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Research Article

THERMAL CHARACTERIZATION OF POTATO STARCH BLENDED LOW DENSITY POLYETHYLENE: A STUDY

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A R T I C L E I N F O

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A B S T R A C T

The long life and durable properties of plastics material make it suitable for many applications. In this project the thermal characteristics of low density polyethylene and potato starch was analyzed by differential scanning calorimeter (DSC). Samples with various levels of concentrations of potato starch with LDPE, along with glycerol and Fe_2SO_4 were formulated. The melting behavior, crystallization temperature and degree of crystallinity were analyzed and comparative study of different combinations of potato starch was done. The comparative study was also done before and after soil burial for six months of duration for virgin LDPE as well as compounded materials. The results of the DSC crystallinity are able to correlate with the mechanical properties.

INTRODUCTION

The longevity and durability properties of plastics make it ideal for large applications such as in packaging, agriculture, industries and commodities, as well as in hygiene products, which caused to litter problems as petroleum based plastics are not naturally degradable in the environment. Numerous approaches had been made for solving the disposal of solid wastes puzzles. These approaches include incineration, landfills, thermal degradation, bio-degradation and photo-catalysis [1]. Recycling of plastics components is also a considerable and possible way to overcome the solid waste disposal problems, perhaps it is limited to certain kinds of plastics materials [2]. Biodegradable polymers are material that could be converted to natural compounds such as water, carbon di-oxide, methane and other biological components by means of microorganisms like algae, fungi, bacteria and other natural occurring agents [3]. Biodegradable plastics developed from renewable resources are well in limelight, although enthusiasm is being counterbalanced by persistent questions of availability, price, performance and processability. These are much like other plastics but in order to completely replace their synthetic counterparts, they require assistance of different additives to overcome the inherent weakness in processability and physical properties [4]. Recently discovered polymeric materials based on the compounding of green polymers with synthetic ones should be compatible while, sides by side possess good thermal and mechanical properties for better performance in different applications [5]. Bio-inertness of low density polyethylene can minimize by incorporating green polymers into it. Starch may be used as green polymers additives [6]. Promising and fruitful development has been done for practical demonstration process and products from natural polymers such as starch, cellulose and lactic acid [7]. The peak temperature of the DSC melting curve is the most frequently determined property of semi crystalline materials. It is the important parameter from processing point of view and it is normally used for material identification [8].

In the current study compounds of low density polyethylene (LDPE) and potato starch with various levels of concentrations were produced. Melting behavior and crystallinity of the compounds were characterized by differential scanning calorimeter. The ultimate purpose of the current study was to analyze the influence of various concentrations of potato starch on melting and crystalline behavior of newly developed polymeric materials.

MATERIALS AND METHODS

Materials

LDPE (Low Density Polyethylene) grade 16MA400 polymerized by high pressure polymerization technique was received from Reliance Polymers, India. The starch was produced from potato purchased from Indian market. Approximately ninety eight percent (98%) purified glycerol of Merk Co., Germany was utilized as a plasticizer. Hydrated crystal purified Fe_2SO_4 of Merk Co., Germany was used as pro-oxidant.

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Methods

The extracted potato starch powder was mixed with similar quantity of glycerol and Fe_2SO_4 (1 mass percent of LDPE) conventionally. The compounded materials were produced with various combinations of potato starch in two roll mill at 150^0-160^0C for 10 – 12 minutes period of time. The compounded materials were subjected to sheet preparation of 0.3 mm thickness by using mini compression molding machine at 150^0C temperature and under pressure. One sheet of virgin LDPE was also molded to be used as controlled reference. The sample sheets of all combinations were turned out into strip shape and subjected to biodegradation in soil for six months. Melting behavior, crystallization temperature and crystallinity of the potato starch based polymer and virgin LDPE was analyzed by utilizing Mettler Toledo (Switzerland) differential scanning calorimeter (DSC). The samples of 5-10milligrams weighed and heated in the temperature range of 25^0 to 160^0 C at 10^0C per minute rate of rise of temperature in nitrogen atmosphere to detect the melting point of the materials before and after soil biodegradation. Further the samples were cooled from 160^0 to 25^0C at 10^0C per minute cooling rate in nitrogen atmosphere to calculate the crystallinity and crystallization temperature. An empty crucible was kept as reference. The instrument was calibrated with indium and zinc.

RESULTS AND DISCUSSION

Differential Scanning Calorimeter (DSC) Analysis

The differential scanning calorimetric results pertaining to the melting temperature (Tm), crystallization temperature (Tc) and degree of crystallinity of potato starch and low density polyethylene (LDPE) compounded materials before and after soil burial has been presented in the Table -1.

The melting peaks of virgin low density polyethylene (100 % LDPE) were found around at 108^0C and negligible change in peaks of virgin LDPE observed after soil burial for six months. On addition of potato starch along with glycerol and Fe_2SO_4 in low density polyethylene (LDPE) slight deviations in peaks of melting occurred due to presence of additives in the compounds, which were also negligible. The heating curves with melting peaks of LDPE and potato starch compounds before and after soil burial plotted in Figure – 1 and Figure – 2 respectively.

The crystallization curves and peaks were found in the cooling phase of differential scanning calorimetric analysis. The crystallization temperature of the virgin low density polyethylene (100 % LDPE) before soil burial was found around at 90^0C and slight change in crystallization temperature of virgin LDPE was observed after soil burial for six months. On addition of potato starch along with glycerol and Fe_2SO_4 in low density polyethylene (LDPE) the crystallization temperature of 20 % potato starch compound and 25 % potato starch compound were found 92.64^0C and 93.19^0C respectively before soil burial and almost no change in peaks of crystallization were observed after soil burial for six months period of time. The comparative cooling curves with crystallization peaks of LDPE and potato starch compounds before and after soil burial plotted in Figure – 3 and Figure – 4 respectively.

The degree of crystallinity was found in cooling phase of differential scanning calorimetric analysis. The crystallinity of virgin low density polyethylene (100 % LDPE) was found around 41 % and negligible change is observed after soil burial for six months.

Table 1 Melting Temperature, Crystallization Temperature and Crystallinity of Starch based LDPE

S.No.	Potato Starch Content	Melting Temperature, Tm in (^{0}C)		Crystallization Temperature, Tc in (^{0}C)		Crystallinity in %	
		Before Soil Burial	After Soil Burial	Before Soil Burial	After Soil Burial	Before Soil Burial	After Soil Burial
1.	0 %	108.69	108.09	90.49	90.54	40.71	41.20
2.	20 %	108.46	108.14	92.64	92.76	39.03	36.44
3.	25 %	108.18	108.02	93.19	93.24	38.29	33.45

Note: The degree of crystallinity is determined by comparing the measured heat of fusion with the theoretical heat of fusion of 100% crystalline low density polyethylene of 140 J/g [9].

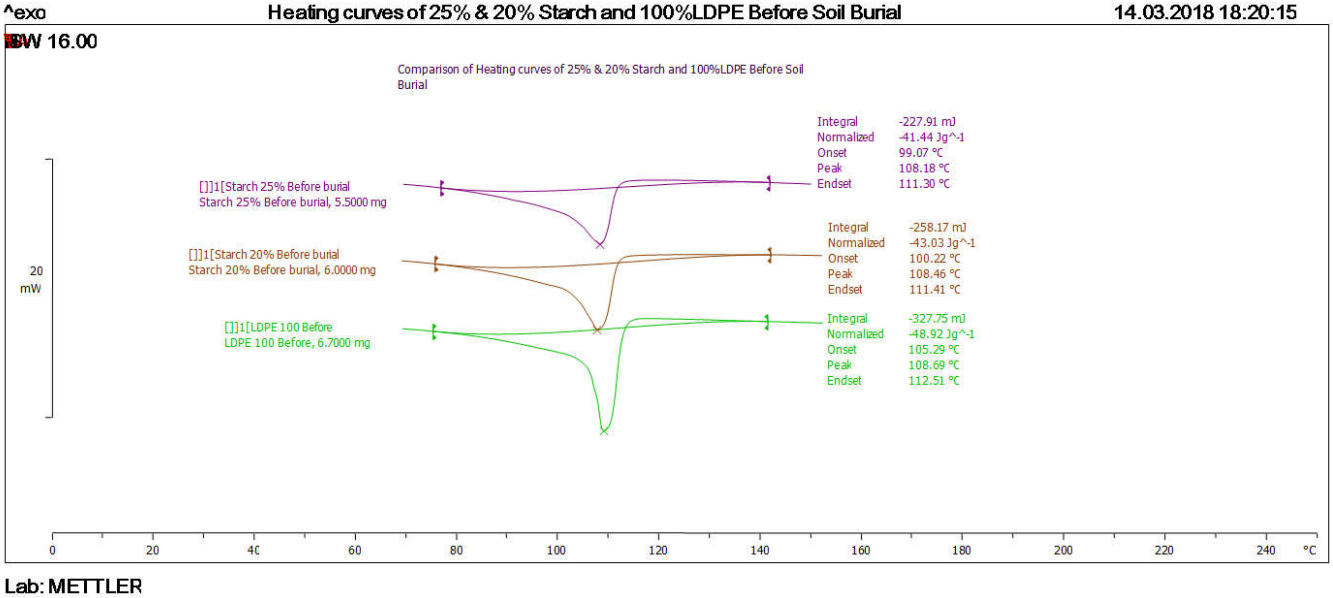

Figure 1 Heating Curves of LDPE and Potato starch Compounds before Soil Burial Obtained from DSC

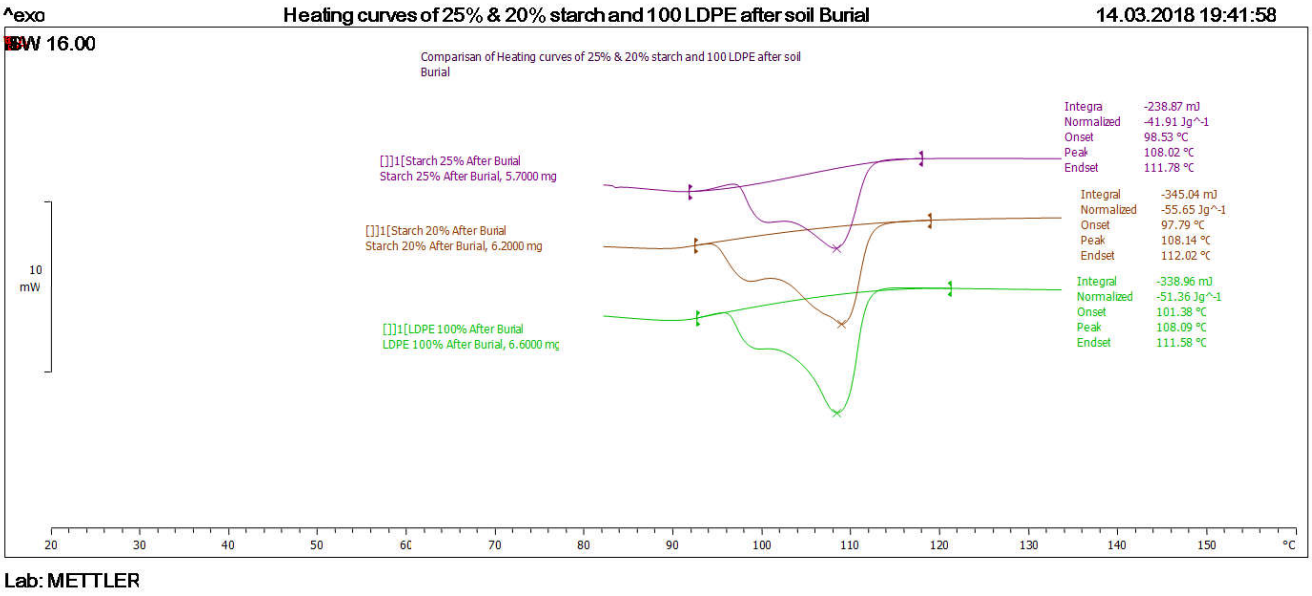

Figure 2 Heating Curves of LDPE and Potato starch Compoundsafter Soil Burial Obtained from DSC

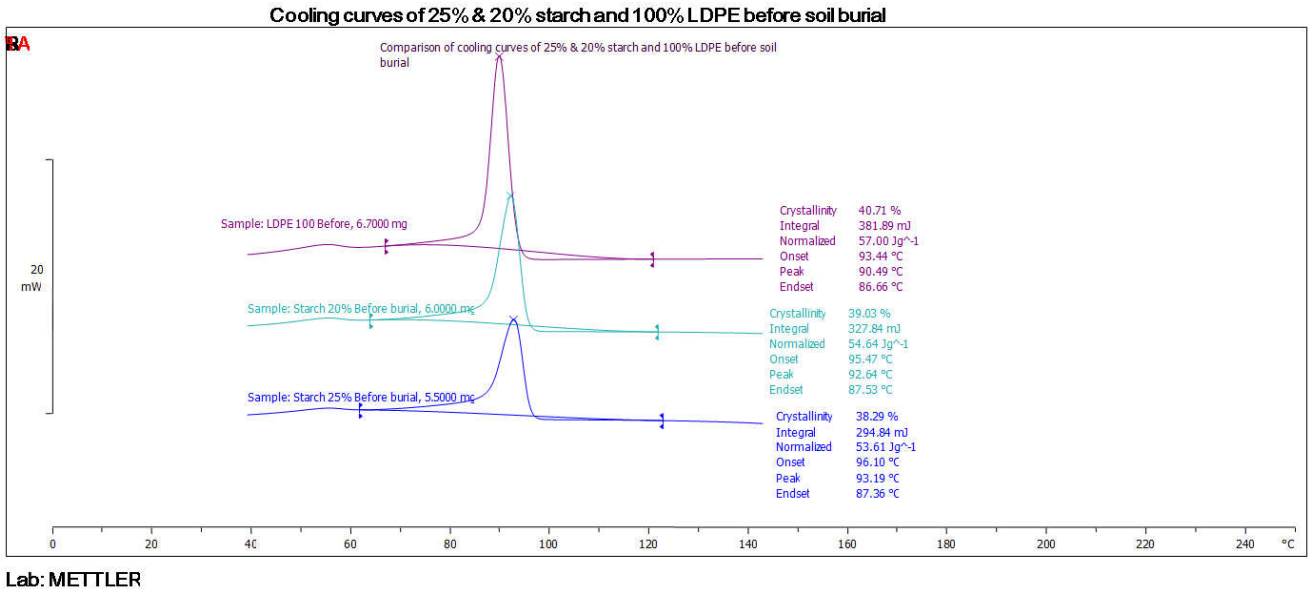

Figure 3 Cooling Curves of LDPE and Potato starch Compounds before Soil Burial Obtained from DSC

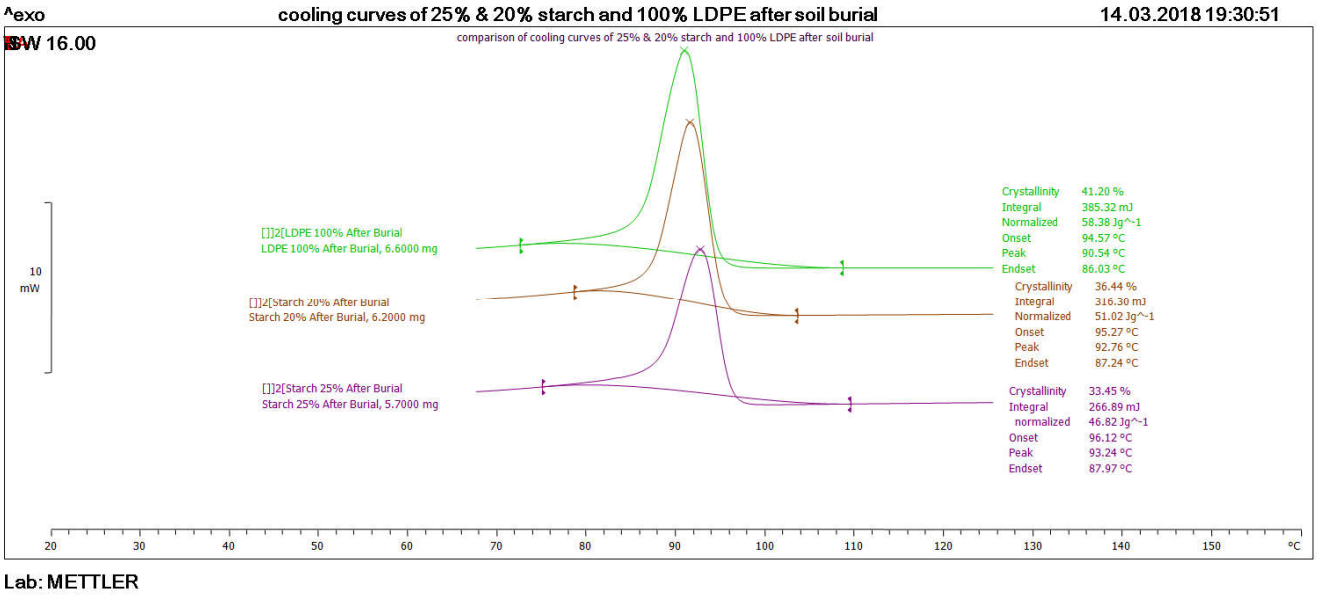

Figure 4 Cooling Curves of LDPE and Potato starch Compounds after Soil Burial Obtained from DSC

On addition of potato starch along with glycerol and Fe_2SO_4 in low density polyethylene (LDPE) the crystallinity of 20 % and 25 % potato starch compound were found 39.03 % and 38.29 % respectively before soil burial and markable decrease in crystallinity were observed after soil burial for six months period of time. The comparative cooling curves with percentage of crystallinity of LDPE and potato starch compounds before and after soil burial plotted in Figure – 3 and Figure – 4 respectively. The area under the peak corresponds to the heat fusion of the samples [8] (Riesen, 2002). The degree of crystallinity was determined by comparing the measured heat of fusion with the theoretical heat of fusion of 100 % crystalline low density polyethylene (LDPE) of 140 J/g [9].

CONCLUSION

In this project work compound of LDPE and potato starch was formulated. On addition of potato starch almost no change observed in the melting peaks as well as in crystallization peaks of compounded materials. The crystallinity decreased with the increase of potato starch concentrations. After six months of soil burial negligible change in crystallinity of virgin LDPE observed, where as markable decrease in crystallinity of potato starch compound was observed. As hardness and strength decrease with decreasing crystallinity, the DSC results can be correlated with the mechanical properties of the polymeric materials [8] (Riensen, 2002). The DSC crystallinity indicates the percentage of the material that is crystalline versus amorphous. The degree of crystallinity depends on how regular the structure of the molecule is (no branches or short branches in regular distance) and on the thermal history. In fact the material characterized underwent differential scanning calorimetric analysis and the dosage of concentrations, conditions and duration employed are completely different from previously utilized.

Acknowledgement

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