Optimisation of the Production of Commingled Recycled Plastic Materials

A thesis submitted for the degree of Master of Engineering Science

by

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Journal paper

H.D. Putra, Y. Ngothai, T. Ozbakkaloglu, and R. Seracino, "Mineral Filler Reinforcement for Commingled Recycled Plastic Materials", *Journal of Applied Polymer Science,* Vol. 112, pp. 3470-3481 (2009).

Conference papers

Y. Ngothai, H. Putra, T. Ozbakkaloglu, and R. Seracino, "Effect of $CaCO_3$ size on the mechanical properties of recycled HDPE", Proceedings: 8th World Congress of Chemical Engineering, Jamal Chaouki Editor, Montréal, Québec, Canada, 23-27 August 2009, ISBN: 0-920804-44-6, USB.

H. Putra, Y. Ngothai, and R. Seracino, "Effects of Fillers on the Flexural Properties of Mixed Recycled Plastic Materials", Proceedings: CHEMECA 2006-34th Australasian Chemical Engineering Conference, D. Patterson & B. Young, Eds., The Institution of Engineers, Auckland, New Zealand, 17-20 September 2006, Paper #443, 5 pp., ISBN: 0-86869-110-0, CD-ROM.

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Errata Sheet

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Page	Section	Article	Reference/Source
4	2.1.2	Figure 2-1	Kaminsky W., 2000, *Plastics Recycling*, in Ullman's chemical engineering, accessed online on 20th June 2008
8	2.2.1	Figure 2-3	Dubnikova I.L., Oshmyan V.G. and Gorenberg A.Y.A., 1997b, *Mechanisms of Particulate Finite Plastic Deformation and Fracture*, Journal of Materials Science, v. 32, pp. 1613-1622
9	2.2.1	Figure 2-4	Dubnikova I.L., Oshmyan V.G. and Gorenberg A.Y.A., 1997b, *Mechanisms of Particulate Finite Plastic Deformation and Fracture*, Journal of Materials Science, v. 32, pp. 1613-1622
10	2.2.2	Figure 2-5	Dubnikova I.L., Oshmyan V.G. and Gorenberg A.Y.A., 1997b, *Mechanisms of Particulate Finite Plastic Deformation and Fracture*, Journal of Materials Science, v. 32, pp. 1613-1622
12	2.2.3.2	Figure 2-6	Wolf., R., 2000, *Plastics, Additives*, in Ullman's chemical engineering, accessed online on 20th June 2008
12	2.2.3.2	Figure 2-7	Chemexper available on: http://www.chemexper.com/chemicals/supplier/cas/2530-85-0.html accessed on 26th May 2009

Abstract

The recycling of post-consumer plastic waste is a challenging task due to the commingled nature of the waste composition. Commingled plastic recycling is one of the most economically viable ways to manufacture plastics waste into commercial products. Similar to virgin polymers, fillers can be added to recycled plastics to improve engineering properties of the final products. The common operations of commingled plastic recycling however lack in depth knowledge in relation to the selection of the appropriate fillers, additives, and optimum processing variables.

This project aimed to investigate three types of mineral fillers, talc, wollastonite and gypsum, for their abilities to modify the mechanical properties of commingled recycled plastic composites. The effectiveness of the fillers to improve the mechanical properties was considered to be influenced by interface bonding (between the filler and matrix) and extrusion variables. These factors were also investigated in this research.

Mechanical test results showed that the talc reinforced composites were significantly better in mechanical properties compared to the gypsum and wollastonite composites (tensile strength and modulus improved by 170% and 20%, respectively at 0.26 v/v loading). Scanning electron microscopy (SEM) showed that gypsum formed large agglomerates in the matrix leading to inferior mechanical properties. The interface adhesion between filler and matrix was evaluated using several established models. The tensile or flexural strength of the composites was satisfactorily predicted using Turcsanyi and Nicolais-Narkis equations. For the tensile and flexural modulus of the composites the Einstein equation was found to give a good correlation.

In attempt to enhance the adhesion, the mineral fillers were pre-treated with silane coupling agents, 3-methacryloxypropyltrimethoxy silane (γ-MPS) and 3-aminopropyltriethoxy silane (γ-APS) before being blended with the plastics. This did not result in any significant improvement to the material properties. The γ-APS treatment, however, increased the tensile properties of the composites by approximately 5% compared to the γ-MPS treatment. The SEM investigations showed that the γ-APS treatment provided better adhesion of filler particles and hence voids were less likely to form in the matrix compared to the γ-MPS composites.

Extruder parameters like screw rotation and barrel temperature did not have a significant influence on the mechanical properties of filler-recycled plastic composites.

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Putra H., Ngothai Y., Seracino R. (2006), Effects of Fillers on the Flexural Properties of Mixed Recycled Plastic Materials, Proceedings: CHEMECA 2006-34th Australasian Chemical Engineering Conference, D. Patterson & B. Young, Eds., The Institution of Engineers, Auckland, New Zealand, 17-20 September 2006, Paper #443, 5 pp., ISBN: 0-86869-110-0, CD-ROM.