Antibacterial Study of Polyvinyl alcohol / Poly vinyl pyrrolidone / Cellulose Ternary Polymer Blends

Maha A. Younus[1], Dhefaf H. Alqudsy[1], Saad A. Ahmed[1], Bassam Ibrahim Khalil[2]

[1]Department of Chemistry/ College of Education for pure science -Ibn-Al-Haitham / University of Baghdad.
[2]Department of Materials Eng., Branch of Polymer Materials Eng. / College of Engineering / University of Technology.

Keywords: poly (vinyl alcohol), poly (vinyl pyrrolidone), cellulose, ternary blend polymers, antibacterial activity, polymer metal complexes.

Received (April), Accepted (June**)**

Abstract

In this study, different weight percent of poly(vinyl alcohol) (PVA)/ poly(vinyl pyrrolidone) (PVP)/ Cellulose (CELL) blend solutions were prepared by solution blending followed by preparing of polymer metal complexes with Ag (I), Cu (II), Ni (II) and Co(II). Antibacterial properties were evaluated by dilute method against five pathogenic bacteria (*Escherichia coli*, *Klebsiella pneumonae* , Pseudomonas *aeruginasa*,, *Staphylococcus aureus* , *Staphylococcus Albus*) . Polymer metal complexes showed different activities against the various microbial isolates. The polymer blend metal complexes showed higher activity than the free polymer blends.

دراسة بكتيرية لخلائط البولي فنيل الكحولي / البولي فنيل البريليدون / السليلوز

مها عبدالوهاب يونس[1] , ضفاف هاشم بدري[1] , سعد علي احمد[1] , بسام ابراهيم خليل[2]
قسم الكيمياء /كلية التربية للعلوم الصرفة -ابن الهيثم /جامعة بغداد[1]
قسم هندسة المواد /فرع هندسة المواد البوليمرية /كلية الهندسة /الجامعة التكنلوجية[2]

الكلمات المفتاحية: بولي فنيل الكحولي, بولي فنيل البريليدون, السليلوز, خلائط بوليمرية ثلاثية, فعالية بكتيرية, معقدات المعادن البوليمرية.

الخلاصة

يتضمن هذا البحث تحضير خلائط بنسب وزنية مختلفة للبوليمرات (البولي فنيل الكحولي والبولي فنيل بريليدون والسليلوز) حيث تم تحضيرها بطريقة خلط المحاليل ومن ثم تم تحضير معقدات المعادن للخلائط واختبار الفعالية التثبيطية بأتباع طريقة التخفيف القياسية ضد خمسة أنواع من البكتريا (*Escherichia coli*, *Klebsiella pneumonae* , Pseudomonas *aeruginasa*, *Staphylococcus aureus* , *Staphylococcus Albus*) وأظهرت جميع معقدات الخلائط فعاليات مختلفة ضد أنواع البكتريا وفعالية أعلى من الخليط نفسه.

Introduction

Blending of two or more polymers to obtain materials with new and unique properties has become one of the most important research in the field of polymers. The main purpose of blending the polymers is to obtain materials of additional properties with minimum sacrifice of their original properties. Polymer blends are prepared by various methods and among them solution blending is very simple and rapid because it requires simple equipment such as glass plates only and not involved any complicated process. Poly (vinyl alcohol), PVA, belongs to the group of polymers which can be used in combination with other non-biodegradable polymers for tuning the required properties in the resultant composite blend. It is one of the synthetic, biodegradable, biocompatible, water-soluble polymers utilized in medical applications such as wound dressings[1]artificial skin, coatings, [2] Transdermal patches,[3]cardiovascular devices ,[4-6] and drug delivery systems. Moreover, it has good barrier

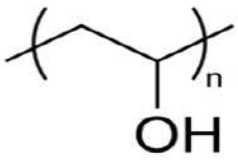
properties against scents, oils, and fats. The physical characteristics of PVA are dependent on its method of preparation by hydrolysis or partial hydrolysis of Poly (vinyl acetate)[7].

Poly (vinyl pyrrolidone) (PVP) is an amorphous vinyl polymer which has wide applications in biomedical field because of its properties including adhesion, excellent physiological compatibility, low toxicity and reasonable solubility in water and most organic solvents [8]. When these two polymers are mixed, the interaction between poly (vinyl alcohol) and poly (vinyl pyrrolidone) are expected to take place through intermolecular hydrogen bonding between the hydroxyl group of PVA and carbonyl group of PVP.

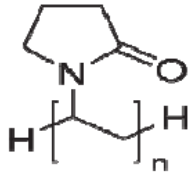
Cellulose is a poly1,4-d-glucopyranose and it is biodegradable, nontoxic, biocompatible, hydrophilic, safe, has high moistureretentivity and chiral. Therefore, making use of cellulose to produce various products not only can protect the environment from pollution but also can save limited oil resources because of its biodegradability and potential to substitute for some petrochemicals; also, it has many uses as emulsifier, stabilizer, dispersing agent, thickener, and gelling agent for the preparation of textiles. However, cellulose has not reached its potential application in many areas because of its infusibility and insolubility [9].

Material and Methods

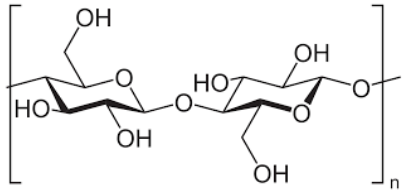
Poly Vinyl Alcohol (PVA) (Mw = 72000), Poly vinyl pyyrolidone (PVP) (Mw=40000) and Cellulose (10000) was purchased from Aldrich and Merck.



Polyvinyl alcohol



Poly (vinyl pyrrolidone)



Cellulose

Preparation of blend polymers:

Poly (vinyl alcohol) (PVA) and Poly (vinyl pyrrolidone) (PVP) solutions were prepared separately by dissolving the required amount of PVA and PVP in doubly distilled water and Cellulose solutions were prepared by dissolving the definite and exact quantity of Cellulose in 2% acetic acid solution at ambient temperature with constant stirring overnight. Then the two same concentration (wt%) of Poly (vinyl alcohol) (PVA) and pyrrolidone) (PVP) solutions were mixed and stirred till the solution become homogenous. Then, the required quantity of Cellulose solutions in different concentrations (2%, 4%, 6% and 8 wt %) was added to the equal quantity binary polymer blend solution. The mixture was stirred till the solution becomes homogenous.

Preparation of polymer blend metal complexes

The metal agent's solutions were prepared by taking ($CuCl_2.2H_2O$ 0.05 gm., $AgNO_3$ 0.0676 gm., $NiCl_2$. $2H_2O$ 0.0884 gm., ($CoCl_2.H_2O$) 0.082 gm.) with 20 ml of deionized water .we obtained four standard solutions (Cu), (Ag), (Ni), (Co).

The general procedure for preparation of metal complex by preparing 5% from polymer blend solution and mixed with equal ratios of metal solution (Cu, Co, Ni, Ag) (10 mmol), mixture was stirred for 1 hr.

Evaluation testing of antimicrobial activity

Antimicrobial susceptibility test measures the ability of an antimicrobial agent to inhibit or kill

bacterial growth in vitro. This ability may be estimated by either the dilution method or the diffusion method. In this work we followed the broth dilution method.Certain bacteria isolates were chosen, *Escherichia-Coli, KlebsiellaPeneumoniae* and *Pseudomonas aeruginasa* were representing gm-ve

isolates, *Staphylococcusaureus* and *Staphylococcus albeus* were representing gm+ve isolates. Those Isolates were taken from about 50 patients at CPHL (Central Public Health Laboratory in Baghdad).

The broth dilution method: Serial twofold dilutions of an antimicrobial agent are incorporated into broth containing tubes that are then inoculated with a standard number of organisms usually 10^5-10^6 colony-forming units (CFU) per milliliter. After the culture has been incubated at $37C^0$ for 18 hr. The lowest concentration that prevents growth after overnight incubation is known as the minimum inhibitory concentration (MIC) of the agent,The MIC is defined as the lowest concentration of antimicrobial agent at which there is no visible growth [10,11].

Results& Discussion:

The antibacterial behavior PVA/PVP blends filled with different weight % of Cellulose and its metal complexes were studied against three Gram-negative bacterial strains *(Escherichia coli, Pseudomonas aeruginasa, KlebsiellaPneumoniae*), two Gram–positive bacterial strains (*Staphylococcus aureus and Staphylococcus albus*).

The table shows that the antibacterial activity of the polymers was PVP> PVA> Cell and for the blends the antibacterial activity was decreased by increasing the percentage amount of Cellulose, also the polymer metal complexes showed higher activity than the polymer blends itself and the order of increasing activities was polymer polymer-Co < polymer-Ni < polymer-Cu < polymer-Ag. This may due to the metal ion break or pass through the cell membrane and bound to the –SH group of cellular enzymes, that's to say the ultimate critically fewer enzymatic activity causes microorganism's metabolism change and stops their development, up to the cell's death. The metal ions also catalyze the generation of oxygen radicals that oxidize molecular structure of bacteria. Metal ions can lead to break down of proteins and cell death because of their reaction with nucleophilic amino acid residues in proteins, and attach to sulfhydryl, amino, imidazole, phosphate and carboxyl groups of membrane or enzyme proteins. Respiration blocking and killing of cell may be the result of forming R-S-S-R bonds.

More over the polymer metal complexes have higher positive charge density which promotes initial adsorption onto the negatively charged bacterial surfaces and disruption of cellular membranes, resulting in significantly enhanced antibacterial activity [12, 13].

Therefore it can be concluded from the present study that these polymer metal complex blends are suitable as natural materials for food packaging and also for controlled release of various pharmaceutical antimicrobial drugs.

Table (1): Minimum Inhibitory Concentration (µg/ml) of polymer metal complexes against *Isolated Bacteria gm-ve and gm +ve*

No.	Polymer Material	Isolates				
		Escherichia Coli	**Klebsiella Pneumoniae**	**Pseudomonas aeruginasa.**	**Staphylococcus aureus**	**Staphylococcus albus**
1	PVA	**1150**	**1050**	**1050**	**1200**	**1250**
2	PVP	**1000**	**900**	**1000**	**1100**	**1150**
3	Cellulose	**1150**	**1200**	**1150**	**1200**	**1250**
4	PVA+PVP+ 2% Cell	**1000**	**1000**	**1050**	**1100**	**1150**
5	PVA+PVP+ 4% Cell	**1050**	**1050**	**1100**	**1150**	**1150**
6	PVA+PVP+ 6% Cell	**1050**	**1050**	**1100**	**1150**	**1200**
7	PVA+PVP+ 8% Cell	**1100**	**1100**	**1150**	**1200**	**1200**
8	PVA + Ag	**650**	**650**	**700**	**800**	**800**
9	PVP + Ag	**600**	**600**	**650**	**700**	**800**
10	Cell +Ag	**800**	**850**	**850**	**900**	**900**
11	PVA+PVP+ 2% Cell + Ag	**700**	**750**	**800**	**750**	**850**
12	PVA+PVP+ 4% Cell + Ag	**700**	**800**	**800**	**850**	**850**
13	PVA+PVP+ 6% Cell + Ag	**750**	**800**	**850**	**850**	**900**
14	PVA+PVP+ 8% Cell + Ag	**1000**	**900**	**850**	**1000**	**1000**
15	PVA + Cu	**800**	**800**	**850**	**900**	**1000**
16	PVP + Cu	**700**	**750**	**800**	**850**	**900**
17	Cell + Cu	**850**	**850**	**850**	**900**	**1000**
18	PVA+PVP+ 2% Cell + Cu	**1000**	**850**	**900**	**900**	**1000**
19	PVA+PVP+ 4% Cell + Cu	**850**	**900**	**1000**	**1050**	**1050**
20	PVA+PVP+ 6% Cell + Cu	**900**	**900**	**1000**	**1000**	**1050**
21	PVA+PVP+ 8% Cell + Cu	**1050**	**1000**	**1000**	**1050**	**1100**
22	PVA + Ni	**900**	**1000**	**1000**	**1000**	**1100**
23	PVP + Ni	**800**	**900**	**850**	**1000**	**1000**
24	Cell + Ni	**1000**	**1000**	**1050**	**1050**	**1100**
25	PVA+PVP+ 2% Cell + Ni	**1100**	**1000**	**1000**	**1050**	**1150**
26	PVA+PVP+ 4% Cell + Ni	**1050**	**1050**	**1000**	**1100**	**1150**
27	PVA+PVP+ 6% Cell + Ni	**1000**	**1000**	**1050**	**1100**	**1100**
28	PVA+PVP+ 8% Cell + Ni	**1050**	**1050**	**1050**	**1100**	**1100**
29	PVA + Co	**900**	**1050**	**900**	**1000**	**1150**
30	PVP + Co	**900**	**1000**	**850**	**1050**	**1000**
31	Cell + Co	**1050**	**1050**	**1050**	**1000**	**1050**
32	PVA+PVP+ 2% Cell + Co	**1100**	**1000**	**850**	**1050**	**1100**
33	PVA+PVP+ 4% Cell + Co	**1000**	**1050**	**1000**	**1050**	**1200**
34	PVA+PVP+ 6% Cell + Co	**1050**	**1050**	**1050**	**1100**	**1050**
35	PVA+PVP+ 8% Cell + Co	**1100**	**1000**	**1050**	**1050**	**1050**

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