

Ultraviolet Shielding Performance of Coconut Coir as a Filler in Low-Density Polyethylene (LDPE) Plastic Mulch

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Abstract

Plastic mulch is a layer of material applied to the soil surface to maintain moisture retention in the soil by preventing evaporation, reduce weed growth by blocking sunlight from reaching underlying weeds, and optimize fertilizer use by minimizing nutrient loss to the environment. However, the degradation of low-density polyethylene (LDPE), a thermoplastic commonly used for mulching, into microplastics is due to exposure to UV radiation. This research explored the potential of coconut coir, a natural fiber with a high lignin content ranging from 30 to 46%, as a UV protective agent. The objective was to develop biodegradable plastic-based mulch composites that have better resistance to UV exposure by incorporating coir as a filler material in LDPE-based composites. Different ratios of coconut fiber were used (10%, 20%, 30%, and 40%), and Maleic anhydride grafted polyethylene (PE-g-MAH) was used as a coupling agent at 2% of the total weight mixed with LDPE in a rheomixer (80 rpm, 120°C for 10 min). The resulting plastic mulch bio-composites were evaluated for thermal, mechanical, UV resistance, and biodegradability properties. The results showed that the higher addition of coconut coir resulted in a decrease in the thermal and mechanical characteristics of the composite. However, adding higher coconut coir in the composite at 40% can increase the composite's resistance to ultraviolet light exposure, and the properties are easily degraded by the environment (biodegradable).

Keywords: plastic mulch, LDPE, coconut coir, ultraviolet resistance, bio-composites.

Introduction

Mulch is widely used in the agricultural industry to protect various crops due to its effectiveness in Indonesia's high temperature and humid tropical climate. The introduction of plastic technology since the 1940s led to the massive use of mulch in horticultural cultivation to increase yield and quality of crops (Menossi *et al.* 2021). Mulch can improve agricultural efficiency by inhibiting weed growth, retaining soil moisture, helping to minimize soil erosion, and maintaining a constant soil temperature (Liu *et al.* 2021). It can also help reduce water loss due to high evaporation in the dry season and prevent excessive accumulation of water on the soil surface during the rainy season (Hernawan *et al.* 2020). Commonly used plastic mulches are made from petroleum thermoplastics such as Low-density polyethylene (LDPE) (Serrano-ruiz *et al.* 2020), which has characteristics that make it difficult to decompose after use due to its long carbon chain.

LDPE thermoplastic is typically thin, translucent, flexible, and relatively light in weight (Szlachetka *et al.* 2021). When compared to other types of polymers, such as High-density polyethylene (HDPE), LDPE degrades more easily (Prakash Bhuyar *et al.* 2019). Polymers break down or disintegrate when exposed to heat or sunlight. One of the most common causes of LDPE thermoplastic breakdown is photodegradation by ultraviolet (UV) light. UVA, UVB, and UVC are the three types of ultraviolet radiation (Amaro-Ortiz *et al.* 2014). The bulk of UVC and UVA photons in the atmosphere are absorbed by ozone, water vapor, oxygen, and carbon dioxide. However, the UVB spectrum is not

greatly filtered, exposing inorganic objects, living beings, and the environment to increased quantities of UVB radiation. Long-term exposure to UVB radiation damages the structure of plastics by rupturing the bonds between their components (Doğan 2021).

In the meantime, Indonesia is a perfect location to cultivate coconuts because it is an island nation with a vast coastline. Utilization of coconut fruits, leaving coconut coir as a byproduct with only limited use in handicrafts. The relatively high production of natural fibers, such as coconut coir, which has a lower selling value than synthetic fibers, is a cost-effective and sustainable option for filler materials in composites (Ahmad *et al.* 2022; Mahmud *et al.* 2023). Coconut coir has cellulose and lignin, which can be used for higher-added-value products (Freitas *et al.* 2022). Coconut coir contains a high proportion of lignin, which ranges from 30 to 46% (Adeniyi *et al.* 2019). Lignin has shown potential as a natural UV protection material in broad-spectrum (UVA, UVB) sunscreens. Compounding lignin with synthetic polymers or natural polymers with less than 10% lignin in composites indicates good potential for transparent UV barrier coatings (Sadeghifar and Ragauskas 2020).

However, the different characteristics possessed by hydrophobic LDPE and hydrophilic coconut coir cannot simply be mixed because they cannot bind to each other, so a coupling agent that can bind the two is required. Maleic anhydride grafted polyethylene, otherwise known as PE-g-MAH is essential in improving the compatibility between nonpolar PE and natural polar materials. Maleic anhydride grafted polyethylene is used as a compatibilizer to ensure the effective distribution of hydrophilic coconut coir lignin

particles in the hydrophobic LDPE matrix of the fabricated composite. PE-g-MAH has an effect that can be attributed to the new bonds formed between the LDPE grafted with maleic anhydride groups and the OH groups of the lignin in coconut coir (Diop *et al.* 2015). Based on the background information provided, the goal of this study is to examine how high lignin content coconut coir can prevent ultraviolet radiation from destroying LDPE thermoplastic and boost LDPE resistance to UV light. Additionally, it was investigated how well LDPE biodegraded when coconut coir was added.

Materials and Methods

Materials Preparation

The low-density polyethylene (Cosmothene F210-6) utilized in this investigation was made by The Polyolefin Company (Singapore) Pte. Ltd. (melting point is 108°C, melting index is 2 g/10 min). Coir is manufactured at Malingping, West Java, Indonesia. Sigma-Aldrich Maleic anhydride grafted polyethylene (PE-g-MAH) was used exactly as received. To achieve a good mixture of LDPE and coconut coir, first, the coconut coir that binds to each other and is still long were separated, and then cut. The coir was then sieved using a 100 mesh sieve (particle size around 149 µm). Next, the coconut coir was dried in an oven at 60°C for 1 hour. The dried coconut coir was then stored in a sealed plastic bag before being mixed with LDPE.

Chemical Composition

The Technical Association of the Pulp and Paper Industry's published procedures were used for chemical analysis (TAPPI). For moisture and ash content analysis, the

coir was dried in an oven at 105°C for 24 hours and combusted at 550°C for 6 hours, respectively. The extractives content was determined using the soxhlet technique with ethanol-benzene (1:2 v/v) solvent at 80°C for 6 hours. For lignin content analysis, the extractive free sample was added with 72% H₂SO₄ and stirred for 2 hours at room temperature. Then, the sample was diluted using distilled water to obtain an H₂SO₄ concentration of 4% and autoclaved for 1 hour at 121°C. After that, the samples were rinsed with hot water, filtered, and dried in a 105°C oven for 24 hours. From the dried samples, the ash content was analyzed, as a subtraction factor in calculating lignin content. Holocellulose content was determined by adding 25% NaClO₂ and glacial acetic acid to an extractive-free sample and heating it at 80°C. The sample was then rinsed with cold water and acetone before being dried to obtain holocellulose. After that, 17% NaOH and aquades were added to the holocellulose sample, which was then given 45 minutes to react before being rinsed with 8.3% NaOH and aquades. To get α-cellulose, the sample was then treated to 10% acetic acid and neutralized. By subtracting the holocellulose content from the α-cellulose content, the hemicellulose content was calculated.

Materials Compounding

The ingredients were mixed for 10 minutes at 120°C with a rotor speed of 80 rpm in a Thermo Scientific HAAKE Rheomixer PolyLab OS. Based on the formula in Table 1, the compounding process was carried out by combining coconut coir with concentrations of 10%, 20%, 30%, and 40% with PE-g-MAH and LDPE thermoplastic granules. The total weight of the combined materials was 50 g and denoted as "LMKK". Figure 1 shows the biocomposite manufacturing process.

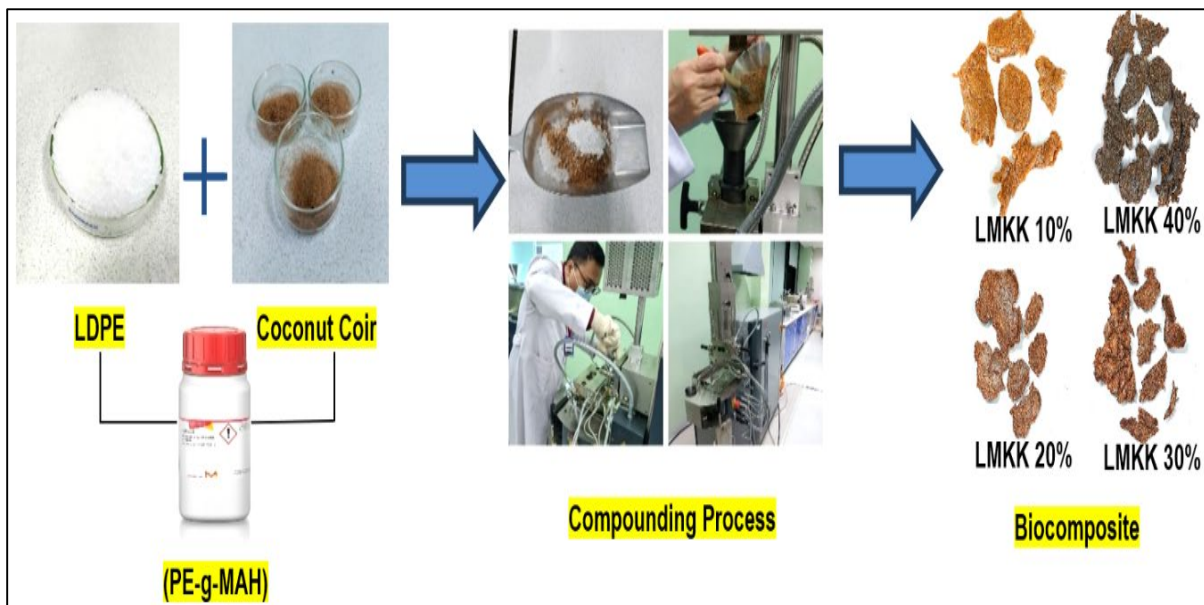


Figure 1. Biocomposite manufacturing process.

Molding and Compressing

In order to manufacture ASTM D638 Type IV tensile strength test samples, a HAAKE MiniJet Pro Piston Injection Molding System has been used. The compound was placed in a chamber that had been heated to 120°C. After that, for 20 seconds the compound was molded with 700 bar pressure and was transferred into a mold heated to 40°C.

Yasuda's hot press machine converted the compound into a plastic sheet efficiently. On a stainless steel plate covered with a teflon sheet, as much as 3 g of the compound was placed. Two steps in the hotpressing process took place. First, the mixture was heated to 140°C without applying pressure for 5 minutes. Second, the compound was subjected for 3 minutes at a pressure of 20 MPa and 140 °C. After the hot-pressing process, the stainless-steel plate containing the plastic sheet was removed from the hot-press machine and left for 2 minutes, before removing the plastic sheet.

Thermal Properties Analysis

Table 1. Materials Formulation

Sample Codes	LDPE (g)	PE-g MAH (g)	Coconut Coir (g)
LMKK 10%	44.0	1.0	5.0
LMKK 20%	39.0	1.0	10.0
LMKK 30%	34.0	1.0	15.0
LMKK 40%	29.0	1.0	20.0

Mechanical Properties

The mechanical properties of plastic composites were examined using ASTM D-638 "Standard Test Method for Plastic Tensile Properties." The Shimadzu Universal Testing Machine (UTM) of type AGS-X 10kN was used for the test. Four samples were examined in each treatment with a 5 kN load cell, a 30 mm gauge length, and a 10 mm/min load speed.

UV Light Resistance Analysis

Plastic composite sheets were cut into 3 x 3 cm square samples and placed in a dark-color container box 100 x 33 x 20 cm in size and coated with aluminum foil. A 30-watt UV lamp was put inside the container box, and the samples were evaluated for 4 months (120 days), with observations on the 30th, 60th, and 120th days. After exposing the samples to UV light, we examined them using a Spectrophotometer UV-Vis Shimadzu 1800 to determine UV absorbance in the 400 - 200 cm⁻¹ frequency range. Additionally, we studied the functional groups of plastic sheets exposed to UV radiation using Fourier Transformed Infrared (FTIR) spectroscopy. The FTIR spectra of plastic sheet composite were collected using a Perkin Elmer Spectrum Two Spectrophotometer in the 4000 - 400 cm⁻¹ frequency range. The sample weight was also measured before and after UV exposure.

Differential Scanning Calorimetry (DSC) was used to evaluate the thermal properties of LDPE and coconut coir composites. A sample of 10 mg was required for the composite tests. DSC is an analytical technique for determining the difference in heat that enters a sample with comparison as a function of temperature. Thermal analysis was performed on LDPE-added coconut coir composite using DSC 4000 Perkin Elmer by heating and cooling with temperature ranges of (-20°C until 300°C) and (300°C until -15°C). Equation (1) was used to compute the degree of crystallinity (Xc) of the LDPE-added coconut coir composite:

$$X_c(\%) = \frac{\Delta H_m}{\Delta H_{m100\%}} \times 100 \quad (1)$$

At where:

Xc = DSC crystallinity percentage obtained.

ΔHm = Melting enthalpy variation as measured by the DSC.

ΔHm100% = Variation of melting enthalpy of a 100% crystalline polyethylene which is assumed to be 281 J*g⁻¹ (Cebe *et al.* 2017).

Biodegradability Analysis

The soil burial test was performed to determine sample biodegradability. *Lactobacillus* sp. and *Saccharomyces* sp. microbe consortia were added to humus soil. The soil media was conditioned for 5 days. Before being buried in a soil medium, plastic sheet samples (2 x 2 cm) were weighed to determine the initial weight. The plastic sheets were then buried at a depth of 3 cm in the soil medium. After burying the plastic sheet for 30 days, the surface and weight loss were examined.

Results and Discussion

Chemical Composition Analysis

The chemical composition of coconut coir from Malingping, Indonesia, is presented in Table 2. The average chemical composition of coconut coir ranges from 32 - 50% cellulose, 0.15 - 15% hemicellulose, and 30 - 46% lignin (Adeniyi *et al.* 2019). This study found that coconut coir waste raw material used for the composite manufacturing process (LMKK) contains moisture content, ash content, extractives content, holocellulose content, α-cellulose content, hemicellulose content, and lignin content of 8.52%, 2.27%, 4.78%, 24.77%, 9.97%, 14.8%, and 34.38%, respectively. The cellulose, and lignin contents of coconut coir are higher

than research result conducted by Puspaningrum *et al.* (2020). Coconut coir's habitat, maturation stage, and environmental factors may have an impact on the variations

in chemical composition of the material (Esmeraldo *et al.* 2010). In this study, it is desirable to know the percentage level of lignin in the coconut coir used.

Thermal Properties Analysis of Composite

The behavior in terms of crystalline and melting properties was examined by evaluating the structural changes in the composite with DSC. DSC analysis was performed to determine the amount of energy absorbed (endothermic phase) and energy released (exothermic phase) when samples at a certain degree of temperature increase were heat treated. As presented in Figure 2, the peak melting temperatures for neat LDPE, LMKK 10%, LMKK 20%, LMKK 30%, and LMKK 40% were 107.00°C, 107.19°C, 109.03°C, 106.38°C, and 106.70°C, respectively. According to the Technical Data Sheet, LDPE has a melting point of 108°C, and coconut coir according to has a lower melting point of about 79.93°C (Ichim *et al.* 2022).

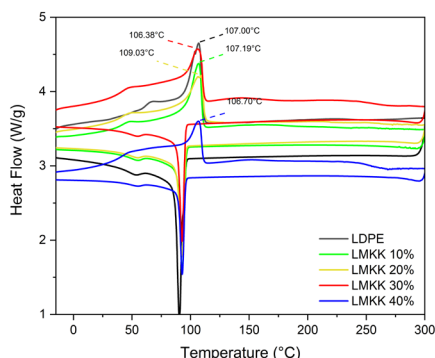


Figure 2. DSC Thermogram of LDPE and coconut coir composite.

Table 2. Chemical Composition Analysis of Coconut Coir

Chemical compositions (%)	Coconut Coir	
	This study	Puspaningrum <i>et al.</i> (2020)
Moisture	8.52	26.0
Ash	2.27	-
Extractives	4.78	-
Lignin	34.38	29.23
Holocellulose	24.77	21.07
α -cellulose	9.97	-
Hemicellulose	14.80	8.50

Table 3 lists the crystallinity values of LDPE-coconut coir composites. In general, the crystallinity of LDPE composites decreased with the addition of 20% and 40% coconut coir compared to the addition of 10% and 30% coconut coir in the control. This decrease could be due to an increase in the dynamic change of the entanglement due to the addition of higher charge content of coir into the LDPE making it difficult for the crystallization of LDPE (Kong & Hay, 2003). LDPE and coconut coir have different polarities, which can lead to voids at the interface of the matrix and fiber due to improper wetting. These voids can increase the crystallization temperature of the composite (92.82°C) when compared to neat LDPE (90.40°C).

Other results show that the addition of coconut coir to the composite causes a decrease in the enthalpy value in the cooling cycle of neat LDPE by (80.6021 J/g) compared to the addition of 40% coconut fiber to the composite by (39.9538°C). Similar research results were obtained by (Burhani *et al.* 2023) with their research using natural fiber fillers in the form of *Halymenia* sp. seaweed, and *Gracilaria verucosa* in HDPE matrices with bio-based coupling agents, which is coconut husk powder. The addition of fillers, coupling agents, crosslinking agents, and exposure to radiation,

temperature, or other materials can disrupt the crystal structure and change the material properties, where natural fibers used in the form of coconut husk powder are detected as nucleating agents that can increase the nucleation rate of crystallization in the composite (Burhani *et al.* 2023), disrupt the crystallization process, and result in inconsistent crystallinity performance (Hidalgo-salazar *et al.* 2020).

While in the cooling cycle, an exothermic peak on the curve associated with the crystallization temperature (T_c) appears. This phase represents the transition from amorphous to solid, the T_c point of the polymer loses its random chain arrangement, forms intermolecular bonds, and the polymer molecules become more ordered. As presented in Table 3, the addition of coconut coir can

Mechanical Properties Analysis of Composite

The effect of coconut coir on the mechanical properties of the composites was analyzed by tensile properties as described in Figure 3 and Figure 4. Some of its important characteristics include tensile strength, elongation at break, and elastic modulus. As reported in previous studies by

Naveen and Dharma Raju (2013), and Onukwuli *et al.* (2022), the addition of natural fiber hydrophilic filler in the form of coconut coir which is getting higher in the composite decreases the tensile strength of polyethylene plastic (Naveen and Dharma Raju 2013; Onukwuli *et al.* 2022). This

is due to poor interfacial adhesion between the hydrophobic matrix and the hydrophilic filler. In this study, the addition of 20% to 40% coconut coir caused a decrease in tensile strength values of up to 8.95% when compared to the control form of LDPE thermoplastic (Figure 3).

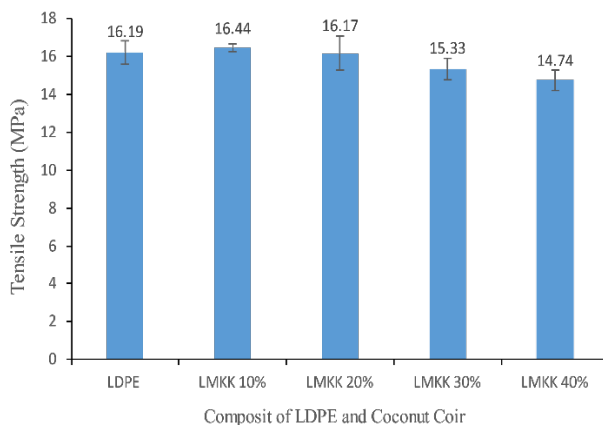


Figure 3 . Tensile Strength of composite.

Table 3. Thermal characteristics of composite.

Samples	T _m (°C)	ΔH _m (J/g)	X _c (%)	T _c (°C)	ΔH _c (J/g)
LDPE	107.00	71.7945	22.55	90.40	80.6021
LMKK 10%	107.19	72.1710	25.68	92.82	62.2030
LMKK 20%	109.03	65.5763	23.34	92.47	56.3918
LMKK 30%	106.38	76.3985	27.19	92.62	54.6016
LMKK 40%	106.70	58.7172	20.89	92.80	39.9538

However, the addition of coconut coir up to 10% gives an increase in tensile strength of 1.54%, where Maleic anhydride grafted polyethylene (PE-g-MAH) as a compatibilizer can help the distribution of external stress between the matrix and filler effectively in composites with 10% filler loading. The tensile strength of LDPE and coconut coir composites in this study is higher than that of another study (Bukar *et al.* 2022) that used coconut fiber in LDPE composites (Bukar *et al.* 2022). Filler size affects the mechanical properties of composites. Smaller filler sizes can be more evenly distributed on the LDPE matrix, resulting in better interfacial adhesion and higher tensile strength composites.

The addition of coconut coir into LDPE, not only affected the tensile strength of the composites but also affected the elongation at break and elastic modulus of the composites. As presented in Figure 4, the addition of 40% coconut coir into the LDPE matrix, resulted in composites with a more significant increase in tensile elastic modulus compared to the other composites and the LDPE thermoplastic, with an increase of 79.48%. Coconut coir affected the stiffness and rigidity of the LDPE composites, indicating that external stresses were transferred from the LDPE to the stiffer coconut coir. The modulus of the LDPE composite increased with 40% coconut coir content as the coconut coir exhibited the ability to assist the matrix resistance to deformation when applying load.

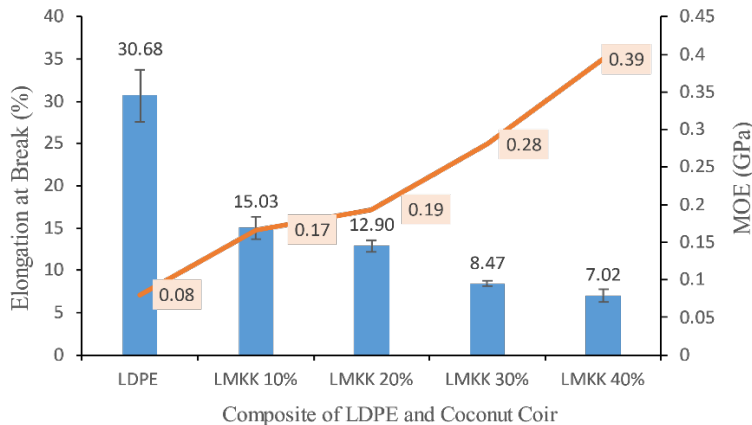


Figure 4. Elongation at break and modulus of elasticity of composite.

In contrast to the trend revealed by the modulus of elasticity of the composite, the elongation at the break of the composite tends to decrease. The use of 10% coconut coir resulted in a composite with a 51.01% elongation at break. Higher coconut coir content in LDPE composites, up to 40%, reduced elongation at the break by 77.11%. Fiber loading reduced the ductility of plain thermoplastic LDPE while increasing its stiffness (Bukar *et al.* 2022). Additionally, because the polarities of LDPE and coir are different, that may be voids at the interface of the matrix and coconut coir as a result of improper wetting of the matrix and coir. Therefore, when subjected to tensile loads, coir particles might cause LDPE molecules to migrate (Brahmakumar *et al.* 2005).

UV Light Resistance of Composite

Testing for UV-VIS absorbance was used to analyze how the addition of coconut coir changed the optical characteristics of LDPE sheets. A UV-Vis spectrophotometer was used to conduct the measurements, which covered the wavelength range of 200-400 nm. The curves show the absorbance of UV radiation by sheets made of LDPE and coconut coir. Lignin in coconut coir has a chromophore functional group that contains many double bonds. These double bonds contain sigma bonds, pi bonds, and non-bonds (Sari *et al.* 2022) so they can absorb UV light with a broad spectrum between 250 to 400 nm (Sadeghifar and Ragauskas, 2020). The UV radiation is split into four different areas of the spectrum, including vacuum UV, UVC (200–280 nm), UVB (280–315 nm), and UVA (315–400 nm) (Blaustein and Searle 2013).

Figures 5, 6, and 7 show that the plastic sheet composites of LDPE and coconut coir absorb ultraviolet light in the range of 200–300 nm after 30, 60, and 120 days of exposure to UV light, indicating the absorbance of UVC and UVB. In comparison to the other plastic sheet composites and the trimmed LDPE, the plastic sheet composites containing

40% coconut coir absorbed more UV light intensity after 30 days of UV exposure (Figure 5).

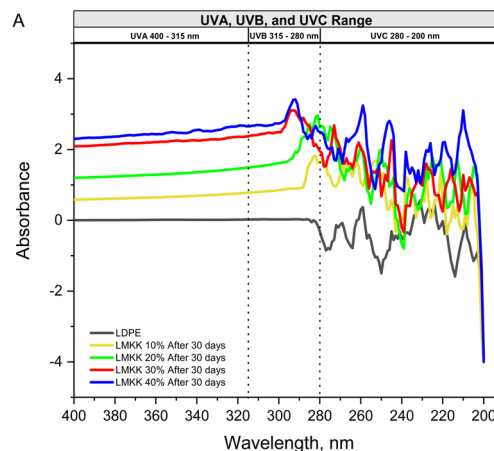


Figure 5. UV-Vis absorbance curves of plastic sheet composite after 30 days.

After 60 days of exposure to UV light, the plastic sheet composites revealed that the higher the coconut coir content in the LDPE plastic sheet composites, the higher the intensity of UV light absorbed, and the LDPE plastic sheet composites containing 40% coconut coir indicated UVA absorbance intensity by absorbing ultraviolet light in the range of 315-400 nm (Figure 6). While neat LDPE produced a negative curve against UV absorbance, showing that neat LDPE could not absorb UV after 30 days, 60 days, and 120 days of exposure to UV light.

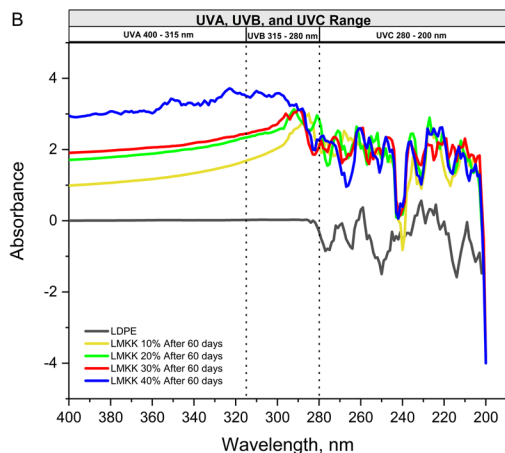


Figure 6. UV-Vis absorbance curves of plastic sheet composite after 60 days.

Based on the UV light absorption analysis, the composite plastic sheet containing 40% coconut coir (LMKK 40%) showed good UV light absorption capabilities (Figure 7). This suggests that when added to LDPE, the lignin in coconut coir can help absorb UV radiation. The 40% LMKK curve in Figure 5 exhibits a peak at roughly 280 nm, demonstrating that 40% LMKK can absorb UVC and UVB. The composite containing 40% coconut coir (LMKK 40%) demonstrated a dominant UVA absorbance intensity among other composites at a peak around 315 nm, where UVA ultraviolet radiation can penetrate directly into polymeric materials and cause photochemical degradation due to a wider wavelength intensity than other ultraviolet radiation. Furthermore, a peak at about 225 nm occurred in the curves of all the composites studied in this work. This suggests that the composite plastic sheet containing coconut coir may absorb UVC rays.

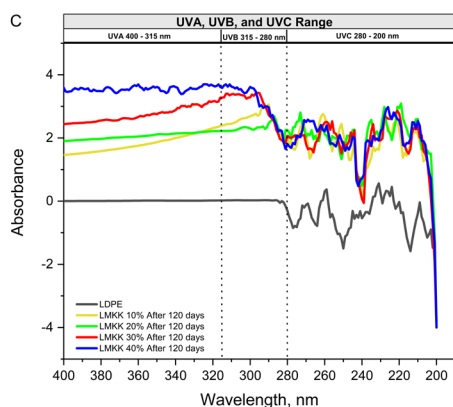


Figure 7. UV-Vis absorbance curves of plastic sheet composite after 120 days.

Table 4 provides a breakdown of the percentage of weight loss in plastic sheet composites after exposure to UV light. The greater the volume of coconut coir to be present in LDPE plastic sheet composites, the more resistant they are to UV light exposure and the less amount of weight degradation is caused by UV light. The composite with 40% coconut coir (LMKK 40%) exhibits the maximum UV light absorption intensity and the least amount of weight degradation (24.89%), making it the composite that is most resistant to UV exposure. Nevertheless, the plastic sheet composite with the lowest coir content (LMKK 10%) displayed the highest rate of weight deterioration brought on by UV light, at 43.66%.

Observations of the color and shape of the sheet samples before and after exposure to ultraviolet light are also recorded in Figure 8. Before exposure to ultraviolet light, the color of the sheet samples looked similar to the color of the composite that had been formed, and the shape was still normal and the texture was elastic. After 30 days of exposure to ultraviolet light, the color of the sheet sample began to fade, the shape was curved unusually, and the texture began to harden. On the 60 days of exposure to ultraviolet light, the color of the sheet sample faded and turned yellow, the shape became more curved, and the texture became brittle. After 120 days of exposure to ultraviolet light, the color of the sheet sample was very faded and yellow, the shape was very curved, and the texture was very brittle. The process of yellow discoloration of the sheet samples is referred to as photooxidation, which occurs when the polymer chains degrade due to interaction with oxygen and UV light.

Natural fibers contain photodegradable components such as cellulose, hemicellulose, and lignin. According to studies, chromophoric functional groups are formed when lignin undergoes photoinduced degradation into water-soluble reaction products during natural fiber weathering under UV exposure (Hon, N.-S and Shiraishi 2000). The degradation is due to lignin absorbing UV light through its hydroxyl groups, carbonyl groups, and double bonds. Further study on the effect of UV light exposure on the plastic sheet composite was carried out by functional group analysis by Fourier transform infrared spectroscopy in the wave number range from 4000 to 400 cm^{-1} .

FTIR was used to study the chemical structure changes between neat LDPE and LDPE composite plastic sheets with varying coconut coir content. The spectra of neat LDPE, Maleic anhydride grafted polyethylene (PE-g-MAH), and coconut coir are presented in Figure 9. Meanwhile, LMKK 10%, LMKK 20%, LMKK 30%, and LMKK 40% after exposure to UV light for 30, 60, and 120 days, are presented in Figures 10, 11, and 12.

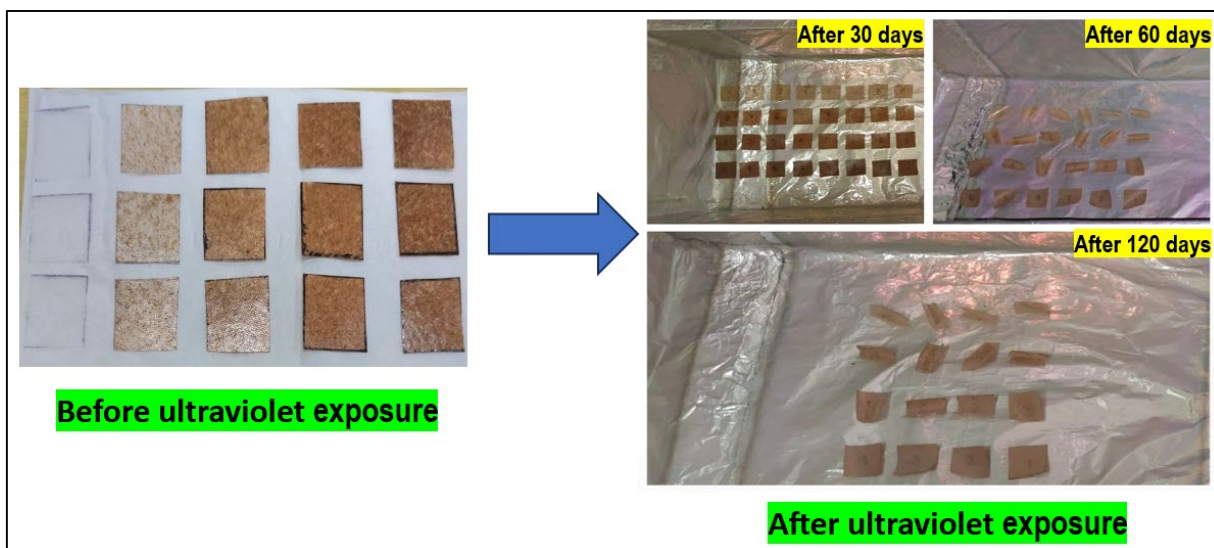


Figure 8. Samples before and after exposure to ultraviolet light.

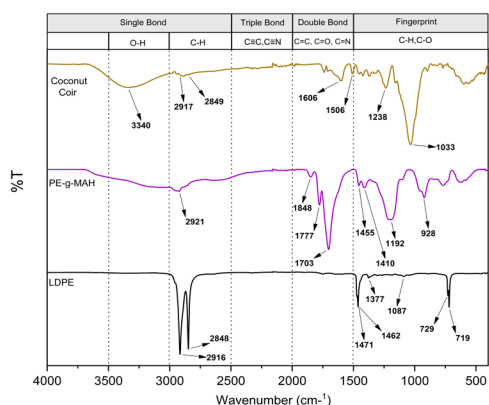


Figure 9. Infrared transmittance curves of LDPE, PE-g-MAH, and coconut coir.

The FTIR spectrum of neat LDPE shows a characteristic, the peaks at 2916 and 2848 cm^{-1} correspond to asymmetric and symmetric C-H stretching bands,

respectively. The peaks observed at 1471 cm^{-1} , 1462 cm^{-1} , and 1377 cm^{-1} are usually associated with bending vibrations of CH_2 and CH_3 groups in the polymer chain (Ashraf 2014; Gulmine *et al.* 2002). Maleic anhydride grafted polyethylene (PE-g-MAH) shows a spectrum strong intensity band at 2921 cm^{-1} is characteristic of CH_2 stretching vibrations in the polyethylene segment of the copolymer. In particular, the peak at 1848 cm^{-1} is due to the asymmetric stretching vibration of the $\text{C}=\text{O}$ bond, while the peak at 1777 cm^{-1} is due to the symmetric stretching vibration of the same bond (Bouaffif *et al.* 2008; Vázquez Fletes and Rodrigue 2021). Coconut coir shows a large and broad spectrum peak in the range of 3340 cm^{-1} , corresponding to the vibration of hydroxyl (OH) groups. The spectrum of coconut coir powder reveals bands with corresponding Guaiacyl (G) and Syringyl (S) characteristic absorption at 1238 cm^{-1} and 1033 cm^{-1} , respectively. The peak at 1033 cm^{-1} , in particular, demonstrates lignin C-H out-of-plane distortion (Jose *et al.* 2017).

Table 4. Plastic Sheet Composite's weight after UV exposure test.

Sample Codes	Sample weight (g)				%wt degradation due to UV light
	Initial	30 days	60 days	120 days	
LMKK 10%	0.2224	0.2170	0.2000	0.1253	43.66
LMKK 20%	0.2244	0.2191	0.2035	0.1625	27.58
LMKK 30%	0.2395	0.2357	0.2202	0.1793	25.13
LMKK 40%	0.2282	0.2247	0.2095	0.1714	24.89

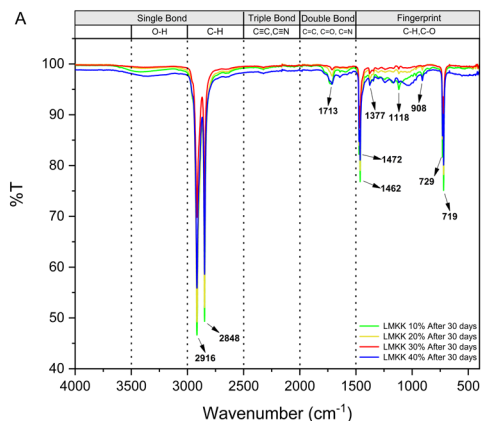


Figure 10. Infrared transmittance spectra after 30 days.

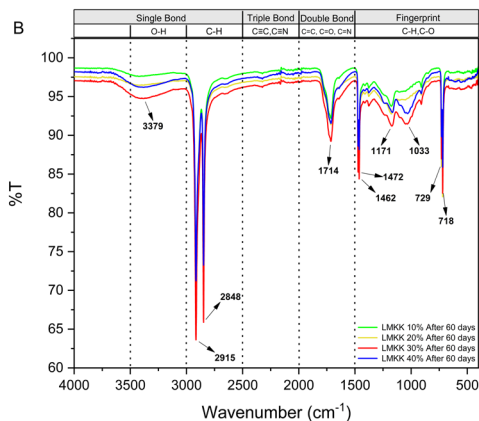


Figure 11. Infrared transmittance spectra after 60 days.

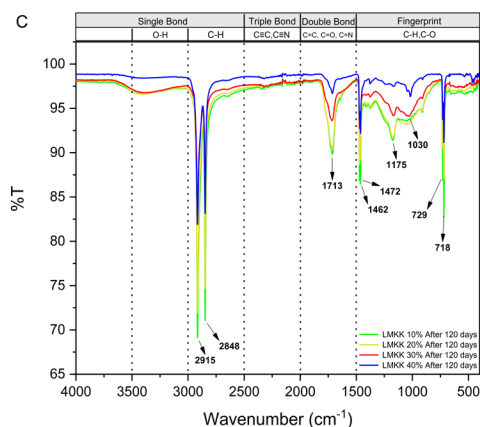


Figure 12. Infrared transmittance spectra after 120 days.

The spectra of plastic sheet composites after 30, 60, 120 days (Figure 9, 10, and 11) of UV exposure contain characteristic peaks at 2916-2848 cm^{-1} (CH and CH_2 stretching), 1713 cm^{-1} (C=O stretching), 1472-1462 cm^{-1} (CH_2 bending), 1377 cm^{-1} (bending vibrations of CH_2 and CH_3), 1175-1118 cm^{-1} (C-O-C stretching vibration), 1033-1030 cm^{-1} (C-O stretching), 908 cm^{-1} (bending vibrations of CH_2 and CH_3), and 729-718 cm^{-1} (bending deformation of C-H). After 60 days of UV exposure, there is a peak detected at 3379 cm^{-1} , which indicates that there are O-H stretching vibrations associated with Al replacing Si (OH(Al)) (Suzuki and Nakashima 1999). The appearance of C=O (carbonyl group) peak intensity is due to the reaction between LDPE and coconut coir. In addition, the characteristic peak of coconut coir lignin disappeared in the plastic sheet composites with a longer duration of UV light exposure. This may be due to the change in lignin structure after absorbing UV light.

Biodegradability Analysis of Composite

The biodegradability of LDPE and coconut coir plastic sheet composites was investigated by measuring weight degradation after a soil burial test. Table 5 displays the weight loss measurements following the soil burial test. After 30 days of burial in soil, the weight loss of all plastic sheet composites and the control LDPE thermoplastic differed by 0.57% - 4.04%. Normally, the amount of coconut coir used influences the percentage weight loss of the composite following the soil burial test. The findings of the 30-day biodegradation test revealed a distinct trend connected to the amount of coconut coir in the composite. The biodegradability test for 30 days revealed that the weight of the composite plastic sheet containing coconut coir was significantly reduced. In this study, the weight decrease of the composite plastic sheet containing 40% coconut coir (LMKK 40%) was the highest compared to the other composites and the LDPE thermoplastic control, which amounted to 4.04%. When compared to LDPE thermoplastic, the bigger the proportion

of coconut coir in the composite, the more organic matter that is easily destroyed by microorganisms.

The use of LDPE, a thermoplastic made from petroleum in plastic mulch, which can not decompose naturally by the end of its use, was replaced partially by biomass of coconut coir, in this study. A 40% coconut coir additive can increase the biodegradability of LDPE plastic and aid in UV light absorption. However, because LDPE is a petroleum-based thermoplastic, microorganisms in the soil cannot decompose it quickly. Coconut coir, an organic

substance, contributes to the biodegradability of the plastic composite described above. If left in the soil, the LDPE-coconut coir composite can partially biodegrade, particularly the coconut coir, but it also leaves behind fragmented LDPE, which has the potential to produce microplastic waste. Therefore, more study is required to create composites using coconut coir and biodegradable bio-based polymers. This will produce a plastic composite for mulch that is genuinely eco-friendly and biodegradable.

Table 5. Plastic Sheet Composite's weight after biodegradability

Sample Code	Initial Sample weight (g)	30 days	
		Sample weight (g)	degradation (%)
LDPE	0.0877	0.0872	0.57
LMKK 10%	0.0906	0.0900	0.66
LMKK 20%	0.1325	0.1306	1.46
LMKK 30%	0.1159	0.1134	2.19
LMKH 40%	0.1081	0.1038	4.04

Conclusions

The addition of coconut coir tends to decrease the enthalpy of melting, the enthalpy of crystallization, and crystallinity values of the composites when characterized by its thermal properties. A decrease in the tensile strength of the composites also occurred. However, in the presence of Maleic anhydride grafted polyethylene (PE-g-MAH), the addition of 10% coir was sufficient to increase the tensile strength of the composites. The addition of stiff coconut coir increases the stiffness and reduces the elongation properties of the composite. The plastic sheet composite containing 40% coconut coir (LMKK 40%) showed a good ability to absorb UVC, UVB, and UVA rays after being exposed to UV light for 120 days and only decomposed by 24.89% compared to the plastic sheet composite containing 10% coconut coir (LMKK 10%) which decomposed up to 43.66%. The results of the biodegradation test using the soil burial test method showed that the LMKK 40% composite could degrade by 4.04% after being buried for 30 days. This study demonstrates the potential of coconut coir to influence various aspects of LDPE mulch properties and show its usefulness in improving UV shielding characteristics.

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