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MECHANICAL PROPERTIES OF POLYPROPYLENE PLASTELIZED BY CHLOROPHYLL

Abdulawahab A. Sultan[1], Mohammed H. Ali Al-Mosawi[2] and Hanaa K. Mousa[3]

[1] **Assistant professor, South Technical University**

[2] **Assistant professor, Technical College-Basrah, malmosawi1953@gmail.com**

[3] **Assistant professor, Basrah University-College of Science**

ABSTRACT

There are many of industrial plasticizers materials used to improve mechanical properties of polypropylene. In this study chlorophyll, natural pigment is used. Its eco – friend and not toxic material, extracted from plants. The chlorophyll, natural pigment is extracted and mixed with polypropylene with following weight percentages (0.0, 0.1, 0.25, 0.5, 0.75, and 1.0), then extruded as a sheet by screw extrusion machine. The mechanical properties of specimens are examined by mechanical testing, such as (Tensile test, Impact test).

The results showed improvements in mechanical properties of polypropylene plasticized by chlorophyll. Where it gives ultimate tensile strength of (32.64, 33.972, 44.63, 40.633, 33.306, and 45.962) Mpa, the modulus of elasticity of (439.27, 1040, 1195.63, 700, 1785, and1525) Mpa, the maximum elongation % at fracture of (24.46, 16.182, 19.632, 61.584, 17.587, and 12.121) mm/mm %, and impact strength of (0.1, 0.2, 0.25, 0.355, 0.24, and 0.2) Joule, respectively with each chlorophyll addition weight percent wt%.

The polypropylene blend consisting chlorophyll of 0.5 wt % presents significant improvements of mechanical properties, high ductility, and impact strength, suitable ultimate strength, and modulus of elasticity.

KEYWORDS: PP; Plasticizer; Chlorophyll; Natural pigment

الخواص الميكانيكية للبولي بروبولين الملدن بالكلوروفيل

عبد الوهاب عبد الرزاق سلطان **محمد حسن علي الموسوي** **هناء كاظم موسى**

الجامعة التقنية الجنوبية **الكلية التقنية- البصرة** **الجامعة البصرة كلية العلوم**

الخلاصه

هنالك العديد من المواد الملدنة الصناعية لتحسين الخواص الميكانيكية للبولي بروبيلين. في هذه الدراسة استعملت صبغة الكلوروفيل الطبيعي، انها مادة صديقة للبيئة وغير سامة استخرجت من النباتات، عوملت ومزجت مع البولي بروبيلين بالنسب التالية (0.0، 0.1، 0.25، 0.5، 0.75، 1.0) ثم بثقت على شكل صفائح بواسطة ماكنة بثق لولبية، ان الخواص الميكانيكية للعينات تم فحصها بالاختبارات الميكانيلة (اختبار الشد، اختبار الصدم).

اظهرت نتائج الاختبارات تحسن في الخواص الميكانيكية للبولي بروبلين الملدن بواسطة الكلوروفيل حيث اعطى مقاومة شد (32.64، 33.972، 44.6.3، 40.633، 33.306، 45.962) MPA، ومعامل مرونة (439.27، 1040، 1192.63، 700، 1525،1785) MPA واقصى استطالة قبل الكسر (24.46، 16.182، 19.632، 61.584، 17.587، 12.121) MM/MM% ومقاومة الصدم (0.1، 0.2، 0.25، 0.355، 0.24، 0.2)JOULE على التوالي مع كل نسبةاضافة كلوروفيل وزنية.% WT .

ان خليط البولي بروبلين المحتوي على 0.5 WT % كلوروفيل ابدى تحسن ملحوظ في الخواص الميكانيكية، مطولية ومقاومة صدم عاليتين واقصى مقاومة شد ومعامل مرونة مناسبتين.

1. INTRODUCTION

Mechanical properties of plastic parts depend on material construction, chemical composition, structure, and added additives. The changes in mechanical properties are influenced by several factors, such as the amount of plasticizers added, and type of plasticizers used (Behalek and Bobek, 2010).

Since the first plastic materials were manufactured, many plasticizers were using natural and industrial materials for plasticization purposes. The development of specialty plasticizers comes from the extensive use of plastics in a wide range of applications, increased quality requirements, the need for materials that meet increasing rigorous product specifications, and compatibility problems relating to particular products (Rahman and Brazel, 2004).

Plasticizers have been known for their effectiveness in producing flexible plastics for applications ranging from the automotive industry to medical and consumer products. The plasticizer industry has grown with the use of plastics worldwide. Recent plasticizer research has focused on technological challenges including leaching, migration, evaporation, and degradation of plasticizers, each of which eventually leads to deterioration of thermo-mechanical properties in plastics (Rahman and Brazel, 2004).

Plasticizers are additives used to increase the flexibility or plasticity of polymers, and occasionally they are used only to facilitate the polymer processing. Several theories have been proposed to explain the mechanisms of plasticization action (Nugraha et al., 2005).

The plasticizers which have been recently used to increase structural flexibility, must be examined for environmental and health related problems. The expansion of plasticizing compounds to meet new material challenges has also led to significant technical advances. The second order transition temperature Plasticizers are actually low molecular weight (MW) resins or liquids, which form secondary bonds to polymer chains and spread them apart. Thus, plasticizers reduce polymer-polymer chain secondary bonding and provide more mobility for the macromolecules, resulting in a softer, more easily definable mass (Rahman and Brazel, 2004).

Food legislation, health and industrial safety and commercial aspects play an important role and, over last 50 years, have led to the development of the vast range of plasticizers currently available. Initially few fatty acid esters, benzoates, tartrates, and chlorinated hydrocarbons were available to meet the new safety requirements (Rahman and Brazel, 2004).

The plastics are extensively used in almost daily activities such as the plastic packaging bags produced from polyethylene and polypropylene.

The products from these polymers cause environmental problems to replace the conventional plastics with biodegradable plastic. The parts produced from biodegradable plastic can be improved by the addition of plasticizers, which will enhance ductility and flexibility of the products (Boonfaung et al., 2011).

The choice of plasticizers to be used as modifiers for PP is limited by the requirement of the application. Only non-toxic substances approved for food contact which can be considered as plasticizing agents in food packaging materials. For a low molecular weight plasticizer an important demand is miscible with PP and stable at the elevated temperature used during processing, thus creating a homogeneous blend. Plasticized PP should be stable all the time because the migration of the plasticizer to the surface could be a source of contamination of the food or beverage in contact with the packaging or may possibly regain the initial brittleness of pure PP (Pavlidou, 2005).

Polypropylene was proved as one of the most interesting commodity thermoplastics in the last years, after metallocene introduction as a catalyst in its production due to its higher isotacticity, enhanced mechanical properties, narrow molecular weight distribution, and increased clarity. Despite all these advantages PP has a very serious defect. Although its resistance to crack initiation is very high, the resistance in crack propagation is very low and when a crack or mechanical failure exists in PP matrix it breaks very easily (Xinping and Kok, 2000).

Maria and Cincu, 2006 studied the influence of the ionic and non-ionic plasticizers on the characteristics of thermoplastic ionic elastomers based on maleinized ethylene-propylene-diene terpolymer elastomer has been determined. The ionic plasticizer has shown filler characteristics leading to an increased hardness and decreased elasticity, elasticity modulus, tensile strength, and tear strength. The non-ionic plasticizer has solvated non-ionizable elastomer chains leading to increased elasticity and elongation at break and decreased hardness, tensile strength, and tear strength.

Marcelo et al., 2009 tried to obtain a modified polypropylene (PP) by the incorporation of pro-oxidant agents, and the influence of plasticized starch (TPS) to iPP. TPS was obtained by the incorporation of glycerin (sub-product of biodiesel). IPP was added using a masterbatch contained, individually, calcium stearate (CaSt) and magnesium stearate (MgSt). The addition of TPS progressively decreased the mechanical properties for all the blends (Marcelo et al., 2009).

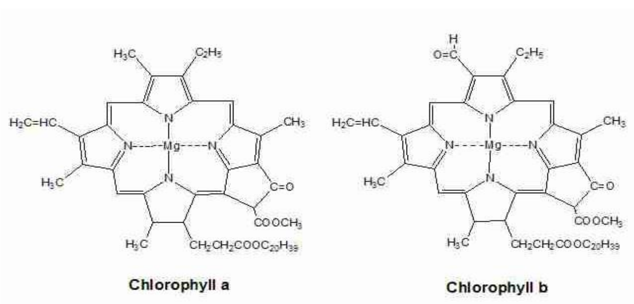
(DeLeo et al., 2010) investigated to evaluate the possibility of developing renewable elastomers based on starch. Potato starch plasticized with glycerol (called plasticized starch, or PLS) was melt-blended with small quantities (5 wt % or 15 wt%) of maleated polypropylene (MAPP). The Maleic anhydride groups of the polypropylene are expected to react with the hydroxy groups of starch under melt blending conditions. The resulting blends of MAPP and PLS were characterized by mechanical testing. The materials showed rubbery properties as judged by a low glass transition temperature (50ºC independent of polypropylene content), and the tensile properties are also characteristic of elastomers.

The main objective of this study to improve the mechanical properties of polypropylene with the addition of the chlorophyll as biodegradable plasticizer which enhances strength, ductility, flexibility of the new polypropylene plasticized produced material.

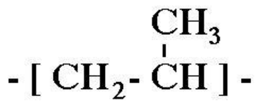
2. EXPERIMENTAL

2.1. Materials

Chlorophyll the natural green pigment extracted from plants. It is one of the most important Mg^{2+} compounds in nature; it has the molecular formula $C_{55}H_{72}MgN_4O_5$ with molecular weight of 893.5 g/Mol. There are several forms of chlorophyll structure one of form chlorophyll is:



A polypropylene presented in this study is provided by a SBCO company, Saudia Arabia of specification MI = 2.3 g/10 min (at 210 ˚C) with a density of (0. 932 – 0.943) g/cm^3. It has molecular formula C_3H_6, with a molecular weight of 42.08 g/Mol, it has chemical structure is:



A chlorophyll was extracted from Chard (Beta Volgaris Subsp Cicla) leaves using method published in Ritchie, 2008.

Polypropylene was mixed with different percentages of chlorophyll (0, 0.1, 0.25, 0.5, 0.75 and 1.0) wt%, extruded by extrusion machine Haak Rhechard Torque Rheometer type attached Mixer – 600, (maximum quantity of 40 – 60 g), Temperature controlled, raising from room Temperature to 500 ˚C at 15 minutes in petrochemical complex – Basrah.

2.2. Mechanical properties

2.2.1. Tensile and Impact tests:

The mechanical properties of plastic materials, tensile properties, are probably the most frequently considered, evaluated, and used throughout the industry. These properties are an important indicator of the plastic material's behavior under loading in tension. Tensile testing provides these useful data; tensile yield strength, tensile strength at break (ultimate tensile strength), tensile modulus (Young's modulus), and elongation at yield and break.

The specimen dumbbell shape type was used in tests of the PP plasticized by chlorophyll.

The testing apparatus used for specimens tension testing is the universal testing machine, GUNT model Wp300 Computerize Universal Material tester, 20kN. The load magnitude supplied by the testing is reading from a load cell inside the machine, and the strain is recorded using an extensometer with 25 gauge length.

Impact test measures the resistance of polypropylene – chlorophyll, natural pigment blend material to the impact. Using the Izod impact testing method to measure the toughness for different pp – chlorophyll blends wt% by impact tester type CEAST, 6546000 from TORINO Company, ITALY. The notch cut on the samples with cutter (CEAST 6530).

3. RESULTS AND DISCUSSIONS

The mechanical behavior of PP plasticized by chlorophyll under the effect of tensile load described through the stress – strain curves shown in Fig. 1 according to the weight percent additives of chlorophyll, natural pigment plasticizer. It is clear from the Fig. 2 that the maximum tensile strength (ultimate stress) of PP little increased with increasing of plasticizer addition.

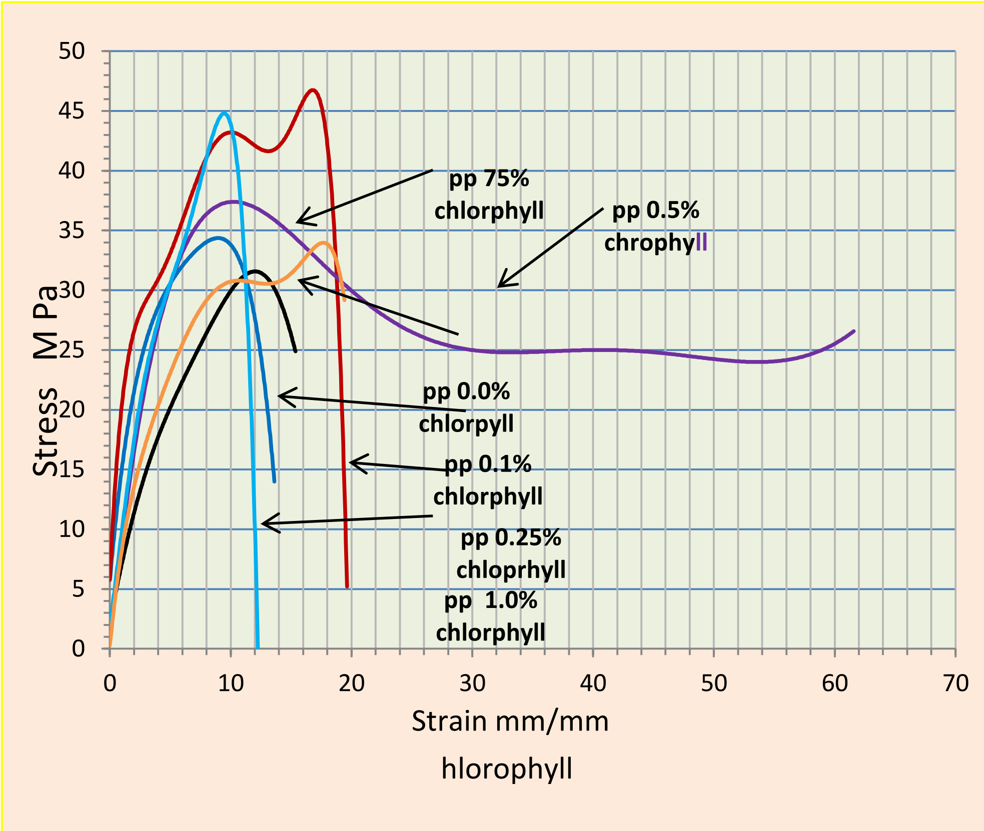


Fig. 1. Stress - Strain curves of PP plasticizer by

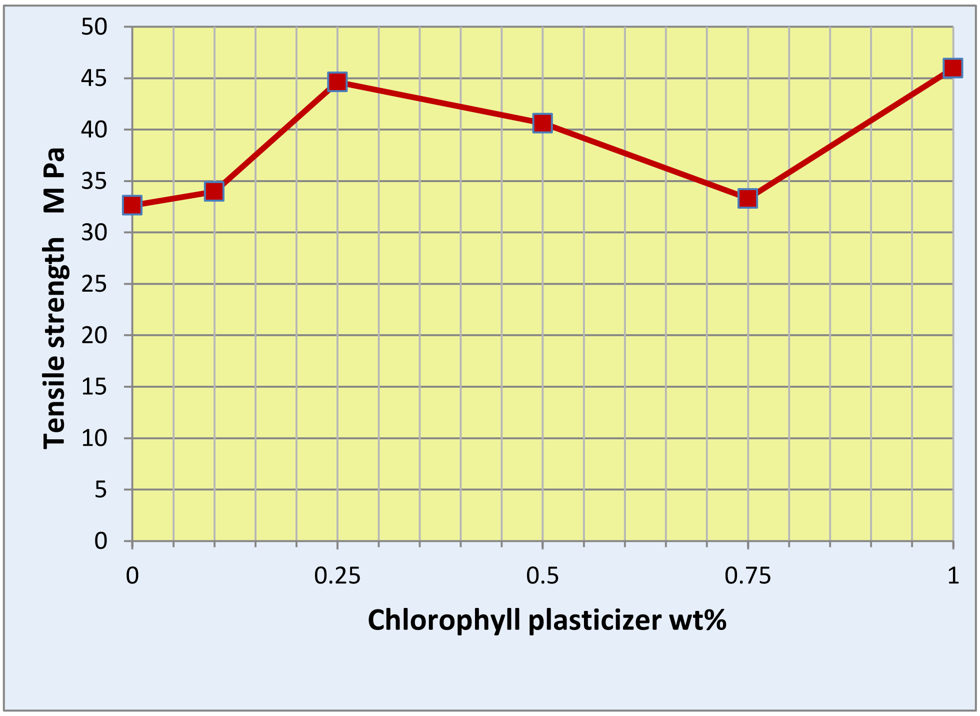


Fig. 2. Maximum tensile strength

wt% up to 0.25 wt% chlorophyll, then reduced with increasing of chlorophyll wt% in the PP blend at 0.5 wt% and 0.75 wt%, respectively, until it was reached the minimum tensile strength to be 33.306 MPa at 0.75 wt% chlorophyll addition.

When the plasticizer chlorophyll wt% increased in polypropylene the ultimate strength increased again to gate maximum stress of 45.962 MPa at chlorophyll of 1.0 wt%. As illustrated in the Fig. (3).

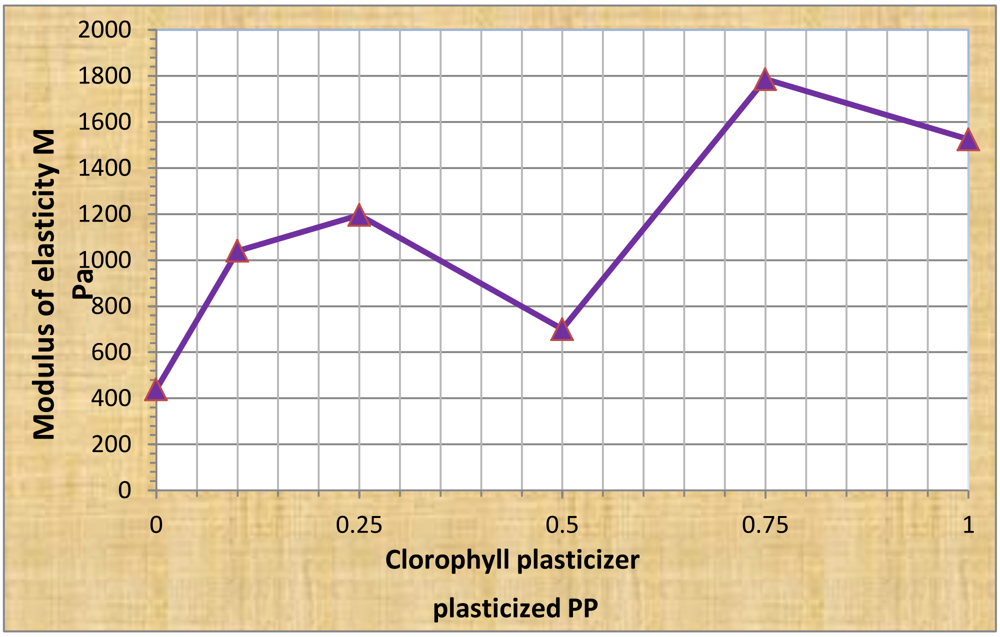


Fig. 3. Modulus of Elasticity of

The modulus of elasticity increased with the increasing of chlorophyll plasticizer wt%, of 439.27 MPa for pure polypropylene and for the blends contained plasticizer of (0.1, 0.25, 0.5, 0.75, and 1.0) wt%, Which had modulus of elasticity are (1040, 1195.63, 700, 1785.7, and 1525) MPa, respectively.

The results of tensile tests for different blends of polypropylene chlorophyll plasticizer wt% ratio, showed decreasing in the elongation percent with increasing of chlorophyll wt%. Where the elongation% for (0.0, 0.1, 0.25, 0.5, 0.75, and 1.0) wt% are (24.646, 16.182, 19.632, 61.584, 17.587, and 12.121) %, respectively, see Fig. 4. Note that, except the elongation% of 0.5 chlorophyll, wt% was sharply increased, since the specimen of this ratio elongates out range of universal materials testing machine as shown in Fig. 5.

The polypropylene – chlorophyll pigment blends suffer to impact stress as shown in Fig. 6. Impact strength first increased with increasing of chlorophyll wt% addition reach maximum value 0.355 J at chlorophyll of 0.5 wt% and with increasing chlorophyll (natural pigment) percent, impact strength will decreases. That belongs to the relation between groups in pigment structure with PP which are saturated in this percent (0.5%) and chlorophyll act filler upper addition of 0.5%. that agrees with the results, and it's the positive pollute here in order to consumes minimum amounts of chlorophyll natural pigment.

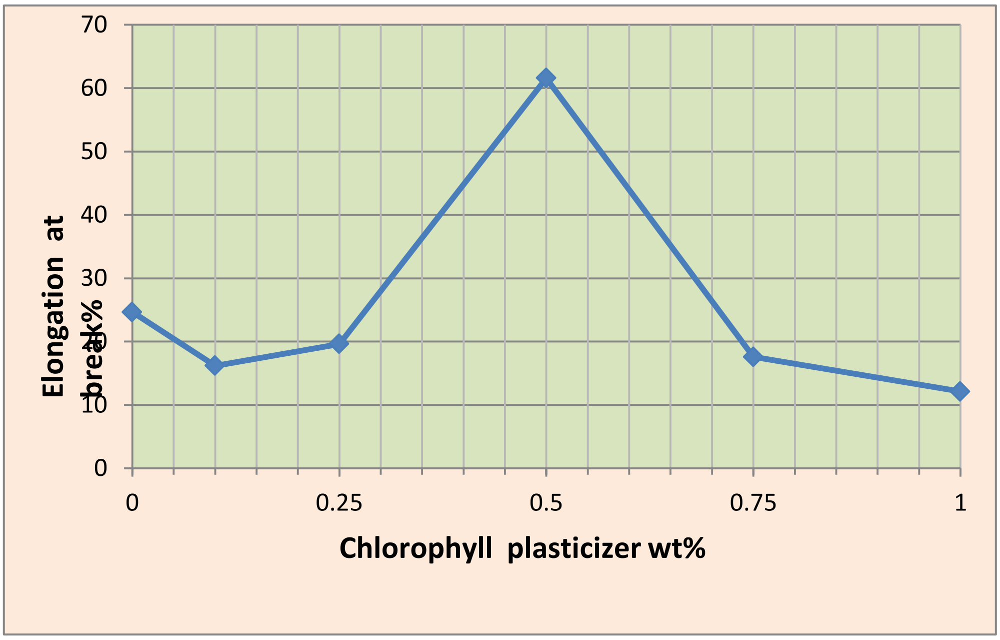


Fig. 4. Elongation percent at fracture of plasticized PP

Fig. 5. Ductility of PP

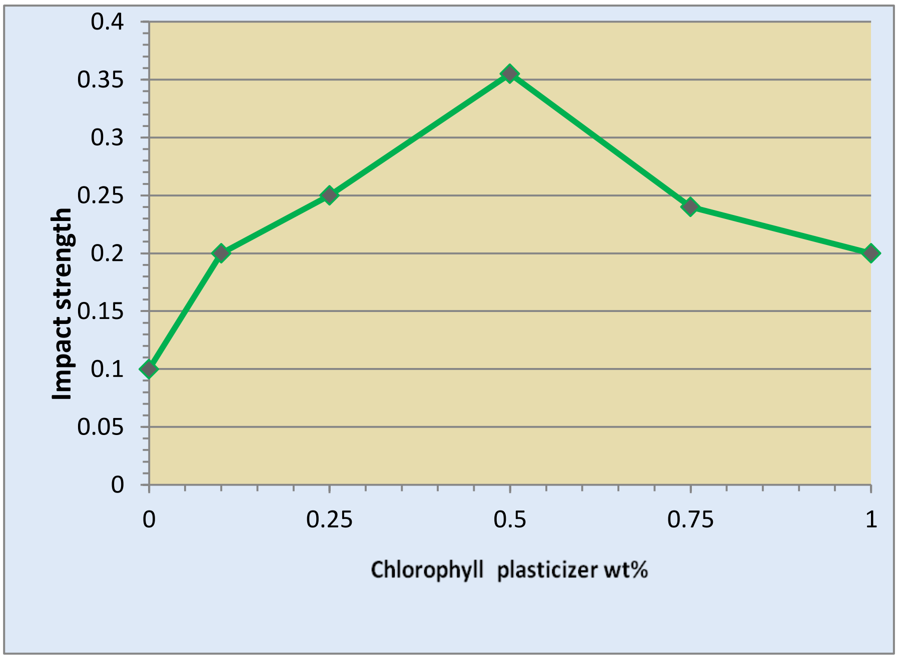


Fig. 6. Impact strength of plasticized PP

The tensile strength, modulus of elasticity, elongation at break %, and impact strength were affected by the amounts of chlorophyll plasticizer wt% as illustrated in Fig. 7. By adding chlorophyll into the polypropylene matrix can be decreased rigidity and ductility because it works as filler penetrates between the polymer chains and inter molecular forces which cause the lower polymer chains cohesion [4]. Except that the effect of chlorophyll of 0.5 wt% addition, where works as plasticizer which connect between polymer chains, increases their length of pp which appears more plastic as ductile material due to this action.

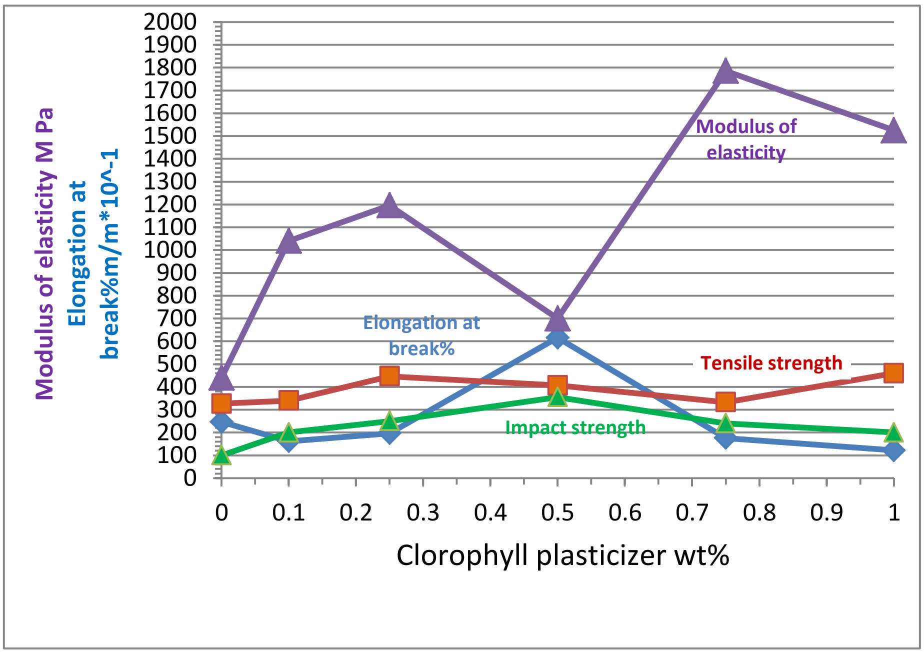


Fig. 7. Tensile and impact testing results for plasticized PP

4. CONCLUSIONS

1. The addition of the chlorophyll plasticizer causes decreasing of tensile strength, modulus of elasticity, and elongation% at break except the effect of 0.5% chlorophyll addition.
2. The PP – chlorophyll 0.5 wt% blend had super plastic behavior.
3. The mechanical properties of PP – chlorophyll 0.5 wt% are improved, where the tensile strength was not much reduced than that of pure PP, increased an elongation% at break and formability.
4. The PP – chlorophyll blend is healthy because not toxic and eco – friendly to the environment, can be used in the food industries.

5. REFERECES

Behalek, L. and Bobek, J. "Contact – Less analysis of polypropylene tensile strain and influence of loading rate"ACTA Technical Corviniensis, Faculty of engineering – Hunedoara Romania 2010.

Boonfaung, P., Wasutchanon, P. and Somwangthanaroj, A. "Development of packaging film from bioplastic polylactic acid (PLA) with plasticizers" Pure and applied chemistry international conference. Bangkok, Thailand. 2011.

DeLeo, C., Goetz, J., Young, B. and Velankar, S. "Renewable elastomers based on blends of maleated polypropylene and plasticized starch" Journal of Applied Polymer Science, Vol. 116, 1775–1781 (2010) V C 2010Wiley Periodicals, Inc.

Marcelo A. G., Bardi, Luci D. B. Machado, Cristina G. F. Guedes, Derval s. Rosa "Influence of processing on properties of aditived polypropylene, starch plasticized with glycerol from biodiesel and their blends" Anais do 10 Congresso Brasileiro de Polímeros – Foz do Iguaçu, PR – Outubro/2009.

Maria D. and Cincu, C. "The plasticizer action on the Physic-Mechanical craracteristics of thermoplastic ionic elastomers based on maleinized ethylene-propylene terpolymer" U. P. B. Sci. Bull.series B, Vol. 68, no. 4, 2006.

Nugraha, E., Suyatma, Tighazert, L. and Copinet, A. "Effects of hydrophilic plasticizers on mechanical, thermal, and surface properties of Chitosan films" Journal of agricultural and food chemistry. 2005.

Pavlidou, E., Bikiaris, D., Vassiliou, A., Chiotelli, M. and Karayannidis, G. "Mechanical properties and morphological examination of isotactic polypropylene/SiO2 nanocomposites containing PP-g-MA as compatibilizer" Journal of physics conference series 10. 2005.

Rahman, M. and Brazel, C. "The plasticizer market: an assessment of traditional plasticizers and research trends to meet new challenges" Elsevier Ltd. 2004. www.elsevier.com/locate/ppolysci.

Ritchie, R. J. "Universal chlorophyll equations for estimating chlorophylls *a*, *b*, *c*, and *d* and total chlorophylls in natural assemblages of photosynthetic organisms using acetone, methanol, or ethanol solvents" PHOTOSYNTHETICA 46 (1): 115-126, 2008.

Xinping, H. and Kok S. "Mechanical properties and ionic conductivities of plasticized polymer electrolytes based on ABS/PMMA blend" Elsevier Ltd. 2000. www.elsevier.nl/locate/polymer.