

PAPER • OPEN ACCESS

## Characterization of mechanical properties polypropylene composites film filled with corncob as reinforcement

To cite this article: A Gunawan *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **711** 012023

View the [article online](#) for updates and enhancements.

### You may also like

- [What is the important factor affecting microwave absorption performance in corncob-derived carbon/Ni composites?](#)  
Zhong Li, Hongyan Li, Tongpan Ying et al.
- [Physico-Mechanical Characterisation of Fuel Briquettes made from Blends of Corncob and Rice Husk](#)  
H. A. Ajimotokan, S. E. Ibitoye, J. K. Odusote et al.
- [Effect of biomass ratio on co-firing of biomass with coal on pozzolanic properties](#)  
Darin Taweetamnusin, Monpilai Narasingha, Karn Panasupamassadu et al.



The Electrochemical Society  
Advancing solid state & electrochemical science & technology

## 241st ECS Meeting

Vancouver, BC, Canada. May 29 – June 2, 2022



ECS Plenary Lecture featuring  
**Prof. Jeff Dahn,**  
**Dalhousie University**



Register now!



# Characterization of mechanical properties polypropylene composites film filled with corncob as reinforcement

**A Gunawan, H Pasaribu, T Lauzia, Y Syamsuddin, L Meiriza, S Kamaruzaman, and S Aprilia\***

Chemical Engineering Department, Engineering Faculty, Universitas Syiah Kuala, Jln. Tgk. Syech Abdul Rauh, Darussalam, Banda Aceh 23111, Indonesia

\*Corresponding author's e-mail: [sriapriliah@unsyiah.ac.id](mailto:sriapriliah@unsyiah.ac.id)

**Abstract.** The use of materials in cars has changed significantly over the last few decades. Polypropylene is the top choice for automotive industry players because it has unparalleled flexibility, affordable cost and performance balance that successfully replace steel and other plastics as the material for the manufacture of motor vehicles. However, since the raw material of polypropylene is derived entirely from petroleum and natural gas which can be discharged at any time. Also, its use is not environmentally friendly which need an action to overcome one of them by developing composite technology. The purpose of this study was to know the relation of mass fraction of corncob fiber into polypropylene composites on tensile strength and composite morphology. Corncobs reinforce in polypropylene are 10, 20, 30 and 40% by weight. XRD analysis investigated at 2 $\theta$  the crystalline part of corncob at 21°. The functional group of Si-OH and Si-O-Si were analyzed at wavelength 1030 and 1100 cm<sup>-1</sup>. The fracture surface of composite shows the crack effect of particle loading. Polypropylene composites filled with corncob increased in tensile strength and decrease in elongation at break with the increase of corncob particle loading.

## 1. Introduction

The non-renewable availability of materials such as petroleum is decreasing, so renewable material is very promising to be used as a green composite material. Renewable materials such as plants, agriculture, plantations are materials that could replace material dependence on petroleum. However, this non-renewable material must not be replaced because the need of food for life continues. But this non-renewable material cannot compete with the need for food for continuity. Therefore, agricultural solid waste disposal can be used as an alternative as a composite material. Kind of agriculture waste that commonly used as reinforcement are bagasse, corn cobs, rice waste (straw, rice husk and ashes), coconut shells, coconut skin and others. This source is a material that contains lignocellulose. Many researchers have conducted to use agriculture solid waste to study biocomposites as reinforcement as many applications.



Today, with the advancement of materials technology has created the need for a single combination of ingredients into composite materials as desired. With the presence of fibers or particles scattered in the matrix, it will create new materials that have properties that are very suitable for the desired applications. The use of agricultural solid waste containing low-cost and lightweight fibers offers the potential to replace most of the glass and mineral fillers in the automotive interior and exterior [1]. Lately, fiber for plants composites as reinforcement with thermoplastic and thermoset polymer matrices have been included by European car manufacturers and suppliers for many objects such as headliners, seat backs, package trays, dashboards, door panels and interior parts [2] [3]. In selecting materials for automotive applications, physical and mechanical properties and the resultant product reliability, feasibility and low costs are needed, and also ability to design and optimize to effectively reduce component weight [4].

The most common system in automotive is thermoplastic polypropylene, particularly for nonstructural components. The used of polypropylene because of favored due to its low density, excellent process ability, mechanical behavior, electrical properties and good dimensional stability and impact strength [1]. Agriculture waste as reinforcement in polymer matrices could be alternative for automotive applications because of low cost and abundant, which can decrease all manufacturing costs and increase stiffness of the materials. Corncob can be use as one of agriculture waste to be alternative lignocellulosic filler such as cereal straw, flax straw, cornstalks, bagasse and rice husk [5]. However, corncob can be used for material composites, can follow a development market and can lead to a new market opportunity for these surplus inexpensive field crop leftovers. In addition, corncob has an additional advantage because it is easy to process and it does not collide with the worldwide food stock and it is generally considered as an agriculture waste [6].

In this study, film polypropylene composites were prepared by adding corncob particle fillers. The aim of this study was to investigate the influence of particle loading on morphology and mechanical behavior. Morphology of the composites including the corncob particle filler was investigated for the functional group by FTIR, degree of crystalline by XRD, fracture surface of film composites by SEM. Mechanical properties of film were analyzed by tensile strength and elongation at breaks.

## **2. Materials and Methods**

The raw material was corncob that was used as particle fiber filler in polymer composites. Polypropylene was used as matrix which has density of  $0.9 \text{ g/cm}^3$ , melt flow index of 3.5 g/10 minute. Xylene was used as solvent.

### *2.1. Preparation of Particle Filler*

Corncob fiber was washed with distillate water to remove any dirt on the surface of the corn cobs, then was dried under sunlight. Then the corncobs were dried into oven at  $85^\circ\text{C}$  for 24 hours. Dried corncobs were crushed by pounding until decrease of size. The corncobs were put into a ball mill as much as 100 grams for 20 hours until the size became powder. Then the corn cobs were sifted with a 200-mesh sieve size so that the corncobs were smooth and dry.

### *2.2 Preparation of Film Composites*

Polypropylene composite was prepared by dissolving polypropylene using xylene at  $190^\circ\text{C}$  and then the filler loading was added with variation concentrations of 10 wt%, 20 wt%, 30 wt%, 40 wt% and 50 wt%, and then continue mixing until the particle fillers appear to have spread evenly in the solution. The solution was casted on flat stainless steel at  $150^\circ\text{C}$ .

### 2.3 Characterization of Film Composites

**2.3.1 XRD Analysis.** X-Ray diffraction analyses were conducted to determine the crystalline of the particle filler. XRD were used by an X-Ray diffractometer with measurement condition are 40 kV and current 30 mA. The range of scattering angle ( $2\theta$ ) was from  $10^\circ$  to  $80^\circ$  with the scan rate of  $10^\circ/\text{min}$ .

**2.3.2 FTIR Analysis.** FTIR analysis employed to characterize the functional groups both of particle fillers and film polypropylene composites. The analysis was used by using a FTIR spectroscopy (Shimadzu FTIR Spectrometer). The sample was put into the Nicolet Avatar FTIR Spectrometer. Spectra were recorded in the range  $4000\text{--}400\text{cm}^{-1}$ .

**2.3.3 SEM Analysis.** To determine fracture surface on polypropylene composites was analyzed by SEM. SEM analysis was performed using Hitachi TM300 tool. The sample is attached to a holder then in a thin layer of platinum (2.5-2.8 nm thick) in a vacuum state.

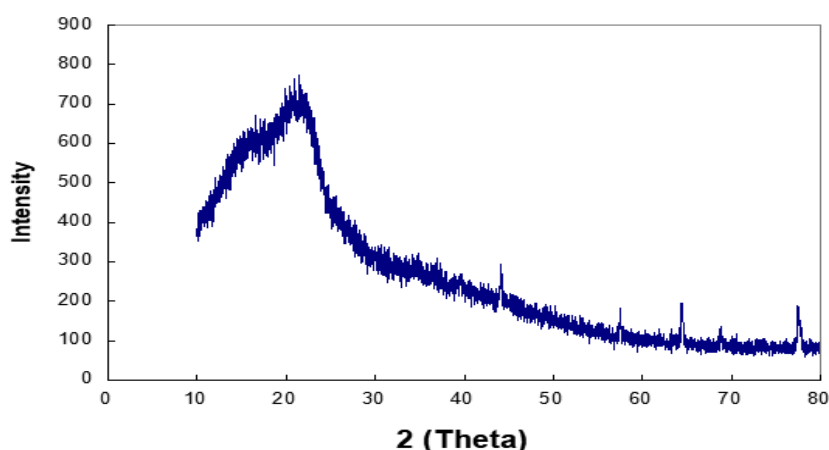
### 2.4 Mechanical Test

Tensile strength and elongation at breaks were performed using the HT-8503 Computer Type Universal Testing Machines device. Mechanical test in this study includes tensile strength and elongation at breaks. Mechanical test followed the ASTM 638.

## 3. Result and Discussion

### 3.1 Crystalline of Particle Filler

The XRD patterns of particle filler of corncob that pass the sieved 200 mesh of size shows in Figure 1. The two patterns are close to each other, where both are seen crystalline peak at  $2\theta$  at  $16^\circ$  and  $22^\circ$ . The peak of the crystalline corncob particle filler is consistent with the results of the study shown by [7]. It indicates that the native cellulose crystal structure. This shows the crystalline phase that begins to appear on corncob fibre [8].



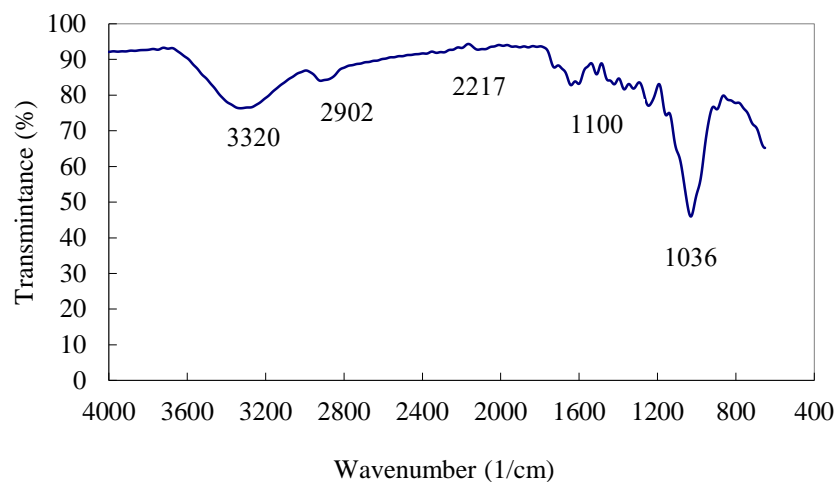
**Figure 1.** XRD analysis of corncob particle filler

### 3.2 Functional Groups of Particle Filler and Film Composites

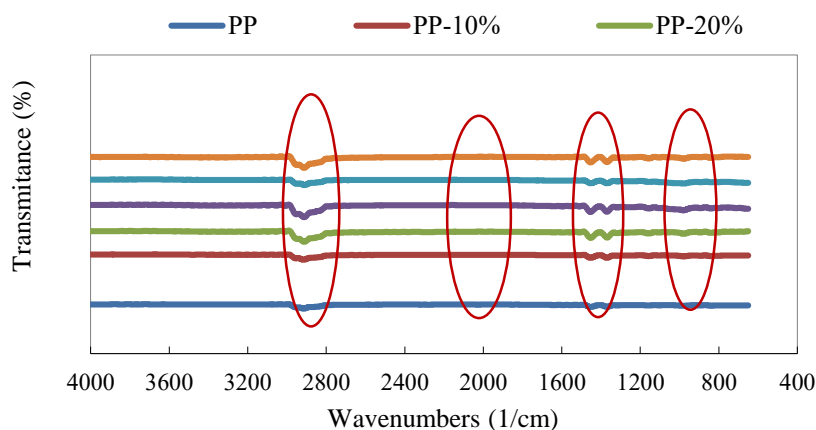
Figure 2 and Figure 3 show the functional group of corncob and film composite polypropylene. The particle filler corncobs fibers observed silica absorption bands using FTIR spectrometers at a wave number of  $4000\text{--}400\text{cm}^{-1}$ . The spectrum shows the main chemical groups that appear on the corncob fibers. The widened absorption band at the area of  $3320\text{cm}^{-1}$  shows the vibration of the O-H bond

stretching on the silanol (Si – OH) group, while the asymmetry stretching vibration of the siloxane bond (Si - O - Si) appears in the wave number between 1030-1100  $\text{cm}^{-1}$  [9 ; 8].

From Figure 3, the FTIR of the four composite polypropylene and comparison with neat polypropylene can be seen. Based on the FTIR graph, in polypropylene without particle filler of corncob, there is no silica functional group. However, after the composite was added with corncobs fiber, the silica groups were detected at wave numbers of 800-1000  $\text{cm}^{-1}$ . In this case, there is no effect of particle filler loading on the functional group of all the composite polypropylene.



**Figure 2.** FTIR analysis for corncob

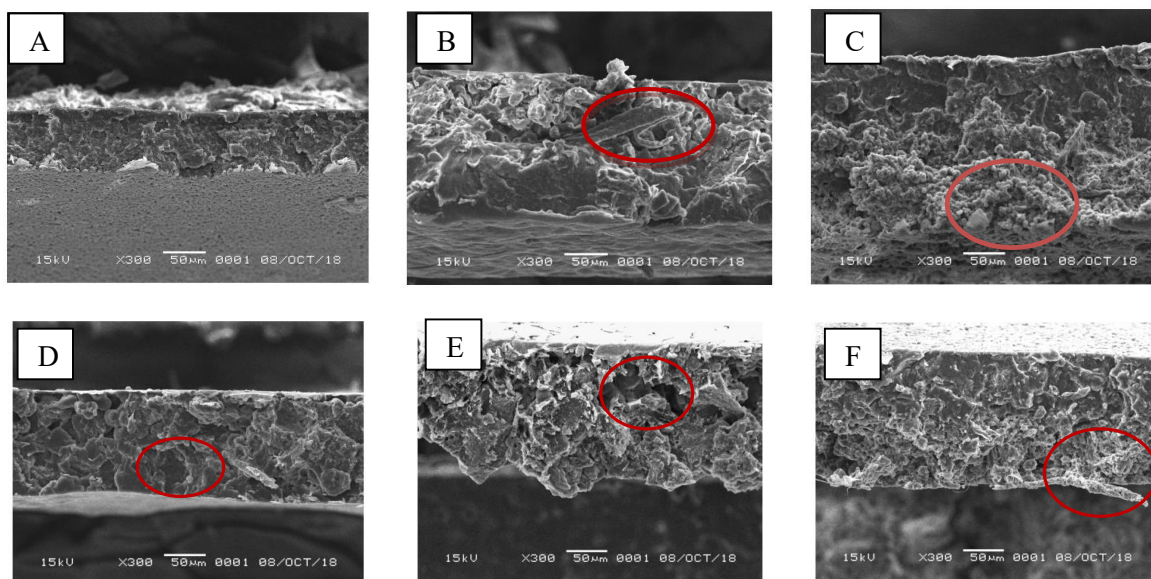


**Figure 3.** FTIR analysis of particles filler and film polypropylene (PP) composites.

### 3.3 Fracture Surface of Film Polypropylene Composites

Figure 4 shows the fracture surface of one film polypropylene without corncob particle filler and five composite polypropylene filled corncob particle fiber. From Figure 4A, the film polypropylene shows the smooth surface area. Figure 4B, 4C, 4D, 4E and 4F show the crack in red circles of the particle corncob filler in fractur surface of composites.

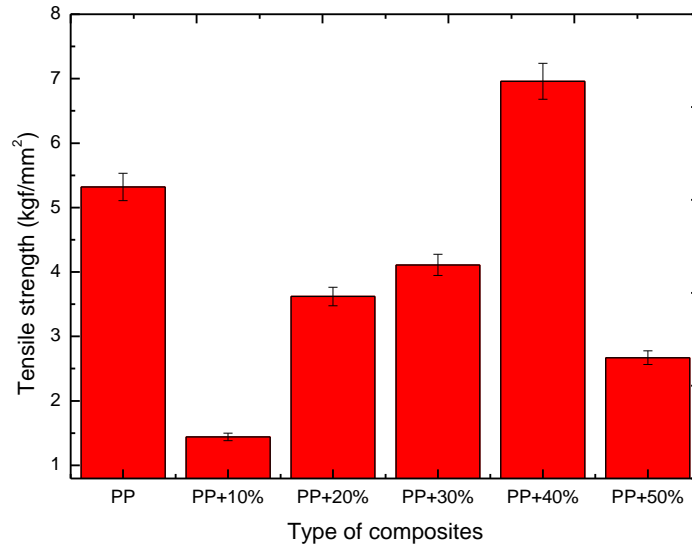
All composites polypropylene (Figure 4B, 4C, 4D, 4E and 4F ) showed the heterogeneous structures and cracks between particle fillers and polypropylene ing that the interfacial adhesion between particle fillers and polypropylene as matrix was still weak [9]. Moreover, the cracks might result in the decrement of mechanical property and water resistance.



**Figure 4.** Fracture surface of film polypropylene composites: A. PP, B. PP+10% filler, C. PP+20% filler, D. PP+30% filler, E. PP+40% filler and F. PP+50% filler.

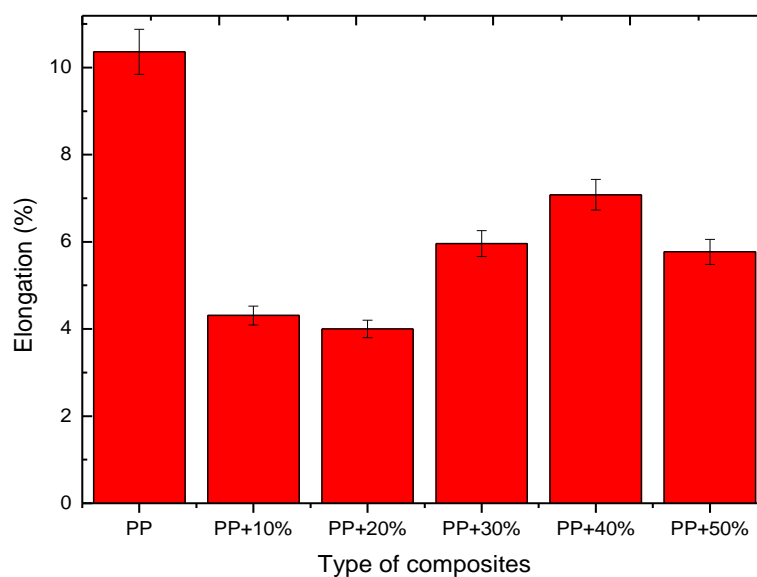
### 3.4 Mechanical Properties

Figure 5 and Figure 6 show the composite polypropylene effect of loading corn cob particle filler on tensile strength and elongation at break. From Figure 5, tensile strength of the 40wt% of corn cob particle filler was higher than that of the neat polypropylene. But, for polypropylene composites, loading of corn cob particle filler decreased in tensile strength. The increase in tensile strength could be attributed to strengthening effect of the corn cob particle filler incorporated into polypropylene matrix. In materials, adding filler into polymer can be improved the rigidity and strength. The higher loading of particle filler incorporated the stronger of composite [10]. The tensile strength of composite decreased from neat polypropylene occurred, may be due to poor interaction between the particle filler and polymer matrix [11;12]. Sometime, excessive incorporation of particle filler may lead to filler agglomeration in the polymer matrix leading to formation of microfiller due to the difficulties in achieving a homogeneous dispersion particle filler [10].



**Figure 5.** Tensile strength of film composite polypropylene.

Figure 6 shows the effect of filler loading on the elongation at break of the polypropylene composites compounded. The loading corncob particle filler at 40 wt% show the higher elongation, but still below from the neat polypropylene. Lower elongations at break were recorded for the loading 20 wt% of corncob particle filler. It is obvious from the data that elongation at break decreased steadily with increase in particle filler loading. Elongation at break is a reflection of the ductility of a material, a direct opposite of brittleness. Filler incorporation into a polymer matrix increased the stiffness and hardness of the composite. This increase in hardness resulted in decrease in ductility of the material [10].



**Figure 6.** Elongation at breaks of film composite polypropylene.

#### 4. Conclusion

The crystalline of corncob particle filler was formed of silica content. The tensile strengths of the composite polypropylene were found to be higher than that of the neat polypropylene. Tensile strength was found to increase with increase in filler loading while elongation at break decreased with increase in filler loading. It is therefore recommended that corncob powder be used as particle filler in polypropylene composites.

#### Acknowledgment

The authors would like to thank The Research Institutes and Community Service University of Syiah Kuala and Directorate of Research and Community Service and Directorate General of Research and Development, Ministry of Research, Technology and Higher Education (PCP) who have funded this research in accordance with the Research Contract No. 59/UN11.2/PP/SP3/2018.

#### References

- [1] J. Holbery and D. Houston 2006 *JOM* **58** (11) 80–86.
- [2] Koronis G, Silva A and Fontul M 2013 *Composites Part B: Eng.* **44** (1) 120–127.
- [3] Friedrich K and Almajid A A 2013 *Applied Comp. Mat.* **20** (2) 107–128.
- [4] Cole G S and Sherman A M 1995 *Mat. Charact.* **35** (1) 3–9.
- [5] Panthapulakkal S and Sain M 2007 *Composites Part A: Applied Sci. Manufac.* **38** (6) 1445–54.
- [6] Pinto J, Cruz D, Paiva A, Pereira S, Tavares P, Fernandes L and Varum H 2012 *Construc. Build. Materials* **34** 28–33.
- [7] Liu C, Li B, Du H, Lv D, Zhang Y, Yu G, Mu X and Peng H 2016 *Carb. Polym.* **151** 716–724.
- [8] Thamilselvi V and Radha K V 2017 *J. Env. Chem. Eng.* **5** (2) 1843–54.
- [9] Wan Y, Wu H, Huang L, Zhang J, Tan S and Cai X 2018 *Polym. Bull.* **75** (5) 2125–38.
- [10] Onuoha C, Onyemaobi O O, Anyakwo C N and Onuegbu G C 2017 *Int. J. Sci. Eng. Appl. Sci.* **3** (4) 145–151.
- [11] Chris-Okafor P U 2017 *Am. J. Polym. Sci. Tech.* **3** (4) 64.