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RESEARCH ARTICLE

Preparation, Characterization and Antimicrobial Activity of Chitosan Schiff Base / Polyvinyl Alcohol Nanocomposite

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Abstract

Schiff base of chitosan with Para-Dimethyl aminobenzaldehyde /PVA-Ag Nanocomposite have been prepared as antimicrobial polymer. The prepared chitosan Schiff base and chitosan Schiff base / PVA-Ag nanocomposite were characterized by FT-IR, SEM analysis and biological activity. The nanocomposite showed good activity against different types of bacteria.

Keywords: *Chitosan, Chitosan Schiff base, Ag-nanocomposite, antimicrobial polymer.*

Introduction

Nano-composites containing normally occurring polymers (bio-polymer) mixed with inorganic nano moiety speak to another material class which is referred to as Bio-nanocomposites (BNCs), which are utilized for fabricating implants, scaffolds, systems of drug-delivery, and diagnostics and bio-medical devices. It is utilized as well in the industry of cosmetics [1, 2]. Chitosan may be utilized as a bio-material because it is bio-compatible, bio-active, bio-degradable, and has a low toxicity effect. This method promoted the chitosan for being utilized in medical [3], agricultural, environmental, and pharmaceutical areas [4, 5]. Moreover, chitosan is utilized in the domain of packaging because it is highly efficient to inhibit spoilage via destroying the pathogenic micro-organisms which contaminate the food [6].

Chitosan's anti-microbial activity may be a result of the basic polymer nature and its amine content. Chitosan is capable of binding and disrupting normal bacteria membrane functions via the promotion of intra-cellular components' leakage and inhibiting the nutrient's transport into cells [7, 9].Schiff bases have been commonly utilized especially in areas of medicine and pharmaceutics. As a result of their wide biological activities spectrum, which include anti-fungal, anti-diabetic, anti-tumor, herbicidal, anti-proliferative, anti-cancer, and anti-inflammatory effects [10] numerous Schiff bases of chitosan have been produced via the coupling of different aldehyde types with free chitosan amine groups in the past few years by numerous scholars and those schiff bases of chitosan were considered as potential anti-bacterial factors [11]. The Schiff-bases of chitosan have been noticed to be more potent anti-microbial agents compared to the chitosan [12, 13, 14].

Nano-particles of Silver (Ag) are of high therapeutic potential and show sufficient anti-microbial activity. Nano-particles of silver have many different anti-microbial activities and show high efficiency even at considerably low values of concentration. Nano-particles of silver were characterized to be possessing sufficient potential for treating cancer [15].Poly (vinyl alcohol) PVA, is considered as one of the oldest and most frequently used synthetic polymers with good biocompatibility properties [16].

PVA as hydrophilic polymer is of exceptional characteristics, like highly sufficient physicomechanical characteristics, non-toxicity and bio-compatibility, in addition to the high swelling characteristics that make them preferable for bio-material and bio-medical applications. Via the physical cross-linking of the PVA, there is a possibility for the elimination of residual amount of the toxic cross-linking factor in comparison with

chemical cross-linking. In addition to that, with the addition of the fillers (fibers or particle) to PVA and producing PVA based blends, preferable mechanical characteristics may be achieved which, as a consequence are capable of mimicking the different texture and characteristics of the human tissues [17].

Experimental

Materials

Chitosan was obtained from HUISUN PHARMA and all reagents and solvents were obtained from Sigma-Aldrich, HIMEDIA, CDH, BDH, and Solvochem.

Preparation of chitosan Schiff base [18]

Chitosan was dissolved in glacial acetic acid and stirred for 30 minutes at room temperature. Then the aldehyde Para-Dimethylaminobenzaldehyde (pDMAB) was added to the mixture to prepare graft polymer. The mixture was magnetically stirred and heated at a temperature of 60°C for 24 hours. After cooling, the crude product has been washed with ethanol. The product was dried at room temperature for 24 hours. The synthetic route of chitosan Schiff base is shown in Figure (1-1).

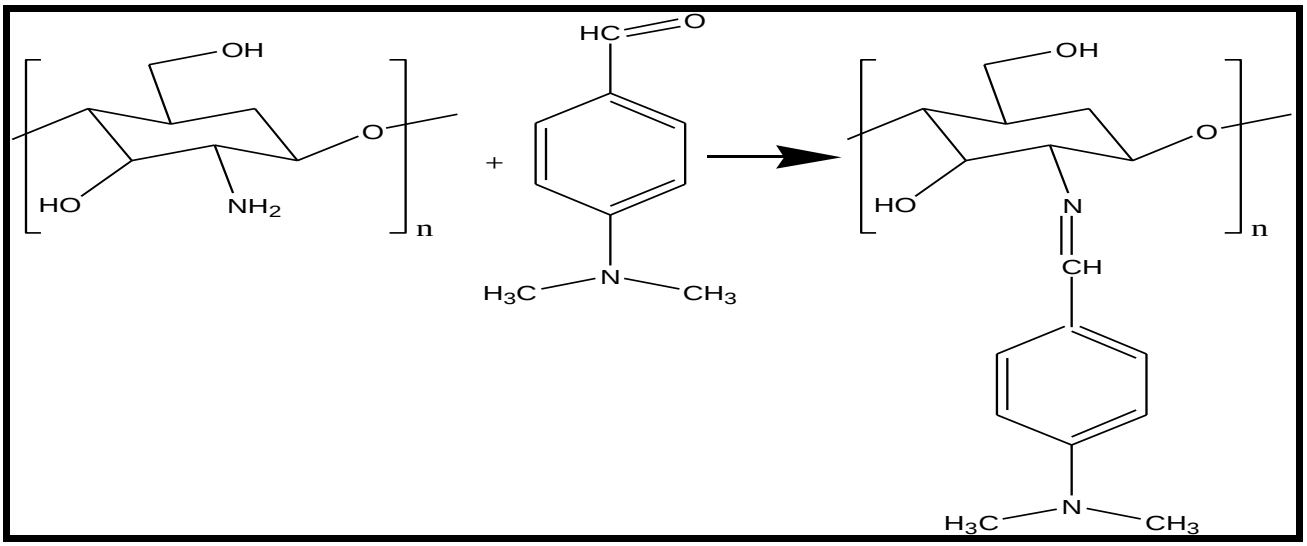

Figure 1-1: The synthetic route of chitosan-based Schiff base

Polymer Blend Preparation [19]

Polymer blends have been prepared with the use of the solvent casting approach. Chitosan Schiff base solutions have been prepared with the dissolution of the Schiff base of chitosan in 2% solution of the aqueous acetic acid with stirring at room temperature. The PVA has been dissolved in hot water in order to produce 5wt% solutions of the polymer. Both the polymer solutions have been mixed and make homogenous solution using sonicator. Cs/PVA blends were done by mixing one ratio Cs: PVA (5:5).

Preparation of Cs/ PVA Silver Nanocomposites [20]

A 100 mg of dried Cs/PVA blend was placed in 50 mL of Ag solution of concentration 250 mg/L and sonication for 1.5 h to bond Ag nano metal in the blend matrix by electrostatic force.

Results and Discussion

FT-IR Analysis for Chitosan Schiff base

Chitosan Schiff base was produced from chitosan reaction with paradimethylaminobenzaldehyde, Figure 1-2, represents the FT-IR spectrum for pure chitosan assigned as follows: The broad band at 3600-3200 cm^{-1}corresponding to (N H and O–H stretching vibration), 2881cm^{-1} is due to (C-H symmetric stretch), 1645 cm^{-1}(C=O stretching vibration) (amide I), 1423 cm^{-1} (C–N stretching vibration), 1601 cm^{-1}(N-H bending) (amide II), 1157 cm^{-1} (C-O-C bending vibration), 1379 cm^{-1} (CH_3 bending vibration), and 1090 cm^{-1} (C–OH stretching vibration).

However, FT-IR spectra of chitosan Schiff base, Figures 1-3 showed a new absorption band at 1639 cm^{-1} attributed to ν(C=N) of imine group. The absorption band at 1554 cm^{-1} assigned for the C=C of aromatic aldehyde. [21, 22]

Polymer blends were prepared by solvent casting method. The FTIR spectrum of the blend polymers showed a broad band of

combined absorption values ranging between 3600 and 3000 cm-1 assigned for primary amine and hydroxyl groups (NH_2 and OH) stretching vibrations, as in Figure 1-4:

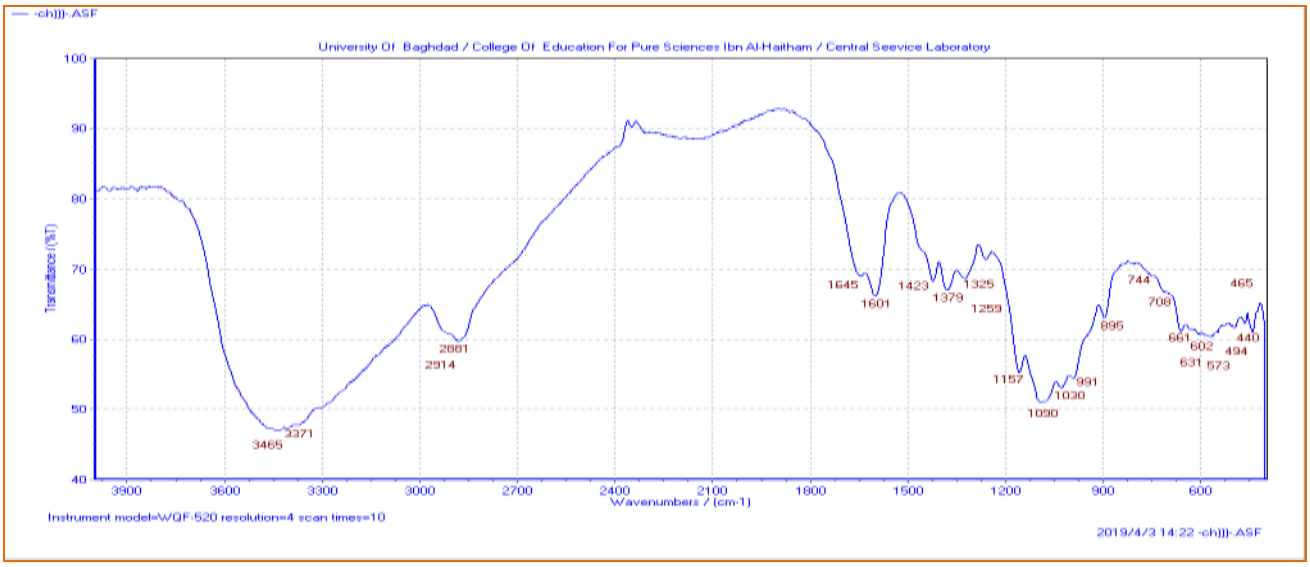

Figure 1-2: chitosan FT-IR spectrum

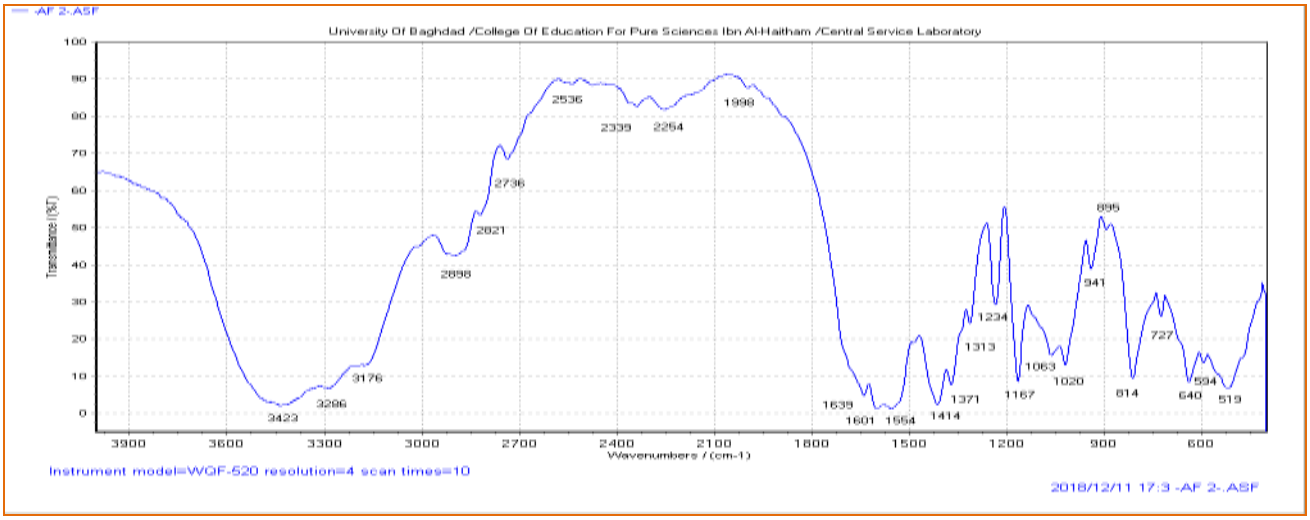

Figure 1-3: FT-IR spectrum of chitosan Schiff base

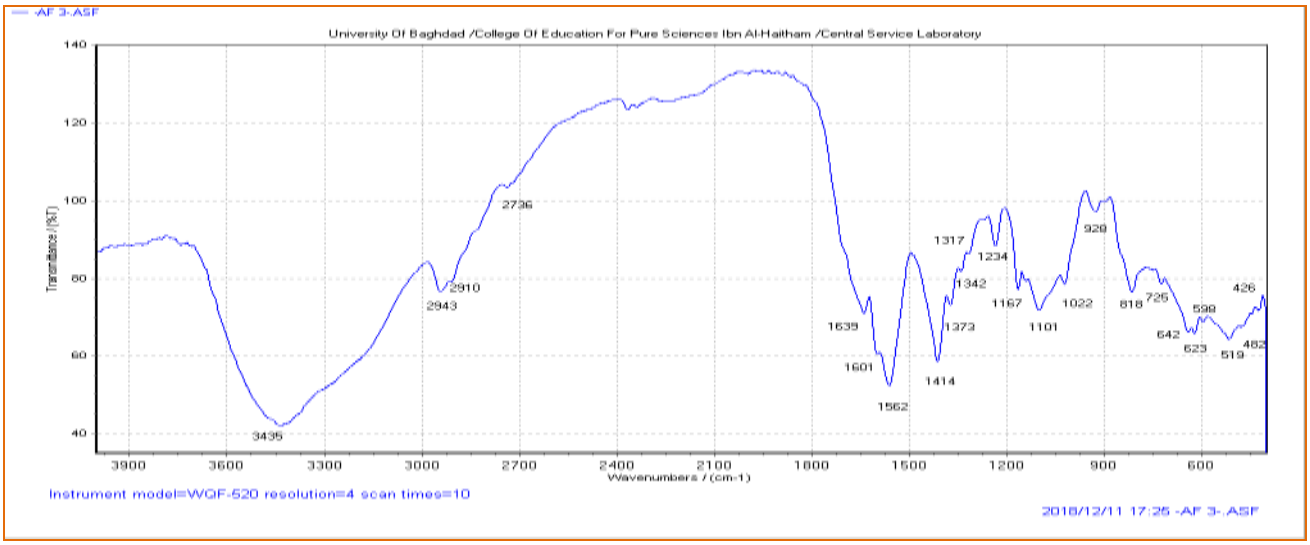

Figure 1-4: FT-IR spectrum of blend

Scanning Electron Microscope Studies (SEM)

The SEM micrograph for chitosan Schiff base/ PVA nanocomposite loaded with nano-particles of Ag (AgNPs) has been depicted in Fig. (1-8).The surface appears porous with some inclusions. The existence of nanoparticles of Ag is noticed to be with

homogenous distribution on the surface of the matrix. Rough appearance of the surface has been noticed for the chitosan Schiff base's surface morphology in the presence of N, N-dimethyl amino benzaldehyde. AgNPs are well distributed through the whole matrix.

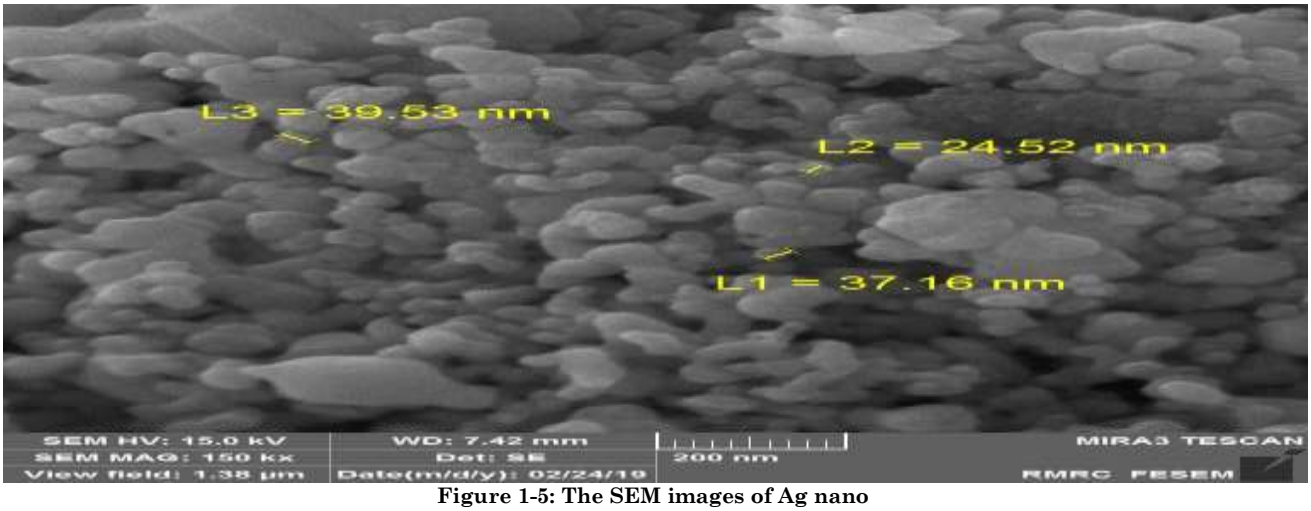

Figure 1-5: The SEM images of Ag nano

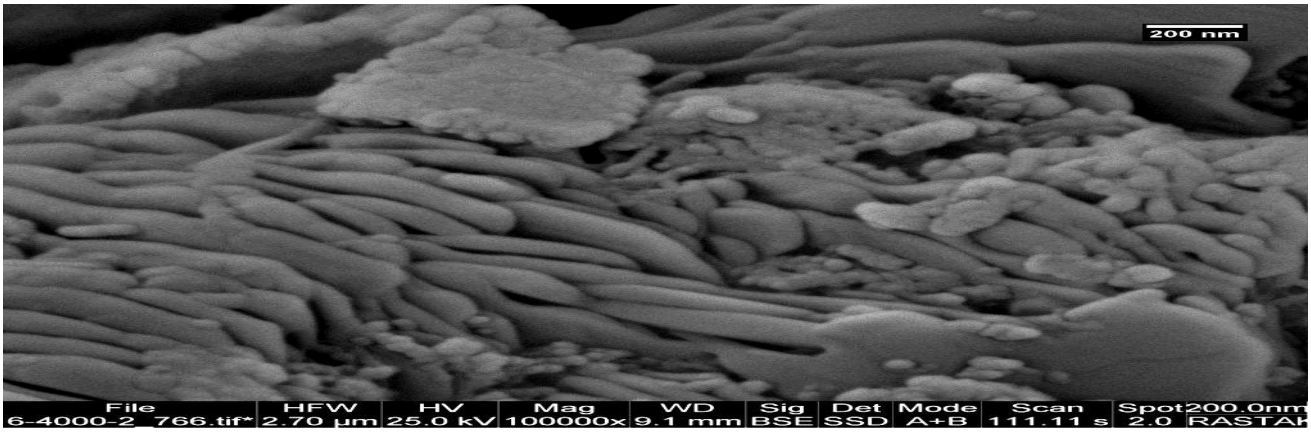

Figure 1-6: The SEM images of chitosan Schiff base

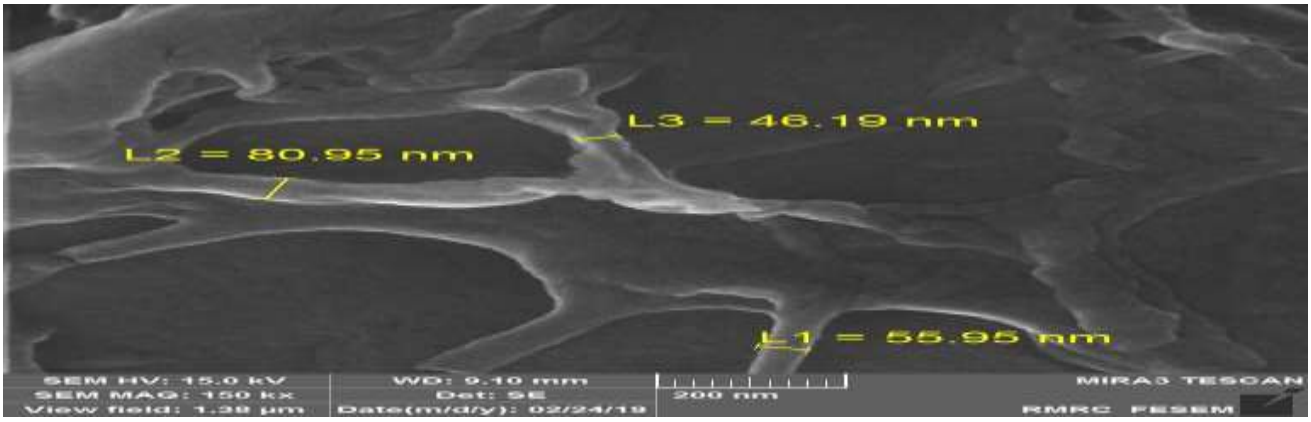

Figure 1-7: The SEM images of blend 50l50

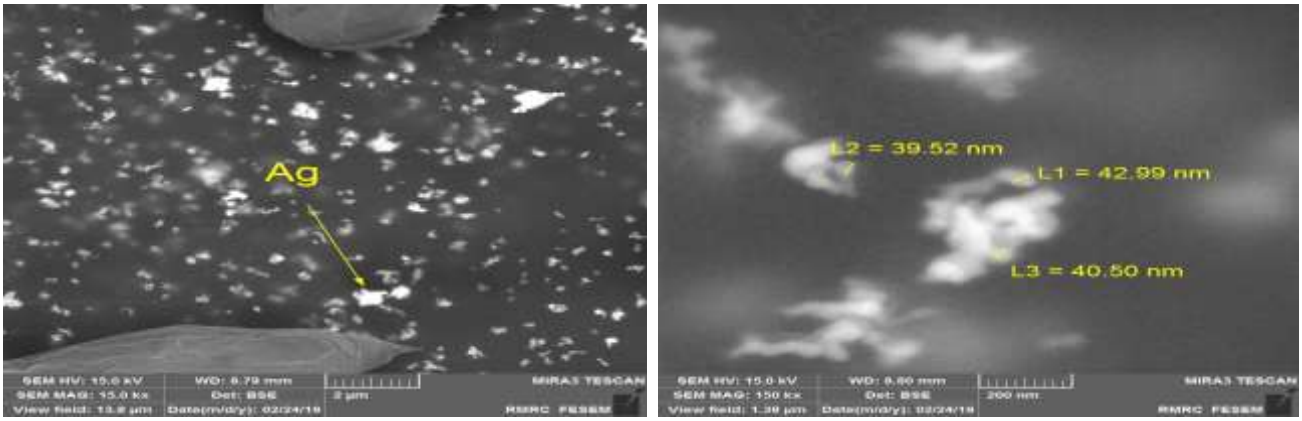

Figure 1-8: The SEM images of nano composite 50l50

Biological Activity

The biological activity of the polymer blend and chitosan Schiff base/PVA Ag nano composite, were tested against four types of pathogenic bacteria using Diffusion inhibition method. The results of anti-bacterial activity have been represented in Table (1-1). Samples have been assessed for the anti-bacterial activity against the Gram negative bacteria (Pseudomonas aeruginosa and Escherichia coli) and Gram positive bacteria (Staphylococcus aureus and Bacillus cerues). It is evident from Table (1-1) that all of the compounds that have been tested exhibited high anti-microbial activities. It has been noticed that the synthesized Schiff base and the nano composite positively impact the growth of each of Gram positive and Gram negative bacteria which produces a zone of inhibition that reached 20mm diameter. The prepared chitosan Schiff base has considerably higher anti-microbial activities towards tested micro-organisms that may be a result of the chemical structure. It's considered that the existence of imine groups,-C=N, of the Schiff-base with its π-electrons could enhance the molecule lipophilicity, which leads to more easily penetrating the molecule of the Schiff-base in the membrane of the cell of the microbe. It can be followed with the respiration process disturbance of the cell of the microbe. Ultimately, proteins synthesis is blocked and additional bacteria growth is going to be hindered. Blending with the PVA and silver nanoparticles increases the polarity, and that subsequently results in the decrease its penetration in the membrane of the cell as a result of increasing the polarity of the chains. Which causes a decrease in the anti-microbial activity to lower degree compared to the actual chitosan Schiff base, as seen from Table (1-1).The nano-particles' action mode in anti-microbial action considerably differs from ordinary biocides. Furthermore, experimental results indicated that the complexes show more activity than ligands under the same experimental conditions with the same kinds of bacteria.

Table 1-1: The biological activity of compounds

Compound	*Escherichia Coli*	*Staphylococcus aureus*	*Bacillus cerues*	*Pseudomonas aeruginosa*
Chitosan Schiff base(Cs)	19	15	30	20
Blend	15	13	_	17
Nano Composite	13	14	14	15

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