# POLY(TRIMETHYLENE TEREPHTHALATE): A "NEW" TYPE OF POLYESTER FIBRE

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**ABSTRACT:** A new type of polyester fibre is being brought into production by Shell Chemicals predominately for the residential and industrial carpet markets. This fibre has the tradename of Corterra7 and is a poly(trimethylene terephthalate) (PTT). These fibres have a number of traits that lend themselves to carpet products. Shell expects to produce 400 million pounds of Corterra7 polymers for the general marketplace by the end of the third quarter of 1999 and, thus, it will begin to appear as evidence in cases.

PTT fibres have many similarities to, but some important differences from, the more common poly(ethelyene terephthalate) (PET) fibres. The history of PTT, its optical and instrumental characteristics, and data from known samples are presented in this technical note.

**KEY WORDS:** Fibers; Polyester; Poly(trimethelyne terephthalate) – PTT.

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## HISTORY

Poly(trimethylene terephthalate) (PTT) was first synthesised and patented in 1941 (Whinfield and Dickson, 1941) but was not produced commercially due to the expense of one of the precursors, 1,3-propanediol (PDO) [5]. The production of PDO was halted in the mid-1960's and ethylene oxide (EO) hydroformulation was developed as an alternative. In the early 1990's, hydroformulation catalyts were created to allow for the economic formulation of PD. through continuous EO hydroformulation. The vast majority of polyester textile fibres are polyethylene terephthalate) (PET); its sister polymer, poly(butylene terephthalate) (PBT), has a very limited application to textiles [10]. PTT, made by Shell Chemicals and marketed under the tradename Corterra7, has many characteristics that lend themselves to a variety of products: Superior elastic recovery, good colour fastness, uniform dye uptake, stain resistance [6] and low static charge generation [5].

## CHEMISTRY AND PRODUCTION

PTT is synthesised by the polycondensation of trimethylene glycol with either a terephthalic acid or dimethyl terephthalate. Trimethylene glycol is now commercially producible through the hydroformulation of ethylene oxide allowing for the economic production of PTT [6]. The chemical structure of PTT is shown in Figure 1. PTT has an odd number (three) of methylene units between each of the terephthalates, whereas PBT and PET have even numbers of methylene units. The odd number of methylene units affects the physical and chemical structure of PTT, giving it elastic recovery beyond that of PBT or PET and into the range of nylon [6] (Table I). PTT is also dyeable without a carrier at boiling temperatures under atmospheric conditions because of the open molecular structure, providing a colour-fastness comparable to nylon with select dyes. PTT also allows for additional tonal shades with pressure dyeing [3], giving designers a greater number of choices for textile colours. Disperse dyes work best on PTT fibres, yielding a uniform colour with good fastness [6, 12].

TABLE I. PROPERTIES OF PTT AND OTHER SYNTHETIC FIBRES [7]

| | PTT | PET | Nylon 6 | Nylon 66 | PP |
|---|---|---|---|---|---|
| Melting point [°C] | 228 | 265 | 220 | 265 | 168 |
| Glass transition [°C] | 45–65 | 80 | 40–87 | 50–90 | –17 to –4 |
| Density [$g/cm^3$] | 1.33 | 0.49 | 9.5 | 8.9 | < 0.03 |

PTT is easily heat set and can be spun in a PTT/PET bicomponent (side-by-side) resulting in a crimp (due to differential shrinkage) that yields a high loft but retains the other desirable traits [5]. Core-sheath bicomponents are also being produced. Although initially targeted for the carpeting market, PTT can be spun and drawn at high speeds, resulting in a fibre suitable for fine denier applications (Figure 2), such as sports wear, active wear, and other speciality textiles [10]. Its heat-setting properties make PTT particularly useful in nonwoven fabrics [7].

## ANALYTICAL PROPERTIES

PTT fibres have optical properties like PET fibres (high refractive indices in $n_{||}$ and $n_{\perp}$) but with a lower birefringence (between 0.06 and 0.08). Other authors have measured the refractive indices of PTT fibres as being 1.626 in parallel and 1.566 in perpendicular ($n\Delta = 0.06$). Homofilaments of PTT display lower order interference colours than PET fibres but higher than nylon

(Figure 3), which accords with the lower-than-PET birefringence (n$\Delta$ PET = 0.098 to 0.183 [1, 2, 8]). Theoretically, dichroism should be possible in PTT fibres but to date none has been observed.

FT-IR spectra have been published on PTT fibres (Hopen, 1999). Raman spectra were collected (Figures 4 and 5) with a Chromex Raman 2000 dispersive CCD spectrometer at 785 nm excitation with Raman shifts between ~150–3000 $cm^{-1}$ with a resolution of 4 $cm^{-1}$. The spectra were white light and bias corrected. A microscope objective was used at 40 × magnification with a spot focus at about 70 mW power. The sample fibres were taped to aluminium foil-covered glass slides. Sampling time was about 30 seconds. Other methods have also been used to characterise this polymer (see [9]).

## DISCUSSION

While no prediction can be made about the future prevalence of PTT fibres in consumer goods, they are currently present in specific markets, such as carpeting. New products are being designed with PTT's qualities in mind. Solenium, for example, is a composite flooring material designed for institutional and hospital use that capitalises on PTT's elastic regain, durability, and colour-fastness properties [4]. Additional information is available at www.shellchemicals.com and www.kosa.com. It is important for the forensic fibre examiner to be aware of the analytical properties of PTT fibres and to be able to distinguish them from PET.

Fig. 1. PTT molecule.

Fig. 2. PTT can be spun to fine deniers for active wear and other speciality clothing.

Fig. 3. PTT fibre in polarised light and under crossed polars.

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