Environmental Effects on Recycled Plastics

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A thesis submitted for the degree of

Master of Engineering Science

DECLARATION

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ACKNOWLEDGEMENTS

I have to say it has been a long and windy journey to get to the completion of this project. At times there were huge obstacles that I had to deal with and without help and support from others this thesis would not have been possible. I would like to extend my gratitude to the following people for their contribution throughout this project.

- My supervisors Dr Yung Ngothai, Dr Togay Ozbakkaloglu and A/Prof Margaret Jollands. Thanks for your patience with and faith in me.
- This project would not have been possible without the financial support from Advanced Plastic Recycling of South Australia through the ARC Linkage Grant- LP 0455409.
- The staff at School of Chemical Engineering who would happily assist with my queries
- The staff at the Rheology and Materials Processing Centre at Royal Melbourne Institute of Technology (RMIT), in particular Mr Michael Allen
- Plastic Granulating Services (PGS) of Kilburn, South Australia. Thank you for providing the assistance in the sample production of this project.
- Fellow post-graduate colleagues at School of Chemical Engineering. A very special thank to Gideon Kuncoro and Kenneth Ho. I really appreciate our friendship and your help.
- My parents and wife for their patience with and constant faith in me.

PUBLICATION FROM THE THESIS

Refereed Australia Conference:

K. Li, Y. Ngothai, T. Ozabakkaloglu, and M. Jollands, "Weather Ageing Effects on the Recycled Low Density Polyethylene", Proceedings: Chemeca 2009-37th Australasian Chemical Engineering Conference, The Institution of Engineers, Perth, Australia, 27–30 September 2009, ISBN: 0-85825-823-4, CD-ROM.

ABSTRACT

A major problem with recycling of post-consumer plastic is the reduction in key strength and durability properties when compared to virgin polymer. This reduction is caused by polymer degradation processes occurring during the plastic lifetime. This phenomenon limits the utility of recycle plastic. In order to enhance the mechanical properties of recycled polymers, fillers are often added to improve the modulus and strength. However, it remains unclear if environmental factors, such as temperature, sunlight, oxidation and moisture lead to any loss in or compromise the durability and mechanical integrity of the composites.

In this work, specimens of recycled low density polyethylene (LDPE) reinforced with different amounts of either fine talc or glass fibre were produced by injection moulding after the constituents were mixed in a twin screw extruder and then granulated using a pelletiser.

This work demonstrated, via tensile testing, that fine talc and glass fibre are able to effectively reinforce recycled LDPE. Differential Scanning Calorimetry has shown that fine talc increases the degree of crystallinity of recycled plastic thereby increasing their tensile strength. Increasing the content of fine talc from zero to 50 wt% in the specimens improved the mechanical properties of the plastic matrix. Furthermore, the use of glass fibres to reinforce the LDPE results in higher tensile strength when compared to the inclusion of fine talc at the same concentration. This advantage, however, comes with a compromise: surface flaws appear in specimens reinforced with 50 wt% glass fibre, weaken the reinforcing effect.

Under various mimicked weather conditions, recycled LDPE composites displayed varying abilities to resist degradation upon UV irradiation and, separately, both high and low temperatures. Upon exposure in a QUV weathering chamber for different intervals to accelerate aging, samples were tested to evaluate their mechanical properties. There was a significant decrease in tensile strength and tensile strain with increasing exposure time for all of specimens. The enhancement of the crystallization properties was explained by the presence of fine talc which leads to an extended life span of recycled LDPE and therefore a reduction in the damage caused by UV irradiation. Similarly, matrix degradation is retarded by the inclusion of glass fibres in the recycled LDPE due to surface protection effects. Of these two fillers, glass fibre proved more effective in resisting UV irradiation. Both, however, were able to limit the network of surface cracks associated with artificial aging via UV irradiation, as confirmed by Scanning Electron Microscopy (SEM).

Varying the temperatures to which samples were exposed demonstrated that recycled LDPE composites exhibit different range of mechanical properties at different temperatures, as might be expected. Under low temperature conditions (-20^{o}C, 0^{o}C), all specimens displayed higher tensile strength and lower tensile strain than was noted at room temperature; this can be attributed to decreases in molecular activity at low temperatures. On the contrary, when exposed to temperatures higher than 20^{o}C, tensile strength drops quickly while tensile strain significantly increases. Among these samples, specimens reinforced with fine talc are more stable under high temperature than those containing glass fibres, a phenomenon related to the change in polymer structure caused by the fillers and demonstrable by SEM. Utilizing fine talc or glass fibres as filler is therefore an effective way to prolong the lifetime of recycled plastics.

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