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Effect of Gum Acacia (GA) on Tensile Properties of Biodegradable Chitosan (CS)/Poly (vinyl alcohol) (PVA) Polymer Blend Films

Saraswati Masti[1], Deepak Kasai[2], Bhagyavana Mudigoudra[3] and Ravindra Chougale[4*]
[1]Department of Chemistry, Karnatak Science College, Dharwad, Karnataka, India
[2]Department of Materials Science, Mangalore University, Mangalgangotri, Karnataka, India
[3]Department of Computer Science, Maharani Science College for Women, Bangalore, Karnataka, India
[4*]P.G. Department of Studies in Chemistry, Karnatak University, Dharwad, Karnataka, India
chougaleravindra@yahoo.com

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Abstract

Biodegradable blend films of gum acacia (GA) doped poly (vinyl alcohol) and chitosan (PVA/CS) were prepared by solvent casting technique. Mechanical properties of obtained films were assessed by tensile test. Addition of gum acacia (GA) to the equal quantity of PVA/CS, blend film shows improved tensile strength (Ts) and young's modulus (Ym) compared to PVA/CS (50/50) blend. Further addition of gum acacia (GA) presented the decreased tensile strength and young's modulus. The increase in tensile strength and young's modulus of the blend containing gum acacia suggested that interfacial strength could be improved. The addition of gum acacia to the blend proves that gum acacia (GA) can improve the interfacial adhesion between chitosan and poly (vinyl Alcohol).

Keywords: Poly (vinyl alcohol), Chitosan, Gum Acacia, Tensile Properties.

Introduction

Now a day's biodegradable water soluble polymer and their blends gained much interest because of their wide applications in detergents, paints, textiles, biodegradable plastics and as chemical intermediates[1]. Chitosan is a natural polycationic polymer derived from the alkaline deacetylation of chitin which is unbranched polysaccharide[2]. Chitosan is present in insects, fungi, bacteria and main component of crustacean's exoskeleton[3]. However, chitosan has unique combination of properties including biodegradability, biocompatibility[4], low toxicity and bioactive property. Chitosan has antimicrobial, antifungal activity[5] and it is successfully probed on food packaging, which protects the contamination and microbial spoilage of food[6]. Now a day's chitosan has receiving greater attention in the field of pharmaceutical and medical applications such as drug delivery system, tissue engineering. Despite of their interesting biological property its utilization has promoted the wound healing and bacteriostatic effects. In addition, chitosan widely used in cosmetics, agriculture, environmental protection and waste water treatment[7-8].

Poly (vinyl alcohol) PVA) is one of the most important synthetic[9], nontoxic and water soluble polymer[10]. PVA is having good flexibility[11-12], barrier and biodegradable property[13-15]. PVA is commercially prepared by the vinyl acetate. The physical characteristic and functional properties PVA depends on the polymerization and its degree of hydrolysis. This synthetic polymer exhibits excellent film forming ability with good mechanical behavior[16], excellent chemical resistance[17], emulsifying and adhesive property[18]. PVA has been used as a biomaterial in various applications like artificial pancreas, implantable biomaterial, pharmacy and also in packaging industry. The main drawbacks observed in PVA, its poor water resistance behavior which limits the use of PVA particularly in food packaging applications.

Gum Acacia or Arabic (GA) is edible natural gum, obtained from the mature stems and branches of Acacia Senegal[19]. GA is a non viscous liquid with rich soluble fibers. The production of gum at stem or branches of trees can be observed usually drought, poor soil fertility and injured plant[20]. GA is having hydrophilic carbohydrate as well as hydrophobic protein components exhibiting different functional properties in food additives[21]. However, the properties observed in GA have wide range of applications in industry, it is used as a stabilizer, a thickener, packaging material in food industry and also used in pharmaceuticals[22].

Materials and Methods

Materials: Poly (vinyl alcohol) (PVA) (Mol. Weight 1,40,000) and chitosan (CS) were supplied by Himedia, Mumbai, and Gum acacia (GA) was purchased from Central Drug House (CDH), New Delhi, and were used as received. Acetic acid received was procured from Spectrochem, Mumbai. Doubly distilled water was used as the solvent.

Preparation of Blend Films: Different weight percent of chitosan and PVA solutions were prepared by dissolving in

respective solvent (2% acetic acid solution and PVA in distilled water) with constant stirring overnight. Meanwhile, different weight percent of GA (0.0, 5, 10, 15 and 20 wt %) solutions were prepared in distilled water. Further, different concentrations of GA solution were mixed with equal quantity binary PVA/CS polymer blend solution. The mixture was stirred overnight to attain the maximum viscosity and solution becomes completely homogenous. After ensuring the complete homogeneity, the bubble free ternary blend solution were poured onto the previously cleaned and dried petri dishes and allowed to evaporate at room temperature. The thickness of the all blend films were controlled by pouring a definite quantity of blend solution. To ensure complete removal of trace amount of solvent from the blend films, petri dishes were kept in hot air oven at 45°C for 72 hours. After complete removal of solvent from the blend films, all films were peeled from petri dishes and kept in vacuum desiccators until use. The thickness of the prepared blend films were measured at five different places for mechanical study.

Methods: Mechanical Properties: The mechanical properties (tensile strength, percent elongation (%) and modulus of elasticity) of the prepared blend films were investigated by using A LLOYD universal testing machine (LLOYDS – 5 KN, London, UK. All the tests were carried out according to ASTM D-882 standard test (ASTM, 1992). The blend film sizes of 2.5 × 10 cm were taken for the analysis of mechanical properties. The instrument with two metallic grips was attached for griping both ends of the test specimen. The upper grip was moved upward with constant rate of extension of 50 mm/min and lower grip was stationary (initial grip separation 50 mm for all samples). The machine was electrically driven and an automatic speed controller was attached to keep the speed of the upper grip. All measurements were carried out at room temperature in air. Tensile Strength of the blend films were calculated by dividing the maximum load for breaking the film by cross-sectional area and elongation at break by dividing the film elongation at rupture to initial gauge length.

Results and Discussion

Mechanical Properties: The result of mechanical study of poly (vinyl alcohol)/chitosan/gum acacia blend films were presented in the Table-1. The observed stress-strain curves for ternary polymer blend films were shown in Figure-1. The mechanical properties were solely depends on the chemical structure, which could be best described by using tensile strength, percent of elongation and modulus of elasticity. The tensile strength presents the maximum tensile stress that the film can sustain. The measure of the stiffness of the blend films gives the modulus of elasticity. However, percent elongation is explained by the maximum change in length of a test specimen before breaking. The addition of gum acacia to the equal percent of all blend film shows significant increase in the elongation at break in comparison with equal percent of PVA/CS (50/50) blend films. This could be attributed to the good interfacial adhesion among the polymer components. Further incorporation of GA to the PVA/CS film shows decreased value. The results of mechanical study confirm the addition of gum acacia can improve mechanical property and decreases with increase in the wt % of gum acacia.

Table-1
Mechanical properties of Poly (vinyl alcohol)/Chitosan/Gum Acacia

Blend Ratios PVA/CS/GA (wt %)	Tensile Strength (MPa)	Young's Modulus (MPa)	Elongation at break (%)
50/50/0.0	8.059	21.168	58.414
47.5/47.5/5	9.101	29.094	116.630
45/45/10	9.690	30.017	115.260
42.5/42.5/15	8.623	45.232	98.526
40/40/20	7.681	22.563	72.235

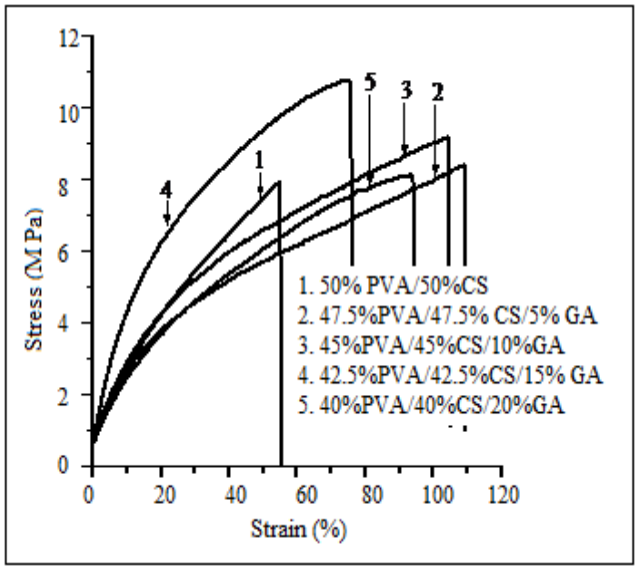

Figure-1
Stress-strain curves of equal weight (%) of PVA/CS blend films

Figure-2 illustrates the tensile strength as a function of added wt% of gum acacia. It was observed that upon addition of gum acacia the tensile strength increases up to 10 wt % of gum acacia and then little decreases with increasing wt % of gum acacia. The increase in tensile strength can be explained by good adhesion between GA phase and CS/PVA blend matrix phase and thus increasing of load bearing cross-section.

From Figure-3 the increase of wt% of gum acacia in the CS/PVA blend increases the young's modulus of the blend film because addition of gum acacia leads to enhance in stiffness suggested that interfacial strength could be improved.

Elongation at break is the elongation which corresponds to tensile breaking strength. Figure-4 shows % elongation at break of GA/CS/PVA/ blend as a function of GA content. From this figure it is clear that increase of wt% of GA in the CS/PVA blend increases the % elongation because addition of GA causes increase in elasticity which leads to increase the % elongation.

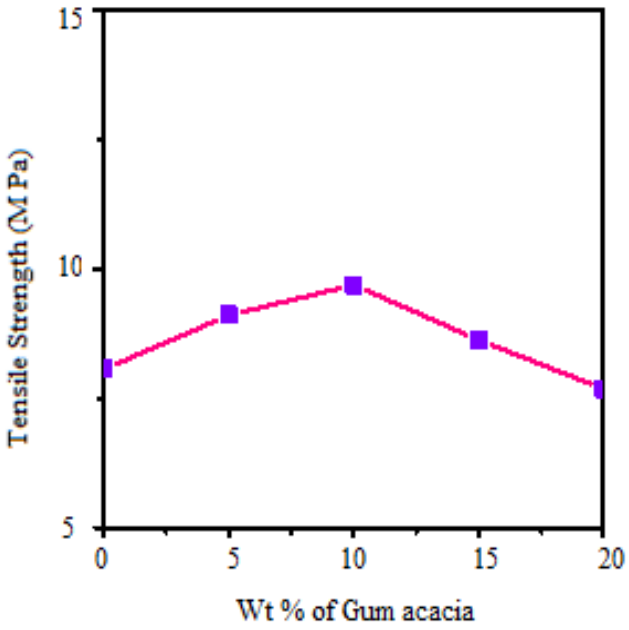

Figure-2
Tensile strength at a break of CS/PVA/GA blends as a function of GA

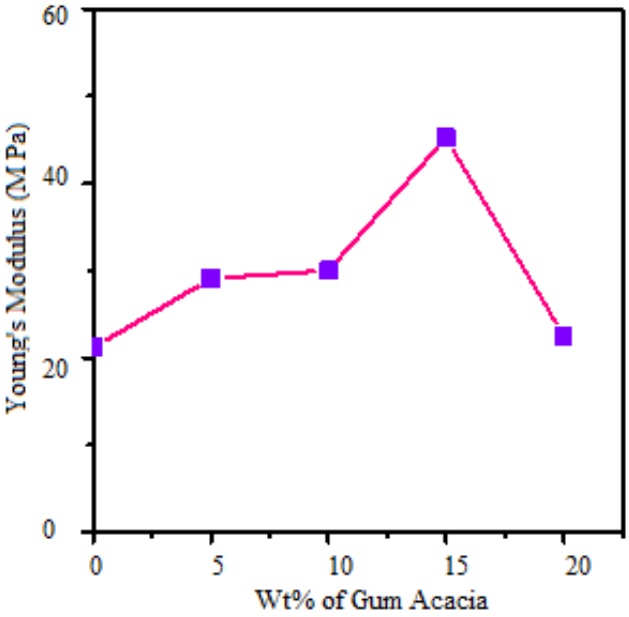

Figure-3
Young's modulus of CS/PVA/GA blends as a function of GA content (wt %)

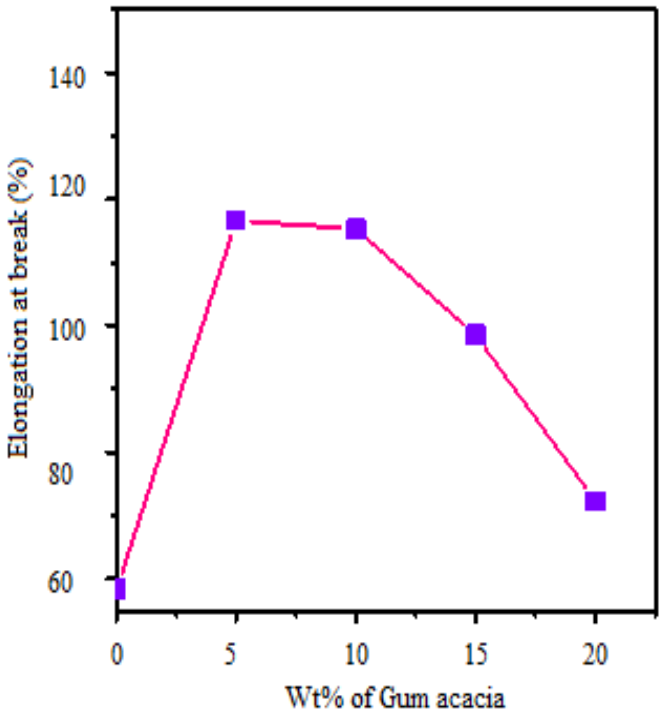

Figure-4
Elongation at break (%) of CS/PVA/GA blends as a function of GA content (wt%)

Conclusion

From the study of mechanical properties, it is found that there is a good adhesion among gum acacia phase and PVA/CS blend matrix phase. The prepared blend films presented improved mechanical properties with addition of gum acacia such blend films. Therefore, the results of this work may show functional properties of PVA/CS/GA blend films are adequate for food packaging applications and in pharmaceutical industry for controlled release of drugs.

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