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Impact of (Wood Particles (Reed) / Polypropylene) Composites on the Physical and Structural Properties

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Abstract
The creation of polypropylene resin/wood particle (reed) composites and the investigation of the impact of incorporating natural material residues on the composite's structural and physical characteristics are the main objectives of the current study. The composite of polypropylene resin and wood particles (reed) was created by extrusion with a weight fraction of 30% and treated with a sodium chloride solution (0.5). Bulk density and absorbance rate are among the physical and structural characteristics that are examined for (pure p.p.), (p.p. + w), (p.p. + w + silan coupling agent), (p.p. + w + Mgo), and (p.p. + w + Zn(C18H35O2)2. The results show that adding wood particles, silane coupling agent, magnesium oxide, and zinc stearate increased the bulk density for all samples. The composite with the highest bulk density rate was the (pp + w + MgO) composite. The results of the absorbance test, which involved immersing each composite in distilled water and the chemical solution, are shown. When comparing the samples before and after immersion, the weight gain of the latter is increasing. All samples were examined using Atomic Force Microscopy (AFM). The topographical image makes it clear that the polypropylene composite reinforced with wood particles had a high roughness value. These findings highlight the qualities of plastic wood composites, which are thought to be stronger and more durable than natural wood.
Keywords: Wood particles, Polypropylene, Physical and Structural Properties
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1. Introduction

Nonetheless, a technological advancement has transpired through the utilization of waste materials, like wood or plastic, to manufacture high-performance products [1]. The Department of Agriculture's Products Laboratory in the United States conducted research and studies that demonstrated the potential for combining wood fibers with recycled plastic materials, including polypropylene, polyethylene, and others, to effectively benefit from reinforced engineered materials [2]. Because natural fibers are inexpensive and have a low renewable density, wood plastic is made of a blend of natural fibers or a filler made of wood flour and other fibers with thermoplastic polymers like vinyl chloride, polyethylene, and polypropylene. [3]. Several fillings, such as talc, clay, and wood, can be used to reinforce thermoplastic and thermoset polymers. This technique enhances the resin's capacity to be treated while lowering its cost [4]. Because it is regarded as one of the most significant solutions for using mixed plastic, which cannot be gathered in large quantities, wood plastic attracted a lot of attention when it first entered the market. Because plastic wood can improve mechanical, electrical, and thermal properties, researchers in this field have turned to using it in a variety of applications [5].

2.Experimental

The most significant agricultural wastes utilized in this project are reed, which is chemically treated with silane after being prepared for grinding and wood addition. particles to the polymeric substance was accomplished (Page 3/19). 30% more reed particles with a 212 mesh grain size were added to the polypropylene. Some improver materials were added in specific proportions, such as magnesium oxide as an antioxidant and zinc stearate, which are considered lubricants with different concentrations, and using an extrusion device at a temperature of 160 degrees, the samples were obtained in sheets, after which the samples were cut according to the standard dimensions (ASTM) to conduct tests.

2.1 Bulk density

For these composites, bulk density can be measured by measuring the sample's dimensions and calculating the mass of the composite material using a sensitive electronic balance. The samples have cylindrical and circular shapes. The following formulas can be used to determine the bulk density [6].

$$B.D = mv \qquad (1)$$

m: the mass of the sample with the unit (gm) v: the size of the sample measured by unit (cm3)

$$B.D = m\pi r2 * h \qquad (2)$$

r: the radius with unite (cm) h: the height of the sample (cm)

2.2 Absorbance test

The purpose of this test is to determine how moisture affects surface hardness and elastic modulus. A digital balance that detects readings to four decimal places is used to measure the samples' weight prior to immersion in distilled water at room temperature at the start of the test. Following an 80-day continuous test, all of the samples are taken out and allowed to dry. Following immersion, the weight is finally determined. The samples are submerged in distilled water and a chemical solution (Bubblegum) to repeat this procedure. The following formula was used to determine the weight gain [1].

$$Weight\ gain\% = m2 - m1 / m1 \qquad (3)$$

Where: m_1 : the mass of the sample before immersion that was measured by (gm)
m_2 : the mass of the sample after immersion measured by (gm)

2.3 Atomic Force Microscopy (AFM)

The AFM device is made up of tiny needles that pierce the sample's surface and are attached to a horizontal holder that is perpendicular to the sample's surface and the stand. The needle begins scanning in accordance with the sample's surface topography after a laser beam is dropped onto the stand. After capturing the laser's reflected beam on a receptor, the scanned morphology was identified.

3.Results and Discussion

3.1 Bulk Density

The bulk density of every polypropylene composite is shown in Figure (1). The findings show that the bulk density rates vary. The (P.P + w + MgO) composite had the highest average bulk density rate, which can be attributed to the antioxidants' ability to strengthen the material and fill existing pores, which reduces dimensions and raises bulk density [7]. The composite (pp + w + silane) has the second-highest bulk density. When the composites are compared before and after being treated with a silane coupling agent, the bulk density rate improves to (0.22) g/cm³. In this case, the silane coupling agent plays a crucial role in strengthening the bond between the matrix and filling materials, or the correlation within the composite material. The bulk density rises as a result of the fine pores' shrinkage and the composite's shrinkage [8]. As can be seen from the preceding figure, the composite with the higher density than P.P. pure, P.P. + W + Zn (C18H35O2)2, had a bulk density rate that was followed by that of P.P. + W + Silane and, lastly, P.P. + W. This is explained by the use of wood particles to fill in the minuscule gaps that were created during the sample preparation process. The wood particles are dispersed throughout the composite material's structure. The joining process between the reinforcement material and the matrix material is improved while the volume and voids are reduced. As a result, the bulk density rises along with the material's cohesiveness and hardness [9]. 3.2 Test of absorbance Because polymeric composites are more prone to absorbing water or other liquids, their mechanical properties are deemed unstable and are therefore impacted by atmospheric humidity. Understanding that the absorption process weakens the interface by decreasing the adherence between the reinforcement material and the polymeric material helps to clarify this. Swelling results from the reinforcement material absorbing more fluids than the matrix material. The polymeric matrix material and the medium to which the compound was exposed are found to be the primary determinants of the composite resistance. To determine how plastic wood would react to chemical additives, the absorbance test was conducted [10, 11].

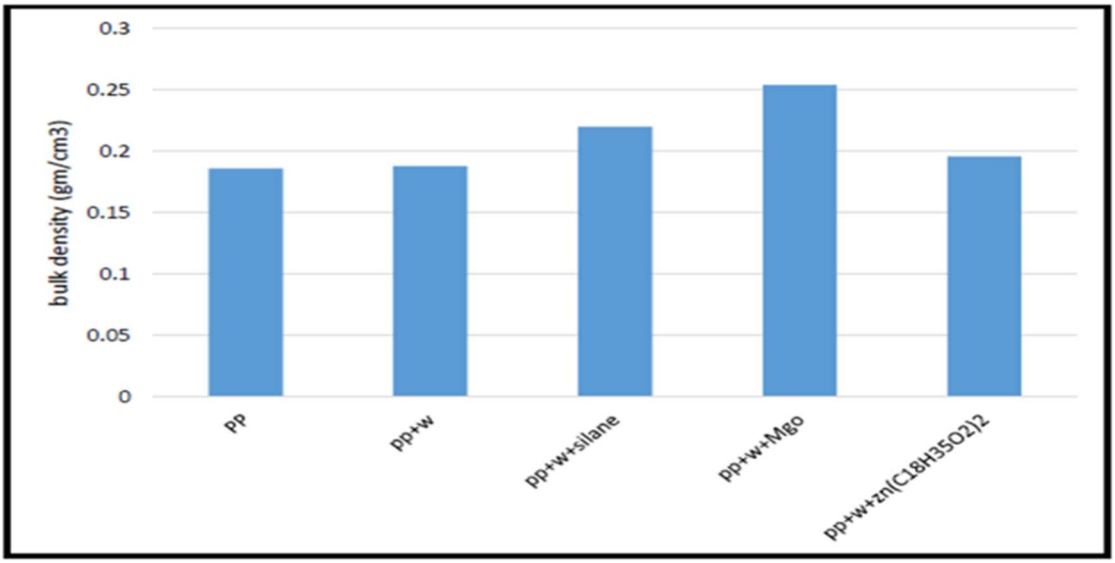

Figure 1 The bulk density for all polypropylene composites

3.2.1 Immersion in Distilled water

Regarding polypropylene composites, research has examined each composite's absorbance rate in relation to immersion time as shown the connection between time and absorption rate. The outcomes documented . There was a noticeable difference in the samples' weight gain before and after immersion. When comparing the samples before and after immersion, the weight gain of the latter is increasing. In this sense, we observe an increase in weight gain following a period of time spent in the water. Over time, the rate of absorption rises when wood particles (reed) are used for reinforcement. This results from the presence of wood particles that create pores when reinforced with agricultural waste, which causes water absorption. Returning to the natural plant waste, we discover that it has a propensity to absorb water from the surrounding medium. Consequently, every result shows that the sample reinforced with wood particles absorbs more quickly, increasing its weight gain over time in the water [12]. The impact of including a silane coupling agent was investigated. The relationship between weight gain and time for the (pp + w + silane) composite distilled water is explained by the silane coupling agent's effect, as can be seen in figure (2). According to the findings, the material particles cannot penetrate when submerged in water after being treated with a silane coupling agent. Additionally, it forms a chemical bridge between the wood particles' surface and the matrix material (polypropylene), which prevents hydrolysis because it increases the binding between the hydroxyl groups (OH) between the urinary Wood particles (reeds) and polypropylene. As a result, adding the silane coupling agent will increase the susceptibility of wood (reed) to the resistance of hydrolysis and decrease the groups that absorb water [13]. As illustrated in figure (3), the other result obtained is the percentage of weight gain and its relationship to the duration of immersion of the (P.P + W + MgO) composite in distilled water. We observed an improvement in the composite's absorbance resistance by submerging the magnesium oxide-containing samples in distilled water, which raised the material's resistance to water seeping into the composite molecule [8]. Figure (4) illustrates how the presence of zinc stearate within the material enhanced the absorbance resistance of the (p.p + w + Zn (C18H35O2)2) composite by improving the consistency between the two materials and strengthening the material's resistance to water penetration.

3.2.2 Immersion in the chemical solution

The weight gain and time of the (P.P + W + Silane) composite in a chemical solution are related, as seen in Figure (5). The findings demonstrate that, in comparison to distilled water, chemical solutions have minimal impact on the composites. As the particles leave the surface and penetrate the material's edges, interfaces, and cracks, the polymer's molecular chains separate from one another. in addition to the interface's deterioration. This indicates that a number of variables, such as the chemical makeup of the polymeric material, the duration of immersion, the degree of bonding and adhesion strength of the constituent materials that created the polymeric composites—that is, the degree of interface efficiency—and the kind of solutions employed, all affect the rate and amount of liquid absorption [14]. Particle type and shape affect the absorbance rate. An increase in the concentration of the liquid causes the absorbance rate to decrease. Because of its oily nature, the compound has less of an impact on the solutions, making it harder to penetrate the gaps inside the composite. Regarding the composites' treatment with the addition of both magnesium oxide and zinc stearate, as illustrated in figures (6) and (7), the effect will be described as in paragraph (1), i.e., when submerged in distilled water. However, in this kind of test, the damage won't be noticeable right away; instead, it might show up months later, depending on the material's characteristics [16].

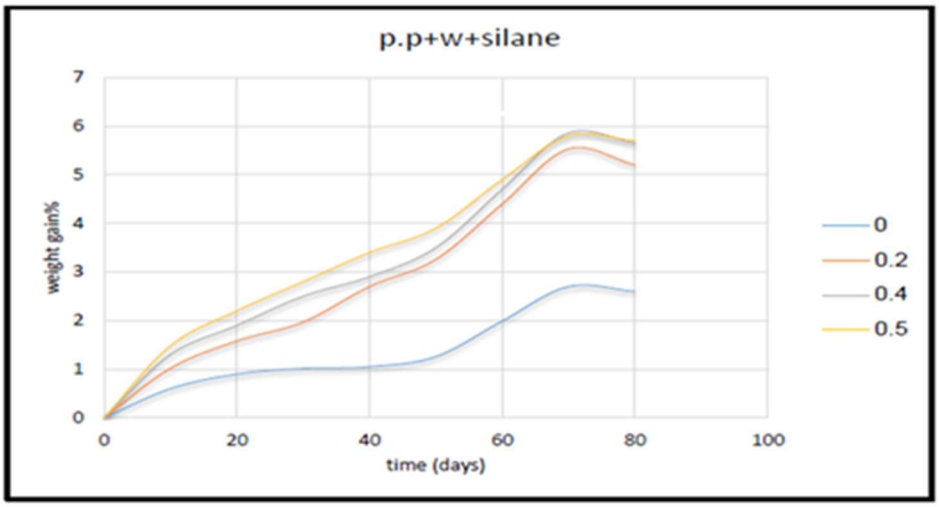

Figure 2 The variation between weight gains with the time for (P.P+W+Silane) composites in distilled water.

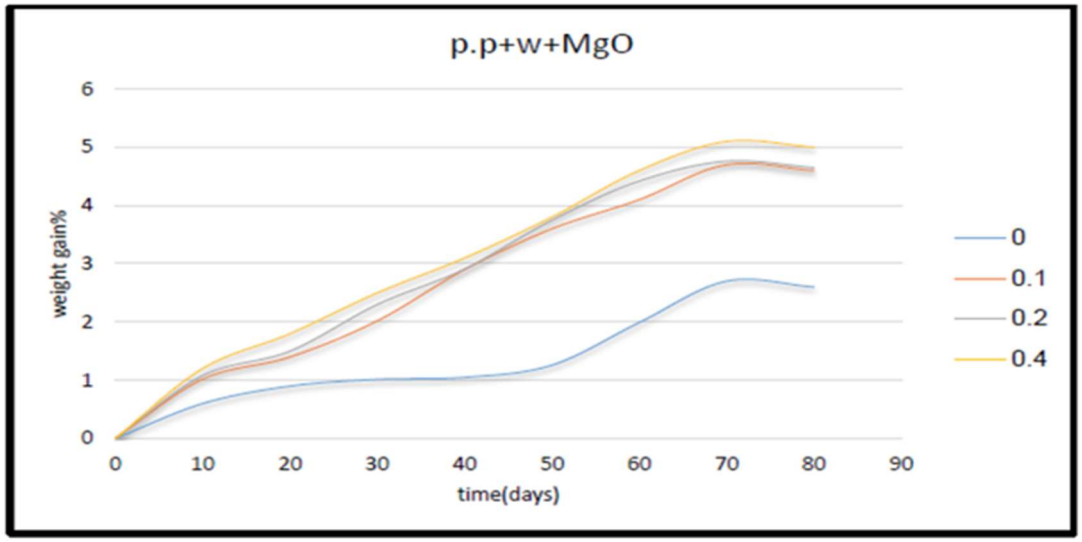

Figure 3 The variation between weight gain with the time for (P.P+W+Mgo) composite in distilled water.

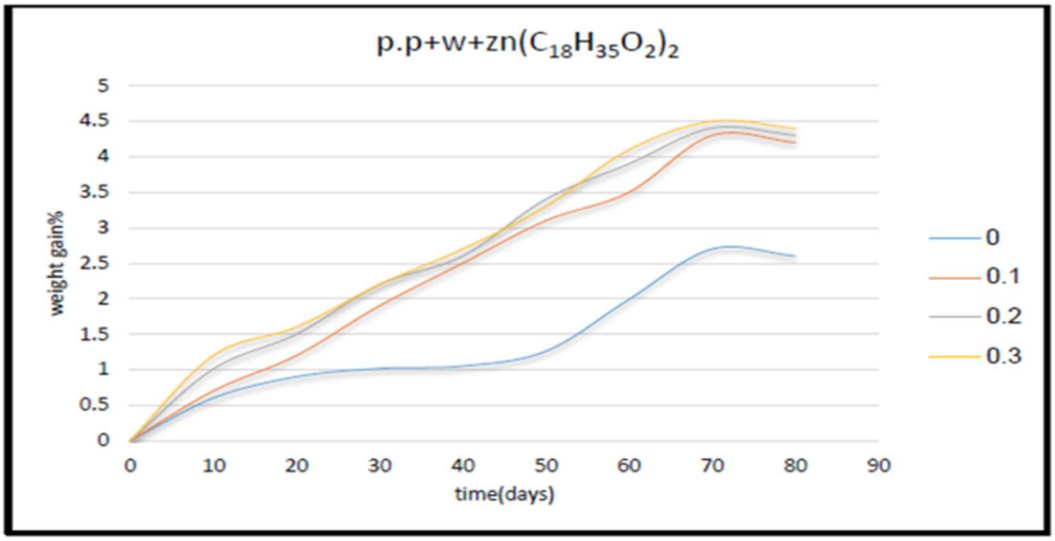

Figure 4 The variation between weight gain with the time for (P.P+W+Zn(C18H35O2)2) composite in distilled water.

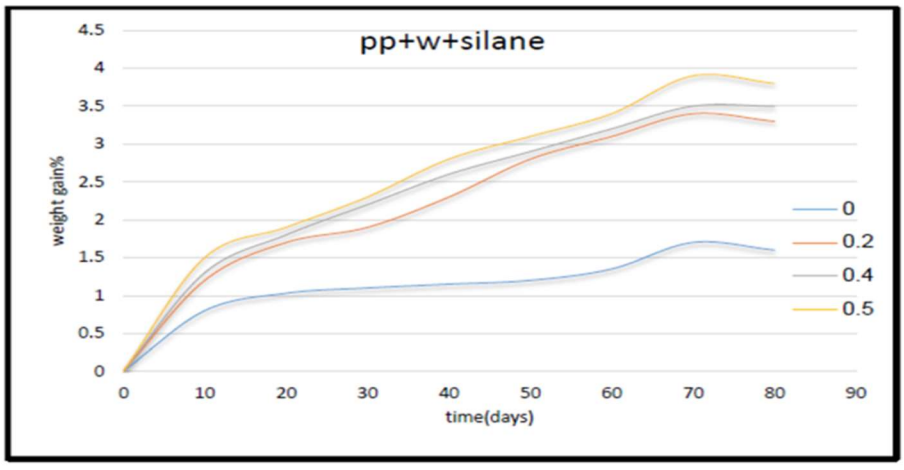

Figure 5 The variation between weight gain and the time of the (P.P+W+Silane) composite in a chemical solution

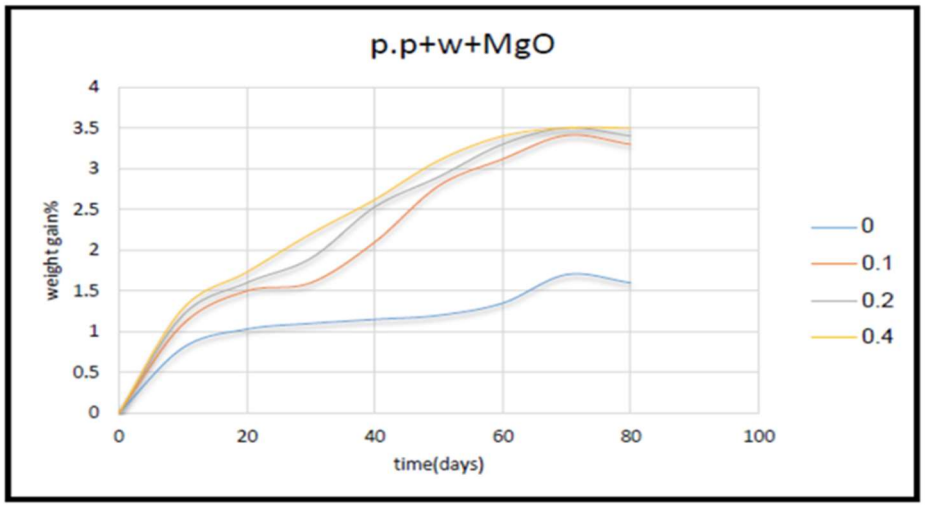

Figure 6 The variation between weight gain and the time of the (P.P+W+MgO) composite in a chemical solution

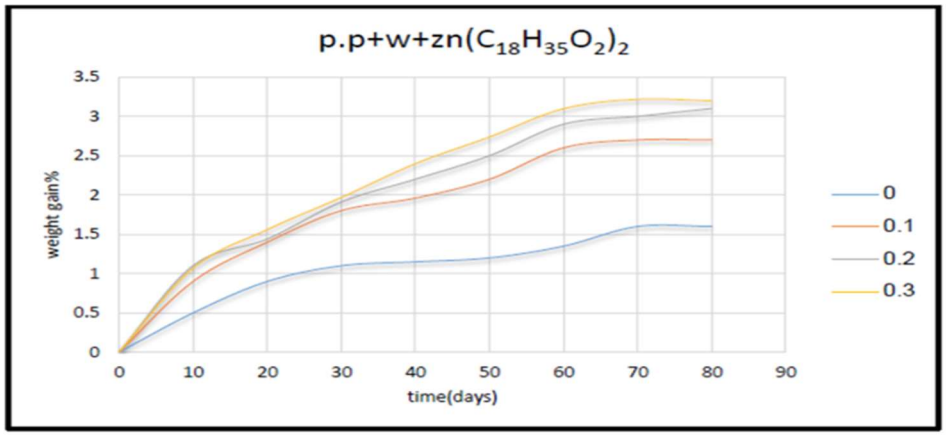

Figure 7 The relationship between weight gain and the time of the (p.p+w+ Zn(C18H35O2)2) composite in a chemical solution

3.3 Atomic force microscopic

One of the crucial synthetic tests that aids in information gathering is AFM, which provides three-dimensional topographical images that depict the surface material's topography [16]. The examination's findings were acquired. The composite coatings are depicted superficially, along with the size (2138 nm), roughness, and square root with pixel (1024) in table (1). As seen in figure (8), the topographical image indicates that the wood particle-reinforced polypropylene composite had a high roughness value. However, as illustrated in Figure 9, the results indicated that the roughness dropped to 8.39 nm after being treated with the silane coupling agent. However, the surface roughness decreased to 7.75 after the addition of magnesium oxide, as seen in Figure (10). Figure 11 shows that the optimal ratio was 1.95 nm for the (p.p + w + Zn (C18H35O2) 2) composite. These findings indicate a notable improvement in impact strength, wear rate, and surface hardness. Put another way, when the material was reinforced, its homogeneity increased, indicating an improvement in the tribology characteristics. The occurrence of the surface causes a separating value between the wear on the surface and the layer beneath it. This occurs when the hardness of the material increases due to the penetration of the additive inside the matrix material that works to reduce and fill the gaps during the preparation process. Furthermore, the polymeric slip on the metal surface of the wear device's rotating disc is responsible for a distortion of the layer beneath the surface. Magnesium oxide exhibits a high degree of cohesiveness between the reinforcement and matrix materials. Consequently, there are fewer cracks, which raises the resistance to cracks [17].

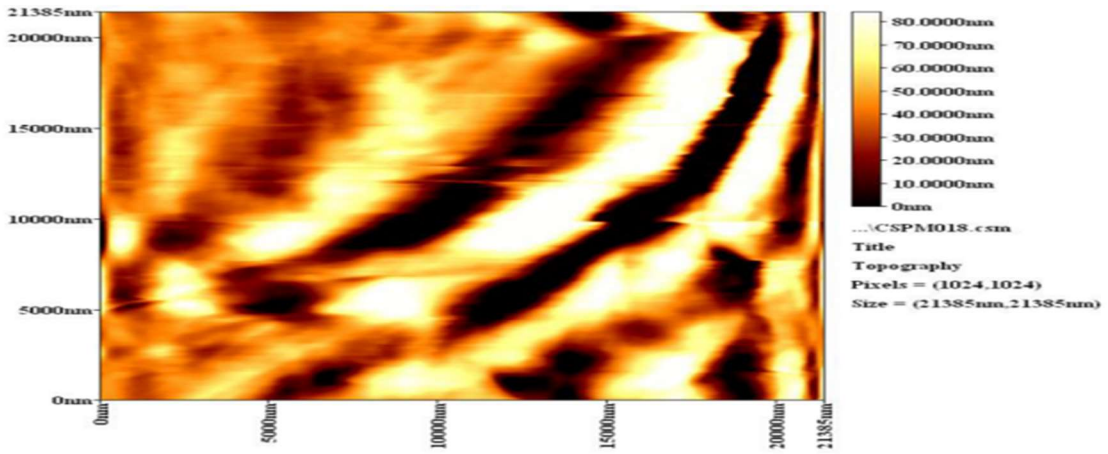

Figure 8 Topography picture (2D) for (p.p+w) by AFM device.

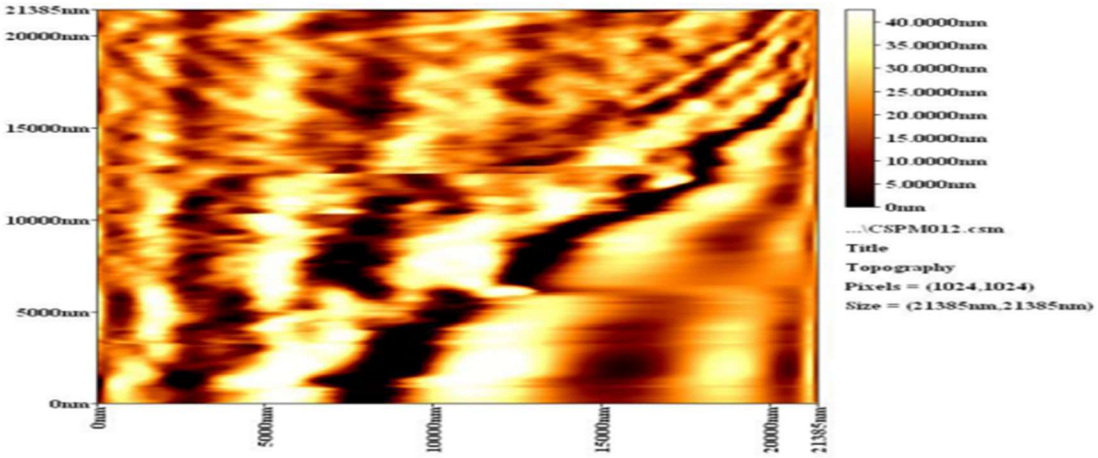

Figure 9 Topography picture (2D) for (p.p+w+silane) by AFM device.

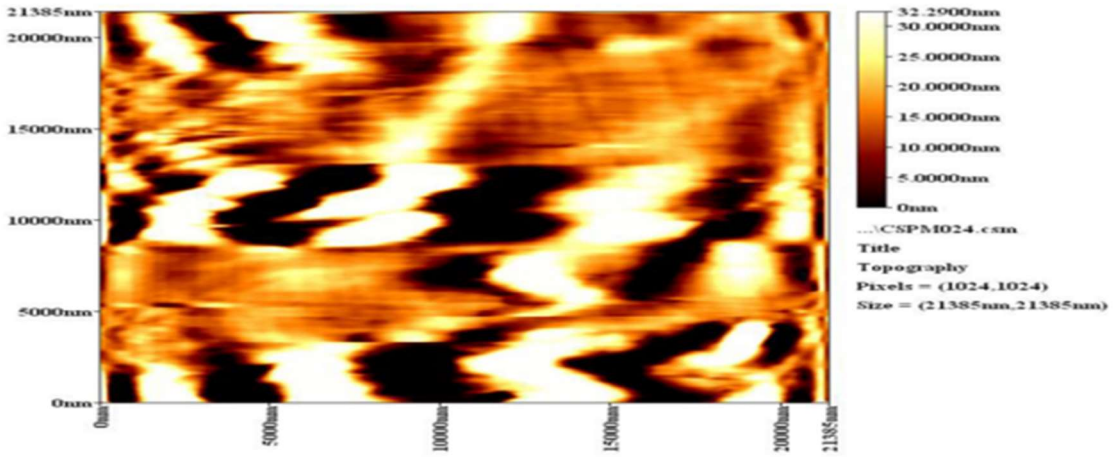

Figure 10 Topography picture (2D) for (p.p+w+Mgo) by AFM device.

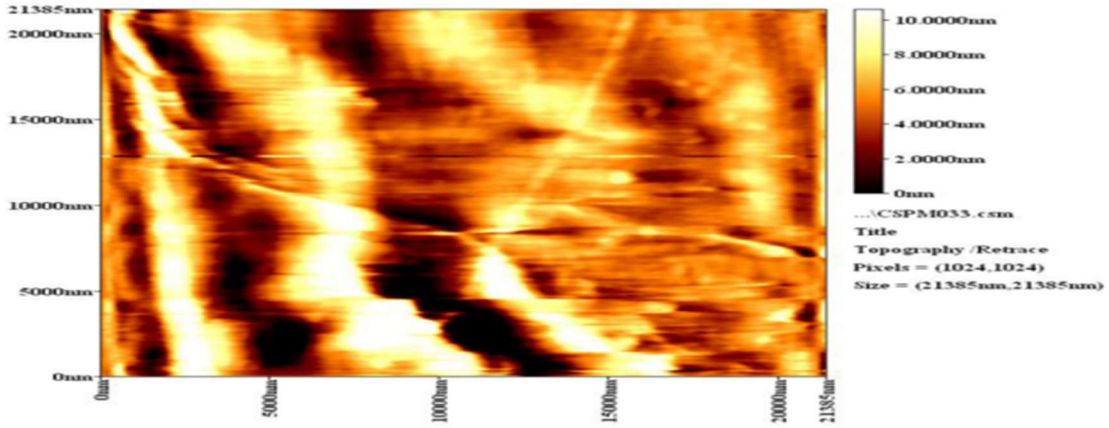

Figure 11 Topography picture (2D) for (P.P+W+Zn(C18H35O2)2) by AFM device

Table 1. The roughness average and root mean square values

samples	Root mean square	Roughness average
p.p+w	53.5 [nm]	18.9 [nm]
p.p+w+silane	10.4 [nm]	8.39 [nm]
p.p+w+MgO	9.68 [nm]	7.75 [nm]
p.p+w+Zn(C18H35O2)2	2.47 [nm]	1.95 [nm]

4.Conclusions

1. The (P.P + W + MgO) composite had the highest average bulk density, indicating that antioxidants had an impact on the material's strength.
2. The weight of the material particles increased as they were submerged in water and treated with the silane coupling agent; consequently, the resistance to hydrolysis increased as the silane coupling agent was added.
3. When zinc stearate and magnesium oxide are added, the absorption resistance improves.
4. When compared to distilled water, chemical solutions have minimal impact on composites.
5. The polypropylene composite reinforced with wood particles had a high roughness value. Nevertheless, the roughness decreased after being treated with the silane coupling agent. The surface roughness, on the other hand, decreased with the addition of magnesium oxide. The composite with the best ratio, p.p + w + Zn (C18H35O2) 2, was 1.95 nm, indicating a notable improvement in both surface hardness and wear rate.

Notes

Statement I confirm that there is no declaration of interest statement. Conflict of Interest I hereby certify that there is no conflict of interest regarding our paper "Impact of (Wood Particles (Reed) / Polypropylene) Composites on the Physical and Structural Properties." Also, this manuscript has not been published before but it introduced to preprint with DOI http://dx.doi.org/10.21203/rs.3.rs-3508708/v1 t. I am interested in the copy right for your journal.

References

Al-ssafi, R. A., Imran, D. M. & Sehil, K. F. (2019), “Study hardness and wear resistance for plastic flooring of urea formaldehyde”, Association of Arab Universities Journal of Engineering Sciences.

Tabarsa, T., Khanjanzadeh, H. & Pirayesh, H. (2011), “Manufacturing of wood-plastic composite from completely recycled materials”, Key Engineering Materials 471–472.

Brydson, J. A. (1989), Plastics Materials, 5th Edn, Butterworth, London.

Alessandro, M. B. (2008), Monomers, Polymers and Composites from Renewable Resource.

Hamada, R. F. (2016), “Preparation and study of some properties for (PP/rice husks powder) composite”, Master Thesis, University of Technology.

Khudair, S. H. (2013), “Study of some rheological and mechanical properties of the composite materials (unsaturated polyester-wood) by ultrasonic waves”, Journal of University of Babylon 21(4), 1379–1390.

Al-Janabi, R. H. (2004), "Study the effect of weathering conditions on some properties of epoxy composites", Master Thesis, University of Technology.

Rosa, S., Santos, E., Ferreira, C. & Nachtigall, S. (2009), "Studies on the properties of rice-husk-filled-PP composites – effect of maleated PP", Materials Research 12(3), 333–338.

Aziz, M. Z. (2009), "Preparation of hybrid composites and studying the effect of temperature on some their mechanical and physical properties", Master Thesis, University of Baghdad.

Wook, S., Jun, D. & Heung, J. (2003), "Studies on applied polymer properties", Journal of Applied Polymer Science 90, 3471–3746.

Huang, G. & Sun, H. (2007), "Effect of water absorption on the mechanical properties of glass/polyester composites", Materials and Design 28, 1647–1650.

Daramola, O. O. & Akintayo, O. S. (2018), "Water absorption characteristics of epoxy matrix composites reinforced with green silica particles", Leonardo Electronic Journal of Practices and Technologies 32, 215–232.

Mishra, S. & Verma, J. (2006), "Effect of compatibilizers on water absorption kinetics of polypropylene/wood flour foamed composites", Journal of Applied Polymer Science, Wiley Periodicals Inc. 101, 2530–2537.

Nasir, R. Md. (2014), "Water-lubricated pin-on-disc tests with natural fibre reinforced matrix", Journal of Mechanical Engineering, Universiti Teknologi Mara (UiTM), Malaysia 11(2), 41–51.

Hussein, M. M. (2018), "Preparation of polymeric composites reinforced cellulose materials and studying some of their physical properties", Master Thesis, University of Diyala.

Effah, B., Van Reenen, A. V. & Meincken, M. (2015), "Characterisation of the interfacial adhesion of the different components in wood–plastic composites with AFM", Composites Journal 12(3), 200–215.

Salih, S. A. (2016), "Study of the some physical properties of epoxy reinforce with nano particles", Ph.D. Thesis, University of Baghdad.