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Assessment of the Antimicrobial Activity of (Copper Sulphate Pentahydrate and Potash Alum) Nanoparticles on Bacteria (Pseudomonas Aeruginosa) Isolated with Bacterial Urinary Tract Infections (UTIs)

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ABSTRACT

This study examines the impact of nanoparticles of copper sulfate pentahydrate and potash alum on bacteria (Pseudomonas aeruginosa) that were isolated from patients with bacterial urinary tract infections (UTIs). Bacterial urinary tract infections (UTIs) are common infections that occur in both outpatient clinics and nosocomial (hospital-acquired) settings, affecting individuals of all age groups. From a clinical perspective, the differentiation between uncomplicated and complicated urinary tract infections (UTIs) has proven to be advantageous. The coordination between the host's defense mechanisms and bacterial virulence factors plays a crucial role in shaping the progression of an infection. Simple urinary tract infections (UTIs) are typically managed solely with medicines, but complex UTIs necessitate extra treatment to address the underlying factors contributing to the infection. The bacteria, specifically Pseudomonas aeruginosa, were isolated and purified between January and June 2023 using urine samples. The purpose was to assess the effectiveness and inhibitory properties of copper sulfate pentahydrate and potash alum nanoparticles against Pseudomonas aeruginosa. The rapid emergence and widespread dissemination of antibiotic resistance are the primary drawbacks of contemporary antibiotic treatment. Various interventions can be implemented to mitigate this trend. Minimize the administration of antibiotics, maintain accurate dosing, prevent infections, and develop innovative chemical substances for antibiotic compounds.

1. INTRODUCTION

In recent years, nanomaterials have become the forefront of research and development in terms of importance and scope. Nanomaterials are fascinating because of their distinct optical, magnetic, electrical, and other properties at this scale. With these qualities, it could have positive consequences in electronics, medicine, space exploration, and other fields [1, 2].

Nanotechnology is one of the most active research areas in modern materials science. Nanoparticles generally exhibit new or improved and unique properties from surface area to volume and external structure. There have been significant developments in the field of nanotechnology in recent years, along with methods that have been developed to synthesize nanoparticles of specific shape and size depending on the specific requirements for their preparation. Hence, we notice that the use of nanoparticles and nanomaterials is increasing.

Nanomaterials are a collection of organic or inorganic materials, either crystalline or amorphous, with diameters ranging from one to one hundred nanometers. Nanostructured, nanophase, and nanoparticle materials are the different categories of nanomaterials [3, 4]. Because of their significant use in numerous biomedical and antibacterial applications, as well as their unique chemical and physical characteristics, such as their high electrochemical correlation coefficient and high photochemical stability, potash alum and copper sulphate pentahydrate have attracted a lot of attention from the scientific and medical communities.

Copper sulfate hydrate and potash alum are compounds that have long been used to control fungal diseases. This fungicide is often used on vegetables. Copper sulfate is a polyvalent substance that can kill many fungi including those that cause downy mildew. This fungicide has been shown to have a low level of toxicity to plants and animals and will not harm the environment as well as control bacterial diseases copper sulfate hydrate and potash alum are compounds that are commonly used in many applications. It is primarily used to prevent and control bacterial diseases. Copper sulfate hydrate and potash alum work by killing bacteria that feed on plant tissue. What makes copper sulfate so effective against bacterial pathogens is its ability to release free oxygen molecules within the bacterial cell membrane. Considered alum is one of the most commonly used in water treatment. It has quite a complex chemistry [3]. $KAl(SO_4)_2$: $12H_2O$ is the Chemical formula of Potassium alum [4]. Potash alum is used in multiple applications such as cleansing products, antiperspirants, skin care products, and food additives. The geometric system of potash alum is the cubic system.

Each year, the significant health issue known as urinary tract infections (UTIs) affects millions of individuals. Urinary tract infections are the second most common type of infection in the body. With 150 million cases globally each year, urinary tract infections (UTIs) are among the most prevalent bacterial illnesses. 0.9 percent of all ambulatory visits are for UTI symptoms in offices, and 2-3 million are for emergency room (ER) visits [5].

The opportunistic bacterium Pseudomonas aeruginosa (P. aeruginosa) causes a variety of human diseases.

Numerous systemic disorders, such as dermatitis, soft tissue infections, bacteremia, bone and joint infections, gastrointestinal infections, urinary tract infections (UTIs), and respiratory infections, are typically brought on by a hospital-acquired pathogen [6]. The mineral chalcanthite, which contains copper sulphate pentahydrate nanoparticles, is found in nature. It is also known as bluestone and blue vitriol [7]. The various varieties of cupric salts have been found to have powerful bactericidal properties, particularly copper sulfate pentahydrate nanoparticles [8]. Copper sulfate pentahydrate Chemical formula ($CuSO_4{\cdot}5H_2O$), Hydrous copper (II) sulfate exists in the form of large bright blue crystals containing five molecules of water. Its density is 2.284 g/cm^3 [9].

Since more than 80 years ago, potash alum has been a widely used adjuvant [10]. An adjuvant in vaccines [11]. The chemical formula of potash alum nanoparticles is $KAl(SO_4)_2{\cdot}12H_2O$, (potassium alum) and this is its trade name is considered a double hydrated salt because it contains 12 water molecules in its crystalline structure.

Alum is generally known as a double aqueous salt consisting of two types of positive ions, one of which is single-charged and the other is tri-charged.

A water molecule (water of crystallization) that plays an important role in this type of salt [12]. This study examined how Pseudomonas aeruginosa bacteria from urinary tract infections (UTIs) responded to copper sulphate pentahydrate and potash alum nanoparticles.

2. MATERIALS AND METHODS

2.1 Subjects and study design

A study of the effect of chemical nanoparticles (copper pentahydrate and potash alum) supplied from (The British Drug Houses ltd labortory Chemical Group) with purity (99.88%). For the samples, we added 50 ml of deionized distilled water to 0.4 g of (copper pentahydrate and potash alum), dissolved it, and then stirred the mixture for 30 minutes on Pseudomonas aeruginosa bacteria isolated from urinary tract infections. The bacteria were isolated and purified during the period from January to June 2023. A loop of sperm was collected to look for bacterial causes [13, 14]. Measuring the effectiveness and ability of the following chemical nanoparticles (copper pentahydrate and potash alum) to inhibit the bacteria (Pseudomonas aeruginosa).

Inclusion criteria: Individuals with urinary tract infections (UTIs) included in the study.

Exclusion criteria: Chronic epididymitis/orchitis, prostate cancer, benign prostatic disease, acute and chronic prostatitis, as well as those undergoing continuous antibiotic therapy.

3. RESULTS

3.1 Optical properties

3.1.1 Absorbance of copper sulphate pentahydrate nanoparticles

The optical properties of any semiconductor material are among the important properties that must be known in order to obtain information about the nature of the material and its uses in various applications. Information about the optical properties of the material can be obtained by measuring the absorbance spectrum. Figure 1 displayed are samples of copper sulphate pentahydrate nanoparticles. To prepare the samples, we combined 0.4 g of copper sulphate pentahydrate with 50 ml of deionized distilled water. After dissolving the copper sulphate, we agitated the mixture for a duration of 30 minutes. Since the absorbance values for all of these concentrations are elevated at high wavelengths, it can be observed that the absorbance value of 2.25 also rises as the wavelength increases (specifically at 345 nm). Concentration measurements were taken for solutions generated from copper sulphate pentahydrate nanoparticles across a variety of wavelengths (200-1200). These measurements show how the absorbance spectrum changes with different wavelengths.

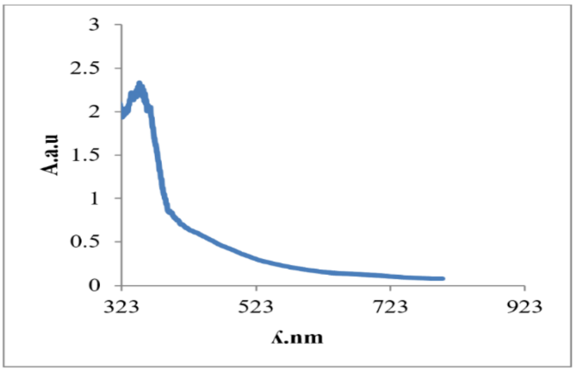

Figure 1. Absorbance of copper sulphate pentahydrate nanoparticles as synthesized

3.1.2 Absorbance of potash alum nanoparticles

Figure 2 samples of potash alum nanoparticles are presented. To create the samples, we employed 0.4 g of potash alum nanoparticles, 50 ml of deionized distilled water, and mixed them for a duration of 30 minutes. Absorbance measurements were conducted in the wavelength range of 200-1200 nm for concentrations derived from potash alum. These results illustrate the variations in the absorbance spectrum with respect to wavelength. As a result of the significant absorbance values observed at higher wavelengths for all concentrations, the absorbance values exhibit fluctuations until they increase with the rise in wavelength.

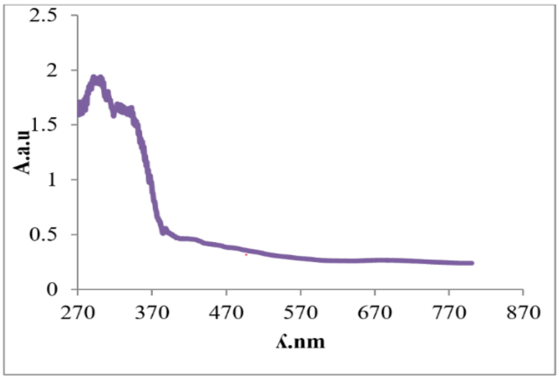

Figure 2. Absorbance of potash alum nanoparticles as synthesized

3.1.3 Energy gap of copper sulphate pentahydrate nanoparticles

The energy gap of copper sulphate pentahydrate nanoparticles was calculated and found to be 4.5eV, as shown in the Figure 3.

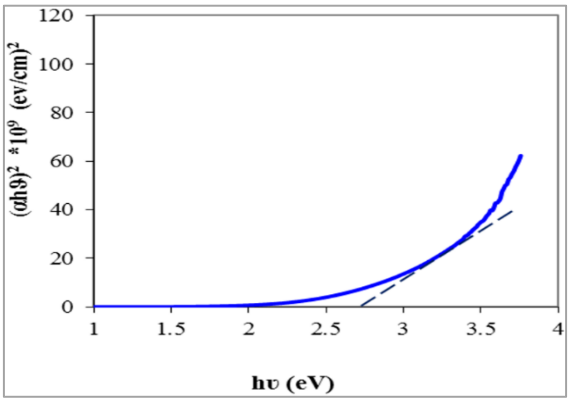

Figure 3. Energy gap of copper sulphate pentahydrate nanoparticles as synthesized

3.1.4 Energy gap of potash alum nanoparticles

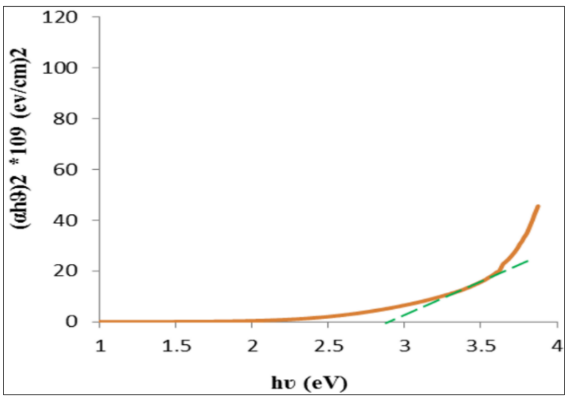

Figure 4. Energy gap of potash alum nanoparticles as synthesized

The energy gap of potash alum nanoparticles was calculated and found to be 5eV, as shown in the Figure 4.

3.2 Structural properties

3.2.1 X-ray diffraction of copper sulphate pentahydrate nanoparticles

Through Figure 5, which shows the diffraction spectrum of the copper sulphate pentahydrate nanoparticles as Synthesized of the presence of seventy-four reflections, which were not at a depth of 2θ = 15.8193.

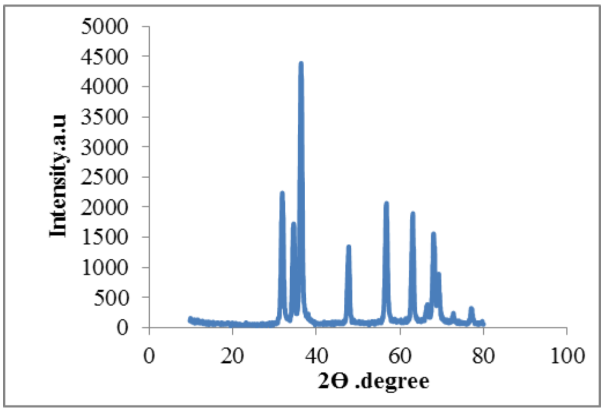

Figure 5. X-ray diffraction of the copper sulphate pentahydrate nanoparticles

3.2.2 X-ray diffraction of potash alum nanoparticles

Through Figure 6, which shows the complete diffraction spectrum of Potash alum nanoparticles the presence of thirty-six reflections, which 2θ = 15.5467.

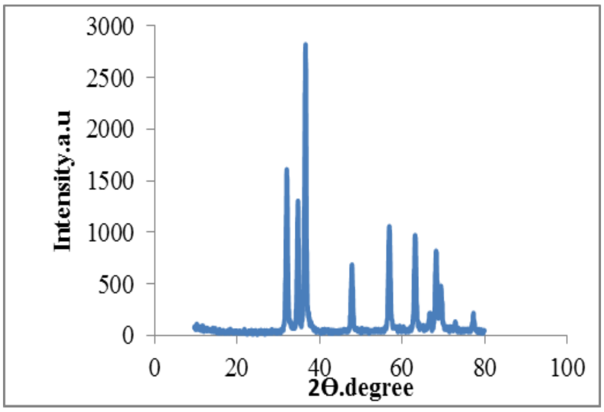

Figure 6. X-ray diffraction of potash alum nanoparticles

3.3 Morphological investigation

3.3.1 Transmission electron microscope of copper sulphate pentahydrate nanoparticles

A transmission electron microscope (TEM) relies on transmitting a beam of electrons through a very thin sample, interacting with the sample as it passes through it. Energetic electrons are used in TEM to provide crystallographic, morphological, and structural information about samples. TEM is widely used in various fields of science and nanotechnology and is particularly useful in observing metal nanoparticles. The electron beam is passed through different electromagnetic lenses and special apertures designed for the sample studied, which is quite weak, and by passing it through its atomic atoms/cellular structure and according to the wavelength of the electron beam, the structure is revealed; The atom provides structural images and diffraction patterns. The TEM images presented in Figure 7 depict the presence of nanoparticles of copper sulfate pentahydrate with a nanostructure exhibiting a spherical morphology. The size of these nanoparticles is approximately 50 nm.

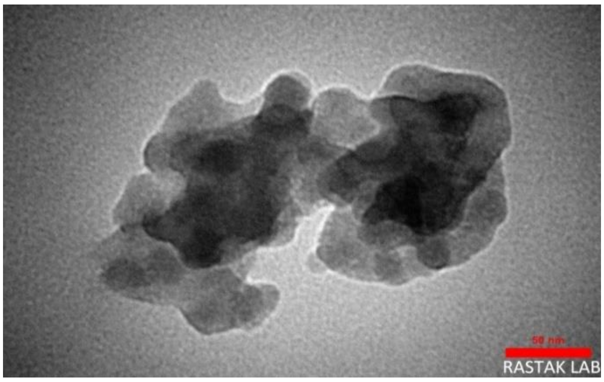

Figure 7. Transmission electron microscope of copper sulphate pentahydrate as nanoparticles synthesized

3.3.2 Transmission electron microscope of potash alum nanoparticles

The TEM images displayed in Figure 8 demonstrate the existence of nanoparticles of potash alum with a spherical nanostructure. These nanoparticles have an approximate size of 50 nm.

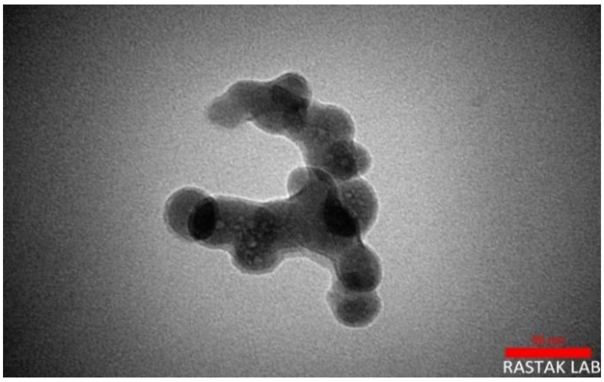

Figure 8. Transmission electron microscope of potash alum nanoparticles as synthesized

3.3.3 Scanning electron microscopy of copper sulphate pentahydrate nanoparticles

The scanning electron microscope is used to study the crystal structure, surface structure, shape and size of particles, and distribution of crystals. The scanning electron microscope technique was used to take an image of the surfaces of the crystals of compounds, as it showed a clear difference in the crystal structures and surface homogeneity. The scanning electron microscope technique was used at a cross-sectional distance of 200 nm. Magnification power K. The surface morphological characteristics of the compound were studied in terms of the size and shape of the particles and the aggregations between them, in addition to their distribution, as the properties and effectiveness of the compounds depend greatly on the nature and shape of their surface.

The FESEM scanning electron scan of the copper sulphate pentahydrate nanoparticles, as shown in Figure 9, showed that they have a semi-spherical circumferential shape, and the particles are agglomerated and irregular in shape, with an average particle size of 63.82 nm.

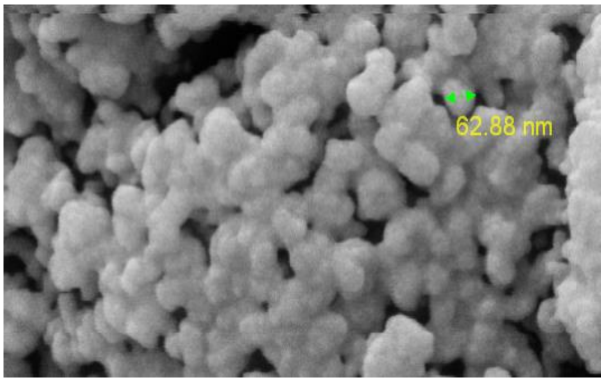

Figure 9. Scanning electron microscopy of copper sulphate pentahydrate as nanoparticles synthesized

3.3.4 Scanning electron microscopy of potash alum nanoparticles

The FESEM scan showed the prepared potash alum nanoparticles as in Figure 10, where we note that they appear as small, spherical particles with a homogeneous surface, with an average particle size of nm (37.96).

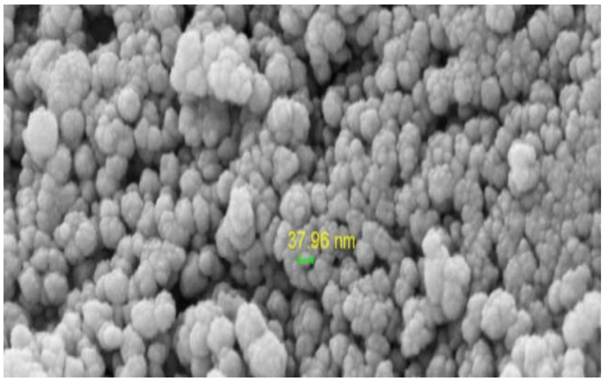

Figure 10. Scanning electron microscopy of potash alum nanoparticles

3.4 Antibacterial activity experiment

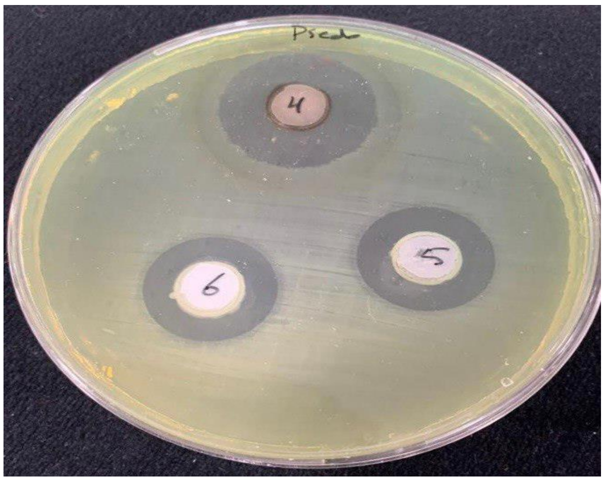

Figure 11. The (copper sulphate pentahydrate and potash alum) nanoparticles impact on bacterial Pseudomonas aeruginosa

As shown in Figure 11, the dishes containing and isolating bacterial cultures, the current investigation found significant suppression of Pseudomonas aeruginosa in both male and female patients with bacterial urinary tract infections.

4. DISCUSSION

The current study aimed to evaluate the behavior of chemicals as antibiotics (copper sulphate pentahydrate and potash alum) in the inhibition of bacteria (Pseudomonas aeruginosa) isolated from urinary tract infections (UTIs) as an effective means inhibiting bacteria. Among the most frequent bacterial diseases contracted in hospitals and the community are urinary tract infections (UTIs) [15].

UTIs and their susceptibility to antibiotics, both in the general population and in healthcare settings, have undergone changes throughout time, with the emergence of antibiotic resistance becoming a significant global concern. The concerning problem arises from various sources, such as the inclusion of antibiotics in animal feed, improper antibiotic prescriptions, and insufficient infection-control practices [16].

Urinary tract infections are the second most common type of infection in the body. Despite improvements in antibiotic treatment, P. aeruginosa-induced UTIs continue to have a high mortality and morbidity rate. Because we don't fully understand the disease's pathophysiology, we are unable to design treatment techniques to prevent the condition, which in turn contributes to this adverse result [17]. The growing concern over antibiotic resistance and hospital-acquired infections has led to renewed interest in the development of antimicrobial agents for public health. We have recommended copper sulphate pentahydrate and potassium alum nanoparticles as supplements to enhance biological safety in hospital environments. The study's goal was to find out how well copper sulphate pentahydrate and potash alum killed bacterial strains that were taken from different clinical sources. Interestingly, copper sulphate pentahydrate exhibited the highest antimicrobial activity against all tested bacteria. Using copper sulphate pentahydrate nanoparticles as an antibacterial agent, whether incorporated into textiles, salts, or liquids, could be of great importance from a clinical perspective. Its proven ability to kill or stop the growth of multidrug-resistant pathogens helps solve the problem of infections and outbreaks caused by these bacteria in hospitals, Copper sulfate hydrate and potash alum are compounds that have long been used to control fungal diseases. This fungicide is often used on vegetables. Copper sulfate is a polyvalent substance that can kill many fungi including those that cause downy mildew. This fungicide has been shown to have a low level of toxicity to plants and animals and will not harm the environment as well as control bacterial diseases Copper sulfate hydrate and potash alum are compounds that are commonly used in many applications. It is primarily used to prevent and control bacterial diseases. Copper sulfate hydrate and potash alum work by killing bacteria that feed on plant tissue. What makes copper sulfate so effective against bacterial pathogens is its ability to release free oxygen molecules within the bacterial cell membrane [18-21].

5. CONCLUSION

The nanoparticle form of copper sulphate pentahydrate exhibits potent antimicrobial properties against urinary tract bacteria. This material functions by releasing dissolved copper ions into the solution upon preparation, which has an antimicrobial effect. We hypothesized that these ions influence the bacterial structures, hindering their growth and reproduction. Potash alum nanoparticles are a chemical that contains potash alum, known for its antibacterial properties. Research has investigated the impact of potash alum on bacteria in the urinary system. Certain studies have demonstrated its ability to hinder bacterial growth, making it a potential anti-infective agent.

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