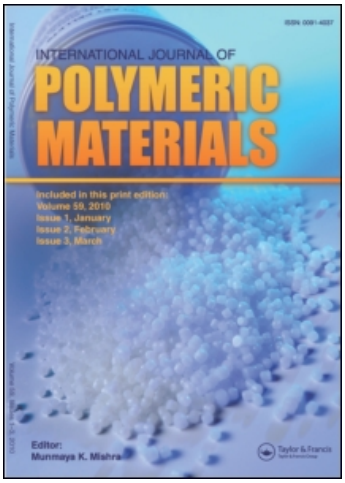

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Biodegradable Composition Based on Low Density Polyethylene

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Sodium salt of partially carboxymethylated starch (Na-PCMS) with degree of substitution DS 0.58 and starch acetate with DS 1.7 were synthesized from starch. These starch ethers and acetates along with starch, poly(vinyl acetate) (PVAc) and poly(vinyl alcohol) (PVA) were blended with low density polyethylene (LDPE) in various proportion using Brabender mixer. Addition of 5% stearic acid as a plasticizer improves the blend compatibility. Change in mechanical properties were monitored and optimum composition of blend were prepared. This blend was studied for growth of Bacillus species (BS) and degradation by means of weight loss and change in mechanical properties viz., tensile strength and % elongation, and total cellular protein. Degradation of pure polymers within one month period was also examined.

Keywords: carboxymethylated starch, polyethylene, blend, biodegradable, starch, starch-acetate

INTRODUCTION

The amount of synthetic wastes has been increasing all over the world, including India. Used packages and articles causes serious economic and environmental problem because they are mostly not easily degradable. Among these synthetic plastics polyolefins shares almost

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90% [1]. Polyethylene is one of the widely used polyolefins due to its excellent performance properties, economics and market availability. Therefore as an attempt to develop plastic material which are biodegradable under natural condition, having optimum mechanical properties as well as cost effectiveness, LDPE was blended with other synthetic polymers, polysaccharides and its derivatives. All the polymers were mixed in different composition maintaining the amount of LDPE (50%) using Brabender mixer. The mechanical properties of the resulting blends were observed. The blend having optimum mechanical properties was studied for biodegradation. The optimum properties of the blend were as below with respect to the weight percent.

LDPE	50
Na-PCMS	18
PVAc	04
starch acetate	10
PVA	08
starch	05
stearic acid	05

Modification of starch was required because starch and PE are incompatible at micro-level, which often leads to poor performance [2–5].

The growth of BS in the blend and total cellular protein was monitored. Weight loss, change in tensile strength and % elongation were examined. Also the degradation of pure polymers within one month was examined.

EXPERIMENTAL

Materials

LDPE from IPCL, Baroda, Gujarat, India and starch, monochloroacetic acid from National Chemical, Baroda. Solvents of LR grade and other laboratory chemicals were used after routine purification.

Synthesis of Na-PCMS

Na-PCMS of DS 0.58 was synthesized by the method reported elsewhere [6].

Synthesis of Starch Acetate

Starch acetate of DS 1.7 was prepared by acid catalyzed acetylation of starch in three-neck flask. The required amount of pyridine and 70

grams of starch were refluxed at 115°C for 1 hr. The suspension was cooled to about 60°C and 180 ml of acetic anhydride was added slowly with continuous stirring. The mixture was then heated at 100°C, for 2.5 hr (150 min). Then cooled to room temperature and starch acetate was precipitated using large quantity of distilled water. The product was filtered, washed with water and dried.

Blending

Blending was carried out as reported [7].

Preparation of Polymer Sheet

Polymer sheets of various thicknesses were prepared as reported [8].

Isolation of Blend Degrading Culture

Organisms capable of degrading blends were isolated by enrichment culture technique using CMS (1% w/v) as sole source of carbon. Medium employed consisted of

Ingredient	gm/lit
Magnesium sulphate	0.2
Calcium chloride	0.02
Monopotassium phosphate	1.0
Dipotassium phosphate	1.0
Ammonium nitrate	1.0
Ferric chloride	0.05

Suspend 3.27 gm of medium in 1000 ml distilled water. Sterilize it by autoclaving at 15 lbs pressure and 120°C for 15 minutes. 50 ml of the above medium was taken in 250 ml Erlenmeyer flasks which were inoculated with garden soil suspension. Upon seven days of incubation under shaking condition (150 rpm) at 300°C, cultures were isolated on starch agar medium. The colonies showing amylase activity were isolated and purified. Of five cultures isolated, BS_2 was selected for further studies as it showed maximum amylase production.

Degradation of Blend

50 gm of the above blend was taken in each 1000 ml flask containing sterile mineral medium (pH 7). To it, 10% v/v of culture suspension

of isolated BS_3 was added. All the flasks were kept on shaker (150 rpm) and every three days one flask was removed and analysed for dry weight of blend, total cellular protein, tensile strength and percent elongation.

Abiotic controls included blends in medium without culture. Above sets were in duplicate and results are the average of the readings obtained.

Weight Loss

Blends were filtered through Whatman filter paper no. 1. The residue was washed with ethanol and dried at 40°C in vacuum oven to constant weight.

Total Cellular Protein

1 ml suspension was centrifuged at 7000 rpm for 10 minutes. The cell pellets were washed with normal saline solution. The cells were then suspended in 1N NaOH and boiled for 10 minutes to disrupt the cells. It was centrifuged to remove cell debris. The supernatant fluid was assayed for protein by Lowry's method [9].

RESULTS AND DISCUSSION

Mechanical Properties

In an earlier paper we have discussed the mechanical properties of LDPE/Na-PCMS blend and effect of addition of PVAc in the blend composition [7]. The optimum mechanical properties were evaluated for blend composition 70/25/5. LDPE/Na-PCMA/PVAc respectively.

In this blend composition starch acetate (SA), PVA and starch are added. Also stearic acid (5%) is used as a plasticizer. Effect of the addition of these polymers on mechanical properties of the blend are tabulated in Table 1. Addition of starch acetate, PVA, starch and stearic acid gradually increased the melt flow index (MFI) values. This indicates the low melt viscosity of the blend which is advantageous from the processing point of view.

Also, tensile strength was increased for addition of 10% SA, 8% PVA, 5% starch and 5% stearic acid in blend composition.

Percent elongation showed different trend. Addition of SA lowered the % elongation while addition of other polymer and plasticizer increased the value.

TABLE 1 Mechanical Properties of the Polymeric Blends

Composition	MFI (gms/10 min)	Tensile strength (Kg/cm^2)	% elongation (%)
A	0.95	37	160
A + Starch acetate			
5	0.95	37	158
10-B	0.97	38	152
15	0.98	38	145
B + PVA			
5	1.01	39	153
8-C	1.10	40	160
10	1.11	39	162
C + Starch (5) + Stearic acid (5)-D	1.20	42	165

A = LDPE(50)/NaPCMS(18)/PVAc(4).
B = A + Starch Acetate (10)
C = B + PVA (8)
D = C + Starch (5) + Stearic acid (5)

From the above results it is clear that optimum properties are obtained in composition D. Therefore it has been selected for biodegradation study.

Biodegradation

Five different bacteria were isolated *viz* BS_1, BS_2, BS_3, BS_4, BS_5. Among them BS_2 was found to be maximum amylase producer (data not shown) and hence was used for further study. BS_2 is gram positive motile, nonspore forming bacilli. Results are shown in Tables 2 and 3.

TABLE 2 % Weight Loss and Total Cellular Protein

Time (days)	% weight loss (%)	Total cellular protein (μg/ml)
0	0	136
3	4.16	185
6	6.25	210
9	18.75	296
12	22.91	303
15	30.25	350
18	37.5	570
21	41.56	470
24	43.70	450
27	45.50	400
30	50.0	305

TABLE 3 Weight Loss of Pure Polymers within One Month

Polymer	Weight loss (%)
LDPE	02
Na-PCMS	100
PVAc	05
SA	95
PVA	100
Starch	100

With BS_2 50% loss in dry weight of the blend was observed in 30 days of incubation, blends consists of 50% LDPE and 50% other polymer. Thus it seems that nearly all the polymer except LDPE was degraded and some part of LDPE was utilised by the isolated BS_2.

Furthermore, total cellular protein was found to increase upto 18 days which reflects increase in biomass after which growth was found to cease. This indicates that extracellular enzymes are involved in the degradation of blends.

Biodegradation study of the pure polymer which are used during the work were carried out for one month by using BS_2 bacteria. The results are tabulated in Table 3.

Tensile Strength and Percent Elongation

Tensile strength (TS) and % elongation of blend were measured after every six days degradation. They are tabulated in Table 4. TS and % elongation decrease with increase in degradation time. After 30 days of degradation TS was lower than that of pure LDPE.

TABLE 4 Tensile Strength and % Elongation After Degradation

Time (days)	Tensile strength (Kg/cm^2)	% elongation (%)
0	42	165
6	40	160
12	37	143
18	34	127
24	31	118
30	29	100

CONCLUSION

From the above study we may conclude that above indicated blend composition based on LDPE have better mechanical properties than neat LDPE, compatibility and degradability. After 30 days of degradation around 50% weight loss was observed and the tensile strength was less than that of pure LDPE.

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