentration of T4 is some 50 times that of T3, The half-life of T4 is 5-7 days; that of T3 is 1-2 days [12]. The thyroid hormone control the basal metabolic rate (BMR) and calorigenesis by enhancement of mitochondrial metabolism, increased heart rate by enhancing the sensitivity of adrenergic receptors to catecholamines, stimulation of protein synthesis or carbohydrate metabolism, increases the synthesis or degradation of cholesterol and triglycerides [13]. The most important regulator of thyroid homeostasis is thyroid-

stimulating hormone (TSH), The secretion of TSH is controlled by negative feedback by the TSH [14-15]. This research deals with the effect of MgO NPs on thyroid hormones (T3,T4) and thyroid-stimulating hormone (TSH) in female rats.

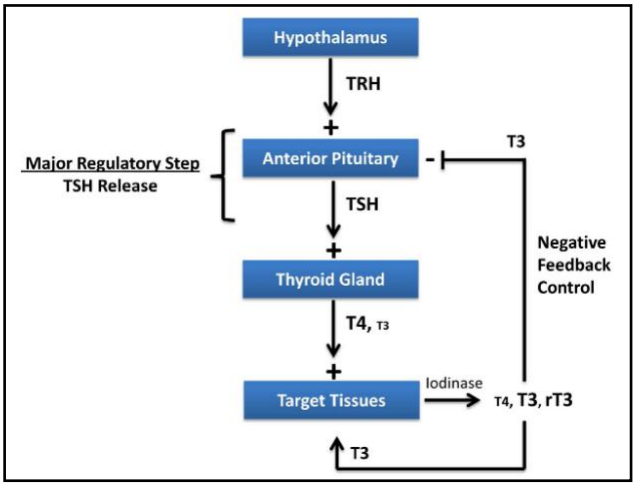

Figure 2. Control of Thyroid Function [114].

2. Materials and Methods

The study was conducted on 15 adult female Sprague-Dawley albino rats (Rattus norvegicus) with average age of 2.5-3 months as a mammalian model, The mature female with average body weight of (225-235) gm. The animals were obtained from the National Center for Drug Control and Research (NCDCR) Ministry of Health and then carried to the animal house of Mustansiriyah University, College of Science. The females were housed in plastic cages covered with a metal Network in a climate-controlled environment with 22-25 degrees Celsius,12 hours of light and darkness, 60 percent humidity, and free access to food and water.

2.1 Experimental design of vivo:

The Rats were split into three groups from group 1 to group 3, each group include five rats. The rats were given daily intraperitoneal injections (80 ppm) of MgO NPs for (14, 28 days) in the following groups:

- Group 1: as the control without injection.
- Group 2: was injected intraperitoneally with MgO NPs 80 ppm at a concentration of 80 for 14 days.
- Group 3: was injected intraperitoneally with MgO NPs 80 ppm at a concentration of 80 for 28 days.

2.2 Collection of blood samples:

After weighing the animals were anesthetized with diethyl ether, the blood samples were collected through a hole in the heart, and then the blood was separated by a centrifuge, then the serum was transferred to another test tube and divided into two parts, the first part is to measure the level of hormones (T3 and T4). and TSH) and then it is kept in the freezer for testing.

2.3 Determination of hormone:

Biological Principles of the procedure: assay is a two-step immunoassay to determine the presence of Hormones in human serum and plasma. This method is similar to the (sandwich ELISA).

1. 20 ml of Sample and 25 of (anti-β antibody) coated paramagnetic microparticles were combined, then were bind Together, Anti-β antibody is (monoclonal antibody).
2. After washing, 25 ml anti-α antibody acridinium-labeled conjugate is added to create a reaction mixture, Anti-α antibody (monoclonal antibody).
3. Following another wash cycle (Wash Buffer containing phosphate buffered saline solution, followed by Solution containing 0.35 N sodium hydroxide) was performed. incorporated into the reaction mixture.
4. The resulting chemiluminescent response was measured in relativity light units (RLUs). There is a direct relationship between the number of Hormones in the sample.

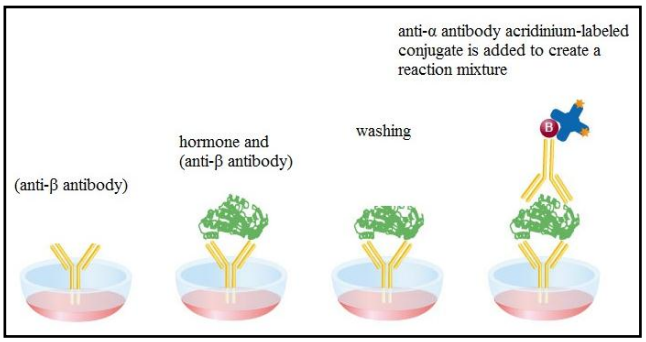

Figure 3. Hormone measurement steps.

3. Results and Discussion

The nanoparticles were characterized by different analytical techniques such as AFM and XRD.

3.1 Atomic force microscope (AFM):

This Shows the two and three dimensions of AFM images the Versus size distribution of (MgO NPs). AFM is used for morphological analysis because it produces topological images of surfaces at a very high enlargement and makes it easier to see the crystals's atomic structure. Where the results indicated that the particle MgO average diameter (41.04 nm).

Avg. Diameter: 41.04 nm, 10% Diameter: 19.00 nm
50% Diameter: 32.00 nm, 90% Diameter: 63.00 nm

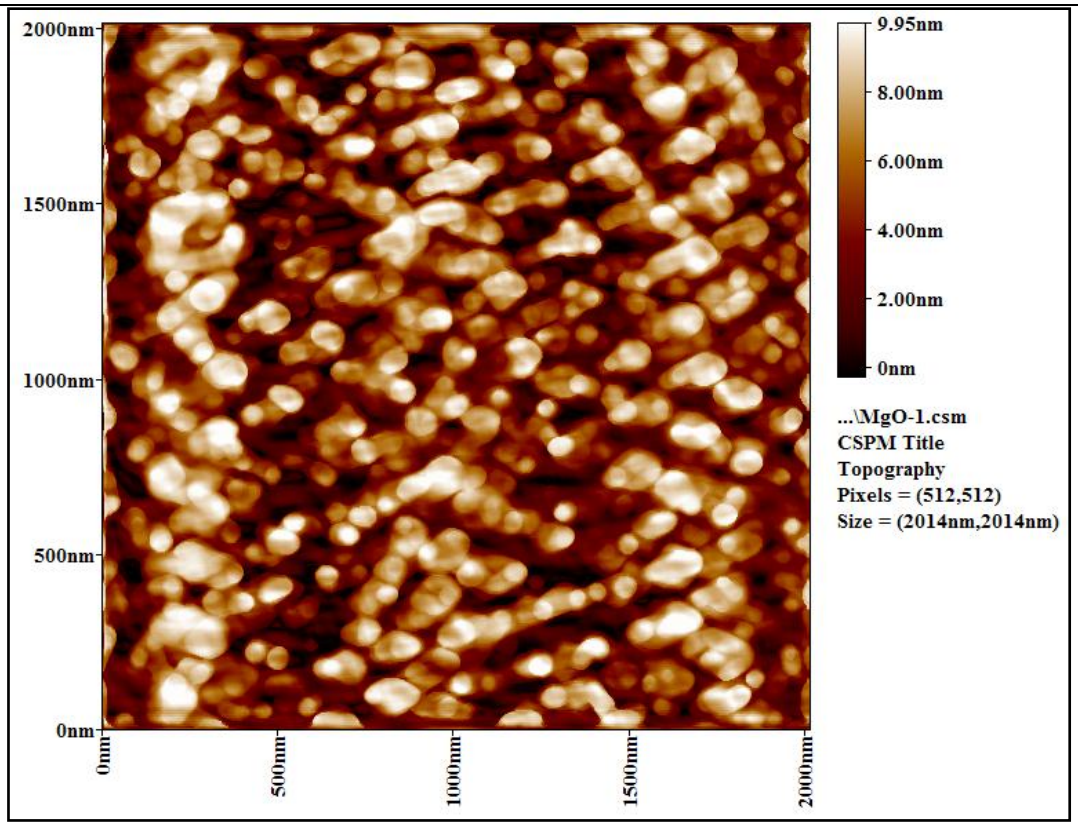

Figure 4. AFM images and size distributions of MgO.

3.2 X-ray diffraction (XRD):

The diffraction peaks were identified by comparison with for (MgO) (41.9242-61.3073-38.7352), (220), (200)°, (111), respectively, reflection planes. The observed peaks are indicative of the cubic structure of MgO [16].

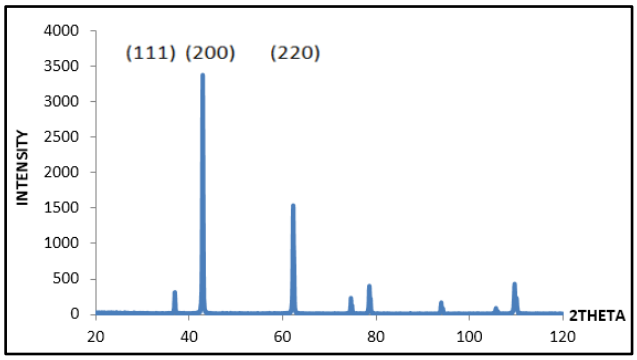

Figure 5. X-ray diffraction MgO.

Effect of doses of MgO NPs (80) mg/kg on (T3, T4, TSH) levels of rats during various time periods (14, 28 days) in comparison to control groups and between treatment groups.

Figures 6-9 depicts the statistical analysis of the current investigation for the impact of MgO NPs on thyroid hormones, which included T3, T4, TSH.

3.3 Triiodothyronine (T3):

High significant lower ($p < 0.01$) on sera level of (T3) (nmole/L) in treatment with MgO NPs at (80) mg/kg at different treatment period (14, 28 days) (2.2840 ± 0.0114), (1.652 ± 0.06979) (nmole/L), respectively, when compared to the control groups (4.008 ± 0.13627) (nmole/L) demonstrated in Figure 6.

3.4 Thyroxine (T4):

T4 (nmole/L) results showed high significant lower ($p < 0.01$) after exposure to MgO NPs at (80) mg/kg for varied treatment period (14, 28) day, (25.76 ± 1.14018), (22. 6 ± 1.23004) (nmole/L), respectively, when compared to control groups (35.724 ± 1.16055) (nmole/L) respectively. Demonstrated in Figure 7.

3.5 Thyroid stimulating hormones (TSH):

High significant increase ($p < 0.01$) on serum level of TSH (nmole/L) in treatment with MgO NPs at (80) mg/kg at different treatment periods (14, 28 days) (0.120 ± 0.00707) (0.271 ± 0.35175) (nmole/L), respectively, when compared to control groups (0.1720 ± 0.04207) (nmole/L) respectively. Demonstrated in Figure 8.

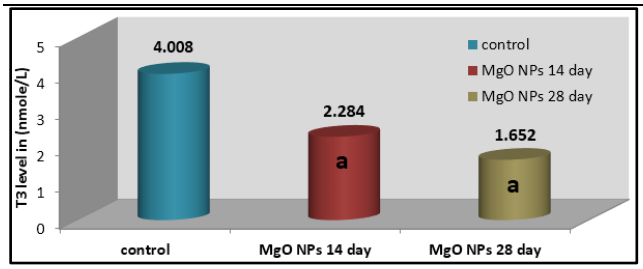

Figure 6. Impact of dosage of MgO NPs (80) mg/kg on triiodiothyronine levels in rats across various time periods (14, 28 days) in comparison to control groups and between treatment groups. (a) high significant decrease ($p \leq 0.01$).

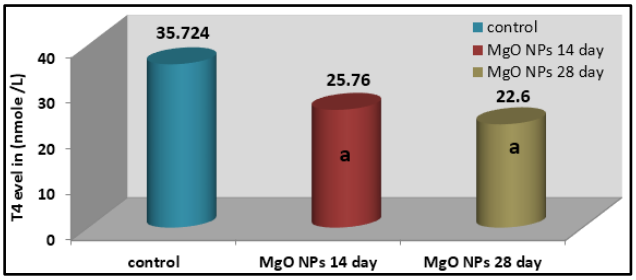

Figure 7. Impact of dosage of MgO NPs (80) mg/kg on thyroxine levels in rats across various time periods (14, 28 days) in comparison to control groups and between treatment groups. (a) high significant decrease ($p \leq 0.01$).

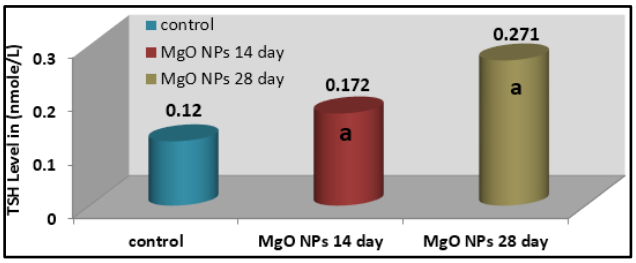

Figure 8. impact of dosage of MgO NPs (80) mg/kg on Thyroid Stimulating Hormones (TSH) levels in rats across various time periods (14, 28 days) in comparison to control groups and between treatment groups. (a) high significant decrease ($p \leq 0.01$).

Data obtained revealed that found low levels of thyroid hormones (T3, T4) in sera samples of rats given MgO NPs (80ppm) for varying lengths of time (14, 28 days). MgO NPs could be inhibited T3 and T4 via two mechanisms: hydrogen bonding between the oxygen in (MgO NPs) and the tyrosine in thyroid hormone or ionic attraction between the negatively charged iodien in thyroid hormone and the positively charged of MgO NPs [17,18]. There is another reason that the resulting inhibition of thyroid hormones is the formation of H-bonded complexes between (–COOH, –NH and –OH) groups of amino acids and oxygen groups for nanoparticles [19]. There are limited studies investigating the effect of thyroid stimulating hormones (TSH), the current study found high levels of (TSH) in sera samples of rats given MgO NPs (80 ppm) for varying lengths of time (14, 28 days) compared to the controls group, This is explained by result of negative feedback on thyroid gland activity resulting from inhibition of thyroid hormone nanoparticles [20].

4. Conclusions

The findings of this investigation revealed that the size, dosages, mode of administration, and time of administration can all have an impact on thyroid hormones In comparison to the controls group, the current study found low levels of thyroid hormones (T3,T4) in sera samples of rats given MgO NPs (80 ppm) for varying lengths of time (14, 28 days) MgO NPs inhibit T3 and T4 [21].The current study found high levels of (TSH) in sera samples of rats given MgO NPs (80 ppm) for varied lengths of time (14, 28 days) compared to the controls group, These findings have negative feedback because decrease of thyroid hormone production [20].

Conflicts of Interest

The authors declare that there is no conflict of interest.

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