# Melt-spinning of Polypropylene (PP) Multifilaments Yarns: Effects of Myrrh Resin on Multifilament Yarns Properties

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## INTRODUCTION

Fibrous materials have already been successfully used for many years in a variety of applications (medical, electronic, packing, etc.) due to their functional performances, offered by modified engineered fibers and filament yarns [1]. Melt-spinning is one of the most widely used processes compared to wet or dry-spinning to produce polymeric filaments. There are two main advantages of melt-spinning: 1) solvents do not need to be used in the production of polymer yarns2), it is possible to use additives and form multicomponent yarns with various functionalities [2,3].

Many polymers can be used in melt-spinning processes, such as polyesters, polyurethanes, polyolefins, polyamides, and biopolymers [3].

PP is a strong, nonbiodegradable, thermoplastic material. The high thermal stability of PP makes it suitable for medical parts that must be frequently sterilized, which require relatively high temperature treatments. It is suitable for a good thermostability used for medical applications. PP sutures, hernia meshes have good resistance, stability, and low-tissue reaction [4,5].

Natural compounds from plants demonstrate antibacterial, antifungal, and antioxidant activity. One of them is myrrh resin, which has long been used as a medicine and wound dressing. It has good antimicrobial effects [6-8].

The aim of this research is to investigate the possibilities of forming melt-spun multifilament PP yarns with 10% myrrh resin. To investigate the influence of myrrh extract on the PP melt spinning process, at different drawing ratios were analyzed. In this investigation, the influence of myrrh extracts on the structure and mechanical properties of PP melt-spun yarns were investigated.

## MATERIALS AND METHODS

The multifilaments yarns were spun from granules of polypropylene (PP) which grades is H253 FF/3 was purchased from (Sibur International GmbH, Vienna, Austria).

Preparation of myrrh ethanolic extract and modification of PP granules are the same conditions and procedure as described in previous work. The modification procedure was repeated four times, while bicomponent PP/Myrrh extract granules of 90/10 wt/wt were formed.

Multifilament yarns of pure PP and PP/Myrrh resin were manufactured by single screw extruder equipment COLLIN® CMF 100 (Dr. Collin Gmbh, Germany) (Figure 1) with seven heating zones, where the temperature during the experiments was set to 220 °C. The average extruder speed was set to 29 rpm. Circular spinnerets with 24 holes (diameter 0.45 mm) were used during these experiments. Cooling of the filaments achieved with cross-flow air quenching at a temperature of 14 °C. The temperature of the stretching rolls (Figure 2.) was as follows: S1 – S4 = 75 °C in all experiments.

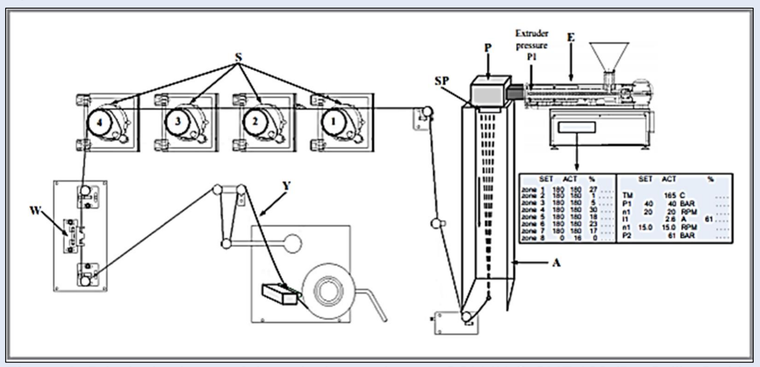



**Figure 1**. Principal scheme of the spinning equipment COLLIN ® CMF 100 (Dr. Collin Gmbh, Germany): E – extruder, P – melting pump, SP – spinneret, A – air quench cabinet, D – display, S – stretching gadgets, W – whirling unit, Y – multi-filament yarn from microfibers [9].

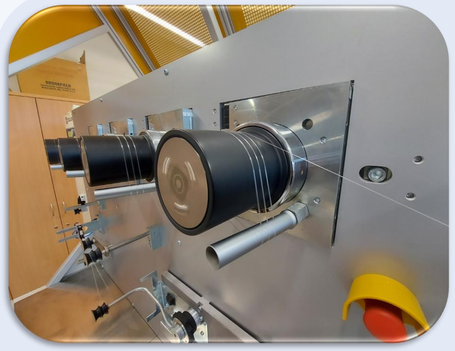


**Figure 2**. The four stretching rolls of COLLIN® CMF 100 equipment.

The linear density of the yarns was measured based on the previous work method [10]. Mechanical properties (tenacity (cN/tex) and tensile strain (%)) of PP and PP/Myrrh multifilament yarns were determined according to the EN ISO 2062:2009 standard. Universal testing equipment Zwick/Roell (Zwick GmbH & Co. KG, Germany) with the testXpert® operating program was used.

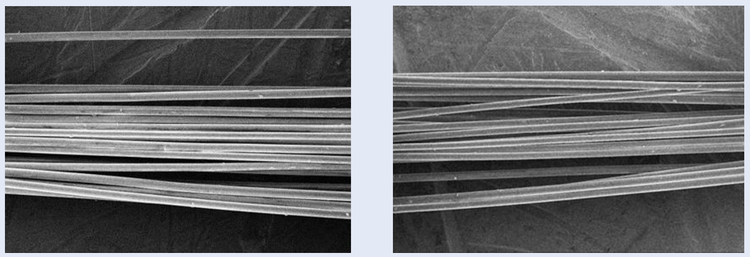
**Table 1.** Constant processing parameter of PLA multifilament yarns formation.

| Code | Samples | Stretching gadgets speed, rpm | | | | Drawing ratio |
|---|---|---|---|---|---|---|
| | | No. 1 | No. 2 | No. 3 | No. 4 | |
| A | PP | 100 | 116 | 139 | 150 | 1.5 |
| B | PP + 10% Myrrh | | | | | |
| A1 | PP | 100 | 150 | 204 | 251 | 2.5 |
| B1 | PP + 10% Myrrh | | | | | |

## RESULTS

Multifilament yarns were successfully formed from PP and PP modified with myrrh extract by melt-spinning process (Figure 3.). From the images presented in Figure 4 it is possible to state that modification of the PP granules with myrrh (Figure 4b) do not have a visual influence on the yarn surface – there are no cracks or myrrh derivatives.

**Figure 3.** First modified PP with 10 % myrrh and second pure PP multifilament yarns,



**(a)** **(b)**

**Figure 4.** SEM images of (a) multifilament PP yarns formed at 2.5 draw ratio; (b) PP with 10 % myrrh resin multifilament formed in the 2.5 draw ratio.

Data of linear density (tex), mechanical properties: tenacity (cN/tex), and tensile strain (%) of pure polymers PP and PP/Myrrh resin multifilament yarns are presented in Table 2 and the typical stress–strain curves are presented in Figure 5.

**Table 2.** Mechanical properties of the formed multifilament yarns

| Code of sample | Linear density of multifilament yarns (tex) | Tenacity, (cN/tex) | Tensile strain, (%) |
|---|---|---|---|
| A | 96.9 ± 1.6 | 9.1 ± 0.4 | 651.1 ± 46.8 |
| B | 85.2 ± 2.1 | 9.5 ± 0.3 | 562.9 ± 37.5 |
| A1 | 54.9 ± 1.1 | 14.1 ± 0.4 | 413.0 ± 25.0 |
| B1 | 50.2 ± 1.2 | 15.9 ± 0.5 | 277.0 ± 15.6 |

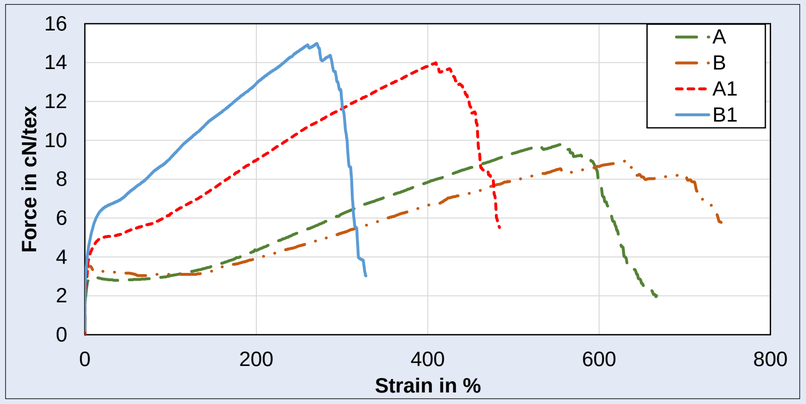



**Figure 5.** Typical stress–strain curves of the multifilament yarns formed A – pure PP – DR = 1.5; B – PP/Myrrh – DR=1.5; A1 – pure PP – DR=2.5; B1 - PP/Myrrh – DR=2.5.

## CONCLUSIONS

- Multifilament yarns from pure PP and PP with myrrh were successfully melt-spun.
- It was determinated that the increase of draw ratio from 1.5 to 2.5, had influence on tenacity and tensile strain of yarns. Multifilament yarns at higher drawing rate have 35-40% higher tenacity and 37-50% lower tensile strain. PP multifilament yarns with 10% myrrh extract have slightly higher (about 13%) tenacity and lower (14-33%) tensile strain nor pure PP multifilament yarns. It is possible to state, that myrrh resin increases PP drawability.

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