

Synthesis and characterization of low density polyethylene graft maleic anhydride (LDPE-g-MA) and polyvinyl acetate (PVAc) blends

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Graft copolymer of low density polyethylene (LDPE) and maleic anhydride (MA) was prepared in a homogeneous medium by using benzoyl peroxide as an initiator. This graft copolymer and polyvinyl acetate (PVAc) was blended by addition of different amounts of PVAc using solution mixing process. The resulting blend was analyzed for melt flow index (MFI), flexural strength, tensile strength, % elongation and durometer hardness. The tensile properties of the blend were compared with that of blends of LDPE/PVAc and LDPE/PVAc using LDPE-g-MA as compatibilizer. The homogeneous blending was confirmed by scanning electron microscope.

Introduction

THE field of polymer science and technology has undergone an enormous expansion over the last several decades. Initially, came development of new polymers from a variety of monomers. Next random, graft and block co-polymerization as introduced.

In the search for new polymers another alternative has been to blend existing polymers to produce materials with new properties. Advantages of this approach are that it usually requires little capital expenditure. It is also possible to produce a range of material with properties completely different from those of the original polymers.

LDPE and its articles are widely used for various purposes both domestically and industrially because of its excellent performance properties⁽¹⁻³⁾. In a search for new plastic materials having a range of performance property we have blended it with PVAc⁽⁴⁾. For further improvement in properties and compatibility there are two options available:

1. Use of graft or blocked copolymer of either polymer as compatibilizer.
2. Modification of one of the polymers

Both options were examined. The blends of LDPE/PVAc by using LDPE-g-MA as compatibilizer is reported by author elsewhere⁽⁵⁾.

Falling in the latter option, LDPE was first grafted with maleic anhydride and then blended with polyvinyl acetate in different compositions by using the solution-mixing process. Blending of LDPE-g-MA with PVAc was found to be difficult due to certain limitations. Mechanical mixing was not possible at lower temperature and mixing a high temperature enhances the possibilities of oxidative degradation. Since both are soluble in xylene, the blends are prepared by the solution mixing process. The resulting blends were tested for MFI, flexural strength, tensile strength, % elongation and durometer hardness. Mechanical properties of the blend were compared with LDPE/PVAc blends with and without compatibilizer. The synthe-

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TABLE-I: MELT FLOW INDEX (MFI)

Ratio LDPE-g-MA: PVAc	MFI gms/ 10 minutes	
	A	B
1:0	0.52	0.55
1:0.25	0.95	1.25
1:0.5	1.40	1.63
1:0.75	2.01	3.08
1:1	3.18	5.02
0.75:1	5.53	7.63
0.5:1	6.50	8.97
0.25:1	7.13	9.95

Where A = LDPE-g-MA (0.4 mole % anhydride group): PVAc
 B = LDPE-g-MA (0.8 mole % anhydride group): PVAc

sis of graft copolymer and blending was confirmed by FTIR spectroscopy. SEM helped us in the study of morphology of blends.

Improvement in physical properties is attributed to the reduction of interfacial tension at the interface of the component as well as penetration of surface molecule in to the polymeric phase⁶.

Experimental

Materials

LDPE from IPCL, Baroda, PVAc, MA from National Chemicals, Baroda. Solvents and other laboratory chemicals were used after routine purification.

Methods

Grafting of maleic anhydride onto LDPE

A three-necked flask equipped with reflux condenser, stirrer and nitrogen gas inlet was charged with LDPE, maleic anhydride and xylene. Benzoyl peroxide was used as initiator. The system was flushed out with inert gas to avoid any possibility of oxidative degradation. Nitrogen gas was continued for a period of 4 hours and the reaction mass was maintained under the reflux condition at

TABLE-II: FLEXURAL STRENGTH

Ratio LDPE-g-MA: PVAc	Flexural strength Kg/Cm ²	
	A	B
1:0	69	66.63
1:0.25	70.14	67.12
1:0.5	73.02	70.25
1:0.75	78.00	75.14
1:1	85.87	81.18
0.75:1	95.37	91.29
0.5:1	111.02	98.57
0.25:1	187.92	175.43

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 mass⁴.

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/cm² pressure at

TABLE III: ELONGATION AND TENSILE STRENGTH

Ratio LDPE-g-MA:PVAc	% Elongation %		Tensile Strength Kg/Cm ²	
	A	B	A	B
1:0	110	125	33	35
1:0.25	130	145	37	40
1:0.5	179	185	40	43
1:0.75	225	250	42	48
1:1	290	305	59	61
0.75:1	325	355	59	61
0.5:1	350	400	60	62
0.25:1	410	470	64	67

TABLE IV: DUROMETER HARDNESS

Ratio LDPE-g-MA:PVAc	% Elongation %		Tensile Strength Kg/Cm ²	
	A	B	A	B
1:0	91	92	39	41
1:0.25	86	88	38	39
1:0.5	85	85	35	36
1:0.75	85	85	34	35
1:1	84	85	30	33
0.75:1	75	78	38	30
0.5:1	70	75	25	27
0.25:1	68	70	23	25

120°C with constant stirring. The grafted product was poured into methanol, filtered and vacuum dried until a constant mass was obtained. Vacuum dried grafted product was used as a compatibility booster as well as the blend constituents of the blends with PVAc⁵.

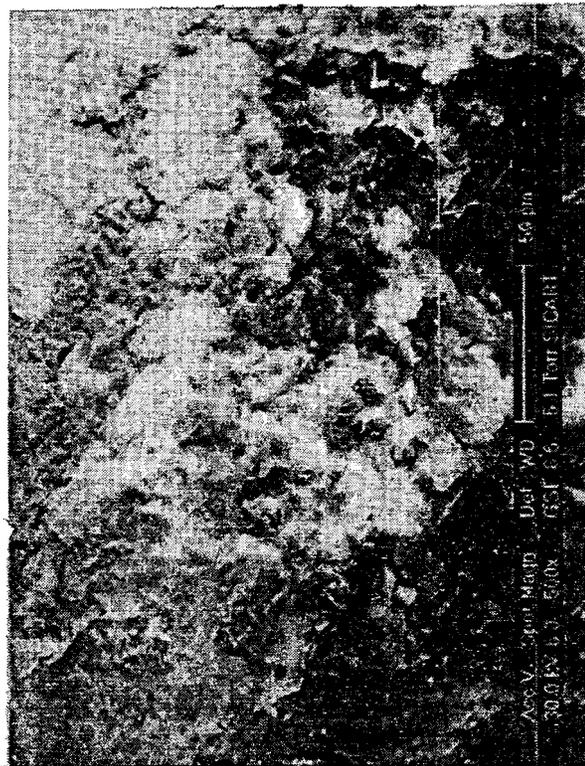
Blending

A three necked flask equipped with water condenser, stirrer and, thermometer was charged with calculated

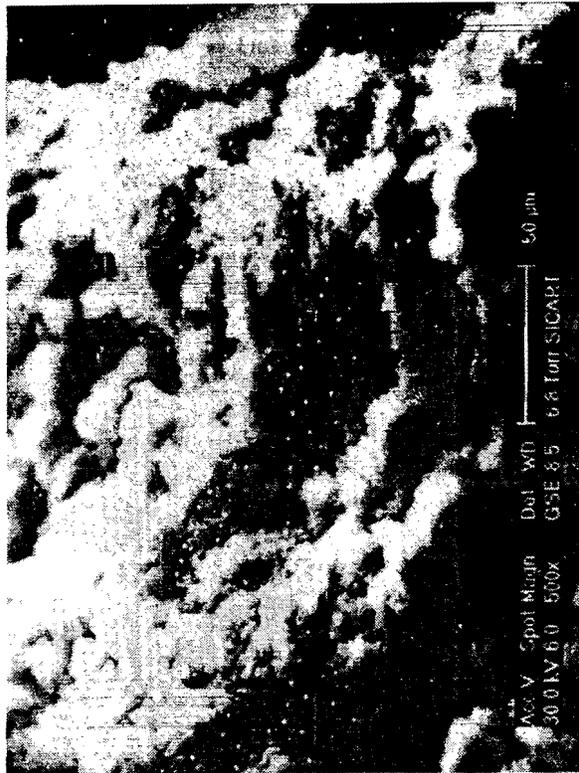
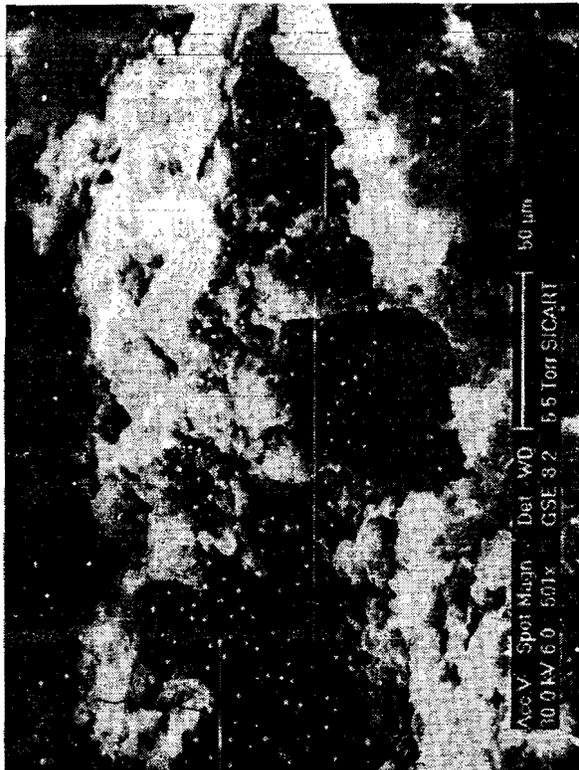
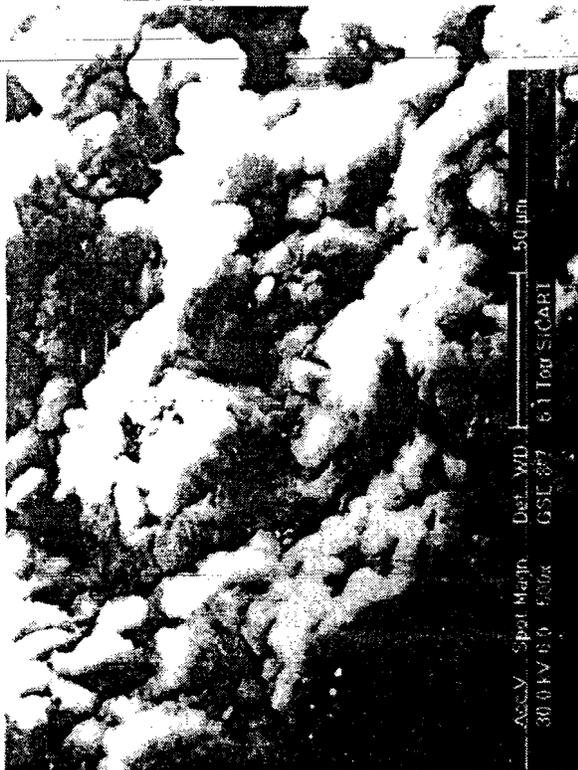
150°C for 5 min and then taken out of the mould for cooling at room temperature⁴.

Analysis

1. Mechanical properties of the blend were measured in accordance with ASTM procedures.
2. The test samples of blend was examined with ESEMTPM, Phillips model scanning electron microscope.



Polymer samples from Industrial Chemistry Dept., V. V. Nagar



Polymer samples from Industrial Chemistry Dept., V. V. Nagar

TABLE V: COMPARISON

Type of Blend	Tensile Strength 1:1	Kg/cm ² 0.25:1	% Elongation 1:1	Gms/10 minutes 0.25:1
LDPE-g-MA (0.4 mole%): PVAc	59	64	290	410
LDPE-g-MA (0.8mole%):PVAc	61	67	305	470
LDPE:PVAc (with compatibilizer)	58	63	295	450
LDPE:PVAc	55	47	266	400

Results and discussion

Melt Flow Index (MFI)

The weight of polymeric blends flowed in 10 minutes under a 2160 gms load (approximately 43.25 psi or 298.2K Pa pressure) at 190°C was measured by a μ indexer. Results of MFI measurements are given in Table-I. The MFI of blends increased with increase in the amount of MA on to LDPE and amount of PVAc in the blend. Increase in MFI indicates there was decrease in resistance to flow the material and ultimately lower the melt viscosity, which is advantageous from the processing point of view.

Flexural strength

A three-point loading system utilizing central loading on a single supported beam was used for measurements. A crosshead speed of 2.5 cm/minute was used for all specimens. Results are tabulated in Table-II. It indicates that flexural strength increases with increase in amount of PVAc in the blend, while somewhat lower values were observed as the amount of MA on LDPE were increased, which may be due to the comparatively hard segment of MA than LDPE. The increase in flexural strength indicates that the ability of the blend to withstand the forces applied perpendicular to its longitudinal axis increases.

% Elongation and Tensile Strength (TS)

% Elongation and TS measurements were conducted by using a tensile tester at room temperature at a cross head speed of 10 cm./min. The results are given in Table III. Both TS and % elongation

were increased, with increasing amount of PVAc. TS and % elongation were increased up to 67 kg./cm². and 470% respectively for the blend composition 0.25:1 (LDPE-g-MA:PVAc). This indicates that the ability of material to withstand forces that tend to pull it apart and to the extent of material stretches before breaking increases.

Durometer hardness

Hardness is measured in terms of shore A and shore D. They represent the hardness of materials when it is subjected to a certain force through a penetrating object of well define dimensions. The results are given in Table IV. The hardness of blend decreases gradually with the increasing content of PVAc because of its relative flexible nature, while comparatively higher values were observed for LDPE-g-MA having 0.8-mole % anhydride group. But all the values are still lower than LDPE-g - MA and gradually decreased.

Comparison

The mechanical properties of blends are compared with that of LDPE/PVAc blends with and without compatibilizer (LDPE-g- MA). The two optimum compositions 1:1 and 0.25:1 were selected for comparison. The comparison is shown in Table V. It is observed that tensile strength is better than both types of LDPE/PVAc blend. % elongation of blend having 0.4 mole % anhydride groups were in between that of non compatibilized and compatibilized ones, while that of 0.8 mole % anhydride groups were the best among all the blends.

Scanning Electron Microscopy

The photograph of a blend taken by

SEM is shown in the figure-177S 8A. TIF and 177S 8B. TIF. From the picture it is clearly observed that uniform mixing was achieved by solution mixing process. Also the blend shows homogeneity, i.e. single phase of both the components LDPE-g-MA and PVAc.

Conclusion

MFI, % elongation and TS increased as the amount of PVAc was increased, while a decrease in flexural strength and durometer hardness was observed. The compatibility of the blends increased with increasing the amount of reactive groups such as maleic anhydride on the LDPE. The blend finds application in the field of packaging as well as wherever Polyethylene used.

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References

- Otey, F. H., Westhoff, R. P. and Russel, C.R. Ind. Eng. Chem. Prod. Res. Dev. 16, 1977, P.305.
- Halkkarainen, M., Albertsson, A. C. and Karlsson, S. J. Appl. Polym. Chem., 66, 1997, P. 959.
- Degradable Polymers, Principles and Applications 1st edition, Chapman and Hall, 1995, P. 216.
- Patel, N. K., Pandya, P. D. and Sinha, V. K. J. Sci. & Ind. Res., 59, 2000, P. 225.
- Patel, N. K., Pandya, P. D. and Sinha, V. K. Int. J. Polym. Mater., 49, 2001, P. 179.
- Viglgis T. A. and Noolandi J. Makromol. Chem. Makromol. Symp. 16, 1998, P. 22. □