MECHANICAL AND THERMAL PROPERTIES OF POLYLACTIC ACID AND PLASTICIZED POLYLACTIC ACID WITH THERMOPLASTIC SAGO STARCH BLENDS

By

EYMAN ELSHAIKH MAHGOUB

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Partial Requirements for the Degree of Master of Science

March 2004

Dedication

With all my love I dedicate this thesis to my parents

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the partial requirements for the degree of Master of Science

MECHANICAL AND THERMAL PROPERTIES OF POLYLACTIC ACID AND PLASTICIZED POLYLACTIC ACID WITH THERMOPLASTIC SAGO STARCH BLENDS

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EYMAN E. MAHGOUB

March 2004

Chairman: Associate Professor Mohd. Nordin Ibrahim, Ph.D.

Faculty: Engineering

The aim of this study was to produce plasticized blends of Polylactic acid, to evaluate the effect of two plasticizers Triethyl citrate (TC) and thermoplastic sago starch (TSS) on the mechanical and thermal properties of PLA and to evaluate the combined effect of plasticizers (TC and TSS) on the mechanical and thermal properties of PLA.

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The biodegradable polymer blends were prepared with various concentrations of triethyl citrate and thermoplastic sago starch in order to obtain a plastic material with a range of different mechanical properties that are suitable for packaging applications.

The blends were melted by using twin-screw extruder. The samples obtained were examined for the effect of TC and TSS addition on thermal transitions and mechanical properties. The blends were characterized by Differential scanning calorimetry (DSC)

for thermal transitions and by Instron testing machine for tensile strength, young modulus, elongation, and toughness.

The addition of a plasticizer TC to a polymer PLA decreased the tensile strength and young modulus while increased the elongation at break and toughness. The addition of TC also shifted the glass transition temperature (Tg) down to lower temperatures and no crystallization of PLA was observed.

The behavior of the PLA/TSS blends did not follow the same trend in all the compositions. Tensile strength and modulus decreased for PLA/TSS blends with 10% and 30% of TSS when compared to pure PLA, the elongation at break decreased insignificantly and no improvement in toughness was observed. On the other hand, PLA/TSS blend with 20% TSS had the highest tensile strength and elongation, but lowest modulus compared to pure PLA and other blends. A clear single Tg was observed for each of the PLA/TSS blends indicating high level of miscibility in each blend and the value of Tg decreased with the addition of TSS, with unstable trend.

The PPLA/TSS blends varied in their mechanical properties and no obvious trend was observed when investigating the effect of TC or addition of TSS on the mechanical properties. This might be attributed to: first the nature of specimens, in which non homogenousity was observed obviously and second the anti plasticizing effect that appears in some of the PPLA/TSS blends containing 10% and 30% TSS due to additionof insufficient amounts of Plasticizer.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi sebahagian keperluan untuk Ijazah Master Sains

SIFAT MEKANIKAL DAN TERMAL ASID POLILAKTIK (pla) DAN PEMPLASTIKAN ASID POLILAKTIK (PPLA) DENGAN CAMPURAN KANJI SAGO TERMOPLASTIK

Oleh

EYMAN E. MAHGOUB

Mac 2004

Pengerusi: **Profesor Madya Mohd. Nordin Ibrahim, Ph.D.**

Fakulti: **Kejuruteraan**

Tujuan kajian ini ada untuk menghasilkan campuran PLA, yang mana digunakan untuk menilai kepelbagaian kesan bahan pemplastikan Sitrat Trietil (TC) dan Kanji Sagu Termoplastik (TSS) ke atas sifat-sifat mekanikal dan termal PLA. Selain daripada itu, kajian ini dijalankan untuk menilai hasil gabungan bahan pemplastikan (TC dan TSS) ke atas sifat-sifat mekanikal dan termal PLA.

Campuran polimer bioboleh rosost ini telah disediakan dengan menggunakan pelbagai kandungan TC dan TSS untuk menghasilkan bahan plastic yang mempunyai pelbagai sifat-sifat mekanikal yang dapat disesuaikan untuk kegunaan pembungkusan.

Campuran ini dicairkan dengan menggunakan penyemperit. Sampel-sample yang diperolehi dikaji dari segi kesan penambahan TC dan TSS ke atas transisi termal dan sifat-sifat mekanikal.. Campuran ini dicirikan oleh *DSC* untuk transisi termal dan oleh

mesin pengujian Instron bagi menguji kekuatan tegangan, modulus, pemanjangan, dan kekuatan.

Hasilan sifat-sifat mekanikal menunjukkan penambahan bahan pemplastikan TC ke atas polimer PLA mengurangkan kekuatan ketegangan da modulus muda. Pada masa yang sama, tahap kekenyalan pemanjangan telah bertambah. Penambahan TC juga telah mengubah suhu transisi gelas (Tg) ke tahap suhu yang lebih rendah, dan tiada penghabluran telah terhasil.

Namun begitu, sifat PLA/TSS tidak mempunyai trend yang sama untuk kesemua komposisi. Kekuatan ketegangan dan modulus telah berkurangan di dalam campuran PLA/TSS sebanyak 10% dan 30% dari TSS berbanding dengan PLA sejati. Tambahan daripada itu, tahap kekenyalan pemanjangan telah berkurangan secara tidak sifikannya, Maka, telah didapati tiada perkembangan di dalam kekuatannya. Sebaliknya, campuran PLA/TSS yang mengandungi sebanyak 20% TSS telah menunjukkan hasil tertinggi di dalam kekuatan ketegangan dan pemanjangan. Namun demikian, ia mempunyai bilangan modulus yang terendah berbanding dengan PLA sejati dan campuran-campuran yang lain. Hasil daripada pemerhatian ke atas satu Tg tunggal yang jelas daripada setiap campuran PLA/TSS telah menunjukkan kadar keterlarutan yang tinggi bagi setiap campuran. Hasil daripada itu, kadar Tg telah dikurangkan dengan penambahan TSS dengan trend yang tidak stabil.

Secara amnya, di dalam mengkaji kesan TC atau penambahan TSS ke atas sifat-sifat mekanikal telah didapati Campuran PPLA/TSS mempunyai sifat-sifat mekanikal yang berbagai dan tiada trend yang nyata. Ini mungkin disebabkan: pertamanya sifat semulajadi sepsimen-spesimen yang tidak homogen (tidak sama), dan keduanya kesan anti pemplastikan telah kelihatan di dalam sebilangan daripada campuran PPLA/TSS yang mengandungi 10% dan 30% TSS. Ini adalah hasil daripada kekurangan jumlah bahan pemplastikan.

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Last but not least I ask Allah S.W.T to bless my beloved parents to whom I remain grateful for their support and unfailing enthusiasm that guided me through the periods of hard work.

Eyman Elsheikh Mahgoub,

Kuala Lumpur, October 2003.

I certify that an examination committee met on 11th March 2004 to conduct the final examination of Eyman Elshaikh Mahgoub on her Master of Science thesis entitled "Mechanical and Thermal Properties of Polylactic Acid (PLA) and Plasticized Polylactic Acid (PPLA) with Thermoplastic Sago Starch (TSS) blends" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the partial requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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EYMAN ELSHAIKH MAHGOUB

Date:

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