RESEARCH PAPER

Synthesis and Study Structural, Morphological, Optical and Antibacterial Properties of TiO_2

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ABSTRACT

In this work TiO_2 nanoparticles (NPs) by using chemical precipitation method. The prepared nanoparticles were characterized their structural properties using X-ray diffractometry (XRD), Energy Dispersive X-ray (EDX), morphological properties by using field emission scanning electron spectroscopy (FESEM). The anti-bacterial activity results presented high inhibition rates against *Escherichia coli* the present study exhibits a new approach to the preparation of metal oxides using a facile and inexpensive method.

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INTRODUCTION

Currently, nanosized materials are the most advanced type of materials, both in scientific knowledge and in commercial applications. Inorganic nanoparticles (NPs), such as silver, copper, titanium, and zinc, are the most interesting NPs due to their applications and positive impact on pathogenic microorganisms [1–4].

Recently, special attention has been given to TiO_2 NPs due to their unique optical, electrical, and chemical properties. TiO2 is a tremendous photocatalyst, which is widely used for antibacterial activity due to its high photosensitivity, high efficiency, nontoxic nature, strong oxidizing power, relative cheapness, and chemical stability [5].

In order to enhance the photocatalytic activity, intensive interdisciplinary researches have been made on TiO_2 [6,7]. It is known that photocatalytic activity of NPs depends upon their crystalline structure [7], doping [8], surface area [9], and hydroxyl group [7]. Currently, different researchers are engaged in improving the efficiency of photocatalysts by using metal dopants like Ag which is the most effective due to its high stability and good electrical/thermal conductivity. Furthermore, Ag doping on the surface of metal oxides employed to enhance photocatalytic activity by preventing fast e− -h+

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recombination processes also, this mechanism could lead to the generation of good antibacterial properties. Several metal ions (Cu^{2+}), have been widely used as anti-bacterial agents because of their excellent spectrum antimicrobial properties [10–12]. Therefore, element alloying by Cu, Ag or Zn is one of the important ways to develop antibacterial metal materials. Copper element represents a more promising alloying element for clinical applications because of its low toxicity and high cytocompatibility [13]. Recently, many studies have reported that Cu-bearing titanium alloys have excellent antibacterial function It was reported that Ti-(1 wt.% and 5 wt.%) Cu alloys showed antibacterial property with an antibacterial rate of about 30% in comparison with cp-Ti [14]. In this work TiO_2 were synthesized using chemical precipitation method, and their antibacterial activity was carefully investigated and discussed.

MATERIALS AND METHODS

Preparation

Use 2g TiO_2 with 100 ml of distilled water, put it in a magnetic stirrer at room temperature for 10 minutes to mix and dissolve with 3 gm of sodium hydroxide in a tube containing 10 ml of distilled water. It is mixed and added to the previous mixture heated to 100 degrees Celsius within 30 minutes and then the material is washed from the salts by ethanol and DW several times. Finally, the specimen was dried by heat treatment at 120 °C to remove any impurities.

RESULTS AND DISCUSSION

Fig. 1 shows the XRD pattern for TiO2. The diffraction peaks at 25,50°, 37,89° 48,40°, 53,98°, 55,29°, 62,65°, 68,47°, 70,57°, 75,34° were indexed to (101), (004), (200), (105), (211), (204), (220), (220) and (215) crystalline planes respectively. This corresponded to the anatase phase of TiO2 according to JCPDS Card No. (21-1272). The anatase phase of TiO_2 is preferred over rutile and brookite for photocatalytic degradation of organic compounds [15]. Table 1 is shown the average of the grain size of TiO_2-NPs.

TiO_2 sample were characterized with respect to their long-range order from XRD patterns. As shown in Fig. 2 were indexed as the anatase phase of TiO_2 with tetragonal structure (powder diffraction file number 21-1272). Diffraction peaks related to secondary phases were detected in addition to the primary anatase phase of TiO_2 These results show

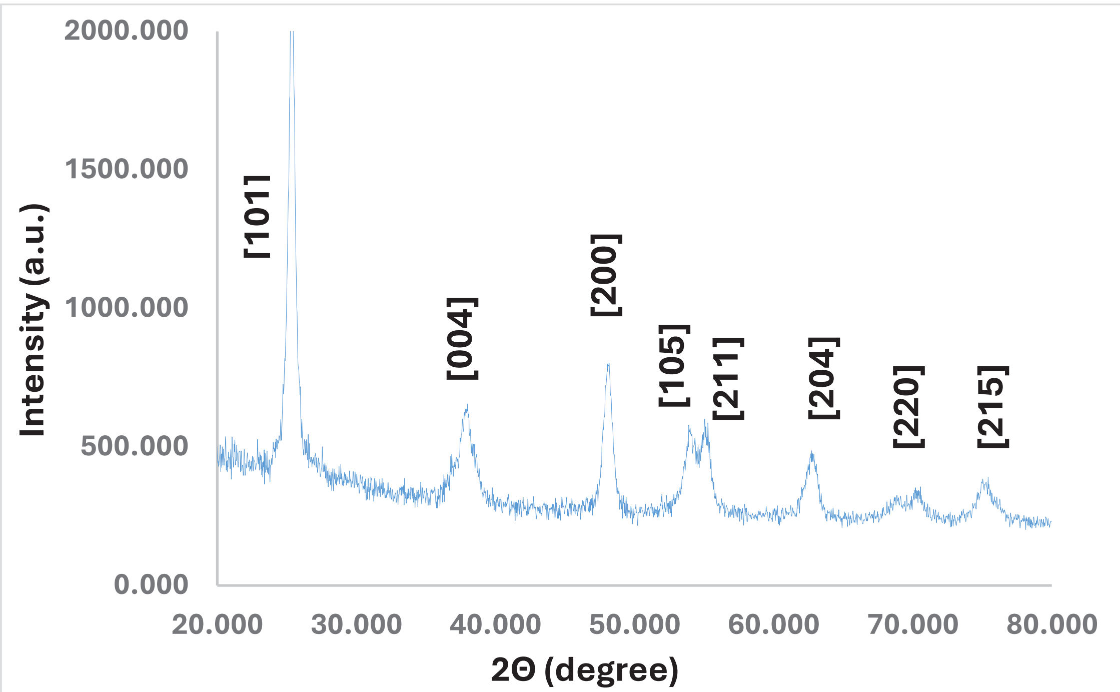

Fig. 1. XRD pattern of TiO_2NPs.

the anatase phase of the nanomaterial has broad peaks; these are an indication of the structural disorder of the nanomaterial [16], which is a consequence of the synthesis method.

The diffraction pattern in Fig. 2 shows peak of anatase phase (101) (004) (200) (105) at 2θ values 25.36°, 38.59°, 48.11°, 54.01° and match index data of JCPDS 00-001- 0562 [17].

The morphology of TiO_2NPs is introduced in Fig. 3. The FESEM image with higher resolution showed that the TiO_2 particles with diameters from 40 to 100 nm are discretely dispersed. FESEM images were recorded in Fig. 3 prepared TiO_2 shows spherical morphology and show small Ag nanoparticles on the surface of TiO_2 spheres. we see the particles in their agglomerated phase and are expected because of the absence of suitable surfactant which usually protect the particles, making them appear in their monodispersed form.

The antibacterial potential of the prepared nanoparticles was investigated against Gram's negative *(E.Coli)* bacterial strains using agar well diffusion assay [18, 20]. About 20mL of on Muller–Hinton (MH) agar was aseptically poured into sterile Petri dishes. The bacterial species were collected from their stock cultures using a sterile wire loop [21]. After culturing the organisms, 6 mm-diameter wells were bored on the agar plates

Table 1. The average of the grain size of TiO_2-NPs.

Peak position (2Θ)	Grain size (nm)	Average of grain size (nm)
25.35	14.53	
36.8	16.73	
37.81	9.32	
48.08	11.14	
53.96	9.90	10.45
55.13	6.89	
62.78	7.56	
68.8	8.74	
70.3	9.71	
75.03	10.01	

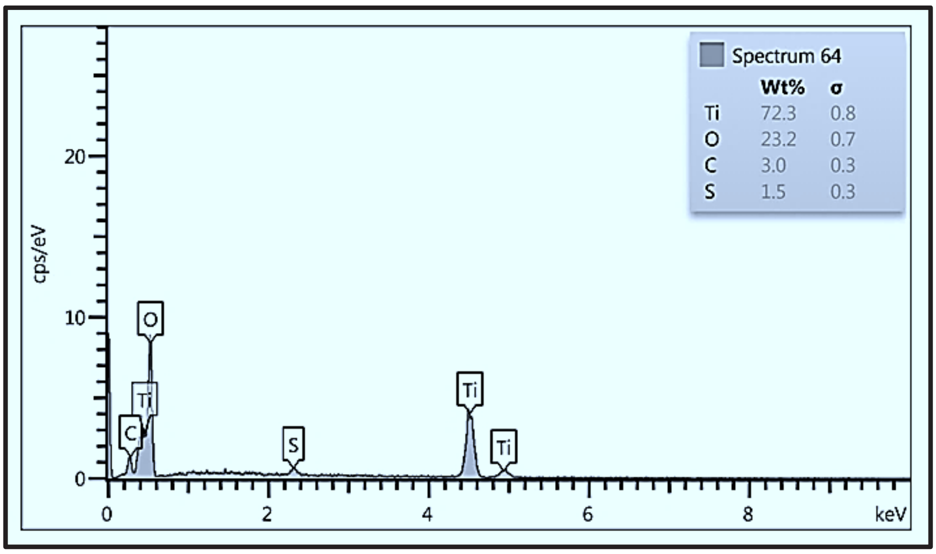

Fig. 2. Energy-dispersive x-ray diffraction (EDX) spectrum of TiO_2.

using of a sterile tip. Into the bored wells, different concentrations of the nanoparticles were used. The cultured plates containing the nanoparticles and the test organisms were incubated overnight at 37°C before measuring and recording the average the zones of inhibition diameter [22,23].

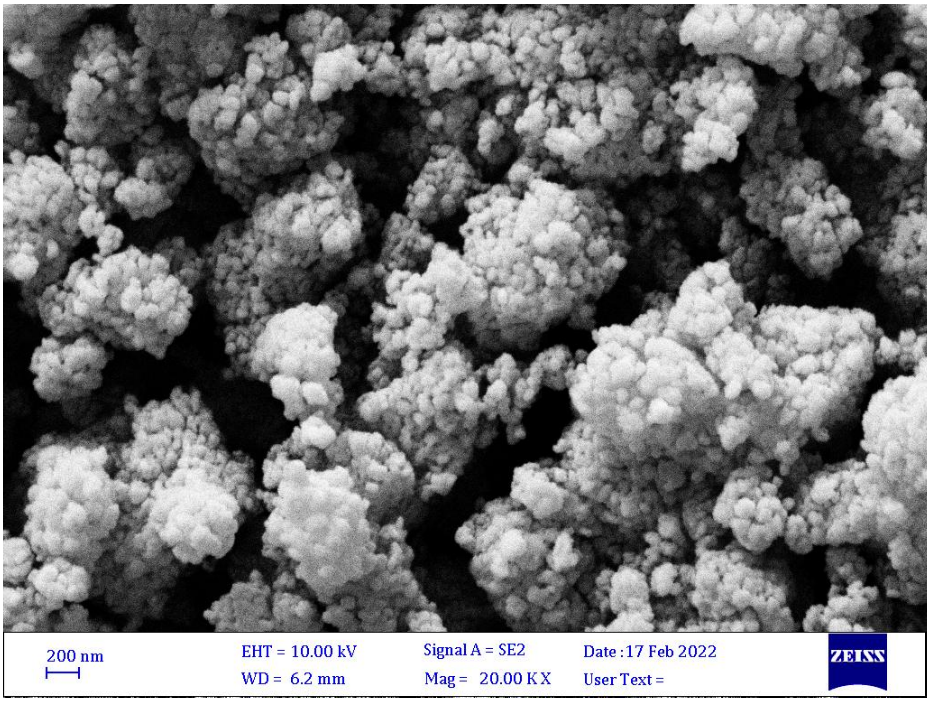

Fig. 3. FESEM of TiO_2.

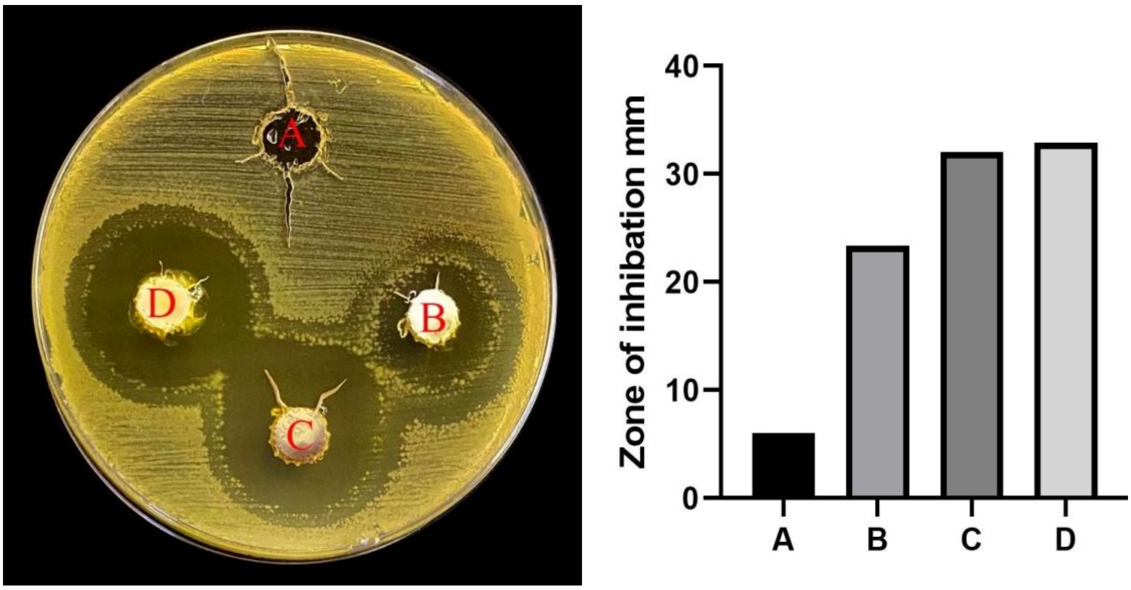

Fig. 4. Antibacterial activity of TiO_2 against *E.Coli.* A) control. B) TiO_2

Data were statically analysis using Graphpad prism program [24]. Data are represented as mean ± SD of three experiments. Indicate statistically significant difference at $p<0.05$ [25].

CONCLUSION

In summary, TiO_2 were prepared via the chemical precipitation method. The synthesized NPs were characterized using XRD, FESEM, EDX. This study may provide new insights into the design and preparation of nanomaterials and the enhancement of antibacterial activity. In comparison to other materials, the antibacterial results were more favorable for assays conducted with the same species.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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