Comparison of the conventional molding techniques for preparation of eco composites as intelligent packaging material

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Abstract

The interest in natural fiber-reinforced polymer composites as intelligent packaging material is growing rapidly due to their high performance in terms of mechanical properties, significant processing advantages, excellent chemical resistance, low cost and low density. In this study, the compression and injection molding of polypropylene (PP) and polylactic acid (PLA) based composites reinforced with rice hulls or kenaf fibers was carried out and their basic properties were examined. Rice hulls from rice processing plants and natural lignocellulosic kenaf fibers from the bast of the plant Hibiscus Cannabinus represent renewable sources that could be utilized for composites. Maleic anhydride grafted PP (MAPP) and maleic anhydride grafted PLA (MAPLA) were used as coupling agents (CA) to improve the compatibility and adhesion between the fibers and the matrix. Composites containing 30 wt % reinforcement were manufactured by compression and injection molding, and their mechanical and thermal properties were compared. It was found that the techniques applied for manufacturing of the eco-composites under certain processing conditions did not induce significant changes of the mechanical properties. The flexural strength of the compressed composite sample based on PP and kenaf is 51. 3 MPa in comparison with 46.7 MPa for the same composite produced by injection molding technique. Particularly, PP-based composites were less sensitive to processing cycles than PLA-based composites. The experimental results suggest that the compression and injection molding are promising techniques for processing of eco-composites. Moreover, the PP-based composites and PLA-based composites can be processed by compression and injection molding. Both composites are suitable for applications as food packaging materials.

Materials

POLYMERS	NATURAL REINFORCEMENTS
Polyhydroxybutyrates (PHB)	Rice straw
Polyhydroxybutyratevalerate (PHBV)	Hemp
Poly(lactic acid) (PLA)	Jute
Polypropylene (PP)	Sisal
Polyethylenterephtalate (PET)	Cellulose (recycled paper)
	Kenaf

Compression molding

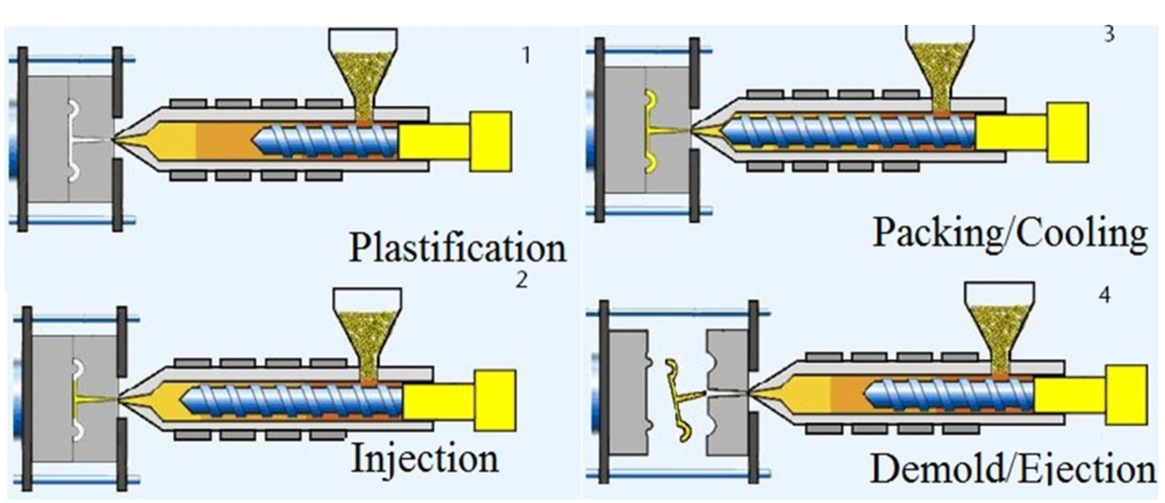
pellets, granules

– rice hulls / PP
– rice hulls / PLA

Processing temperatures in the zones of the injection machine, °C

Composite samples	*PP/K/CA*	*PP/RH/CA*	*PLA/K/CA*	*PLA/RH/CA*
Temperature in the hopper	35-40	35-40	25-35	25-35
Temperature in the feeding zone	120-150	120-150	110-140	110-140
Temperature in the in the compressing zone	150-180	150-180	140-170	140-170
Temperature in the metering zone	185-195	185-195	170-185	170-185
Temperature in the in the nozzle	190-200	190-200	185-190	185-190

Injection molding



Codes of composite samples

Codes	Matrix (wt%) Type	Matrix (wt%) Content (wt%)	Fiber/Filler Type	Fiber/Filler Content (wt%)	Coupling agent (CA) Type	Coupling agent (CA) Content (wt%)
PP/K/CA	PP	65	Kenaf fibers	30	MAPP	5
PP/RH/CA			Rice Hulls			
PLA/K/CA	PLA	65	Kenaf fibers	30	MAPLA	5
PLA/RH/CA			Rice Hulls			

The mechanical properties of the composites produced by compression molding

Characteristics	Unit	Composite: PP/K/CA	Composite: PP/RH/CA	Composite: PLA/K/CA	Composite: PLA/RH/CA
Flexural strength	MPa	51,3 ± 4,84	42,6 ± 3,45	46,7± 3,83	**28,8 ± 3,14**
Flexural modulus	GPa	2,11 ± 0,07	1,94 ± 0,08	2,05 ± 0,11	**3,03 ± 0,09**
Impact strength	kJ/m^2	71,4 ± 4,67	69,2 ± 3,83	54,3 ± 3,49	**48,7 ± 4,16**
Compression strength	MPa	47,2 ± 2,93	36,3 ± 2,39	34,5 ± 3,11	**21,6 ± 2,67**
Compression modulus	GPa	1,86 ± 0,12	1,58 ± 0,09	1,74 ± 0,11	**1,46 ± 0,07**
Tensile strength	MPa	29,6 ± 3,84	22,7 ± 4,82	28,3 ± 6,54	**26,7 ± 1,49**
Tensile modulus	**GPa**	**1,65 ± 0,025**	**1,78 ± 0,014**	**2,87 ± 0,23**	**2,76± 0,11**

The mechanical properties of the composites produced by injection molding

Characteristics	Unit	Composite: PP/K/CA	Composite: PP/RH/CA	Composite: PLA/K/CA	Composite: PLA/RH/CA
Flexural strength	MPa	40,1 ± 4,82	32,8 ± 3,44	34,1± 3,75	**20,7 ± 2,82**
Impact strength normal to the axis	kJ/m^2	57,1 ± 4,76	55,0 ± 4,13	40,7 ± 3,86	**36,1 ± 3,46**
Compression strength parallel to the axis	MPa	38,2 ± 2,93	28,1±2,43	26,5 ± 2,51	**15,8 ± 1,91**
Compression strength normal to the axis	GPa	27,8 ± 2,27	23,5 ± 2,44	22,6 ± 2,01	**13,6 ± 1,83**
Tensile strength	**MPa**	**23,6 ± 2,14**	**17,9 ± 1,24**	**21,8 ± 1,02**	**20,6 ± 0,91**

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