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Synthesis and Evaluation Biological Activity of Some New Polymers Derived From 3,3'-dimethoxybiphenyl-4,4'-diamine

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ABSTRACT

In this study, synthesis of polymer Nanocomposites through the blending of prepared polymers with polyvinyl alcohol (a synthetic polymer) or chitosan (a natural polymer) then mixed with nano oxide silica by many steps. The new compound [I] was obtained via reaction of 3,3'-dimethoxybiphenyl-4,4'-diamine as starting material with malic anhydride in DMF then treatment with ammonium persulfate $(NH_4)_2S_2O_8$ (as the initiator) in order to produce polymer [II]. Also, we prepared new polymers [III-V] by using the same starting material (3,3'-dimethoxybiphenyl-4,4'-diamine) with glutaric acid or adipic acid or isophthalic acid in DMF and pyridine. In this study, new polymer blending [VI-IX] and [X-XIII] were synthesized from a prepared polymer [II-V] mixed with different polymers [polyvinyl alcohol (a synthetic polymer) or chitosan (a natural polymer), respectively. Then it was mixed with silica nanoparticles to produce newly nanocomposites [XIV-XVIII] and study their effect on two types of bacteria then compare with Amoxilline as antibiotic drug. The anticancer activity human breast cancer cell line (MCF-7) of some prepared polymers were also studied and compare with normal cell line Rat Embryonic Fibroblasts(REF).

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INTRODUCTION

A polymer blend is a mixture of two or more polymers that have been blended jointly to form a new material with various physical properties. Polymer blending has attracted a lot of interest as a simple and low-cost prosperous method of expanding polymeric materials that have fluctuations for commercial implementations. Also, the properties of the blends can be involved in flowing to their end users through the right selection of the component polymers. Polymer blends are materials that are made by blending to create a new substance with complementary properties. Polymer mixing is an appealing strategy for developing new materials for particular uses since it is both cost-effective and simple [1]. Blended polymers are used in medical applications for assessing, addressing and increasing the function of biological systems, as well as replacing organs or tissues that may need to be replaced [2,3]. Polymer nanocomposites are an emerging biomedical technological, agriculture, drug delivery, and biotechnology applications domain showing high- accomplishment materials with individual and innovative characteristics, ideal for many advanced implementations [4]. The final properties of nanocomposites are based on the polymer matrix used , the functional groups, and the size with the shape of the nanofillers , also dispersion into the polymer matrix, interfacial

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interactions [5]. Due to their applications across a variety of fields, like building blocks in the construction regarding functionalized organometallic/organic materials as well as sensor materials, benzidine derivatives, like 3,3'-dimethoxybiphenyl-4,4'-diamine , have attracted increasing attention recently [6-9]. Additionally, benzidine derivatives have made it possible for them to be used in cell biology as staining agents as well as electroactive organic polymeric compounds [10-13].

In this study, new polymer blending was synthesized from a prepared polymer mixed with different polymers [polyvinyl alcohol (a synthetic polymer) or chitosan (a natural polymer). Then it was mixed with silica nanoparticles to produce newly nanocomposites and study their effect on different types of bacteria.

MATERIALS AND METHODS

Instrumentation

The FT-IR Spectra have been registered on

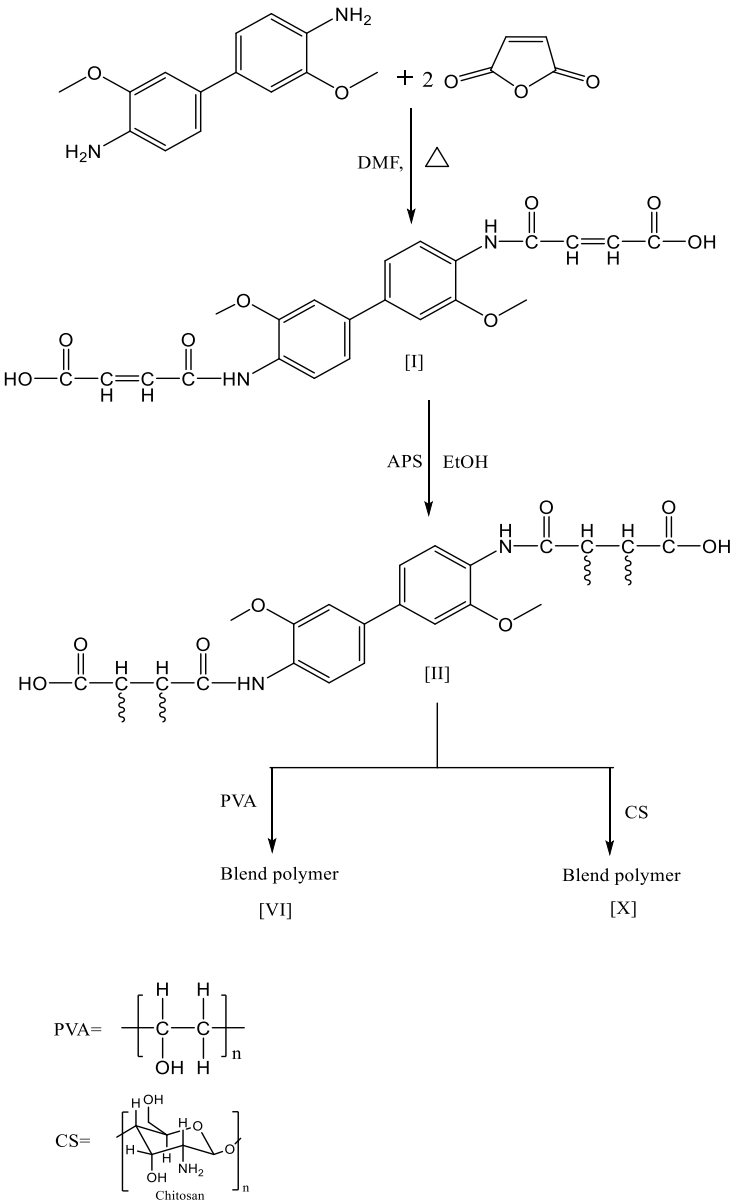

Fig. 1. Synthesis of polymer and polymer blend

Shimadzu FT-IR-8400s, ranging between 400-4000cm^{-1}, using the KBr disk. ^{1}H-NMR spectra were carried out by company: Ultra Shield 400MHz, Bruker, University of Tehran-Iran.

General procedure methods

In order to obtain newly polymers, we illustrated Figs. 1-3.

Synthesis of 4,4'-((3,3'-dimethoxy-[1,1'-biphenyl]-4,4'-diyl) bis(azanediyl)) bis (4-oxobut-2-enoic acid) compound [I] [14]

Maleic anhydride (1.96 g, 0.02 mol) and 3,3'-dimethoxybiphenyl-4,4'-diamine (2.44 g, 0.01 mol) were combined in 25 ml of DMF, refluxed for roughly 4 hours, and the viscous byproduct washed with diethyl ether before being dried at room temperature. Yield 90%; Color: pale brown.

Synthesis of polymer [II][15]

(0.44 g, 0.001 mol) of compound [I] in (15 mL) of EtOH, then add 0.14 g of ammonium per sulfate

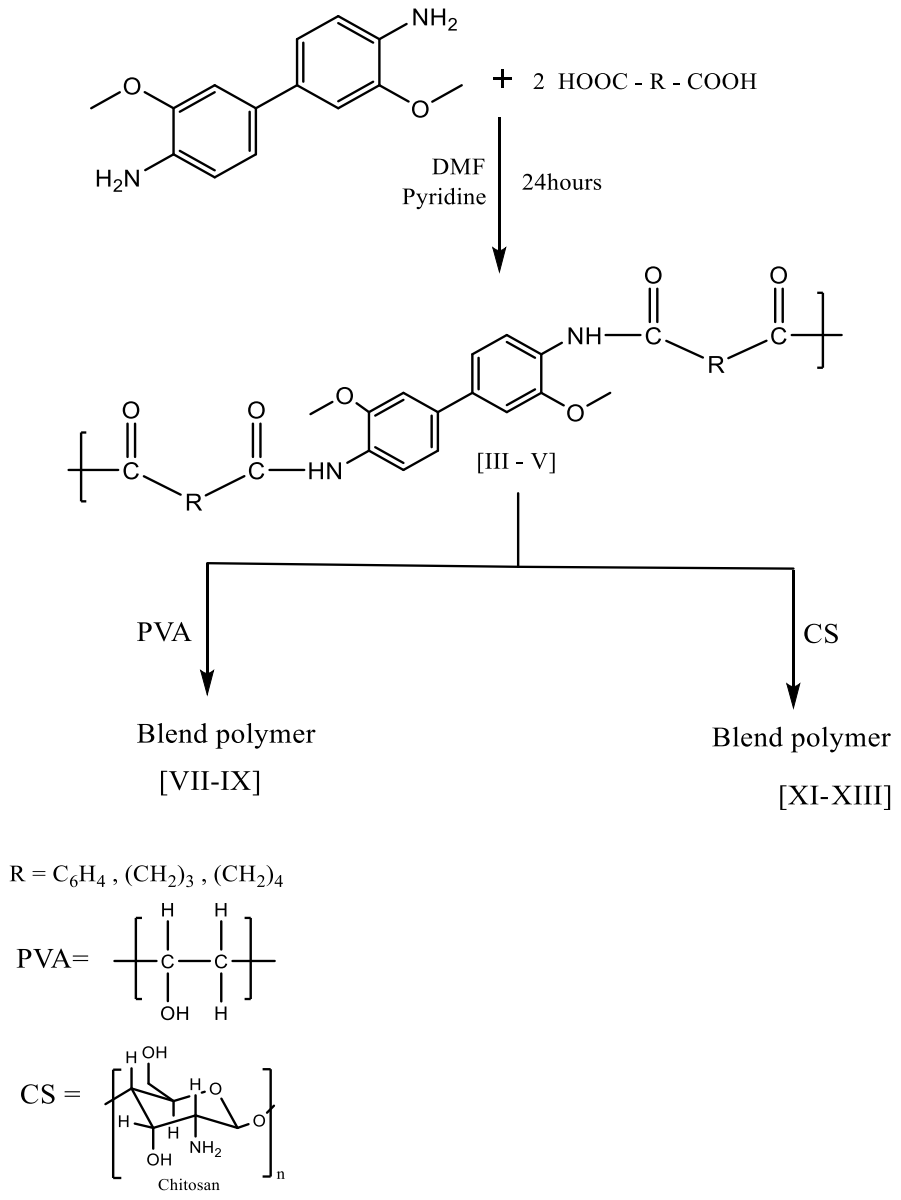

Fig. 2. Synthesis of polymer and polymer blend

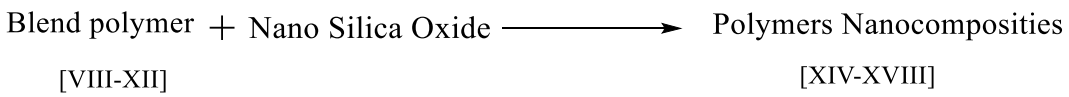

Fig. 3. Synthesis of Nanocomposites

(APS) As a polymerization initiator and were combined. The mixture refluxed for around 12 hours after 3 hours of room temperature stirring. To produce the desired product, the mixture was filtered, washed with cold EtOH absolute, dried and recrystallized with ethanol: dietylether (1:2).

Synthesis of polymers [III-V] [16]

3,3'-dimethoxybiphenyl-4,4'-diamine (2.44g, 0.01 mol) has been dissolved in DMF (10mL). with the help of a few drops of dry pyridine .After the mixture had cooled , adipic acid or glutaric acid or isophthalic acid (0.02mol.) were added while stirring. The stirring persisted for a full day. Afterward, the mixture was transferred to ice water along with 5ml of concentrated hydrochloric acid. The precipitous item has dried and been filtered.

Synthesis of Polymer Blend [VI-IX] [17]

The polymer blends were prepared from prepared polymer [II-V] blending with polyvinyl alcohol in 5:5: ratio using solvent casting method. PVA was dissolved in the hot water for the purpose of producing 5 wt% solutions of polymer then mix with one of solution of prepared polymers [II-V]. Both solutions of the polymers were mixed and a homogenous solution has been made with the use of hot-plate stirrer for a duration of 60min.

Synthesis of Polymer Blend [X-XIII] [17]

Polymer blends were produced by using solvent casting method. chitosan dissolved in 2% solution of aqueous acetic acid with the stirring at the temperature of the room, then mix with solution of prepared polymers [II-V] Both solutions of the polymers were mixed and a homogenous solution has been made with the use of hot-plate stirrer for a duration of 60min. polymer [II-V] and chitosan have been done through the mixing of (one ratio) in (5:5).

Synthesis of Nanocomposites [XIV-XVIII] [18,19]

100mg of the dried polymers blend [VIII-XII] has been put in 50mL of the silica oxide solution of a 250mg/L concentration as well as 1.5h sonication to bond the silica nano metal in blend matrix by the electro-static force, then the mixture was poured into petri dish.

RESULT AND DISCUSSION

The study includes synthesis regarding a series of polymer blending based on 3,3'-dimethoxybi phenyl-4,4'-diamine moiety with different polymers polyvinyl alcohol (synthetic polymer) or chitosan (natural polymer). The final step employs

Table 1. FT-IR data of polymers [III-V]

Comp. No.	υ (N-H)	υ (C-H) aliph.	υ (C=O) amide	υ (C=C)	υ C=O of (COOH)
[III]	3161	2983,2908	1664	1600	1708
[IV]	3180	2958,2877	1660	1590	1693
[V]	3186	2924,2854	1662	1596	1690

Table 2. FT-IR data of blend polymers [VI-IX]

Comp. No.	υ (O-H) and (COOH)	υ (C-H) aliph.	υ (C=O) amide	υ (C=O)of ester	υ (C=C)
[VI]	2400-3600	2950,2843	1651	1716	1590
[VII]	2400-3600	2900,2873	1651	1705	1600
[VIII]	2400-3600	2939,2912	1662	1708	1586
[IX]	2400-3600	2985,2885	1635	1708	1602

Table 3. FT-IR data of blend polymers[X-XIII]

Comp. No.	υ (O-H) and (NH_2)	υ (C-H) aliph.	υ (C=O) amide	υ (C=O)of COOH	υ (C=C)
[X]	2400-3600	2920,2870	1666	1689	1600
[XI]	2400-3600	2943,2912	1651	1690	1590
[XII]	2400-3600	2900,2873	1651	1881	1600
[XIII]	2400-3600	2912,2800	1674	1885	1585

designing of a newer nanocomposite [XIV-XVII] using greener method from polymers blend [VIII-XII] with nano oxide silica by stirring only. The structures of each synthesized compounds have been identified using their spectral data and physical compounds. Compound [1] produce from 3,3'-dimethoxybiphenyl-4,4'-diamine with Maleic anhydride in DMF. Compound [I] was identified by FTIR spectroscopy. The FTIR absorption (υ, cm^{-1}) disappearance (-NH_2) group and appearance 1660 cm^{-1} (C=O-NH), In addition to the peaks: 3400-2400 (OH), 3180 (NH)group, 1693 (C=O) of the carboxylic acid. Polymer [II] was synthesized by the reaction of compound [I] in absolute EtOH by the use of the APS as the initiator. FT-IR spectrum (υ, cm^{-1}): show stretching band that refers to O-H related to COOH moiety in a region 3400-2400, a stretching band regarding N-H group appearing at 3180 , 3035 (C-H aromatic), (2908,2843) of (C-H aliph.) as well as a stretching band to (C=O-NH) and (C=O- COOH) appeared at1651,1685, respectively [20,21].

^{1}H NMR (δ ppm) of polymer [II]: singlet signals at 3.85 ppm due to six protons for two OCH_3 groups, -CH=CH chemical shifting is disappeared and show signals at δ (4.35) because of -[CH-CH] $_n$-, (6.90-8.58) ppm that attributed to the eight aromatic protons, 8.59 ppm and 12.07 ppm for a sharp signal could be a result of to 2(NH)and proton of 2(OH) carboxylic group. Polymer [III-V] were synthesized by the reaction of 3,3'-dimethoxybiphenyl-4,4'-diamine with Glutaric acid or Adipic acid or iso phthalic acid in DMF and pyridine, FT-IR spectrum of polymer [IV] show disappearance (-NH_2) group and appearance 1660 cm^{-1} (C=O-NH), 3180 (NH) group, (2958,2877) cm^{-1} of (C-H aliph.) and 1693 cm^{-1} of (C=O-OH). ^{1}H NMR (δ ppm) of polymer[V]: a multiple signals at(1.23-1.39)ppm to $CH_2CH_2CH_2CH_2$, singlet signals at 3.80 ppm due to six protons for two OCH_3 groups, triplet signals at (4.30-4.32), (4.84-4.80) (due to NH-C=O-CH_2 and CH_2-C=O respectively , (6.63-7.26) ppm that attributed to the eight aromatic protons, 8.25ppm for a sharp signal could be a result of to 2(NH) [22]. Polymer

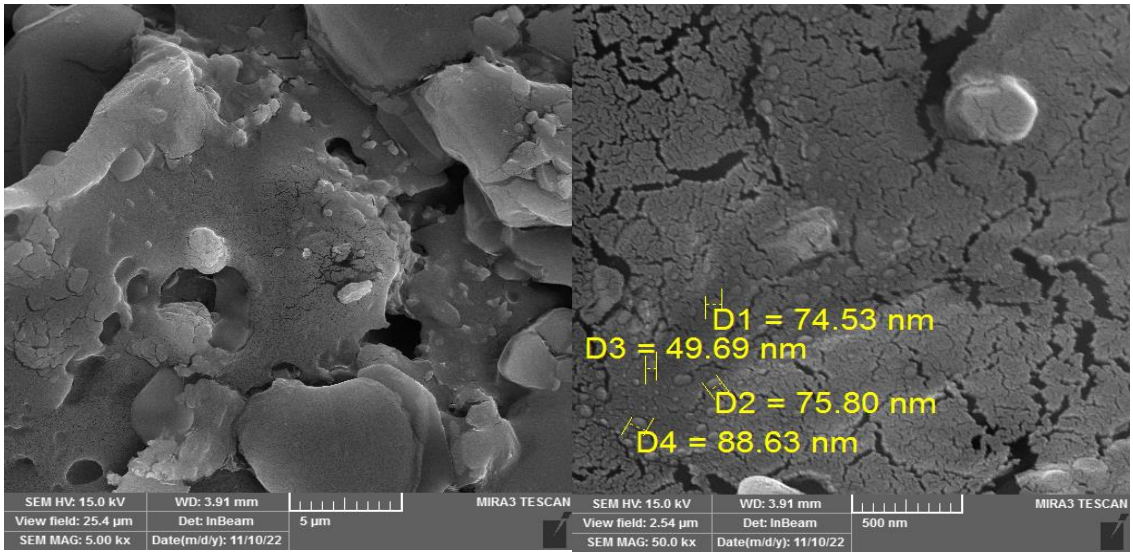

Fig. 4. SEM of polymer [VIII]

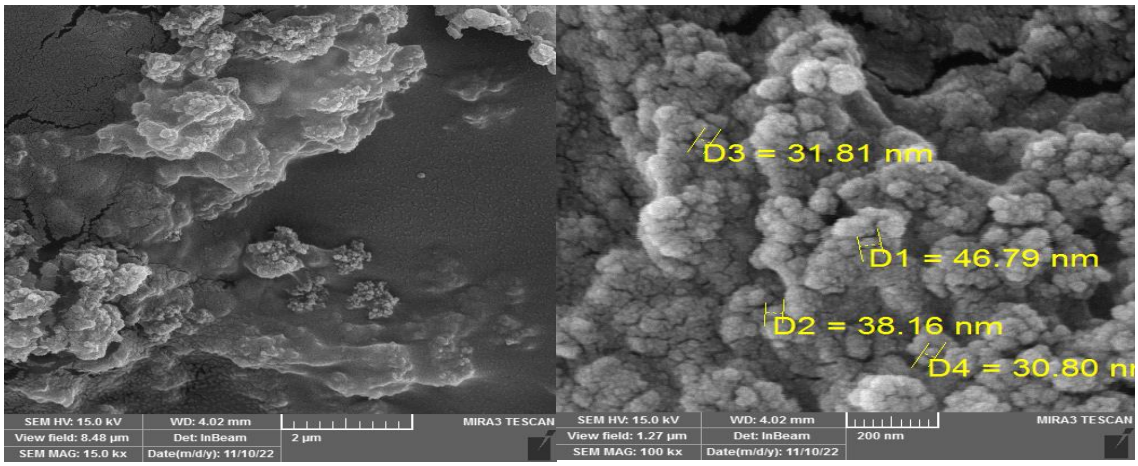

Fig. 5. SEM of polymer nanocomposite [XIV]

Blend [VI-XIII] were prepared from prepared polymer [II-V] with polyvinyl alcohol or chitosan respectively using solvent casting method. The FT-IR spectrum of polymer [VI] shows a broadening peak in (3600-2400) cm^{-1} region because of a strong inter-molecular bonding of hydrogen that exists between hydroxyl groups of polymers [II] and PVA's hydroxyl groups, 1716 cm^{-1} as a result of (C=O) of ester. FT-IR spectrum of polymer [X] show, the peak broadening in (3600–2400) cm^{-1} region because of a strong inter-molecular bonding of hydrogen that exists between amino groups of Chitosan and hydroxyl groups of polymers [II] and 1666 cm^{-1} as a result of (C=O-NH)[23,24]. Tables 1, 2 and 3 provide a list of the collective FT-IR spectral data collected for significant compounds.

Scanning Electron Microscope Studies (SEM)

The morphology of the surface varies for selected polymer blends [VIII] produce from polymer [IV] blends with polyvinyl alcohol, polymer nanocomposite [XIV] produce from polymer blend [VIII] with nanocomposite (silica oxide) that has been loaded with the silica. Adding PVA imparts roughness to blend membrane and results in the alteration of the blend membrane surface topography and has considerable impact upon the cell spreading. The average size of the particles of polymer [VIII] is ranged between (49-88) nm, Fig. 4.While SEM micrograph of for presence of silica oxide has been noticed to be with the homogenous distributions on the matrix surface. The average nano size of the particles is ranged between (30-46) nm for silica nanoparticles, Fig. 5. The particles in nanocomposite film were found with almost spherical morphology. However, some of the agglomerations of nanoparticles were also found the figures and the surface was somewhat rough [25,26].

Biological activity

Biological activities of the selected blended polymer [VIII, XII] produce from polymer [IV] blended with PVA or chitosan, respectively and Polymers nanocomposites [XIV],[XVIII] produce from polymers [VIII,XII] with silica oxide have been tested against two pathogenic bacteria types *(G+) Staphylococcus aureus* and *E. coli* (G-), utilizing the diffusion inhibition approach and compare with Amoxilline (Fig. 6). The results of antimicrobial

Table 4. Antibacterial screening data of some synthesized polymers.

Comp.No.	*Escharia .coli*	*Staphylococcus aureus*
Amoxilline	17	21
[VIII]	8	8
[XII]	10	9
[XIV]=[VIII] with Silica	21	22
[XVIII]=[[XII] with Silica	23	25

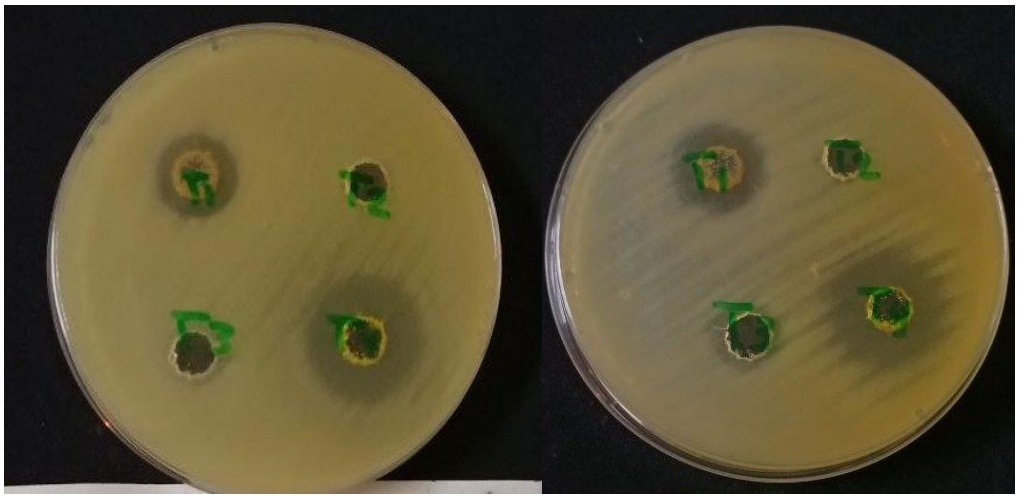

Fig. 6. Antibacterial activities of polymers against *Staphylococcus aureus* and *E.coli*

Table 5. Inhibition in different concentration

Comp.No.	Inhibition rate of Concentration12.5 µg mL^{-1}	Inhibition rate of Concentration25 µg mL^{-1}	Inhibition rate of Concentration50 µg Ml^{-1}
[XIV]	70.61	75.4 3	80.13
[XVIII]	74..90	79.28	85.34

activity are represented in Table 4. The ternary mix polymers blend [VIII, XII] with Si nano composite that was exhibit very good antimicrobial activities when compared with Amoxilline commonly used as antimicrobial agents. Due to an excess of carboxylic groups, which dissociate to leave a negatively charged cell surface, bacteria have a negative surface charge at biological pH levels. Electrostatic forces are responsible for the bioactivity and adhesion regarding bacteria and NPs because of their opposing charges. In comparison to larger particles, NPs have a higher surface area available for interactions, which boosts their ability to have a bactericidal impact. As a result, they cause cytotoxicity in the microorganisms. The amount of surface area that the NPs had an impact on their antibacterial qualities. Greater antibacterial activity is exhibited by smaller particles with a higher surface to volume ratio [27,28].

Anticancer activity

Cell lines were prepared for cytotoxicity assay [29] by using cultured cells (96 Wells) in a micro titer plate. The absorbance was measured at (620 nm) on a micro plate reader. The anticancer activity of various concentrations of some nanocomposites were investigated against human breast cancer cell line (MCF-7) and Rat Embryonic Fibroblasts (REF) revealing a good activity, which had no effect on the growth of normal Rat Embryonic Fibroblasts. Calculated cell growth inhibition rate granted to equations [30]:

$$\text{Inhibition rate} = \frac{mean\ of\ control - mean\ of\ treatment}{mean\ of\ control} \times 100$$

The nanocomposites [XIV],[XVIII] exhibit good inhibition in concentration (12.5,25, 50) µg/ml . SiNPs can induce cytotoxicity through increase the ROS level, generating damage to cellular components through intracellular oxidative stress

CONCLUSION

Polymer blending based on 3,3'-dimethoxybi phenyl-4,4'-diamine were prepared with different polymers [polyvinyl alcohol (synthetic polymer) or chitosan (natural polymer). Then Nanocomposites were designed from polymers blending with

silica nanoparticles (SiNPs) in very good yield. Numerous antibacterial activities were found in synthesized Nanocomposites polymers. Significant antibacterial activities against *E. coli and S. aureus* were seen in vitro for [XIV] , [XVIII], then study anticancer activity human breast cancer cell line (MCF-7) of and compare with normal cell line Rat Embryonic Fibroblasts(REF) for nanocomposities [XIV] , [XVIII]; this may be due to the existence of Nano silica with -amide groups in its composition. As a result, more biological analysis and cutting-edge research are anticipated to show them to be extremely attractive lead and parent compounds regarding the synthesis and design of novel pharmaceutical medications.

CONFLICT OF INTEREST

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

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