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BLENDED POLYPROPYLENE FIBERS

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ABSTRACT

The preparation, and especially the dyeability of blended fibers polypropylene and terpolymer acrylonitrile-butadiene-styrene and/or polypropylene and polystyrene, respectively are presented in this paper. Modified polypropylene fibers fix the dyestuffs much better and have lower tenacity according to the amount of the additive.

INTRODUCTION

The modification of commercial homopolymers (and especially polypropylene) with the aim to improve some of their properties has several aspects. Among these aspects basically influencing the appreciation of the modification we can state:

- harmless
- price of the modification (price of the additive, availability, compatibility, and functionality)
- technological possibility to completely assure the modification
- method of modification (physical, chemical)
- durability and effectiveness of the modification

For modified fibers, there are some another aspects (crystallinity, orientation).

All aspects are connected to each other and sometimes they are contradictory. Mono- (better multifunctional modification depends on the concentration and efficiency of the (polar) groups introduced into, or at the end of, the chain of PP (the method of the chemical modification) or it depends on the concentration and dispersion of the additive (the method of the physical modification).

The degree of crystallization also has an important influence during the modification and for the final state and properties of the (fibrous) product.

The preparation of the blended fiber-forming system polypropylene containing the additive (with suitable groups, compatible, not expensive, commonly used in the commerce and in the industry) led us to prepare the M/F modified PP fibers with better dyeability. However, some properties can be partially deteriorated so the compromise between the improving of desirable property and the smallest deterioration of other (e.g. mechanical) properties has to be found.

As additives for polypropylene, we can use on principle either low molecular modifiers or polymers. Stability of the polymers in the blended polymer system is usually much better than the stability of the low molecular modifiers.

Polypropylene (PP) as a hydrophobic polymer has little capability to fix polar molecules of the dyestuff. For the dyeing of the PP fibers, there are mainly three possibilities. Each of these methods has its own advantages:

(A) Classic method of dyeing the unmodified PP with pigments in the bulk during the preparation of fibers [1-5]. This method has many advantages - economic, ecological, and qualitative ones, but it is advantageous for great quantities of dyed fibers.

(B) The preparation of a dyed master batch (consisting of functional additives and the dyestuff), its incorporation and dispersion into PP essentially before the spinning [6-9]. This method uses the technological devices of the classic method, it utilizes the principles of the modification, and the interactions of dyestuff with the functional additive, as well as the interactions between the additive and the PP has to be assured.

(C) The modification of PP with additive(s), its spinning and dyeing of the modified PP fibers with dyestuff by exhaustion method [10-12]. The dyeing by the exhaustion method is performed practically only in the noncrystalline areas and the fibers with very high crystalline content can be dyed with difficulty. Closed, uniform internal structure of PP fibers with the crystallinity degree up to 60% defends a free diffusion of the dyestuff into the fibers. The amorphous areas have also a limited accessibility for the dyestuff.

Sufficient flexibility of macromolecular segments and increased free volume (at the increased temperatures during the dyeing (favor the diffusion of the molecules of the dyestuff).

Addition of the noncrystallizable additive, which effectively lowers the degree of crystallinity, increases the flexibility of macromolecular segments and free volume, with satisfactory compatibility with PP, containing some (polar) groups or rings could assure the conditions for successful dyeing by the exhaustion method.

For the modification of the fiber-forming PP (according to method (C), we selected the terpolymer acrylonitrile-butadiene-styrene and the polystyrene as the additives which could fulfill the above mentioned requirements and could improve the dyeability of PP fibers by the exhaustion method mainly with the disperse dyestuffs.

EXPERIMENTAL

The topic of the presented paper was the preparation of experimental blended PP fibers from mixtures PP and terpolymer acrylonitrile-butadiene-styrene (ABS, the content 0-40 wt%) and PP and polystyrene (PS, the content 0-25 wt%) and the study of their properties, essentially the dyeability.

The following materials were used for the preparation of modified polypropylene:

- polypropylene TF 411 from Slovnaft Bratislava, Slovak Republic, melt flow index 8-11.5 g/10 min.
- terpolymer [ABS-acrylonitrile-butadiene-styrene] Forsan 548, melt flow index 15-20 g/10 min.
- polystyrene [PS] Krasten 552, melt flow index 3.5-7 g/10 min., both from Kaučuk Kralupy nad Vltavou, Czech Republic,
- C. I. Disperse Red 60
- C. I. Disperse Blue 3

The polypropylene with ABS, and/or PS, were mechanically mixed and melted in a single-screw-ribbon extruder at the temperatures $T_1 = 250^\circ\text{C}$, $T_2 = 260^\circ\text{C}$, $T_3 = 250^\circ\text{C}$. The blended ribbon was cooled down and cut. The PP and dried, blended granulars were used for spinning and drawing of unmodified and modified PP fibers by the laboratory equipment. The spinning temperatures were $T_1 = T_2 = T_3 = 250^\circ\text{C}$, the spinning speed was 150 m/min^{-1} and fibers with two drawing ratio $\lambda_1 = 3$ and $\lambda_2 = 3.5$ were prepared.

Tab. 1 Tenacity and elongation to break of unmodified and modified PP fibres

Conc. of additive, wt. %	ABS	0	5	10	15	20	25	30	40	0	0	0
	PS	0	0	0	0	0	0	0	0	5	10	15
T_{dt} , dtex		13.6	13.2	13.7	13.3	13.5	13.1	13.8	13.1	13.5	14.0	14.4
σ , cN.dtex ⁻¹		3.44	3.24	3.04	2.81	2.66	2.38	2.23	2.10	2.46	2.29	2.14
ϵ , %		25	28	22	28	27	28	24	19	23	21	22

Dyeing of the unmodified and blended PP fibers was carried out in the dispersion of the disperse dyestuff $c = 1 \text{ kg.m}^{-3}$, the carrier SPOLAPREN X $c = 2 \text{ kg.m}^{-3}$, the dispersing agent KORTAMOL NNO $c = 1 \text{ kg.m}^{-3}$ and $T = 100^\circ\text{C}$, $t = 60$ minutes. After the dyeing, the fibers were washed in the water, fixed ($T = 120^\circ\text{C}$, $t = 15$ minutes), treated with alkali-reduction solution at $T = 70^\circ\text{C}$, $t = 20$ minutes (with NaOH, $\text{Na}_2\text{S}_2\text{O}_3$ and the detergent SLOVAPON N $c = 1 \text{ kg.m}^{-3}$) and washed with the water to remove all impurities.

The amount of the fixed dyestuff in the dyed fibers was determined by the spectrophotometric measurements of the dyed solution (after the extraction of the dyestuff from the dyed fibers with the chloroform p.a.) by using the calibrated straight line.

The tenacity and elongation to break nondyed, unmodified and modified PP fibers were determined by INSTRON 1112.

RESULTS AND DISCUSSION

The preparation of PP fibers modified with ABS and/or PS is possible. The spinning process was stable in all intervals of composition, and the process of drawing showed that the polystyrene is less suitable in comparison with terpolymer ABS. All modified fibers can be drawn to the ratio $\lambda = 3$, to the ratio $\lambda = 3.5$ it is possible for all fibers except PP fibers modified with 20 wt% and more of PS.

Tenacity of the modified PP fibers drops with the rising amount of additive, more in the case of polystyrene, which confirms the above mentioned note that PS is less suitable. Elongation to break is practically not influenced (Table 1).

Tab. 2 Dyeability of PP fibres modified by ABS and PS

Content of additive, wt. %		Content of fixed dye, mg of dyestuff/1 g of dyed fibre			
		C.I. Disperse Red 60		C.I. Disperse Blue 3	
ABS	PS	$\lambda = 3$	$\lambda = 3.5$	$\lambda = 3$	$\lambda = 3.5$
0	0	0.2	0.17	0.2	0.2
5	0	0.93	1.1	0.7	1.0
10	0	2.37	2.27	1.2	1.53
15	0	3.07	3.1	1.73	1.6
20	0	3.57	3.63	2.37	2.13
25	0	4.7	4.43	2.6	2.23
30	0	5.8	6.17	2.7	2.63
40	0	6.1	6.47	3.06	2.93
0	5	0.33	0.53	0.4	0.43
0	10	1.0	1.03	0.57	0.63
0	15	1.5	1.1	0.9	0.97
0	20	2.3	-	1.1	-
0	25	2.47	-	1.23	-

Dyeability of modified PP fibers is effectively influenced especially with ABS up to 30 wt%. In contrary, PS has little effect.

The drawing ratio λ also has little influence.

Between the two dyestuffs, we can see a great difference. C. I. Disperse Red 60 is fixed much more than C. I. Disperse Blue 3. This effect is evident especially for fibers modified with ABS when the amount of fixed Red 60 is 23 times higher, while for Blue 3 it is 13 times higher (25 wt% of additive and $\lambda = 3$) in comparison with unmodified PP fibers. For the PP fibers modified with PS, these values are 7.5 and 3 times higher, respectively (Table 2).

CONCLUSION

ABS is a more suitable additive for modification of the dyeability of PP in comparison with PS. The maximum (effective) amount of ABS is 40 (30) wt%. PS is acceptable to 15 (max. 25) wt%.

Tenacity of modified PP fibers drops with the amount of additive, more dramatically if PS is used. Elongation to break is not largely influenced.

Dyeability of modified PP fibers is essentially influenced by ABS especially to the level of 30 wt%. PS is much less effective.

Type of the dyestuff substantially influences the dyeability. C. I. Disperse Red 60 is much better fixed than C. I. Disperse Blue 3.

There is not a great difference in dyeability of fibers drawn to $\lambda = 3$ and $\lambda = 3.5$.

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