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The Fabrication of SeO_2 Nanoparticles from Cinnamon extract: Optical properties and its application

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Abstract

Nanoparticle biogenic synthesis (NP) has attained widespread interest due to its benefits such as simplicity, environmental friendliness, rapidity and cost-effectiveness. Selenium nanoparticles (SeO_2NPs) were synthesized utilizing Cinnamomum verum bark extracts (CVBE) and selenium tetrachloride. In this study. XRD, TEM, UV and FTIR techniques were used to characterize the biosynthesized SeO_2 NPs. The crystal structure of SeO_2-NPs is hexagonal as evidenced by XRD results. The crystalline size was achieved at about 24.5 nm and theTEM image showed that the diameter of SeO_2 was less than 100 nm with spherical and spherical-semi shapes. The effect of SeO_2 on antifungal and diverse types of bacteria was the subject of this investigation. SeO_2 inhibited Staphylococcus epidermidis activity against 23 mm and staphylococcus aureus activity against 21 mm, as well as antifungal isolates 18 mm, which was more effective than bacterial Klebsiella Sp. and Escherichia coli.

Keywords: Antimicrobial activity, Biosynthesis; Green route, SeO_2, Staphylococcus

Introduction

In response to the growing demand for nanotechnology in various fields, various methods may be chemical or physical for the preparation of NPs have been developed, including pulse laser ablation in liquid, milling by ball, CVD, and co-precipitation, chemical and electrochemical reduction [1-4.] chemical-Physical procedures, furthermore, have several defects, involving the utilization of hazardous chemicals, high costs, and the highest consumption of energy[5-7].Environmental attention to the use of hazardous materials must be addressed[8,9], thankfully, green technology overcomes these constraints [10-12.]

Nanoparticles produced at the nanoscale differ from those produced in bulk due to their distinct optical, magnetic, electrical, and chemical properties. These features are distinct due to the increase in the surface area concerning the sٰall size. Due to specialized catalytic uses in addition to anti-microbial effective 36tagents, NPs more active under effect the of solar light and UV have recently drawn the interest of the scientific community[13, 14]. Environmentally friendly technologies are required, and nanoparticles manufactured using green methods are critical[1,2]. Biogenic synthesis for nanoparticle syntheses has arisen as a promising field of nanotechnology that is both cost-effective and ecologically friendly [13-16].

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Severe bacterial and fungal infections have resulted in an increase in morbidity and death, necessitating aggressive treatment, including broad-spectrum antibiotic therapy [1-3]. Antibacterial drugs are frequently used to treat this condition, and the overuse of traditional antibiotics leads to antibiotic resistance, making infections extremely difficult to treat. Nano-materials are currently gaining favor as innovative antibacterial and antifungal agents, due to their huge specific surface area and to-volume ratio and unique physicochemical properties[17-20]. Candida spp. is one of the most common organisms that cause fungal infections, which usually result in hospital-acquired sepsis [4,21], which has a death rate of up to 40%. Polyenes (amphotericin B), and diazoles (fluconazole, Itraconazole and echinocandins are currently the most efficient antifungal drugs (caspofungin, micafungin and anidulafungin). However, side effects such as amphotericin B toxicity and inverse effects of some azoles, such as toxicity, medication interactions[5–8], and yeast resistance to antifungal therapy [9,10], are common when these antifungals are used. As a result, to avoid the above-mentioned negative effects, new effective antifungal therapy options must be found. SeO_2NP_2 nanoparticles were made utilizing a biological synthesis technique in this study, and their antibacterial and antifungal capability was then assessed.

Materials and Methods

Experimental part

Cinnamomum verum (C.V.) bark powder was ground in an electric grinder and sieved through a 300 m size sieve. Then, 1 g powder was mixed with 100 mL DW and heated at 60 ºC for 1/2 hour with constant stirring. At last, the mixture was filtered and utilized to make SeO_2 NPs. This reaction typically involves 2 grams of selenium tetrachloride in 100 ml of distilled water at 70°C for 60 minutes. The extract (5 mL) was then added and well mixed at 60°C for 1 hour under normal atmospheric pressure. The color change indicated that solution NPs were being synthesized. As depicted in Fig 1.

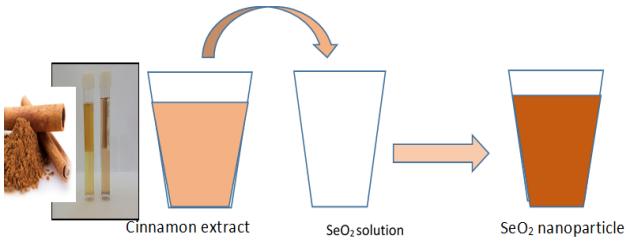

Figure 1. Steps mixed the extract solution with SeO_2 solution

Results and Discussion

A typical XRD diffraction of SeO_2 produced by green synthesis and then precipitation by drop casting on glass substrate has been presented shows as Fig 2. The XRD of the nanoparticles selenium oxide indicated the summits located at 2θ = 24.2º, 31.6º, 41.8º, 43.2º, 45.0, 56.1 º, 63 º, 65.3 º and 68.7 º respectively, which were typical for the selenium oxide structure. The narrow and sharp peak positions agreed with (ICDD XRD Card No. 06-0362)[22]. The crystalline directions (h k l) indices for nanometer-sized SeO_2: (100), (101), (110), (102), (111), (003), (202), (210) and (211) respectively for the hexagonal structure of selenium oxide crystals [22,23]. The average size evaluated according to Scherer Eq 1 was 24.5 nm[23].

$$D=\frac{0.9\lambda}{B\ Cos\ \theta} \quad \ldots\ldots\ldots 1$$

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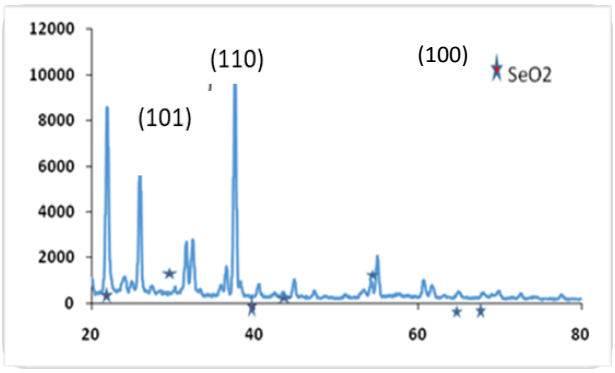

Figure 2. XRD image of SeO_2 nanoparticles.

TEM micrographs of SeO_2 NPs produced through green synthesis are shown in Fig 3. Note that the particles are either spherical or semi-spherical of the SeO_2 NPs, while the diameters of particles about from 4 to 22 nm, according to TEM images. It's worth noting that the average crystal diameter (24.5nm) calculated using Scherer's calculation agrees well with the value calculated using transmission electron microscope images. Both XRD and TEM give the crystal size of the material but TEM is accurate

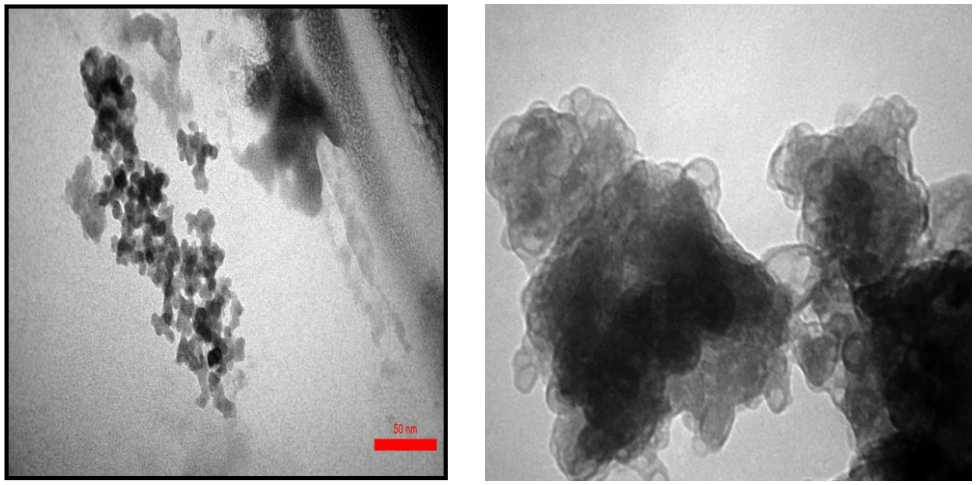

Figure 3. TEM micrographs of SeO_2 NPs.

Fig 4. shows the FTIR spectroscopy of produced SeO_2 NPs is represented by the transmission spectrum behavior of SeO_2NPs in the wavelength ranging from 500 to 4500 cm^{-1}. It's observed from the FTIR spectrum a waveband that corresponding IR and NIR wavelength ranges with the distinctive peaks refer to SeO_2NPs. Depend on the previous studies found that their vibrational modes of SeO_2 NPs, where summits at about 597 and 732 (1/cm) specified to the vibrational modes of v2 and v3, while it observed the stretching frequency at 1654 cm^{-1} of C=O bonds. Also, hydrogen bonds that are strong molecular with (OH), amine and carboxyl groups were noticed close to the broadband between (322–3395 cm^{-1})[22,24].

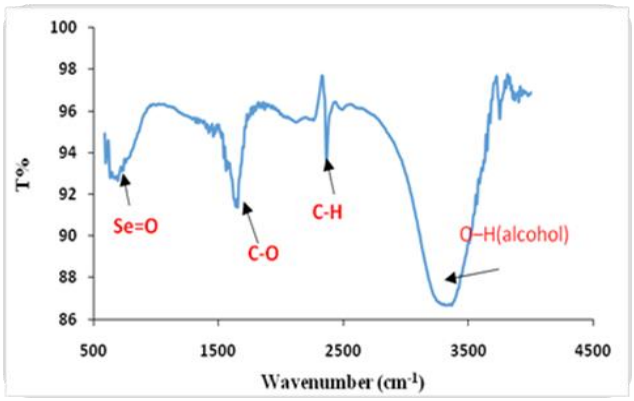

Figure 4. FTI R of SeO_2 NPs

The optical transmittance properties of SeO_2 nanoparticles are shown in Fig 5. There are two peaks at 249 nm and 322 nm observed, also, the result confirms the formation of SeO_2 Nanoparticles. These peaks could be attributed to the existence of two different sizes or shapes of the Nano-particles [25]. The sample exhibits high transparency properties in

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the spectral range 460-900 nm. At wavelengths of 890 nm, SeO_2 NPs had a maximum transmittance of roughly 0.7 percent. It is important to understand that the properties of SeNPs depend on their size and shape. According to a recent report, SeNPs have shown numerous absorption bands at UV-vis wavelengths due to the quantum confinement effect and synthetic protocols[26].

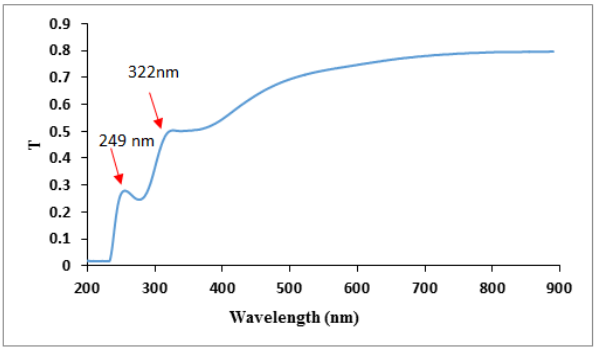

Figure 5. UV- Visible Spectroscopy of SeO_2 NPs from Cinnamomum verum extract

Fig 6: Gap optical SeO_2 NPs, where the plot of $(\alpha h\upsilon)^2$ vs. the photon energy denoted by hυ, and α represented to (the coefficient of absorption). The band gaps of SeO_2 NPs were discovered to be 3.8 eV and 5.1 eV by projecting the linear component of the curve toward the photon energy axis by Tauc's model [27]

$$(\alpha h\, v)^2 = A\,(h\, v - E\, g) \ldots\ldots 2$$

The fluctuation of the edge of absorption produced by the structure of the energy band, as well as the variation in the density of state with energy level, can explain the occurrence of a two-energy gap. The energy gap has widened, which may be belonged to the size restriction [27].

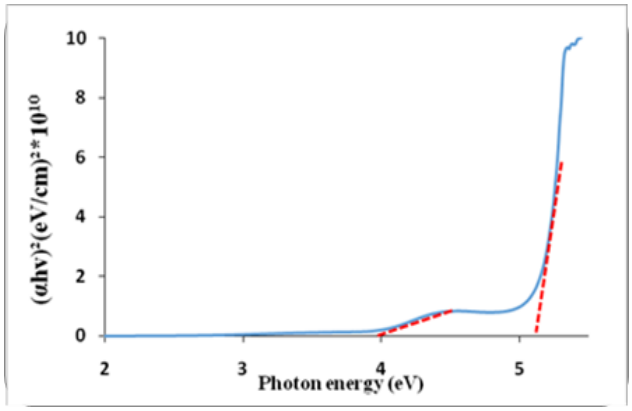

Figure 6. Energy gaps plot of SeO_2 NPs

The activity for antibacterial and anti-fungal of the synthesized SeO_2NPs was tested against pathogenic organisms like (Staphylococcus aureus, E. coli, Klebsiella Sp., Candida and Staphylococcus epidermidis). The strains were grown in LB broth for one day at 37°C for bacteria and 30°C for Candida albicans before being spread on LB agar plates with a sterile glass spreader. Following that, sterile paper discs (6mm in diameter) were placed on inoculated plates, followed by the loading of SeO_2 NP samples onto each disc, the inhibitions zones were utilized to measure the activity of the antibacterial and antifungal, where it formed around the discs. The Staphylococcus epidermidis activity against 23 mm and Staphylococcus aureus 21 mm was demonstrated by the plant-mediated synthesis of SeO_2NPs. The results showed that SeO_2 NPs also have efficiency contra isolates of antifungal as in Fig 7. Also, Table1. The literature explains potential pathways for SeO_2 NPs' antifungal action, where the diffusion and endocytosis were routes to enter SeO_2 NPs to the cell, interfering with mitochondrial activity in cytoplasm contact and may cause the releasing of ROS (reactive oxygen species) and Se^{2+}. These ions can pass through the cell membrane and then to DNA, which causes damage to DNA and cell death [28]. The exact mechanism of NPs mode antibacterial action is unknown at this time. It postulated three distinct mechanisms so far: I rupture of cell walls and membranes, (II) the penetration of intracellular then the damage, also (III) the oxidative stress [29-34]. SeO_2 NPs' antifungal action is mediated by nanoparticles and is dependent on ROS.

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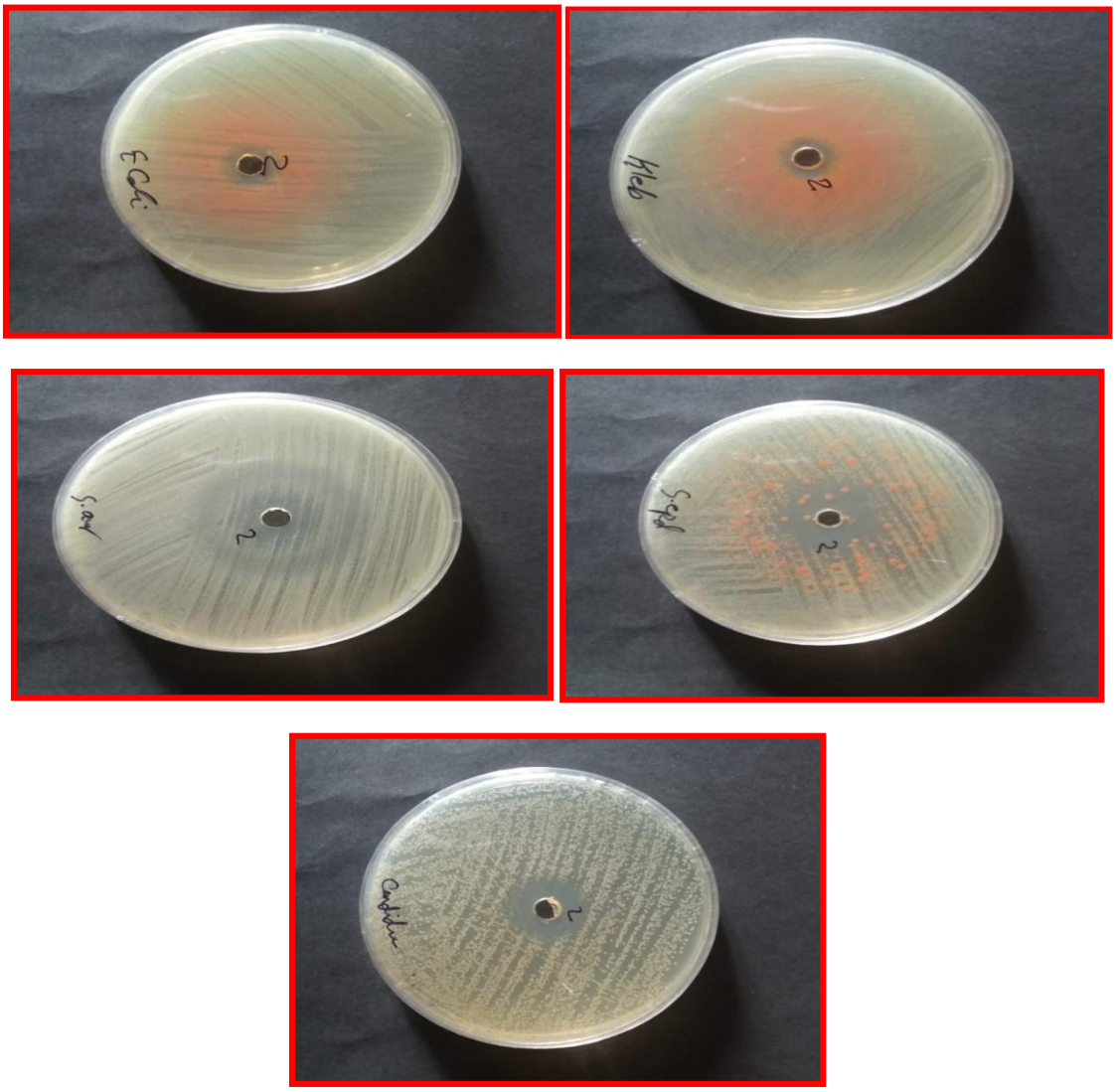

Figure 7. Activity of selenium oxide NPs contra anti-bacterial and anti-fungal

Table 1. Activity of selenium oxide NPs contra anti-bacterial and anti-fungal

Klebsiella sp.(gram –ve)	**E-coli(gram –ve)**	**Staphylococcua aureus (gram+ve)**	**Staphylococcua Epidermidis(gram +ve)**	**candida**
11mm	10mm	21mm	23mm	18mm

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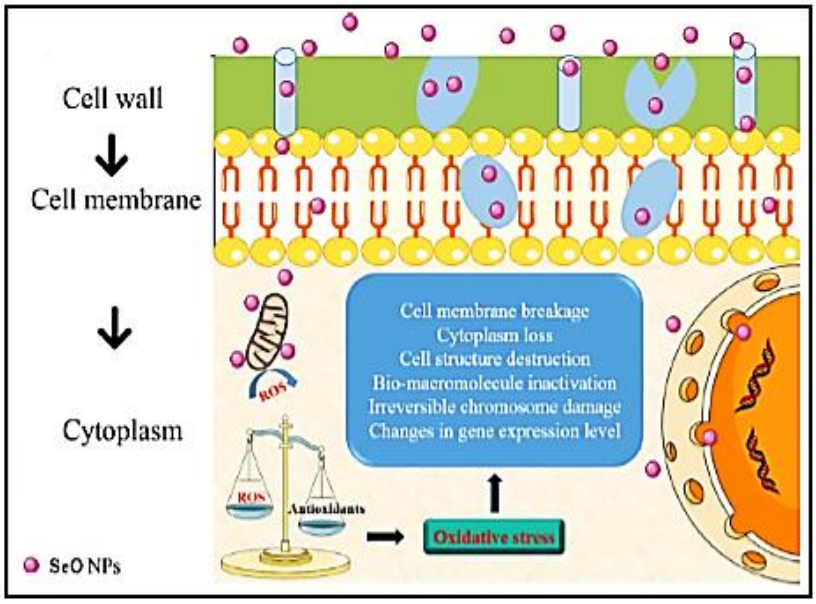

Figure 8. ROS produced by SeO_2NPs - depending on the antifungal activity

Conclusion

(SeO_2NP_s) were made utilizing Cinnamomum verum bark extracts (CVBE) and selenium tetrachloride as a Se precursor in this study. XRD, TEM, FT-IR, and UV-Vis routes were utilized to characterize the biosynthesized SeO_2NPs. The average crystalline size of SeO_2NPs was 24.5 nm. Images of TEM illustrated that the SeO_2 NPs were spherical and semi-spherical in shape with a diameter between 4mm to 22 nm. Results revealed the plant-meditated synthesis of SeO_2NPs exhibited good Staphylococcus epidermidis activity against 23 mm and Staphylococcus aureus 21 mm, as well as efficiency against isolates of anti-fungal 18 mm.

Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at Mustansiriyah University.

Authors' Contribution Statement

S K and R A conceived of the presented idea S K designed, developed the theory and performed the computations R A , and SK verified the analytical methods. SK and H A J Encouraged H A to investigate Algorithms and compare different approaches related to service problem in future networks . HA and RA supervised the findings of this work. the authors write the article be careful and the results were discussed, and contributed to the final manuscript

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تصنيع الجسيمات النانويه لاوكسيد السلينيوم من مستخلص القرفه :خصائصه البصرية وتطبيقاته

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الخلاصة

حظي التصنيع الحيوي للجسيمات النانوية باهتمام واسع النطاق بسبب فوائده مثل البساطة والملائمة للبيئة والسرعة والفعالية من حيث التكلفة. تم تصنيع جسيمات السيلينيوم النانوية (SeO_2NPs)باستخدام مستخلصات لحاء القرفة (CVBE) ورباعي كلوريد السيلينيوم. في هذه الدراسة ,تم استخدام تقنيات XRD و TEM و UV و FTIR لتوصيف SeO_2 NPs المُصنَّع بيولوجيًا ,البنية البلوريه لها تكون سداسية كما يتضح من نتائج الاشعه السينية . تم تحقيق الحجم البلوري حوالي 24.5 نانومتر وأظهرت صورة TEM أن قطر SeO_2 كان أقل من 100 نانومتر بشكل كروي وشبه كروي. كان تأثير SeO_2 على مضادات الفطريات وأنواع مختلفة من البكتيريا موضوع هذا البحث. SeO_2 كمثبط لنشاط المكورات العنقودية مقابل 23 ملم ونشاط المكورات العنقودية الذهبية مقابل 21 ملم ، وكذلك العزلات المضادة للفطريات 18 ملم ، والتي كانت أكثر فعالية من البكتيرية .Klebsiella Sp والإشريكية القولونية.

الكلمات المفتاحية: الفعالية ضد المايكروبات – التصنيع الحيوي – الطريقة الخضراء –اوكسيد السلينيوم –الاشريكيه القولونيه.