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Effect of Guar Gum on Mechanical and Morphological Behavior of Chitosan Films

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Abstract

Guar gum doped chitosan (GG/CS) films prepared by solvent casting method. The tensile properties of fabricated films containing different concentration (wt %) of GG/CS were characterized using universal testing machine (UTM). As concentration of GG increases, tensile strength and young's modulus decreases and elongation at break increases compared to pure CS film. The structural morphology of GG/CS films were studied using scanning electron microscope (SEM). The SEM micrograph of the pure CS shows smooth and homogeneous surface with some straps on the top surface and GG/CS films shows smooth surface with reduced straps on the top surface.

Keywords: Chitosan, guar gum, tensile properties.

Introduction

The polymer plays an important role from the beginning of life[1]. The chemical modification is one of the important routes to modify the properties of naturally occurring biopolymers and to use as renewable source. The main purpose of modifying the polymer is to obtain materials with improved properties. The films of natural polymers and natural gums represent a new class of materials which have attracted much attention especially in biopolymers as biomaterials. The successive of polymeric film as biomaterials mainly depends on mechanical properties.

Among biopolymers chitosan (Poly-(D) glucosamine) is naturally occurring biodegradable polysaccharide[2]. It is environment friendly biodegradable polymeric material and has attracted much attention of researcher in various parts of the globe. Chitosan is a semicrystalline, high molecular weight, nontoxic, linear amino cationic polysaccharide of glucosamine and N-acetylglucosamine units. It is produced by excessive hot alkaline deacetylation of the second most abundant naturally occurring chitin (poly (N-acetyl-D-glucopyranose) of crab and shrimp shells[3]. Chitosan (Poly-(D) glucosamine) can be isolated directly from the cell walls of certain fungi[3], but commercially available chitosans are usually prepared from chitin which is most plentiful natural based biopolymer next after cellulose on this planet. Chitosan exhibits non-toxic, bio-functional and strong antimicrobial and antifungal activity[4-8]. The high sensitivity and low water barrier property of chitosan[9] towards the moisture makes the use of chitosan film in most of the food packaging applications and biomedical applications[10-11]. The hydroxyl and amine groups of chitosan act as the active sites to the new and desired functional groups. Pure chitosan films were brittle and have good mechanical properties. Further these properties were enhanced and storage life of foodstuffs can be extended by doping with other polysaccharides.

Natural gums have attracted an increasing attention of young researchers over the last two decades due to their abundance and environmental concern. Guar gum, a natural polysaccharide used as one of the raw materials. It has a linear chain of β 1, 4-linked mannose and 1,6-linked galactose residues at second mannose. Guar gum is an alternative source for products of biodegradable materials. Guar gum is high molecular weight, cold water soluble polysaccharide and possesses rigid, non-toxic character. Because of its high water retention, high thickening efficiency[12-15], in industry it is widely used as a stabilizing and thickening agent[16].

S. P. Chawla et al. have developed composite films based on chitosan and guar gum and evaluated optical, mechanical, barrier and antimicrobial properties of films[17]. T. M. Aminabhavi et al have reported the development of IPN microparticles of chitosan and guar gum coated with NaAlg and Magnesium aluminum silicate for controlled release of isoniazid and characterized by the physicochemical techniques, encapsulation efficiency, in vitro drug release and equilibrium[18].

From the literature survey we came to know that there were no study and reports on correlation studies on mechanical and morphological behavior of chitosan containing guar gum. Therefore we have undertaken the study to correlate the mechanical and morphology developments of films containing chitosan and guar gum films.

Material and Methods

Materials: Chitosan was procured from (TCI) Tokyo, Japan, having degree of deacetylation was 75%. Guar gum was procured from Central Drug House (CDH), New Delhi. Acetic acid was procured from, spectrochem, Mumbai, and was used as received. Doubly distilled water was used throughout the experiment. The chemical structure of chitosan and guar gum is given below.

Methods: Preparation of Film: Different concentration of (wt %) chitosan and guar gum films were prepared by solvent casting technique. The composition of chitosan/guar gum is given in table-1. Chitosan solution was prepared by dissolving in 2% acetic acid with constant stirring overnight. Guar gum solution was prepared by dissolving in distilled water at room temperature. Different weight percent of guar gum (5, 15, 25, 35 wt %) were mixed with chitosan solution and stirred till the solution becomes homogeneous and subsequently highly viscous. The bubble free chitosan and guar gum mixed solutions were poured onto cleaned and dried Petri dishes. The solvent was evaporated at room temperature. After drying, all films were peeled off from Petri dishes and kept in vacuum desiccators. Images of chitosan and guar gum blend films are given in figure-1.

Thickness Measurements: The thickness of the film samples were measured using a Mitutoyo Dial Thickness Gauge made in Japan. Several thickness measurements were taken at several points of the film and then average was calculated. The thickness of the films was found to be around 0.15 mm.

Mechanical Behavior: Mechanical properties like tensile strength, young modulus elongation at break were measured using a universal testing machine (UTM) (LLOYDS – 5 KN, London, UK) according to ASTM D-882 standard test (ASTM, 1992) at room temperature in air. Rectangular shaped sample of films (2.5 × 10 cm) were taken for the evaluation of tensile properties. Two metallic grips were attached for griping both ends of the test specimen of the film. The lower grip was stationary and the upper grip moved upward with constant rate of extension 50 mm/min keeping constant initial grip separation 50 mm for all samples. An automatic speed controller was attached to keep the speed of the upper grip. The tensile properties such as tensile strength, young's modulus and elongation at break were calculated using NEXYGEN Plus software.

Scanning Electron Microscopy: Films surface morphology was examined using scanning electron microscopy (SEM). Prior to the examination, films were dried overnight in a hot air oven at 45^0C and mounted on a metal stub with double side sticky tape. Then the films were coated with a thin layer of platinum in order to improve conductivity and prevent electron charging on the surface. The morphological structures of the films were studied by a JSM- 6360 scanning electron microscope (SEM) of JEOL, Germany, and the images were taken at accelerating voltage 10 kV and a magnification 500 times of origin specimen size.

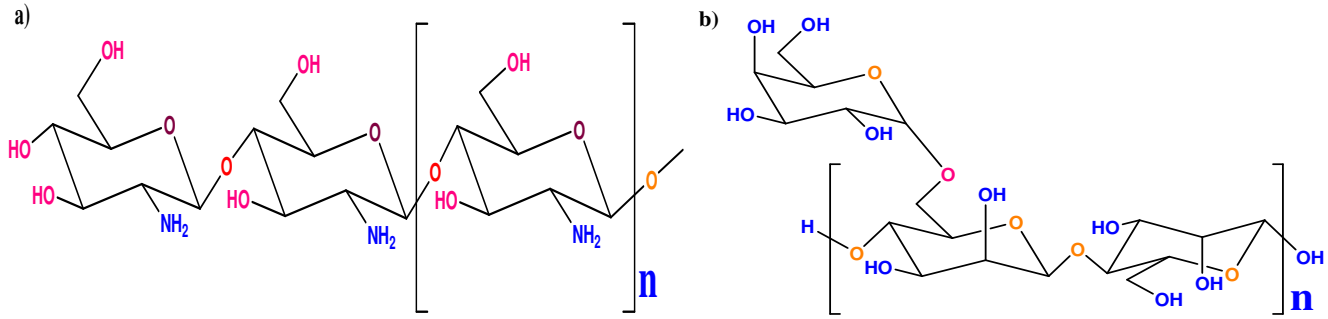

Figure-1
Chemical Structure of a) Chitosan b) Guar Gum

Table-1
Composition of Chitosan/Guar Gum films

Sample code	Compositions Chitosan (CS)/Guar Gum (GG)	Chitosan (Wt %)	Guar Gum (Wt %)
A	100	100	0
B	95/5	95	5
C	85/15	85	15
D	75/25	75	25
E	65/35	65	35
F	50/50	50	50

Results and Discussion

In food packaging application the ability of the material to resist breaking under certain load is one of the most important and widely used properties. The tensile strength is defined as a maximum load that a material can support without fracture when being stretched. In this study, film made from chitosan and guar gum usually brittle and has poor mechanical properties. The stress-strain curves of films shown in figure 2. From this stress-strain curve, we estimated maximum tensile strength (TS), young's module (YM), elongation at break (EB. These summarized in table-2 and in figure-3, 4, and 5.

Table-2
Mechanical properties of guar gum doped chitosan films

Sample Code	Composition Chitosan/Guar gum (wt %)	Tensile strength (MPa)	Young's Modulus (MPa)	Elongation at Break (%)
A	100	40.37	1603.69	3.90
B	95/5	23.07	1182.78	21.78
C	85/15	20.80	1178.45	12.15
D	75/25	19.77	1155.37	10.14
E	65/35	17.64	1026.77	6.10
F	50/50	16.94	637.37	4.47

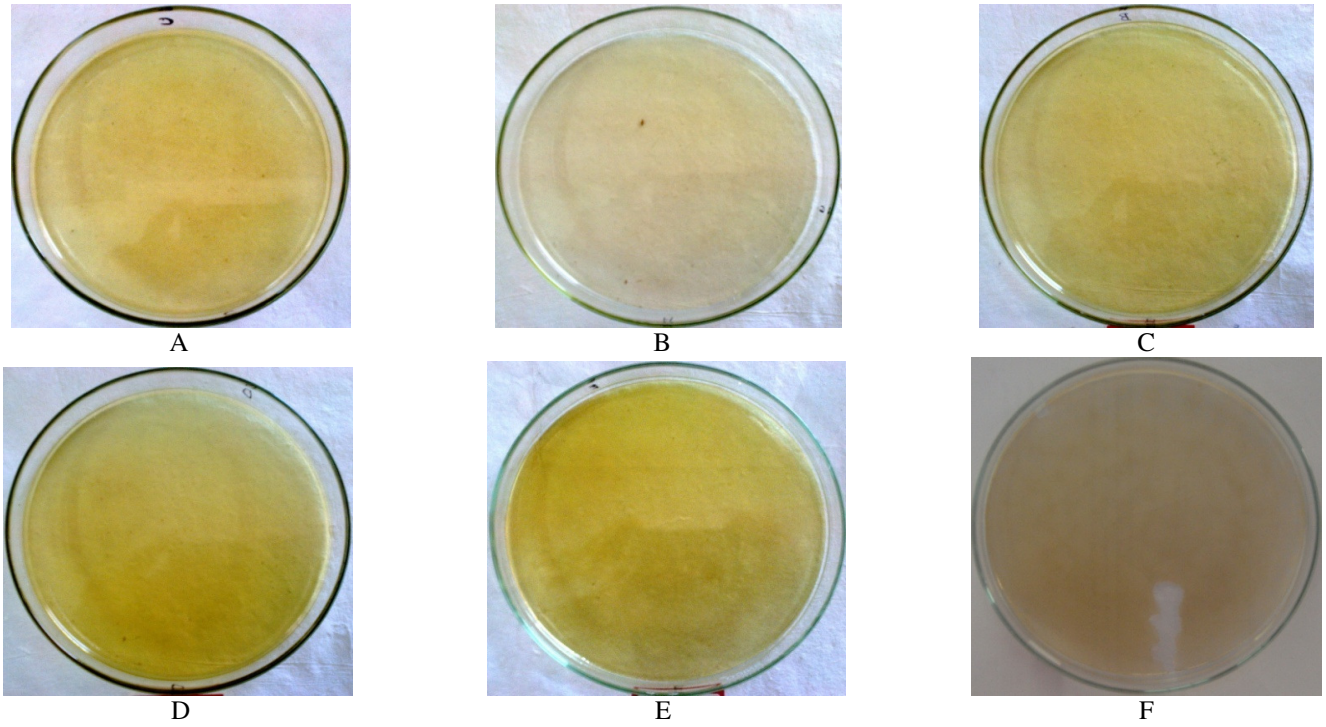

Figure-2
Images of prepared blend films with different composition

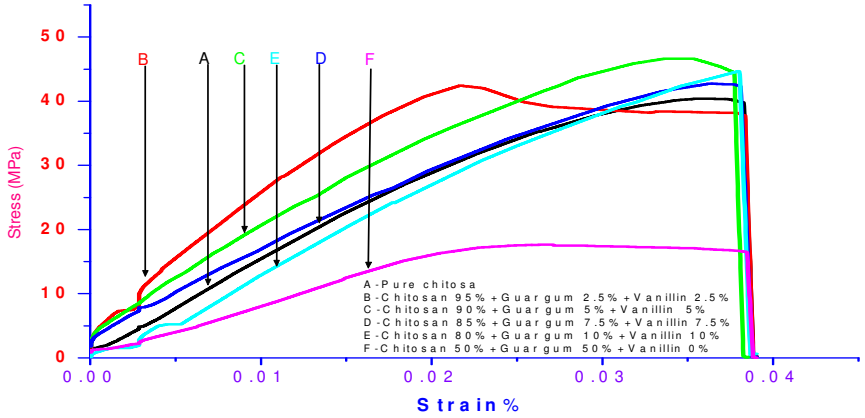

Figure-3
Stress-Strain Curves of Chitosan/Guar Gum Blend films

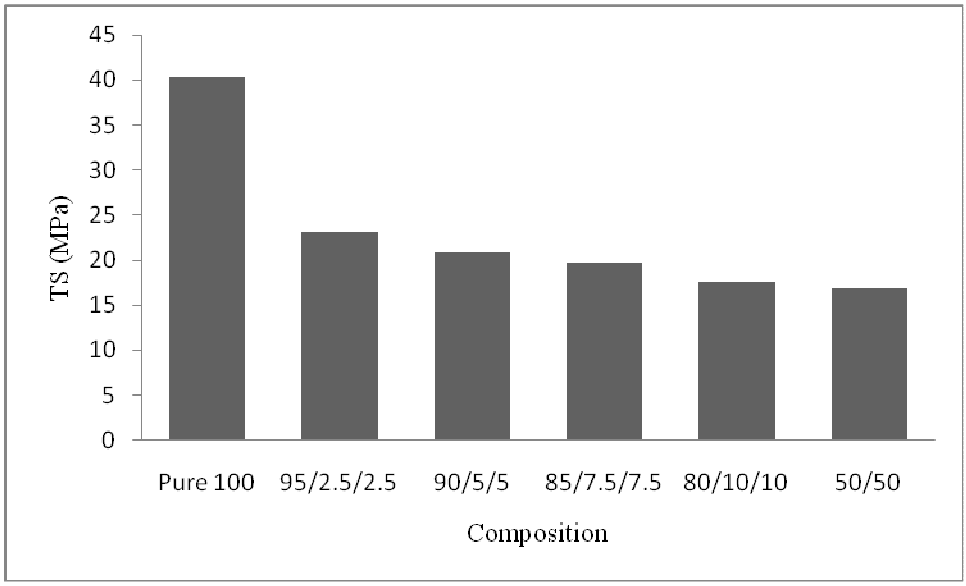

Figure-4
Tensile Strength

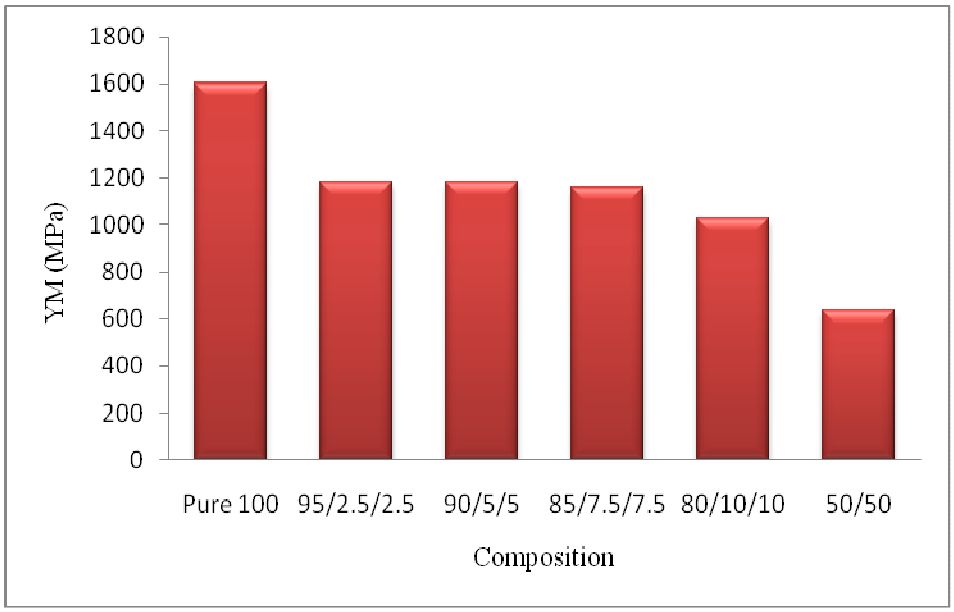

Figure-5
Young's Modulus

We noticed that, the tensile strength of the films shows significant decrease with incorporation of guar gum in chitosan films. This is due to the reduction in viscosities of film forming solution containing guar gum (5% to 35%) in films. The reduction in viscosities decreases the tensile strength of films and it could be due to the weak intermolecular hydrogen bonding between NH_3^+ of the chitosan and OH^- of the guar gum. The higher guar gum content may lead to poor distribution of filler across the chitosan which caused the stress in the continuous phase to decrease the tensile strength[19-20]. At the same time we observed there is overall decrease in young's modulus and significant increase in elongation at break.

In figure-6 show all films have smooth and homogeneous surfaces and some straps on the top surface of the films with different concentration (Wt %) of guar gum. Straps are attributed to the hydrophilic nature of the film and these are significantly decreases as the concentration (wt %) of guar gum increases. These results shows the micrographs of films are uniform, continuous and completely miscible. Films are quite rigid and less brittle.

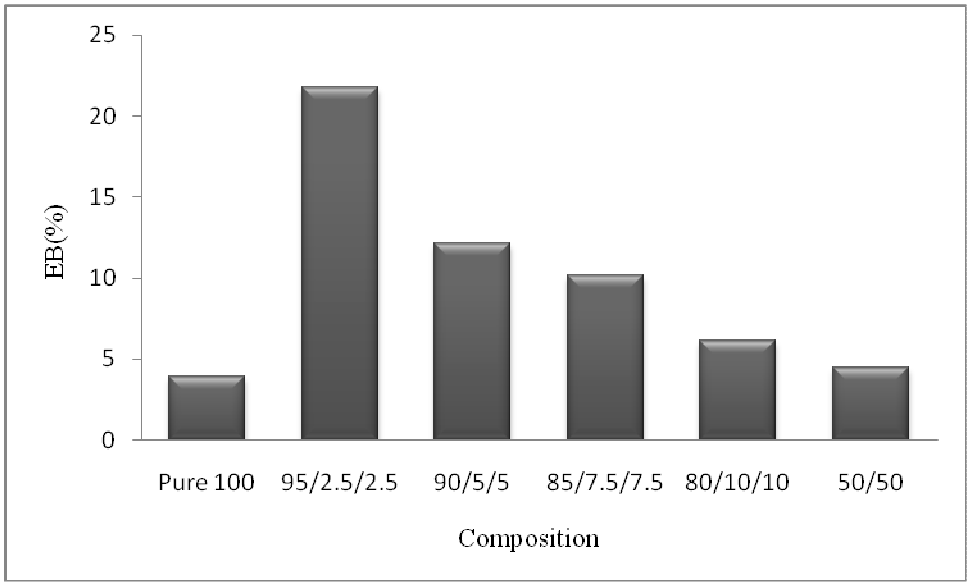

Figure-6
Elongation at Break (%)

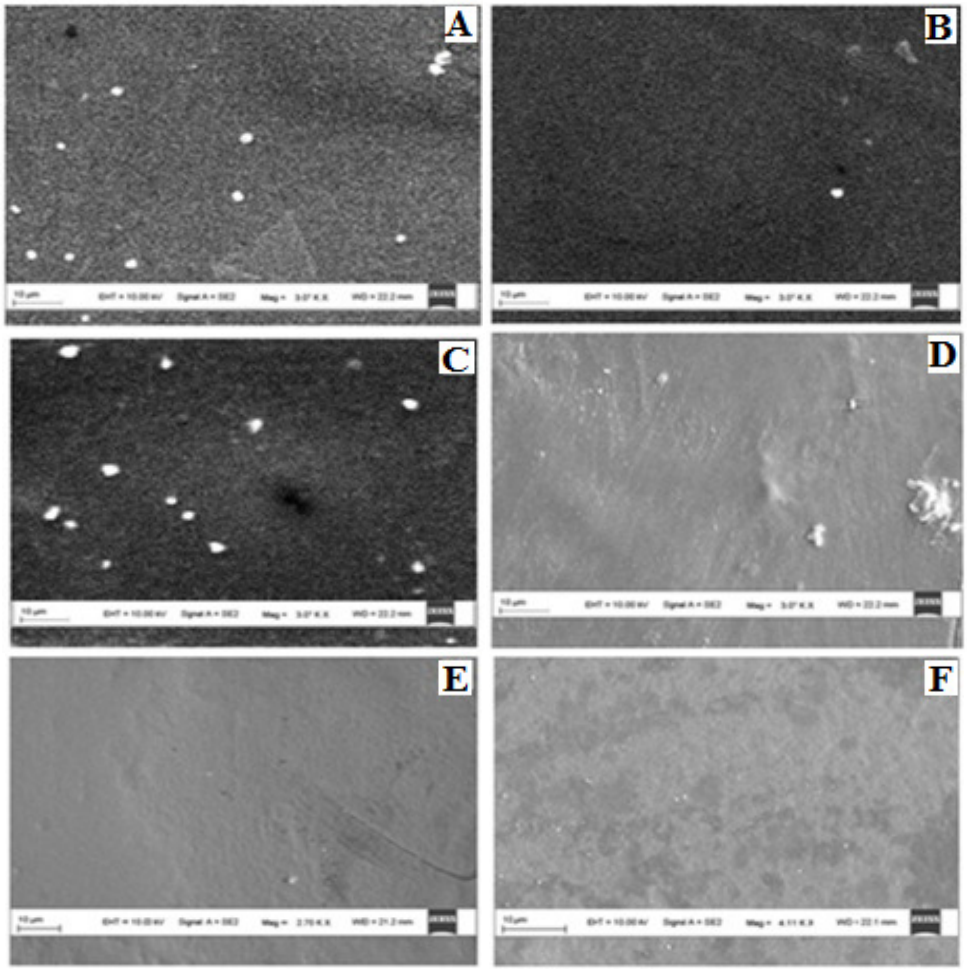

Figure 7
Images of Scanning Electron Microscope (SEM)

Conclusion

It was observed that the viscosity of chitosan is higher than the guar gum and on mixing chitosan with guar gum the viscosity of chitosan reduces due to colloidal dispersion of guar gum. This leads to the formation of weak intermolecular hydrogen bonding and also uniform distribution of guar gum in chitosan. As the concentration of the guar gum (wt%) increase in the films, there is a decrease in tensile strength and young's modulus and increase in elongation at break, due to weak hydrogen bonding formed between chitosan and guar gum. The SEM shows the micrographs of films are uniform, continuous and completely miscible. Obtained films are quite rigid and less brittle compare to pure chitosan film. These polymeric materials could be used in implantable devices to release the pharmaceutical drugs in controlled manner and also as a potential material for development of food packaging especially as edible films and coatings.

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