From Recycled Polypropylene to Engineering Plastic Composite via Addition of Waste Paper

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SUMMARY

In this paper, the upcycling of recycled polypropylene with the addition of waste paper, appropriate compatibiliser, lubricant and antioxidant is presented. Compounding was performed on the twin-screw extruder. The addition of waste paper varied from 5 wt.% to 30 wt.% in the 5 wt.% steps. To improve the compatibility between the paper and rPP, the graft copolymer PP-*g*-MA was added in a concentration of 4 wt.%. The research proved, that good homogenisation was achieved with addition of the lubricant, and the oxidation was prevented with the addition of antioxidant. For the characterisation purposes, the test specimens were prepared by injection moulding. The results of tensile, bending and DMA tests proved that stiffness and strength increased significantly with the addition of 30 wt.% waste paper. The research results proved, that composite is industrial applicable since high compatibility was achieved. •

INTRODUCTION

In recent times the recycling of PP is an important topic due to increasing amount of PP in the thermoplastic municipal waste material. rPP is very often physically modified by the addition of various fillers. Due to low price, low density and high stiffness the natural fibres and waste paper attracted the attention of researchers. The improvement of the interfacial bonding between the hydrophilic natural fibre and the hydrophobic rPP has been a key research issue because the interfacial adhesion between natural fibre and rPP plays an important role in the determination of the properties of the composites. PP-*g*-MA as compatibilizer facilitates the dispersion and enhances surface bonding of waste paper in rPP. The waste paper promotes the crystallization, enhances the strength, stiffness, and toughness of waste paper rPP composite. The aim of this study was to enhance the strength and stiffness of rPP with the modification of the matrix with additives and waste paper. Eight different samples were prepared by compounding and injection moulding. Mechanical, thermal and rheological properties of biocomposites were investigated in detail and compared with rPP. •

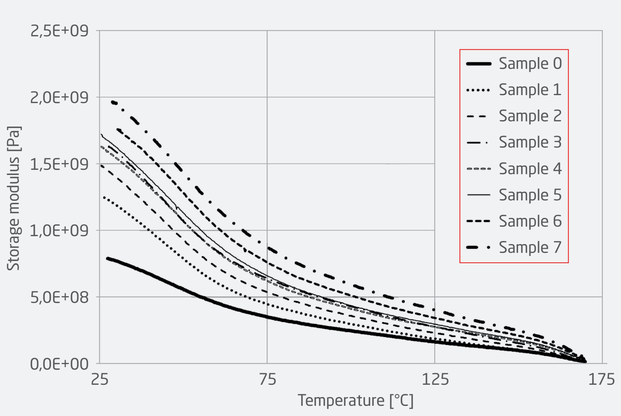
RESULTS

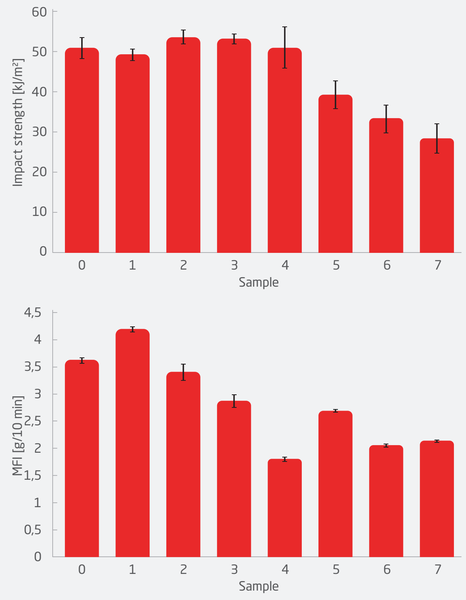
EXTRUSION AND INJECTION MOLDING

Sample	rPP (wt.%)	PP-*g*-MA (wt.%)	Lubricant (wt.%)	Antioxidant (wt.%)	Waste paper (wt.%)
0	100.00	0	0	0.00	0
1	94.62	4	1	0.38	0
2	89.62	4	1	0.38	5
3	84.62	4	1	0.38	10
4	79.62	4	1	0.38	15
5	74.62	4	1	0.38	20
6	69.42	4	1	0.38	25
7	64.62	4	1	0.38	30

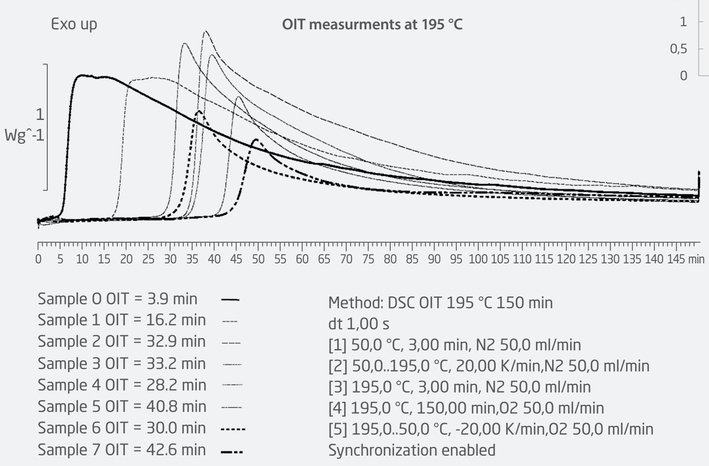
CHARACTERIZATION

Sample	DSC results				
	T_m (°C)	T_c (°C)	ΔH_m (J/g)	ΔH_c (J/g)	X_c (%)
0	166	124	67	72	32.3
1	166	122	54	61	27.5
2	166	123	55	67	29.6
3	167	122	47	58	26.8
4	167	123	56	62	34.0
5	166	124	52	57	33.7
6	167	124	50	55	34.7
7	167	124	45	49	33.6





Sample	Bending test results			Tensile test results			
	E_f (GPa)	σ_{fM} (MPa)	ε_{fM} (%)	E_t (GPa)	σ_m (MPa)	ε_m (%)	ε_{tb} (%)
0	1.02±0.01	28.4±0.1	6.67±0.13	1.15±0.07	26.4±0.1	6.55±0.10	59.68±2.51
1	1.07±0.01	29.2±0.1	6.57±0.12	1.36±0.15	25.3±0.1	6.81±0.12	79.03±10.29
2	1.17±0.01	30.3±0.2	6.45±0.07	1.38±0.07	25.7±0.2	6.51±0.14	30.80±10.29
3	1.25±0.01	31.3±0.2	6.28±0.11	1.45±0.12	26.8±0.2	5.90±0.17	15.50±2.43
4	1.39±0.01	34.0±0.1	6.41±0.08	1.53±0.05	28.1±1.2	6.19±0.17	10.38±1.28
5	1.50±0.01	34.9±0.1	6.34±0.08	2.03±0.14	29.8±0.2	5.83±0.08	8.97±0.75
6	1.67±0.01	37.5±0.2	6.23±0.05	1.92±0.13	31.0±0.2	5.99±0.10	8.94±0.87
7	1.89±0.04	40.3±0.2	6.09±0.04	2.17±0.31	33.1±0.2	5.86±0.06	7.43±0.55



CONCLUSIONS

Stiffness and strength of biocomposites with waste paper and PP-*g*-MA were higher compared to rPP. T_m and T_c of biocomposites did not change compared to those of rPP. The degree of crystallinity of biocomposites is at higher loading of waste paper higher compared to the pure rPP. Incorporation of 30 wt.% waste paper together with PP-*g*-MA into the rPP matrix enhanced bending and tensile strength (+42% and +25% respectively) and stiffness (+85% and +89% respectively) as well as rised crystallinity (+2%) due to good interfacial adhesion between waste paper and rPP matrix and acted as nucleation agent for rPP matrix. In the same time, the addition of waste paper prolong the residence time of the melt in the cyclinder (+150%). The novel biocomposites are suitable for applications such as technical parts that require higher stiffness, strength and dimensional stability as rPP. •

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