POLYPROPYLENE COMPOSITE FIBRES, SPINNING STRUCTURE AND PROPERTIES

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The organoclays and carbon nanotubes represent unique solid particle and nano-fibrous nano-fillers for polypropylene composites because of their shape, morphology and properties [1-2]. Radically improved mechanical properties of polymers by (nano)fillers result from this modification. Application of these fillers into matrix of synthetic fibres appears in periodic literature more rarely. The organically modified montmorillonites (organoclays) and multiwall carbon nanotubes (MWCNT) have been used for reinforcing of synthetic fibres based on polyamide (PA6) [3], polyethylene terephthalate (PET) [4] and polypropylene (PP) [5].

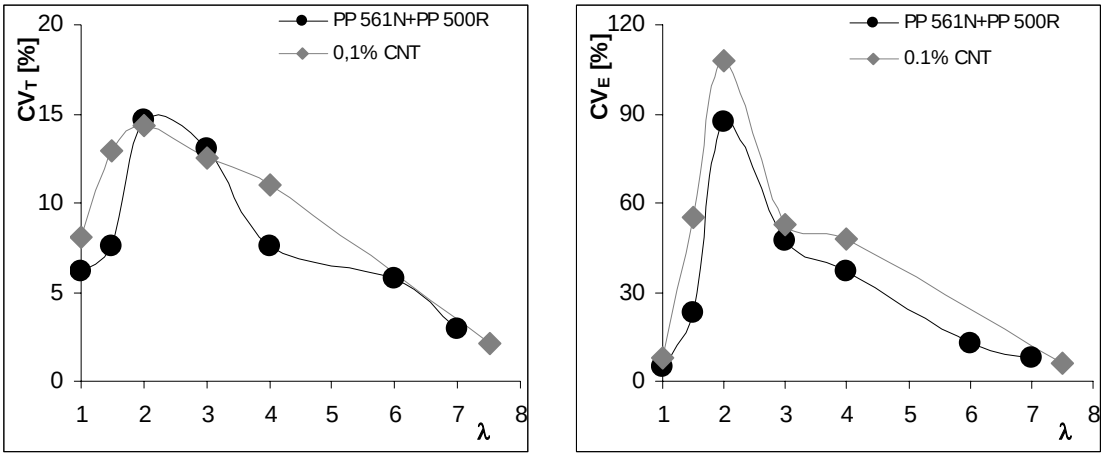
In this paper, spinning of polypropylene/organoclay and polypropylene/carbon nanotube composite fibres and their selected mechanical properties are presented. The laboratory twin-screw extruder, Φ=28 mm, was used for preparation of PP composites before spinning. Composite fibres were prepared using laboratory spinning line with extruder Φ=16. The multifilaments were drawn for various drawing ratio. The mechanical properties of PP composite fibres in dependence on spinning and drawing conditions were evaluated. The effect of compatibilisers–dispersants on non-uniformity and mechanical properties of fibres, resulting from processing of PP composites in spinning and drawing, was estimated. The factors leading to PP composite fibres with enhanced tenacity and Young's modulus are discussed in the paper, as well.

The following polymers and materials were used: PP Moplen 500R (PP M500R), flakes, MFI 25 g/600 s. and PP Moplen HP561N (PP M561N), MFI 11 g/600 s, both produced by Basell, Italia. Commercial organoclay based on montmorillonitte (MMT) used in this work was Cloisite 15A (C15A), produced by Southern Clay Product, USA and Multi-Wall Carbon Nanotubes - Nanocyl® 7000 (MWCNT), produced by Nanocyl S.A., Belgium. The ester of stearic acid and polypropylene glycol (S44P) and alkyl-polysiloxane (TEG) were used as compatibilisers-dispersants.

The coefficients of variation of basic mechanical properties, tensile strength (CV_T), elongation at break (CV_E) and Young's modulus (CV_{YM}) were evaluated and used for estimation of structural and geometrical non-uniformity of fibres. An Instron (Type 3343) was used for measurements of the tensile strength and elongation at break according to ISO 2062:1993 as well as Young's modulus**.**

Analysis of experimental results shows on extremely high non-uniformity of PP and PP composite fibres at middle drawing ratio. The highest CV_T and CV_E were obtained in this case. CV_T and CV_E in dependence on drawing ratio pass through maximum and decrease to the lowest values at maximum drawing ratio (at the highest tenacity), as a rule (Figure 1).

The nano-fillers Disperal 40 and Cloisite 15A in combination with compatibilisers provide structure of PP/MWCNT fibres with good deformability and high orientation, leading to enhancement of both tenacity and Young's modulus of fibres. At the average elongation of fibres about 20-22% the tenacity and Young's modulus of PP composite fibres were enhanced about 20% (Table 1).



a. b.

Figure 1 Dependence of CV_T (a) and CV_E (b) on drawing ratio for PP/CNT composite fibres

Table 1. Tenacity T, Elongation E, Young's modulus YM, and their coefficients of variation for PP/MWCNT drawn composite fibres

Composition of fibres [%]	T [cN/tex]	CV_T [%]	E [%]	CV_E [%]	YM [N/tex]
PP 561N + PP 500R	64.8	2.9	22.6	7.6	7.2
PP 561N/MWCNT	65.1	7.6	22.6	8.1	7.3
PP 561N/MWCNT + D40	76.1	6.8	20.7	6.9	8.7
PP 561N/MWCNT + C15A	72.8	5.3	21.6	5.5	7.9
PP 561N/MWCNT + C15A+ S44P	71.7	8.3	20.3	5.0	8.2
PP 561N/MWCNT + C15A + TEG	81.2	2.1	21.7	6.2	9.5
PP 561N/MWCNT + C15A + S44P+ TEG	77.0	2.3	21.7	4.4	9.1
PP 561N/MWCNT + PP-g-MA + TEG	76.6	6.2	22.0	9.3	8.9

On the basis of experimental results the following conclusions can be drawn:
The unambiguous positive impact of organoclay and MWCNT on Young's modulus of PP composite fibres was found. PP composite fibres exhibited higher deformability in drawing process and higher uniformity expressed by coefficients of variation of tenacity CV_T and elongation CV_E.

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