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Evolution of the biological effect of synthesized zinc-iron oxides nanoparticles on organic pollutants in drinking water

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Abstract

This study aimed to explain the biosynthesis process of Zinc and Iron oxide nanoparticles (Zn^- O^+ Fe^- ONPs) using an extracellular enzyme, which in turn produced from particular environmental bacteria isolates Escherichia coli a stabilizing and reducing agent. Biosynthesized (ZnO+FeO) nanoparticles have presented many applications such as catalysis, biosensing, anticancer, and biomedical, etc. The optimum condition for Zn-O and Fe-O biosynthesis was characterized through several techniques such as UV-Vis, AFM, XRD, FT-IR, and FE-SEM. In particular, a cut-off phenomenon of the biological synthesized Zn-O and Fe-O was found at around 287 nm using UV-Vis, while spherical shape particles were noticed using FE-SEM techniques. Also, the AFM analysis revealed that Zn-O and Fe-O NPs have an average diameter size of 75.03 nm. Determine the FTIR spectrum of the biosynthesized Zn-O and Fe-O nanoparticles showing Zn-O at the broad peak at 509.17-426.24 cm. Where the study shows the best removal of organic pollutants after using the nano-mix oxides of the following organic pollutants (Henecosaine, Eicosane, Tridecane, Docosane, Tetradecane) The removal percentage was straight (6.13-2,34-0,49-1.87-0,84%). After measuring the drinking water sample before and after using the nanoparticles with the GC-Mass device. The best percentage for removing inorganic pollutants of (Pb, Cr, Cu) after treatment mixture nanoparticles, and the removal percentages were respectively (12.24-1.37-0.44%). As for (Cd, Al) the percentage was respectively (8.11-3.94) after using the nanoparticles with the ICP-EOS device.

Keywords: biosynthesis; nanoparticles; organic pollutants; Zinc oxide; Iron oxide.

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1- Introduction

Pollution emerges as a serious environmental concern and it is a global issue faced by the present generation and can be a huge threat to future generations if left untended. Different types of pollutants have been reported in the drinking water as well as surface water streams including physiochemical, biological, heavy metals (trace elements), chlorophenols, dyes, and pesticides. Pesticides have been used in agricultural as well as domestic fields from so many decades. Several pesticides are prohibited by the government due to their detrimental nature., Nonetheless, their capacity to endure in the environment for extended durations renders it one of the most hazardous pollutants, as it infiltrates water via contaminated soil through soil permeability or surface spillage [1]. Notwithstanding stringent regulations, numerous prohibited pesticides have been detected in soil and water [2]. Toxins and pesticides have been reported in several drinking water sites in India [3]. However, the existence of organic contaminants in samples of drinking water is also not to be disregarded [4]. Organic pollutants are health hazardous to all living creatures, so they should be taken out or contaminated from their source. There are several methods involved in the process of pollutant removal from river water as well as wastewater streams. Numerous treatment strategies have been accounted for the expulsion of poisons from water among these methods is a (AOP) which is considered one of the best, most effective, and useful methods. Numerous researchers have reported that Nanoparticles and nano-biomedicine provide an alternative pathway to overcoming the addressed typical organic pollutants limitations due to excellent biocompatibility, high antimicrobial activity, and good thermal stability of the nanoparticles [4]. Several nanoparticles, ZnO and FeO in particular, deliver an outstanding, and organic pollutants performance in drinking water such as decan and dodecan [5]. The ability to calculate, appear, control, and create things on a nuclear scale, repeatedly between 1 and 100 nanometers, is what nanoparticles and nano-biomedicine are presenting. Furthermore, ZnO has demonstrated some attractive applications such as solar cells, catalysts, photodetectors, and biomedical/antibacterial activity. Herein, the interaction between the bacteria and ZnO and FeO nanoparticles is highly effective if the ZnO is prepared using a biological method due to the absence of undesired/toxic chemical compounds. Also, ZnO nanoparticles are biocompatible and non-toxic [6]. The aforementioned advantages provide great potential in the utilization of ZnO and FeO nanoparticles as antiorganic

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pollutants agents. Therefore, this study aims to evaluate the antibacteria activity of ZnO nanoparticles against Organic pollutants through a biosynthesis approach using Extracellular enzyme as a reducing agent [7], containing macromolecules, most of which are within the nanometer run [8]. Cellular Extraction from these bacterial species is utilized to create nanoparticles of different sizes and biological compositions. The components displayed within the microbes extricated are capable of the lessening of iron Worthy substrates, such as ferric sulfate, can moreover be utilized to reduce microbes extricates. Organic nanotechnology offers a remarkable array of intriguing applications that reduce or eliminate harmful compounds for protecting the environment [9]. Natural sources supply more focal points than chemical strategies and physical strategies since it is straightforward to prepare, exceptionally cost-effective, and versatile for large-scale generation [10]. For natural and restorative forte applications, attractive press oxide nanoparticles are the primary choice due to their biocompatibility, superparamagnetic behavior, and chemical stability [11]. This study aims to evaluate the antibacteria activity of ZnO and FeO nanoparticles against organic pollutants through a biosynthesis approach using an Extracellular enzyme as a reducing agent.

2- Materials and methods

2.1. Bacterial isolation and culture media

In this study, 200 specimens were collected from various locations in Baghdad, Karkh, and Resafa. The collected specimens were directly streaked on nutrient and MacConkey agar and Eosin methylene blue and subsequently incubated at 37 °C for 24 hr. More than one type of bacteria was diagnosed after isolating drinking water samples [12], using the vitic II system, and the most common types were the corresponded specimens were found to be green metallic sheen colonies, while another test such as the biological and morphological analysis was also performed [13]. The zinc and iron sulfate were added to the bacterial extract in a ratio of 1 gram of the metal salts to 10 ml of the extract and placed in a shaking incubator Jissy Korea at room temperature for a full day at a speed of 120 cycles/min. The filtrate, then deionized water was added to the precipitate and placed in a centrifuge for 10 minutes. This process was repeated twice to ensure that the particles were washed from any remaining extract and sulfate. The precipitate was taken and placed in a petri dish and placed in an incubator at 37°C to dry. This way zinc oxide nanomaterials were extracted. In this way, we got the zinc and iron oxide nanomaterials [14].

2.2. Characterization of nanoparticles

A spectrophotometer was used to analyze the auxiliary characteristics of nano-zinc oxide using bright, visible rays. It was also inspected by a nuclear constrain magnifying instrument to determine the sizes of the shaped nanoparticles. The X-ray diffraction SHIMADZU 600 X-ray Japan of the nanoparticles was inspected to guarantee the immaculateness of the shaped nanoparticles which were free of pollution infrared spectroscopy was also examined to increase confirmation on the formation of nanoparticles and free from impurities. It was inspected by a checking electron magnifying lens to know the external shapes of the nanoparticles and their arrangement [15].

2.3. Gas chromatographic-mass spectrometric (GC)

When gas chromatography is combined with a mass spectrometer that includes just one quadrupole, it is often referred to simply as GC-MS Applied biosystem Iran. GC-MS is well suited to the everyday analysis of samples where either targeted or untargeted analysis is required as these systems can be operated using either targeted selected ion monitoring (SIM) or untargeted full scan acquisition. Practical applications include the detection of pesticides in environmental and food samples, also the detection of drugs of abuse in biological samples, and the detection of volatile organic compounds in water samples [16]. The bioactivity of the iron oxide particles and the nano-mixture that were synthesized against natural toxins was inspected by the GC-Mass gadget [17].

3- Results and discussion

The bacteria that showed up on the dishes were analyzed with the Vitec apparatus Bio Merieux France, as the species showed up agreeing to what is appeared in Table 1 and it was found that the foremost common sort of microbes that showed up to us is *Escherichia Coli*, agreeing to Fig. 1.

3.1. UV-Vis spectrophotometer

The optical properties of the nanoparticles were studied using a UV-visible spectrometer (200 to 800) nm SHIMADZU 1800 double beam (1901100) Japan. Fig. 2 the absorbance of zinc oxide nanoparticles, Fig. 3 the absorbance of bacteria extract of E. coli, and the absorption peak was 325 nm. and this result agrees with [3]. The acquired UV-Vi’s peak indicates direct electron recombination between the valence and conduction bands. The result was identical to (287) its UV-visible spectrophotometer to detect the maximum absorption. Absorbance is measured at 287 nm.

3.2. Atomic force microscopy (AFM) analysis

The AFMA A300 Angstrom advanced (Inc. USA) was presented to explore the Zn-O and Fe-O nanoparticles' surface highlights employing 2D and 3D imaging Fig. 4. Particularly, the AFM results uncovered that the Zn-O and Fe-O nanoparticles display a circular shape with a normal distance across measure of 75.03 nm. The result was identical to [3] it the size of an average diameter of 45.02 nm.

Table 1. (vitic-2-system) for Escherichia Coli

										96% Probability		***Escherichia coli***	
Biochemical test													
2	APPA	-	3	ADO	-	4	PyrA	-	5	LARL	-	7	DCEL
10	H_2S	-	11	BNAG	-	12	AGLTP	-	13	DGLU	+	14	GCT
17	BGLU	-	18	MAL	+	19	Dman	+	20	DMNE	+	21	BXYL
23	PrOA	-	26	LIP	-	27	PLE	-	29	TYRA	+	31	URE
33	SAC	+	34	Dtag	-	35	Dtre	+	36	GLT	+	37	MNT
40	ILATK	+	41	AGLU	-	42	SUCT	+	43	NAGA	-	44	AGAL
46	GLYA	-	47	ODC	-	48	LDC	-	53	HISA	-	56	CMT
58	O129R	+	59	GGAA	-	61	LMLTA	-	62	ELLM	-	64	LATA

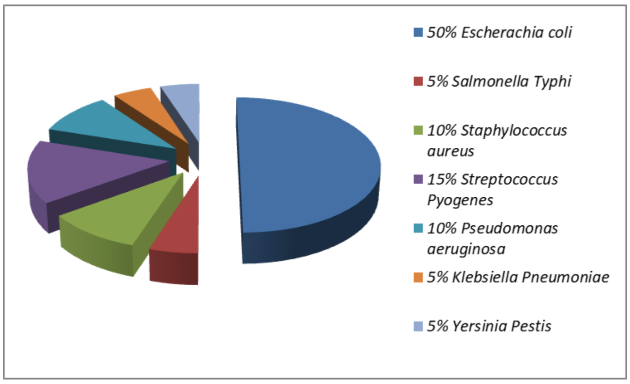

Fig. 1. Percentage of bacteria appearing in drinking water

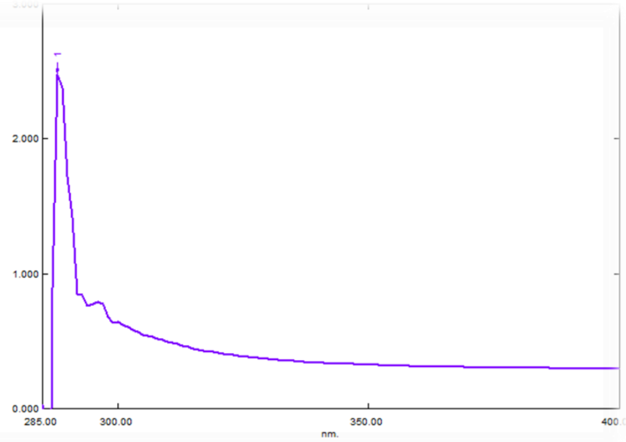

Fig. 2. UV-Vi's spectrum of the biosynthesized Zn-O and Fe-O

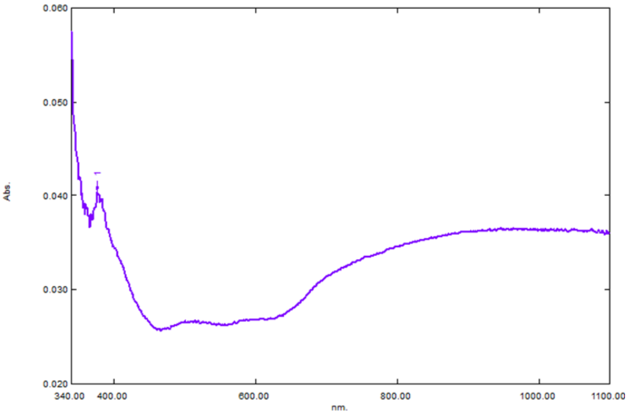

Fig. 3. UV-Vi's spectrum of the bacterial extract of *E. coli*

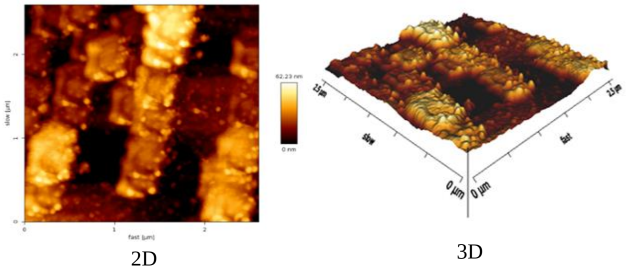

Fig. 4. Atomic force microscopy of the bio-synthesized Zn-O and Fe-O

3.3. X-ray diffraction (XRD) examination

The XRD SHIMADZU 600 X-ray Japan patterns obtained from the bio-synthesized Zn-O and Fe-O nanoparticles are elucidated in Fig. 5. The XRD spectrum of the synthesized zinc oxide nanoparticles. The result revealed the presence of diffraction peaks, which are (202), (004), (201), (112), (200), (103), (110), (102), (101), (002), (100) at the values of (θ = 2), which correspond to the characteristics of the diffraction pattern of Fe3O4 nanoparticles according to the data of the JCPDS standard, and the deviation angles were (76.64°, 71.70°, 68.87°, 67.84°, 66.11°, 62.69°, 56.45°, 47.35°, 36.11°, 34.22°, 31.60°) degrees. The result was identical to [3] the result uncovered that there exist eight strong diverse diffraction crests compared to the gem planes of crystalline Zn-O and Fe-O NPs watched at 2θ (θ=diffraction point) values of (30-40).

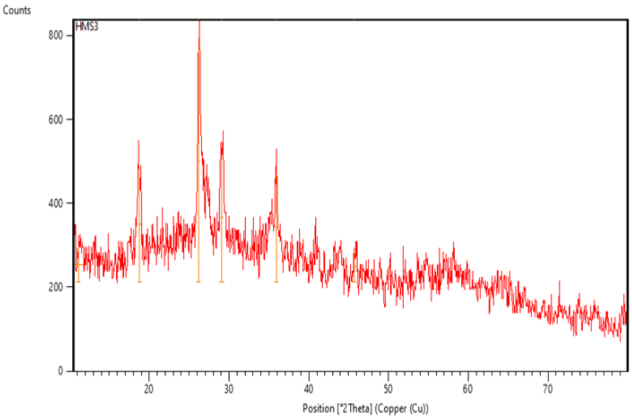

Fig. 5. XRD patterns of the bio-synthesized Zn-O and Fe-O nanoparticles

3.4. Fourier transforms infrared (FT-IR) spectroscopy analysis

The FT-IR SHIMADZU(FT-IR) 8400S Japan results for the bio-synthesized Zn-O and Fe-O nanoparticles are demonstrated in Fig. 6 For biosynthetic Zn-O Fe-O nanoparticles, Zn-O and Fe-O appears in the broad peak at 509.17-426.24 /cm^{-1}. The result respectively with (34) is 694.33 /cm^{-1}.

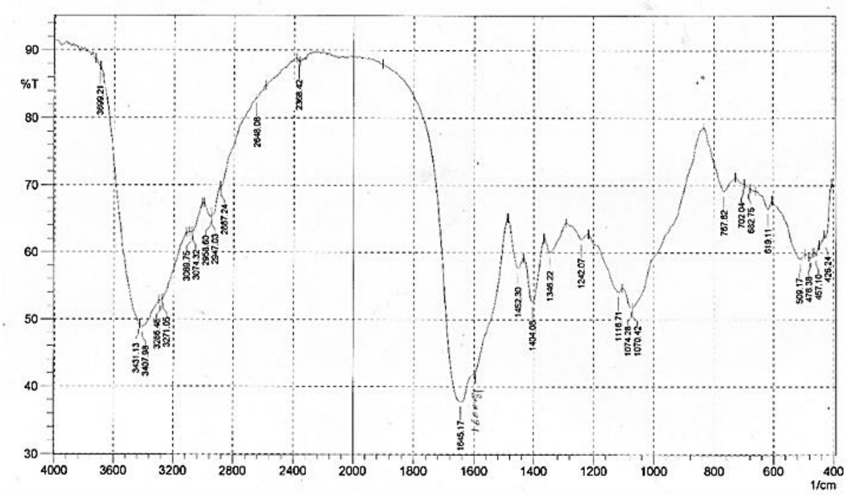

Fig. 6. FTIR spectrum of the biosynthesized Zn-O and Fe-O

3.5. Field emission scanning electron microscopy (FE-SEM) analysis

The morphological properties of the bio-synthesized Zn-O and Fe-O NPs were inspected utilizing the FE-SEM S-4160 Japan strategy. As outlined in Fig. 7. The arranged Zn-O and Fe-O NPs test displayed circular particles as well as plate-like structures. It is worth specifying that the normal nanoparticles breadth was found to be around 44 nm utilizing the ImageJ computer program. The result was identical to [3] the result shape in the form of Zn-O and Fe-O spherical particles as well as plate-like structures.

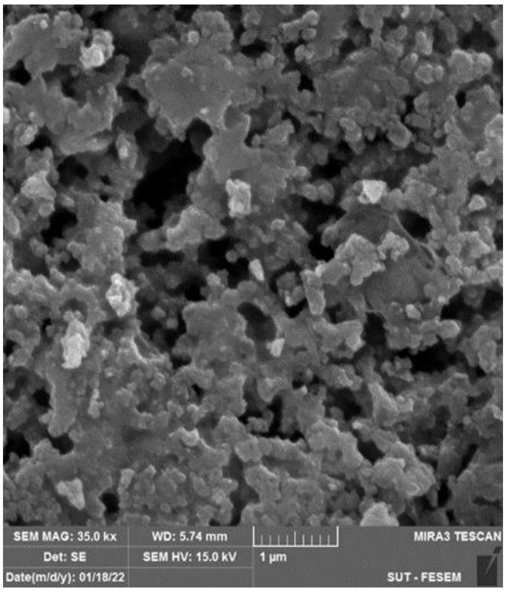

Fig. 7. FE-SEM image of the bio-synthesized Zn-O and Fe-O nanoparticles

3.6. Gas chromatographic-mass spectrometric (GC)

The movement of zinc and iron oxide particles against natural toxins was inspected utilizing Gram-negative microscopic organisms, Escherichia coli, Isolated from drinking water. The natural poisons were inspected utilizing the GC-MAS apparatus, as Table 2. Water tests sometime recently treated with nanoparticles, and Table 3. Water tests after treatment with zinc and oxide nanoparticles, where the most noteworthy rate of natural toxin decrease was obtained. By examining the GC-Mass system. The organic compounds present in the drinking water were identified. As the Table 1 and Table 2, the organic compounds that appeared in the drinking water, as well as the chemical formula for each compound, the molecular weight, and the chemical composition [18, 19].

Table 2. Drinking water samples before treatment

Sample	Number of beaks	Area %	Time/min	Organic compound
Before drinking water treatment	1	0.75	7.221	Decane,4-methyl
	2	1.79	8.051	Dodecane
	3	3.62	10.541	Silane,cyclohexyl dimehoxymethyl
	4	0.65	11.776	Undecane,2,6-dimethyl
	5	1.17	12.933	Decane,1-iodo
	6	2.09	13.307	Pentadecane
	7	0.08	16.415	Pentadecane
	8	0.68	17.053	Octadecane
	9	0.63	17.245	Tridecane
	10	7.56	17.951	Tetradecane

Table 3. Drinking water samples after treatment

Sample	Number of beaks	Area %	Time/min	Organic compound
After Mixture (Zinc and Iron Oxide) nanoparticles treatment	1	1.40	8.051	Octane,2,4,6 trimethyl
	2	3.33	10.542	Silane,cyclohexyl dimethoxymethyl
	3	1.19	12.934	4,4-diprophylheptane
	4	2.08	13.307	Dodecane
	5	0.77	16.420	Octadecane
	6	0.66	17.250	Tridecane

4- Conclusion

In this study, the biosynthesis of Zn-O and Fe-O nanoparticles using extracellular enzyme of Escherichia coli as a reducing agent was demonstrated successfully. Additionally, the attained Zn-O and Fe-O NPs were characterized using UV-Vis, AFM, XRD, FT-IR and FE-SEM techniques. In particular, the XRD patterns showed the successful Zn-O and Fe-O NPs phase formation, while the FE-SEM demonstrated that the prepared Zn-O and Fe-O NPs exhibited spherical particles as well as plate-like structures with an average diameter size ranging around 35 nm. While the AFM revealed an average diameter of 75.03 nm. In the anti-organic pollutant activity test, it was found that the bio-synthesis has a strong effect activity against the organic pollutants in drinking water.

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توصيف الجسيمات النانوية لأكاسيد الحديد والزنك المركبة بيولوجيا من مياه الشرب في معالجة الملوثات العضوية

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الخلاصة

هدفت هذه الدراسة إلى توضيح إجراء التخليق الحيوي لجسيمات أكسيد الزنك والحديد النانوية باستخدام مكونات خارج الخلية من العزلة البيئية Escherichia coli كعامل مختزل ومثبت. من إضافة ١جرام من كبريتات الزنك والحديد إلى ١٠مل من المستخلص البكتيري في تحضير جزيئات أكسيد الزنك والحديد النانوية حيث تعتبر هذه الملوثات من أهم حالات التسمم التي تسبب مخاطر صحية كبيرة للإنسان كما تعتبر من أخطرها. الملوثات البيئية لأنها سامة ومضرة بالبيئة. تم تمييز الحالة المثلى لتخليقZn–O وFe–O الحيوي من خلال العديد من التقنيات مثل UV–Vis و AFM و XRD و FT–IR و FE–SEM. على وجه الخصوص، تم العثور على ظاهرة الانقطاع لـ Zn–O وFe–O المركب البيولوجي عند حوالي ٢٨٧ نانومتر باستخدام UV–Vis ، بينما لوحظت جزيئات الشكل الكروية باستخدام تقنيات FE–SEM. أيضًا، كشف تحليل AFM أن Zn–O و NPs Fe–O يبلغ متوسط حجم قطرها ٥٧,٠٣ نانومتر. تحديد طيف FTIR لجسيمات Zn–O وFe–O النانوية المُصنَّعة حيوياً والتي تُظهر Zn–O و Fe–O في الذروة الواسعة عند ٥٠٩,١٧–٤٢٦,٢٤سم.

الكلمات الدالة: التخليق الحيوي، الجسيمات النانوية، الملوثات العضوية، اوكسيد الزنك، اوكسيد الحديد.