

# Terylene, The New British Fiber

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AN entirely new synthetic fiber is now being exploited in England which may in time rival in importance nylon, Vinyon, and the other synthetics now in industrial use.

This new fiber, "Terylene", was developed by J. R. Whinfield and J. T. Dickson in the laboratories of the Calico Printers' Association, and was first announced in 1946. Its name is a condensation of the names of the two chemicals from which it is made (terephthalic acid and ethylene glycol). Both of these materials are cheap and available in quantity; ethylene glycol is the popular "antifreeze", better known to motorists as "Prestone", and terephthalic acid is obtained from a by-product in the manufacture of phthalic anhydride from petroleum.

From the chemical standpoint a comparison of the formula of Terylene with that of nylon is of interest:



Nylon



Terylene

Two essential differences will be noted. First, the nylon molecule is entirely aliphatic, while the Terylene molecule contains recurring benzene rings; second, the nylon synthesis is based on the formation of polyamides (using hexamethylenediamine), while the Terylene synthesis is based on the formation of polyesters.

It is interesting to note that Carothers, in his researches leading to the discovery of nylon, investigated the possibilities of the polyesters for fiber-formation, but considered the polyamides superior. Whinfield (1) pointed out that the substitution of an ester linkage for an amide linkage (in the case of Terylene) resulted in increased resistance of the fiber to heat and light. He further stated that the presence of the "recurring benzene nuclei in the linear chain" is a contributing factor in giving the fiber its high melting point. He found that neither phthalic acid nor isophthalic acid, when substituted for terephthalic acid, gave a product of any value for fiber-making. A writer (2) in *Silk and Rayon* explained that the usefulness of terephthalic acid lies in the fact that it

can form part of a *straight* long-chain molecule (the carboxyl groups being in the *para* position to each other), while the other two acids (*ortho* and *meta*) would lead to the formation of "kinks". Much work has been done (2) with other aromatic dicarboxylic acids, but the results, although extremely interesting, are beyond the scope of this brief paper.

Regarding the glycol component, Whinfield (1) stated that on substituting propylene or butylene glycol for ethylene glycol, fibers of lower melting point were obtained; diethylene glycol produced nothing of value.

After the C. P. A. had selected polyethylene terephthalate as the most promising for fiber production of all the various superpolymers investigated, they invited Imperial Chemical Industries, Inc., to take over the task of converting the laboratory process to commercial production. This

work is now proceeding rapidly, but so far as has been learned, production to date has been very limited, as many difficult problems have first to be solved.

## Preparation of the Fiber

Writers (2), (3) in *Silk and Rayon* give details of the process for producing the Terylene fiber, which is covered by various British patents (4). From 1 to 6 mols of ethylene glycol and 1 mol of terephthalic acid, both in a high state of purity, are heated in an inert atmosphere until a clear solution is obtained. A suitable catalyst, such as hydrochloric acid, speeds up the reaction. An alternate method consists of using an ester of terephthalic acid (e.g. the methyl ester) instead of the free acid, and adding a metallic catalyst (e.g. sodium). By this process, heating for three hours at 197° C. in a current of nitrogen gas completes the reaction. The resulting glycol terephthalate is then heated further at 280° C. for one-half hour at ordinary pressure, and then for ten hours *in vacuo*. The polymer obtained is white, melts at

256° C. and has a molecular weight of 8,000 to 10,000.

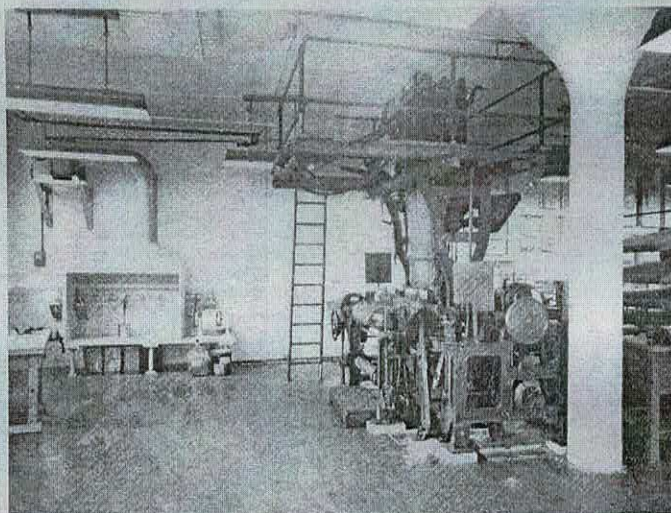
Conversion to fibers is accomplished by heating the mass to fusion and forcing it through a spinneret, as in the case of nylon. Since the polyester is somewhat hygroscopic, and will decompose in the molten condition in presence of even a small amount of water, it must be thoroughly dried *in vacuo* before spinning.

The fibers, which at this stage are weak and highly extensible, are now drawn out to several times their original length in order to increase their strength. The amount of stretching can be varied (5), producing either very strong yarns (8 g. per denier or higher) with relatively low extensibilities, or somewhat weaker yarns with increased extension. The stretching of the fibers has a pronounced effect on their affinity for dyes. Undrawn Terylene is readily dyed by the ordinary acetate dyes, but after stretching, the affinity is "very much reduced" (1).

## Properties of Terylene

It is perhaps a little early to give complete details of the physical and chemical properties of this new fiber. It can be stated, however, that it has a high initial modulus of elasticity (i.e., a relatively high load must be applied to produce a small extension). At the same time, the length recovery of the yarn, especially from low extensions, is very high and takes place rapidly, so that it behaves rather like a "heavy spring" (5). It is thus well adapted for weaving and knitting. Its tensile strength is outstanding, and is only slightly lessened on wetting. Ordinary dry-cleaning solvents have no effect on it, and it resists bleaching agents. Boiling dilute mineral acids have no action, and it is reasonably stable to alkalis. It may be heated up to 200° C. without injury or discoloration, but it is necessary to "set" the fibers by a suitable heat treatment if it is to be dimensionally stable on subsequent heating (5). This would seem to apply particularly to hosiery. The moisture absorption at 65 per cent relative humidity is less than 1 per cent, and the fiber does not swell when immersed in

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A Section of the Pilot Plant at Alexander Smith and Sons Carpet Company Showing Carpet Loom Used for Experimental Purposes Together With Size Mixing Equipment.

mill processes and new products can be studied without interference with regular mill production schedules. Skilled mechanics with long weaving experience and experience with equipment are a part of the laboratory staff assisting in pilot plant operations.

The staff of the Research and Development Division is active in the technical societies of the textile and allied industries, with company membership and support of such organizations as the American Society for Testing Materials, the American Association of Textile Chemists and Colorists, the American Society for Quality Control, the Industrial Research Institute, the Textile Research Institute, and the American Chemical Society. Members of the staff are chairmen or members of committees in these various societies and have presented papers during

the past several years which have created favorable interest and comment.

The Research and Development Division is internationally known and during the past year distinguished scientists have visited the Laboratories from England, Scotland, Holland, Sweden, Australia, and India.

During the past year, in addition to the applied research and development of equipment, the Division has performed more than 220,000 recorded physical and chemical tests on fibers, yarns and carpets for control, development and research. During the same period over 200 specifications and standards were issued, and 34 development projects, which have contributed to annual savings of more than a million dollars in material and processing costs, were completed.

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water. It is resistant to molds and bacteria and particularly stable to light.

From the above properties it would appear that Terylene should be eminently suitable for tents, screening and other outdoor fabrics, particularly in the tropics. Its high tensile strength should make it excellent for tire cords. Its resistance to chemical action should recommend it for filter cloths. The one serious weakness, which to date has apparently not been overcome, is its lack of affinity for dyes; so far only pale shades have been successfully produced. Until this problem has been solved, Terylene will be seriously handicapped.

However, a recent I.C.I. patent (6) states that colored fibers can be obtained by adding pigments to the molten polymer before spinning. According to the patent, the pigment is first dispersed in "a different linear polyester or in a polyesteramide." Further details are lacking at this time.

It is interesting to note that the Du Pont Company are also interested in Terylene, which they are temporarily designating as "Fiber V". Production in this country may therefore be expected in due time.

### References

- (1) Whinfield, J. R. "Nature" 158, No. 4026, 930 (1946).
- (2) Anon. "Silk and Rayon" 21, 534 (1947).
- (3) Anon. "Silk and Rayon" 21, 1396 (1947).
- (4) B. P. 578,079; 588,411; 588,497.
- (5) Anon. "The Knitter", July, 1947, p. 32.
- (6) B. P. 596,688.

## Patent Digest—

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procedure. According to an example a discharge paste contains Indigosol Violet AZB, Cellosolve and ethanol as solvents, sodium thiocyanate, sodium nitrite, urea, thickener and about 10% zinc formaldehyde sulfoxylate. The printed fabric is dried, aged for 12 minutes at 102° C, acidified in sulfuric acid and dichromate at 80° C. for one minute, rinsed, soaped and washed again. The discharge patterns are said to be sharp and very bright.

References: U. S. Pat. 1,944,372 (Celanese) described discharges containing insoluble reducing agents mixed with solvents (alcohols) or swelling agents. U. S. Pat. 1,957,494 (same company) recommends a discharge paste, composed of zinc formaldehyde sulfoxylate, methanol and China clay. U. S. Pat. 1,981,907 (Du Pont) suggests to use a discharge paste—likewise on acetate of cellulose—containing Rongalite, zinc thiocyanate in soluble form and diethylene glycol as a swelling agent.

## Cellulose Acetate Dyeing— Tetrahydrofuran as a Dyestuff Solvent

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Brit. P. 596,264

(Rhodiaceta, Dec. 31, 1947)

It is known to dye cellulose acetate or polyvinylfilaments from organic dyestuff solutions of water insoluble dyestuffs. The use of tetrahydrofuran:

$$\begin{array}{c} \text{CH}_2 - \text{CH}_2 \\ | \quad \quad \quad \backslash \\ \text{CH}_2 - \text{CH}_2 \quad \quad \quad \text{O} \end{array}$$
 O, proposed in the present patent, has the special advantage of bringing about deep colorations in a relatively short time, even on a pad, because of the fine dispersion of the dyestuffs and because of the high volatility of the solvent. A further advantage is that the solvent is readily soluble in water.

References: U. S. P. 2,292,433 (Celanese): the following organic solvents are used for dyeing acetate of cellulose with acid dyestuffs: methanol, ethanol and propanol. Brit. P. 470,333 (Celanese) proposed dichloroethylene as a solvent for the same purpose. Brit. P. 576,927 (Celanese): direct dyes are dyed on acetate of cellulose using a mixture of lower acids and ethanol. French Pat. 809,836 (Usines de Melle): furfuralcohol and tetrahydrofurfuralcohol—thus compounds closely related to furane are used as dyestuff solvents.