IASJ
المجلات الاكاديمية العراقية

Journal of Kufa for Chemical Sciences
ISSN(P) :2077-2351 ISSN(E): 3006-3280
Journal Homepage:
https://journal.uokufa.edu.iq/index.php/jkcs/index

Article

Synthesis, Characterization and Antimicrobial Activity of Polyacetal/ Nano Chitosan Polymer Blend

Aalaa B. Nashter, Maha A.Younus

Department of Chemistry/College of Education for pure Science (Ibn Al-Haitham) / University of Baghdad, Baghdad, Iraq.
alla.bdai1205a@ihcoedu.uobaghdad.edu.iq

ABSTRACT

Polymer blend of polyacetal/ nano chitosan was prepared by solution casting method. All prepared compounds have been characterized by FT-IR, SEM, as well as biological activity. Antimicrobial activity related to prepared blends against four types of bacteria namely, Staphylococcus aureas, S.typhi, P.aeruginosa, Escherichia Coli and C.albicans fungal were examined and evaluated. The results reveal that the prepared polymer blends have good antimicrobial activity against all kinds of microbials.

Keywords: PVA, Polyacetal, nanochitosan, polymer blend, antimicrobial polymer

1. Introduction

Polymer blends (PBs), also called polymer mixtures, are materials in which two or more polymers are mixed to create a new material with particular physical properties. [1] . Polymer blending is a quick and easy way to create novel polymeric materials that mix the best qualities of several different polymers. This method is generally less expensive and time-consuming than creating totally new polymeric materials by developing novel monomers and/or polymerization pathways. As a result, the financial risk associated with developing novel materials is reduced in the case of polymer blends. Another advantage of polymer blends is that by just altering the blend composition, it may get a wide range of material characteristics [2].

The polymer known as polyacetal (PAC) is created when alcohol and aldehyde combine, forming an ether bond.One of the few materials thought to have potential use in the production of components that improve blood flow in blood vessels (stents) and that gradually break down in the body to release integrated medications is polyacetal. The simplest polycyclic acetal medicinal use currently under investigation. Utilize supplies to create orthodontic braces. [3].

Chitin, which is naturally polycationic, is the source of chitosan, a polycationic linear polysaccharide.. Chitosan's poor solubility in neutral and alkaline solutions restricts its use. Chemical modification of composites or hydrogels, on the other hand, confers new functional characteristics for a variety of applications. Because of its non-toxicity, low allergenicity, biocompatibility, and biodegradability, chitosan is regarded as a versatile biomaterial [4]. A naturally occurring substance with superior physicochemical qualities is nano-chitosan. It is beneficial to the environment and bioactive.. Several methods have been used to create nano-chitosan, such as pentasodium tripolyphosphate, which physically crosslinks chi-tosan with specific negatively charged macromolecules through ionic gelation.. Furthermore, natural or synthetic antibacterial agents, antioxidants, enzymes, or functional materials like plant extracts, probiotics, minerals, or vitamins can be incorporated into chitosan and chitosan nanoparticle films and coatings. During the storage period, chitosan nanoparticles had more antibacterial activity than chitosan. [5].

One common water-soluble nonionic synthetic polymer containing vinyl is polyvinyl alcohol (PVA). Because it is safe and comparatively environmentally friendly, it is regarded as harmless [6]. Because of its easy fabrication process ability, it is widely employed in a variety of industrial applications, including food packaging, pharmaceutical, and biomedical fields. PVA-based films are easily produced [7]**.** With excellent dielectric and tensile strength, chemical resistance, charge storage capacity, and dopant-dependent optical and electrical properties, this material shows significant promise. Fuel cells, medication delivery, coating materials, functional membranes, and biomaterial applications all use PVA because it produces films with good improvements in their physical and chemical characteristics and transparency [8]. PVA is a type of flexible polymer with a wide range of mechanical uses. [9].

2. Experimental

Materials poly vinyl alcohol (PVA) 1gm was dissolved in 25mL di methyl sulfoxide (DMSO) and stirred for 1/2 h at room temperature, para hydroxy benzaldehyde (1gm) was dissolved in 20
mL ethanol with (3 drops) of concentrated H_2SO_4 and stirred for 1/2 h at 50 ◦C and mixing all materials to prepare poly acetal. The mixture was heated to 50 ◦C for nine hours while being magnetically agitated. To get the product combinations' pH to 7, a few drops of (1N) NaOH solution were added. Following cooling, the product was filtered and dried in an oven for 24 hours at 50 °C [10].

2.1. Polymer Blend preparation

The polymer blend was prepared by solvent casting method. poly acetal solution was prepared by dissolution 1gm of the poly acetal in 100 mL of DMSO with stirring at 50 ◦C. Nano chitosan solution was made by dissolving it in a 2% aqueous acetic acid solution and stirring it at room temperature. After being placed on petri dishes, the combined solution was dried for 24 hours at 50 °C in an oven. Blends of PA and nano chitosan were created by combining various ratios as shown in table 1.

Table(1) The weight fraction of PA /Nano Chitosan Polymer blend

Polymer blend	PA %	Nano Ch%
PB(1)	25	75
PB(2)	75	25
PB(3)	50	50

3. Results and Discussion:

3.1. FT- IR Analysis for Polyacetal.

FT-IR The bands at roughly 3369 and 1649 cm^{-1} in pure PVA Fig. (3-1) are attributed to the hydroxyl group's OH stretching and bending vibrations, respectively. About 2953cm^{-1} is the band that corresponds to the asymmetric stretching vibration of the methylene group (CH_2) [11,12].

The wide band in Polyacetal Fig. (3-2) is situated at 3178 cm^{-1}, corresponding to the (O-H) stretching vibration, 2913 cm-1 to the (CH_2) symmetric stretch, and 1127 cm^{-1} to the ligand's (C-O-C) acetal group.

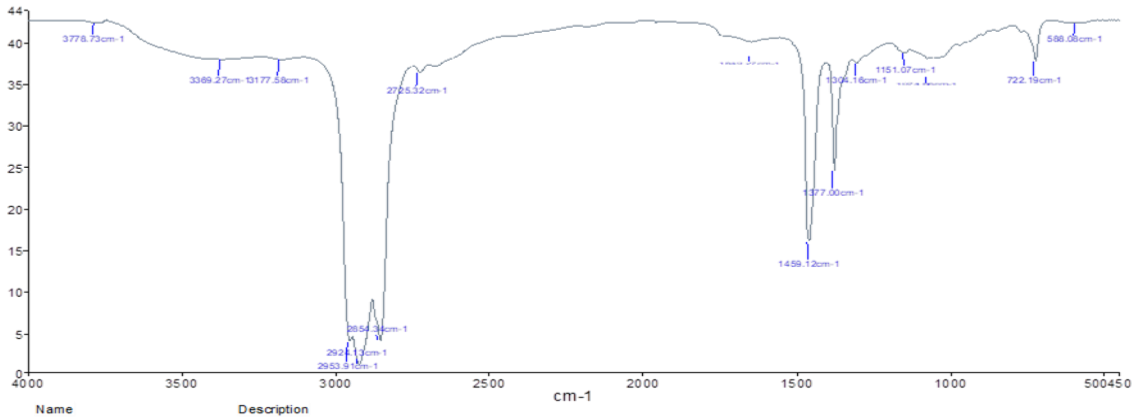

Figure (3-1) : FT-IR spectrum PVA

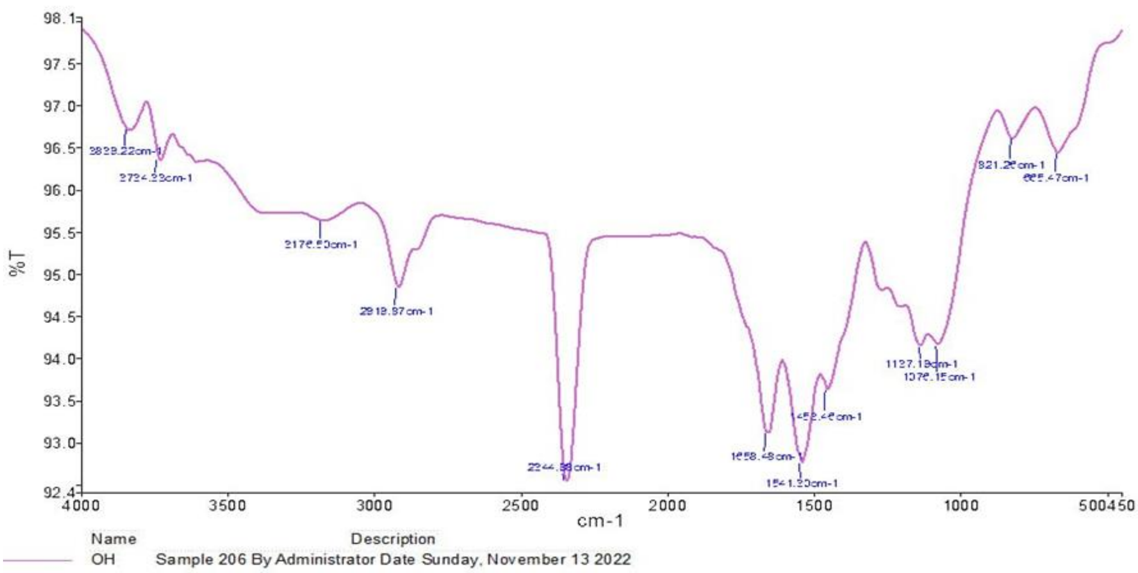

Figure (3-2): FT-IR spectrum Polyacetal.

3.1. Scanning electr0n microscope studies (SEM)

The SEM micrograph for polyacetal and polyacetal/ nano chitosan polymer blend are represented in Figures (3-3). The surface appears to have various inclusions and be porous. The surface appears to be porous and to have some inclusions. The surface morphology of polyacetal shows a rough appearance when p-hydroxy benzaldehyde is present. For polymer blends PB1 and PB3, the average nano size of the chitosan in the blend is between (34) and (64) nm. Following the polymer-to-polymer interaction, the generated blends' surfaces displayed notable alterations.

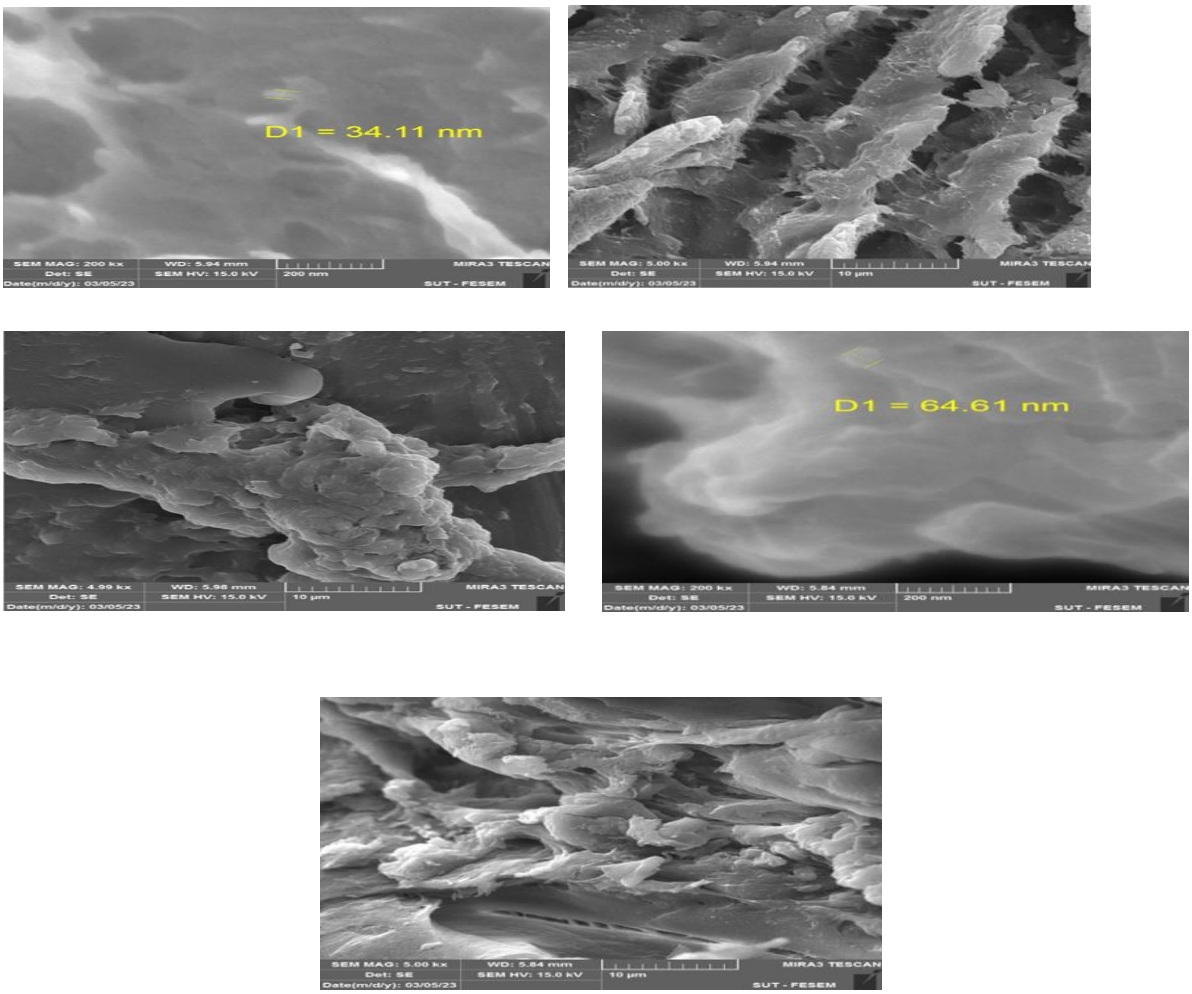

Figure (3-3) SEM image of A-(Polyacetal), B,C- (polymer blend PB1), D- (polymer blend PB2)   E,F- (polymer blend PB3).

3.1. Thermal Analysis

The thermo gravimetric (DSC/ TGA) for PA/nanochitosan polymer blend and polyacetal was measured in temperature which ranges between 25°C and 600°C with a constant rate which is equal to 1o$^{\circ}$C/ min $^{-1}$.

Figure 3-4 of the PA TGA curve showed four phases of a mass loss sequence, with the first stage showing a mass loss of volatile chemicals of -10.60%. For the chain breakdown, the second step had a weight loss of roughly (-45.57%), the third stage had a weight loss of roughly (-23.76%), and the fourth stage had a weight loss of around (-18.75%). The polyacetal DSC curve in figure 3-4 displayed a Tg of 125.40°C. Peak with respect to the polymer melting temperature (419.84°C) Tm.

Three phases of a sequence mass loss were depicted by the TGA curve of the PA/NanoChitosan polymer blend (PB1) figure 3-5, with the first stage showing mass loss (-10.49%) of volatile chemicals. For the chain decomposition, the second phase had a weight loss of roughly (-34.52%), while the third stage had a weight loss of roughly (-53.95%). The polymer mix DSC curve in Figure 3-5 displayed a Tg of 103.10°C. Peak with respect to the polymer melting temperature (446.81°C)Tm.

Five phases of a sequence mass loss were depicted by the TGA curve of the PA/NanoChitosan polymer blend (PB2) figure 3-6, with the first stage showing mass loss (-9.535%) of volatile chemicals. For the chain decomposition, the weight loss in the second stage was roughly (-13.78%), in the third stage it was approximately (-27.91%), in the fourth stage it was approximately (-13.29%), and in the fifth stage it was approximately (-34.80%). The polymer blend DSC curve in Figure 3-6 displayed a Tg of 100.02°C and a peak at 446.58°C with respect to the polymer melting point Tm.

Five phases of a sequence mass loss were depicted by the TGA curve of the PA/NanoChitosan polymer blend (PB3) figure 3-7 with the first stage showing mass loss (-7.610%) of volatile chemicals. For the chain decomposition, the weight loss in the second stage was roughly (-11.10%), in the third stage it was approximately (-28.68%), in the fourth stage it was approximately (-6.816%), and in the fifth stage it was approximately (-45.61%). Figure 3-7's DSC curve for the polymer blend revealed a Tg of 116.61°C and a peak at 73.17°C in relation to the melting of the polymer Tm.

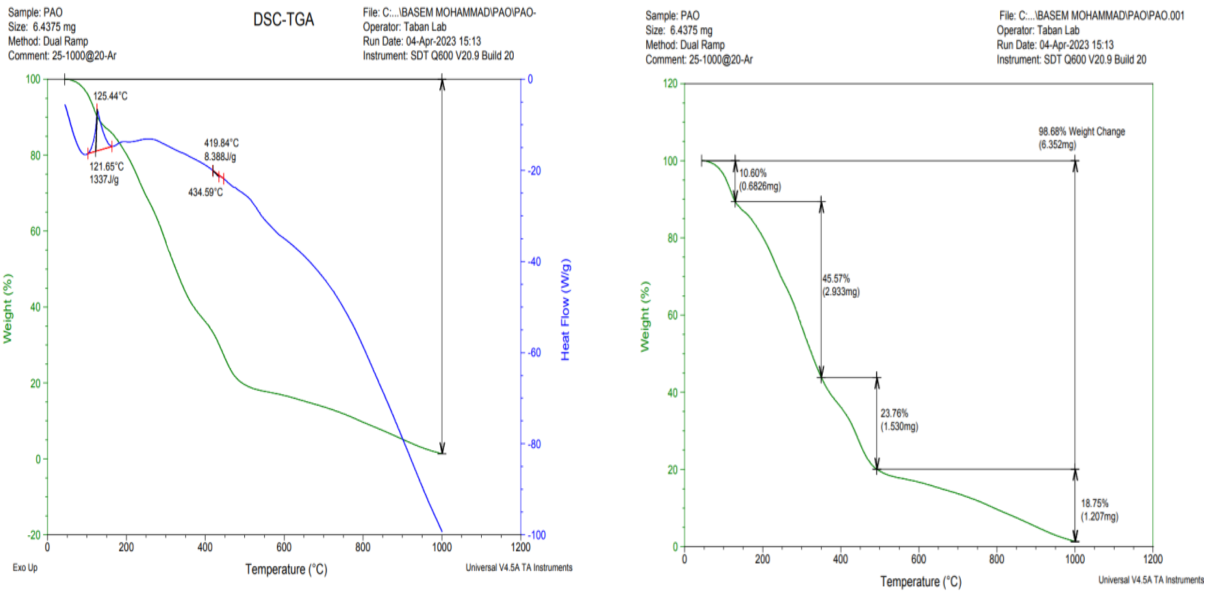

Figure (3-4) Thermal analysis of polyacetal

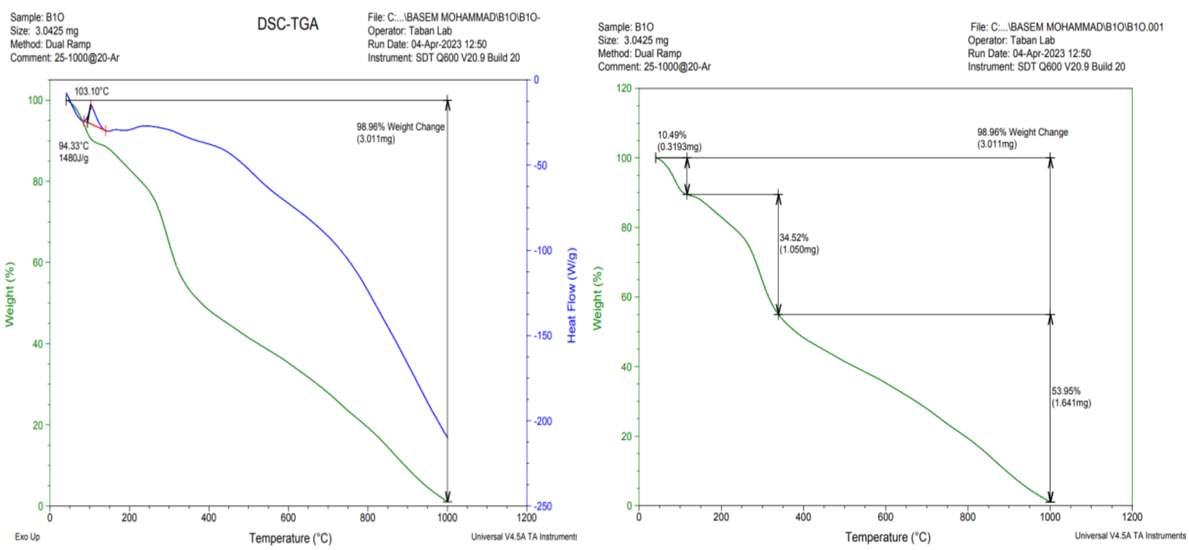

Figure (3-5) Thermal analysis of polymer blend PB1

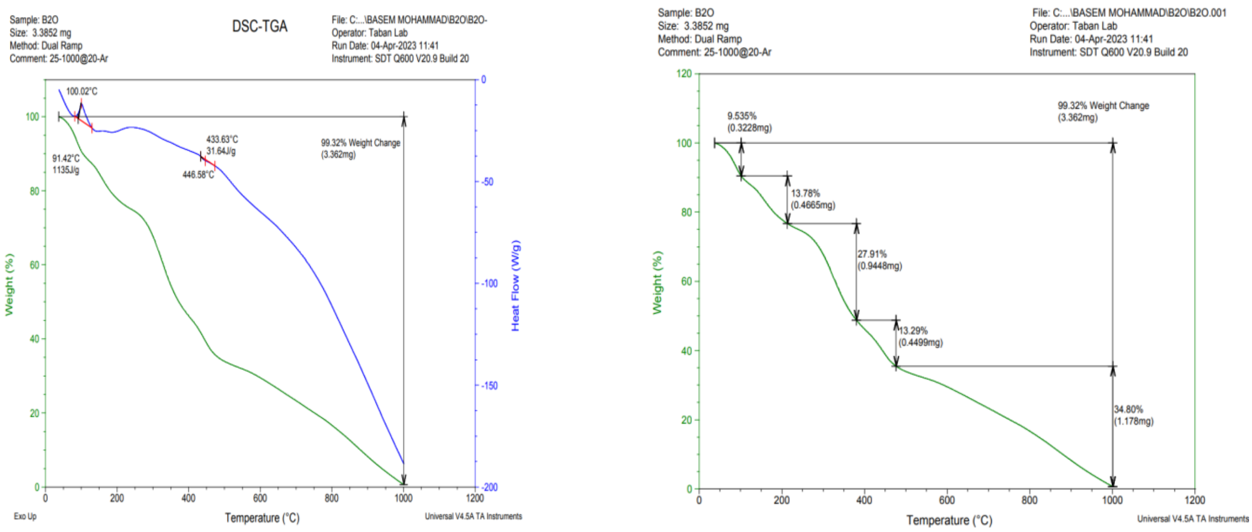

Figure (3-6) Thermal analysis of polymer blend PB2

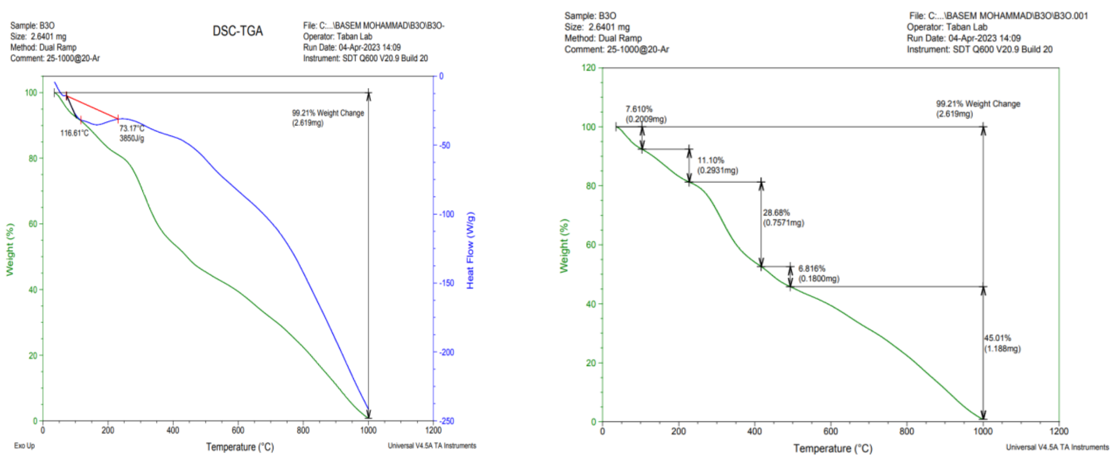

Figure (3-7) Thermal analysis of polymer blend PB3

3.1. Biological activity.

The biological activity of the polymer blend of Polyacetal /NanoChitosan, were tested against four types of pathogenic bacteria using (Diffusion inhibition method). The results of antimicrobial activity are represented in Table (2). It is clear from the Table that all tested compounds exhibit good antimicrobial activities on growth of both Gram +ve and Gram-ve bacteria producing an inhibition zone reaching (25mm) diameters.

Due to the higher percentage of nanochitosan in the prepared polymer blend B1, the antimicrobial activity of the blend is comparatively higher against the tested microorganisms. This is because the action of the nanoparticles is usually attributed to their small size, which allows them to pass through the cell membrane of the bacteria. Furthermore, the positively charged (PA/Nano Ch) and negatively charged lipidic bacterial membrane may interact to inhibit the cells from taking nutrients, restricting both cell growth and survival [13][14].

Table (2): Antimicrobial activity of Polymer blends and Polyacetal on the bacterial and fungal isolates by well diffusion test.

Test	*C.albicans* Inhibition zone(mm)	*P.aeruginosa* Inhibition zone(mm)	*S.aureus* Inhibition zone(mm)	*E.coli* Inhibition zone(mm)	*S.mutans* Inhibition zone(mm)
Polyacetal	9	6	8	7	7
PB1	25	15	20	18	15
PB2	20	13	15	11	10
PB3	15	8	12	8	8

Conclusion

In this work, the antimicrobial activities of the prepared polyacetal, Polyacetal /NanoChitosan polymer blends with different ratios were investigated. The obtained compounds were studied by FT-IR, SEM, DSC-TGA spectroscopy. The results revealed that the activity increased by increasing the percentage nanochitosan.

References

[1] Nashter, A, Younus M. [2021]: Preparation, Characterization and Antimicrobial Activity of Polyvinyl Alcohol/Polyvinyl pyrrolidone/Chitosan nano composite. J. Biochemical & Cellular Archives. 21 (2), pp. 4513-4519.

[2] Tarhini, A, Tehrani-Bagha, A. [2023]: Advances in preparation methods and conductivity properties of graphene-based polymer composites. Applied Com-

posite Materials. 30 (6), pp. 1737-1762.

[3] Younus, M, et al.[2020]: Synthesis and Antibacterial Activity of PEG Polycyclic Acetal Metal Complex/PVA Polymer Blend Film. Ibn AL-Haitham Journal For Pure and Applied Sciences. 33(3), pp. 44-54.

[4] Kumar, Deepak, et al. [2020]: A review on the synthesis of graft copolymers of chitosan and their potential applications. International Journal of Biological Macromolecules. 163, pp. 2097-2112.

[5] Saeedi, M, et al.[2022]: Customizing nano-chitosan for sustainable drug delivery. Journal of Controlled Release. 350, pp. 175-192.

[6] Xiang, Xuezhu, et al.[2023]: Enhanced biodegradation of thiamethoxam with a novel polyvinyl alcohol (PVA)/sodium alginate (SA)/biochar immobilized Chryseobacterium sp H5. Journal of Hazardous Materials. 443, pp. 130247.

[7] Lee, Hohyun, et al.[2020]: Chemical and physical reinforcement behavior of dialdehyde nanocellulose in PVA composite film: A comparison of nanofiber and nanocrystal. Carbohydrate polymers. 232, pp.115771.

[8] Rani, Priyanka, et al.[2023]: Dielectric properties of graphene/nano-Fe_2O_3 filled poly (vinyl alcohol)/Chitosan blends. Materials Chemistry and Physics. 295, pp. 126986.

[9] Arefian, M, et al.[2020]: A review of Polyvinyl alcohol/Carboxymethyl cellulose (PVA/CMC) composites for various applications. Journal of Composites and Compounds. 2 (3), pp. 69-76.

[10] Hasan, M, Younus, M. [2020]: Synthesis, Characterization and Antibacterial Activity of PVA Cyclic Acetal (CU) Metal Complex/Chitosan Polymer Blend. Biochemical & Cellular Archives. 20 (2), pp. 3367-3377.

[11] Kanchana, S. K., et al.[2023]: Structural and optical properties of polyvinyl alcohol/copper oxide (PVA/CuO) nanocomposites. Solid State Communica-

tions. 370, pp. 115221.

[12]Meng, Lina, et al.[2023]: Improved mechanical and antibacterial properties of polyvinyl alcohol composite films using quaternized cellulose nanocrystals as nanofillers. Composites Science and Technology. 232, pp.109885.

[13]Ahmed, S. B., et al.[2021]: Investigation of the antimicrobial activity and hematological pattern of nano-chitosan and its nano-copper composite. Scientific Reports. 11(1),pp. 9540.

[14]Lopez De Dicastillo, C, et al.[2020]: Antimicrobial bilayer nanocomposites based on the incorporation of as-synthetized hollow zinc oxide nanotubes. Nanomaterials. 10(3), pp. 503.