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Synthesis and Characterization of Nano-Aluminum Oxide Via Biological and Electrochemical Methods

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Abstract

In this research work, the nanoparticles of aluminum oxide were synthesized by two ways. The first way is the biological by using (Pseudomonas aeruginosa) bacteria with a rate diameter (102.35) nm. The second way is the electrochemical with a rate diameter (62) nm. These nanoparticles were characterized by Atomic Force Microscopy (AFM), X-Ray diffraction technique (XRD), Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). Alumina nanoparticles are thermodynamically stable particles over a wide temperature range. The biological activity of these nanoparticles toward different species of pathogenic bacteria (Staphylococcus aureus) and (Pseudo monas) has been investigated. The nanoparticles prepared by chemical way was more effective in the inhibition of bacteria compared with that nanoparticles prepared by biological way.

Keywords: Nanotechnology, Biological method, Electrochemical method and Nano-aluminum oxide.

الخلاصة

تم في هذا البحث تحضير الدقائق النانوية لاوكسيد الالمنيوم بطريقتين: الطريقة الاولى هي الطريقة البايولوجية بأستخدام بكتريا (Pseudomonas aeruginosa) وبمعدل (١٠٢,٣٥) نانومتر. اما الطريقة الثانية فهي الطريقة الكهروكيميائية وبمعدل (٦٢) نانومتر. تم تشخيص هذه الجسيمات باستخدام اجهزة (مجهر القوة الذرية، تقنية الاشعة السينية، مجهر الانتقال الالكتروني ومجهر الماسح الالكتروني) ووجد ان هذه الجسيمات مستقرة ثرموديناميكيا على نطاق حراري واسع. كما ودرست الفعالية البايولوجية للجسيمات النانوية تجاه انواع مختلفة من البكتريا المسببة للامراض مثل (Staphylococcus aureus) و (Pseudo monas) ووجد ان الدقائق النانوية المحضرة بالطريقة الكهروكيميائية اكثر فعالية في تثبيط هذه الانواع من البكتريا مقارنة بالدقائق النانوية المحضرة بالطريقة البايولوجي.

Introduction

Nanotechnology is one of the main logical fields today since it joins learning from the ambit of Physics, Chemistry, Biology, Medicine, Informatics, and Engineering. It is a developing innovative area with awesome potential to lead in incredible leaps forward that can be connected, in actuality. Novel nano biomaterials and nano devices are created and controlled by nanotechnology instruments and methods, which explore and tune the properties, reactions, elements of living and non-living issue, at sizes below100 nm. The application and utilization of nano materials in electronic and mechanical gadgets, in optical and attractive segments, quantum figuring, tissue building, and different biotechnologies, with smallest features, widths well below 100 nm, are the economically most important parts of the nanotechnology nowadays and presumably in the near future[1]. Nanotechnology has created in the extent of gadgets, space, sustenance, material, optics, and medication and so on. In the field of prescription, the innovation has created with different angles for example; medicate conveyance, tissue designing broadly utilized for the conclusion of illnesses like malignancy, diabetes, heart and cerebrum disease for the analysis of different infections[2]. A noteworthy explanation behind expanded

enthusiasm for nanotechnology is that life science analysts are disclosure structures and instruments whose portrayal includes more than conventional organic chemistry or even macromolecular protein science[3]. The impression of nanoscale gadgets has guided to the extension of biodegradable self-gathered nanoparticles, which are being designed for the focused on conveyance of anticancer medications and imaging contrast operators. Nanoconstructs would thus be able to fill in as adaptable, directed medication conveyance vehicles sufficiently capable in transporting substantial measurements of chemotherapeutic operators or restorative qualities into threatening cells while not hampering solid cells[4][5]. In this research nanoparticles of aluminum oxide (alumina), which its crystal structure shown in Figure 1. were synthesized according to electrochemical and biological, They are corundum like structure with oxygen particles grasping hexagonal lose squeezing with alumina particles filling 66% of the octahedral goals in the matrix. The particle lead was in like manner affected by atom size, shape, and surface charge. Nanoparticles tend to add up to in hard water and seawater in light of particle participation with common issue show in water[6]. Collections of molecule are additionally affected by pH and saltiness, which reflects the scattering capacity of particles in the suspension that prompt adjust lethality evaluation. Before executing poisonous quality investigations certain essential parameters must be mulled over, for example, molecule measure, size distribution, morphology, composition, surface area, surface chemistry, and particle reactivity in solution that needs to be accurately characterized as prerequisites. They inquired about the qualification in toxic response of micron evaluated and nano measured alumina towards Scenedesmus sp. besides, Chlorella sp. An improvement inhibitory effect of the nanoparticle was seen against both the species and an evident reducing in the chlorophyll content was furthermore found in the cells treated with nanoparticles. A participation of the nanoparticles with the cell surface was proposed as the possible segment for the harmful quality[7]. Al_2O_3 nanoparticles can be synthesized by different strategies including, ball processing[8], sol-gel, pyrolysis, sputtering, aqueous[9], and laser removal Among them, the laser removal is a broadly utilized procedure for the combination of nanoparticles since it can be blended in gas, vacuum or fluid[10]. This technique offers several advantages such as rapid and high purity process compared with other. Furthermore, nanoparticles prepared by the laser ablation of materials in liquid are easier to be collected than those of in gas atmosphere[11].

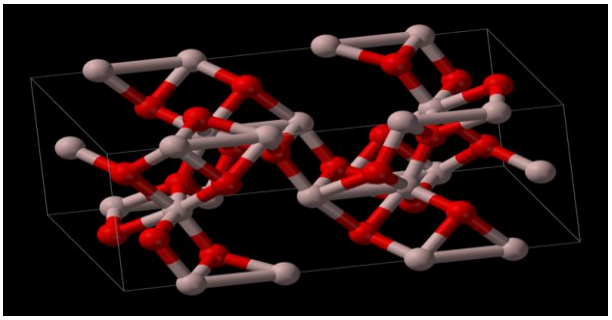


Figure 1: Crystal Structure of Aluminum Oxide.

Experimental

1. Preparation of aluminum oxide nanoparticles by electrochemical method (Anodization method)

in this method the electrochemical cell of dimensions (70×50 mm) was used, which consists of two electrodes (Anode) is aluminum plate with purity (99%) and (Cathode) is graphite rod with purity (99%) and the distance between them (25 mm) and electrolyte solution, the cell is connected to power supply (8)volt and (0.01) Amber.

2. Preparation of aluminum oxide nanoparticles by biological method

0.15g of aluminum acetate was dissolved in (100 ml) of distilled water and preparation of a sample of Nutrient broth. The sample was inoculated with inoculator of (*Pseudo monasaeruginosa*) bacteria and was added (10 ml) of aluminum acetate solution was added, the sample was incubated at (37 ˚C) for (48 hours), the change in the color was observed every (24 hours) and the nanoparticles were

synthesized by measurement the particles size resulting in solution using (AFM) device[12].

3. Preparation of some isolates of pathogenic bacteria

a. Preparation of agricultural medium of bacteria

Mueller Hinton agar was prepared by dissolving a certain weight of medium in certain volume of distilled water, it was sterilized using autoclave device, and varnishes in petri dishes and thus it become agricultural ready medium for bacteria.

b. Preparation of bacterial suspension

The bacterial suspension was prepared by transfer colonies of bacteria cultivated, which synthesized on alimental medium dish and dissolved in test tube consists of solution contain sterile nutrient then were mixed by using vortex device to obtain the bacterial suspension and was compared with the standard McFarland solution to calibrate the number of bacterial cells, which gives approximate number of cells (1.5×10^8) cell.

Results and Discussion

1. Atomic Force Microscopy (AFM)

a. The Prepared Samples by Biological Method

Aluminum oxide nanoparticles prepared by biological method were tested using (AFM) technique; Figure 2 illustrates the AFM vertical analysis. While Figure 3 shows the surface structure of theses nanoparticles

Figure 4 and Table 1 showed the statistical analysis of AFM data for alumina nanoparticles diameter. It has been found that the average diameter of nanoparticles was (102.35 nm) and nanoparticles of (50 nm) diameter considered to be the fewer obtained while the nanoparticles of (80 nm) diameter were the most abundant in this way.

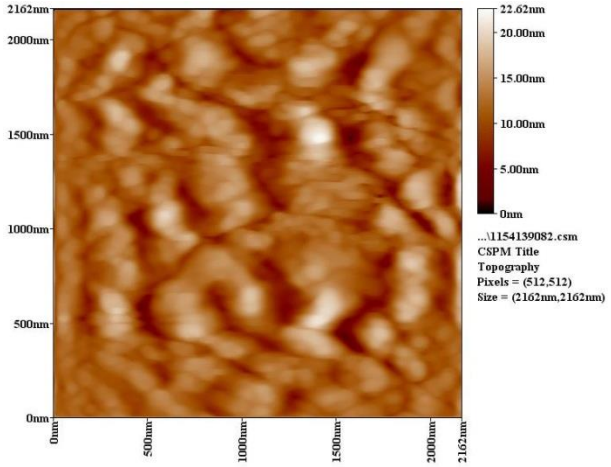


Figure 2: Vertical Analysis of AFM for Nanoparticles of Aluminum Oxide.

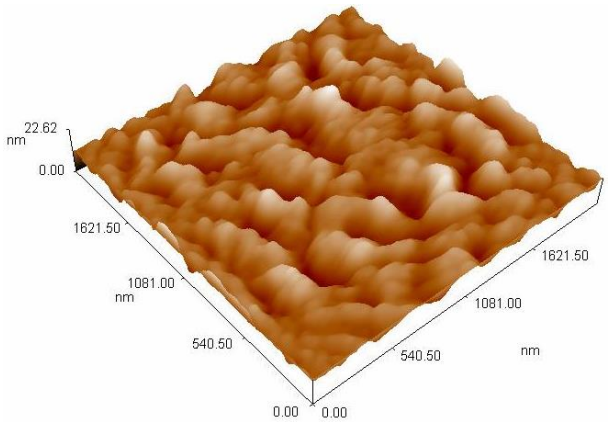


Figure 3: Surface structure of Nanoparticles of Aluminum Oxide Using AFM.

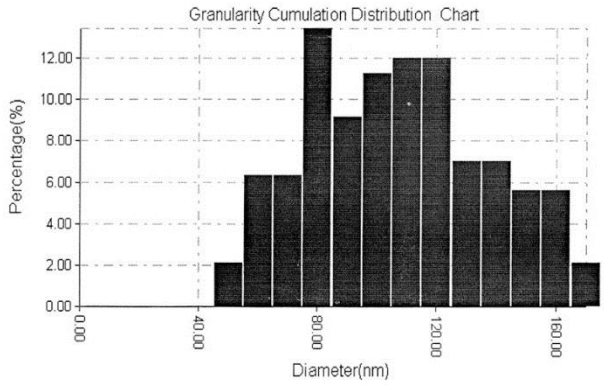


Figure 4: The statistical Analysis of Nanoparticles of Aluminum Oxide Using AFM in Biological method.

Table1: The Statistical Analysis of Nanoparticles of Aluminium Oxide using AFM in Biological Method.

Volume (%)	Diameter (nm)
50	2
60	6.4
70	6.4
80	14
90	8.12
100	10.12
110	12
120	12
130	6.12
140	6.12
150	4.16
160	4.16
170	2

b. The prepared samples by electrochemical method

In this method, two types of nanoparticles were obtained. The first type was free to grow un restricted in flooring (substrate) inside the electrolyte solution, while the second type was the growth limited in flooring represent the surface of aluminum electrode, this means that the radius of the tube determined by the topography of the aluminum surface. The nanoparticles of aluminum oxide that prepared by electrochemical method were examined using (AFM) and appeared group of nanoparticles with various measurements as in figure 5.

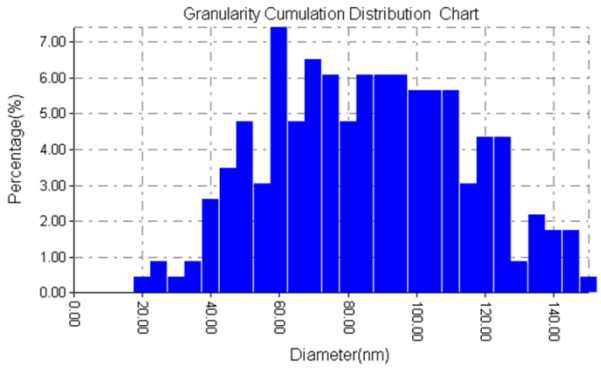


Figure 5: The statistical Analysis of Nanoparticles of Aluminum Oxide Using AFM in Electrochemical Method.

Figure 5 and Table 2 showed the statistical analysis of AFM data for alumina nanoparticles diameter. It has been found that the average diameter of nanoparticles was (62 nm) and nanoparticles of (20 nm) diameter considered to be the fewer obtained while the nanoparticles of (60) nm diameter were the most abundant in this way.

Table2: The Statistical Analysis of Nanoparticles of Aluminium Oxide using AFM in Electrochemical Method.

Diameter (nm)	Volume (%)	Diameter (nm)	Volume (%)
20	0.4	90	6.1
25	0.8	95	6.1
30	0.4	100	5.4
35	0.8	105	5.4
40	2.5	110	5.4
45	3.4	115	3
50	4.8	120	4.3
55	3	125	4.3
60	7.4	130	0.9
65	4.8	135	2.1
70	6.4	140	1.8
75	6	145	1.8
80	4.8	150	0.4
85	6.1		

2. X-Ray Diffraction (XRD)

The X-Ray diffraction technique was used to determine and identify the nanoparticles The X-Ray diffraction device was characterized by contentious scanning model specification (step size of 2θ = 0.05 deg) with speed (10 deg/min), Processed voltages (40 kV) and current (30 mA), X-rays were generated using a copper target with wave length for generated X-Ray (1.54 Å). Figure 6 confirm the appearance of nanoparticles of aluminum oxide. The crystal size can be calculated according to Scherer formula:

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

Where K=0.9 Scherrer constant , λ is the wavelength of the cu-kα radiation, β is the full width at half maximum and θ is the angle obtained from 2θ values corresponding to maximum intensity peak in XRD pattern. The mean crystal size of Al_2O_3 nanoparticles was 28 nm.

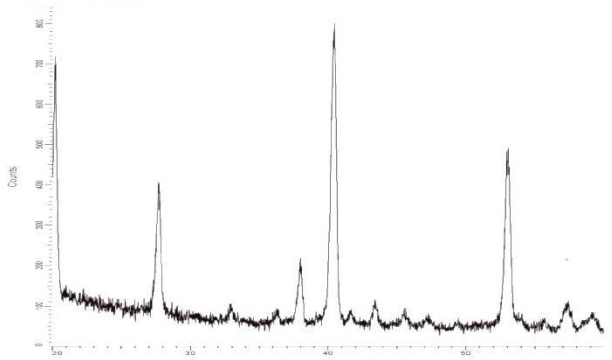


Figure 6: XRD of Aluminum oxide Nanoparticles.

3. Transmission Electron Microscopy (TEM)

The average particles size were determined From the TEM images of Al_2O_3 nanoparticles were 22.9 nm as in Figure 7.

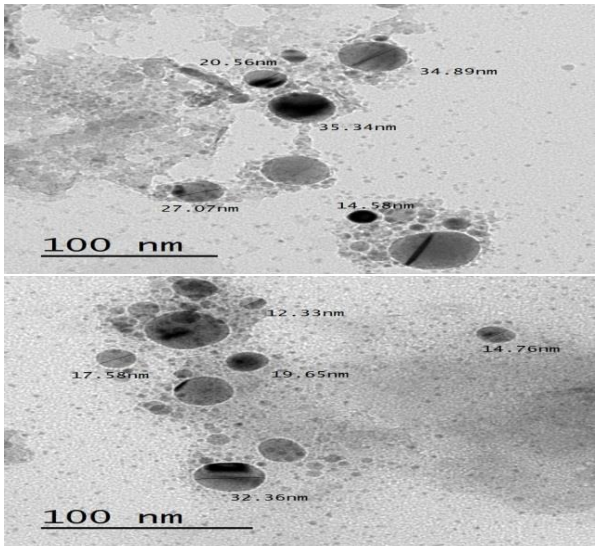
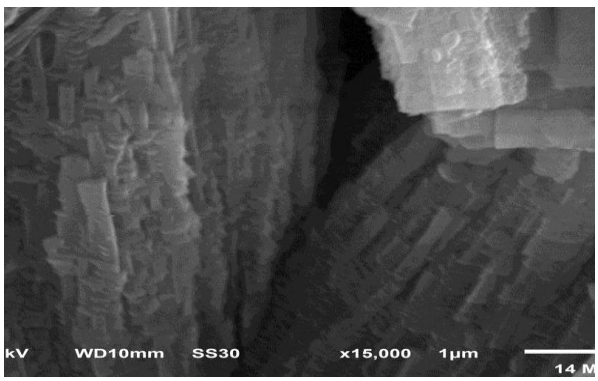


Figure 7: TEM of Aluminum Oxide Nanoparticles.

4. Scanning Electron Microscopy (SEM)

The average particles size was determined by the SEM images of Al_2O_3 nanoparticles were 26 nm as in Figure 8.



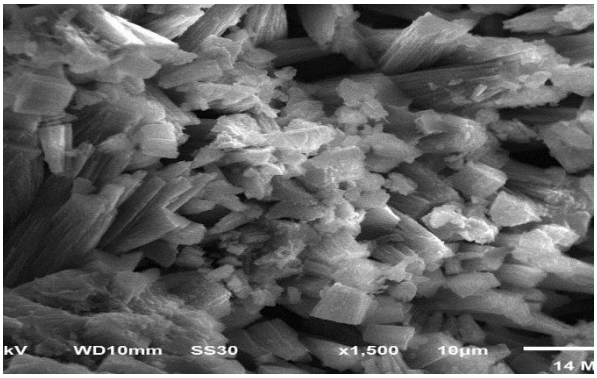


Figure 8: SEM of Aluminum Oxide Nanoparticles.

5. Antimicrobial Activity of Aluminum Oxide Nanoparticles

The activity of prepared nanoparticles by electrochemical and biological ways was tested towards the pathogenic bacteria (Staphylococcus aureus and Pseudomonas aeruginosa), The result of examination of nanoparticles prepared via biological way was positive and able to prevent the growth of Pseudomonas up to 8mm diameter and 4.8mm diameter for Staphylococcas. Nanoparticles prepared by electrochemical way gave positive results too and their ability of inhibition was 10mm diameter for Pseudomonas and 6mm.diameter for Staphylococcus.

We noticed that the cells of Staphylococcus aureus were less affected by nanoparticles compared with cells of Pseudomonas aeruginosa because there is a thick layer of peptidoglycan in *Staphylococcus aereus* bacteria.

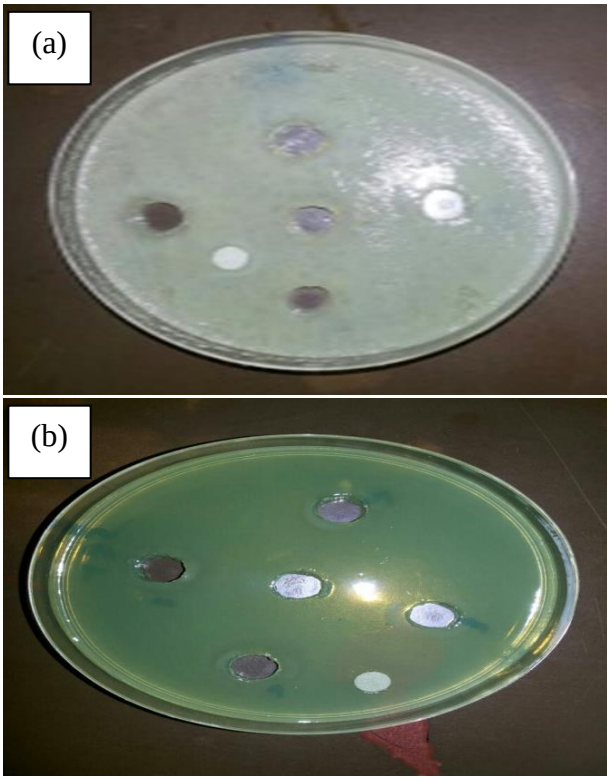


Figure 9: Effect of Aluminum Oxide Nanoparticles Prepared in electrochemical and biological ways on The Pathogenic Bacteria (a) *Staphylococcus aureus* and (b) *Pseudomonas aeruginosa.*

Conclusion

We concluded that the electrochemically and biologically prepared aluminum oxide nanoparticles have ability to inhibit the pathogenic bacteria for gram pigment. *Pseudomonas* bacteria was less affected by these nanoparticles electrochemically prepared were more efficient on bacteria growth inhibition than biologically prepared nanoparticles did.

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