DEVELOPMENT OF BLOOD MEAL PROTEIN THERMOPLASTIC

C. J. VERBEEK, K. M. KU ISHAK

Department of Science and Engineering, University of Waikato,
Hamilton 3240, New Zealand
jverbeek@waikato.ac.nz

Introduction

Polymers are blended with other polymers to combine their properties or improve physical characteristics and blending turns to be the most reliable techniques compare to synthesis of chemically new polymers. In the research of sustainable materials from non-potential food sources, bloodmeal is one of the best candidates for bioplastic manufacture. It is one of the highest non-synthetic sources of nitrogen coming from meat processing and approximately 80000 tonnes of raw blood is collected annually in New Zealand. Natural polymers often present processing difficulties as well as maintaining product quality over extended periods because of their hydrophilic nature. Blending bloodmeal with other polymers may offer a solution to this problem. However, most blends are immiscible, and the processing are challenging because of dissimilar nature of natural and synthetic polymer, thus requiring compatibilization to achieve good blends performance. The process to solve incompatibility is the compatibilizer should migrate to the interface, reducing the interfacial tension, stabilizing the blend morphology and improving the adhesion between phases in solid state, hence improving the mechanical properties. True thermodynamic term of miscibility of polymer blends is a mixture containing two or more components that form one phase system but this determination of miscibility may be rather ambiguous. In practice, polymer blend compositions is said compatible if they exhibit two phases on a microscopic level but the interactions between polymer groups might be reasonable in a manner that provides useful properties of the multicoponent system. In many instances, it is desirable to have two phases present, as long as we can control the multicomponent systems which depend on their structure, polymer interactions and phase sizes. We have identified several strategies in order to improve miscibility;

1. Addition of a small quantity of a third component that is miscible with both phases
2. Addition of a copolymer whose one part is miscible with one phase and another with another phase
3. Compounding blends in the presence of chemical reactants that lead to modification of at least one macromolecular species (reactive compatibilization), resulting in generation of an *in-situ* desired quantity of compatibilizer.

The propose of this paper is to explore the potential of blending bloodmeal with other thermoplastic by taking account the type of polymer, type of compatibilization and processing condition in order to improve processability and mechanical properties.

Methodology

There are 3 stages of developing thermoplastic protein has been identified. Stage 1 involves blending of protein blood meal with synthetic polymer with compatibilizer and without compatibilizer. Stage 2 will be using synthetic biodegradable polyester blends with protein blood meal and stage 3 will introduce grafting modification whether by third component or in situ reactive compatibilization. Extruder and injection moulder were used as processing aid. All samples will be analyzed to study

1. Mechanical properties: Tensile stress, Elongation at break, Young's Modulus
2. Physical/Morphology properties: FTIR/SEM
3. Miscibility/Compatibility: TGA, DSC, DMTA

Preliminary research on protein based thermoplastic blending

The research has been commenced by studying the blending of thermoplastic blood meal protein with low linear density polyethylene (LLDPE). The purpose of this experiment is to measure the performances of blood meal when blends with other polymer and evaluate to what degree the mixture are compatible. Various ratios from 0-100% of LLDPE with blood meal were conducted using extrusion and injection moulding. The extruder speed was set at 150 rpm with temperature settings of 70^{o}C 100^{o}C 100^{o}C 100^{o}C 120^{o}C. A dumb bell shape sample were produced by injection moulder prior to testing. The samples were placed in a conditioning chamber at 23^{o} C and 50% for 7 days to remove water from the samples. Tensile tests were done to measure tensile stress for unconditioned and conditioned samples. These samples will be used as control when comparing to addition of compatibilizer, poly(2-ethyl-2-oxazoline) in blending.

Experimental results

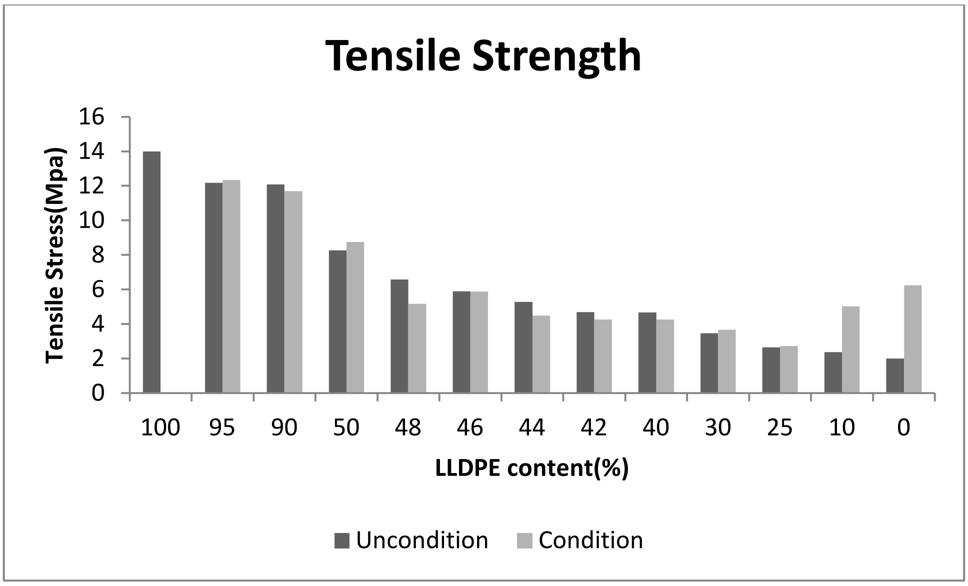

Figure1: Tensile Strength of various ratios from 0-100% of LLDPE with blood meal

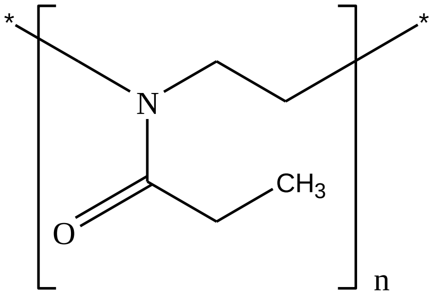

Figure 2: Poly (2-ethyl-2-oxazoline) PEOX

Table 1: Mechanical properties of blends with and without compatibilizer

Sample	Formulation	Tensile strength	Modulus	Elongation at break
		Mpa	Mpa	%
6	Uncondition 50NTP/50LLDPE	8.26	123.13	57.64
6C	Condition 50NTP/50LLDPE	8.70	140.07	43.53
W1	Uncondition 48NTP/50LLDPE/2%PEOX	3.87	49.12	380.08
W2	Uncondition 50NTP/48LLDPE/2%PEOX	2.92	64.84	339.12

Discussions

The tensile strength of various ratios from 0-100% of LLDPE loading measured before and after conditioning is shown in Figure 1. Ratio of 50:50 shows the best performance in term of tensile strength and morphology. Although 95% and 90% of LLDPE loading show high tensile strength but it obviously shows two phases when injection molded. Table 1 shows mechanical properties of LLDPE/BM blends (50:50) with 2% of poly (2-ethyl-2-oxazoline) as shown in Figure 2 and the results were compared with blends without the compatibilizer, PEOX. The tensile properties for blends WI and W2 decreased to 2-3Mpa while the elongation at break increase greatly from 57.64% to 339.12% and 380.08%. PEOX could be considered as a good candidate for the toughening of rigid polymer in NTP/LLDPE binary blends. The failure mode changed from brittle fracture of NTP to ductile fracture of the blends. PEOX is hydrophilic thus it miscible with BM. The reactions of PEOX with moisture in BM prevented reaction of NTP and LLDPE lead to decrease in tensile strength. PEOX tends to function as a LLDPE binding domains than NTP-binding domains and that explained why it has good elongation at break and ductile properties.

References

Paul, D.R. and S. Newman, *Polymer Blends*. Vol. 2. 1978, New York: Academic Press.

Rudin, A., *Copolymers in Polymer Blends.* Journal of Macromolecular Science, Part C: Polymer Reviews, 1980. **19**(2): p. 267-292.

Utracki, L.A., *Commercial Polymer Blends.* 1998.

Roe RF, R.D., *Advances in Polymer Science*. Polymer Physics. Vol. 82. 1987, Berlin: Springer-Verlag.

Market New Zealand.   [cited 2011 3 August]; Available from: : http://www.marketnewzealand.com.