

Development of sustainable polymer composites using recycled polypropylene and organic fillers

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INTRODUCTION

Polypropylene [PP] is an extremely versatile material and can be used for a wide range of applications. Recycling is the third component of the reduce, recycle and reuse waste hierarchy and is an important part of modern waste reduction. The research work was focussed on effective utilisation of industrial waste obtained from car battery casing made from PP material, recycled PP (rPP) and organic fillers such as coconut shell (CCS) powder, wood filler(WF) powder, rice husk (RH) powder, banana fibre (BAF) powder, bamboo fibre (BF) powder which are biowaste.

ABSTRACT

Polypropylene [PP] is an extremely versatile material and can be used for a wide range of applications. PP is also one of the most popular plastic packaging materials in the world, and only around 1% is recycled, which means most PP is headed for the landfill. This decomposes slowly over 20-30 years. Recycling is the third component of the reduce, recycle, and reuse waste hierarchy and is an important part of modern waste reduction. In this study, recycled PP sourced from car battery casings were compounded with organic fillers such as coconut shell (CCS) powder, wood filler (WF) powder, rice husk (RH) powder, banana fibre BF (BAF) powder, and bamboo fibre (BF) powder, and hybrid combinations of wood filler with coconut shell powder, rice husk, banana fibre powder, and 5wt/wt% of PP-g-MA compatibilizer in a ratio of 75/20/5 were used to enhance the compatibility between the fillers and the PP matrix. The various ingredients were melt-mixed using a twin screw extruder and the test specimens were moulded using an automatic injection moulding machine. The main objective of this work was to study the changes in the mechanical properties of the prepared composites with respect to that of virgin polypropylene. Testing for physical and mechanical properties was carried out as per the ASTM standards. From the test results, it was inferred that banana- and bamboo-reinforced rPP had the highest tensile strength at yield and flexural strength. The hardness values of all composites were close to recycled PP. Among the hybrid composites, rPP/WPF/RH and rPP/WPF/BF show the highest resistance to abrasion. Finally, composites containing banana fibre, bamboo fibre, and rPP/WF/BF showed good mechanical properties, as did other combinations.

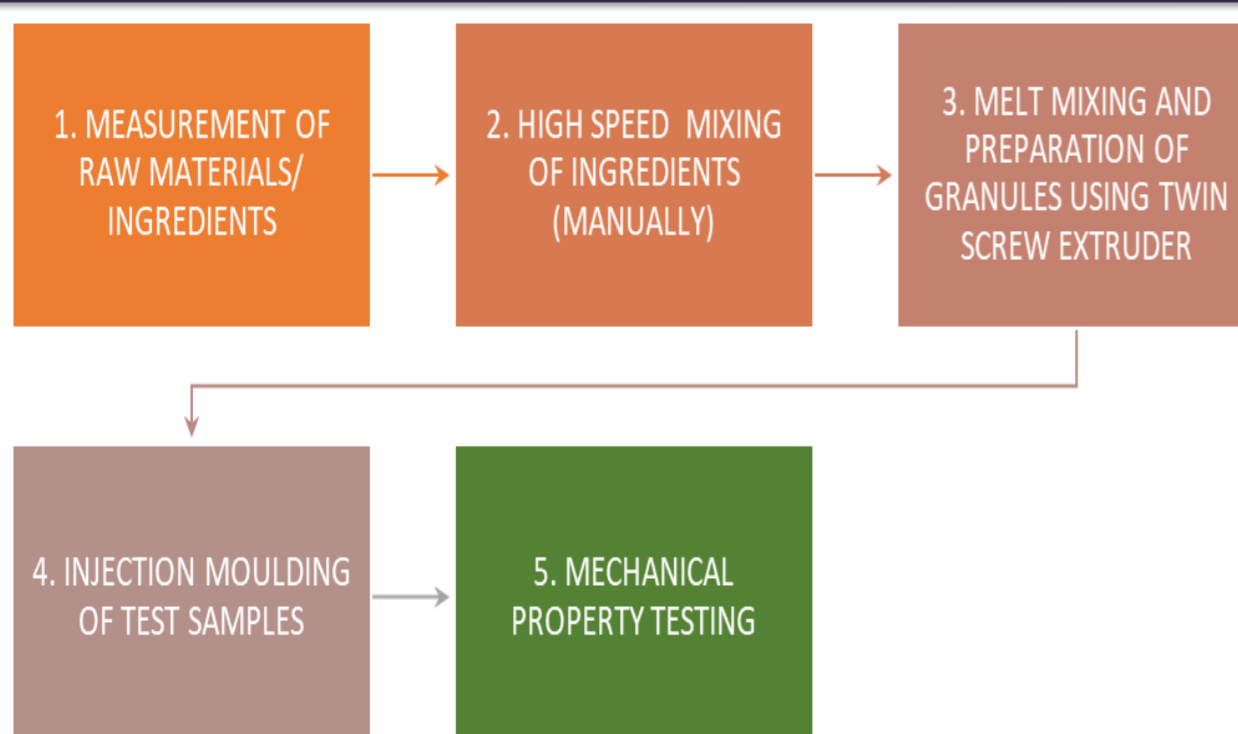
Keywords recycle: polypropylene: organic: fillers: composites

OBJECTIVE

The objective of the study is:

- To utilize waste generated battery casings, recycled Polypropylene (rPP) with organic fillers such as coconut shell powder, millet husk powder and wood powders using a twin screw extruder.
- To characterize the prepared composites for their mechanical properties (tensile properties, hardness and flexural properties).

METHOD



Organic fillers

- Recycled polypropylene and individual fillers were taken in 75:20 percentage ratios along with 5% compatibiliser and antioxidants.
- For the hybrid composition, the combination of two individual fillers were taken in 10%+ 10% to sum up as 20% along with 5% compatibiliser and antioxidants.

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RESULTS & DISCUSSION

SL NO	Trial no	Composition	Tensile Strength (MPa)	Elongation at Break (%)	Tensile Modulus (MPa)
I	1	PP	32.15	16.22	1352
	2	RPP	26.20	20.15	745.79
II	1	WPF	28.04	10.15	500.86
	2	CSP	25.36	10.85	475.72
	3	RH	22.32	11.21	396.43
	4	BF	28.63	9.94	531.88
	5	BAF	29.05	8.57	1285
III	1	WPF+CSP	26.13	10.8	402.1
	2	WPF+RH	24.78	12	355.5
	3	WPF+BF	30.05	9.37	806.35

SL NO	Trial no	Composition	Hardness (shore D)
I	1	PP	76
	2	RPP	70
II	1	WPF	64.5
	2	CSP	62.16
	3	RH	66
	4	BF	70.5
	5	BAF	64.8
III	1	WPF+CSP	67.5
	2	WPF+RH	59.25
	3	WPF+BF	65.5

SL NO	Trial no	Composition	Flexural Strength (MPa)	Flexural modulus (MPa)
I	1	PP	31.5	1762
	2	RPP	33.0	1504
II	1	WPF	37.8	1993
	2	CSP	35.4	1732
	3	RH	34.0	1232
	4	BF	41.20	2215
	5	BAF	39.30	2113
III	1	WPF+CSP	36.30	1810.59
	2	WPF+RH	33.76	1256.24
	3	WPF+BF	40.61	2428.89

- Bamboo filler and wood powder hybrid shows the highest tensile strength.
- Banana filler shows excellent flexural strength, the hybrid of bamboo filler and wood filler shows good flexural modulus
- Bamboo fibre shows very good hardness
- Banana fibre shows exceptional impact strength in comparison with the others

CONCLUSION

- In this study the composites with recycled polypropylene material collected from industry and natural fillers were prepared.
- It was inferred that banana- and bamboo-reinforced rPP had the highest tensile strength at yield and flexural strength.
- The hardness values of all composites were close to recycled PP.
- Among the hybrid composites, rPP/WPF/RH and rPP/WPF/BF show the highest resistance to abrasion.
- Finally, composites containing banana fibre, bamboo fibre, and rPP/WF/BF showed good mechanical properties, as did other combinations.
- Effective utilisation of single used industrial plastic waste and natural fillers.

FUTURE WORK / REFERENCES

Future work includes

- Design and fabrication of two plate mould
- Products like key chain holders , table mats , bricks etc moulding using the formulations prepared.

References

1. Agnivesh Kumar Sinha, Harendra Kumar Narang & Somnath Bhattacharya (2020), Mechanical properties of hybrid polymer composites: a review, Journal of the Brazilian Society of Mechanical Sciences and Engineering volume 42, Article number: 431
2. Femiana Gapsari, Mudjib Sulaiman A., Thesya Marlia Putri, Hans Juliano, Ludfi Djakfar, Rinawati P. Handajani, Sugeng P. Budio, Pitojo T. Juwono, Praveenkumara Jagadeesh, Sanjay Mavinkere Rangappa, Suchart Siengchin (2022), Influence of calcium carbonate fillers on pine fiber reinforced polyester composites, Polymer Composites Volume 43, Issue 7 p. 4306-4317
3. Md. Tangimul Islam, Subrata Chandra Das, Joykrisna Saha, Debasree Paul, M. Tauhidul Islam, Mahbubur Rahman, Mubarak Ahmad Khan (2017), Effect of Coconut Shell Powder as Filler on the Mechanical Properties of Coir-polyester Composites, Chemical and Materials Engineering 5(4): 75-82