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SYNTHESIS AND CHARACTERIZATION OF POLYPROPYLENE BLENDS FROM RECYCLED PLASTIC AND CASSAVA DREGS

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ABSTRACT

A composite membrane of polypropylene (PP) mixture from recycled plastic and cassava dregs (CD) by external mixer has been synthesized and characterized. XRD results obtained cassava dregs have a monoclinic structure and a size of 200 mesh. The best mechanical properties were obtained in the mixture (PP/CD) (94/6) % wt, the tensile strength of 0.98 MPa, Young's Modulus of 0.14 MPa, and strain of 6.78%. SEM results obtained that the surface on the mixture (98/2) % wt is smoother, and the mixture is more evenly distributed. The addition of cassava dregs to polypropylene from recycled plastic influences its mechanical properties, where the tensile strength, Young's modulus, and strain increase.

Keywords: Synthesis, Polypropylene, Recycling, Cassava Dregs, Mechanical Properties.
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INTRODUCTION

The development of polymer-based composite materials is gaining more and more attention, especially in finding alternative materials that are more environmentally friendly and sustainable. Polypropylene (PP), one of the most widely used thermoplastic polymers, has good mechanical properties, such as high tensile strength, chemical resistance, and easy processability.[1] However, for applications that require higher mechanical resistance, polypropylene often requires improved properties through the addition of fillers. One natural filler that has attracted attention in recent years is cassava dregs, a waste from the cassava processing industry that is abundant in tropical countries such as Indonesia. One of the main challenges in using natural fibers such as cassava dregs as fillers is the compatibility issue between the fibers and the polypropylene matrix. Due to the hydrophilic nature of cellulose fibers and the hydrophobic nature of polypropylene, there is often poor adhesion between the two. This can lead to a decrease in the mechanical properties of the composite if the fibers are not evenly distributed or do not bond strongly with the matrix. To solve this problem, several studies have suggested using compatibility agents or fiber surface modification to improve the adhesion between the fiber and the polymer matrix. Research by Marin showed that using binding agents such as maleic anhydride grafted polypropylene (MAPP) can improve the mechanical properties of composites containing natural fibers.[2] This bonding agent helps improve the interaction between cellulose fibers and polypropylene matrix, thereby increasing the tensile strength and elastic modulus of the composite. The results of this study indicate that with proper selection of binding agents, the development of polypropylene-based composites with natural fiber fillers such as cassava dregs has great potential for industrial applications.[3] In addition to compatibility issues, the composite manufacturing process also plays an important role in determining the final mechanical properties of the material. The parameters of mixing temperature, mixing time, and molding pressure can influence the distribution of fibers in the matrix and the mechanical properties of the composite.[4,5] For example, a mixing temperature that is too high can cause thermal degradation of cellulose fibers, while a too-low temperature can cause uneven mixing. Therefore, proper setting of process parameters is essential to produce composites with optimal mechanical properties.[6]

Research conducted by Nurazzi to determine the effect of cassava pulp fiber ratio on the mechanical properties of polypropylene composites. Their results showed that increasing the fiber content in the composite can increase the tensile strength up to a certain limit, after which the mechanical properties tend

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to decrease due to fiber agglomeration, which disrupts the fiber distribution in the matrix. This research emphasizes the importance of determining the optimal fiber ratio to achieve the desired mechanical properties.[7] The use of cassava dregs as a filler material in polypropylene composites has several significant advantages. Firstly, the use of natural materials such as cassava dregs helps to reduce reliance on synthetic fillers that are less environmentally friendly. Cassava dregs can be used as a filler in biodegradable plastic materials.[8] Secondly, the utilization of agro-industrial waste supports the concept of circular economy by converting waste into value-added products. Natural fiber-based composites have great potential to replace conventional composite materials in a variety of applications, including in the automotive, construction, and consumer products industries.[9,10] This study aims to examine the mechanical properties of polypropylene composites reinforced with cassava dregs fibers, with a focus on improving tensile strength, elastic modulus, and resistance to mechanical loads. Through this approach, it is expected to obtain composite materials that not only have superior mechanical properties but are environmentally friendly and sustainable. This research makes an important contribution to the development of greener and more economical composite materials and encourages the use of natural materials in industrial applications.

EXPERIMENTAL

Material and Methods

The materials used in this research are cassava dregs, polypropylene from recycled plastic, and aquadest pro-analysis. The cassava is grated and squeezed, and 1 kg of cassava dregs is taken. Dry the cassava in the sun for 2 days. Then, after drying, the cassava is crushed so that the resulting cassava dregs powder is finer and filtered using a 200-mesh sieve. Provide 3 kg of plastic waste made from polypropylene and then clean it using clean water. Dry it in the sun for 1 day and then cut it into small pieces and put it in a container that has been heated and stirred until it melts. Then, it was allowed to stand for 30 minutes and then removed from the container. The dried plastic is pulverized again by crushing and taking the powder. Try to use tools that do not contaminate the plastic material, such as rusty iron, wood, and so on, and avoid mixing dust or sand into the plastic powder. PP plastic powder and cassava dregs powder were weighed based on the composition variations of 0%, 2%, 4%, 6%, and 8% for cassava dregs powder with a total mass of 30 grams. After weighing according to the composition, the two powders were put into the mold container and stirred first before being put into the furnace. After mixing evenly, insert the mold that has been filled with composite material into the furnace. The time and temperature settings used in the furnace are the temperature rise time is 15 minutes, the holding time is 30 minutes, and the temperature used is 145°C, then cooled naturally. After that, it was characterized by XRD, SEM, and mechanical tests with ASTM D638 type V.

RESULTS AND DISCUSSION

The synthesis of cassava dregs (CD) with a size of 200 mesh, polypropylene (PP) from recycled plastic, and a mixture of both (CD and PP) has been characterized by X-ray diffraction obtained diffractogram as shown in Fig.-1.

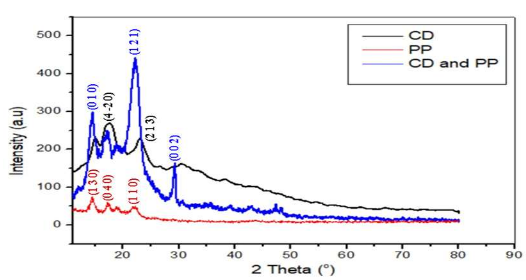

Fig.-1: XRD diffractograms of Cassava Dregs (CD), Polypropylene (PP) from recycled plastic, and a mixture of PP and CD

Figure-1 shows the XRD diffractograms of cassava dregs, polypropylene from recycled plastic, and a mixture of both. The peaks that occur in cassava dregs at 2θ angles of 14.60°, 17.46°, and 23.10° with a monoclinic structure are to the research of Jeencham.[11] In this diffraction peak has an index miller as follows (4 -2 0), and (2 1 3). The peaks that occur in polypropylene from recycled plastic at 2θ angles are 14.52°, 17.27°, and 22.12° with monoclinic structure and peak has an index miller as follows (1 3 0), (0 4 0), and (1 1 0). The peaks that occur in the mixture of polypropylene from recycled plastic and cassava dregs at 2θ angles are 17.06°, 21.16°, and 29.11°. The highest peak at 2θ = 21,16° corresponds to a distance of 4.0622 Å. The resulting crystal system is orthorhombic with index miller as follows (0 1 0), (1 2 1), and (0 0 2) and lattice parameters a = 8.0200 Å, b = 10.3500 Å, and c = 10.4500 Å. After mixing, it can be seen that there are diffraction patterns that reinforce each other or maximum interference where there are higher peaks, and there is also minimum interference or mutual negation where there are smaller peaks and even some become absent. This can occur because the constituent substances of these two materials react with each other in a strengthening and weakening manner. These peaks are the cellulose structure of cassava dregs.[12] The tensile test results of cassava dreg blends of 0%, 2%, 4%, 6%, and 8% with polypropylene from recycled plastics are shown in Fig.-2.

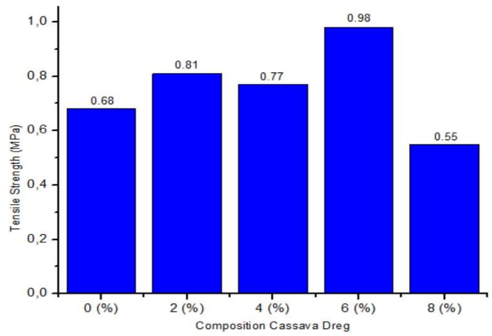

Fig.-2: Tensile Strength with Composition Cassava Dreg

The maximum tensile strength was obtained in the mixture of polypropylene from recycled plastic with cassava dregs (94/6) %, namely 0.98 M. Pa, while the minimum tensile strength was obtained in the mixture (92/8) %, namely 0.55 M.Pa. So, this cassava dregs mixture can increase the tensile strength of recycled plastic by 44.12%. This shows that the addition of cassava dregs has a good enough impact to increase the tensile strength of the composite. The addition of cassava dregs in this composition provides a high binding force between cassava dregs and polypropylene. This result is better than research by Rahim and Musta with a tensile strength of 0.22 MPa at a composition of 1: 2.5.[13] Factors that affect tensile strength depend on various factors such as filler content, particle size, and dispersion.[14,15] Figure-3 shows the relationship between Young's modulus and the composition of cassava dregs.

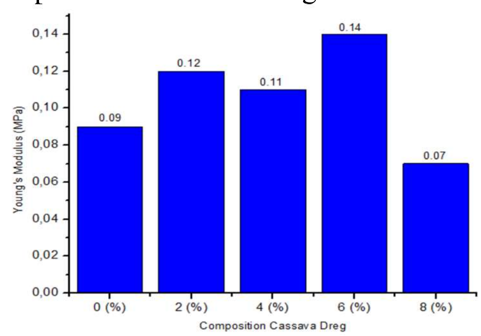

Fig.-3: Young’s Modulus with Composition Cassava Dreg

Figure-3 shows the best Young's Modulus value is the composition of polypropylene from recycled plastic with cassava dregs (94/6) % of 0.14 M.Pa. This result is greater than the Young's modulus of the pure PP sample (without cassava dregs mixture), which obtained a Young's modulus value of 0.09 M.Pa. These results are from research by Rafid on recycled PP with cassava pulp filler, which obtained the highest Young's modulus value of 2 M.Pa with a 3% filler composition, this shows that the addition of cassava dregs has a good enough impact to increase the Young's modulus value of the composite.[16]

Figure-4 shows that the largest elongation at break is the polypropylene composition of recycled plastic with cassava dregs (94/6) % at 6.78%. This elongation at break also exceeds the elongation at break value of pure recycled PP, which obtained an elongation at break value of 6.71%. From this mixture of cassava dregs, the results are not so different, but this shows that the addition of 6% cassava dreg filler has a good effect on increasing the elongation at the break value of PP thermoplastic. This result is by research by Zaroh, which obtained an elongation at a break of 14.27% with the presence of cassava dregs filler of 50% wt. [17]

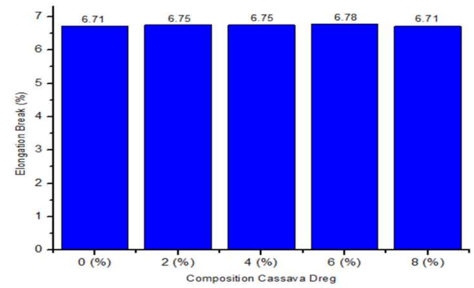

Fig.-4: Elongation Break with Composition Cassava Dreg

The SEM results of the mixed membrane of cassava dregs and PP from recycled plastic can be shown in the following Fig.-5. Figure-5 shows the surface morphology of the membrane with a magnification of 6000 X for various mixtures of cassava dregs. In Fig.-(5a), it can be seen that there are cavities or pores, which shows that the recycled plastic formed is less homogeneous, Fig.-(5b) shows a mixture of cassava dregs with PP from recycled plastic is more homogeneous than Fig.-(5c) and (5d). The surface of the membrane is less flat or wavy; this can occur due to a less homogeneous mixing process and a less thorough manufacturing process, both stirring, unstable temperature, and poor drying process.[18] From the picture, it is obtained that the more the percentage of cassava dregs is added, the more uneven the surface looks.

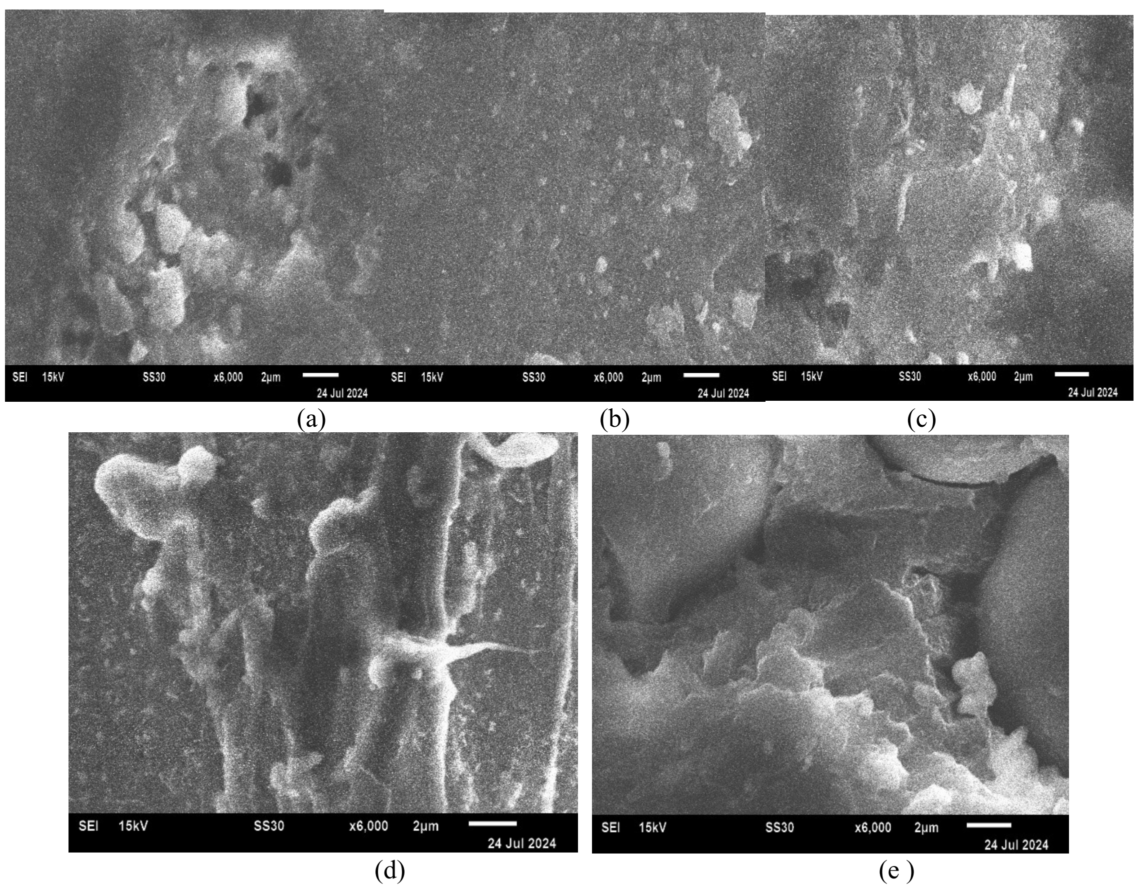

Fig.-5: SEM Results of PP Membrane from Recycled Plastic Mixed with Cassava Dregs with 6000 X Magnification (a) Cassava Dregs Mixture (CD) 0%, (b) CD Mixture 2%, (c) CD Mixture 4%, (d) CD Mixture 6%, (e) CD Mixture 8%.

CONCLUSION

The synthesis and characterization results obtained cassava dregs with a monoclinic structure with a size of 200 mesh. The best mechanical test results of polypropylene blends from recycled plastics and cassava dregs were obtained at (94/6) % wt sequentially, namely tensile strength of 0.98 M.Pa, Young's Modulus of 0.14 M.Pa and strain of 6.78 %. SEM results showed that the surface of the (98/2) /% wt mixture was smoother, and the mixture was more evenly distributed with fewer pores. The addition of cassava dregs to polypropylene from recycled plastic influences its mechanical properties, where the tensile strength, Young's modulus, and strain increase.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

All the authors contributed significantly to this manuscript, participated in reviewing/editing, and approved the final draft for publication. The research profile of the authors can be verified from their ORCID ids, given below:

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