MICROSTRUCTURE OF POLYESTER FIBRES INCLUDING AG-NANOPARTICLES IN THE BULK FIBRE. INFLUENCE OF THE NANOPARTICLE CONCENTRATION

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INTRODUCTION

Numerous efforts have being carried out in the last years to introduce nanoparticles in textile fibres to confer them certain properties and high added-value. Nanostructures are capable of enhancing the characteristics of conventional textiles such as their anti-microbial, anti-static and flame-retardant properties, water and dirt repellence, self-cleaning, UV-blocking, dyeability, colour fastness and strength.

This paper is focused in the changes in the polyester fibre microstructure in the presence of silver nanoparticles.

CHARACTERIZATION

Load-extension curve

The traction parameters (tenacity, elongation and module) have been determined in an USTER TENSOKID equipment according to the standard UNE-EN ISO 2062.

Differential scanning calorimetry

Dynamic heating tests have been carried out in the following conditions: initial temperature: 40ºC, final temperature: 300ºC, heating rate: 20ºC/min and purge gas: Nitrogen 2 kg/cm^2.
Dynamic cooling tests have been carried out in the following conditions: initial temperature: 300ºC, final temperature: 40ºC, cooling rate: 20ºC/min and purge gas: Nitrogen 2 kg/cm^2.
From total enthalpy of the substrates, crystallinity of the substrates has been determined by the equation:

$$crystallinity\ (\%) = \frac{\Delta H_s}{117.6} \cdot 100$$

where ΔH_s is the enthalpy of the substrate and 117.6 is the melting enthalpy (J/g) of a perfect 100% polyester crystal.

EXPERIMENTAL

Fibre/nanoparticle production

Authors have developed a process to introduce nanoparticles in the bulk of the fibre (Fig. 1) in order to avoid agglomeration. This work has been focused in the use of silver nanoparticles (A). Those nanoparticles have been functionalized or layered with polymeric compounds (B) to include in the masterbatch (D) and, finally, it has been mixed with the polymer (polyester) and extruded (E). Afterwards, multifilament obtained has been textured by different process: false twist (ref. textured), friction textured (ref. Tangled) and air textured (ref. Taslan).

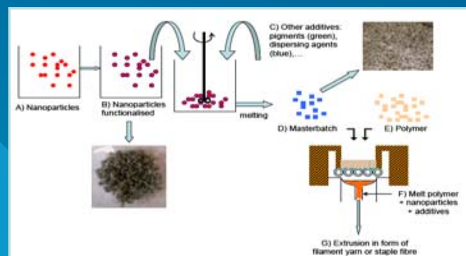

Fig. 1. Diagram of the process to obtain fibres containing nanoparticles

Material

Original: Poly(ethylenetherephthalathe)
A: Poly(ethylenetherephthalathe) containing 12.5 ppm of Ag nanoparticles.
B: Poly(ethylenetherephthalathe) containing 7 ppm of Ag nanoparticles.

RESULTS

DYNAMIC HEATING THERMOGRAMS

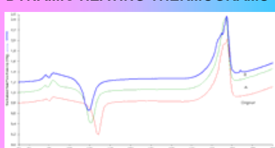

FIG. 3. DSC THERMOGRAMS OF ORIGINAL FIBRES

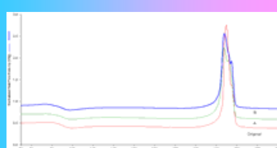

FIG. 4. DSC THERMOGRAMS OF TASLAN TEXTURED FIBRES

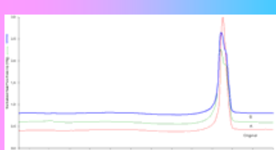

FIG. 5. DSC THERMOGRAMS OF FALSE TWIST TEXTURED FIBRES

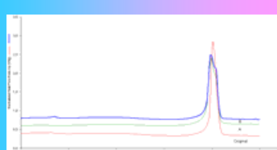

FIG. 6. DSC THERMOGRAMS OF TANGLED TEXTURED FIBRES

DYNAMIC COOLINGTHERMOGRAMS

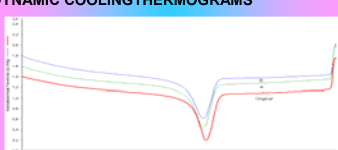

FIG. 7. DSC OF DYNAMIC COOLINGTHERMOGRAMS

LOAD/ EXTENSION CURVES

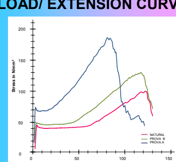

FIG. 8. LOAD/ EXTENSION CURVE OF ORIGINAL FIBRES

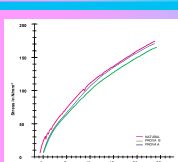

FIG. 9. LOAD/ EXTENSION CURVE OF TASLAN TEXTURED FIBRES

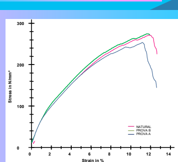

FIG. 10. LOAD/ EXTENSION CURVE OF FALSE TWIST TEXTURED FIBRES

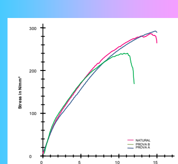

FIG. 11. LOAD/ EXTENSION CURVE OF TANGLED TEXTURED FIBRES

Table 1. Results obtained from DSC dynamic heating thermograms

	REF	Cristallization zone		Effective temperature of the texturizing treatment zone		Melting zone		ΔH_{TOTAL} (J/g)
		T_c (ºC)	ΔH_c (J/g)	PEP (ºC)	ΔH_{PEP} (J/g)	T_m (ºC)	ΔH_m (J/g)	
Original	0	127.4	-25.8	-	-	254.2	50.7	24.9
	B	118.2	-28.0	-	-	252.3	50.5	22.5
	A	121.5	-28.5	-	-	253.1	51.4	22.8
Taslan	0	97.6	-23.7	-	-	249.8	58.2	34.5
	B	95.4	-24.2	-	-	248.0	55.7	31.5
	A	96.6	-22.1	-	-	247.7	54.4	32.4
Tangled	0	-	-	152.4	5.3	250.8	59.0	64.3
	B	-	-	150.6	5.2	248.5	56.9	61.8
	A	-	-	151.3	5.6	248.3	56.2	62.1
Textured	0	-	-	151.0	6.3	250.5	60.4	66.8
	B	-	-	150.3	5.7	248.3	58.4	64.1
	A	-	-	147.8	5.1	248.0	58.3	63.4

Dynamic heating thermograms

- **Crystallization and melting enthalpies decrease in the presence of Ag nanoparticles in the fiber. That means that the presence of nanoparticles in the bulk fibre are impeding the crystallization of the poly(ethylenetherephthalathe).**
- **Cristallization and melting temperatures decrease in the presence of Ag nanoparticles in the fiber. That corresponds to the normal melting temperature decrease in the presence of impurities.**

Dynamic cooling thermograms

On the other hand the behaviour to cool crystallization takes place at lower temperatures when nanoparticles are present in the fibre.

Load/extension curve

Mechanical parameters show that resistance of the fibre decreases on increasing the nanoparticles content and that not significant difference on elongation exists.