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Fabrication of composite for wastewater treatment from Escherichia and Staphylococcus pathogen

Mustafa A. Ibrahim Alqadoori[*], *Sadeer M. Majeed*

Department Applied Science, University of Technology-Iraq, Baghdad
[*]) Email: Mustafa.A.Alqadoori@uotechnolog.edu.iq

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The health hazards of microbial pollution leaded to many people died. Most of these pollutants are due to the discharge of wastewater into groundwater, rivers and seas. A compound prepared from Active carbon, Kaolin and magnesium oxide (*ACKMO*), the electric properties of the composite is distinguished by manufacturing supercapacitor, for knowledge the relative constant and ability on redox reaction. The polarization constant and polarization molar of the material sample calculated via relation Clausius-Mosotti. SEM, BET Surface analysis, characterized the morphology surface and active area of composite. The antibacterial activity examined of the specimen, the composite has been good as zeolite, capability redox reaction, high capacitance, polarization constant and polarization molar, also exhibited excellent antibacterial efficacy against; E-Coli and Staphylococcus pathogen. The composite has a PH range 2-6, and is made of environmentally friendly and non-toxic materials, as an applicant in wastewater treatment.

Keywords: Active carbon; Kaolin; Zeolite; Antibacterial study; Supercapacitor.

1. INTRODUCTION

Bacteriological contamination of water sources is a significant problem that has negative consequences for the environment as well as human health. This makes it necessary for search kinds have a high technician in order to find the most effective disinfection, as by using material have high activity [1]. Escherichia coli bacteria is one of the causes of the frequency and severity of common infections that affect human health, and its damages include a series of diseases such as meningitis, diarrhoea, sepsis and other diseases are common in the world. As well as for staphylococcus bacteria, the organisms most commonly implicated in infection for both adults and children alike [2]. Traditional methods, notwithstanding their antibacterial efficacy, can frequently create disinfection by products because of their contact with organic and inorganic substances [3]. Alternatives to traditional bacterial inactivation methods must not produce toxic by-products and must be cost effective. Because Nano-structures have a large surface to volume ratios, nanotechnology is an appealing option for surface reactions. As a result, new pasteurization and antimicrobial treatments are necessary.The influence of antibacterial activity of ceramic particles has recently received a lot of interest as a new technology that can replace traditional methods that use organic agents [4]. The researchers Mustafa A. Ibrahim et al., 2015 had reached of fabricated supercapacitor from a composite of raw clay, active carbon A.C. and transition material ZnO, that composite has high polarizaton and active surface area [5]. Also, the researchers Mustafa A. Ibrahim and Mukhis M. Ismail in 2020 is founded, the kaolin at PH 3M from NaOH solution, is had highest the dielectric constant PH (2, 3, 5, 8) from NaOH solution [6]. The researchers Tadele Assefa Aragaw and Fikiru Temesgen Angerasa, in 2020, researched the ability of kaolin to absorb pigment, and found that the results of raw kaolin have the ability to be considered as low-cost alternatives to removing pigments in industrial wastewater at a concentration of 20mg/L, in a solution having pH 9 at 30oC [7]. Also, there the researcher M. Sundrarajan et al, in 2012, has could disinfected drinking water by mixing activated carbon with MgO by Calcination temperature process, in an ion exchange column, and the material can be used as a new antibacterial agent to treat bacterial contamination [8]. Organic compounds such as quaternary ammonium salts and chlorine disinfectants are been employed as traditional antibacterial agents to eliminate microbial contamination, however toxic elements found in the human body could be contained in the organic effect [4]. Free Ag + ions play a major role in treating both types of bacteria, Escherichia and Staphylococcus, the effectiveness is very large when prepared as nanoparticles, anti-bacterial and anti-fungal [9,10].

Depending on the design and functional properties of the Nano product, specific kinds of particles might discharge: single nanoparticles, clustered or encapsulated nanoparticles, or nanoparticles embedded in a Nano- or micrometer scale matrix material. External forces such as abrasion, pressure, or heat can unintentionally release nanoscale particles from commercially available items. As a result, the product life cycle and design are critical in determining which exposure scenarios are significant and which environmental and health concerns may arise. There may be another difficult aspect to consider. It is necessary to develop a quick, low-cost, and user-friendly approach for evaluating the antibacterial activity that may be used to quickly screen the antibacterial potency of a single material among a large number of producing Nano materials. Researchers can then focus on some nano-materials instead of wasting time and money on unpromising ones after this quick assessment where the basic information regarding the antibacterial activity of the nanomaterial is gathered. The biocompatibility of the nanoparticles explored by examining their impact on biological parameters such as cell proliferation, cytotoxicity, and the ability to generate free radicals both extracellular and intracellular [11].

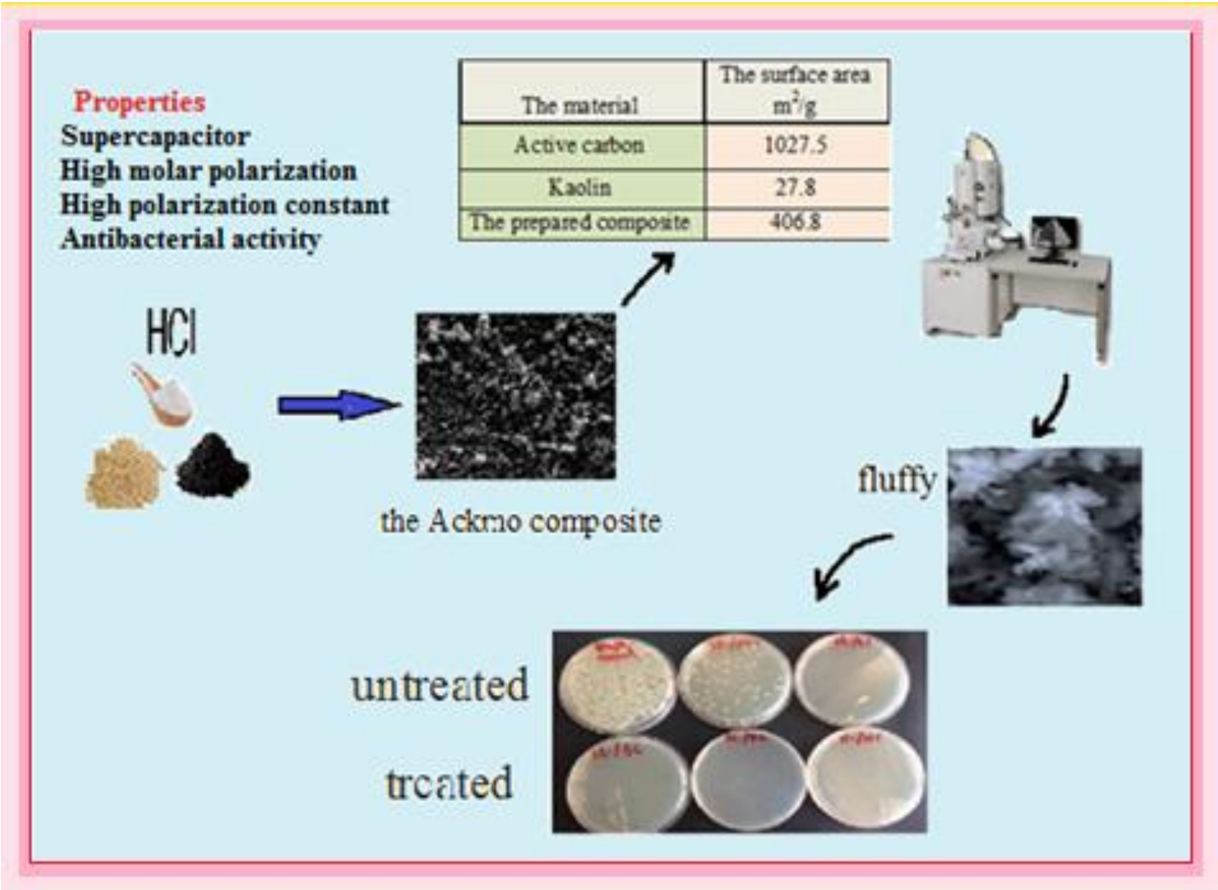


Figure 1 The graphical briefly of the work done.

2. EXPERIMENTAL

2.1 Syntheses Material

The transition material is used magnesium oxide (MgO) and kaolin, Active carbon, acid solution of HCl (1N). Mixed 5%wt MgO with an acid solution of HCl (1N), as the reaction below [12]: as in chemical reaction equation (1)

$$MgO + HCl \rightarrow H_2O + MgCl_2 \quad (1)$$

Then, the resulting mixture with kaolin 25%wt and active carbon 65%wt, for obtaining active composite. To calculate the dielectric constant and know the ability of the compound to interact with the applied electric field, it is necessary to make a capacitor, for knowing scientific results of specifying scientific-power of compound. About 3.5g from prepared compound, taken and placed on each graphite electrode, and a layer of low-density polyethylene (PELD) with a thickness of 1µm inserted between the two electrodes, as the figure 2.

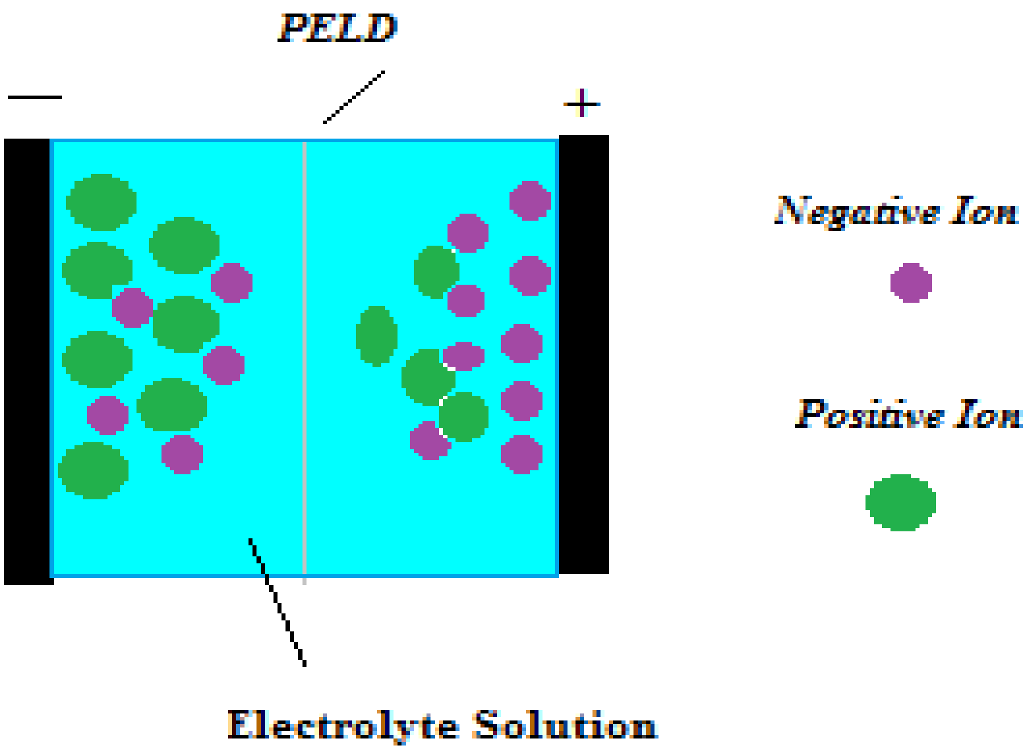


Figure 2 Illustration of capacitor shape.

3. SPECIMEN TEST

3.1 PH

The concentration of hydrogen ion in solution has a great role in the processes of chemical and biological reactions, especially in the processes of oxidation and reduction (Redox) on which the treatment process depends on this research. The acidity of this synthesized compound is (1N) and this acidity is considering into boundary the acidic natural of wastewater (2-6) PH.

3.2 BET test

This test used for the known the surface area of pores compound (*ACKMO*), by surface adsorption process of liquid nitrogen N_2 at 77K.

3.3 Electric measurement

For fabricate on best composite in treatment the wastewater, it must this composite have a distinctive and specific characteristic, because High efficiency processing, must is need to knowing the ability of the *ACKMO* compound, on the polarizability. Calculated the capacity of capacitor by charge and discharge method, the capacitance C is:

$$V = V_{\circ} e^{\frac{-t}{RC}} \tag{2}$$

Then calculated the total molar polarization P_M of orient able dipoles without existing external applied electric field, via the Clausius-Mosotti law is:

$$P_M = \frac{(\epsilon_r - 1)}{(\epsilon_r + 2)} \cdot \frac{M}{\rho} = \frac{4\pi N_a \alpha}{3} \tag{3}$$

Where ϵ_r the relative constant, *M* is molecular weight, ρ is density, α is the polarizability constant, and N_a is Avogadro's number.

3.4 Scanning electron microscopy (SEM)

SEM is employed to investigate the microstructure of the composite material; the growth of the phases formed the composite materials, and the nature of the surface area.

3.5 Antibacterial activity of composite

A volume of (100 mL) of each tested (*ACKMO*) sample of (0.25, 0.5, 1, and 2) mg/ml concentration is spotted separately on Muller Hinton agar well previously seeded with *E. coli or S. aureus* at 0.5 McFarland density (106 CFU/ml). At (37) ° C, the inoculated plates are incubated for (24 hr.). The antimicrobial activity is determined by determining the diameters of the growth inhibition zones in millimetres [13].

4. RESULTS AND DISCUSSION

4.1 BET surface

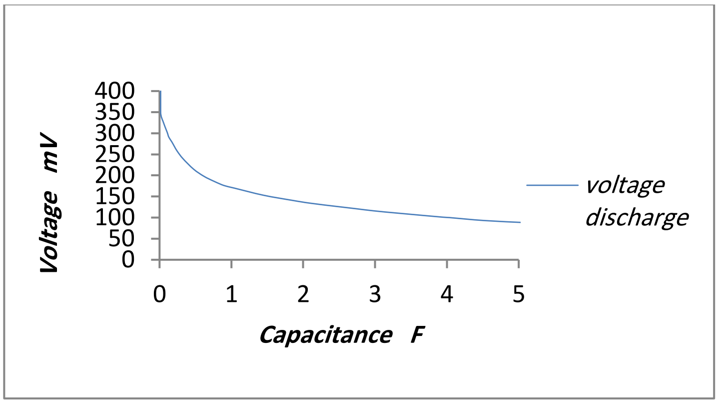
Shown in the table (1-A) the prepared composite has surface area is reaching to 406.8 m2/g, while the active carbon pure has surface area is reaching to 1027.5 m2/g, also, the active carbon is characterized by reduced material only. But, the prepared composite is becoming material has Redox process, due chemical active which owned it.

The adsorption of atoms, ions or liquid nitrogen molecule on the surface of the material, that is generated by van der Waals forces, so it is called physical adsorption [14]. After introducing nitrogen into the pores, a thermal conductivity detector (TCD) has used to determine the surface area with high efficiency.

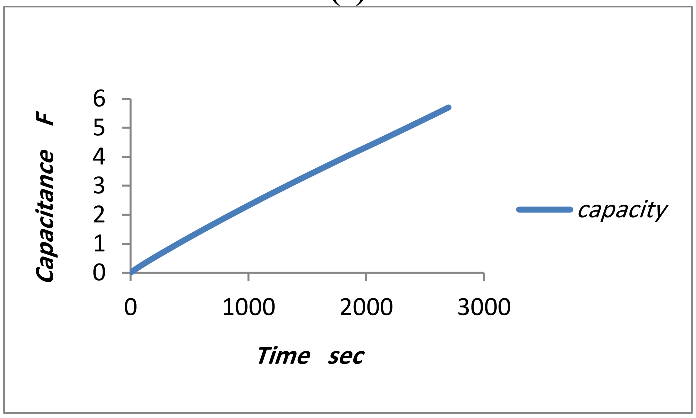
4.2 Electrical measurement

Shown in the table (*1-B*) too, the values of the related results in this work as capacitor and the results of electric measurement of capacitor by used *ACKMO* compound. The results of electric properties of the compound have conformed to the capability in capture of wide range from the bacteria. Because the composite has high value of induced polarization, which is reaching to 4.55×10^{-18}C.m, that lead to create electric field between the big adjacent molecules, versus the bacteria, that is considered sufficient and can able to kill the bacteria, by is generating the induced dipole molecular, of production effective electric field E_f, able to kill the bacteria. In addition, the compound can estimate capability through knowledge, the total molar polarization, polarizability constant and induced polarization of material, without applied electric field, the highest values of the polarizability constant, leaded to capability the material, of made effective electric field, between particles to able killed the bacteria.

Also, table (*1-C*) express the results of the polarization of compound *ACKMO* without applied electric field.The figure (3-a) and (3-b) display the relation between the voltage with capacitance, and the capacitance with time. Recorded the results between the interval (0.4-0.1) V, this test show on the capability of the material used in fabricated the capacitor.



(a)



(b)

Figure 3 Displayed the capability of capacitor of interval (0.4-0.1)V at (a) voltage with current. (b) capacitance with time.

4.3 SEM analyses

Shown in figure (4) the magnification of the image is up to 10 µm, the powder dimension of composite is reaching to (20-25) µm. That has a special morphology building, so, there inserts phases with others, like as fluffy. These forming are reason to increase the ability of excess the exposures, processing composite of other particles.

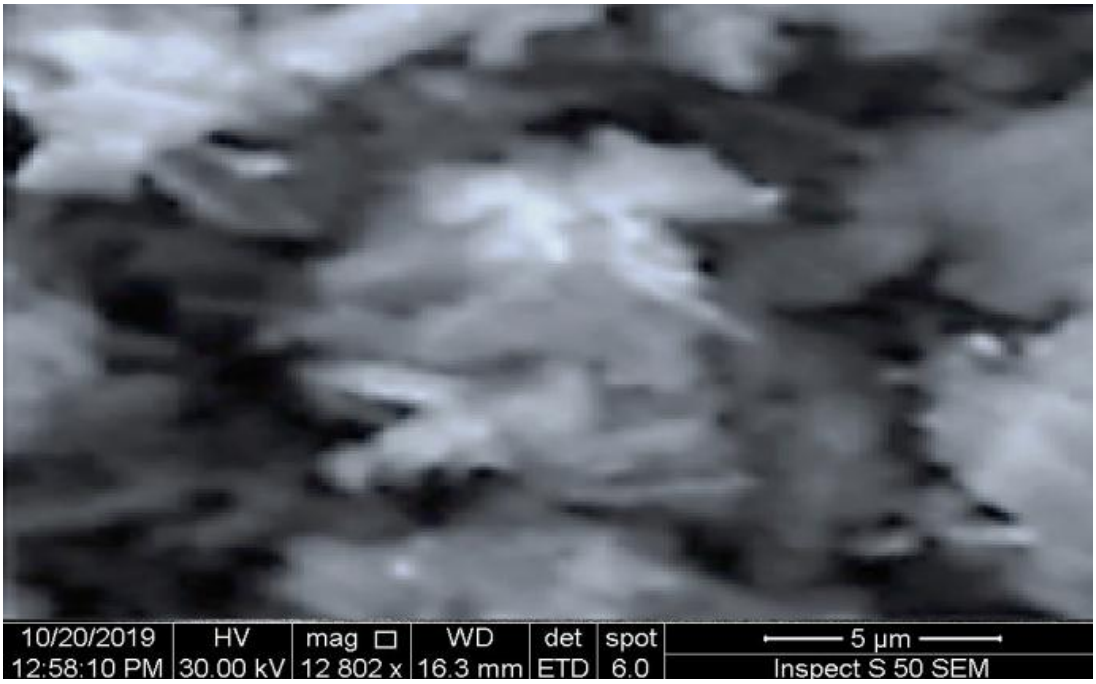


Figure 4 Composite powder, fluffy shapes and little rod shape.

The magnification of the figure (5) is up to 50 µm. That formed naturally of powder, has been leading to two important points: the first, the increasing of the active surface area of composite particle, and this has verified by BET test. Second point, the increasing of the bonding process with charged particles, at the thin end of the composite molecules, due to the reduction-oxidation process, and that is checked, through big succeeding in the result obtained, of the killing mechanism of *Escherichia and Staphylococcus*, and then can consider, as antibacterial [15].

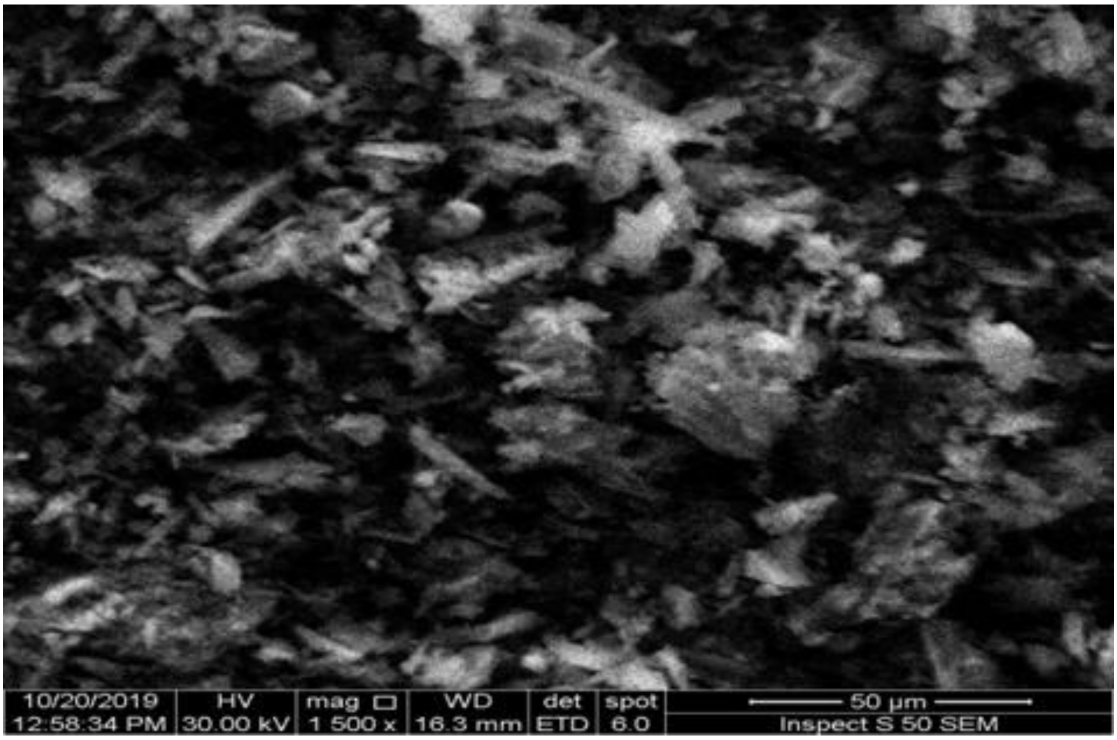


Figure 5 Interaction with charged objects.

4.4 Antibacterial studies

The antibacterial properties of the microorganisms *Staphylococcus aureus* and *Escherichia coli* has been investigated. Shown in figure (6) represents bacterial growth onto the nutrient agar medium (control), and Figure (7) the inhibitory samples of the nursery at 37 ^{o}C after 24 hours with *E. coli* and *s. aures* pathogen on nutrient agar medium (with high concentrate). The antibacterial effectiveness of nanoparticles has been studied in relation to their size, Smaller MgO particles exhibit antibacterial effective against of each gram positive and gram-negative bacteria, but larger MgO nanoparticles only affect gram-negative bacteria. Reactive oxygen species (R.O.S.) are produced more frequently as a result of nanoparticles, which kills bacterial cells. Lipid peroxidation is just one of the many impacts of this high R.O.S. on the bacteria. As a result, as nanoparticle concentration rises, bacteria begin to die because of the disintegration of their cell walls. It is crucial to remember that the surface area accessible to nanoparticles determines their capacity to bind to bacteria. Bacterial permeability of nanoparticles is considering poorly known. However, according to specialized studies, the treatment of bacteria with nanoparticles has been connected to changes in the form of the cell membrane. Nanoparticles have consistently been shown to be able to penetrate bacteria due to their unique structure. The rate of diffusion of nanoparticles over bacterial membranes is directly correlated with their size. Smaller nanoparticles are more likely to harm bacterial membranes. The difference in the zone of inhibition of two the samples at temperature 37˚C can show in table (*1-D*) diameter of inhibition zone of compound (ACKMO) by agar diffusion method. In comparison to the gram (negative, positive) bacteria inhibited, observed the zone inhibition diameter is being larger in positive bacteria in one gram [13]. The inhibitory effects of magnesium oxide nanoparticles work by preventing the development of microorganisms by penetrating and disrupting their cell walls utilizing an electrochemical mode of action. When the cell walls are breached, metabolites seep out and other cell activities are disrupted, rendering the organism incapable of functioning or reproducing [16,17].

Figure 6 bacterial growth on to the nutrient agar medium (control) Of *E. coli* and *s. aures* pathogen.

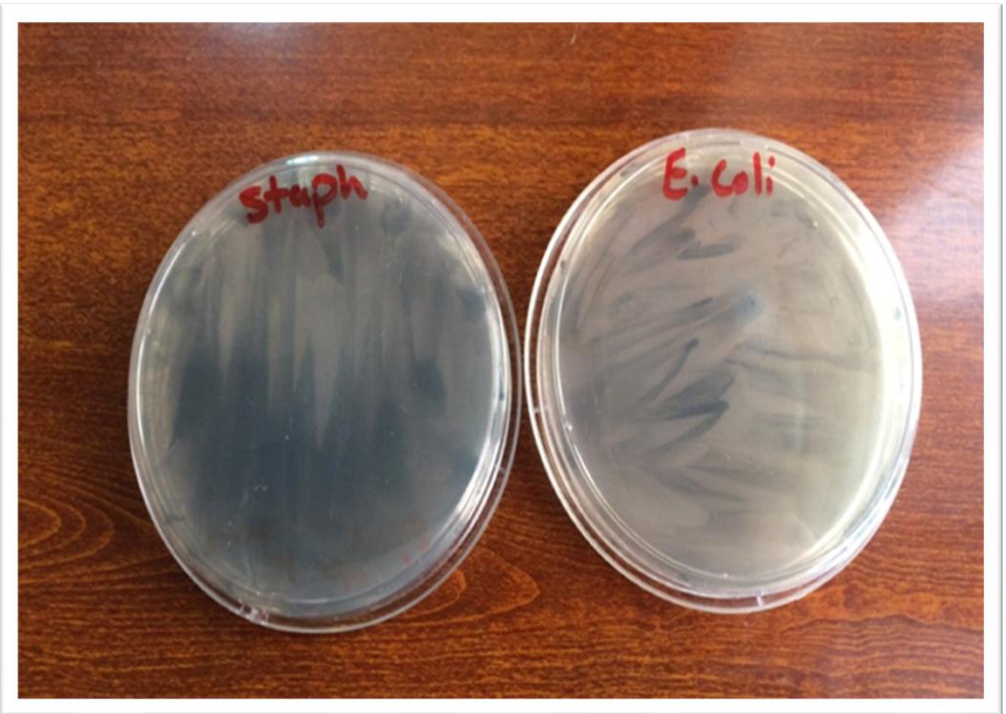


Figure 7 the inhibitory samples of the nursery at 37˚C after 24 hours with *E. coli* and *s. aures* pathogen on nutrient agar medium (with 2mg/ml).

(*ACKMO*) composite is display an obvious antibacterial high effective at the disappearance of light, also, the capability (*ACKMO*) as antibacterial. this is because, it contains $MgCl_2$ can consider, good contributor of antibacterial agent, of reason it is has strong redox process, to be due to the generation of active oxygen from reacting with HCl acid, the magnesium chloride is very high diffusion and solvent in the water, and also considers a mineral element essential to the human body [18]. Increasing the diffusion distance between active oxygen and the bacteria increases, lead to decreasing the activity of active oxygen. As demonstrated by Yamamoto et al., activated carbons had a high affinity for microorganisms and absorbed a substantial number of bacteria [19]. The antimicrobial properties of zeolites have compared to their ion loading capacity against a wide range of pathogens, including bacteria. It is discovered that mg^{+2} ion-loaded zeolites had higher antibacterial activity than other metal ion-embedded zeolite samples. The results suggest that Mg^{+2} can be ion changed with various synthetic zeolites, with the ions acquiring antibacterial capabilities or ion-releasing properties to enable longer or stronger action. Non-toxic zeolite Nano crystals with intriguing physicochemical features predicted to provide significant benefits in everyday life applications [20]. Many investigations have found that silver-loaded FAU-type zeolites have antibacterial action against Escherichia coli (E. coli), indicating a rise in bacterial susceptibility in the case of rifampicin [16, 18]. Salt formulations could be coupled with numerous materials used in manufacturing, medical equipment, surfaces, fabrics, or home products where antibacterial qualities are required, according to the current study. The novelty in this research is the method of preparing *ACKMO* does not depend on heating at preparing, also it is the micrometer grain size, i.e. the grain size of (*ACKMO*) composite is not nanomaterial. However, the speed of its decomposition leads to the generation of small nano-sized ions that penetrate the bacterial wall, thus oxidizing the bacteria, and thus their death and disintegration [21]. The (*ACKMO*) compound contains both hydrated and dehydrated elements. Hydrated materials, also known as hydrophilic materials, are materials that contain water molecules in their structure and have a high polarity. Dehydrated materials, on the other hand, are termed hydrophobic materials because they lack water molecules in their structure and lack polarity [22]. The *ACKMO* composite has two syntheses: First is hydrophilic because, the kaolin molecule structure is contained on the alumina and silicates, in addition to a water molecule H_2O. In addition, the other is hydrophobic, because the *ACKMO* composite have based on $MgCl_2$/AC, therefore, is having high adsorption [23-33].

Table 1 represents all the physical characterization and diameter of inhibition zone by agar diffusion method of the *ACKMO* compound.

A

The material	The surface area [m^2/g]
Active carbon	1027.5
Kaolin	27.8
The prepared composite	406.8

B

Capacitance [F]	Relative constant ϵ_r	Total charge of capacitor [C]
5.7	2.57×10^{8}	55.28

C

Total molar polarization P_M [m^3/Kg]	Polarizability constant α [$C\cdot m^2\cdot V^{-1}$]	induced polarization μi [C . m]
1.829	4.69×10^{-25}	4.55×10^{-18}

D

Zone inhibition diameter [mm]	
S. aureus (Gram positive)	*E. coil (Gram negative)*
17	17
23	21
21	19
19	17

4. CONCLUSIONS

The demonstrated that the *ACKMO* composite has great specifications, as high redox reaction, high polarization molar, good zeolite, exhibited excellent antibacterial efficacy against; *E-Coli* and *S. Aureas* pathogen, Furthermore, the biological activity revealed that the novel compounds containing Mg^{+2} are efficient against Gram-negative and Gram-positive bacteria. This activity of compound has caused to the presence of ions and effective groups in the material associated with the ions, the most important of which is the atom Mg associated with the compound, which boosted the effectiveness of associated compounds through the redox process. As well as, it´s considered environment friend. Therefore, that can use in treating the wastewater, for get rid of bacterial contamination. The manufactured *ACKMO* composite of Active carbon, kaolin and MgO has satisfied new results in being a highly effective compound in the treatment of *Escherichia-coli* and *Staphylococcus aures* bacteria.

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