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Spectroscopic Analysis of Copper Minocycline Novel Complex and Evaluation of its Potent Antibacterial, Antioxidant and Anti-breast Cancer (MCF-7) Properties

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ABSTRACT

Background: Minocycline (Mino) has a longer half-life than 1st-generation tetracycline. A trace element, Cu is necessary for the operation of numerous cellular enzymes as it is an essential component in free radical scavenging and enzyme redox chemistry.

Methods: FT-IR, electronic spectra (UV), X-ray diffraction (XRD), thermogravimetric analysis, SEM, TEM were used to characterize the novel complex (Mino/Cu). The molar conductance value validates that the Cu (II) complex is not electrolytic. Mino is chelated with Cu (II) *via* (C=O) ketonic oxygen atoms and (OH) groups based on spectral data. Cu (II)'s complex surface morphology showed up as tiny rectangular projections, according to SEM analysis. TEM showed that the Cu (II) chelate formed black spots with particle sizes between 9 and 23 nm. Cytotoxicity against MCF-7 breast cancer cell proliferation and antibacterial activity against three resistant strains (*Salmonella enteritidis*, *Klebsiella pneumonia* and *Bacillus subtilis*) are estimated *in vitro* along with the scavenging capabilities of ORAC free radicals.

Result: The study found that the Mino/Cu complex had strong anticancer properties, inhibiting MCF-7 proliferation growth and cancer cell viability by 57.54 µg/ml at concentrations of 100 ug/ml. It also showed strong antibacterial properties against *S.enteritidis*, *K. pneumonia* and *B.subtilis* at low concentrations. The complex also demonstrated high antioxidant activity with ORAC activity 1581 (µM Trolox eq/ml).

Key words: Antibacterial activity, Anticancer, Antioxidant, Copper complexes, Minocycline.

INTRODUCTION

Minocycline is a second-generation, semisynthetic analogue of tetracycline (Arezoo *et al*., 2020), which inhibits Gram-positive and Gram-negative bacteria and can cross the blood-brain barrier (Kim and Suh, 2009). Its main mechanism of action is to stop protein synthesis. Minocycline has a longer half-life and more tissue absorption into the central nervous system and cerebrospinal fluid (Sapadin and Fleischmajer., 2006). Its higher efficacy is attributed to modification in ring D through 7-9 carbons (Nelson, 1998).

The FDA has approved 2nd-generation tetracycline (Mino) for treating certain infectious diseases (Blum *et al*., 2004; Good and Hussey, 2003), with its rapid tissue penetration, longer half-life and strong bioavailability making it a promising treatment for breast cancer. Mino has shown anticancer effects through various pathways in different types of cancer (Barza *et al*., 1975; Kramer *et al*., 1978; Macdonald *et al*.,1973; Garrido-Mesa *et al*., 2013).

A recent study by Zihan *et al*., (2024) indicated that **(**Mino) may suppress chemotherapy-induced neuroinflammation, but its effects in cancer survivors are still need more study. They evaluated the effects of (Mino) on affective behaviors and inflammations in women with breast cancer undergoing chemotherapy with proven attenuation of IL-8, but Mino did not alter self-effective symptoms or congestions in breast cancer survivors.

Breast cancer now accounts for 1 in 8 cancer diagnoses and 2.3 million new cases in both sexes combined, surpassing lung cancer as the most frequent disease diagnosed worldwide (Sung *et al*., 2021). It was by far the most frequent cancer in women in 2020, accounting for a quarter of all female cancer cases and its prevalence has been rising globally, especially in transitioning nations (Arnold *et al*., 2022). According to estimates, breast cancer claimed the lives of 685,000 women in 2020, accounting for 16% or one out of every six female cancer fatalities. The World Health Organization (WHO) has launched the Global Breast Cancer Initiative in response to the public health

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community's inadequate response to this development (Anderson *et al*., 2021).

Copper metabolism is affected by cancer, infection and inflammation, with increased concentrations of ceruloplasmin and Cu. Interleukins (IL-1) and IL-6 stimulate hepatocytes' production and secretion of plasma ceruloplasmin (Tapieroa *et al*., 2003). Copper supports cellular and humoral immunity (Percival.,1998; Huang and Failla., 2000) and is crucial for immune response, including the generation of IL-2 by activated lymphocytic cells (Hopkins and Failla.,1999).

Generally, neither humans nor rodents have any problems with the typical levels of Cu that are consumed, nor even with intakes that are significantly higher. For children ages 4 to 8, daily Cu intakes of up to 3 mg/d and for adults, 8 to 10 mg/d are deemed tolerable. These intakes are seven to eleven times higher than the daily allowance (Tanner.,1999).

A trace element, Cu is necessary for the operation of numerous cellular enzymes. Because Cu ions can assume 2 different redox states either oxidized Cu(II) or reduced Cu(I)-the metal can be an essential component of Fe absorption, mitochondrial respiration, elastin cross-linking, free radical scavenging and enzyme redox chemistry, as oxidative stress occurs when there is an imbalance between free radicals and antioxidants (Jain and Shakkarpude., 2024), such as lipid peroxidation that plays an essential role in many disorders (Gürgöze *et al*., 2024). Copper (Cu), trace element likely to be of most practical significance (Tej *et al*., 2024). The amount of Cu in cells is determined by a delicate balance between the uptake and efflux of Cu ions. If present in excess, free Cu ions can damage cellular components. Molecular characterizations of Cu homeostasis in biological systems have been made.

Cu is the body's 3rd most common trace element, after Fe and Zn and it is an essential catalyst for hematopoiesis and iron absorption (Kui *et al*., 2024). Because of the risk of cellular damage from both copper overload and deficiency, copper transport and levels within cells are carefully controlled. Overly high Cu concentrations have the ability to trigger the production of toxic reactive oxygen species (ROS), which are highly cytotoxic and can cause damage to cells (Scheiber *et al*., 2013). Numerous studies have shown that clinical signs of anemia, leukopenia, neutropenia and allogeneic cytopenia are correlated with Cu deprivation (Halfdanarson *et al*., 2008).

Clinical signs of Cu deficiency can also resemble the neurological symptoms of vitamin B12 deficiency-related spinal cord neuropathy (Jaiser and Winston., 2010). Notably, growth, angiogenesis and metastasis are three aspects of tumor progression where Cu may be a limiting factor (Denoyer *et al*., 2015).

Cu compounds exhibit strong antitumor and anti-metastatic properties when applied to solid tumors (Santini *et al*., 2014; Balsa *et al*., 2023; Leon *et al*., 2017). They are potential therapeutic agents for cancer treatment due to their biocompatibility, decreased toxicity, improved biological availability and higher levels in cancer tissue (Ron *et al*., 1988). Cu complexes offer a substitute for breast cancer treatment, producing stable copper complexes with distinct functionalities. However, issues with solubility in physiological buffers and complex, unpredictable mechanisms of action hinder their use in clinical settings (Fisher *et al*., 2007).

At present as appeared, the majority of reports have concentrated on minocycline's non-antibiotic characteristics. We provide experimental research regarding the synthesized novel complex (Mino/Cu) with the obtained data regarding the antibacterial activity against three strains (*Salmonella enteritidis, Klebsiella pneumonia and Bacillus subtilis*), anti-breast activity (MCF-7) and antioxidant activity regarding the novel complex capability of free radicals scavenging activities via (ORAC test) for evolving of potent and novel effectiveness of Mino.

MATERIALS AND METHODS

Experimental work

Chemicals

All chemicals used: minocycline hydrochloride ($C_{23}H_{28}ClN_3O_7$), copper chloride ($CuCl_2$), Ethanol are procured from The Sigma-Aldrich Chemical Company which provides pure grade Chemicals.

Synthesis of copper complex

Copper minocycline complex was prepared by mixing minocycline hydrochloride (2 mmol of 30 mL ethanolic solution) with copper chloride (1 mmol of 20 mL of distilled water). After that, reflux for six hours. The green solid product was filtered, cleaned with a water-ethanol mixture and vacuum-dried over calcium chloride ($CaCl_2$), all the analyses were performed in both labs of Taif University (Synthesis) and Zagazig University (Spectroscopic analysis) between January and August 2024; as shown in Fig (1).

Instruments

The infrared spectra of minocycline hydrochloride and its copper complex were captured as KBr disks using an IR spectrophotometer set to 400-4000 cm^{-1}. The Spectrophotometer UV2 Unicam UV/Vis was used to record UV spectra between 800-200 nm and the CHN 2400 Perkin Elmer was used to measure the C, H and N spectra. The HACH conductivity meter model was used to determine the conductivity data for the compound manganese minocycline compound using a DMSO solution at a concentration of 10-3M. Using a Shimadzu thermo-gravimetric analyzer and Joel JSM-6390 equipment, thermogravimetric analysis (TG/DTG-50H) was carried out. SEM images were measured. The X-ray diffraction was recorded. JEOL 100s microscopy was used to measure TEM images.

Inoculum preparation (colony suspension method)

100 milliliters of broth medium were mixed with strains of *Salmonella enteritidis* (ATCC 13076), *Klebsiella pneumoniae*

(ATCC 13883) and *Bacillus subtilis* (ATCC 6633). The mixture was then incubated for 24 hours at 35°C. After streaking each broth onto an Agar medium with a loopful, the aforementioned conditions were allowed to develop, with the exception of *B. subtilis*, which was cultured on a fresh agar plate for 24 hours at 30°C ± 1.0. To make a direct sterile

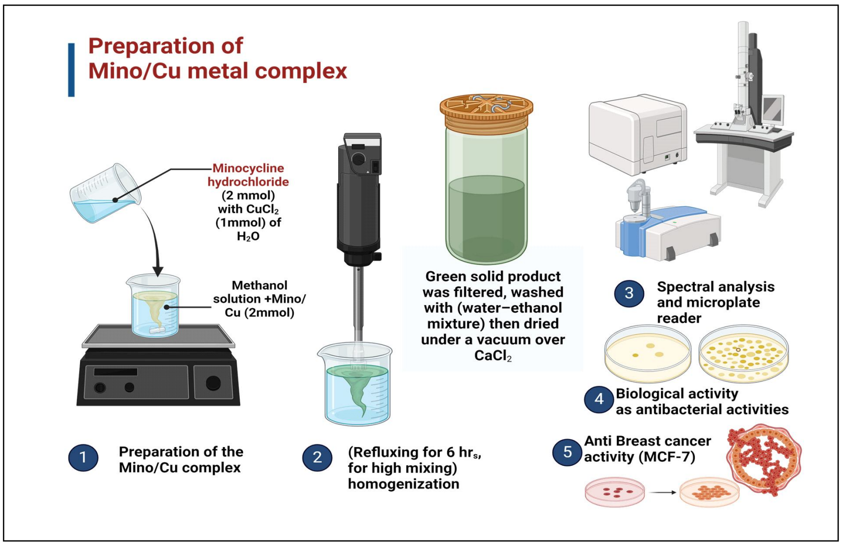

Fig 1: Experimental design.

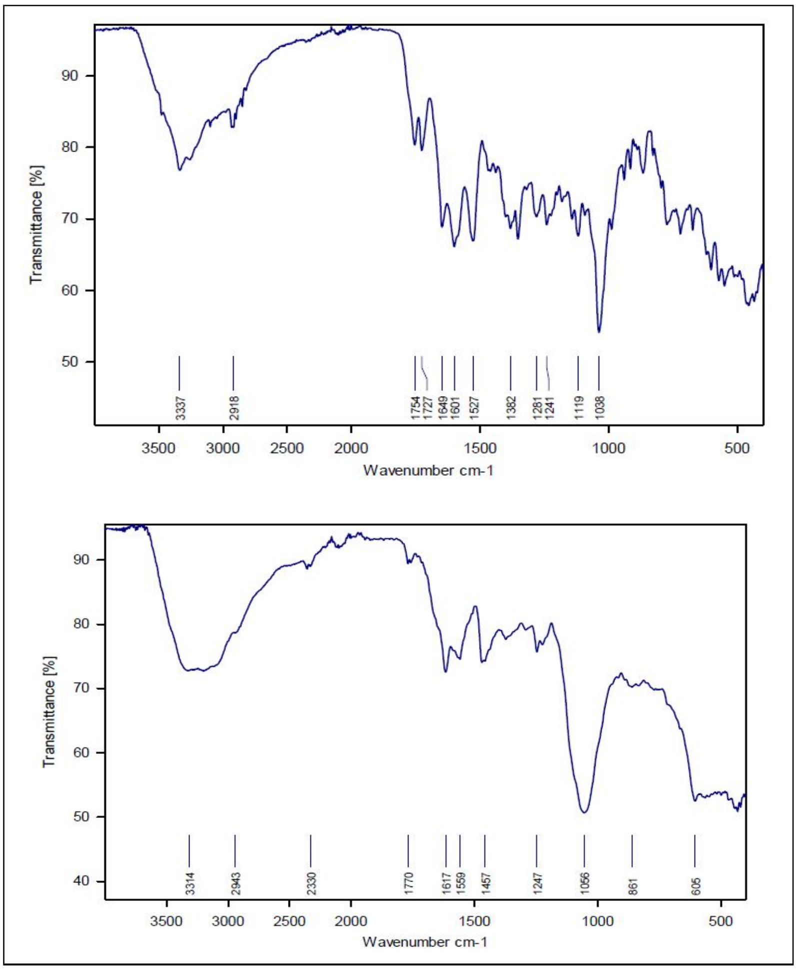

Fig 2: FT-IR spectral analysis of (A) Minocycline El-Megharbel *et al.*,2024 and (B) Minocycline/Cu.

0.1 N NaCl solution, three to four colonies were inoculated. The Densi CHEK© optical device was then used to adjust the suspension in order to achieve turbidity, resulting in a suspension with 1-2 × 10^8 CFU/ml (Al-Thubaiti *et al*., 2022).

Broth Macro-dilution Method

The study involved inoculating samples with Muller Hinton Broth (MHB) into 24- or 12-well plates. Each well was inoculated with two milliliters, then transferred to the next well. This procedure was repeated eight times for each sample. The plates were then incubated and set on a dark surface to track bacterial growth (Al-Thubaiti *et al*., 2022).

Antibacterial Activity against *Salmonella enteritidis* (ATCC13076), *Klebsiella pneumoniae* (ATCC13883) and *Bacillus Subtilis* (ATCC 6633)

Bacillus subtilis, *Salmonella enteritidis* and *Klebsiella pneumoniae* were injected into broth medium and incubated at 30°C for 24 hours. A loop from each broth was streaked into the agar medium and the mixture was incubated at 30°C. Control wells were given to each plate and each well was incubated at 30°C for one day. After incubation, the well plates were placed on a dark surface to evaluate bacterial growth (Al-Thubaiti *et al*., 2022). The test's validity was confirmed by the presence of turbid growth in all growth wells and clear, turbidity-free (El-Megharbel *et al*., 2024) control wells.

Cell culture

MCF-7 breast cancer cells were procured from Cairo, Egypt. The cells were cultured at 37°C in 5% CO_2 atmosphere using DMEM medium supplemented with streptomycin, penicillin and bovine serum (Promega Co., USA) (Skehan *et al*., 1990).

Cytotoxicity assay

The study tested MCF-7 breast cancer cells and their supplements in DMEM medium using the SRB assay. After three days of exposure to the Mino/Cu complex, the cells were fixed with 10% TCA and washed three times with acetic acid. The absorbance at 540 nm was measured using a German microplate reader called "BMGLABTECH®-FLUOstar (Allam *et al*., 2018). The concentration of the complex inhibited or killed 50% of the cells.

Antioxidant activity

ORAC assay

The antioxidant activity of Mino/Cu novel metal complex was measured using Liang *et al*.'s (2014) methodology. Samples were incubated with fluoresceine for 10 minutes at 37°C, followed by 3 cycles of fluorescension measurements and 70µL of newly prepared 2,2-Azobis dihydrochloride, taking approximately 60 minutes with 40 cycles.

Statistical analysis

The treated groups were compared using a One-Way Analysis of Variance with post-hoc testing and the data were displayed as mean ± S.E. P≤0.05 indicates statistical significance Dean *et al*., 2022.

RESULTS AND DISCUSSION

Microanalytical and molar conductance value

Copper minocycline chelate is solid, stable and insoluble in water. Molar conductance value measured in 1.0 × 10^{-3} mol/ cm^3 DMSO for copper compound was Λ_m = 21 (Ω^{-1} mol^{-1} cm^{-1}), confirming the non-electrolytic character (El-Megharbel and Hamza., 2022) due to absence of Cl^{-1} ions inside and outside chelation sphere. For [Cu $(Mino)_2$] · H_2O ratio is 1:2 for Cu (II): minocycline according to values of elemental analysis C, H , N and molar conductance. The sites of donation for minocycline with Cu (II) were confirmed IR, UV, XRD.

Infrared spectra (FT-IR)

Fig 2 shows the infrared data for minocycline and its Cu (II) chelate. The stretching vibrations of (O-H), (N-H) and (C-H) aromatic molecules are responsible for the vibrational bands in the 3400-2800 cm^{-1} range observed in the infrared spectrum of the free ligand minocycline (Nakamoto., 1986). Chelation with the Cu (II) metal ion causes some shifts in wave numbers because of the change in the distribution of electronic density for the aromatic rings and the major attached functional groups. The band at 3350 cm^{-1} that was assigned to v (OH) for the minocycline free ligand was absent from the Cu (II) complex. The (C=O) amide group was not involved in the complexation process, as evidenced by the appearance of the Cu (II) complex of free minocycline and its v band at 1649 cm^{-1}. Two bands at 1754 and 1727 cm^{-1} on minocycline are indicative of (C=O) ketonic rings; these two bands vanish on Cu (II) chelate. These data indicate that the compound minocycline chelates with the Cu (II) metal ion via the oxygen atoms of the hydroxyl and (C=O) ketonic groups. For C-C, C=C and C-H variation of modes of vibration may change due to complex formation (Masoud *et al*., 2005). There are new bands at 605 and 550 cm^{-1} appeared for Cu(II) complex, corresponding to v(M-O) (Nakamoto.,1970; Bellamy, 1975). According to the information above, as illustrated in Fig 2, minocycline functions as a bidentate ligand and Cu(II) metal ion is chelated through the oxygen atoms of ketonic and hydroxyl groups.

UVVis spectra

The electronic spectra of minocycline and its Cu (II) chelate in DMSO solvent are shown in Fig 3. Minocycline has absorption bands at 215,230 and 250 nm that are attributed to $\pi \rightarrow \pi*$ transitions due to its organic moiety. Additionally, a band that appears at 355 nm is attributed to $n \rightarrow \pi*$ transitions. The Cu (II) complexity exhibits weak bands at 220, 230, 240, 250, 275 and 315 nm as transitions between $\pi \rightarrow \pi*$ and $n \rightarrow \pi*$.

XRD, SEM and TEM investigations

X-ray diffraction was carried out in Fig 4. XRD patterns explain the crystallinity arrangement. Using Cu Ká radiation and X-ray diffraction, Mino and its Cu (II) chelate were examined at room temperature. From 10° to 80°, the diffractograms were analyzed. The Scherrer formula (Cullity,1972), D=k/Cosq is used to determine the crystalline

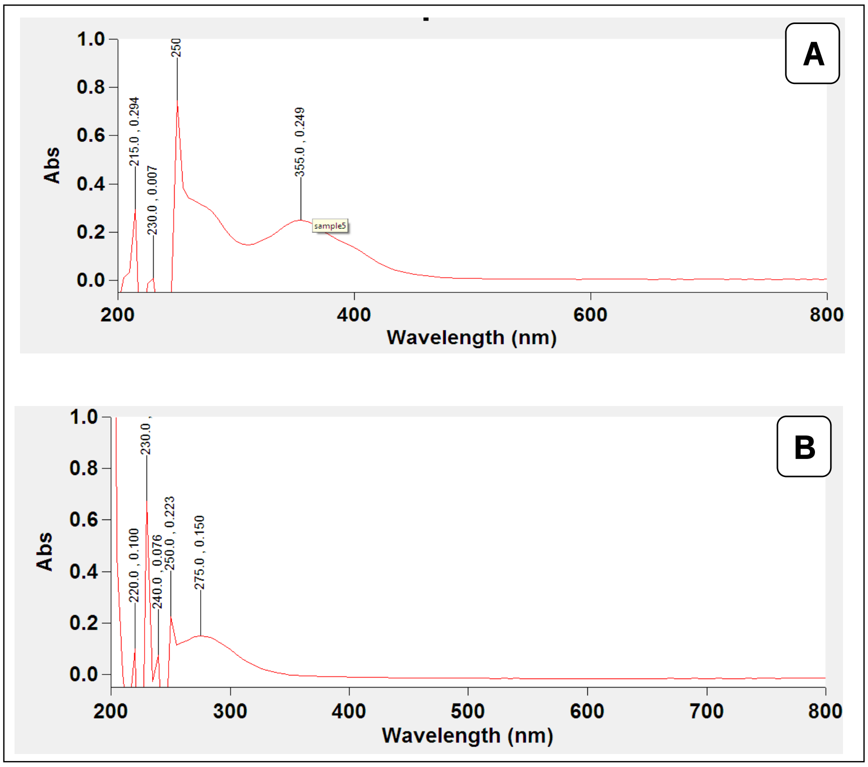

Fig 3: UV-Vis spectral analysis of (A) Minocycline El-Megharbel *et al*., 2024 and (B) Minocycline/Cu

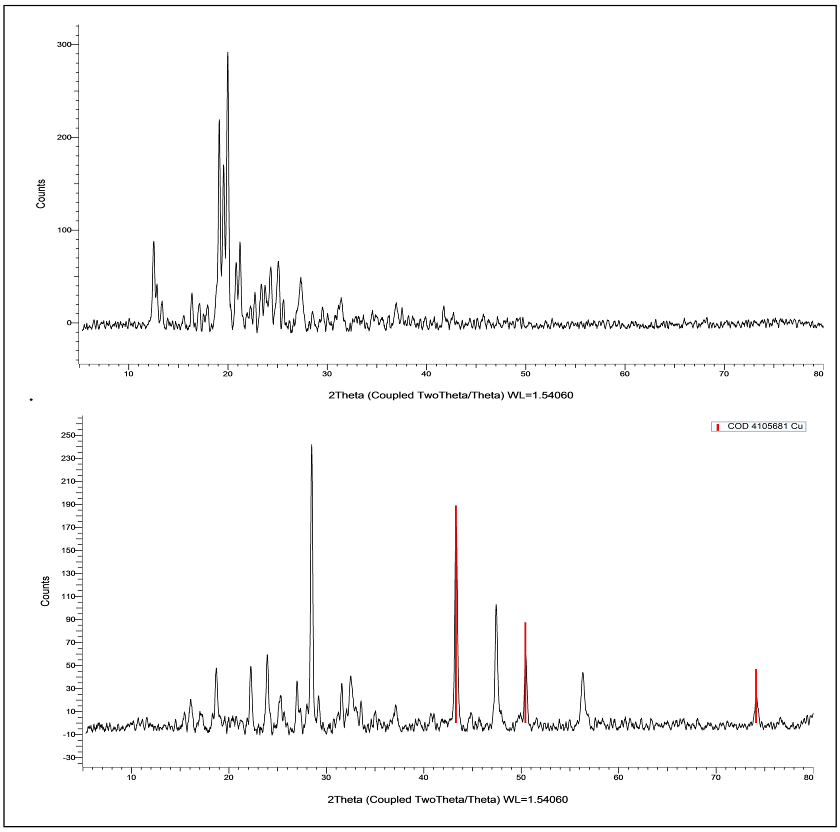

Fig 4: XRD of (A) Mino (B) Mino/Cu novel complex.

size, where k is a constant equal to 0.94, λ is the X-ray wavelength (0.154 nm) and β is the full width at half maxima peak of the XRD pattern. 2.91 nm was determined to be the computed crystalline size for manganese complexity.

The TEM images for Mino and its Cu (II) complexity are shown in Fig 5 (A,B). For Mino and its Cu (II) chelate, the orderly matrix of the pictograph was revealed. This proves the existence of the Cu (II) /Mino complex's homogenous phase material. The spherical black spot-like shape of Cu (II)/Mino chelate is accompanied by particle sizes that range from 2.91 to 9.95 nm.

Fig 5 (C.D) shows SEM pictures of Mino and its Cu (II) /Mino complex. The pictures demonstrate how tiny and within the nanoscale the particles are. Because of their uniform sizes, all of the particles had a greater capacity for agglomerate formation, according to the surface morphology of minocycline and Cu (II)/Mino.

Mino showed up as tiny rectangular protrusions.

Thermogravimetric analyses

As shown in Fig 6, thermogravimetric and differential thermogravimetric analysis (TGA-DTG) for Cu (II) chelate was performed up to 1000 °C. The presence of an external water molecule is confirmed by a weight loss of up to 154 °C caused by the loss of uncoordinated water. Cu (II) chelate's thermal analysis curve reveals a weight loss of up to 819 °C as a result of the breakdown of two minocycline ligands and the loss of coordinated water molecules. There are two phases involved in the breakdown of Cu (II) chelate. CuO that has been tainted with a few carbon atoms is the most stable final product.

Antioxidant activity

The antioxidant capacity of Mino/Cu metal complex obtained by measuring the oxygen radical absorbance (ORAC) is shown in Table 1. Activity of Mino itself was lower by 80.30 % than that of Mino/Cu, this result is very promising result and confirm the greatest free radical absorbance activity of Mino/Cu than Mino itself.

Anti-breast cancer activity (MCF-7)

The cellular inhibitory concentration (IC50) of the viability of the cells was determined using MasterPlex 2010 software. For the novel complex (Mino/Cu), the percentage of viable cells was 94.91 µg/mL at concentrations of 10 ug/mL and 57.54 µg/mL at concentrations of 100 ug/mL. The faint color in the column of the cellular viability test on the well plate at concentrations of 100 ug/mL, which clearly shows the death of the majority of breast cancer cells, demonstrated the novel potent record of the newly synthesized complex of Mino/Cu in inhibiting the growth of breast cancer cells (MCF-7) to very low cellular viability percentages (Fig 7).

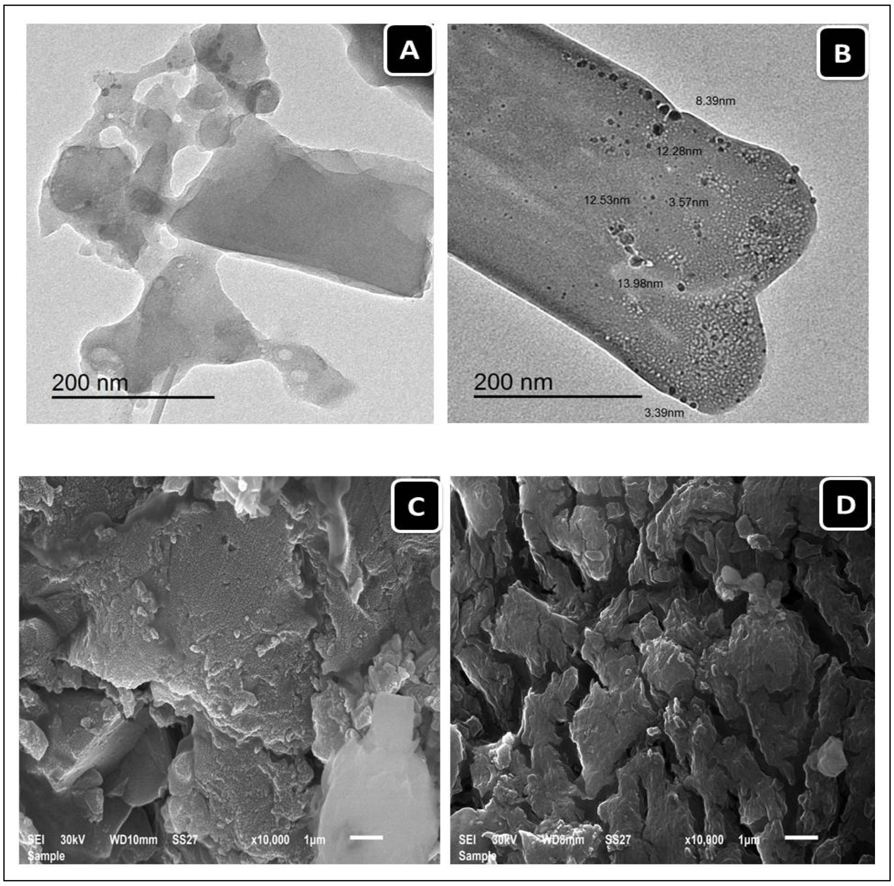

Fig 5: TEM (A, Mino, B, Mino/Cu) SEM (C, Mino, D, Mino/Cu).

Antibacterial activity evaluation

The target complexes were assessed biologically using bacterial strains (*Bacillus subtilis*, *Klebsiella pneumonia* and *Salmonella enteritidis*). The results of the antimicrobial activities of the Mino/Cu metal complex are shown in (Fig 8). It was discovered that the Mino/Cu complex exhibited high antimicrobial activities against a variety of bacterial strains and was sufficient. It was discovered that the complex had high levels of inhibition against Gram-positive and Gram-negative bacteria (*K. pneumonia, S.enteritidis* and *B.* subtilis) at incredibly low concentrations of 0.625 mg/ml for *B. subtilis* and 1.25 mg/ml for Mino/Cu against both *S.enteritidis* and *K. pneumonia* (Fig 8).

An efficient antibiotic for treating a variety of skin, respiratory and genital infections is minocycline "Mino". In patients who are allergic to penicillin treatment, it is also used as a 2nd-line medication for infections. Due to the adverse reactions that occur after systemic administration, Mino's application for these infections has been restricted. The intriguing anti-inflammatory and neuroprotective efficacy of Mino has been the subject of numerous studies recently; this subject was initially brought up in case reports in 2007 (Arezoo *et al*., 2020).

After zinc (Zn) and iron (Fe), copper (Cu) is the 3rd most common trace element in the body and it is an essential catalyst for hematopoiesis and Fe- absorption (Kui *et al*., 2024). Because of the risk of cellular damage from Cu-overload and deficiency, Cu transport and levels within cells are strictly controlled. Overabundance of Cu has the ability to trigger the production of toxic reactive oxygen species (ROS), which are highly cytotoxic and can cause damage to the cells , which supports the current findings by anti-cancer potency of the novel synthesized Mino/Cu complex against MCF-7 cellular growth (Scheiber *et al*., 2013; Denoyer *et al*., 2015).

Interestingly, growth, angiogenesis and metastasis are three aspects of tumor progression that Cu may limit (Denoyer *et al*., 2015) . Against a variety of solid tumors, several Cu complexes have shown strong anti-tumor and anti-metastatic effects (Santini *et al*., 2014; Balsa *et al*., 2023; Leon *et al*., 2017). Moreover, copper's lower toxicity and greater biological availability, combined with its elevated levels in cancer tissue, make it a viable therapeutic agent for the treatment of cancer (Ron *et al*., 1988).

Numerous studies have shown that clinical signs of anemia, leukopenia and allogeneic cytopenia are correlated with Cu deficiency (Halfdanarson *et al*., 2008). Additionally, low birth weight babies and young children with Cu deficiency frequently have abnormalities in their bones, such as osteoporosis, fractures and skeletal deformities (Sutton *et al*., 1985). Clinical signs to the neurological symptoms of spinal cord neuropathy linked to vitamin B12 deficiency can also result from Cu deficiency (Jaiser and Winston., 2010).

Chemotherapy, radiotherapy, immunotherapy and surgery are all used to treat breast cancer. However, only a small number of patients can receive immunotherapy and the quality of life of patients receiving chemotherapy and radiation therapy is significantly impacted. As a result, copper complexes represent a novel therapeutic option for breast cancer. A wide variety of stable copper complexes with distinct functionalities are produced when copper ions combine with metal nuclei in suitable organic ligands to form

Table 1: Antioxidant activity of Mino and it's metal complex (Mino/Cu).

Sample name	ORAC (µM trolox eq/mg)	
	Mean	SD
Mino	311.42[b]	32.38
Mino/Cu	1581.44[a]	104.52

Trolox eq: Trolox equivalents; SD: Standard deviation; Superscript *letters indicate significant differences ($p < 0.05$) between Mino and it's metal complex capacities.

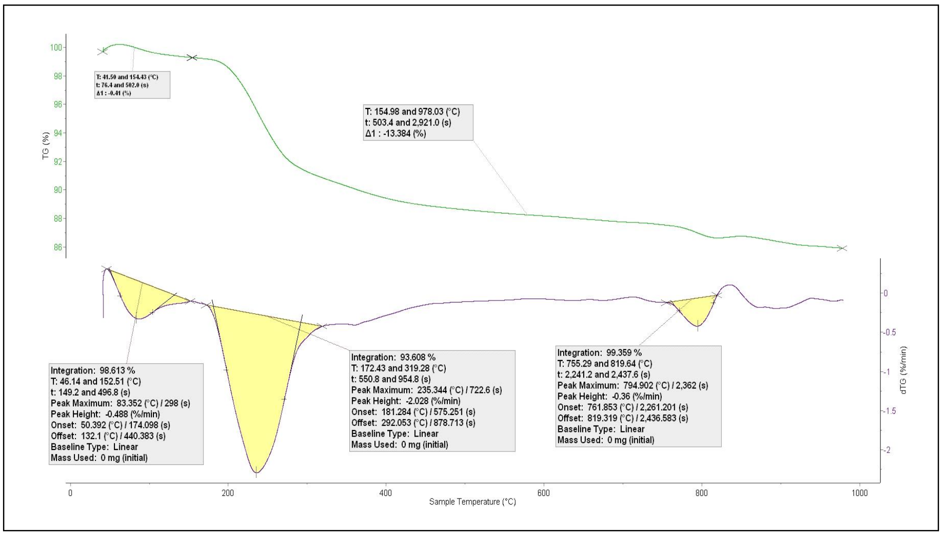

Fig 6: TGA of Mino/Cu novel complex.

these complexes. However, issues remain with their solubility in physiological buffers and their complex and unpredictable mechanisms of action, which hinder their use in clinical settings (Fisher *et al*., 2007) . With continued research efforts, complexes seem to have limitless potential for treating cancer.

The current study revealed that the novel complex Mino/Cu potent antibacterial efficacy against risky bacterial strains such as: *Salmonella Enteritidis*, Previous study (Doorduyn *et al*., 2006) confirms known risk factors for salmonellosis.

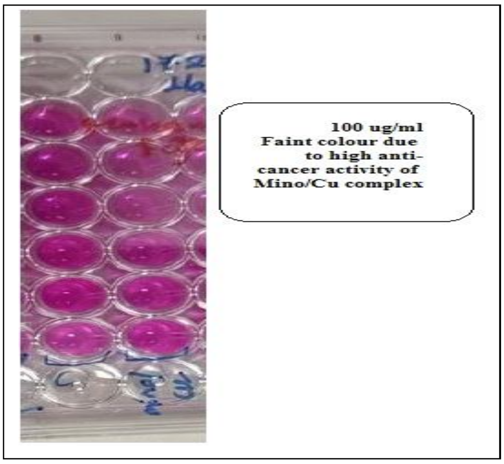

Fig 7: Well-plate anticancer activity of Mino/Cu at both concentration (10 and 100 ug/ml).

Mino/Cu complex inhibited it's growth at concentration 1.25 µg/ml, which is a bacterial disease of poultry and can cause foodborne illness in humans such as gastroenteritis (commonly known as 'gastro') when contaminated food is consumed. Symptoms of a salmonella infection usually include diarrhea, fever, abdominal cramps, headache, nausea, or vomiting. The risk may involve infection of salmonella, it may enter the bloodstream, it can infect tissues throughout your body, including: The urinary system (urinary tract infection), or the tissues surrounding the brain and spinal cord (meningitis), thus the current results present potent data regarding inhibition of this risky bacterial growth.

Klebsiella species cause infections in various sites, including the lung, urinary tract, bloodstream, wound and brain. Preexisting health conditions increase the risk of these infections. *Klebsiella pneumoniae* is a major global concern due to hypervirulent and carbapenem-resistant strains (Chang *et al*., 2021). The prognosis is poor, especially in patients with diabetes or nosocomial infections. Mortality rates are above 50%. A novel complex, Mino/Cu, showed promising activity at a concentration of 1.25 µg/ml.

B.subtilis is a Gram (+ve) spore-forming bacteria. *B. subtilis* contains *B. subtilis* subsp. It is commonly found in the environment and in the human gut (Brutscher *et al*., 2022).

The current study revealed activity against *B.subtilis* at very low conc. at 0.625 µg/ml, which can be beneficial results in case of resistant strains of *B. subtilis*.

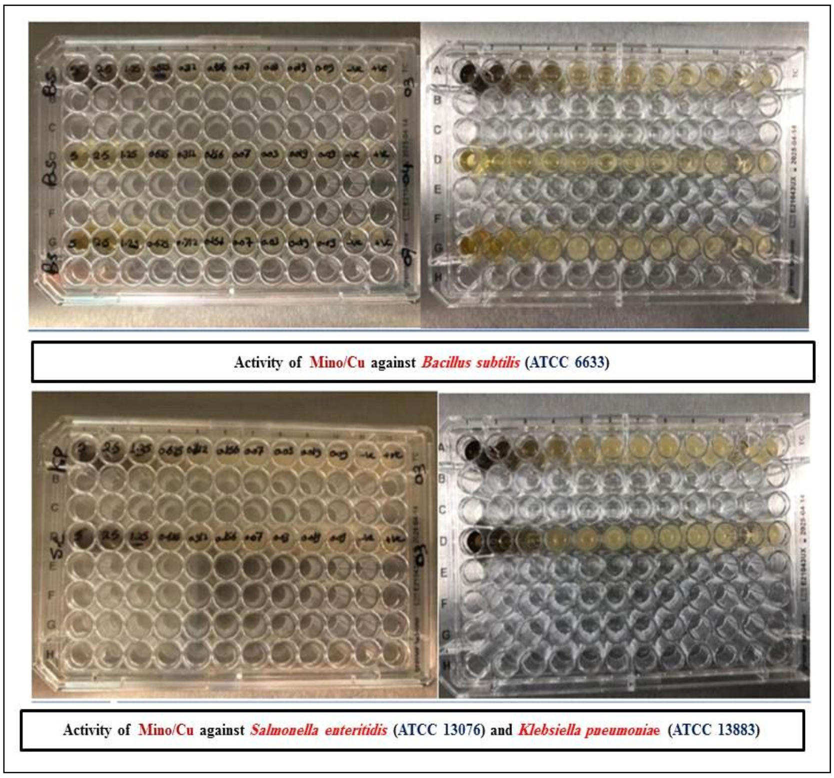

Fig 8: Bacterial disc inhibition growth for the tested bacterial strains.

Copper (Cu) can produce reactive oxygen species (ROS) that are crucial for various pathologies, including cancer, nervous system disorders and aging (Halliwell and Gutteridge., 1984). Cu can also exhibit antioxidant activity by complexing with other drug ligands. This investigation used the ORAC test to show the novel complex (Mino/Cu)'s antioxidant activity, which could be a strong regulatory mechanism to prevent toxic accumulation of Cu ions. The addition of an antibiotic increases its antibacterial activities and the novel complex could serve as a potent antioxidant mechanism (Halliwell and Gutteridge., 1990).

The study reveals the strong anticancer activity and genuine insight into the strong anticancer activity of the Mino/cu novel complex in inhibiting MCF-7 breast cancer cell proliferation at 57.54 µg/ml at conc. 100 ug/ml of the tested novel complex. Cu-complexes can have therapeutic effects on breast cancer cells through the non-Cu death pathway, which is more selective for the mode of action of recently developed Cu complexes (Chu *et al*., 2023). This study provides evidence that Cu complexes can inhibit breast cancer cells by targeting proteins associated with cellular death, which in turn causes oxidative stress, apoptosis, oxidative stress and autophagy. More synthesis of novel Cu-complexes with increased specificity may lead to effective treatments for breast cancer in the future.

CONCLUSION

Utilizing elemental analysis and spectroscopic methods like infrared, ^{1}HNMR, ultraviolet, X-ray diffraction, magnetic susceptibility, SEM and TEM, the novel complex known as minocycline/Cu (Mino/Cu) was produced and investigated. For the novel Mino/Cu novel complex induced high potent anticancer activities by inhibition of MCF-7 proliferation growth by 57.54 µg/ml at concentration 100 ug/ml. Mino/Cu has potent antibacterial activities against the bacterial strains (*Salmonella enteritidis, Klebsiella pneumonia and Bacillus subtilis*), at very low concentration recording at 1.25 ,1.25 and 0.625 mg/ml respectively. The novel complex Mino/Cu exhibited a potent high antioxidant activity via ORAC activity at 1581 (µM Trolox eq/ml).

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Conflicts of interest

The authors would like to confirm that there are no known conflicts of interest associated with this publication and there has been no conflict with any financial support that could have influenced its outcome.

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