Supertex – Sustainable technical textile from recycled polyester

The plastics industry is an important sector of the European economy having a significant and increasing influence on the municipal solid wastes stream. Plastics recycling has thus become a 'hot topic' nowadays. The project Supertex (ECO/10/277225) – Sustainable Flame Retardant Technical Textile from Recycled Polyester – is aiming to demonstrate that post-industrial and post-consumer polyester waste can be exploited in the textile industry for the production of high added value multifilament yarns to be applied in the production of technical textiles.

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Plastic products are omni-present in our everyday life. They are an extensively used material in a number of industries e.g. automotive, electrical and electronic, building and construction, as well as the food and beverage sector. The total global production of plastics grew from around 1.5 million tons in 1950 to 280 million tons in 2012 [1]. Due to the distinctive properties of plastic as well as its growing innovation applications, the trend in production for this material will continue to grow. The growth of the plastics industry has on the other hand also a significant and increasing influence on the municipal solid wastes stream (MSW). Eurostat [2] estimates that around 150 million tons/year (16.8 %) of the municipal solid waste generated in the EU-27 is in the form of plastics. Of this amount 21.3 % is recovered for recycling and roughly 29.0 % is combusted in waste-to-energy (WTE) facilities to generate electricity.

Analysis of plastic solid waste and the potential of plastic recovery

Plastics recycling has become a 'hot topic' nowadays. This is particularly the case since the revised EU Waste Framework Directive [3] has set a minimum recycling target of 50 % for household waste and 70 % for building and construction waste, which must be reached by all EU member states, by 2020 for each of the different materials, including plastics.
While in principle all resins are accepted for recycling, economics dictate that only PET, HDPE and PP are recovered for recycling purposes. PET is the most profitable polymer.
The success of plastics recovery depends on a proper collection of the plastic waste. A proper separation from non-plastics and a subsequent separation of the individual resins are necessary. A major hurdle for mechanical recycling is that the different polymers are generally non-miscible or compatible with each other [4]. This means that a mixture of different polymers can have inferior mechanical properties which make the recyclates unsuitable for many applications. Consequently, the mechanical recycling of plastics waste is generally only feasible for homogeneous, single polymer streams or for defined mixtures of polymers that can be effectively separated into the individual polymers.

Fig. 1
Left: PET flakes obtained from post-consumer PET colorless bottles
Right: PET flakes obtained from post-industrial scraps of packaging industry

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The objective of the Supertex [5] project is the development of technical textiles from rPET (recycled polyethylene terephthalate) sources for applications in the automotive and home furnishing sectors.

Polyester use in the textile industry

Polyester fibers and treads have dominated the textile raw material market since 1970 [6]. The total consumption in Europe is around 4 million tons.
Fabrics woven or knitted from polyester yarn are used extensively in apparel and home furnishings, from shirts and trousers to jackets and hats, bed sheets, blankets, upholstered furniture and computer mouse pads. Industrial polyester fibers, yarns and ropes are used in tire reinforcements, fabrics for conveyor belts, safety belts, coated fabrics and plastic reinforcements with high-energy absorption.
While synthetic clothing in general is perceived by many as having a less natural feel compared to fabrics woven from natural fibers (such as cotton and wool), polyester fabrics can provide specific advantages over natural fabrics, such as improved wrinkle resistance, durability and high color retention. As a result, polyester fibers are sometimes spun together with natural fibers to produce a cloth with blended properties. Synthetic fibers can also create materials with superior water, wind and environmental resistance compared to plant-derived fibers.
Considering the huge amount of PET that is consumed in the textile industry, as illustrated above, there is also a great potential for PET reuse.

Post-industrial or post-consumer PET

The main source of rPET scraps is reclaimed post-consumer packaging, as bottles for drinks and beverages collected and separated in many EU countries. The advantages of using post-consumer stream are the high environmental, ethical and often even socio-economic value together with the high availability and low cost of the raw material. Recycling of post-consumer PET could on the other hand be a challenge due to the heterogeneous composition. However, in Europe the bottles from selective waste reclaiming are ground and washed accurately in proper plants. Hence the post-consumer material is relatively pure and can be employed in many application fields.

Additional sources of rPET can be found in post-industrial scraps of the packaging sector. In particular, PET is used to produce trays and other containers of various sizes for food packaging. For this purpose PET is often coupled as a bilayer with polyethylene (PE) to increase the barrier to gases, thus improving the ability to preserve food freshness. To ensure good adhesion between the PET and PE layers, an adhesive is often used. In many cases the fraction of PE and adhesive in post-industrial PET scraps is large enough to promote degradation reactions during processing. Such degradation results in a decrease of melt viscosity and prevents the spinning into fibers, especially those with smaller diameter. From a structural point of view the degradation of PET during melt processing is due to residual moisture causing the cleavage of main chain polymeric ester linkages, thus resulting in macromolecules with an average molecular weight lower than virgin PET. Thus the recycling of PET/PE is more difficult than that of PET flakes from bottles.

Within the Supertex project 3 recycled PET (rPET) sources were selected and compared with the virgin PET (table).

From an economical point of view the usage of PET-PE is the most beneficial due to the low cost of the resin. The PE, on the other hand, may cause problems in the melt spinning. Scanning electron microscopy of the PET-PE pellets clearly shows the presence of PE droplets in the polyester matrix, indicating the immiscibility between the 2 polymer types. In addition, it was observed that at the side of the pellet smaller PE droplets were present compared to the core.

Since the presence of PE might have a negative influence on the fiber spinning properties, a 50 % blend with L-PET is also included to decrease the actual PE content and to keep the raw material price at a reasonable value.

rPET sources selected for the Supertex project

	Product description	Unit cost [€/kg]	Intrinsic viscosity [dl/g]
Virgin PET	Virgin PET	1.3-1.35	0.63
L-PET	Polyester recovered from colorless bottle scrubs	1.2-1.3	0.75
PET-PE	Blend of polyester and polyethylene recovered from post-industrial sources	0.66-0.74	0.63
50 % L-PET / 50 % PET-PE	Blend (50:50) of colorless bottle scrub recycled polyester and post-consumer recycled polyester	0.93-1.02	0.66

Fig. 2
SEM images of PET-PE

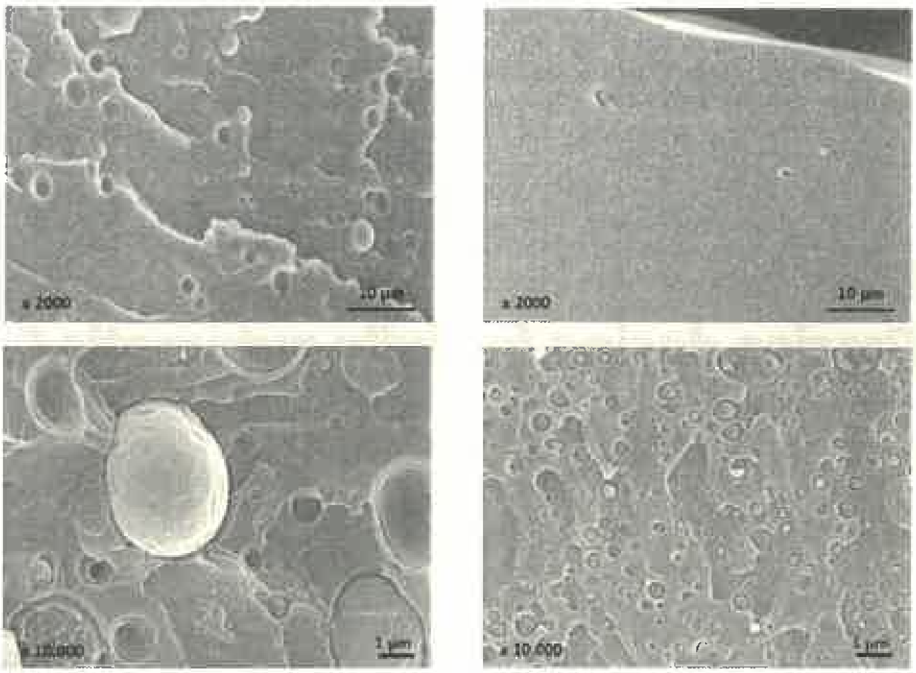
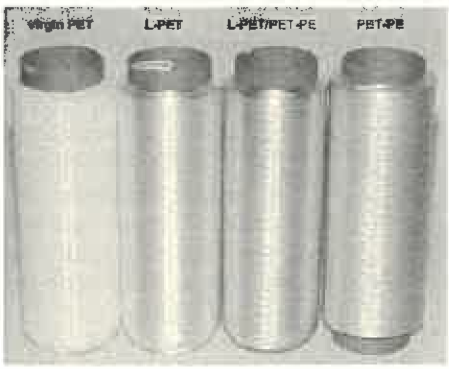


Fig. 3
Bobbins from recycled PET



Multifilament extrusion of rPET grades

In order to better understand the spinning and melting behavior of recycled PET-PE, multifilament extrusion of virgin PET with added PE was performed first. Starting from 5 % LDPE, the achievable draw ratio was lower. In addition, the temperature of the stretch rolls and duo's needed to be decreased because the yarns stuck to the rolls. This is due to the low melting temperature of LDPE (100-110 °C). The effect is only observed when a considerable amount of LDPE is present (starting from 5 %). In conclusion, the presence of PE limits the processability of PET. The PE concentration should be below 5 % in order to allow for a good extrusion process. The recycled PET-PE pellets on the other hand contain approximately 7.5 % PE. Multifilament extrusion trials demonstrated that L-PET and 50 % L-PET/50 % PET-PE could be spun under the same conditions as the reference PET.

In contrast to the extrusion of virgin PET + PE, in which spinning was only possible below 5 % PE, rPET PET-PE can be processed even at 7.5 % PE. This could be explained by the fact that small amounts of EVA are present in the PET-PE. EVA works as a sort of compatibilizing agent, allowing for a higher amount of PE. Indeed, EVA [7] is expected to form a boundary layer between the incompatible PET and PE. This compatible effect results from the miscibility between the polyethylene chains of EVA and PE, and the compatibility of the ester groups of EVA and PET. Additionally, the acetate groups can react with polyester by a transesterification reaction [8]. It is known that the rate of this transesterification, is very slow at temperatures below 200 °C and therefore, a catalyst (such as e.g. Bu_2SnO, ZnO) is generally used to ensure compatibilization within realistic extruder residence times. Yet, in this work the temperature may be high enough to realize the compatibilization. Furthermore, it might be that a catalyst is also present in the rPET samples. In addition, while the temperature of the stretch rolls and duo's needed to be lowered when spinning virgin PET + PE (starting from 5 % PE) because of sticking of the yarns to the rolls, this was not necessary when processing rPET PET-PE. Moreover, the temperature of the up-take roll was even increased to facilitate the spinning. The SEM images above show that the PE droplets at the side of the pellets in recycled PET are smaller, which may explain the easier processing of rPET at higher roll temperatures.

Multifilament extrusion of recycled PET is a promising approach for the reuse of post-consumer PET. Even though the melt flow index significantly changed compared to virgin PET, the processing of rPET was shown to be relatively similar to the processing of virgin PET. Only some small changes to the process parameters are needed to be performed. The mechanical properties of the resulting yarns, in the case of L-PET and 50 % L-PET/50 % PET-PE were good. A decrease in mechanical properties was noticed when processing PET-PE as such.

In conclusion, mainly the mixture 50 % L-PET/50 % PET-PE shows to be promising since it contains the cheap recycled polyester PET-PE while it still results in end-products comparable with virgin polyester material. ■

References

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[5] SUPERTEX Eco-Innovation, ECO/10/277225, http://www.eco-supertex.eu/

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Krüss

Precise dosing for fully automatic CMC measurements

At the analytica 2014 in April 2014 in Munich/Germany, Krüss GmbH, Hamburg/Germany, will present the Micro Dispenser, a dosing unit for fully automatic measurements of the critical micelle concentration (CMC). It was developed especially for the Force Tensiometer K100, which has taken up an established position in the market for some time now. 2 combined Micro Dispenser units create the whole concentration series for the surfactant to be analyzed directly inside the measuring vessel of the tensiometer. The K100 measures the surface tension between the respective dosing steps fully automatic by using the ring, plate or rod method.

Force Tensiometer K100 with Micro Dispensers (Krüss)

By software-controlled dosing and subsequent removing the added volume between measurements, a vast number of concentrations can be analyzed without being limited by the vessel size. Thus, a dilution by several orders of magnitude can be achieved in order to cover the concentration range of the CMC reliably. Since the concentration steps can also be chosen very close to one another, the CMC can be determined based on a large number of measurements and thereby with high precision. The very accurate dosing volume of the Micro Dispenser minimizes the systematic measurement error even for very large concentration series. This also contributes to the precision of the system. ■

Oerlikon Barmag

Metering pumps with high precision

At this year's PU TECH, the international trade fair for the polyurethane industry, March 12-14, 2014 in New Delhi/India, Oerlikon Barmag, Remscheid/Germany, presented components used in technologically demanding processes, such as PUR applications or in the dye and paints industry.

Oerlikon Barmag metering pumps are responsible for the precise metering of the various liquid materials in the numerous chemical processes carried out during the production of extremely strong and resilient components for high-performance compound materials. They guarantee precise material flows wherever highly-accurate metering of liquids and chemical fluids is absolutely essential to the process stability. To this end, the deviation in metering accuracy for a pump lies at ±0.15 %. Parallel to the proven GM series from Oerlikon Barmag, the GA range of pumps has been especially designed for conveying media with higher viscosities of up to 1,500 Pa•s as well as for temperatures of up to a maximum of 225 °C. With the new range of pumps, Oerlikon Barmag now offers tailor-made solutions for applications requiring accurately-defined, even metering.

Furthermore, the GM series with the round plate package has been expanded to include an option for the pressure build-up capacity especially for use in high-pressure technology with small throughputs and low viscosities. It is available in 0.05 through 20 cm^3/rev feed sizes and guarantees the build-up of the required high operating pressures even at low viscosities. ■