EXPERIMENTĂRI PRIVIND PROPRIETĂŢILE MECANICE ALE UNEI ECO-RĂŞINI BAZATĂ PE DAMMAR PENTRU OBŢINEREA UNOR MATERIALE COMPOZITE

EXPERIMENTS REGARDING THE MECHANICAL PROPERTIES OF AN ECO-RESIN BASED ON DAMMAR FOR OBTAINING SOME COMPOSITE MATERIALS

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In this paper the mechanical characteristics of a new gree resin, with and without natural reinforcement are presented. In the fist part of the investigation, from the tensile test, some mechanical characteristics are determined, such as: breaking strength, elongation at break, Poisson ratio, static Young modulus and tensile stiffness. A representative image with the samples breaking section using the scanning electron microscopy analysis has been presented. Then, from the free vibrations recording by clamping the bar at one end and leaving it free at the other, the damping factor per unit mass, per unit length, the dynamic flexural stiffness, dynamic Young modulus and the loss factor are determined. Using the thermogravimetric analysis (TGA), the thermal stability of the studied resin is investigated. In the las part of the study, some green composites by using the poposed resin reinforced with wheat straw fibers are manufactured. It has been found out that the proposed eco-resin reinforced with wheat straw has incresed mechanical properties compared to other eco-resins from the engineering literature such as: soy based resins (reinforced with cotton, jute, flax, kenaf, hennequen or hemp), polylactic acid resin reinforced with wheat straw and so on.

În această lucrare sunt prezentate prorpetăţile mecanice ale unei răşini verzi noi, cu şi fără ranforsant. În prima parte a investigaţiilor, din încercarea la tracţiune sunt determinate caracteristici mecanice precum: rezistenţa la rupere, alungirea la rupere, coeficientul lui Poisson, modulul de elasticitate static şi rigiditatea la tracţiune. A fost prezentată şi o imagine reprezentativă cu secţiunea de rupere a epruvetelor folosind microscopia electronică de baleiaj. Apoi, din înregistrarea vibraţiilor libere prin încastrarea barei la un capăt şi lăsarea acesteia liberă la celălalt, sunt determinate factorul de amortizare pe unitatea de masă, pe unitatea de lungime, rigiditatea dinamică la încovoiere, modulul lui Young dinamic şi factorul de pierdere a energiei. Folosind analiza termogravimetrică TGA, s-a investigat stabilitatea termică a răşinii. În ultima parte a studiului, s-au fabricat câteva compozite verzi folosind răşina propusă ranforsată cu paie de grâu. S-a descoperit că eco-răşina propusă ranforsată cu paie de grâu are proprietăţi mecanice mărite în comparaţie cu alte eco-răşini din literatura de specialitate, cum ar fi: răşini pe bază de soia (ranforsate cu bumbac, iută, in, kenaf, henequen sau cânepă), răşină din acid polilactic ranforsată cu paie de grâu, etc.

Keywords: *green composite, green resin, static behaviour, dynamic behaviour, wheat straw*

1. Introduction

The tendency to develop eco-composites or green composites has appeared and increased because the synthetic based materials have adverse negative effects on the environment, such as: emissions during incineration, entrapment and ingestion by fish, fowl or other animals and so on. Another explanation of the growing usage of green composites is the exhaustion of the petroleum-based ones, which increases year after year. In the category of eco-composites enter both composite materials combined from petroleum and bio resources and 100% biobased materials. The mostly used reinforcements for the eco-composites are: flax, corn stalk, coir, hemp, pineapple leaf fiber, wood, grasses, jute, sisal, reed, bulrush, kenaf, coconut, kapok, bananas, henequen, chicken feathers, abaca, rice straws, wheat straws, corn straws, bamboo fibers, switch and elephant grass, and so on [1]. Usually, these fibers are combined with synthetic resins such as: epoxy, ambresit or polyester resins. Using natural fibers for composites reinforcement has more advantages, for example: relative low cost, nature abundance, lightweight, few damages to manufacturing equipments, finishing improved surface of castings (in comparison with glass fibre composites), acceptable, mechanical properties, low density, and ease of separation. The

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disadvantages of using natural fibers is that the tensile strengths, static Young modulus or other mechanical properties are lower than the E-glass fibers usually used in building composites [1]. Some mechanical properties like tensile strength, Young modulus and elongation at break for several natural and synthetic fibers are presented in [1-3]. The chemical composition for several natural fibers can be found in [1], [3], [4] or [5]. Natural resins can be divided in some important groups in this way: vegetal resins (such as, Sandarac, Mastic, Copal, Dammar, Desert Shrub or Dragon's blood [6]), fossil resins (for example, Amber), or of animal origin (for example, Shellac). As usage, these can be included in different domains, as: Mastic – in medicine because it contains anti-oxygens, Sandarac is used as perfumes ingredient, Shellac is used at finishing wood objects as finishing varnishes, Amber at jewels, etc. Natural resins are water insoluble, but are slightly soluble in oil, alcohol and partially in gasoline. With certain organic solvents they form usable solutions as finishing varnishes. The Turpentine, Colophony, Mastic are created after refining pine resins. The main disadvantage of these resins is that they harden in a long time (between 6 and 12 months). This fact narrows their usability range in engineering. Other important biopolymers can be [7,8]: modified polyethylene tetraphalate, polyhydroxyalkanoates, polyhydroxybutyrate, polyhydroxybutyrate-valerate copolymer, polylactic acid, polylactic acid aliphatic copolymer and starch composites.

Resins hybridize for part of the biopolymer category and involve a combination of two basic constituents: one organic and one inorganic. Most are such resins that are found in the coating industry characterized by natural resin dissolved in alcohol, oil or turpentine [9 - 14]. These lakes have been used since medieval times by people in order to beautify and to protect paintings, musical instruments or pieces of furniture.

Researches based on the study of dammar resin are known. Dammar resin is obtained from the Dipterocarpaceae family of trees in East Asia, especially India, through small incisions made on trees. Both resin and trees are used in making paper, wood varnishes or paintings [15]. The polymeric component of the dammar is called polycaninene [16]. The alcohol-insoluble part of the dammar is called β-resene, and the soluble part α-resene. It also contains a small amount of sesquiterpenoid (C15) [17]. The resin contains mostly compounds from the Dammarane tetracyclic skeleton, to which are added pentacyclic derivatives of oleanane, ursane and hopane.

In [18], 3 comparative pyrolysis methods used to characterize the dammar resin extracted from fossils are presented. The following methods were used: flash pyrolysis, open isothermal furnace pyrolysis and closed isothermal pyrolysis. It was found that the pyrolysis obtained by the first two methods is identical, and by the third composition was dominated by reaction by-products, similar to the natural ones of crude oils, partially derived from the fossils of dammar resins.

In [19], natural resins from sandarac, copal, rosin, mastic and dammar dissolved in alcohol, oil and turpentine were used. The samples were irradiated by artificial light rays and analyzed with the FT-IR (Fourier Transform Infrared) method. Through this study it was understood and followed the evolution of the characteristic absorption bands in order to differentiate the types of varnishes by FT-IR analysis. The kinetics and evolution of the composition of lakes during photo-aging were studied. Through photo degradation it was found the loss of some characteristics of the absorption bands but also the appearance of new ones.

The antioxidant properties of some natural resins have been investigated in [20]. Dammar resin has been found to increase the rate of oxidation of sunflower oil regardless of the concentration used.

Spectral decomposition and multivariate analysis by FT-Raman (Fourier Transform Raman) and FR-IT (Fourier Transform Infrared) were undertaken in [21]. PCA (Principal Component Analysis) studies have been performed, a method that aims to recognize the material or identify a component of a mixture. The two main components abbreviated to PC1 and PC2 have been identified. PC1 close to 0 and negative PC2 with -3 were obtained for dammar. The positions of the 10 decomposition Raman bands for several natural and organic substances, including dammar and sandarac, were also presented in the same study.

It is known that the dammar resin is used as a component in some medicines. In this regard, in [22] a study is performed on the continuous delivery of the drug atenolol made of cross-linked dammar gum with biodegradable hydrogel composites based on polyacrylamide and zirconium. The crosslinking process was successfully synthesized, obtaining better properties for the polyacrylamide dammar gum, which was explained by the presence of an inorganic component in the zirconium mixture. The properties of the hydrogel (dammar gum combined with zirconium iododalate) are analyzed [23-25]. Samples were prepared by incorporating inorganic zirconium precipitates into a polymeric mixture under vacuum conditions. Morphology and structure were studied using techniques FTIR (Fourier transform infrared spectroscopy), SEM (Scanning Electron Microscopy) with EDS (Energy dispersive Spectroscopy).

In [26], samples of the red fruit resin of the "dragon's blood" palm mixed with an excipient, dammar gum, to obtain a solid substance were studied. Dammar gum has been found to protect

the active components in the sample created from moisture and oxygen, thus prolonging the shelf life of the product.

The original contribution of the authors is creating a new eco-resin, based on dammar resin, which is biodegradable. The natural resin dammar was diluted by turpentine, and if it was kept in closed containers, it stayed in a liquid state. The disadvantage lies in that the process of resin hardening is very long, even if it is applied in thin layers. This shortcoming was eliminated by adding a reduced proportion of synthetic resin, together with its associated hardener, to generate points of quick activation of the polymerization process. The casting temperature for the eco-resin and for the eco-composite (dammar resin + wheat straw) was of 21-23^{0}C. For this new created eco-resin, the static and dynamic characteristics have been determined. In the end, an eco-composite has been created, using this type of resin and wheat straw as reinforcement.

2. Static behaviour of the samples made from the proposed eco-resin

The natural resin dammar was diluted by turpentine, and if it was kept in closed containers, it stayed in a liquid state. This composition was used for painting (varnish) protection. The disadvantage lies in that the process of resin hardening is very long, even if it is applied in thin layers. In order to reduce the curing time of the resin, a small quantity of classical epoxy has been inserted in the samples composition (40% epoxy resin Resoltech 1050 with its hardener Resoltech 1055) in order to generate points of quick activation of the polymerization process. The samples manufacture was at the temperature of 21-23^{0}C with a hardening time of 7 days. The samples were obtained by hand lay-up technique casting.

Six samples have been built with this resin, with the mass between 22-23 g, having the next geometrical dimensions: 200x25x4.3 (length, width and thickness). These samples are presented in Fig. 1. A Walter Bai universal testing machine, with the maximum force of 300 kN, was used for the tensile test. The Poisson ratio was measured with an extensometer. The stress strain curve, for a representative sample, is presented in Fig. 2.

For these samples, the next mechanical characteristics were obtained:

- the breaking strength has values between 26 and 29,5 MPa, with the arithmetic mean value of 26.833 ± 1.438 MPa;
- the static Young modulus has values between 1760 and 1812 MPa, with the arithmetic mean value of 1787 ± 23.1 MPa;
- the Poisson ratio has values between 0.48 and 0.5, with the arithmetic mean value of 0.49 ± 0.01;
- the elongation at break has values between 1.1 and 1.4%, with the arithmetic mean value of 1.233 ± 0.137;
- the tensile stiffness has values between $1.892 \cdot 10^5$ and $1.948 \cdot 10^5$N, with the arithmetic mean value of $1.921 \cdot 10^5 \pm 2483$.

Important remark: the $\pm$ values presented above are the standard deviation results, obtained for the six tested samples.

In Fig. 3.a there is presented a representative scanning electronic microscopy (SEM) image, with one of the samples breaking section. In Fig. 3.b. there is presented the breaking section area for the representative sample taken with a stereomicroscope. It was noticed that the sample fracture is brittle and no deformations appeard before the breakage; this result was expected because a low elongation at break was observed from Fig. 2 (around 1.23%). By analyzing the Fig. 3, there weren't any air bubbles in the samples studied section. This means that the hardening reaction (which produces bubbles during the polymerization process) took place completely, with the release of all air bubbles through the plates upper surface.

Fig. 1 . A general view with the samples made from the green resin / *O vedere generală cu epruvetele realizate din rășina verde.*

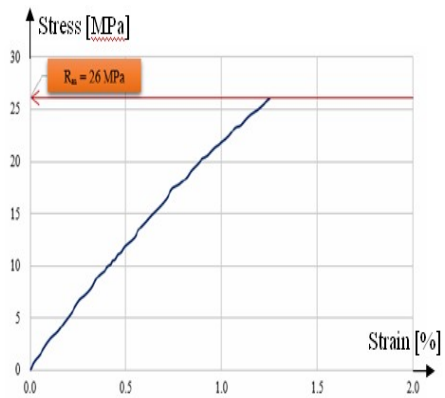

Fig. 2. The stress-strain curve for a representative sample/*Curba tensiune-deformaţie pentru o epruvetă reprezentativă.*

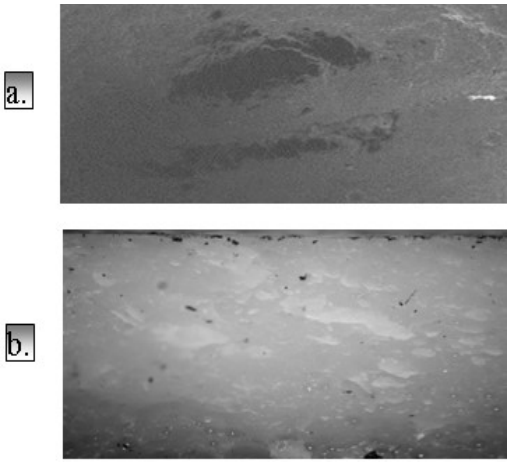

Fig. 3 - The breaking section for a representative sample/ *Secţiunea de rupere pentru o epruvetă reprezentativă.*

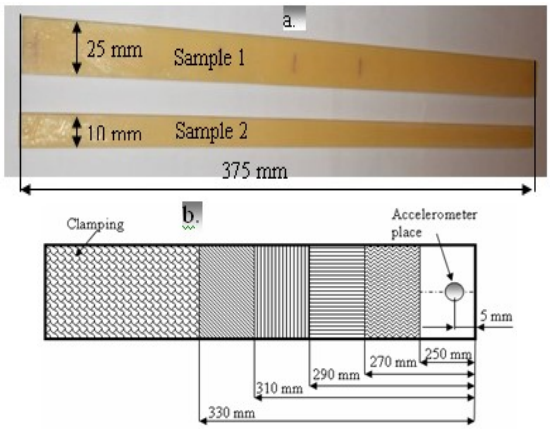

Fig. 4. – The samples used for dynamic loading/ *Epruvetele folosite pentru solicitarea dinamică.*

3. Dynamic behaviour of the samples made from the proposed eco-resin

Some samples with the geometrical characteristics presented in Fig. 4 have been built.The samples have a thickness of 4 mm. The samples were clamped at one end and were left free at the other end where an accelerometer was placed to record the samples free vibrations. An initial force was applied to the bar to deform it, the force was then remoed and the bar was left to freelz vibrate. A similar experimental montage was used by the authors before in [27,28], where good results for the vibrations recordings have been obtained. There were used several samples free lengths for the samples: 330, 310, 290, 270 and 250 mm. From the free vibrations recordings, like in [27,28], the samples damping factor per unit mass and the eigenfrequency was determined.

The experimental recording with the damping factor and the eingenfrequency calculus, for the sample 1 with the 330 mm free length, are presented in Fig. 5.

The dynamic elasticity modulus is 2210 ± 45.069 MPa for sample 1 and 2051 ±16.423 MPa for sample 2. If an arithmetic mean from the mean values of the experimental results was made, the 2130.5 MPa value was obtained. The flexural stiffness was 0.29 ± 0.06 Nm^2 for sample 1 and 0.13 ± 0.007 Nm^2 for sample 2. The loss factor was 0.055 ± 0.003 for sample 1 and 0.047 ± 0.002 for sample 2. All the dynamic values are presented in Fig. 6.

Important remark: the ± values presented above are the standard deviation results, obtained from the free lengths five values (330, 310, 290, 270 and 250 mm).

$$v_\xi = T^{-1};\ \omega \approx 6.2831853 \cdot T^{-1};\ \mu = \Phi^{-1} \cdot T^{-1} \cdot \ln(b_i \cdot b_{i+\Phi}^{-1});$$

$$C = 2 \cdot \Phi^{-1} \cdot T^{-1} \cdot \ln(b_i \cdot b_{i+\Phi}^{-1}) \cdot \rho \cdot A;\ \eta = \frac{1}{\pi} \cdot \frac{\mu}{v_\xi}; \quad (1)$$

$$E = \frac{12 \cdot \rho \cdot l^4 \cdot v_\xi^2}{\lambda_\xi^2 \cdot g^2};\ v_\xi \approx 0{,}1591549 \frac{(EI)^{0,5} \cdot \alpha_\xi}{(\rho A)^{0,5} \cdot l^2} \quad (2)$$

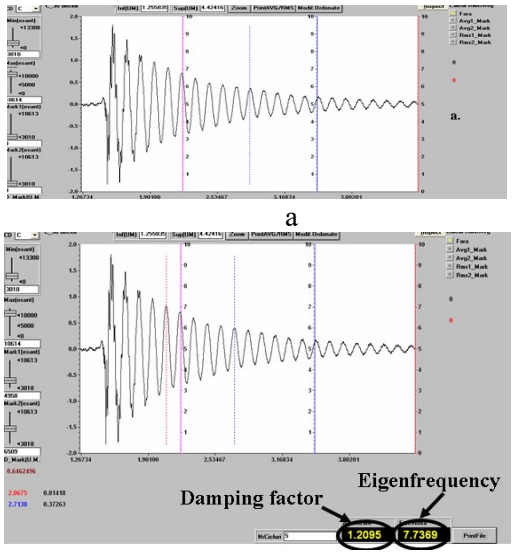

Fig. 5. - a Free vibrations experimental recording for the sample 1, with the 330 mm free length; b. The eigenfrequency and damping factor calculus for 5 cycles. / *a. Înregistrarea vibraţiilor libere pentru epruveta 1, cu lungimea liberă de 330 mm; b. Calculul frecvenţei proprii şi a factorului de amortizare pentru 5 cicluri*

In the relationships (1) and (2) there are marked the next parameters: v is the eigen frequency, T is the time inverval between two consecutive cancellations, ω is the pulsation, μ and C are the damping factors per unit mass and length, ρ·A is the specific mass, η is the loss factor, b_i and $b_{i+\Phi}$ are maximums separated by Φ periods, ξ is the eigen mode number (equal to 1 for this research), λ= 0,5596 - a constant for the first eigen mode, α is a constant for the strips end conditions equal to 1.875.

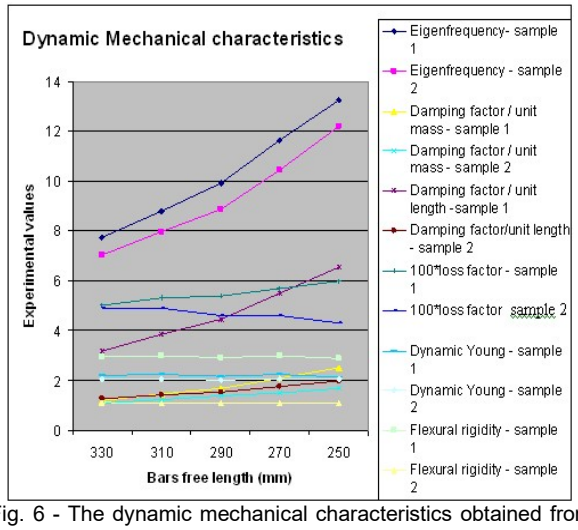

Fig. 6 - The dynamic mechanical characteristics obtained from the tested samples / *Caracteristicile mecanice dinamice obţinute din epruvetele testate.*

4. Thermal stability of a sample made from the green hybrid resin

The thermal stability can be determined through the thermogravimetrical analysis (TGA). So, for this, a sample was heated up at a chosen temperature (800^{0}C in this research with ramps of 10^{0}C/min because it was considered that above this value, no significant changes will happen; the experiment shows the weight loss at high temperatures) and the weight change is investigated. A TGA Q 50 connected to a desktop which can heat up a sample up to 1000^{0}C was used. After the experiment, the air was cooled within 20 minutes. The gas used in this experiment is nitrogen with purity 5.0. From the samples made with dammar, a sample was collected with the mass of 0.63 mg and it was turned into small pieces with the cutting blade of a scissor (Fig. 7) and we loaded it into the apparatus pan made from platinum. The weight loss obtained from the experimental data, versus the temperature and the time of experiment is presented in Fig. 8. The TGA Q 50 has software for experimental data analysis called Universal Analysis 2000, which furnishes the weight loss at certain temperature values, presented in Fig. 7.b and 8.a,b.

Five stages of decomposition were shown by thermogravimetry analysis of resin:

- a weight loss of 0.03540%·min/^{0}C from 39^0 up to 219,6^0, with a peak value to 95.20^{0}C; this case mostly appears due to water parts evaporation that compound the resin; we somehow expected this result because in natural resins there is water, so at around 100^{0}C there should have been a weight loss because of water parts evaporation
- a weight loss of 0.1945% ·min/^{0}C up to 300^{0}C with a peak value at 247.94^{0}C; there remain residue values from epoxy and dammar resins;

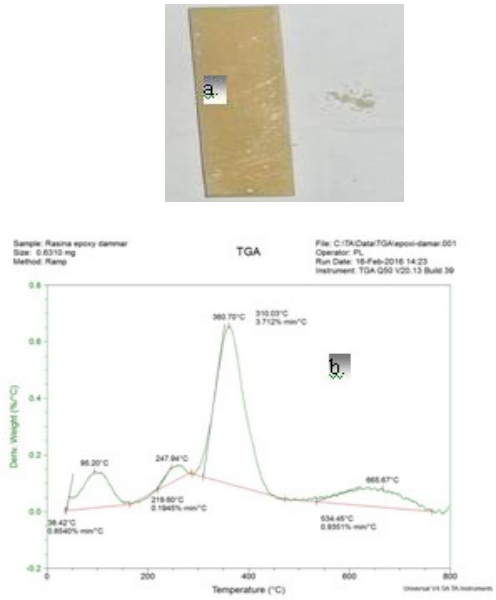

Fig. 7 - a Cutting small pieces from the sample to load them in the platinum pan; b. Weight loss at certain temperature values / *a. Tăierea unor bucăţi mici din epruvete pentru încărcarea lor în pan-ul de platină; b. Pierderea de masă la anumite valori de temperatură.*

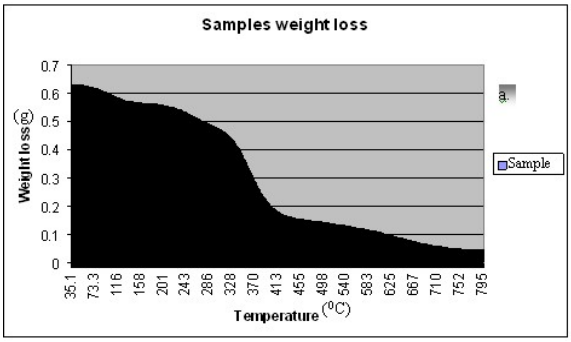

Fig. 8 - a The weight loss versus heating temperature; b. weight loss versus time of experiment / *a. Pierderea de masă versus temperatura de încălzire; b. pierderea de masă versus timpul de experiment*

- a weight loss of 3.712% ·min/^{0}C up to around 534^{0}C, with a peak value at 360.7^{0}C; there remain residue values from epoxy and dammar resins;
- a weight loss of 0.9351%·min/^{0}C up to around 795^{0}C, with a peak value at 665.67^{0}C;
- from 795 to 800^{0}C, no concluding changes are observed.

5. Static behaviour of a green composite with the proposed hybrid resin reinforced with wheat straw

In this part of the study, a green composite was created from the dammar-based resin reinforced with wheat straw, with the mass between 16-16.5 g, with the next geometrical dimensions: 200x25x5 mm (length, width and thickness). These samples are presented in Fig. 10. A Walter Bai universal testing machine, with the maximum force of 300 kN, was used for the tensile test. The stress strain curve, for a representative sample, is presented in Fig. 11.

Important remark: the ± values presented above are the standard deviation results, obtained for the six tested samples. A representative SEM image with one of the eco-samples breaking sections is presented in Fig. 9.b and with a stereomicroscope in Fig. 9.a. It was noticed that the resin had a brittle fracture, but the wheat straw fibers suffered a deformation before breaking so they had a ductile fracture.

If an analithycal validation is made, then the samples elasticity modulus is determined with (3), where E_m, E_f are the matrix and fibers Young modulus and V_m, V_f are the matrix and fiber volume fraction. The reinforcement is placed only in the longitudinal samples direction. In the engineering literature, the E_f parameter has different values, because it depends on the wheat straw type, moisture, celulare structure, stalk diameter, maturity, and so on [29]. Therefore, from [30] E_{f13} = 6066 MPa and from [31-34] E_{f14}= 6580 MPa. The errors are written in Table 1 and we can see that, for certain values the errors are very small (under 6%). For the samples, the matrix volume fraction is 0.35 and the fiber volume fraction is 0.65. These values were obtained by weighing, at the beginning of the manufacturing process, the resin with its hardener and the wheat straw. The green composite was casted in a mold with the dimensions of 220x320 mm. After casting, an uniform pressure of 2,44 N/cm^2 was applied to press the plate. After 7 days, the final plate was removed from the mold and the samples from Fig. 10 were cut from it.

$$E = E_m V_m + E_f V_f \quad (3)$$

The errors from the Table 1, which are not too high, can be explained by the fact that, beside the elasticity modulus value which oscillates and depends on many factors, the chemical composition and reaction between the wheat straw fibers and the dammar resin is unknown nowadays. For the tensile strength, there is taken into account the results from [13], because other researches regarding the wheat straw present only the tensile strength from bending loading or the shear stress. According to [30], the tensile strength can be determined with (4).

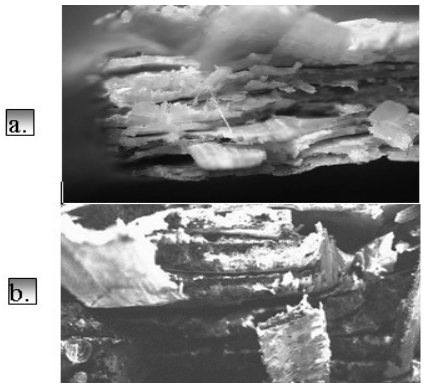

Fig. 9 - Images with the breaking section of a representative sample; a. steremicroscope , b. SEM / *Imagini cu secţiunea de rupere a unei epruvete reprezentative; a. stereomicroscop; b. SEM.*

Fig. 10 - A general view with the eco-composites/ *O vedere generală cu eco-compozitele.*

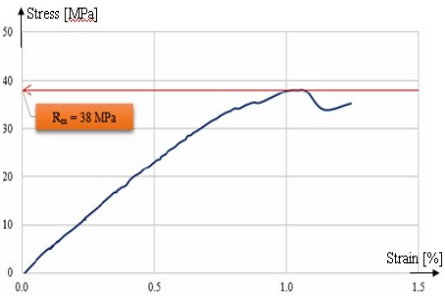

Fig. 11 - The stress-strain curve for a representative eco-composite sample / *Curba tensiune-deformaţie pentru o epruvetă reprezentativă din eco-compozit.*

Table 1

Experimental results of the elasticity modulus and errors compared to the experimental results/
Rezultatele experimentale ale modulului de elasticitate şi erorile comparate cu rezultatele experimentale

Sample	This paper	E_{f12} [30]	E_{f13} [31-34]
Young Modulus	5233	4568	4902
Error (%), related to this study value	0	12.708	6.325

Table 2

Mechanical characteristics for various green composites / *Caracteristici mecanice pentru compozite verzi variate*

Material	Tensile strength σ_r (MPa)	Tensile modulus E (MPa)	Poisson ratio ν	Elongation at break A (%)
Eco-resin (this study)	26.833	1787	0.49	1.233
Eco-composite (this study)	38.333	5233	0.49	1.167
Polylactic Acid (PLA) + 30% cotton [1]	30	6800	-	-
PLA + jute 40% [1]	100	9400	-	-
Soy-Based Resin (SBR) + 15% flax [1]	15	2000	-	-
SBR+15% kenaf [1]	19	2700	-	-
SBR + 15% hennequen	30	3000	-	-
SBR [1]	8.5	2000	-	-
SBR+15% hemp [1]	17.8	1500	-	-
SBR +30% hemp [1]	19.8	2100	-	-
PLA + 30% flax [1]	70	8400	-	-
PLA + 40% fax [1]	68	7200	-	-
PLA + 50% flax [1]	99	6000	-	-
PLA + 20% Wheat straw [35]	23.68	1470	-	-
PLA + 30% Wheat straw [35]	34.379	1990	-	-
Cellulose Acetate Butyrate (CAB) + Hemp [36]	98.1 ± 12.7	8500 ± 1.3	-	-
Cellulose Acetate Butyrate (CAB) + Sisal [36]	92.9 ± 9.3	5500 ± 0.5	-	-
Polylactide (PLLA) + hemp [36]	110.5 ± 27.2	11800 ± 4.2	-	-
Polylactide (PLLA) + sisal [36]	78.9 ± 14.7	7900 ± 0.5	-	-
Epoxy resin + 50% wheat straw [30]	43.3	4030	-	-
Dammar+epoxy resin (DER) + cotton/flax fibers [20]	74	5982	0.37	3.4
DER+silk/cotton [37]	43	3087	0.36	10.1
DER+cotton [37]	66	4134	0.24	8.9
DER+hemp [37]	75	6548	0.51	2.3

In (4) there were marked with σ_{rf} the fibers tensile strength and *c* was a factor that takes into account the probability that all the fibers used in the composite are perfectly aligned in the sample longitudinal plane. If c=1, the σ_r = 43.3 MPa (equal to the wheat fibers tensile strength value) and an error of 11.471% is obtained compared to the experimental result. If c=0.95 (around 5% of the fibers are not perfectly aligned with the longitudinal samples direction), the σ_r = 41.411 MPa and an error of 7.109% is obtained compared to the experimental result. In Table 2, the mechanical properties for the eco-composite studied in this paper were given (with a dammar-based resin reinforced with wheat straw) and the mechanical properties of other green composites, found in the literature.

$$\sigma_r = \sigma_{rf} \cdot \frac{E_m V_m + c \cdot E_f V_f}{E_m V_m + E_f V_f} \quad (4)$$

The poposed green composite from this research has acceptable properties compared to the other existing eco-composites, and can be used for the automotive industry to make interior parts for vehicles, like the examples in [36]: interior door panelling, door pannels, wind shield, dash board, spoilers, and so on. The comparison is made to see if the proposed green composite from this research can replace other materials already studied, from the mechanical properties point of view. By analyzing the Table 2, it can be seen that, in some cases, the proposed green composite has increased mechanical properties compared to other eco-resins from the engineering literature such as: soy based resins (reinforced with cotton, jute, flax, kenaf, hennequen or hemp), polylactic acid resin reinforced with wheat straw and so on. We think that our study has brought originality in the eco-composite materials field of research because in some previous researches it was stated that the dammar resin cannot be hardened (see for example [38]).

5. Conclusions

The added value of this study is creating an eco-resin or green resin and determining its mechanical characteristics like: tensile strength, elongation at break, Poisson ratio, static Young

modulus and tensile stiffness, the damping factor per unit mass, per unit length, the dynamic flexural stiffness, dynamic Young modulus and the loss factor, thermal stability with the thermogravimetric analysis; compared to other eco-resins, like the soy-based resin from [2], our poposed eco-resin has increased breaking strength and elasticity modulus.

The characteristic curves have three different domains: in the first domain, the loading is supported by both matrix and fibers, which assures the composite material cohesion and also the Hook law is checked, appearing a proportionality between stress and strains; in the second domain there appears a non-linearity in the characteristic curve because the tensile strength in the matrix is reached and it breaks in some points; in this domain the adhesion between the fibers and the matrix is lost and pluckings of reinforcement from the matrix appear; in the last domain there is almost a linearity between the stress and strain which suggests that the composite breakage is made when in the fibers is reached the tensile strength; the are some inflexion points until the samples breakage which show that not all the fibers were broken at the same time, a part of them broke in the same time and the loading is subjected by the remained fibers.

The damping factors analysis show that these factors must be experimentally determined for each type of material and sample, being difficult to deduce a quantitative correspondence with the parameters which influence the damping, directly or indirectly. The values of damping factors may depend on several features such as: sample dimensions, specific mass or the quantity of material from sample, elastic and damping properties of component materials. The sample width can influence the damping coefficient, by the fact that it determines the surface on which the air friction acts on the sample.

For their obtained dynamic mechanical properties (vibration damping, dynamic Young modulus, dynamic stiffness, loss factor), these types of composites may be used for: making reusable devices in order to mobilize fractures (making one-size-fits-all pieces that can be fixed afterwards by a self-adhesive bandage systems), making almost-environment-friendly parquet floors (in order to replace wood or PVC) making reusable formworks for some construction elements making almost-environment-friendly house and furniture decorations, and so on.

With the eco-resin a green composite (reinforced with wheat straw fibers) was created. For the samples reinforced with wheat straw the modulus of elasticity, the breaking strength, Poisson ratio and the elongation at break were determined experimentally, by tensile tests. Then by using the formula (3), the experimental results for the modulus of elasticity were checked. By taking into account the values from the engineering literature for the wheat straw modulus of elasticity, errors around 6.3% were obtained. By using the relationship (4), the breaking strength was approximated theoretically. An error of 7.1% compared to the experimental results was obtained.

Because the proposed composites are new, all the result presented in this paper are original.

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