

Study Mechanical Properties of Low Density Polyethylene / Luffa Composite.

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Abstract

The Mechanical properties of (LDPE-463): luffa composite was assessed with respect to the effect of filler content luffa varying from 2.5% to 25% by weight in the composite. Obvious improvement in the mechanical parameters was recorded when adding luffa with 2.5% weight ratio. The mechanical properties of loaded film have been evaluated through several parameters concerning the elastic deformation based on measuring the load – elongation characteristics. The behavior of the stress - strain curve was analyzed in terms of the cold drawing model. Experimental difficulties appeared above 5% mixing ratio, and these difficulties were due to the separation in phase which makes the sample processing impossible. Experimental results showed that elastic behavior increased with increasing luffa filler up to 2.5 % concentration.

دراسة الخواص الميكانيكية لخليط (بوليمر الاثيلين واطى الكثافة/ الليف)

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المستخلص

تم في هذا البحث تقييم الخواص الميكانيكية للخليط البوليمري (بوليمر الاثيلين واطى الكثافة 463 / الليف) كداله الى نسبة المضاف الوزنيه والتي تمتد ما بين (% 2.5 إلى 25%) وعند حجم دقيقة مساوي او اقل من (212<) مايكرومتر حيث تمت الدراسة من خلال عدة متغيرات بالاعتماد على منحنى الإجهاد – المطاوعة وبيئت النتائج المستحصله ان الياف الليف المضافة تعمل على تباعد السلاسل البوليمرية مما يعكس إمكانية البوليمر الضعيفة بتحمل الإجهاد المسلط عليه وان منحنى (الإجهاد- المطاوعة) من النوع السحب البارد للحالة النقية وان درجة التجانس عالية بين كل من البوليمر المضيف والحشوات المضافة وان نسبة الاستطالة في هذا البوليمر تتناقص بصورة تدريجية مع زيادة النسبة المئوية للملئيات وتشهد الاستطالة نقصانا كبيرا في القيم عند النسب العالية من المضاف وأشارت النتائج أيضا على ان قوة الشد عند القطع وقوة الشد عند الوهن تنخفض مع زيادة نسبة المضاف مما يعكس الانخفاض في مرونة البوليمر المطعم بالليف.

Keywords: Mechanical Properties, Low density polyethylene, Luffa, stress - strain curve.

Introduction

A number of additives had added to the polymer to serve different industrial requirements. Among of these are lubricants , antioxidant, anti blocking agent, slip agent , antistatic ,stabilizer ,color compounds ,foaming agent and fillers (1,2) . The term filler is very broad and encompasses a very wide range of materials including a variety of solid particulate materials (inorganic, organic) that may be irregular, acicular, fibrous or plate-like in shape and which are used in reasonably large volume loadings in plastics(3). Traditionally, fillers are considered as additives, which, due to their unfavorable geometrical features, surface area or surface chemical composition, could only moderately increase the modulus of the polymer, while strength (tensile, flexural) remained unchanged or even decreased. Their major contribution is in lowering the cost of materials by replacing the more expensive polymer; other possible economic advantages are faster molding cycles as a result of increased thermal conductivity and fewer rejected parts due to war page. Depending on the type of filler, other polymer properties could be affected; for example, melt viscosity could be significantly increased through the incorporation of fibrous materials. On the other hand, mold shrinkage and thermal expansion would be reduced, a common effect of most inorganic fillers. Almost 85% of polymers produced worldwide are thermoplastics (4-5). Thermoplastic resins, such as polypropylene, polystyrene, polyvinyl chloride and polyethylene, are softened when heated and harden when cooled. These characteristics allow other filler to be mixed with the plastics to form composite product. The product can be easily processed into various shapes and can be recycled(6).

The physical properties of LDPE behind its potential mechanical properties are candidate its utilization in different applications compared to others. Polyethylene is exposed to oxidation and suffered from thermal degradation when exposed to heat, so adding some additives such as 2, 6-di-t- butyl- 1- Para cresol is important to save the color and that flow throw the storage and production. Calcium silicate was commonly used as anti adhesion, where fat acid amine was observed to reduce the friction between the contact thin layer of the polymer and work as anti lubricant. Waxes works as surface modifiers in a number of polymers that have limited ability, which causes them to migrate to the surface, where their activity is needed(7).

The additives may not only alter mechanical properties, but also affect other properties such as dielectric, optical, thermal etc. Previous study (8) showed that adding carbon black to LDPE will increase its conductivity to reach the semi conducting limits. The additive affected mechanical parameters such as tensile strength and rigidity modulus. In this case the important of compatibility is



needed to decide the required filler concentration to serve for a certain application. In the present investigation, mechanical properties of (LDPE: Luffa) have been investigated for different Luffa weight percentage (2.5%-25%). Parameters such as tensile strength(σ_M), tensile strain (ϵ_M), tensile stress at break(σ_B), tensile strain at break (ϵ_B), tensile strain at yield(ϵ_y) and Young's modulus(Y) have been measured at room temperature. The results were analyzed based on (stress - strain) relationship and microscopic analysis is used to interpret the physical behavior.

Experimental Procedure

Additive-free LDPE (SCILEN 22004) grade supplies from the state company for the petrochemical industry (SCPI) of (MI=0. 39 GM/10min.) and (density = 0.922 GM/cc). The Luffa is obtained from local market Figure (1). The average Luffa particle size used in this work is (<212) μm . Six concentrations of luffa particles (2.5, 5, 10, 15, 20 and 25 weight%) are used in the LDPE compounds. Luffa as a fine powder is mixed with LDPE using Rheomix mixer 600 instruments attached to the Haake Rheochard meter with the following conditions; mixing time 15 min; mixing temperature 160°C ; mixing velocity 32 RPM. After that the final mold product is introduced in a laboratory compress under 5 tons at 175°C for 3 minutes in a square frame where the pressure rises gradually up to 15 tons for a (6) minutes and after this period the sample sheet is cooled up to reach room temperature . This sheet of final product is used to prepare Samples dumbbell in shape for measuring the mechanical properties by using Instron instrument Zwick/Roel type [BT1-FR2.5 TN.D14] with the following conditions; chart speed (10) mm/min., crosshead speed 50 mm/min. The test specimen is positioned vertically in the grips of device then the grips are tightened evenly and firmly to prevent any slippage. The relationship between elongation and load is obtained directly from the instrument. All measurements are made according to [ASTM D638 2008] (9).



Figure 1: Photograph of luffa.

To measure the tensile strength of a polymer sample, we usually stretch it using an Instron machine. This machine simply clamps each end of the sample and stretches the sample. It measures the amount of strength (σ) of force (F) it is exerting. When we know the force being exerted on the sample, we then divide that number by the cross-sectional area (A) of our sample. The answer is the stress that our sample is experiencing by increasing the amount of force, and stress naturally, on the sample until it breaks. The stress needed to break the sample is the tensile strength of the material. Tensile strain is a type of deformation where the sample deforms by stretching, and becomes longer, we call this Tensile strain. Usually we talk about percent Tensile strain, which is just the length the polymer sample is after it is stretched (L), divided by the original length of the sample (L₀), and then multiplied by 100(10,11).

$$\sigma = F / A \dots\dots\dots(1)$$

$$\text{Tensile strain \%} = \frac{L - L_0}{L_0} \times 100 \dots\dots(2)$$

$$(\text{Young's modulus}) Y = \text{stress/strain} \dots\dots(3)$$

To measure tensile modulus, we do the same thing as we did to measure strength and ultimate elongation. This time we measure the stress we're exerting on the material, just like we did when we measured tensile strength. We slowly increase the amount of stress, and then we measure the elongation the sample undergoes at each stress level. We keep doing this until the sample breaks. Then we make a plot of stress versus elongation.

This plot is called a stress-strain curve. (Strain is any kind of deformation, including elongation. Elongation is the word we use if we're talking specifically about tensile strain.) The height of the curve when the sample breaks are the tensile strength, of course, and the tensile modulus is the slope of this plot. That plot of stress versus strain can give us another very valuable piece of information.

Results and Discussion

The basic characteristics of mechanical properties of solid are usually determined by testing resulting in various deformations versus dependencies, such as stress-strain diagram (12). Tensile test is widely used for measuring stiffness, strength and ductility of the polymer. Stress-strain relationship in polymers is considered as complex dependencies, and is not linear in nature. Tensile characteristics (tensile strength(σ_M), tensile strain (ϵ_M), tensile stress at break(σ_B), tensile strain at break (ϵ_B), tensile strain at yield(ϵ_y) and Young's



modulus(Y)) have been determined from the stress-strain curve. Figure (2) and table 1. Shows the (stress - strain) curve of LDPE loaded with luffa percentage measured at a constant rate loading at room temperature. Stress- strain curve has been dependent in description instead of load-elongation curve because it describes the material characteristics and is less dependent on the arbitrary choice of specimen profile. It's well known that polyethylene belongs to (soft & tough polymer) where this behavior has characterized with low modulus and low yield stress. According to the break down classification, the stress-strain curve is exemplifying the second behavior of the fracture nominally cold drawing (13). In this type three regions can be distinguished; first is the linear region, second is the yield region, third is the elongation region up to the break. In the first region, (linear region), where the deformation was not very large, Hook's Law is obeyed which characterized the instantaneous and recoverable deformation associated with the bending and stretching the interatomic bonds between the polymer atoms. Also there is no permanent displacement of molecules relative to others. Linear region can reflect the elastic limit region of the polymer, in which the uniform extension due to stress increased with a constant rate (14,15). One of the most important engineering parameter which reflects the material resistance against deformation, and should be measured before designing polymer is Young's modulus. Young's modulus can be estimated from the slope of the portion of the first region, which is found a higher for a sample with a higher extension rate. The variation of Young's modulus against luffa filler is shown in Figure (7) Young's modulus varied between 43.93 to 165.89 for luffa ratio between 2.5 - 25% respectively. This increment in young's modulus can referred to increase the resistance of material to deformation. The volume of the specimen remains constant during elastic deformation, so as the gauge length elongates, its cross-sectional area is progressively reduced. Mechanical properties are essentially depend upon the molecular behavior, includes chemical composition and physical structure. The nonlinearity in the stress-strain curve neither be caused by increasing free volume or heat specimen nor to be connected to the viscous flow. It can be related to the shear component of the applied stress(15). In the region confined between the proportionality limit and the yield point the deformation in this region is not stantaneously recoverable, but it's ultimately and can be characterized like straightening out of a coil portion of the molecular chains (16). The uncoiling mechanism is known as a relatively slow mechanism.

When the work hardening caused an insufficient increase in load to compensate the reduction in cross section, all further plastic deformation will be concentrated in a region where specimen undergo necking. This minimum was followed by increasing the elongation with a nearly fixed stress where the specimen is deforming no uniform ally at a certain specimen cross section. A



narrowing suddenly appears which then grows at the expense of the gradually diminishing initial thick part of the specimen. The final increasing of the stress at the high strain region was corresponding to the traveling the shoulder of the neck along the specimen (plastic instability) up to occurring the rupture. The transition to the horizontal part of the strain-stress diagram called a (neck). Each of stress & extension at break can be directly calculated from this region. The result of the tensile strength at yield and break of luffa particle: polyethylene composite are shown in figure (3&4) respectively. The tensile at break increases steadily up to 5% filler concentration; afterward it decreases gradually, it appears as a shoulder. Maximum tensile may be explained due to the perfect homogeneity of filler distribution in the polymer matrix.

Studied the mechanical properties of Low density polyethylene. Figure (5&6) shows the stress - strain curves of polymer composite with luffa as a filler. The curves appear the stress – strain value of pure polymer within normal value, and the Proportional limit is 15.9MPa, then decreasing this value reduced to 14.6 MPa. When add 2.5% of the filler and begin to decrease to 13.1 MPa, 13.1 MPa, 12.6 MPa, 11.9 MPa and 13.1 MPa when decreasing ratios fillings 5%, 10%, 15%, 20% and 25%.

The Interaction between the particles of cannabis and polymeric chains can be obtained in the extreme value at 5% thus the homogeneity of the polymeric network good and get the highest toughness value, this makes polymer resist impact and tension and these qualities make him the application of industrial. While the homogenization process between the polymer and the additive in 2.5% give brittle polymer without any plasticity, due to absence of ability of the polymeric chains slide with the of particles of filler and the increasing the percentage of filler to 10% also the slide between polymer and filler decreasing but the composite polymer appear some plasticity(17-22).

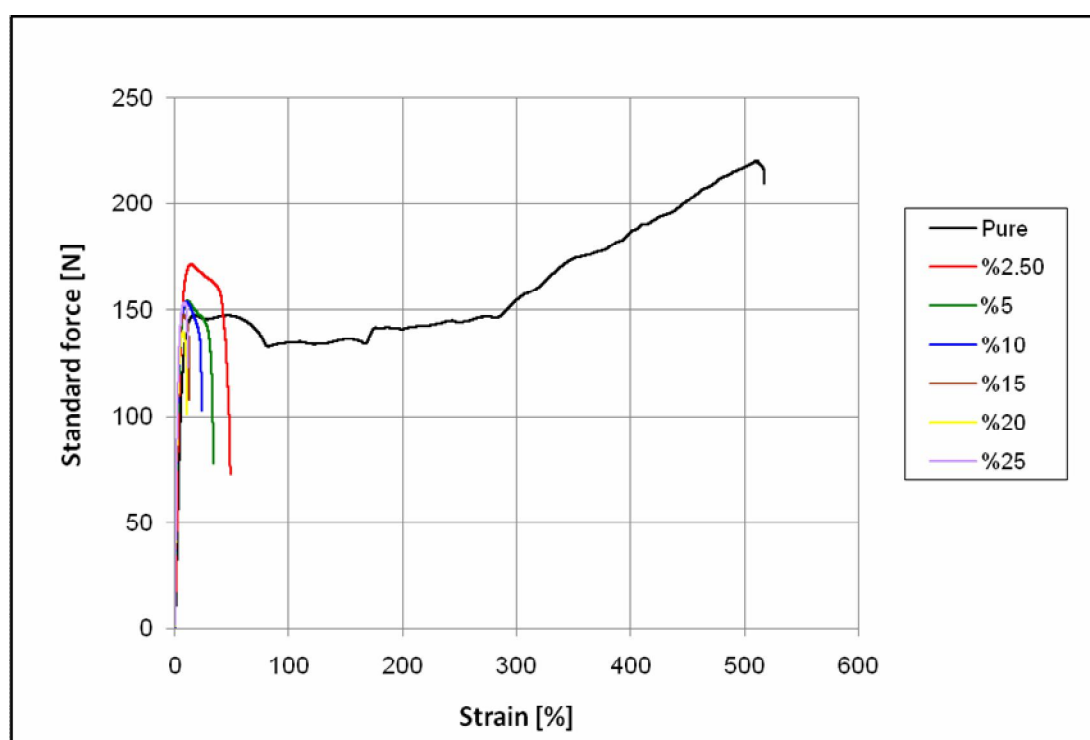
Table 1. Parameters of mechanical properties

Filler content (wt.%)	σ_M (MPa)	ϵ_M %	σ_B (MPa)	ϵ_B %	ϵ_y %
0	15.9	510.3	15.10	517.60	21.22
2.5	14.6	14.4	6.27	48.8	10.26
5	13.1	12.2	5.68	42.0	8.67
10	13.1	10.3	8.78	23.6	7.44
15	12.6	8.2	9.21	12.6	6.07
20	11.9	7.4	8.64	10.7	6.07
25	13.1	8.5	10.50	11.3	5.38



Table 2.Values of Young modulus

Filler content (wt.%)	Young modulus (Y)
0	4.27
2.5	43.93
5	59.14
10	86.58
15	148.46
20	164.52
25	165.89

**Figure 2: The stress - strain curves of polymer composite with luffa.**

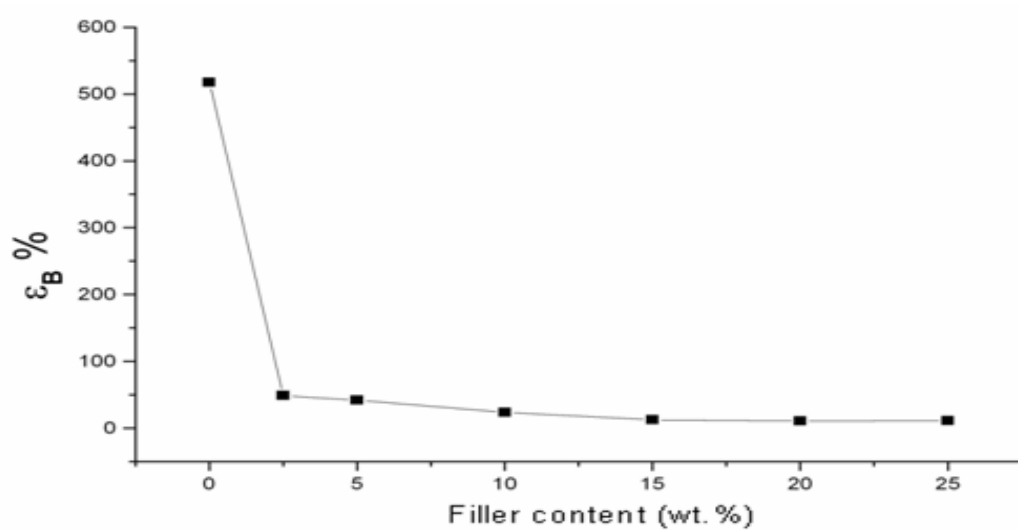


Figure 3: Variation between tensile strain at break and Filler content (wt.%).

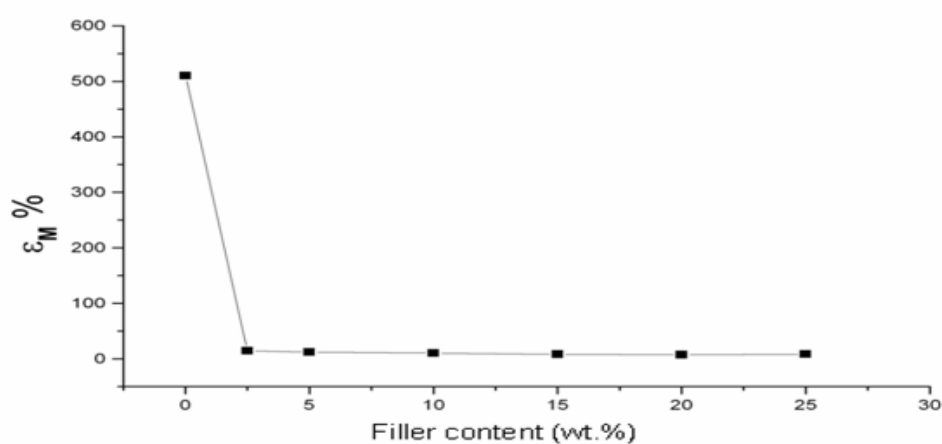


Figure 4: Variation between tensile strain and Filler content (wt.%).

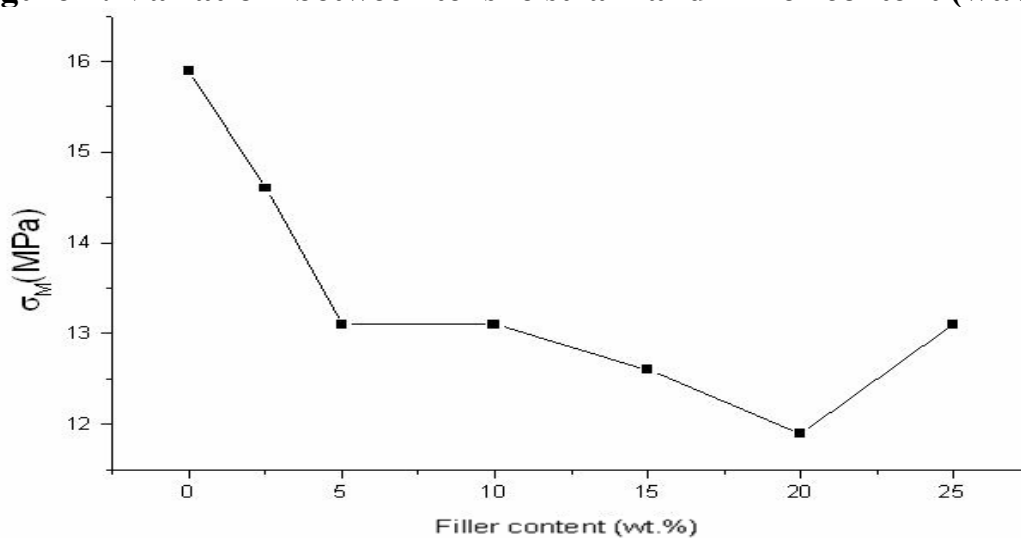
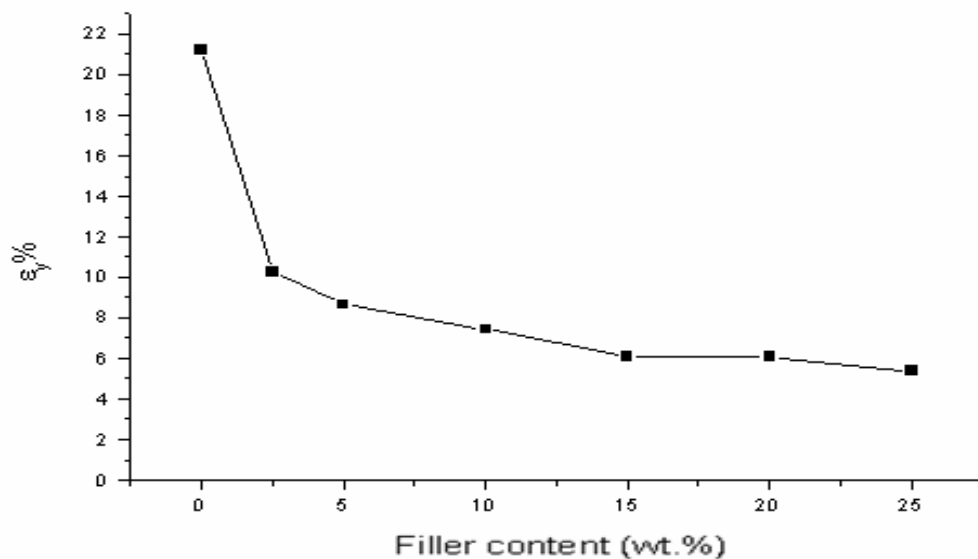
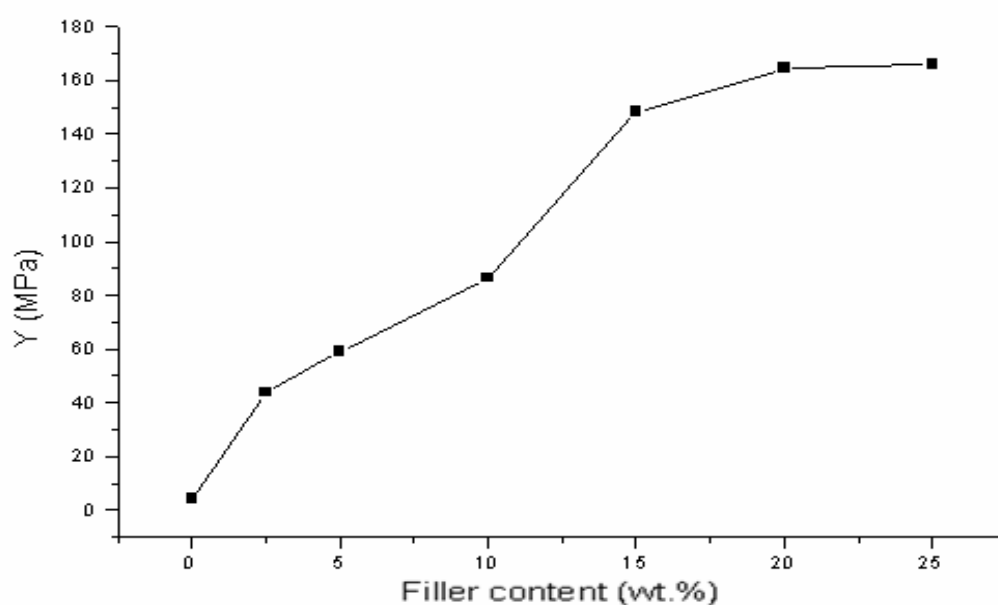


Figure 5: Variation between Tensile strength and Filler content (wt.%).**Fig 6. Variation between tensile strain at yield and Filler content (wt.%)****Figure 7: Variation between Young Modules and Filler content (wt.%).**

Conclusion

Mechanical properties of low density polyethylene were not improved by adding (luffa) with different weight percentage. Polymer phase was diluted by stiffer material (luffa). This is interpreted the weekend observed in mechanical properties above 5% percentage. Accordingly, LDPE with 2.5% luffa is recommended for industrial applications.

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Figure 8: Tensile test of the specimens was carried out with a Zwick/Roel type [BT1-FR2.5 TN.D14]



Figure 9: Hydraulic press.