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RESEARCH PAPER

Synthesis and Characterization of New Carboxymethylcellulose Coated Ag Nanoparticle as Antibacterial

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ABSTRACT

Carboxy methyl cellulose has been used to coat Ag nanoparticles to synthesized Nano solutions. FTIR and SEM methods were used to analyze the physicochemical characteristics of Nano solutions as they had been synthesized. Due to their use in medical applications, silver nanoparticles are discovered to exhibit potent antibacterial activity. By manipulating the synthetic silver nanoparticles' size and form, antibacterial activity can be controlled. The synthetic chemicals' antimicrobial properties carboxymethylcellulose coated (Ag) nanoparticle was also screened on various bacteria. The prepared polymer shows excellent antimicrobial activities. The findings demonstrated that together "Gram-positive as well as Gram-negative bacteria" may thrive without being hampered by nanoparticles. Compared to Gram-negative bacteria, Gram-positive bacteria were highly responsive to biogenic NPs. This is consistent with the finding that gram-positive bacteria are more vulnerable to Ag NPs coated with biogenic polymer (CMC) than gram-negative bacteria. As a consequence, it might be challenging to evaluate bacterial exposure to NPs.

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INTRODUCTION

Nanotechnology has recently been acknowledged as a crucial and fruitful technology that can contribute to a variety of fields including physics, chemistry, engineering, medicine, and biology. These attributes include high oxidation resistance, strong antibacterial activity and high thermal conductivity. It manifests a lot of potential for spawning a variety of innovations that will change the direction of technological advancements in the near future. [1, 2]. Silver is also thought to be particularly essential because it performs better in a variety of applications [3]. Aside from their numerous applications SERS, or surface-enhanced Raman scattering catalysis, electronics, as well as sterilization that is antimicrobial to lessen toxicity toward mammalian cells, silver nanoparticles may be produced in a variety of forms, such as cubes, spheres, discs, rods, wires, stars, and right bipyramids [4,5]. Various techniques for creating silver nanoparticles, including physical, chemical, and biological ones, have been established. Chemical reduction has some benefits, including producing nanoparticles without aggregation, a high yield, little preparatory costs, and a simple and gentle process. [6,7].

Since It has been discovered that silver

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nanoparticles have potent antibacterial and strong inhibitory influences and a wide range of antimicrobial activities, they are utlized for centuries to both stop as well as treat illnesses, particularly infections. Numerous studies claim that the antifungal, antiviral, anti-inflammatory, and antiangiogenic properties of silver nanoparticles [8, 9]. Ag NPs' adherence and penetration to bacterial cell membranes is one key mechanism of silver nanoparticles' antibacterial properties [10]. The antimicrobial properties of the silver nanoparticles are effectively utilized in fields and applications such as materials for water filtration [11], textiles [12], as well as disinfection or for medical purposes. [13].

In this research is to prepared the new polymer coated nanoparticles (Ag) as antimicrobial polymers and test against different types of microorganisms for determination the biological activity including as Gram-positive microorganisms Pseudomonas aeurginosa, a gram-negative bacterium, and Staphylococcus aureus.

MATERIALS AND METHODS

Carboxy methylcellulose (MERCK), silver nanoparticles (MERCK). ciprofloxacin and amphotericin –B drugs (BDH).

Instruments

FTIR TENSOR 27, a Fourier transform infrared spectroscope made by Braun, Germany the measurement was done at the University of AL Qadisiyah College of Engineering. The shape of the nanoparticles' fracture surface and the distribution of the nanoparticles were determined using scanning electron microscopy (SEM). The in-strument was a FEI Nova Nano SEM 230 from Eindhoven, the Netherlands, and it was utilized at IRAN on the Electron Microscopy Unit at the setting.

Synthesis of polymer-coated nanoparticles (Ag)

A quick and inexpensive hydrothermal synthesis technique was used to create polymer-coated nanoparticles (NPs) under ambient air conditions. The synthesis techniques have been previously published with changes. The polymer coated nanoparticles were made by mixing 25 mL of ultrahigh quality water and 3.6 g of polymer (carboxymethylcellulose) at 80 °C for 10 minutes. The solution was swirled at 80°C. Ag Nano-particles (1.0 gm) were added to the solution and agitated for another 10 minutes at 80 °C. Sonication was used to re-distribute the suspension in water. For the experiment on oil removal, NPs solutions were kept.

Organisms tested

Gram-positive microorganisms The synthetic polymers' antibacterial properties was evaluated using Staphylococcus aureus and the Gram-negative bacterium Pseudomonas aeurginosa, that came from the College of Science and Biology at AL-Qadisiyah University.

Antibacterial activities

For antibacterial activity, pure cultures of the pathogenic bacteria Staphylococcus aureus, Salmonella typhi, used, as well as Pseudomonas aeurginosa. using a cup or well method has been utilized in antibacterial research. The bacteria were cultured on nutrient agar medium. The mixture was composed of distilled water (1000 ml), peptones (5.0 g), sodium chloride (5.0 g), agar-agar (15 g), as well as beef extract (3 g). Autoclaving was done with the nutrient agar medium. for 15 minutes at 15 psi as well as 121 °C. Petri dishes were sterilized and set on the laminar flow bench. Each petri dish's lid was lifted at one end, and 15 to 20 ml of molten agar medium were then poured inside, where they were left to set. These were then inoculated using the spread plate method with a 0.2 ml suspension of the organismSix wells were made in the medium using a sterile borer—five on the periphery and one in the center—and the standard medication, ciprofloxacin, at the same concentration, was placed in the central well. Then, the filling of peripheral wells with a 500 ppm solution of synthesized carboxy methylcellulose coated Ag nanoparticles. Other petri dishes are paraffin-sealed and incubator-incubated at 37 °C. After 24-48 hours, the zone of inhibition within the petri dishes was investigated. The concentration of samples used to test for antibacterial activity was 500 g/ml. [14].

RESULTS AND DISCUSSION

FTIR Spectrum of CMC- Ag

FTIR spectra of CMC-Ag (carboxymethyl cellulose-Ag) was analyzed Fig. 1. In the FTIR spectrum while the peaks were observed at 476cm^{-1} in CMC-Ag NPs spectrums agree with the occurrence of Ag^+ ions. The vibrations of the adsorbed water, (OH), (CH_2), and (O-CH) are seen at 3554 cm $^{-1}$ and 3324 cm $^{-1}$, 1675 cm $^{-1}$, 1433 cm $^{-1}$, and 1383 cm $^{-1}$, correspondingly A visible band is present at 3434 cm^{-1} due to the presence of -OH groups, intermolecular hydrogen bonds, and intramolecular hydrogen bonds. Strong bands at 1595 cm^{-1} and 1186 cm^{-1} as well as 968 cm^{-1} were attributed to (COO) and (CH-O-CH2) stretch, respectively. [15-17].

SEM of Carboxymethylcellulose-Coated Ag Nanoparticles

The SEM image capture of Ag nanoparticles produced by CMC on drop-coated films. The size, shape, and morphologies of developing silver nanoparticles have been described using scanning electron microscopy. Fig. 2 displays the sample's SEM image. The findings revealed a more pronounced morphology of Ag NPs, with circular, polydispersed particle shapes that ranged in size from 200 to 500 nm. Silver nanoparticles of different sizes as well as shapes might be synthesized by controlling the environment of nanoparticle synthesis, which resulted the entire structure is a transparent network with a smooth surface.

According to Fig. 3, this test reveals the Ag nanoparticles' size and shape at two different magnifications of 5 m and 2 m. The layers and structure of the Nano solution are depicted in these images.

Effects of Antimicrobials on Growth of Organism

Antimicrobials are chemicals which either eradicate or stop the development of microbial cells. Due to their selective activity, some antimicrobials, like penicillin, which are medicines made from microorganisms that treat illnesses brought on by microbial pathogens. In other

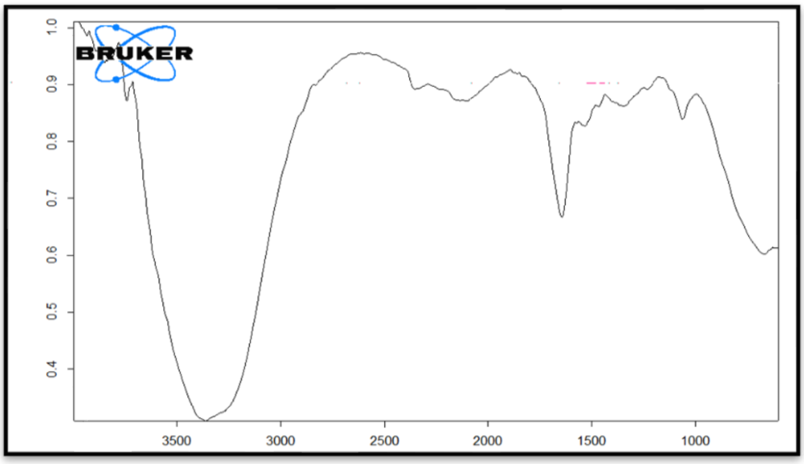

Fig. 1. FTIR Spectrum of CMC- Ag

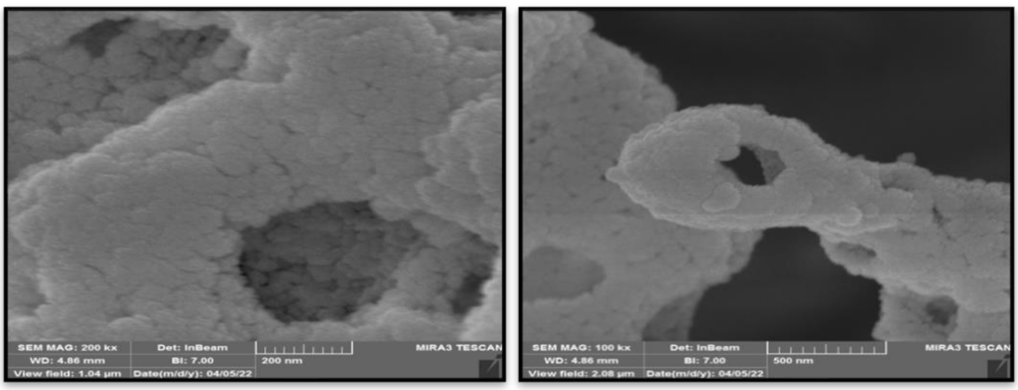

Fig. 2. SEM Image of CMC-coated Ag nanoparticles at of 200 and 500 nm.

words, they disrupt a pathogen's metabolic process or factor while having little to no impact on the host. Selectivity is typically caused by the absence of the biggest component or activity in the host cell. [18].

Factors effected on antimicrobial activity based on synthetic polymers

Numerous groups have demonstrated successful replication of the biochemical activity of antimicrobial polymers. By carefully adjusting the hydrophobicity, specifics of membrane insertion, and charge density of the molecule, this has been made possible. [19] As a result of the interaction of numerous factors, polymeric synthetic mimics' biological characteristics cannot yet be precisely predicted from their chemical structure. However, it has been shown here that the impact of specific design elements, like charge as well as hydrophobicity, onto the characteristics of a polymer series is known. The interactions of polymeric with membranes are relatively the interactions of small antibacterial molecules with membranes as well as cells are poorly understood in comparison to the known mechanistic information. [20].

Charge effected

Due to the negatively charged phospholipids at the outside membrane of Gram-negative

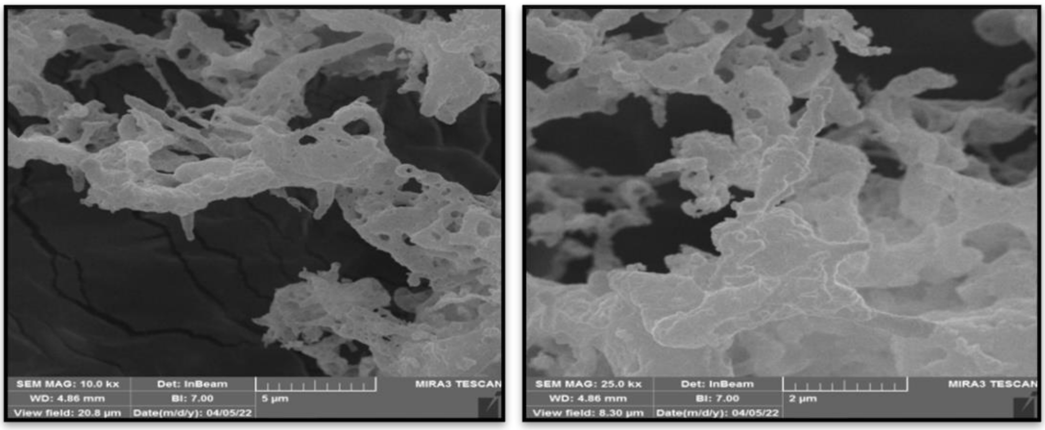

Fig. 3. SEM Image of CMC-coated Ag nanoparticles at 5 and 2 nm.

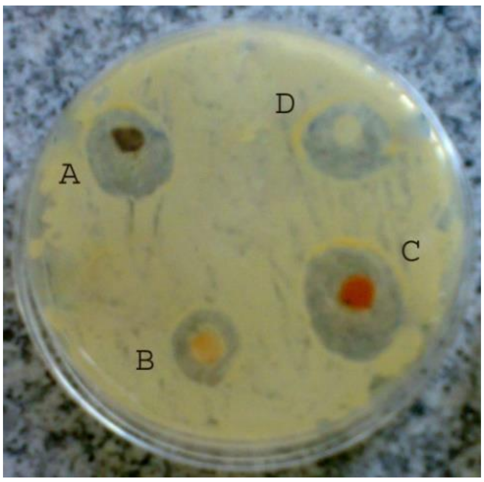

Fig. 4. Anti-bacterial activity of biogenic polymer CMC coated (Ag) NPs against Staphylococcus aureus bacteria. "(1.6 μg/ml), (1.4 μg/ml), (1.2 μg/ml)."

bacteria as well as the teichoic acids of Gram-positive bacteria, microbial cells typically have a negative net charge on the surface. In this way, polycations are drawn to one another, and if they are sufficiently amphiphilic, they can disrupt both the outer and cytoplasmic membranes of the cell, causing death to cell [21].

Hydrophilic/hydrophobic effected

The concept of hydrophilicity as well as hydrophobicity, which determines how prepared polymers interact with bacteria in an antimicrobial manner, is also based on water. Most polymers, it was found to have an overall facially amphiphilic architecture, consisting of an aromatic backbone, cationic hydrophilic and hydrophobic groups arranged on the molecule's opposing faces. [22]. Hydrogen bonds between molecules are also absent. The repeat units changed their functional groups to a facially amphiphilic conformation when they came into contact with the cell membrane or another hydrophilic-hydrophobic interface. by rotating around the single bonds of the backbone [23]. But as the hydrophobicity of the polymers rises, so do their toxicity to microbial cells.

Biological Activity

A polymer called an antimicrobial polymer can get rid of microorganisms by providing sanitizing ions or molecules.

Usage of traditional antimicrobial substances is typically accompanied by issues with residual

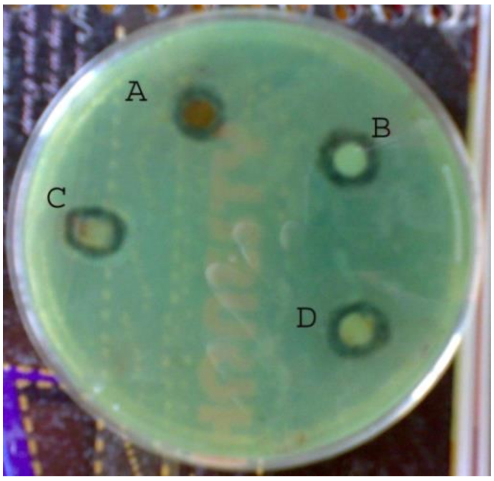

Fig. 5. Anti-bacterial activity of biogenic polymer CMC coated (Ag) NPs against Pseudomonas aeruginosa bacteria. (1.6 µg/ml), (1.4 µg/ml), (1.2 µg/ml).

Table 1. Inhibition zone of bacteria by polymer coated NPs.

Polymer	Bacteria	Zone of Inhibition (mm) Ag (1.0 µg/ml)	Ag (1.2 µg/ml)	Ag (1.4 µg/ml)	Ag (1.6 µg/ml)
CMC-coated Ag	*Pseudomon-as aeruginosa*	**25**	**26**	**27**	**28**
CMC-coated Ag	*Staphylococcus aureus*	28	30	32	34

toxicity of these agents, that may result in higher serious environmental issues. When antimicrobial agents are used in food packaging, for instance, there is a chance that these agents will diffuse into the food as well as lead to a variety of issues [24]. Use of chlorine and other related chemicals is the most widely used treatment method for water disinfection and sterilization. However, because of the concentration of their residues in the environment and food chain, and the potential creation of halomethane similar that are thought to be carcinogenic, their use ought to be avoided. [25].

FTIR Spectra were used to confirm the chemical composition of the prepared polymers. Staphylococcus aureus and Pseudomonas aeruginosa are examples of gram-positive and gram-negative bacteria, correspondingly. are just a couple of the microorganisms that the activity that is antimicrobial of the prepared polymers have shown to be effective against.

High antimicrobial activity in contradiction of gram-positive and gram-negative bacteria is found in polymers having the phenolic, Nitro, Chloro, Amine, Sulfonic, as well as Carbonyl groups [26]. In general, it was discovered that the tested microorganism and the microstructure of the polymer had an impact on the diameter of the inhibition zone. Because there are more and different types of functional groups in polymers, the diameter of the inhibition zone grew higher out of homo-polymer to coated-polymer. The lengthening of the distance between the function groups and polymer backbone also caused an increase in the reserve zone's diameter for prepared polymers [26].

Antibacterial activities

The antibacterial activity was tested using Muller Hinton agar. of prepared polymers was investigated thru inoculating 50 ml of fresh culture broth (18 hrs.).

The made polymers were tested for 24 hours at 37 *°C* against gram positive and gram-negative bacteria, staphylococcus aureus, and pseudomonas aeruginosa. The disc technique was applied to measure the inhibition zones. Antibacterial activity of polymer-coated nanoparticles NPs.

Staphylococcus aureus, gram negative bacteria, and biogenic polymer CMC coated Ag NPs have all been tested for their antibacterial activity. Aeruginosa pseudomonas. The agar well diffusion method was utilized for detecting the antibacterial activity of biogenic polymer CMC coated NPs. Polymer CMC coated Ag NPS with different concentrations (1.0,1.2,1.4, and 1.6 μg/ml) showed inhibition activities against all tested bacteria. The highest inhibition zone of NPs observed in Gram positive bacteria was (34mm) with concentration (1.6 μg/ml) polymer CMC-coated Ag, while the lower inhibition zone was (25mm) in with concentration (1.0 μg/ml) in polymer CMC-coated Ag NPs. as in (Figs. 4 and 5) and (Table 1). It was very similar to other reports where the NPs could inhibit the growing of bacteria at high concentration. The findings demonstrated that together Gram positive as well as Gram negative bacteria can grow without being hampered by nanoparticles. Gram positive bacteria were additionally sensitive to biogenic polymer CMC-coated Ag NPs than Gram negative bacteria. This agrees with reported Gram positive and negative bacteria are more susceptible to NPs as a result, interpreting bacterial exposure to NPs is difficult.

CONCLUSION

Through penetrating the membrane of the cell as well as interacting through amino acids, proteins, as well as nucleic acids, the CMC-coated Ag NPs increase the inhibition zone treated with Ag NP nanoparticles. Additionally, the outcomes support the development of interactive oxygen species and consider increased pressure as well as oxidative stress. Oxidative stress was one of the markers that makes it possible to monitor how toxic heavy metals affect bacteria. The toxic effect of silver ions binding within the bacterial cell wall and plasma membrane is the foundation for this., which results in bacterial respiration being inhibited and disrupting functions like permeability and breathing. It might be fair to say that the amount of particle surface area obtainable for interaction determines the relationship amid the particles as well as the bacteria. Additionally, it is discovered which smaller particles own a greater compared to larger ones, surface, which means that they will interact with bacteria more potently than larger particles.

CONFLICT OF INTEREST

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

REFERENCES

1. Vishakha P, Kalyani D, Balika L, Prof. Vishal B. Automated Robot for Warehouse using Image Processing. International Journal of Engineering Research and. 2016;V5(03).
2. Choi S, Kim K-S, Yeon S-H, Cha J-H, Lee H, Kim C-J, et al. Fabrication of silver nanoparticles via self-regulated reduction by 1-(2-hydroxyethyl)-3-methylimidazolium tetrafluoroborate. Korean J Chem Eng. 2007;24(5):856-859.
3. Beğiç N. Development of silver nanoparticles based on the method using quince seed mucilage for ascorbic acid determination. Phytochemical Analysis. 2023;35(1):87-92.
4. Ijaz Hussain J, Kumar S, Adil Hashmi A, Khan Z. Silver nanoparticles: preparation, characterization, and kinetics. Advanced Materials Letters. 2011;2(3):188-194.
5. Feng A, Wu S, Chen S, Zhang H, Shao W, Xiao Z. Synthesis of Silver Nanoparticles with Tunable Morphologies via a Reverse Nano-Emulsion Route. Materials Transactions. 2013;54(7):1145-1148.
6. Shameli K, Mansor Bin Ahmad M, Yunis WZ, Ibrahim NA, Mohsen Z, Shabanzadeh P, et al. Synthesis and characterization of silver/montmorillonite/chitosan bionanocomposites by chemical reduction method and their antibacterial activity. International Journal of Nanomedicine. 2011:271.
7. Kim KD, Han DN, Kim HT. Optimization of experimental conditions based on the Taguchi robust design for the formation of nano-sized silver particles by chemical reduction method. Chem Eng J. 2004;104(1-3):55-61.
8. Budhiraja N, Sharma A, Dahiya S, Parmar R, Vidyadharan V. Synthesis and Optical Characteristics of Silver Nanoparticles on Different Substrates. International Letters of Chemistry, Physics and Astronomy. 2013;19:80-88.
9. Kemp HA, Fleisher MS. The Bactericidal Influence of Various Substances Upon Gram-Positive and Gram-Negative Bacteria. Experimental Biology and Medicine. 1926;24(1):101-103.
10. Shrivastava S, Bera T, Roy A, Singh G, Ramachandrarao P, Dash D. Retracted: Characterization of enhanced antibacterial effects of novel silver nanoparticles. Nanotechnology. 2007;18(22):225103.
11. Mpenyana-Monyatsi L, Mthombeni NH, Onyango MS, Momba MNB. Cost-Effective Filter Materials Coated with Silver Nanoparticles for the Removal of Pathogenic Bacteria in Groundwater. International Journal of Environmental Research and Public Health. 2012;9(1):244-271.
12. Tang B, Wang J, Xu S, Afrin T, Xu W, Sun L, et al. Application of anisotropic silver nanoparticles: Multifunctionalization of wool fabric. Journal of Colloid and Interface Science. 2011;356(2):513-518.
13. Haider AJ, Mohammed MR, Al-Mulla EAJ, Ahmed DS. Synthesis of silver nanoparticle decorated carbon nanotubes and its antimicrobial activity against growth of bacteria. Rendiconti Lincei. 2014;25(3):403-407.
14. Joshi A, Kanthaliya B, Arora J. Current Scenario of Potential Renewable Energy Sources for Sustainable Development in India. The journal of plant science research. 2019;35(2):205-214.
15. Whiting A. The Systematic Identification of Organic Compounds, 7th edition. By R. L. Shriner, C. K. F. Hermann, T. C. Morrill, D. Y. Curtin, and R. C. Fuson. John Wiley & Sons: New York, 1997. 36.50. ISBN 0-471-59478-1. The Chemical Educator. 2000;5(4):212-212.
16. Vyvyan JR, Pavia DL, Lampman GM, Kriz GS. Preparing Students for Research: Synthesis of Substituted Chalcones as a Comprehensive Guided-Inquiry Experience. J Chem Educ. 2002;79(9):1119.
17. Erratum. Relict Species: Springer Berlin Heidelberg; 2009. p. 451-451.
18. Saif MJ, Anwar J, Munawar MA. A Novel Application of Quaternary Ammonium Compounds as Antibacterial Hybrid Coating on Glass Surfaces. Langmuir. 2008;25(1):377-379.
19. Mahmoud YAG, Aly MM. Anti-Candida and mode of action of two newly synthesized polymers: a modified poly (methylmethacrylate-co-vinylbenzoylchloride) and a modified linear poly (chloroethylvinylether-co-vinylbenzoylchloride) with special reference to Candida albicans and Candida tropicalis. Mycopathologia. 2004;157(2):145-153.
20. Juergensen L, Busnarda J, Caux P-Y, Kent RA. Fate, behavior, and aquatic toxicity of the fungicide DDAC in the Canadian environment. Environ Toxicol. 2000;15(3):174-200.
21. Witte W. Medical Consequences of Antibiotic Use in Agriculture. Science. 1998;279(5353):996-997.
22. Chang Y, McLandsborough L, McClements DJ. Cationic Antimicrobial (ε-Polylysine)–Anionic Polysaccharide (Pectin) Interactions: Influence of Polymer Charge on Physical Stability and Antimicrobial Efficacy. Journal of Agricultural and Food Chemistry. 2012;60(7):1837-1844.
23. Zhang C, Zhu Y, Zhou C, Yuan W, Du J. Antibacterial vesicles by direct dissolution of a block copolymer in water. Polym Chem. 2013;4(2):255-259.
24. Worley SD, Li F, Wu R, Kim J, Wei CI, Williams JF, et al. A novel N-halamine monomer for preparing biocidal polyurethane coatings. Surface Coatings International Part B: Coatings Transactions. 2003;86(4):273-277.
25. Sun Y, Sun G. Durable and refreshable polymeric N-halamine biocides containing 3-(4'-vinylbenzyl)-5,5-dimethylhydantoin. J Polym Sci, Part A: Polym Chem. 2001;39(19):3348-3355.
26. Baveja JK, Li G, Nordon RE, Hume EBH, Kumar N, Willcox MDP, et al. Biological performance of a novel synthetic furanone-based antimicrobial. Biomaterials. 2004;25(20):5013-5021.