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Preparation and Characterisation of Polypropylene/ EVA Blends with Nano Clay Composites

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Abstract: In this study the potentiality of thermoplastics elastomer EVA to Polypropylene has been investigated. This specimen based thermoplastic elastomer EVA is used as an toughening agent in PP. The various compositions of PP and EVA in addition of NANOCLAY were prepared by melt mixing technique by using twin screw extruder. Mixing conditions were optimized in order to get a homogeneous melt / Blend. The extrudate is obtained in the form of cylindrical strands and the strands were cut into regular small sized cylindrical pellets which are predried and injection moulded for test specimen preparation. The specimens for various tests were prepared according to ASTM standard. The specimens of different compositions of PP and EVA along with NANOCLAY as constant are tested for mechanical, thermal and physical properties using universal testing machine, impact tester, MFI tester etc. The composition of NANOCLAY is fixed as 1% whereas EVA used in PP were 5 %, 10% and 15%. The compositions were PP (94%), PP (89%), PP (84%) . Basis for each of the sample is 3kgs. The results show important improvement in the impact properties of PP + EVA with NANOCLAY blend as compared with PP virgin and other toughened blends. The study reveals that the optimum set of properties is obtained between 5.0 to 15% of EVA, especially the impact strength is increased to a big extent between these combinations. This increased impact strength is very much required in the field of Automobile sector, outdoor application, so this combination of PP/EVA with NANOCLAY can fulfill the necessary requirement.

I. ABBREVIATIONS

PP	Poly Propylene
EVA	Ethylene vinyl Acetate
MFI	Melt flow index
ASTM	American Standard of Testing & Machine
EPDM	Ethylene Propylene diene monomer
ESCR	Environmental Stress Cracking Resistance
HDT	Heat Deflection temperature
MBS	Methacrylate — butadiene-styrene
MF	Melamine formaldehyde
PBT	Polybutylene terephthalate
PC	Polycarbonate
PE	Polyethylene
PEEK	Polyether ether ketone
PF	Phenol formaldehyde
PO	Polyoxymethylene
PPS	Polyphylenesulphide
PS	Polystyrene
PVC	Polyvinylchloride
TGA	Thermo gravimetry Analysis
TMA	Thermo Mechanical Analysis
TPU	Thermo Plastic Polyurethane
UF	Urea formaldehyde

II. INTRODUCTION

A. Overview of Polymers

Historians frequently classified the early ages of man according to the materials that he used for making his implements and other basic necessities. The most well known of these periods are the Stone Age, the Iron Age & the Bronze Age. By the time of the ancient civilizations of Egypt & Babylonia he was employing a range of metals, stones, woods, ceramics, glasses, skins, horns & fibers. Until the 19th century man's inanimate possessions, his home, his tools, his furniture, were made from varieties of there light classes of material. During the last century & a half, two new closely related classes of material have been introduced which have not only challenged the older materials for their well established uses but have also made possible new products which have helped to extend the range of activities of mankind. These two classes of materials are plastics & Rubbers which falls under the category of polymers materials without these two groups of materials, it is difficult to conceive how such everyday features of modern life such as motor car, the telephone & the television set could ever have been developed.

Polymers is a micro molecule which is made up of many small molecules that are combined together to form a single long or large molecule. The individual small molecules from which the polymers are formed are called as monomers & the process by which the monomers are linked to form a big polymers molecule is class polymerization process.

B. Classification of Polymers

1) *Natural & synthetic polymers:* Depending on their origin polymers can be grouped as natural or synthetic. Those isolated from natural materials are called Natural polymers.
   - *a)* Example: Cotton, Silk, Wool Polymers derived from low molecular cot compounds are called synthetic polymers
   - *b)* Example: PE, PP, PS, etc.

2) *Organic & Inorganic:* A Polymer whose backbone chain is essentially of carbon atoms is termed as organic polymers. The majority of synthetic polymers are organic.
   - *a)* Example: Polyethylene
   - *b)* Inorganic Polymers: The molecules of inorganic polymers has no carbon atom in their backbone chain.
   - *c)* Example: Glass, Polysyloxin, etc.,

3) *Thermoplastic and Thermosetting Plastic*
   - *a)* Thermoplastic: PE, PVC, PS
   - *b)* Thermosetting: PF, UF, MF
4) *Plastics, Elastomer, Fibre & Liquid Resin*
5)

Depending on its ultimate use & form a polymer can be classified as plastic, Elastomer, fiber or Liquid resin

When polymers is shaped into a hard & tough particles by the application of heat & pressure it is used as a plastic

Example: PVC, PC

When vulcanized into rubber products exhibiting good strength, elongation, the polymers are used as Elastomers.

Example: Natural Rubbers silicone Rubber etc.,

If drawn into long filament like materials whose length is at least 100 times its diameter, the polymers are set to have been converted into Fibres.

Examples: Nylon, Jerrylene.

Polymers used as adhesives, sealants in Liquid farm are described as liquid resins.

Examples: Epoxy adhesives, Polysulphide sealants

C. History of Plastics

The history of mankind use of polymers & eventual development of plastics has followed a general pattern of events.

1) Discovery of the polymers (This usually implies a naturally occurring polymer, but some recent discoveries of synthetic polymers were made in the laboratory unintentionally)
2) Use of polymer (The early application are usually based upon the obvious properties of the materials)
3) Realization of deficiencies of the materials & attempts at modification, usually by trial & error.
4) Investigation of the properties of the mat & development of a conceptual view or model of the material's basic nature.
5) Systematic modification based upon the properties & basic nature that have been developed.

The First man made Plastic, a form of cellulose nitrate, was prepared in 1838 by A. Parker. It was intended to be a replacement for natural materials such as ivory to be used in making billiard balls and it was called parkesine.

In 1870, a patent was issued to J.Hyatt of New York, for celluloid, a type of cellular nitrate with low nitrate content produced at high temp & pressure. This was the first commercially available plastic, and the only one until the development of Bakelite by Back eland in 1907. Bakelite is the oldest of the purely synthetic plastics & consisted of a resin abstained by the reaction of phenol & formaldehyde.

By 1900 the only plastics materials available were shellac, gutta percha, ebonite and celluloid. In the year 1930, the growth in the number of polymers & their application become immense.

D. Plastics

Plastic is a general term that describes materials composed principally of very large molecules (called polymers) that are synthetically made or modified from small components (called monomers).Plastics are solid that, in some stage have been shaped by flow or molding in the liquid, molten or softened form.

E. Classification of Plastics

Plastics need no introduction in today's world. In every sphere of life its indispensability is felt by each & cell of the society-rich or poor. Such is the diversity of the properties of these materials, that it is essential to classify them into different groups for better understanding of the properties.

Plastics are classified into two main groups

1) *Thermoplastic:* Plastics that can be repeatedly moulded & reshaped by application of heating & cooling cycle under pressure are termed as thermoplastics.
   a) *Example:* PE. PVC, PS.
2) *Thermosetting Plastics* that are once shaped by application of heat & pressure & do not have the versatility of repeat process ability are called thermosets.
   a) *Example:* PF, UF, Epoxies

One more classification commonly used in the industry parlance divides plastics in three groups:

3) *Commodity Resins*: These are low-performance high volume resins, characterized by HDT 100 °C & tensile strength a < 50 Mpa

Properties of Commodity: 1.Ease in processing, 2.Low Cost.

Example: PE, PP, PS, PVC, etc.,

4) *Engineering Plastics* These resins are characterized by HDT 100 °C & tensile strength a 40 Mpa. Plastics are used in engineering application because of the following special properties.
   a) High Mechanical strength
   b) Local Bearing Capacity
   c) High dimensional stability
   d) High wear & corrosion resistance
   e) Anti-friction properties
   f) High HDT
   g) High creep resistance
   h) High impact properties etc.,

Examples include Nylon, PC, POM, ABS

5) *Speciality Plastics:* To this category belong low volume, high performance, high temp & and high cost polymers these resins are characterized by high modules, tensile & impact strength.

   Examples: PPS, PEEK

F. Importance of Plastics

Plastics have a wide variety of application in modern society. The applications touch almost every facet of our lives viz. agriculture & water consumption, building construction, Communication, small & bulk packaging, Education, medicine, transportation, defence, consumer durables and have become virtually indispensable often without us being aware that a plastic part has been used. One of the reason for great popularity of plastics is due to tremendous range of properties exhibited by them because of their case of processing. Hence the demand for plastics has been increasing in modern living & it will grow further.

1) *Plastics help to improve quality of life:* The Internet, globalization, increased speed of communication, faster, means of transportation, the advance of surgical medicine-all these would not be possible without plastics, continuous technological innovation by the plastics industry means that ever more efficient, lightweight & adaptable forms of plastics are being developed for an increasing range of uses. It is these advance that allow plastics to play an imp role in the pursuit of sustainable development.
2) *Preserve Land, Water & Forest Resources:* Plastics have been providing help to tackle the world's water, distribution crisis, with affordable, easily constructed piping, providing solutions to clean, water shortages for 5.5 million people in Asia, the Middle East and Africa. Also the use of plastics drastically reduced the use of traditional usage of wood & other forest products thus resulting in reduction of deforestation.
3) *Enable Efficient use of Non-Renewable Energy Resources:* It is estimated that the use of plastic as a whole actually saves more oil than is needed for their manufacture. At the end-of-life, plastics can be valuable alternative energy source in their own right. Plastics recycling continue to increase in world while energy recovery is a responsible use of our oil resources, diverting waste from landfill & helping to preserve fossil fuels.
4) *Possess a more Favourable Cost-Benefit Ratio:* Continuous improvements in the material itself and recovery technologies mean that, in the future, packaging will become even lighter & more resource efficient. The recently introduced smart car-largely made of plastics-is a sign of things to come.

In this way plastics has contributed in each & every field and how acted as a replacement to metal & wood in many instances.

G. Introduction To Blends

Most Materials, be it natural or synthetic to blend have a limited utility, it is the ingenuity of man that he has used all the possible technical skill to increase the utility of these materials beyond the wildest of imagination.

Existing trend reveals a rapidly growing interest in research in the field of polymer blends as a major endeavor. A particular polymer may have a set of properties superior to another polymer while this polymer may be rich in different set of properties which are lacking in the former. By blending of different polymers, several properties can be improved while retaining some of the other remaining properties. The total research on rubber and plastics carried out today comprises of about 25% in the field of blending alone and this figure could even go up to 50% by the year 2000 A.D as per its present trend. This shows the importance blending of polymers would have in the years to come. In recent years, elastomeric rubber plastics blends have become technologically interesting for use as thermoplastics elastomers. They can have many of the properties of rubber, but can be processable as thermoplastics. They offer a substantial economic and thermo logical advantage in respect to the fabrication of finished parts.

A blend will usually have properties that are averages of the properties of the polymers that were combined to form the blend.

H. Types of Blends

1) Homologous polymers Blends - a sub class of polymers blend limited to mixtures of chemically identical polymers different in molecular mass.
2) Miscible polymer Blends - A sub class of polymer blend encompassing those blends which exhibit single phase behaviors. Miscible blends appear to mix at the molecular level.
3) Immiscible polymers Blend - A subclass of polymer blend referring to those blends that exhibit two or more phases at all compositions and temperatures. In this type, the polymer molecules phase-separate into distinct domains containing nearly exclusively molecules of only one component.
4) Partially Miscible polymers Blends - A sub class of polymers blend referring to those blends that exhibit a "window" of miscibility i.e. they are miscible only at some concentration and temperature.

I. *Advantage of Blends*

Today, polymers blends constitute over 30 % wt of polymer consumption, and with the annual growth rate of 9% (constant for the last 12 years) their role can only increase benefits of blending can be discussed from the perspective of material properties & economic it can bring to the manufacturer. There are a number of good reasons for blending they are.

1) Developing materials with a full set of desired properties
2) Extending engineering resins performance by diluting them with low-cost commodity polymers.
3) Improving a specific property, e.g., impact strength, ductility, solvent resistance, barrier properties, abrasion resistance etc.
4) Adjusting the material performance to fit customer's specification at the lowest price.
5) Recycling industrial and /or municipal plastics waste.
6) Better processability, thus improved product uniformity & scrap reduction.
7) Quick formulation changes, thus plant flexibility & high productivity.
8) Blending reduces the no of grades that need to be manufactured and stored, thus savings in space & capital investment.

J. *Preparation of Polymer Blends.*

1) *Melt Mixing:* In general, it is used for systems in which thermal degradation does not ordinarily occur. The amount of heat necessary to maintain low viscosity and shearing rates needed for thorough mixing are controlled properly for avoiding degradation of polymers.

K. *Rubber Toughened Blends*

These are the types of blends in which a toughening agent or impact modifier is added to main polymer matrix by blending process in order to increas.e its resistance to impact loads.

Impact toughness is strongly dependent upon the ability of the material to more or deforms to accommodate the impact. This movement is elongation or strain. Therefore, Materials which exhibit high elongation are tough especially if they have good strength.

Rubbers are the most common toughness modifiers added to the plastic material in order to absorb the impact energy. When thoroughly mixed with the plastic materials, these toughness modifiers give additional movement when the plastic is impacted, thus improving the ability of the material to absorb the impact energy and, consequently, improving the toughness.

Rubber Toughened Blends are,

1) ABS / TPU TPU is added to increase the impact resistance
2) ABS /PC
3) PBT / TPU
4) PP / EPDM
5) PP / EVA
6) ABS / HYTREL
7) TPU / EPDM
8) PVC / HYTREL

L. *Toughening Agents used in Blends*

Toughening Agents can also be classified as Impact modifiers. They are incorporated in the plastic materials for increasing the impact strength of materials. There are basically two ways of increasing the impact strength of a material either by adding impact modifier to the resin or incorporating Elastomer (Rubber) in the plastic materials through blending process.

Toughening Agents commonly used

1) *MBS Modifiers:* Used to improve impact strength of PVC compounds without sacrificing the other characteristics used in Blow moulding of bottles, calendaring of film & sheet.
2) *Acrylic Modifiers:* Significantly improve impact characteristics of PVC without any effects of weatherability main application are profiles, sheet & pipes.
3) *Butadiene:* it is a type of elestomer used in PS material to make it ductile & increase its impact resistance. 4.
4) *EPDM:* This comes under the category of Elastomer, used in conjunction with pp to increase its impact strength to be used in Automobile applications.
5) *EVA:* It is copolymers of ethylene & vinyl acetate. It is a thermoplastic materials ocinraining 5-50% vinyl acetate & act as Elastomer to increase toughness of plastic materials like PP. PE.

6) *TPU:* It is a type of elastomer used in conjunction with many plastics like ABS, PC in order to increase their resistance to impact loads. It falls under thermoplastics eleastomer. It is a combination of di-isocyanate & polyol. It specific properties include high tensile strength load bearing capacity & good thermal & chemical resistance.
7) Elastomers like silicones, fluropolymers also have play equal importance in some cases in increasing the impact behavior of plastics.
8) *Hytrel:* It is a type of toughening agent used to increase the impact strength of materials to a big extent as compared to other elastomers. Hytrel is polyester based thermoplastic elastomer. It came into existence in year 1970. Dupont is the manufactures. Not much work has been reported till now of blending this material with other plastics except PVC. It unique properties are high flex fatigue resistance, easy processability, no need of plasstimers, high impact strength etc, which makes it different from other elastomers.

M. Blending

Blending or mixing is the combining of polymers , after they home formed , in such a way that the resultant homogenous polymer material is two or more phoser . There are various methods to blend two or more polymers .

1) *Dry Blender*
a) *Tumbling Blenders*
    - Drum blender
    - Double cone blender
    - V – blender
b) *Mechanical Blender*
    - Ribbon blender
    - Conical screw blender
    - Double arm mixer
2) *Melt Blender*

a) High intensive mixer
b) Two roll mill
c) Banburry mixer
d) High speed mixer
e) Single screw extruder
f) Twin screw extruder
g) Reciprocating screw kneader

For our blending purpose we have usedTwin Screw Extruder – Co rotating.

III. EQUIPMENTS & PROCEDURE

A. Compositions

S.no	Polypropylene %	Ethylene Vinyl Acetate(EVA)%	Nano Clay %
1	94	5	1
2	89	10	1
3	84	15	1

Nano Clay composition is held constant and by varying the % of PP and EVA the properties are studied.

B. Drying

The prepared Compositions must be placed in Tray drier for 1hour at 110 degrees Celsius.

Fig 4.2 Sample after Drying in Tray Drier.

C. Twin Screw Extruder

For melt mixing technique, the most appropriate equipment is twin screw extruder. An obvious advantage of this equipment over a single screw is the additional distance along the periphery over which the melt dragged in one revolution. Less obvious features distinguish the machine as polymers mixer. The cross blow between screw causes efficient phase orientation and strew peaks. Twin screws are starve fed so that component of a formulation can be fed instead of pre blending them, machines are easily configured for multiple feed addition and vent stages.

Fig 4.3 Twin screw Extruder Machine

Fig 4.4 Product formed after Twin-Screw Extruder.

D. Cutter

This is being used for cutting the product from the Twin screw extruder.

Fig 4.5 Product formed after cutting.

E. Injection Moulding

Injection moulding is a manufacturing process for producing parts by injecting material into a mould. Injection moulding can be performed with a host of materials mainly including metals, (for which the process is called die-casting), glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers. Material for the part is fed into a heated barrel, mixed, and forced into a mould cavity, where it cools and hardens to the configuration of the cavity. After a product is designed, usually by an industrial designer or an engineer, moulds are made by a mould-maker (or toolmaker) from metal, usually either steel or aluminium, and precision-machined to form the features of the desired part. Injection moulding is widely used for manufacturing a variety of parts, from the smallest components to entire body panels of cars. Advances in 3D printing technology, using photopolymers which do not melt during the injection moulding of some lower temperature thermoplastics, can be used for some simple injection moulds.

Parts to be injection moulded must be very carefully designed to facilitate the moulding process; the material used for the part, the desired shape and features of the part, the material of the mould, and the properties of the moulding machine must all be taken into account. The versatility of injection moulding is facilitated by this breadth of design considerations and possibilities.

Fig 4.6 Injection Molding Machine

Fig 4.6 (a)Injection moulding Machine

Fig 4.6 (b) Molds used in injection molding

Fig4.6 (c) Product formed after injection molding.

The formed product is kept in air for 48 hours and sent for testing.

F. Tests Of Blends

Testing is done in order to assess the performance of a materials in relations to the duty which it is to perform i.e , to establish suitability for purpose . Judicious use of such measurements ideally will obviate the inspired guests , or gross wastage because of the necessity to "play safe" and in this way the necessary experience , above which the future actions will rely , will be assembled with minimum of headaches .

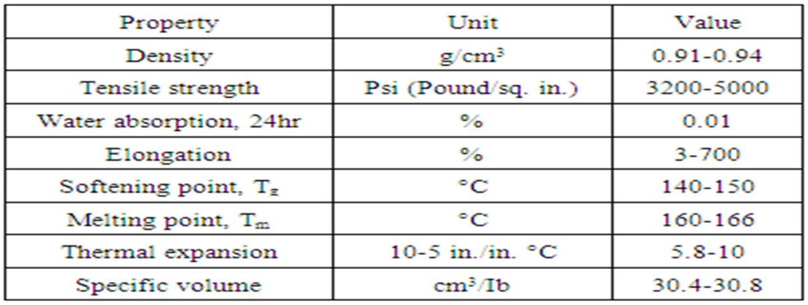
The following are some of the major reasons for testing

1) To improve design concept.
2) To provide a basis of reliability.
3) To evaluate competitors products .
4) Protection against product liability suit .
5) To meet standards and specifications .
6) To verify the manufacturing process .
7) To establish history of new materials .
8) Quality control .
9) Safety .

a) ***Selection of PP as base material:*** Materials suitable for a much wider range of applications can be made by compounding poly(propene) with, for example, fillers and pigments, and elastomers.

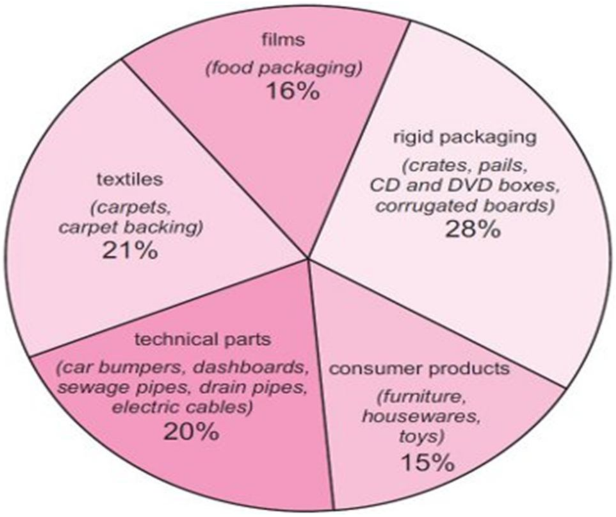
Poly(propene) has remarkable properties, making it suitable to replace glass, metals, cartons and other polymers. These properties include:

i) Low density (weight saving)
ii) High stiffness
iii) Heat resistance
iv) Steam barrier properties (food protection)
v) Good transparency
vi) Good impact/rigidity balance
vii) Stretch ability (film and fiber applications)
viii) Good hinge property (for example where a lid and box are made together, for DVD boxes)
ix) High gloss (appearance)
x) Easy to weld (design)
xi) Recyclability.



Property	Unit	Value
Density	g/cm³	0.91-0.94
Tensile strength	Psi (Pound/sq. in.)	3200-5000
Water absorption, 24hr	%	0.01
Elongation	%	3-700
Softening point, T_g	°C	140-150
Melting point, T_m	°C	160-166
Thermal expansion	10-5 in./in. °C	5.8-10
Specific volume	cm³/Ib	30.4-30.8

b) ***Applications of PP***



c) ***Selection Of Eva As A Toughening Agent:*** Various types of toughening agents or in other words impact modifiers are available in order to provide high impact resistance to the plastic materials , to be used in high impact application like in the case of Automobile, Engineering products.

Unique Properties of EVA

i) Excellent Resiliency
ii) Easy Processing
iii) Easy Coloring
iv) Shock & Vibration Absorption properties
v) Good Chemical Resistance
vi) High Mechanical properties like Impact strength, Tear Resistance, Tensile Strength.

One more important feature of EVA is the design flexibility which it provides through which we can design the parts with style, shape and still retain the properties of the part.

All these characteristics of EVA makes it ideal toughening agent for PP.

d) ***Nano Clay**:* Nano Clay (also called clay nano) is made up of thin layers, each with a thickness of one to several nanometers , and a length of several hundred to several thousand nanometers. The first type of Nano clay found in the world was montmorillonite (in Montmorillon , France , 1874).

Properties

i) Molecular mass (g / mole) 540.46
ii) Average Gravity (g / cm3) 2.35
iii) Monoclinic crystal system
iv) Color white, yellow
v) Crystalline properties swell several times when absorbing water

e) ***Advantages of Nano Clay Additions**:* The Nanocomposites 2000 conference has revealed clearly the property advantages that nanomaterial additives can provide in comparison to both their conventional filler counterparts and base polymer. Properties which have been shown to undergo substantial improvements include

i) Mechanical properties e.g. strength, modulus and dimensional stability
ii) Decreased permeability to gases, water and hydrocarbons
iii) Thermal stability and heat distortion temperature
iv) Flame retardancy and reduced smoke emissions
v) Chemical resistance
vi) Surface appearance
vii) Electrical conductivity.
viii) *Present Study:* In the present study we have selected Polypropylene(PP) as a base materials to toughen it with EVA(Ethylene vinyl Acetate) material as toughening agent. Three compositions of PP with EVA & Nano Clay were blended and their properties are studied.

f) ***Steps For The Preparation Of Product***

i) The compositions are mixed thoroughly.
ii) Mixed proportions are separated according to their compositions and placed in Tray Drier separately, at 110 □ for 1hour.
iii) The dried sample is used as a feed for Twin Screw Extruder. First the feed is used for purging i.e, removal of unwanted material in the machine.
iv) The temperature is maintained at 150 – 170 □.
v) The product formed from the Twin Screw Extruder is in the form of wires.
vi) Then the product is further processed for cutting into granules in the cutter.
vii) The granules are dried according to their compositions in the tray drier separately, at 110□ for 1hour.
viii) The dried samples are processed as a feed for Injection Moulding .
ix) The feed is placed in the hopper and the feed is used to purge the unwanted material deposited in the machine.
x) The time required to form a mould is called cycle time, which is between 45-47 secs for polypropylene mixture.
xi) The product formed from the injection moulding is stored in a cool place for 48hours .
xii) After 48hours the product is then taken for testing .
xiii)

IV.TESTING AND RESULTS

A. *Physical Property*

1) *Density Test*

a) *Test Condition:* The test condition for the specimen or materials is atmospheric pressure and at room temperature in a closed weigh apparatus.

b) *Test Specimen:* The test specimen taken is 3no.s of 1cm*1cm for each sample that is introduced into the weighing apparatus.

c) *Procedure:* First reset the weigh balance to zero and measure each of the sample specimen in air followed by weighing it in 75-80 ml of n-butyl reagent. Repeat the procedure for the remaining no.s taken and find out the average of the three.

d) *Formula*

$$\rho = \frac{A}{A-B} \times reagent\ density(n-butyl)[0.8782gm/cc]$$

Where,

A→weight of sample in air [gms]

B →weight of sample in reagent [gms]
ρ →density in gm/cc

2) *Results of Density Test*

a) *Sample Weights in grams*

Density	Sample 1	Sample 2	Sample 3
A	0.3598	03101	0.3314
	0.3652	0.3750	0.3728
	0.3429	0.3986	0.3592
B	0.0152	0.0136	0.0153
	0.0155	0.0164	0.0176
	0.0144	0.0171	0.0168

b) *Density in gm/cc*

Density	Sample 1	Sample 2	Sample 3
1	0.9164	0.9184	0.9207
2	0.9171	0.9183	0.9216
3	0.9166	0.9175	0.9212
Average	0.9168	0.9180	0.9211

Fig 6.1 Density Test Apparatus

B. *Mechanical Property Tests*

1) *Tensile Strength:* Tensile strength is the ability of the material to withstand the tensile forces applied to its longitudinal axis.

a) *Test Condition:* A uniform length of samples is considered.

b) *Test Specimen:* A standard dumbbell shape test specimen is used.

c) *Apparatus:* The universal testing machine from INSTRON is used as an apparatus.

d) *Procedure*

i) We take 3 samples of each composition

ii) Using vernier calipers we measure width , thickness and Guage length.

iii) For universal testing machine we use Trepizium software where parameters are set according to the requirements.

iv) We get the following results according to the set parameers.

v) According to the above mentioned conditions, the specimen is clamped in the machine and the load is obtained and tensile strength of the specimen at break is calculated by using the formula,

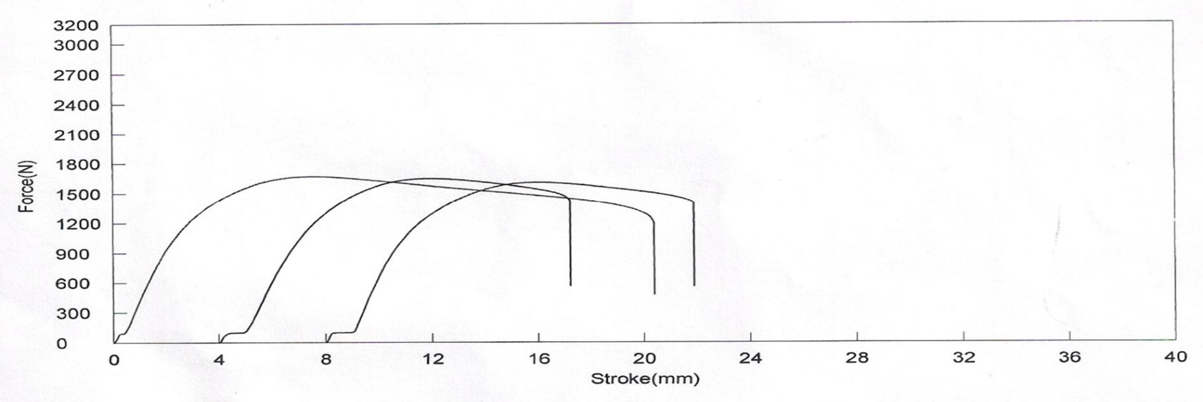
$$T.S.\,at\ break\left(\frac{kg}{cm^2}\right)=\frac{load\ at\ break}{cross\ sectional\ area\ of\ the\ specimen}$$

2) Tables and Observations

a) Sample 1

	Thickness	Width	Gauge Length
Units	mm	mm	Mm
94-05-01	3.4500	13.0000	115.0000
94-05-01	3.3700	13.0000	115.0000
94-05-01	3.3500	13.0000	115.0000

Name	Max Force	Max_Disp	Max Stress	Max Strain	MODULUS
Parameter					Points(2-20)
Units	N	mm	N/(mm)2	%	N/(mm)2
94-05-01	1669.45	7.63950	37.2230	6.64304	1541.44
94-05-01	1647.81	7.88900	37.6127	6.86000	1430.82
94-05-01	1607.03	7.93000	36.9008	6.89565	1655.78
Mean	1641.43	7.81950	37.2455	6.79956	1542.68

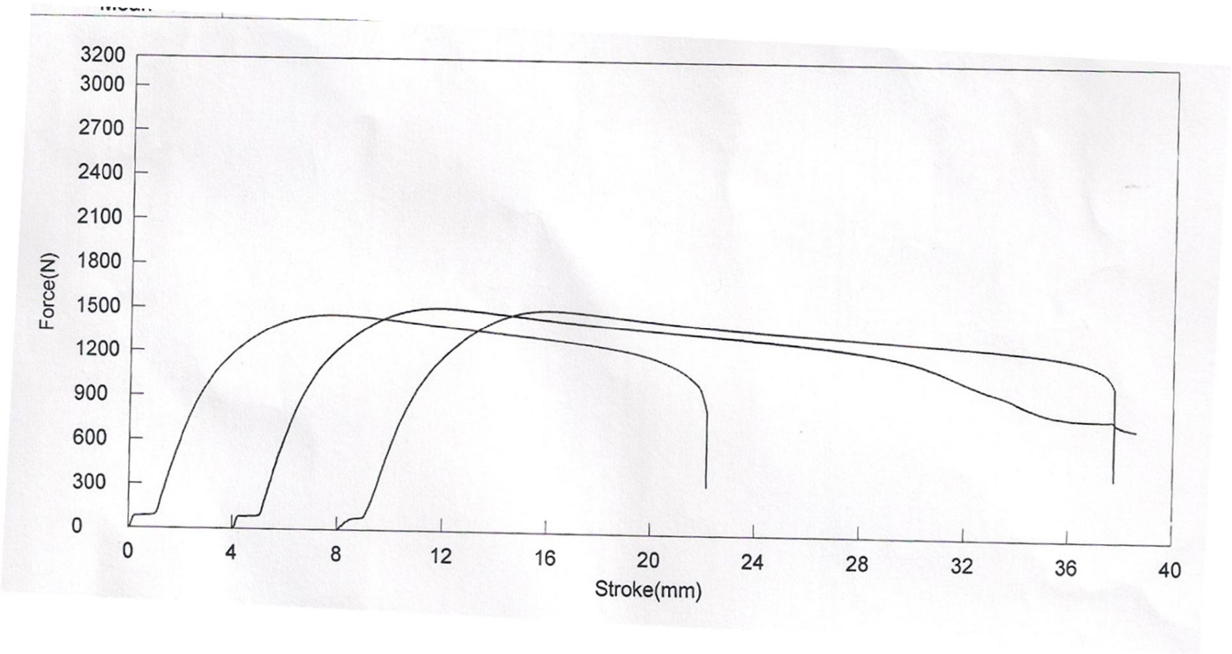


From graph we can observe that, When we increase the force there is an elongation and at a certain point the graph is parallel to Y-Axis which is called Break point.
Similarly for sample 2&3

b) Sample 2

	Thickness	Width	Gauge Length
Units	mm	mm	mm
89-10-01	3.3900	12.8500	115.0000
89-10-01	3.3800	12.8500	115.0000
89-10-01	3.3800	12.8500	115.0000

Name	Max_Force	Max Disp	Max Stress	Max Strain	MODULUS
Parameter					Points(2-20)
Units	N	mm	N/(mm)2	%	N/(mm)2
89-10-01	1456.48	7.77700	33.4351	6.76261	1562.17
89-10-01	1512.42	7.80000	34.8219	6.78261	1608.23
89-10-01	1507.11	8.04300	34.6996	6.99391	1486.41
Mean	1492.00	7.87333	34.3189	6.84638	1552.27



c) *Sample 3*

	Thickness	Width	Gauge length
Units	mm	mm	mm
84-15-01	3.3900	12.7300	115.0000
84-15-01	3.3900	12.7300	115.0000
84-15-01	3.3900	12.7300	115.0000

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain	MODULUS
Parameter					Points(2-20)
Units	N	mm	N/mm2	%	N/(mm)2
84-15-01	1357.66	7.46300	31.4602	6.48956	1408.21
84-15-01	1310.70	7.63200	30.3722	6.63652	1443.80
84-15-01	1365.78	8.03300	31.6485	6.98522	1331.58
Mean	1344.71	7.70933	31.1603	6.70377	1394.53

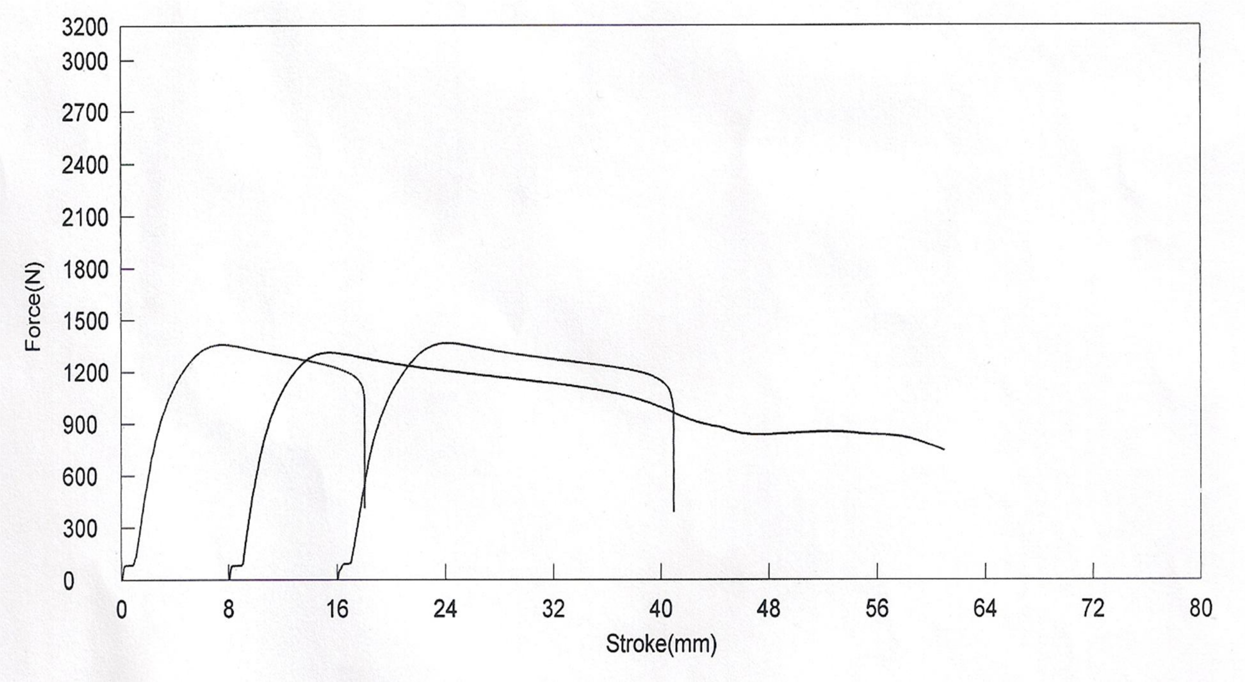


Fig 6.2 Universal Testing Machine

C. *IZOD Impact Strength*

Impact strength is a measure of energy required to fracture a material by sharp blow on fall.

1) *Test Condition*
   a) room temperature
   b) Samples are considered of 6.3cms of length.
2) *Test Specimen:* Izod test specimens are 6.3cms length with a notch depth of 0.2mm in the centre.
3) *Apparatus:* Pendular type Impact test machine contains.
   a) The pendular applying the known potential energy to the test piece.
   b) The test piece supports.
4) *Procedure:* To find the impact (Izod) strength of the specimen, the specimen is placed vertically on the clamps and broken by the swing of the pendulum and the excess of energy in the pendulum was taken as the scale reading and impact strength is calculated using the below formula.

$$impact\ strength = \frac{scale\ reading\ \times\ 1.02^2}{cross\ sectional\ area\ of\ specimen}$$

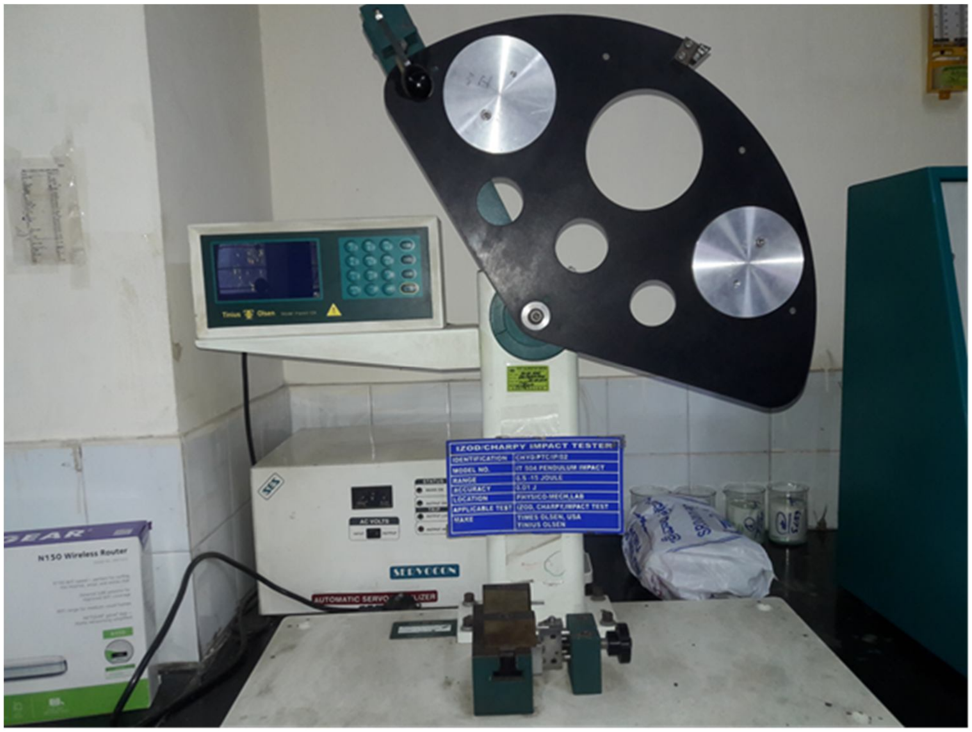


Fig 6.3 IZOD Test Apparatus

D. *Flexural Strength*

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis.

1) *Test Condition:* We consider uniform lengths of all the samples to be tested.
2) *Apparatus:* The universal testing machine from INSTRON Instruments is used to determine the flexural strength of the material.

a) *Procedure*

i) We take 3 samples of each composition
ii) Using vernier calipers we measure width , thickness and Guage length.
iii) For universal testing machine we use Trepizium software where parameters are set according to the requirements.
iv) We get the following results according to the set parameers.
v) According to the conditions, the specimen put into the span of UTM machine and the load is obtained and flexural strength of the specimen is calculated using the formula,

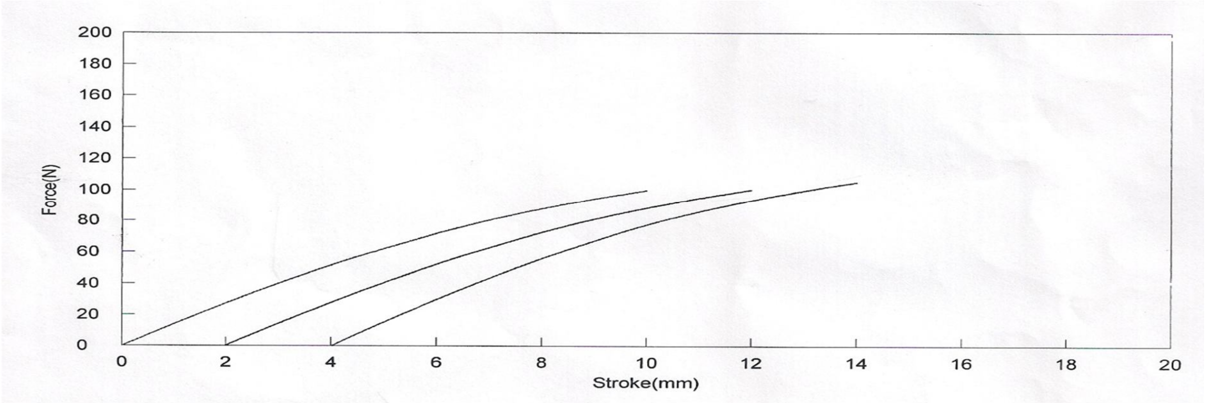
$$flexural\ strength\left(\frac{kg}{cm^2}\right) = \frac{3PL}{2bd^2}$$

Where,

P→Load
L→Span Length
b→Breadth of the specimen
d→Depth of the specimen

6.4.1Tables and Observations :

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain	Modulus
Parameter					Points(2-20)
Units	N	mm	N/mm2	%	N/mm2
94-05-01	99.8438	9.98350	28.3580	3.89356	1310.76
94-05-01	100.453	9.99700	28.5311	3.89883	1397.19
94-05-01	105.313	9.96300	29.9112	3.88557	1454.80
Mean	101.870	9.98117	28.9334	3.89265	1387.58

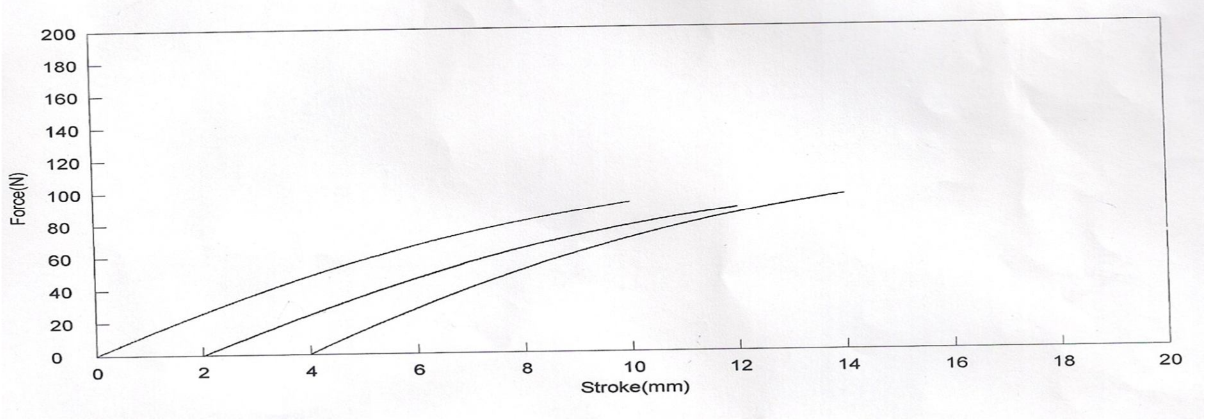


From above graph we can observe that, When the three point force is applied at the three pints of the flexural it is observed that the sample bends upto the given limit i.e 10mm
Similarly for samples 2&3

b) Sample 2

	Thickness	Width	Lower Support
Units	mm	mm	mm
89-10-01	6.4000	12.5000	100.0000
89-10-01	6.4000	12.5000	100.0000
89-10-01	6.4000	12.5000	100.0000

Name	Max_Force	Max_Disp	Max_Stress	Max_Strain	Modulus
Parameters					Points(2-20)
Units	N	mm	N/mm2	%	N/mm2
89-10-01	92.1094	9.99400	26.9852	3.83770	1282.63
89-10-01	88.2969	9.98100	25.8682	3.83270	1297.72
89-10-01	95.8750	9.99800	28.0884	3.83923	1373.17
Mean	92.0938	9.99100	26.9806	3.83654	1317.84



c) Sample 3

	Thickness	Width	Lower Support
Units	mm	mm	mm
84-15-01	6.2500	12.5000	100.0000
84-15-01	6.2500	12.5000	100.0000
84-15-01	6.2500	12.5000	100.0000

Name	Max_Force	Max_Disp	Max Stress	Max Strain	Modulus
Parameter				_	Points(2-20)
Units	N	mm	N/mm2	%	N/mm2
84-15-01	81.5781	9.98400	25.0608	3.74400	1263.80
84-15-01	83.9844	9.99500	25.8000	3.74813	1377.22
84-15-01	83.5156	9.99100	25.6560	3.74663	1442.03
Mean	83.0260	9.99000	25.5056	3.74625	1361.02

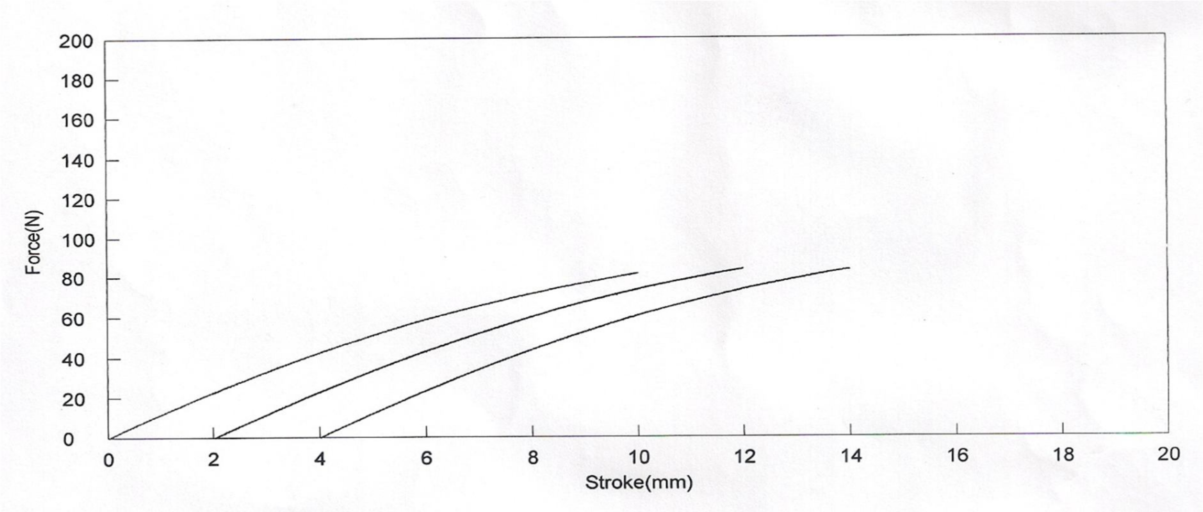


Fig 6.4 Universal Testing Machine

E. Thermal Tests

1) *Melt Flow Index Test(MFI Test):* The Melt Flow Rate Test measure the rate of extrusion of a thermoplastic materials through an office of specific length and diameter under prescribed conditions of load and temperature.

a) *Test Condition:* The apparatus is set at 230 degrees Celsius and weight of 2.3kgs as load.

b) *Apparatus:* MFI test machine.

c) *Test Specimen:* Granules of the sample are taken 4gms per testing.

d) *Procedure:* The apparatus is first cleaned with Xylene($C_6H_4(CH_3)_2$). Then it is set to 230 degrees Celsius. Sample granules are kept in the piston using rod. About 4-5 grams of the sample fits into the piston. The piston has markings where the purge should be collected only within it. The sample purge in collected for every ten seconds and rolled with a weight in order to avoid air gaps in between the purge. These so formed pellets are weighed and MFI is calculated.

e) *Formula*

$$MFI = \frac{average\ weight\ of\ the\ sample\ purge\ pellets}{successive\ time\ difference} \times 600$$

2) *Tables and Observations*

a) *Sample 1*

S.no	Time (secs)	Trial 1 weight (gms)	Trial 2 weight (gms)
1	10	0.1794	0.1709
2	20	0.1765	0.1729
3	30	0.1750	0.1741
4	40	0.1820	0.1763
Average			
MFI value		10.693	10.413

b) *Sample 2*

S.no	Time (secs)	Trial 1 weight (gms)	Trial 2 weight (gms)
1	10	0.2864	0.1342
2	20	0.2563	0.1338
3	30		0.1371
4	40		0.1393
Average			
MFI value		16.332	16.334

c) *Sample 3*

S.no	Time (secs)	Trial 1 weight (gms)	Trial 2 weight (gms)
1	10	0.4063	0.3014
2	20	0.3613	0.3073
3	30	0.3555	0.3015
4	40	0.2803	0.3220
Average			
MFI value		19.942	18.483

Fig 6.5 MFT Apparatus

V.CONCLUSIONS

- The results shows important improvement in the impact properties of PP + EVA with NANOCLAY blend as compared with PP virgin and other toughened blends. The study reveals that the optimum set of properties is obtained between 5.0 to 15% of EVA, especially the impact strength is increased to a big extent between these combinations.
- This increased impact strength is very much required in the field of Automobile sector, outdoor application, so this combination of PP/EVA with NANOCLAY can fulfil the necessary requirement.

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