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Study of mechanical properties behaviour of biodegradable blends based on wood adhesive, lactic acid, polyvinyl alcohol, and aloe Vera

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ABSTRACT

In this work, polymer blends of PVA and wood Adhesive with aloe Vera gel as antibacterial (germs-killing) were prepared by pouring the solvent and bonded with lactic acid to improve its properties. Mechanical properties were examined closely with the presence of aloe Vera gel and lactic acid into PVA /wood Adhesive polymer blends, while the lactic acid crosslinking promoted the formation of good polymer blends with anew behavior in comparison to those of the polymer blends without lactic acid and aloe Vera gel. The worth the mechanical properties of (PVA/wood adhesive) blends measured the elongation, Young's modulus, and stress–strain have good mechanical properties of these polymer blends can be used for many applications such as packaging, wound healing, and drug delivery applications.

Selection and peer-review under responsibility of the scientific committee of the 3rd International Conference on Materials Engineering & Science.

1. Introduction

The wood adhesive was used to tightly cut the bonds of the wood together. Many materials were used as adhesives. Many wood adhesives have a weak capacity to seal gaps and this property should be treated by characterizing some materials as additives such as polymers. The wood adhesive is one of the relatively inexpensive adhesives The woodworking industry has used it for decades [1–3]. Although non-toxic and has a very little negative impact on the environment, wood adhesive suffers from a major disadvantage, it has very weak performance in fire and moist conditions [4,5]. The mechanical presentation of wood adhesive disintegrates with increasing temperature and loses its ability to resist bonding at more than 70 °C [6]. Adhesive formulations often include some Additives or modifiers such as plasticizers, fillers, pacifiers, and viscosity to provide the rheological rates, dilators, solvents, and various solvents in formulated. Poly (vinyl acetate) adhesives Can be used without any additional modification; In adhesives, they should be a habit combined to adapt the product to various applications.

Wood adhesive formulations depend strongly on the molecular weight and the clearly defined properties of the additives. The effect of filler on the properties of adhesive creations has been the subject of various investigations. Inwood the adhesives, the fillers may have a specific effect on the properties of the adhesive. Among the many polymeric adhesives used in the woodworking industry, the wood adhesive has wide applications, as the tithe adhesive is used on joints, doors, windows, and other wood materials. The bonding strength is much higher than that of the wood itself. This is caused by the hydrolysis of wood adhesive present in adhesive joints when hydrophobic alcohol chains form in the molecule. Therefore, it is very important to produce PVA breaking up/spreading out that would make the glue bond strong enough in wet conditions. Recognition of the drug-based, medicinal and money-based value of medicinal plants continues to grow, although this differs/changes widely between countries. Although (having soft stems/having no wood) plants have been used in many countries, only a (compared to other things) a small number of plants (the group of similar living things) have been studied in a wide range of uses. (a plant where they get soothing lotion from) Vera, a (related to areas near the Equator/hot and humid) plant of the Liliaceae family, can be found in (vitamins, minerals, etc.), cosmetics and beauty products [7]. The interest of this plant is related to its (group of different things mixed) composition. For example, (a plant where they get soothing lotion from) Vera contain not only many active compounds but also sugars that express different health benefit [8]. Vera has germ-killing, (based on a prej-

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Table 1
Composition of prepared samples (A, B, C, D, and E).

Symbol	PVA weight %	Wood adhesive weight %
A	100	0
B	75	25
C	50	50
D	25	75
E	0	100

udiced mental picture), anti-tumor, and anti-swelling activity as many studies have given [9]. Vera has been used for many purposes including treatment of healing of wounds. The clear/white gel that comes from the leaf parenchyma has been used to treat burns because besides being a strong humidity agent, it helps in the healing path of skin and helps (to reduce) pain [10–12] and can be used as plasticizer [13]. Much research on aloe Vera has searched use in combination with produced and natural polymers that aim to create matrices such as Nanofibers and films, and that based on the above qualities [14]. In this research, we study the influence of addition a PVA polymer and lactic acid in presence of aloe vera on the mechanical properties of the wood adhesive, positive effects were observed on the mechanical properties, compatibility, of the resulting mixture by combining aloe Vera, lactic acid with PVA and wood adhesive.

2. Materials and methods

Wood Adhesive was obtained from commercial suppliers and used without further purification, PVA and lactic acid were purchased from HAMIDA. Aloe Vera gel was isolated from aloe Vera leaves.

2.1. Synthesis

2.1.1. Extraction of the aloe Vera gel

Aloe Vera leaves are cleaned with distilled water. The shell was separated from the parenchyma. The fillet was cleaned with distilled water several times to remove secretions from the surface of the fillet. The slices were mixed in a mixer to obtain a homogeneous substance, and then the mixture was filtered. Then, the aloe Vera gel was fixed at 65 °C for 15 min and stored at 4 °C before use [15].

2.1.2. Synthesis of polymer blends (PVA and wood adhesive)

A group of samples (A, B, C, D, and E) prepared with different weight ratios of polyvinyl alcohol and wood Adhesive. PVA was dissolved in 20 ml of distilled water with 80 °C then; a wood glue, which dissolved in 30 ml of distilled water, then added to the solution of PVA and stirred for 8 h with a magnetic stirrer at 50 °C, according to Table 1.

2.1.3. Preparation of hydrogel films

Another group of samples (A, B, C, D, and E), which prepared in section 2.1.2. were prepared with different proportions of lactic acid as a plasticizer and a stable percentage of aloe Vera gel as a natural bacterial antagonist the samples were prepared according to Table 2.

3. Mechanical properties study

Mechanical properties of all samples were measured by A universal testing machine (Z wick Rell) was used, this device origin (Germany), from type (BTI-FR2.5 TN.D 14), power operating card (100–129 V/4, 4–3,7A) at room temperature (RT).

Table 2
Composition of prepared samples (A series-E series).

$Seires_1$	$Seires_2$	$Seires_3$	$Seires_4$	$Seires_5$	Lactic acid weight ratio%	Aloe Vera gel%
A	B	C	D	E	0	5
A_1	B_1	C_1	D_1	E_1	20	5
A_2	B_2	C_2	D_2	E_2	25	5
A_3	B_3	C_3	D_3	E_3	30	5
A_4	B_4	C_4	D_4	E_4	35	5

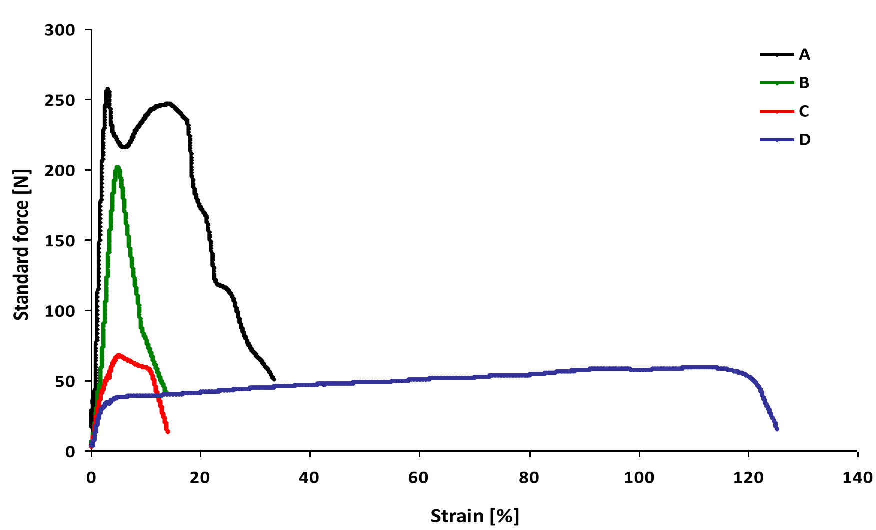

Fig. 1. The stress–strain curves of (A, B, C, and D).

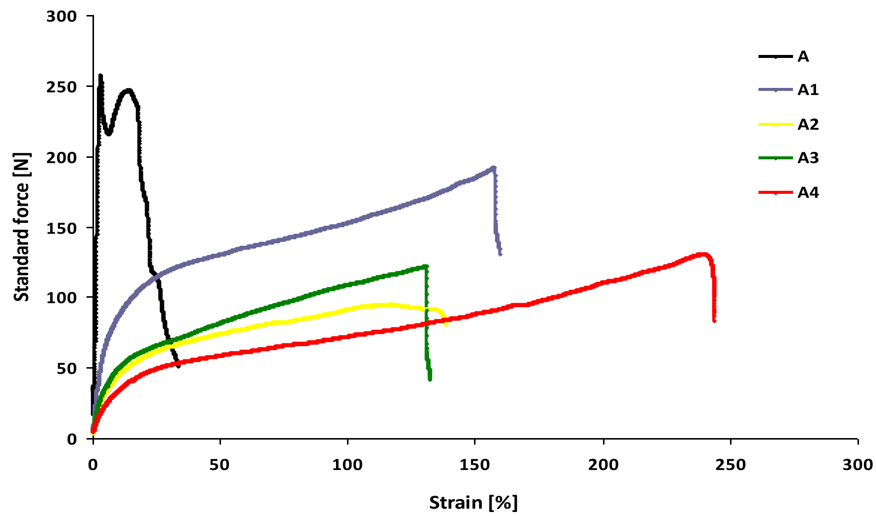

Fig. 2. The stress–strain curves (A, A_1, A_2, A_3, and A_4).

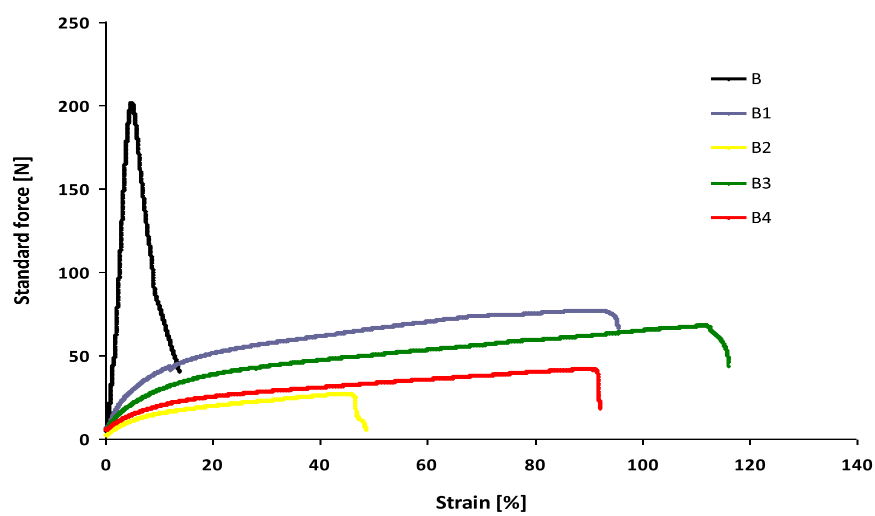

Fig. 3. The stress–strain curves (B, B_1, B_2, B_3, and B_4).

3.1. Result and discussion

Fig. 1 shows the stress–strain curve A, B, C, and D measured at a constant load rate at room temperature without (E) sample because it does not make any measured. Three areas have been distinguished: The first is the linear region, the second is the elongation zone, and the third is the elongation of the fracture region. In the first region, (the linear region), there is no permanent displacement of the particles relative to the other particles. The linear region can reflect the elastic boundary region of the polymer, as the uniform stretch due to stress increases at a constant rate.) shows that adding a PVA rate ranging between (25–75%) leads to an increase in the percentage of elongation and this is a result of the good property that is distinguished the PVA, as for the Figs. 2-5, we note adding Lactic acid by a percentage (20–35%) that leads to an increase in the elongation rate, as the lactic acid is considered a plasticizer agent and crosslinking agent in the same time. Fig. 6 shows that adding the lactic acid material leads to a decrease in the maximum stress borne by the material, and the material increases the elasticity of the polymeric chains, which leads to a decrease in the maximum stress borne by the material.

Fig. 7 shows the relationship between the percentage elongation with the increase in the percentages of the additive and the elongation of the polymer mixture begins with (2%) of the polymer (117%) and then increases at the percentage (4%) is (273%) for (A), while the behavior begins at the percentage of (2%) is (44%) and then increases when the percentage (3%) is (112%) for (B), while the behavior begins at the percentage of (1%) is (50%) and then increases when the percentage (4%) is (276%) for (C) While the percentage (0%) of the polymer (175%) then decreases when the ratio (2%) (142%) of (D), it is a low elastic polymer and thus lactic acid works to fill the gaps between the main polymer chains. The movement of the chains is limited and the elongation increases, until it reaches its maximum value when the ratio (4%) (276%) is for (C), and the polymer at this ratio, has high elasticity and low stiffness, then the maximum decreases when the percentage (1%) is (50%) The polymer chains are not restricted by any owed movement to the homogeneity of the mixture, including the hardened nature

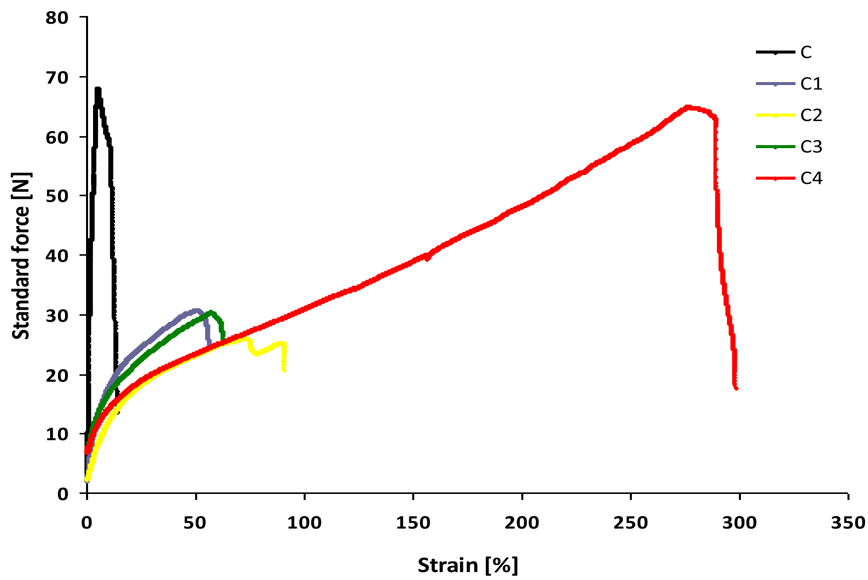

Fig. 4. The stress–strain curves of (C, C_1, C_2, C_3, and C_4).

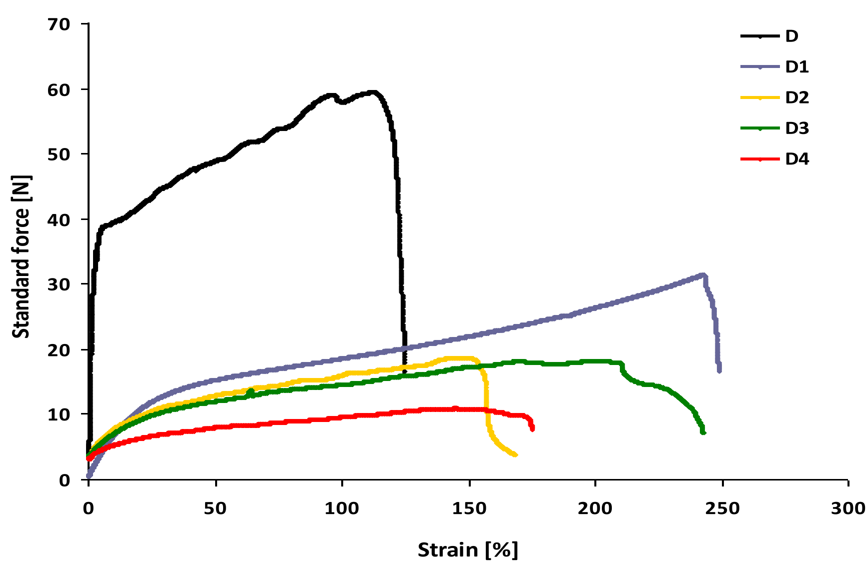

Fig. 5. The stress–strain curves (D, D_1, D_2, D_3, and D_4).

wood adhesive, which in turn increases the stiffness of the polymer and reduces elongation which increased the concentration of additive and worked to increase the density of the polymer.

Fig. 8 shows the effect of lactic acid on the modulus of elasticity (the modulus of youth. The young modulus was (1190 Mpa) when the percentage of (0%) for (A), and then decreases when the percentage (4%) is (2.1 Mpa) for (D), The reason for the decrease in Young Modules when lactic acid at the percentage (4%) of (D) among the additions is due to the heterogeneity of the model even though the mixing models were under the same conditions, this indicates that the polymer has high elasticity (great elongation) and low hardness. Tables 3-6 show the results of the Young Modules, elongation ratio, and elongation at break.

4. Conclusion

Through the study, the presence of polyvinyl alcohol and the lactic acid in addition to the presence of aloe vera as an antibacterial agent in helped to enhance the mechanical properties of the wood adhesive as all the prepared series were recorded the mechanical properties from different proportions of the basic components of the prepared polymer blends except for the series consisting of 100% wood adhesive, the sample (E) did not record any mechanical properties due to the weak mechanical properties of wood Adhesive films without any additions, while the other polymer blends had good properties. from the results, we notice that the highest value of the maximum stiffness of the polymer blends

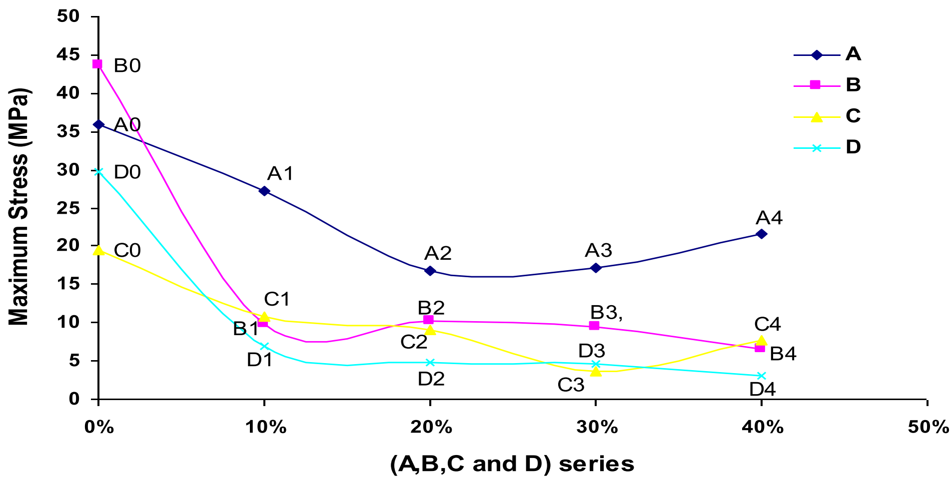

Fig. 6. The maximum stress curves (A, B, C, and D series).

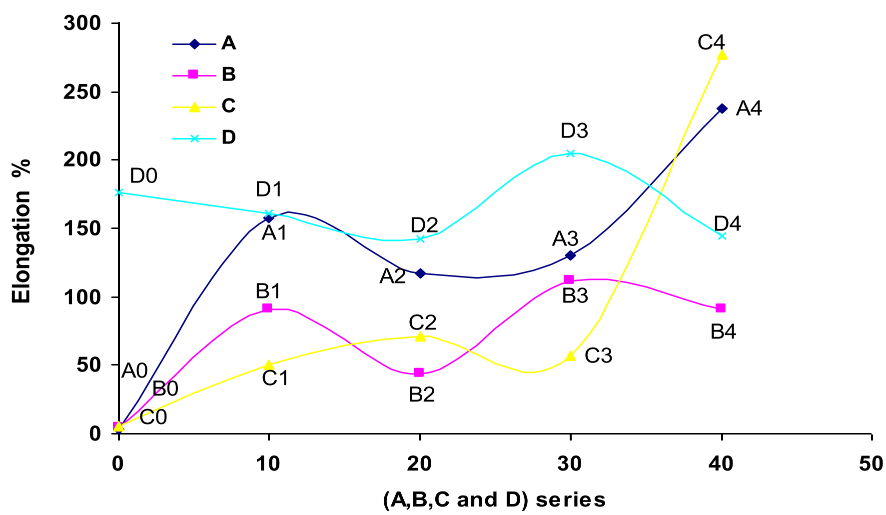

Fig. 7. The Elongation curves (A, B, C, and D series).

Table 3
Mechanical properties of A series.

$Series_1$	Young Modulus (Mpa)	ε_B %	δ_B(Mpa)	ε_M %	δ_M (Mpa)
A	1190	33.2	7.15	3	35.9
A_1	17	159.5	18.5	157.6	27.2
A_2	14	138.4	14.1	116.7	16.7
A_3	13	132.2	5.93	130.7	17.2
A_4	9.1	243.9	13.9	237.2	21.7

Table 4
Mechanical properties of B series.

$Series_2$	Young Modulus (Mpa)	ε_B %	δ_B(Mpa)	ε_M %	δ_M (Mpa)
B	908.3	13.7	8.70	4.8	43.6
B_1	10.9	95.6	8.50	90.5	9.89
B_2	23	48.6	2.02	44.2	10.2
B_3	8.5	116.1	6.09	111.4	9.49
B_4	7.1	92.2	2.85	90.7	6.49

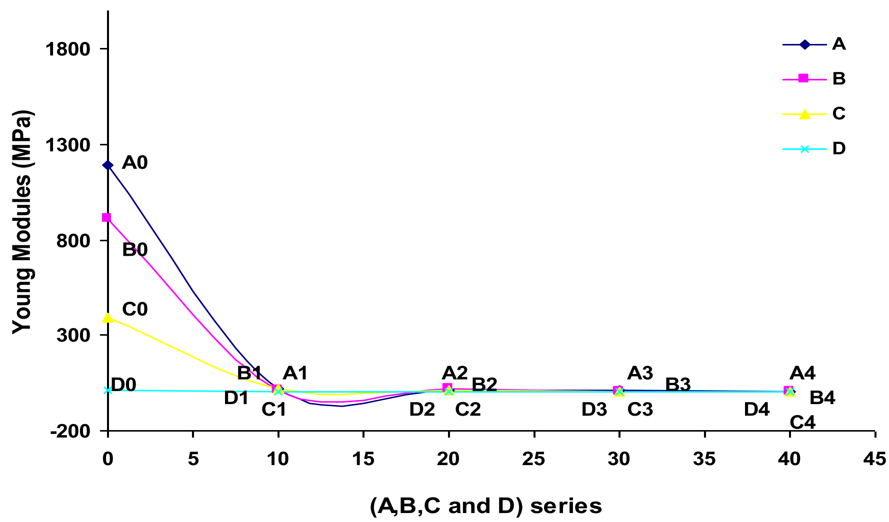

Fig. 8. The Young Modules curves (A, B, C, and D series).

Table 5
Mechanical Properties of C Series.

$Series_3$	Young Modulus (Mpa)	ε_B %	δ_B(Mpa)	ε_M %	δ_M (Mpa)
C	390	13.9	3.87	5	19.5
C_1	21.4	55.9	8.76	50.3	10.8
C_2	12.6	91.0	7.24	71.6	9.09
C_3	6.43	62.3	3.03	56.9	3.66
C_4	2.82	298.1	2.12	276.7	7.81

Table 6
Mechanical properties of D series.

$Series_4$	Young Modulus (Mpa)	ε_B %	δ_B(Mpa)	ε_M %	δM (Mpa)
D	16.9	189	5.93	175.8	29.8
D_1	4.3	190.7	3.86	160.6	6.92
D_2	3.4	168.7	0.982	142.4	4.91
D_3	2.2	242.6	1.80	204.3	4.57
D_4	2.1	175.2	2.14	145.0	3.10

is (43.6 Mpa) for the (B) blend, where the value of Young's modulus is (908 Mpa), as this blend is characterized by high stiffness and low elasticity and the elasticity value for this blend is (4.8), which the chains of the polymer blend are bound Movement due to the nature of the material, which is characterized by high hardness, while the minimum value of stiffness is (3.10 Mpa) for the (D_4) blend, where the blend is highly elastic and the value of Young's modulus is (2.1 Mpa), where the blend is characterized by high elasticity and low stiffness, and in this blend, the value of elasticity is (145). The highest elasticity value of the polymer blends is (276.7) for the (C_4) blend, as this blend is characterized by high elasticity and the chains are free to move without being restricted, and the stiffness value for this blend is (7.81 Mpa).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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