

## Blends of Polyvinyl Acetate and Low Density Poly Ethylene

Nirmal K Patel, Prashant D Pandya and Vijay Kumar Sinha\*

Department of Industrial Chemistry,  
VP and RPTP Science College, Vallabh Vidyanagar 388 120, Anand, Gujarat, India

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The feasibility of synthesing a series of polyvinylacetate(PVAc): low density polyethylene (LDPE) blends of different weight ratio 0.25:1, 0.5:1, 0.75:1, 1:1, 1:0.75, 1:0.5 and 1:0.25 respectively is studied by using solution mixing process. An improvement in physical properties of blends is observed in comparison with those of blends of LDPE with Nitrile Butadiene Rubber(NBR) and Styrene Butadiene Rubber(SBR). It is found that these blends have superior mechanical properties as compared to those of rubber blends. Confirmation of blending is done with the help of IR. Thermal stability of PVAc: LDPE blends is determined by thermogravimetric analysis(TGA). Practically no weight loss is observed up to 275 °C and a high value of MFI provides ease of processing within varying temperatures.

### Introduction

Synthetic polymers have gained importance due to their versatile nature and their products of tailor made properties at reduced cost. The development in this field has lowered the consumption of conventional and natural products.

Low density polyethylene(LDPE), one of the synthetic polymers, is being extensively used presently and disposal of its waste is causing a serious environmental problem due to its nonbiodegradability. It has been reported that polysaccharides (starch, cellulose, and its derivatives) can be used in blend composition to improve biodegradability of LDPE.<sup>1-6</sup> But natural polysaccharides being hydrophilic in nature hamper the electrical and mechanical properties of blends<sup>7</sup>.

Blending of polyethylene with other synthetic polymers, such as polypropylene, polyester, polystyrene, polyamide and modified polyamide, polyethylene terephthalate(PET), polycarbonate, modified EPDM and BR, polymethylmethacrylate (PMMA), block propylene-ethylene copolymer, and LLDPE graft maleic anhydride copolymers, has been reported earlier<sup>8-23</sup>.

To incorporate the biodegradability along with improved mechanical and electrical properties we blended PVAc with LDPE. Blending of polyethylene with PVAc was found to be difficult due to certain limitations. Mechanical mixing was not possible at low temperature and mixing at high temperature enhanced the possibility of oxidative degradation. Thus, solution mixing was carried out for homogeneous blending of LDPE with PVAc. Since, both PVAc, and LDPE are soluble in xylene, their blends were prepared by solution mixing process and tested for melt flow index(MFI), flexural strength, tensile strength, heat distortion temperature(HDT), and durometer hardness. IR spectroscopy confirmed the formation of polymeric blend. Thermal stability of blends was also studied by means of thermogravimetric analysis(TGA).

Improvement of physical properties is attributed to the reduction of interfacial tension at the interface of the components as well as penetration of surface molecules into the polymeric phase<sup>24</sup>.

### Material and Methods

PVAc from National Chemical, Baroda, LDPE from Indian Petrochemicals Corporation Limited (IPCL), Baroda, and laboratory grade xylene and methanol were used.

\*Author for correspondence

### Blending

A threenecked flask equipped with water condenser, stirrer and, thermometer was charged with calculated amounts of PVAc, LDPE, and xylene. The mixture was heated at 100 °C with constant stirring for 2 h. The blend cooled to room temperature and precipitated in methanol. It was filtered and dried in vacuum to constant mass<sup>25-27</sup>.

### Preparation of polymer Sheet

Sheets of specific thickness were prepared by sandwiching the blend between mould plates of compression machine at 150°C for 10 min. The sheet was held under 60 kg/cm<sup>2</sup> pressure at 150 °C for 5 min and then taken out of the mould for cooling at room temperature<sup>28</sup>.

## Results and Discussions

### Melt Flow Index (MFI)

The measurement of MFI was carried out as per the procedure described in ASTM D 1238-53T. The weight of polymeric blend flowed in 10 min under a 2.16 kg load at 190°C was measured by a Melt Indexer. Results of MFI measurements are given in Table 1. The MFI of blends increased with increase in the amount of PVAc.

Table 1 — Physical properties of PVAc: LDPE blends

Ratio	MFI	Flexural strength	Per cent elongation	Tensile strength	HDT
PVAc:LDPE	g/10 min	kg/cm <sup>2</sup>	per cent	kg/cm <sup>2</sup>	°C
(mean)	(mean)				
0:1	0.5	69.63	100	31	42
0.25:1	0.91	70.25	133	35	47
0.5:1	1.3	73.87	166	38	50
0.75:1	1.67	78.50	200	40	52
1:1	2.01	86.92	266	55	55
1:0.75	4.26	97.17	300	54	58
1:0.5	5.08	112.82	333	50	67
1:0.25	6.67	197.43	400	47	70

### Flexural Strength (FS)

The measurement of FS was done as per the procedure described in ASTM D790. A three point loading system utilizing central loading on a single supported beam was used for measurement. A crosshead speed of 2.5 cm/min was used for all specimens. Results given in Table 1 indicate that flexural strength increases with increasing amount of PVAc in the blend composition. For example, flexural strength of 1:0.25 (PVAc : LDPE) composition is nearly three times compared with that of polyethylene.

### Tensile Strength (TS)

Tensile strength measurements were conducted by using a tensile tester at room temperature, following the process described in ASTM D 638. A crosshead speed of 10 cm/min was use in all measurements. It is observed that TS of 1:1 PVAc: LDPE is optimum compared to other blends. On the other hand, per cent elongation (flexibility) continued to increase with increasing contents of PVAc in blends (Table 1).

### Heat Distortion Temperature (HDT)

HDT measurement was carried out following procedure described in ASTM D 648. HDT of the blends increased on increasing the amount of PVAc in blend. For example, HDT of LDPE is 42°C and that of 1:0.25(PVAc : LDPE) is 70°C (Table 1).

### Durometer Hardness

Durometer hardness measurements were done as per the procedure described in ASTM D 2240-75. Hardness is measured in terms of shore A and shore D. They represent the hardness of a material when it is subjected to a certain force through a penetrating object of well defined dimensions. The hardness of blends decreases gradually with the increasing content of PVAc because of its relatively flexible nature (Table 2).

### Comparison of Mechanical Properties of Different Polymeric Blends

The mechanical properties of blends synthesized in our laboratory are compared with that of LDPE-Rubber blends reported by Mohamad *et al.*<sup>29</sup>. It is observed that tensile properties (tensile strength and per cent elongation) of PVAc: LDPE blends are better than those of NBR: LDPE and SBR: LDPE blends.

Table 2 — Durometer hardness

Ratio	Durometer hardness	
	Shore A	Shore D
PVAc:LDPE		
0:1	90	40
0.25:1	88	38
0.5:1	87	35
0.75:1	85	33
1:1	84	29
1:0.75	75	27
1:0.5	72	23
1:0.25	68	21

### Infrared Spectroscopy

The IR spectral analysis of blends prepared by solution mixing process was carried out on DuPont 951 IR spectrometer. In IR spectra the sharp peak around  $1752\text{ cm}^{-1}$  confirms the presence of ester linkage present in PVAc in a blend. A sharp absorption band at  $1031\text{ cm}^{-1}$  is attributed to the aliphatic olefins— $(\text{CH}=\text{CH})_n$ — present in the blend based on LDPE. C-O stretching band is observed at  $1254\text{ cm}^{-1}$ . Sharp band around  $2925\text{ cm}^{-1}$  determines the vibrational stretching of  $-(\text{C}-\text{H})-$  and  $-(\text{CH}_2)-$  present in LDPE. The presence of above key peaks IR spectroscopy confirms the successful synthesis of LDPE:PVAc blends.

### Thermogravimetric Analysis of LDPE:PVAc blend

Measurements were conducted using a DuPont 2000 thermogravimetric analyzer under nitrogen atmosphere at a heating rate of  $20^\circ\text{C}/\text{min}$  up to  $950^\circ\text{C}$ . From the percentage weight loss, thermal stability of the blend was estimated. The blend of LDPE with PVAc showed two decomposition stages, (Figure B). The first decomposition occurs at  $285^\circ\text{C}$  to  $425^\circ\text{C}$  which is attributed to PVAc decomposition. The structure of PVAc is branched, brownian movement within the molecule occurs more rapidly compared to the straight chain LDPE polymer. The second stage, appearing at about  $510^\circ\text{C}$  was due to LDPE decomposition. There was no weight loss up to  $275^\circ\text{C}$ . Integral Procedure Decomposition Temperature (IPDT) of the blend was found at  $540^\circ\text{C}$ . Thus, blend offers wide range of processing temperatures.

Table 3 — Comparison of PVAc:LDPE blends with rubber -

Type of blend	LDPE blends		
	LDPE Content	Tensile strength	Per cent elongation
PVAc:LDPE	25	47	400
	50	55	266
	75	54	300
NBR:LDPE	25	21	355
	50	32	340
	75	35	230
SBR:LDPE	25	18	200
	50	29	160
	75	34	180

### Conclusion

A series of compatible blends of PVAc and LDPE were successfully synthesized by using solution mixing process. Blending of LDPE with PVAc enhances its physical and thermal stability. The comparison indicates that PVAc: LDPE blends have better mechanical properties than those of NBR : LDPE and SBR : LDPE blends.

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