STUDYING THE PROPERTIES OF LOCAL POLYESTER FIBER, FORMED FROM POLYETHYLENE TEREPHTHALATE GRANULES

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ABSTRACT

In this work, the properties of local polyester fibers are studied on the basis of physicochemical and physicomechanical analyzes. On the basis of X-ray diffraction analyzes, it was found that the degree of crystallization of local polyester fibers is lower than that of the usual traditionally used lavsan fiber; they hardly differ in physical and mechanical properties. IR spectroscopic and sorption analyzes, as well as characteristic reactions of polyester fibers, showed that local polyester fibers are formed from modified polyethylene terephthalate. It is concluded that, due to the high sorption properties of the fibers, there is a wide possibility of using it in the textile industry.

KEYWORDS: *Polyester, Polyethylene Terephthalate, Sorption, Degree Of Crystallization, IR Spectroscopy, Modification, X-Ray Diffraction Pattern.*

INTRODUCTION

For the first time in 1929, the possibility of obtaining fibers based on polyester was proved.To date, a number of scientific studies are being carried out to obtain this fiber, the production of polyester fibers for household and technical destination. In our republic, in recent years, a number of industries have produced fibers from various semi-finished products based on polyester. Currently in the world more than 20 different types of blended fabrics with polyester are produced **[1]**. Considering all this, expanding the possibility of using local polyester fibers in the textile industry, the study of the macromolecular structure, composition fiber, its sorption and physico-mechanical properties is very relevant task. By studying the structure and properties of the fiber, one can establish the order and composition processes of chemical finishing of textile products based on this fibers.

It is known that polyester fibers are obtained as a result of a polycondensation reaction terephthalic acid or its dimethyl ether and ethylene glycol **[2]**. But in dependence of the reaction conditions, reagents used, fiber spinning conditions polyester fibers produced in different countries use different names: Dacron (USA), Teteron (Japan), Trevir and Lanon (Germany), Tergal (France), Tesil and Svitlen (Czech Republic), Elana (Poland), Lavsan (Russia) **[3]**. Also, in order to reduce static electricity, increase hygroscopicity, improve dyeability, making the fiber fireproof or slow combustible, also to eliminate other disadvantages of polyethylene terephthalate are modified, i.e. upon receipt of the polymer, along with the main monomer add another monomer in the amount of 5-10% (in relation to basic monomer). Depending on their properties and quantity, the resulting copolyester changes its properties **[4]**.

In experiments, the sorption properties of the samples were studied on mercury high-vacuum McBen installation with quartz balances. The measurements were taken at at a temperature of 298K and at a pressure of 10-3 - 10^{-4} Pa. X-ray studies were carried out on the X-ray diffractometer "Dron-3M" with an irradiance of 22 kV, monochromatized with CuKα, at a current strength of 12 mA. The measurements started after grinding samples and giving them the form of a tablet. The measurements were carried out within the limit 2θ = 100 - 350. IR - spectroscopic analysis was carried out in the spectrometer IR-FURE (model 2000, scan 100, at 4 cm-1 latitude) from Perkin-Elmer. Physico-mechanical parameters of the samples were determined at the certification center of the institute "SENTEX UZ" according to GOST 3813-72 **[5]**.

Typically, the supramolecular structure of polyethylene terephthalate (polyester) consists of crystalline and amorphous parts. The crystalline part determines the physical mechanical properties of the fiber, amorphous part - its sorption properties. Polyester (PE) has a polydisperse structure, with a strong chain and it crystallizes. Internal structure fiber has a high degree of order, its 55-75% is the crystalline part. The degree of crystallization of polyester fibers produced in various enterprises (Table 1.).

TABLE 1 DEGREES OF CRYSTALLIZATION OF POLYESTER FIBERS

Samples	Degree of crystallization, θ, %
Polyester fiber, imported in Russia	53
Polyester fiber produced in JV LLC "Reprocessing Uz"	44
Polyester fiber produced in EKO Plastex Ltd.	35
Polyethylene terephthalate granule used for polyester fiber production	61

From the above information, it can be seen that imported polyester fiber Russia has a degree of crystallization of 55%, when the degree of crystallization of the local polyester fiber is 35-44%. The degree of crystallization of the granule used for fiber production is 61%. The reason for the low degree of crystallization local fibers, apparently, is the rapid cooling of polyethylene terephthalate on enterprise. In the macromolecule of the fiber obtained with rapid cooling polyethylene terephthalate amorphous part is relatively larger. It is known that despite the fact that the monomer units of the polymer are the same, their degree of crystallization may differ [6]. It depends on the application of the catalyst, its nature and the temperature of the thermal processing. Due to the high sensitivity of the supramolecular structure of the polymer to heat treatment one of the ways to control their properties is thermal treatment. Typically, the cooling time is determined depending on the required degree crystallization of the finished fiber. This means that during the molding process of the polyester fibers by changing the heat treatment conditions, it is possible to form a fiber with desired properties.

The difference in the supramolecular structure of the two studied fibers obtained in different enterprises of the Republic due to differences in the factors of fiber formation, also using various semi-finished products. In order to study the type of used semi-finished products to obtain fibers, IR spectral analyzes of the fibers were carried out (Fig.1-3).

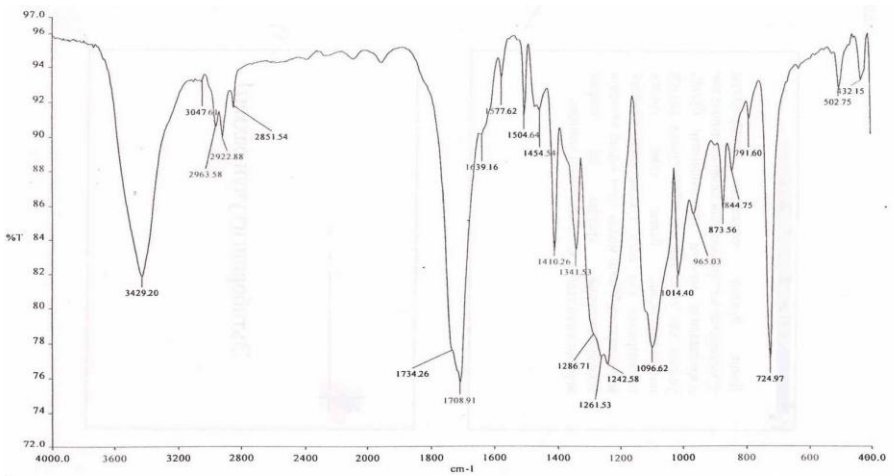

Fig.1. IR spectrum of polyester fiber imported from Russia (lavsan)

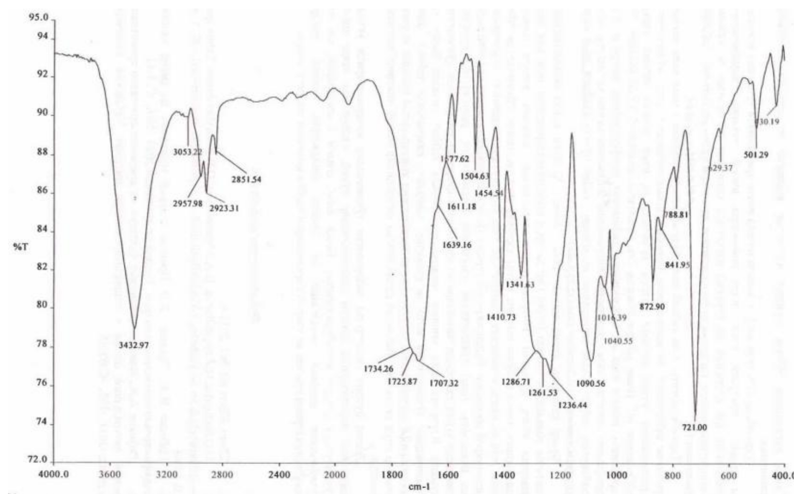

Fig.2. IR spectrum of polyester fiber produced in JV LLC "Reprocessing Uz"

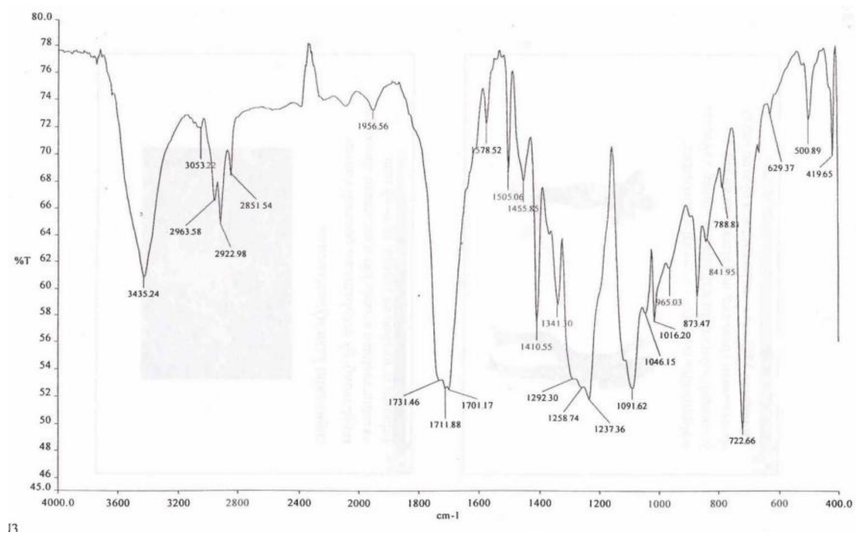

Fig.3. IR spectrum of polyester fiber produced in EKO Plastex LLC

Usually, the production of polyester fiber begins with the synthesis of monomers. Terephthalic acid (TPA) or its dimethyl ester (dimethyl terephthalate - DMT) is considered raw material for the production of polyethylene terephthalate (PET). In many PET enterprises obtained from DMT despite the fact that for the first time PET was obtained from TFA. This is due to the fact that Absolutely pure TFA is required to obtain PET. The TPA purification process is difficult. After obtaining TFA or DMT, PET is obtained batch or continuous way. At these stages, diglycol terephthalate - DHT is synthesized in parallel, then it polycondensate. In this case, ethylene glycol or ethylene oxide is used. On the specified processes, polymer granules are obtained, the next step is the process getting fiber. The resulting finished fiber may contain reagents, used in the preparation of the monomer or polymer. On the given spectral curves on the IR spectra of local PE fibers, a decrease in fluctuations is observed, corresponding to carbonyl groups 1725 cm-1 and 1711 cm-1, this means that =C=O groups replaced by other groups. Hence, the fiber can be considered as obtained from copolymer or modified fiber. These fibers are manufactured in the USA (codel) and in Germany (vestan). By changing the =C=O group with other groups, improvement is possible some textile properties of the fiber. On the spectral curves of the fiber SP OOO "Reprocessing Uz" appearance of a line corresponding to 1611 cm^{-1} - NH^2 amino groups shows that the fiber is modified with a monomer containing amino groups. On the Spectral curves of the fiber of EKO Plastex Ltd. did not detect fluctuation corresponding to 1611 cm^{-1}. This means that semi-finished products are polymers of both studied fibers have different compositions. The study showed that the change =C=O groups in fibers into acid or alkaline groups leads to a high hygroscopicity compared to imported fibers. Due to the dense structure and lack of hydrophilic groups, polyester fibers are considered hydrophobic. At relative humidity 65% it absorbs 0,4% humidity, at relative humidity 100% absorbs 0,6-0,8% moisture. In the aquatic environment, the fiber does not swell at all. It has the property of accumulating electric charge to a high degree. These properties degrade fiber dyeing and mechanical working conditions. In the following The table shows the sorption of water vapor on the studied samples and their capillary-porous characteristics.

TABLE 2 SORPTION OF WATER VAPOR INTO SAMPLES AT A TEMPERATURE OF 25^{0}C

Samples	Fiber, imported production	Granule polyethylene terephthalate	Polyester fiber, produced in JV OOO "Reprocessing Us"	Polyester fiber, produced in OOO EKO Plastex
Relative humidity, %	Sorption, %			
10	0,20	0,15	0,25	0,25
30	0,25	0,20	0,30	0,30
50	0,30	0,30	0,40	0,35
65	0,40	0,35	0,50	0,45
80	0,50	0,40	0,65	0,55
90	0,55	0,45	0,70	0,65
100	0,65	0,50	0,80	0,70

It follows from the table that the amount of water vapor sorption into the granule, which was used to obtain fibers lower than the amount of water vapor sorption in all studied fibers. From this we can conclude that the sorption properties of fibers the process of forming fibers affects, and not the functional groups in the composition of the polymer, which impart hygroscopicity. At the same time, high values of sorption properties both polyester fibers obtained in our Republic in relation to imported fiber, indicates the presence of hydrophilic groups in their composition. Sorption difference properties between both fibers to say that when they were obtained, various chemicals. The capillary-porous characteristics of the fiber can vary depending on the structure of the macromolecule and the conditions of fiber formation [7]. In table. 3. capillary-porous characteristics of the studied samples.

The table. 3. shows that the capillary-porous characteristics of all the studied fibers are closely related. This shows that fiber macromolecules have similar or the same buildings.

TABLE 3 CAPILLARY-POROUS CHARACTERISTICS OF SAMPLES

Samples	Fiber, imported production	Granule polyethylene terephthalate	Polyester fiber, produced in JV OOO"Reprocessing Us"	Polyester fiber, produced in OOO EKO Plastex
Monolayer volume, Xm, g/g	0,0034	0,0019	0,0042	0,0039
Specific surface, Syg. m^2/g	12,22	6,86	13,84	13,95
Total pore volume, Wo, sm^3/g	0,0070	0,0060	0,0080	0,0092
Pore radius (capillary), rk, A0	11,46	17,48	12,56	11,76

Decreased specific surface area and total pore volume is explained by the decrease in the monolayer of fibers in the process of obtaining a thread from staple fiber and structure sealing in the process of twist communication. By structure macromolecules in the process of fiber formation, according to the existing conformational changes in the structures and nature of the side groups capillary-porous characteristics local polyester fiber are different from the characteristics of imported fiber. Changes in the sorption properties of fibers affect their physical and mechanical properties (Table 4.). The increase in the hygroscopicity of chemical fibers is usually carried out in three ways. ways: by introducing functional groups into the macromolecule of the fiber, which can contact with water (modification); formation on the fiber or on the thread controlled capillary porosity; change in the shape and structure of the fiber surface. However it must be taken into account that imparting hygroscopicity with a change in the structure of the fiber negatively affects its physical and mechanical properties.

TABLE 4 PHYSICAL AND MECHANICAL PROPERTIES OF POLYESTER FIBERS

Polyester samples fibers	Breaking strength, (at least) N/teks	Discontinuous elongation, % (no more)
Fiber, imported production	0,45	49
Fiber produced in JV LLC "Reprocessing Uz"	0,40	47
Fiber produced in EKO Plastex LLC	0,38	46
GOST 26022-94 Polyester fiber	0,36	50

It can be seen from the obtained results that although the sorption properties of the fibers differ, have similar physical and mechanical properties. it's the same confirm the results of X-ray and IR spectroscopic analyses, which means - the main part of the polymer consists of polyethylene terephthalate.

According to the literature data, PE fiber can be produced in a modified condition, adding to it in an amount of 5-10% one of the following substances – dimethyl isophthalic acid ester, potassium salts of isophthalic acid dimethyl ester, adeptic acid dimethyl ester, hydroxyethoxybenzoic acid methyl ester, 5-hydroxyisophthalic acid dimethylester, 2,6-naphthalene dimethyl ester dicarboxylic acid [8]. Obtained experimental results confirm that the polyester fibers produced in our Republic are obtained from modified polyethylene terephthalate.

PE - thermoplastic fiber, softening temperature is 258-260^{0}C, in dissolves in organic solvents. PE fiber exposed to certain chemicals (benzoic and salicylic acids) swells, and this circumstance is used in the process dyeing of this fiber. When wet, the elongation at break does not change. PE products retain their shape well, have high elasticity. On PE fiber weak acids do not act even at boiling point. In low temperature fiber resistant to strong acids and weak alkalis. At high temperatures do not resistant to the action of caustic alkali, while they are hydrolyzed. PE fiber relative resistant to oxidizing agents, but resistant to biological effects, microorganisms and moths. In table. 5 shows the results of reactions characteristic of polyester fibres.

TABLE 5 RESULTS OF CHARACTERISTIC REACTIONS OF POLYESTER FIBERS

Polyester fiber samples	Dissolution time, min	
	In 40% solution NaOH at 90^0C	In 60% solution H_2SO_4 at 100^0C
Fiber, imported production	6	4
Fiber produced in JV Reprocessing Uz LLC	17	18
Fiber produced in EKO Plastex LLC	25	24

From the information given in the table it can be seen that for the dissolution of local polyester fibers in alkali and sulfuric acid solutions take longer than to dissolve imported fiber. In addition, in a solution of local polyester fibers in alkali, 30 minutes after dissolution, the formation of crystals is observed, which requires deep analysis of the composition of local polyester fibers. This, polyester fiber produced in the republic in terms of its physical and mechanical properties, supramolecular and morphological structure similar to practically used imported fiber, differs in sorption properties in positive side - which shows the possibility of widespread use of this fibers in the textile industry.

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