World Applied Sciences Journal 14 (11): 1730-1733, 2011
ISSN 1818-4952

Thermal Properties of Low Density Polyethylene with Oyster Shell Composite: DSC Study

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Abstract: In this study low density Polyethylene-based composites are prepared using oyster shell as natural filler. Oyster shell powder was mixed into low density polyethylene (LDPE) at 10 and 20 wt.% using a thermal mixing head. By the differential scanning calorimetric (DSC) the thermal behavior of these composites was determined. Also, the melting temperature (Tm) and the enthalpy (ΔH) of these bio composites were determined. As a results of this study, DSC scans show that this bio composite do not have different melting temperature per LDPE but have significant effects on the oxidation and degradation properties of this polymer. DSC results show that melting thermal properties of the polyethylene has not been effected much by the addition of oyster shell. This project has shown that the composites treated with oyster shell as natural additive and as a inorganic particle-filled polymer will be desirable as building materials due to their improved thermal properties of LDPE.

Key words: LDPE · Oyster · Natural filler · Polymer composite · Thermal Properties · DSC study

INTRODUCTION

Low density polyethylene (LDPE) represents the majority of thermoplastics currently used in food packaging materials or in other industrial application [1]. HDPE has excellent low temperature toughness, chemical resistance, good dielectric properties and relatively high softening temperatures but poor weatherability [2]. In order to reduce cost or enhance physical and mechanical properties of HDPE, some additives can be added to it. Fillers and reinforcement used including talc, calcium carbonate (CaCO3), mica, wollastonite, glass fibre, glass bead, jute, etc. [2,3]. During the last decade, eco-friendly, biodegradable bio-flours and fibers have been used as reinforcing fillers in the commercial plastic industry to produce composite materials [4,5]. These bio-fillers exhibit a number of attractive advantages, including low cost, low density, low processing requirements, less abrasion during processing, renewability, eco-friendliness and bio degradability [4].

One of this natural fillers Rice husk flour (RHF) which is a surplus byproduct of the rice production process and is totally biodegradable in the natural environment. It therefore shows promise as a bio-filler in composites to replace various materials such as construction materials, furniture and many plastic products in a variety of future industrial applications [4].

Oyster shells are one of the renewable natural products found in a large amount in different area near to the water environmental areas but it have limited use in industrial applications especially in polymer fields; M.H. Chong and his co workers [6] used this material as fire-retardant for polyethylene and the results of his study show that the Oyster-shell powder decomposed to calcium oxide and carbon dioxide at temperature higher than 800°C, thus preventing fire from access of oxygen by the produced carbon dioxide. This fire-retardation mechanism is environmental-friendly.

In this work we attempt to use powder of oyster as natural filler and reinforce material in PE to produce composite structure and then evaluate it's thermal properties by the differential scanning calorimetry (DSC) to study the effect of oyster filler on thermal properties of LDPE. Evaluating other physical and mechanical properties in process to obtained more understanding for using this filler in industrial application of polyethylene or other polymers.

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MATERIALS AND METHODES

Pe Composites Preparation: LDPE, (density 0.923 g/cm3, melt Index 6.0 g/10min from state company for petrochemical industries-Basrah-Iraq) was mixed with fine powder of oyster (obtained from the beach of Shat Al-arab river) after (washed, dried, grinded then sieved to the size less than 75 µm.). The composites were prepared in different filler contents of 10 and 20 (w/w %) by hakee instrument (hakee rheocord torque rheometer,USA)at 160°C and 60 rpm for 10 min.

Molding Step: To mold samples for DSC testing, the mixture of two samples are sand in the center of square metallic block and between two sheet of aluminum foil and pressed in the compression molder at 160°C and 0.9 MPa for 5 min. After pressing, the slaps are removed from the press and air cooled to room temperature. The resultants panels with 0.2 cm in thickness.

Differential Scanning Calorimetry (DSC) Analysis: The DSC tests were performed using a Shimadzu apparatus DSC-60 model, made in Japan. The samples (10 mg) were sealed in aluminum pans under air atmosphere in a temperature range between ambient temperatures up to 450°C at a heating rate of 10°C/min. The melting and the degradation temperatures of the samples were determined.

RESULTS AND DISCUSSION

Oyster-shell powder was found to be mainly composed of calcium carbonate and it has successfully focused on the research and the development on health care products for third party licensers and distributors. A series of plastic materials from recycled polyethylene (PE) and oyster-shell powder were prepared to test their fire-retardant properties with an aim of finding a practical way of waste recycling [6].

In our work we used this suitable thermal mixing method to synthesis LDPE-oyster shell compounded by mixing the two components at two percentage 10% and 20% and then compared the thermal properties of this samples with that of pure LDPE, the overall shape of DSC thermogram of pure LDPE figure 1 show as slight decrease in heat flow, followed by some thermal transitions such as the melting endotherm peak which appears at 114-115. 8°C with heat of melting about-69.42J/g and also figure 1 show other exothermal transitions one of them at about 280 °C as broad peak may result to oxidation reaction of LDPE with oxygen in the carrier air, while the second appear as large thermal peak in the region between 360-493°C this exothermic attributed to thermal degradation of this polymer and the degradation process is completed at 493°C. figure 1.

On the other hand, it was observed from DSC scans of LDPE-Oyster Shell 10%; figures 2 and LDPE-Oyster Shell 20%; figures 3 that the melting point remains unaffected even after blending with this additive where it can be seen that oyster shell did not make any noticeable effect on the onset and end-set temperature of the melting region of LDPE-Oyster Shell composite this behavior reflects high compatibility between the two component of this composite (Figs. 2 and 3), The behavior of this additive on the melting properties of LDPE could be attributed to the more homogeneous dispersion of the oyster shell powder resulting from increasing it's wet-ability. And also this effect may appear if the filler does not play any role to effect on the restrict of the movement of molecular chains, thus there was no

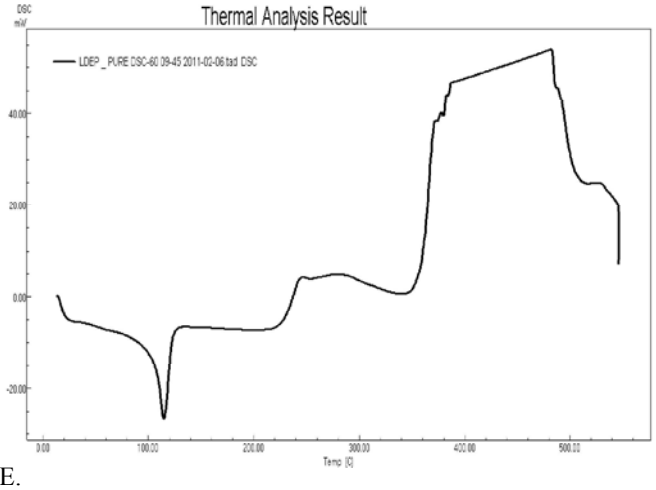

Fig. 1: DSC scan of pure LDPE.

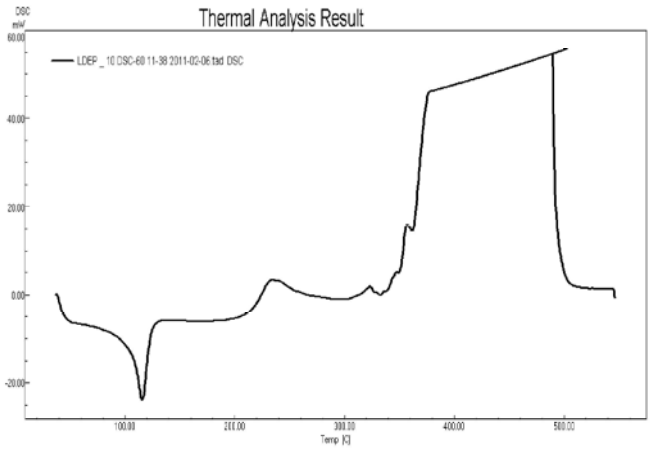

Fig. 2: DSC scan of pure LDPE-Oyster Shell 10% composite.

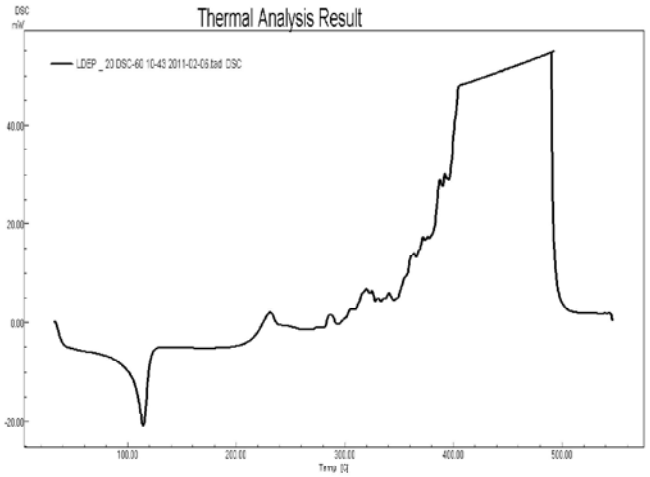

Fig. 3: DSC scan of pure LDPE-Oyster Shell 10% composite.

significant changes in melting properties of polymer, therefore most of nanoclay are placed in amorphous phase [7]. It is important that Oyster Shell has a significant effect on the oxidation process of LDPE and decreases it from about 279°C for pure LDPE to 230°C for the composite (Fig. 1-3). But there are a clear changes in the shapes of the oxidation thermal peaks in figures 2 and 3 when compared it with that of pure LDPE where as it become more small and divided into some secondary peaks continues to 340°C to 350°C.

As oxidation process LDPE was characterized by a exothermal peaks between 230-340°C the enthalpy (ΔH) for composite oxidation show significant decreasing from 198.3 J/g for pure LDPE to 27.3 J/g and 13.7J/g for LDPE-Oyster Shell composites 10% and 20%, respectively.

The thermal decomposition of all samples are illustrated in the region between 360°C to 495 °C this behavior appear as extremely sharp exothermic transition noticed started at about 350°C for pure LDPE and 365°C, 385°C for LDPE-Oyster Shell composites 10 and 20 %, respectively, but there are a significant decrease in the enthalpy of this process from 1.61 KJ/g for pure LDPE and reach to 1.55KJ/g and 352.4KJ/g for LDPE-Oyster Shell composite 10 and 20%, respectively. the phenomenon of this additive may generalize from the natural structure of oyster shell which consist of calcium carbonate major component which act as retardant to more moved or soluble of oxygen into the polymer matrix during oxidation or thermal degradation process which lead to unsteady process.

CONCLUSIONS

The above brief discussion aims to analyze the potential capacity of filler obtained from natural sources (oyster shell); Generally organic or inorganic filler have important roles into polymers which have received much more attention in the last decades due their potential applications in the fields of polymer uses and applications

related to environmental availability and the maintenance of physical and chemical properties the results of this study state that the LDPE-Oyster shell composites (10 and 20) % w/w have suitable compatibility and non different in melting temperature. In addition to that, less oxidation reactions and more thermal degradation resistance appear, the oyster shell that was used in this study as bio filler or bio extender for LDPE can be used with LDPE in it's applications that need to use fillers with other properties such as mechanical properties and may give other information about the effect of this filler on whole properties of PE..

ACKNOWLEDGEMENTS

The authors are so grateful to Dr. M. Jasim, A.L. Assadi (manager of Polymer Research Center/University of Basrah/Basrah/Iraq) for his support and advises for complete the work and also the authors thank Miss. Wafaa Shakir (English Dept./Collage of Education / Univ. of Basrah / IRAQ) for critical reading of the manuscript before its submission.

REFERENCES

1. Behjat Tajeddin, Russly Abdul Rahman, Luqman Chuah Abdulah, Nor Azowa Ibrahim and Yus Aniza Yusof, 2009. Thermal Properties of Low Density Polyethylene-Filled Kenaf Cellulose Composites, European Journal of Scientific Research, 32(2): 223-230.
2. Woishnis, W., Polypropylene, 1998. PDI Publisher: New York.
3. Herzig, R. and W.E. Baker, 1993. Correlations Between Image Analysed Morphology and Mechanical Properties of Calcium carbonate-Filled PP. Journal of Materials Science, 28: 6531.
4. Hee-Soo Kima, Sumin Kima, Hyun-Joong Kima and Han-Seung Yang, 2006. Thermal properties of bio-flour-filled polyolefin composites with different compatibilizing agent type and content, Thermochimica Acta, 45(1): 181-188.
5. Justin R. Barone, F. Walter Schmidt, Christina F.E. Liebner, 2005. Compounding and molding of polyethylene composites reinforced with keratin feather fiber, Composites Science and Technology, 65: 683-692.
6. Chong, M.H., B.C. Chun, Y.C. Chung and B.G. Cho, 2006. Fire-retardant plastic material from oyster-shell powder and recycled polyethylene. Journal of Applied Polymer Science, 99: 1583-1589.
7. Hajir Bahrami, S. and Zahra Mirzaie, 2011. Polypropylene/Modified Nanoclay Composite-Processing and Dyeability Properties, World Applied Sciences Journal, 13: 493-501.