International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

Effect on Tensile and Flexural Properties of Polyolefin's/Maleic Anhydride Grafted Polyolefins and Starch Modified with Different Plasticizers

Manjari Sharma

Ambedkar Institute of Advanced Communication Technologies & Research, Geeta Colony, Delhi

Abstract: ***One of the most important and most studied groups of biodegradable polymers is carbohydrate. Research is on, to use starch and modify it, in such a way, so that it becomes useful and provides an alternative to biodegradable polymers developed. The cost effectiveness of this natural polymer is attracting researchers to find an alternative. Potato starch based biodegradable polymers were prepared using mA-grafted polyolefins, LDPE, LLDPE, HDPE and PP. Different plasticizers like Glycerol, Sorbitol and Urea were used for gelatinization of potato starch. The compositions were extruded through twin screw extruder and sheets were prepared through compression moulding technique. Typical mechanical and flexural properties of the compositions have been compared in order to find the strength of the prepared samples. Observations are a) mixing of starch up to 15% with different plasticizers does not affect the mechanical & flexural properties of blends, b) blends with PP show good mechanical & flexural properties in comparison, c) Glycerol based GTPS blend samples show the best results in comparison.***

Keywords: GTPS: Glycerol Thermoplastic Starch; STPS: Sorbitol Thermoplastic Starch; UTPS: Urea Thermoplastic Starch, Biodegradable polymer

1. Introduction

Demand is the mother of innovation. Due to precious space crunch at our mother earth there is consistent pressure on researcher community to develop truly biodegradable cost effective polymer. Biodegradable requirement is again for the purpose cost effectiveness as well as for stopping the pace of pollution created destroying our nature at a much rapid pace than ever recognized. In turn our society is getting affected directly or indirectly. Several new diseases are getting developed due to certain level of our exposure to pollutants, especially of our children knowingly or unknowingly.

Demand of biodegradable polymers is increasing at an approximate rate of 30% per year due to renewed interest of community today, having understanding of resource constraint and requirement of proper utilization of resources to have sustainable growth in future. Demand is the fuel for development of innovative biopolymers materials all over the world.

Synthetic polymers are usually originating from petroleum and most of the conventional ones are regarded as non-degradable. Petroleum resources are limited and the blooming use of these resources has caused serious environmental problems like use of synthetic polymers in packaging applications in one time use products. The advantages of synthetic polymers are obvious, including predictable properties, batch-to-batch uniformity and can be tailored easily [2]. The main issue with synthetic polymers is its strong backbone which does not break down naturally after the use of items prepared using these polymeric materials. Which is a tough target because this backbone strength at one side becomes the strength of product in use condition and becomes a weakness after the lifetime of the product. Due to synthetic polymers non degradation capability focus is shifted on to natural polymers, which are inherently biodegradable [3] and can provide the capabilities like synthetic polymers to meet different requirements. Natural polymers does not possess physical properties as of synthetic polymers and environmental resistant capability over a period of time due to natural decay in prevailing environmental conditions.

Hydrophilic bonds containing groups of natural polymers are naturally degradable such as starch, cellulose. Among such type of natural polymers, starch is of more interest as It is regenerated from carbon dioxide and water by photosynthesis in plants [4]. Owing to its complete biodegradability [5], low cost and renewability [6], starch is considered as a promising candidate for developing sustainable materials. Because of which starch has been continuously explored in combination with various other materials, since 1970s [7, 8]. Many efforts have been exerted to develop starch-based polymers for conserving the petrochemical resources, reducing environmental impact and searching more applications [9–11].

To overcome limitations of synthetic and natural polymeric materials, efforts were made to combine both synthetic and natural polymer in such a way that an alternative could be searched. Although it is known that mixing of these non polar and polar components is quite difficult but using different techniques of gelatinization, grafting polar group in the base chain and through optimization of compositions attempts have been made to strike a balance[12,13,14]. Research is on for devising system which can lead to a development of cost effective biodegradable polymer product. One of the efforts made in this direction is presented in this paper. The first and foremost use of this material could be in industry for packaging applications. The materials developed during study are Biodegradable plastics with varying characteristics.

In order to forward the steps towards this target, an effort is made in this study for which combination of thermoplastic starch based natural polymers and typical in use synthetic polymers has been mixed. Different types of biodegradable polymer compositions were prepared using modified potato starch with different poly olefins through twin screw extruder and compression moulding. Efforts made to utilize different compatible modifiers like Glycerol, Sorbitol and Urea. The system thus prepared is characterized.

Observations are a) mixing of starch up to 15% with different compatibilizers does not affect the mechanical & flexural properties of blends, b) blends with PP show good mechanical & flexural properties in comparison, c) During comparison study of different modifiers it was observed that GTPS blend gives better mechanical and flexural properties than STPS and UTPS blends. d) the blending with HDPE show different trend in comparison to other compatibilizers.

2. Experimental

2.1 Materials

The Potato starch (10.0% moisture) Glycerol, Sorbitol, and Urea was procured from M/s S. D. Fine Chemical Ltd. Pune, India. Low Density Polyethylene (LDPE), Linear Low Density Poly Ethylene (LLDPE), High Density Poly Ethylene (HDPE) and Polypropylene (PP) polyolefin's were procured from M/s Reliance Industries, India. MA-g LDPE, MA-g HDPE, MA-g-LLDPE and MA-g-PP were procured from M/s Pluss Polymer Pvt. Ltd. Faridabad, Haryana.

2.2 Sample Preparation

2.2.1 Compounding

Potato starch with different plasticizers (glycerol, sorbitol and urea) were mixed in the ratio of 70:30 through grinding & shearing in a high speed mixer at near 3000rpm at room temperature for 5minutes, thereafter the starch was left overnight at room temperature to allow swelling action. Material was pre dried to remove moisture before mixing.

After chemical treatment of starch, it was mixed with different polyolefins with same polyolefin with grafted maleic anhydride (1:1) in 0,5,10,15,20,30% (wt./wt.) ration have been extruded through twin screw extruder. Finally samples of LDPE, LLDPE, HDPE and PP samples were prepared. Samples for testing were prepared through compression moulding.

2.2.2 Sample Preparation for testing Mechanical Properties

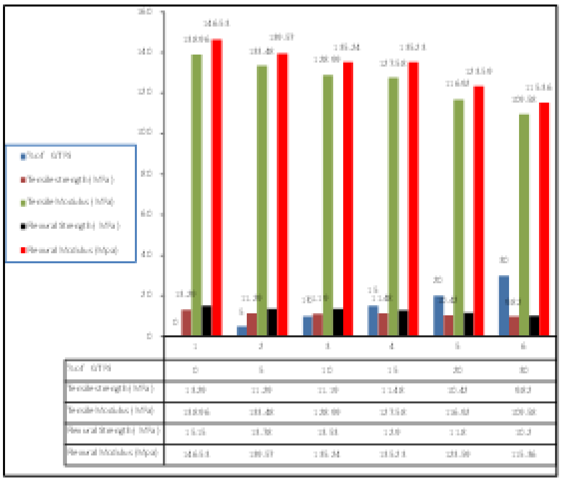
Tensile strength and flexural properties were examined by M/s Instron Universal Tensile Machine (Model 3382) having Capacity-100KN using ASTM D 638. Dumble shaped specimens were conditioned for examination – at 30°C& 38%RH. Dimensions of Tensile Specimen- Gauge length- 25mm Width- 12mm Thickness- 3mm, Area- 16.24 mm^2. Dimensions of Flexural Specimen - 60mm x 25mm x 2.8mm, Span length for each batch - 40mm.

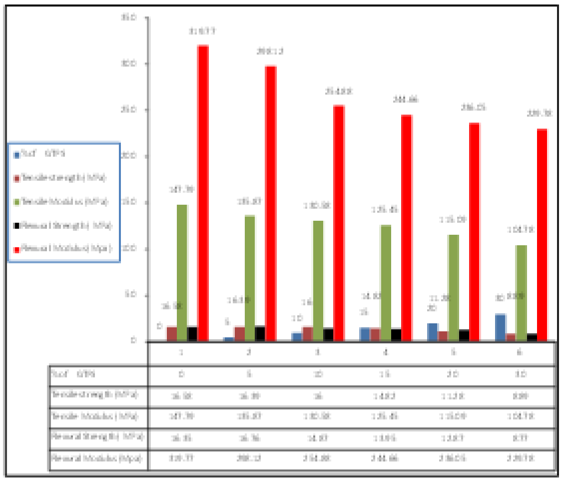
3. Results and Discussion

3.1 Mechanical Properties

3.1.1 GTPS Blend Study

The mechanical properties of LDPE, LLDPE, HDPE & PP compositions with GTPS have been depicted in figure 1. Tensile strength, flexural strength, tensile modulus and flexural modulus were compared in these matrices of samples for compositions of GTPS ranging from 0 to 30%. There are three variables here. a) different polymers b) different compositions and c) different properties which have been analysed. Combination of GTPS has been analysed first. As expected the flexural modulus in LDPE and LLDPE blends with GTPS were having similar trend of decreasing as the level of GTPS is increasing.





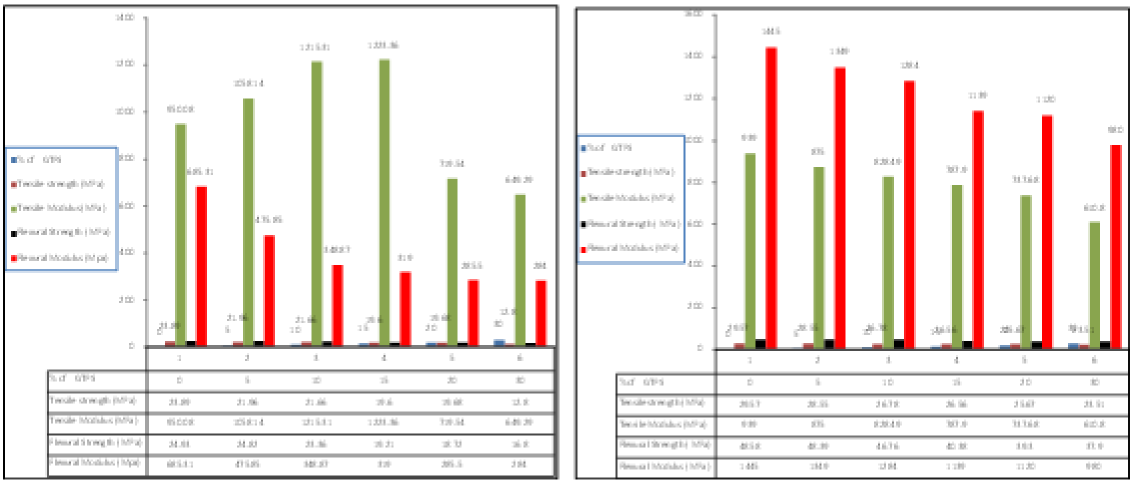


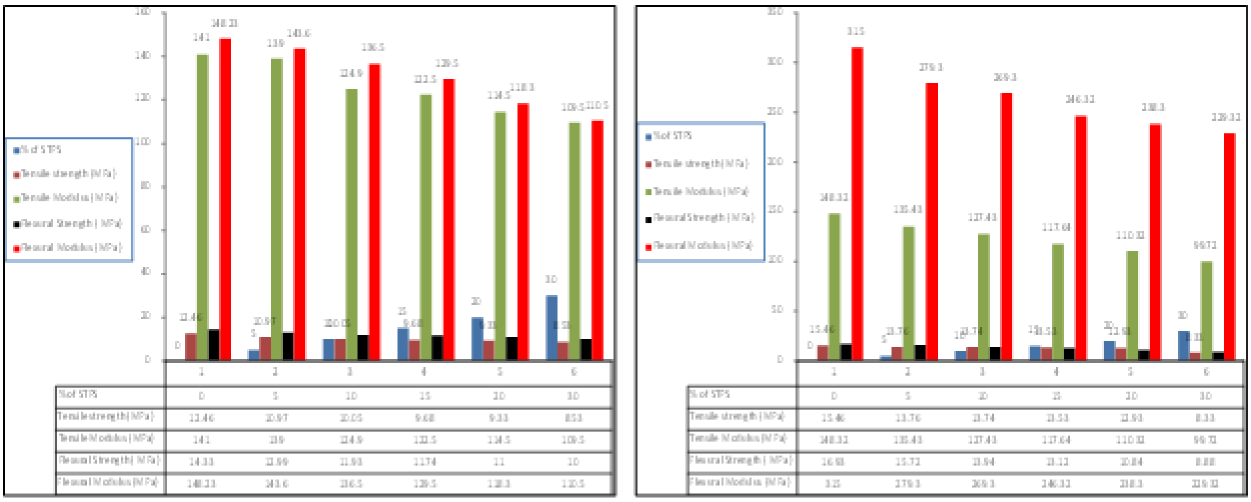
Figure 1: Tensile and Flexural properties of LDPE, LLDPE, HDPE & PP-GTPS blends

The tensile modulus and flexural modulus levels in LDPE are nearly equal while these have significant difference in case of LLDPE. It is due to nature change in between LDPE and LLDPE. At the same time HDPE blends displayed high tensile modulus in comparison to flexural modulus and PP shows its reverse. HDPE tensile strength was reduced by nearly 15% only while decrease in the flexural modulus was nearly 50% for compositions up to 15%GTPS. The decrease in 20% GTPS samples was observed to be less in comparison to LDPE & LLDPE compositions of similar ratio. But a typical characteristics was observed that values of tensile modulus have improved instead of decrement up to a ratio of 15% of HDPE GTPS blends and thereafter it has decreased significantly. The phenomenon could be further investigated and property can be exploited. LLDPE tensile strength was reduced by 12%% only while decrease in the flexural modulus was 24% for compositions up to 15%GTPS.

PP tensile strength was reduced by 18% while decrease in the flexural modulus was 22% for compositions up to 15%GTPS. However, compositions with 30% GTPS have shown comparatively lower decrease in tensile properties in comparison to all other blends prepared during study. Hence, it can be concluded that GTPS (Glycerol –TPS) mixing did not affect the properties of these basic materials significantly.

3.1.2 STPS Blend Study:

Similar comparison studies of Tensile strength, flexural strength, tensile modulus and flexural modulus were conducted with STPS (Sorbitol-TPS) and observations were depicted in the figure 2. As expected the flexural modulus in LDPE, LLDPE & PP blends with STPS were having similar trend of decreasing as the level of STPS is increasing. While the behavior in case of HDPE was observed typically opposite and instead of decrease the values were increased for tensile modulus which shows that specific properties of STPS-HDPE blends has been enhanced and could be studied further.



International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

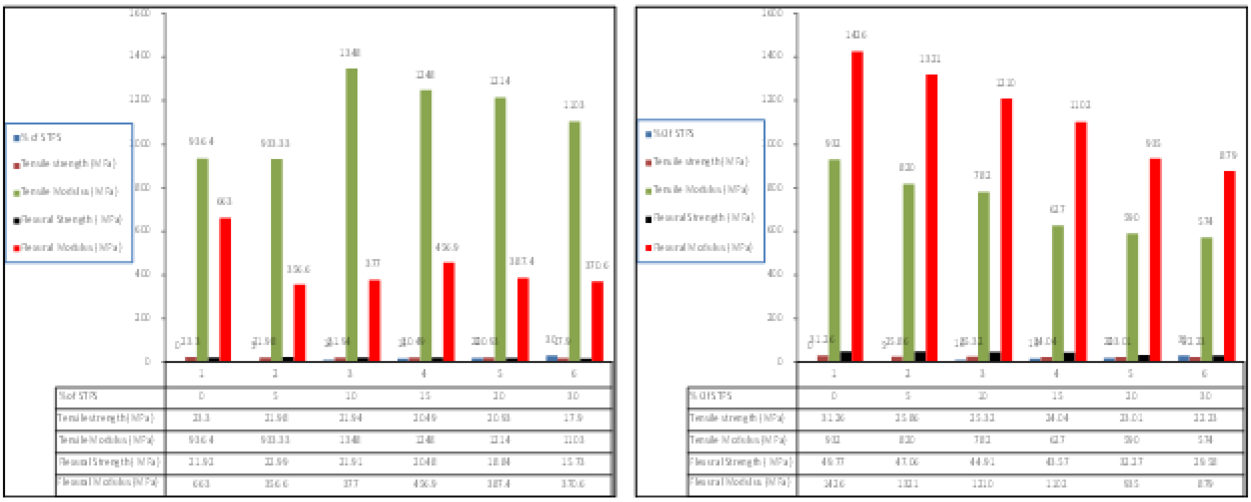


Figure 2: Tensile and Flexural properties of LDPE, LLDPE, HDPE & PP-STPS blends

3.1.3 UTPS Blend Study:

The mechanical properties of LDPE, LLDPE, HDPE & PP compositions with UTPS (Urea-TPS) have been depicted in figure 3. Tensile strength, flexural strength, tensile modulus and flexural modulus were compared in these matrices of samples for compositions of UTPS ranging from 0 to 30%. Different mechanical properties were analysed. As expected the flexural modulus in LDPE and LLDPE blends with UTPS were having similar trend of decreasing as the level of UTPS is increasing while HDPE has shown different trend as above.

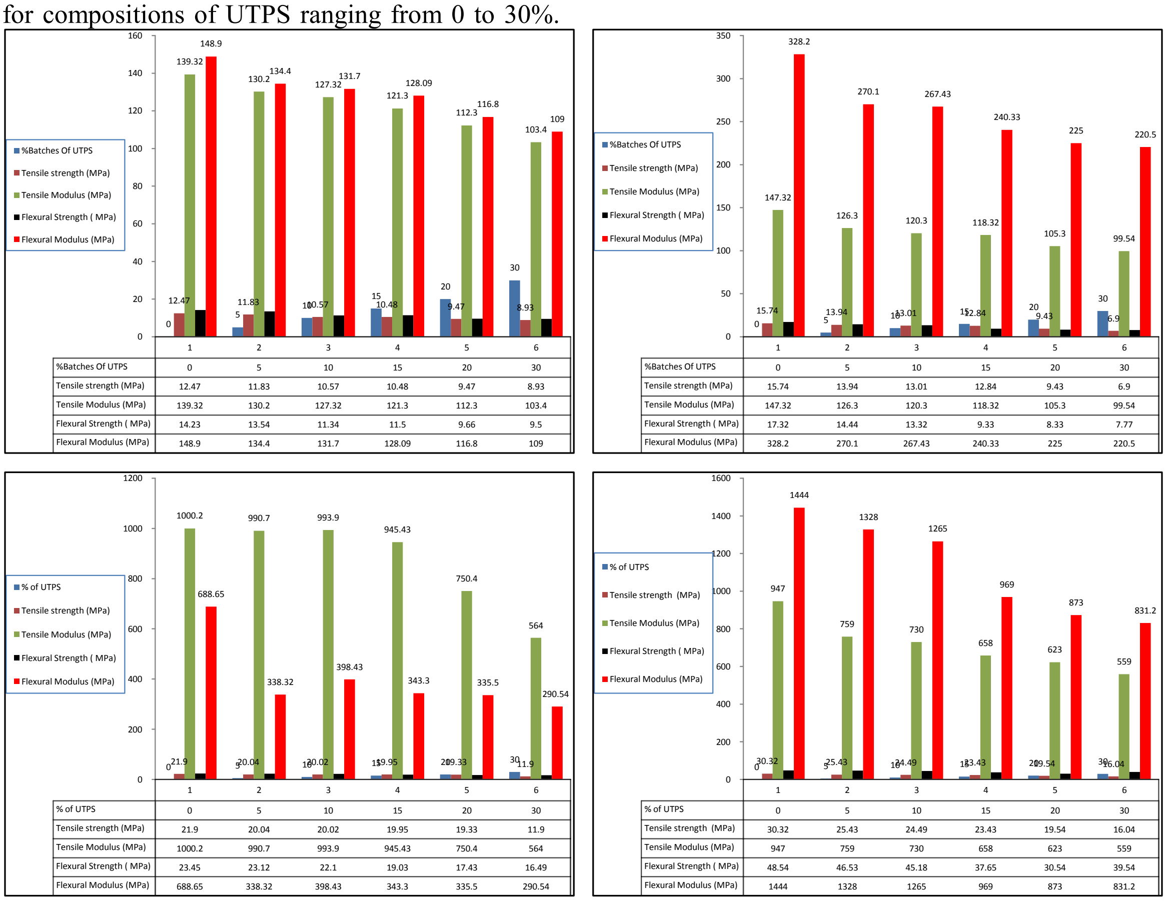


Figure 3: Tensile and Flexural properties of LDPE, LLDPE, HDPE & PP-UTPS blends

4. Conclusion

Overall compositions have displayed that the tensile strength and tensile modulus changed slightly during mixing of starch based polymers from 5 to 15% TPS batches. On 20 to 30 % mixing of Starch based polymers, the tensile strength and tensile modulus have decreased significantly in all compositions.

In comparison among LDPE, LLDPE, HDPE and PP the PP show good mechanical properties. More loading of TPS into LDPE, LLDPE, HDPE and PP were investigated to decrement in mechanical behavior.

If we discuss about the flexural properties of different blends, initially, the flexural strength and flexural modulus slightly changed for 0 to 15% TPS batches. But on increase in the percentage of TPS the flexural properties and modulus have decreased significantly and show same trend as in tensile properties.

References

[1] Vert M., Santos I. D., Ponsart S., Alauzet N., MorgatJ-L., Coudance J., Garreau H.: Degradable polymers in a living environment: Where do you end up Polymer International, **51**, 840–844 (2002).DOI: 10.1002/pi.903
[2] Nair L. S., Laurencin C. T.: Biodegradable polymers as biomaterials. Progress in Polymer Science, **32**, 762–798 (2007).DOI: 10.1016/j.progpolymsci.2007.05.017
[3] Chiellini E., Solaro R.: Biodegradable polymeric materials. Advanced Materials, **4**, 305–313 (1996). DOI: 10.1002/adma.19960080406
[4] Teramoto N., Motoyama T., Yosomiya R., Shibata M.: Synthesis, thermal properties, and biodegradability of propyl-etherified starch. European Polymer Journal, **39**, 255–261 (2003). DOI: 10.1016/S0014-3057(02)00199-4
[5] Araújo M. A., Cunha A., Mota M.: Enzymatic degradation of starch-based thermoplastic compounds used in protheses: Identification of the degradation products in solution. Biomaterials, **25**, 2687–2693 (2004). DOI: 10.1016/j.biomaterials.2003.09.093
[6] Zhang J-F., Sun X. Z.: Mechanical properties of PLA/starch composites compatibilized by maleic anhydride. Biomacromolecules, **5**, 1446–1451 (2004). DOI:10.1021/bm0400022
[7] Griffin G. J. L.: Starch polymer blends. Polymer Degradation and Stability, **45**, 241–247 (1994). DOI: 10.1016/0141-3910(94)90141-4
[8] Pareta R., Edirisinghe M. J.: A novel method for the preparation of starch films and coatings. Carbohydrate Polymer, **63**, 425–431(2006).DOI:10.1016/j.carbpol.2005.09.018
[9] Park J. S., Yang J. H., Kim D. H., Lee D. H.: Degradability of expanded starch/PVA blends prepared using calcium carbonate as the expanding inhibitor. Journal of Applied Polymer Science, **93**, 911–919 (2004).DOI: 10.1002/app.20533
[10] Schwach E., Avérous L.: Starch-based biodegradable blends: Morphology and interface properties. Polymer International, **53**, 2115–2124 (2004). DOI: 10.1002/pi.1636
[11] Stepto R. F. T.: Understanding the processing of thermoplastic starch. Macromolecular Symposia, **245–246**, 571–577 (2006).DOI: 10.1002/masy.2006513822J
[12] Gupta A.P., Sharma M. & Kumar V.: Formulation and characterization of biodegradable packaging films derived from Potato Starch and LDPE grafted with maleic anhydride-LDPE composition ,18,484-491(2010)
[13] Gupta A.P., Sharma M. & Kumar V.: characterization of biodegradable packaging films derived from Potato Starch and LDPE grafted with maleic anhydride-LDPE compositionPart-II,18,482-499 (2010)
[14] Khoramnejadian S, Zavareh J. J, Khoramnejadianc S. Effect of Potato Starch on thermal & mechanical properties of Low Density Polyethylene. Curr. World Environ 2013;8(2). doi :http://dx.doi.org/10.12944/CWE.8.2.06