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Preparation of Starch-Poly Vinyl Alcohol (PVA) Blend Using Potato and Study of Its Mechanical Properties

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ABSTRACT : *Potato is a well known source of starch for a long time. But this huge resource has never been commercialised. In this present work, potato starch is used to prepare the film. This starch has been blended with PVA (Polyvinyl Alcohol) at different ratios. Nanoclay has also been mixed with the blend at 1%, 2% and 3% weight ratios. The mechanical strength of the clay filled and unfilled films having different ratios of starch and PVA have been investigated. The mechanical strength shows variation with varying compositions. The percent transparency and sealing property of the material have also been studied.*

KEY WORDS: *Polyvinyl Alcohol, Starch, Blend, Nanocomposite, clay*

I. INTRODUCTION

The use of plastic at various sectors in life is at a new high. With increasing demand of polymers, scientists are working towards development of new materials, blends and composites which will be stronger, tougher and with higher performance level compared to the presently available materials. While working towards this direction, nanocomposites with different nanomaterials, new functional polymers and composites have been invented. But with increasing level of plastic usage, the challenge of increasing solid waste is on rise. Moreover, from environmental point of view, renewable and sustainable resources for polymers are on high demand. Looking into all these factors, the potato starch is thought to be suitable and useful for packaging application as starch is a biopolymer with a sustainable resource.Many people have already worked with starch based blends and have studied various properties. Otey et. al. have worked on the extraction of starch from potato and blending with PVA [1]. Other research groups have also worked on processing and crosslinking similar blends and also have prepared nanocomposites of the same [2-4]. The modifications mentioned in the previously mentioned references have improved the processibility, casting and improvement in properties of the blends. Guilbert et. al. have worked on biodegradable packaging material and its surface treatment while there are other groups who has used various blends and crossllinked them to make films for food packaging [5-7]. The films made by various techniques are tested for tensile properties and barrier properties [8].In this paper we have selected starch–PVA blend of different ratios as our base polymer. These blends have been modified to enhance its mechanical properties and further mixed with nanoclay to check the effects of nanoclay on its film. The mechanical properties of these blends are reported in this paper.

II. EXPERIMENTAL

2.1. Materials

2.1.1. Starch: Commercially available Potato Starch is purchased from Loba Chemie Ltd.
2.1.2. Polyvinyl Alcohol (PVA): PVA (Mol.wt.:-1,15,000)is purchased from Loba Chemie Ltd.
2.1.3. Acetyle Chloride: Acetyl Chloride (Mol.wt.:-70.5) is purchased from Loba Chemie Ltd.
2.1.4. Cloisite 30B: Cloisite 30B is generously supplied by Southern Clay Products, U.S.A.

2.2. Instruments

2.2.1. **Universal Testing Mechine (UTM):** The Mechanical Testings are done using the Universal Testing Mechine manufactured by Star Testing, Mumbai Model No. STS-348, Series no. -9036 at a overhead speed **50minutes/mm** with a load cell **100kgs** using **ASTM method D882** for films. The testing specifications are as follows:

(a) Length of sample: - 115mm.; (b) Width of sample: - 25mm.; (c) Gauge length: - 50mm.; (d) Load: - 100Kgs; (e) Thickness: - 0.25mm.; (f) Temperature: - 25ºC.; (g) Speed: - 50 min/mm.

2.2.2. Sealing Test: The Sealing Testings are done using the Sealing Machine manufactured by Khera Instruments Pvt. Ltd., Model No. –K I 351, serial no. – 1632.

2.3. Sample Preparation:

Film Preparation- Starch-PVA were taken in water in different composition, Like 30:70, 50:50, 70:30.The reaction mixture was heated at 70ºC until uniformity appears. After cooling solution at 35ºC, all the solutions are mixed and modified with 40%acetyl chloride. Then the solutions are poured onto casting mold and dried under oven at 75ºC to remove water contents. After complete drying, the films are stored in moisture free environment.Nano-film preparation- A specified amount of Nano Clay (1%, 2%,3% by wt. of starch-PVA used) was dissolved in the starch-PVA solution. The starch solution containing the clay was heated to 70 °C, held at that temperature for 20 min, then cooled to 50 °C and poured onto petridish and kept in an oven at 75°C for drying and peeled off.

2.4. Nomenclature:

Table 1: Nomenclature of Various Nanoclay filled and Unfilled Samples

Composition	Sample Name	Composition	Sample Name
Starch:PVA=30:70	A	B+1%cloisite 30B	BN1
Starch:PVA=50:50	B	B+3%cloisite 30B	BN3
Starch:PVA=70:30	C	C+1%cloisite 30B	CN1
A+1%cloisite 30B	AN1	C+3%cloisite 30B	CN3
A+3%cloisite 30B	AN3	A+2%cloisite 30B	AN2

III. RESULTS AND DISCUSSIONS

Mechanical strength

For the present work, three different compositions of starch and PVA blend have been prepared. The mechanical properties of the films made, have been tested by standard ASTM process. The results show, with increase in the percentage of PVA in the blend, the mechanical properties are improved with all the three different loadings of nanoclay (1%, 2% and 3%). The mechanical properties of unfilled and 1%, 2% and 3% nanoclay loaded samples of A, B and C are compared in Table 2. The results show, that the tensile strength of unfilled samples has improved by 32.5% and 64.15% respectively compared to the previous one as the starch:PVA ratio has changed from 70:30 to 50:50 and 30:70. Pure starch films without PVA shows shrinkage and is poor in strength. PVA is blended with starch to improve the dimensional stability and strength. Thus there is an overall improvement in terms of strength as the PVA loading increases. Similar changes are also noted with 1%, 2% and 3% loading of samples as well. The change in mechanical strength in very sharp when the PVA concentration is increased from 50% to 70% compared to other composition. As an explanation to this result, it may be said that PVA having higher numbers of hydroxyl groups, incurs higher strength and better mechanical properties. On the other hand, starch although has a lot of OH functionalities, but during acetylation probably, many of them are getting modified leading to lesser strength in starch. In Figure 1 the variation in mechanical strength with varying blend ratio is shown below.

Table 2: Mechanical Properties of Nanoclay Filled Samples

Sample	Peak Load (KG)	Break Load (KG)	Tensile Strength (MPa)
A	5.62	3.44	8.7
B	3.36	3.36	5.3
C	2.53	2.53	4.0
AN1	9.83	1.8	15.4
AN2	5.29	1.42	8.3
AN3	2.9	0.32	4.5
BN1	5.32	5.32	8.3
BN2	2.37	2.37	3.7
BN3	2.28	2.28	3.6
CN1	4.85	4.85	7.6
CN2	2.48	2.48	3.9
CN3	2.26	2.26	3.5

Addition of nanoclay has modified the properties to certain extent. Addition of 1% nanoclay to A, B and C has resulted in increase in mechanical strength upto 83%, 56% and 90% respectively. Thus maximum increase is observed in the case of 70% PVA followed by the 70% starch blend. When the 1% nanoclay filled sample of A, B and C are compared in Figure 2 the plot shows that AN1 has maximum strength followed by BN1 and CN1. Nanoclay 30B being polar in nature probably mixes better and shows enhanced properties when mixed with polar matrix having more OH functional groups.

On studying the mechanical strength it may be noted that as the clay loading is increase beyond 1% the mechanical strength reduces as a result of poor filler dispersion in A, B and C. In Figure 3 as the filler loading is increased from 0% to 3% in sample A, the 1% filler loaded sample shows maximum strength which decreases on further clay loading.

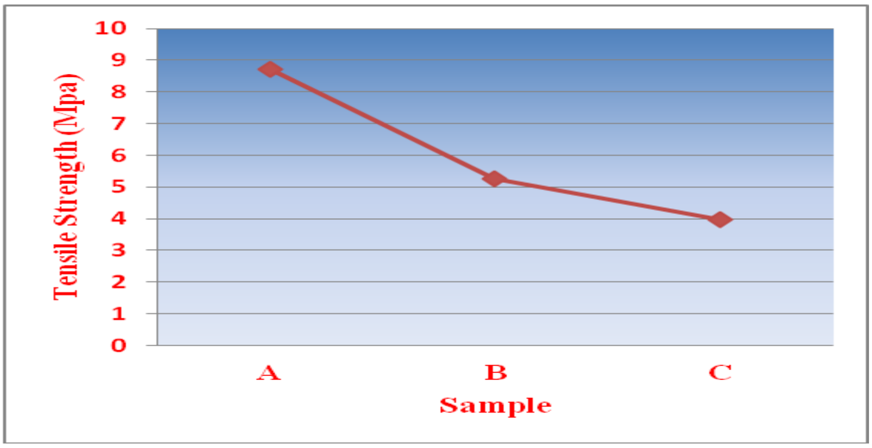

Figure 1: Variation in mechanical strength with varying ratio of starch and PVA in the blend

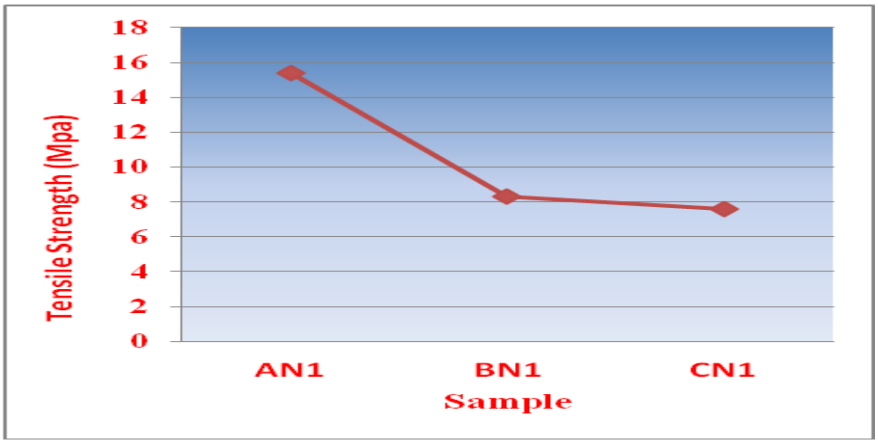

Figure 2: The Change in Mechanical strength in 1% clay filled sample of starch and PVA blend with varying blend ratio

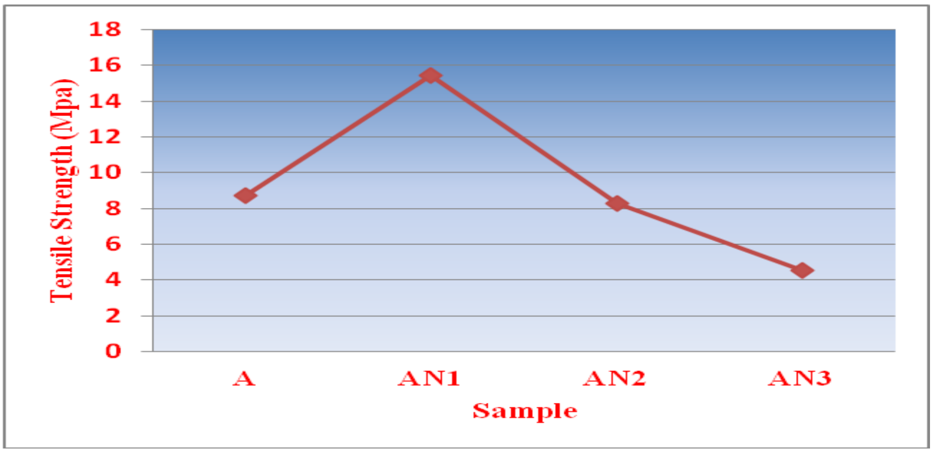

Figure 3: Variation in Mechanical strength with increasing filler loading

Transparency

The pictures of sample A, Sample AN1 and sample AN3 are given in Figure 4, 5 and 6. The %transparency of the above mentioned three samples are given in the Table 3.

Table 3: Percent Transparency of the nanoclay filled and unfilled sample A

Sample	Percent Transparency
Standard (Transparent PE Film)	3.41
A	17.37
AN1	16.85
AN2	14.30
AN3	11.40

Comparing them, it may be concluded that with loading of nanoclays the transparency of the films have reduced as the nanoclays are not dispersed at a very finer level T 2% and 3% loading.

Fig. 1: Transparent Film of Sample A

Fig. 2: Film of Sample AN1

Fig. 3: Film of Sample AN3

IV. SEALING TEST

To test the sealing properties of the samples, they are heat sealed under pressure at 150^0C. The samples are easily sealable both before and after mixing with nanoclays. Nanoclays have no significant effect on the sealing properties of the samples.

V. CONCLUSIONS

The present study, the mechanical properties of the starch and PVA blend have been studied with and without filler. The blend with 70% PVA and 30% starch shows the best mechanical strength. On addition of nanofiller the mechanical strength has increased significantly in all the samples. Sample with 70% starch shows maximum increase in strength compared to the unfilled sample. But the AN1 shows maximum strength among all the 1% nanoclay filled samples. In all the compositions 1% clay loading is the optimum clay loading as beyond 1% clay loading the strength of the composite decreases. The percent transparency of the unfilled and clay filled samples of starch:PVA= 30:70 is studied. The unfilled sample is very transparent. On increasing filler loading the transparency decreases. All the samples may be heat sealed at 150 degree C under pressure.

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