ANALYSIS OF THE EVOLUTION OF PRODUCTION OF HYDRATED CELLULOSE TEXTILE FIBRES

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In summing up the observations given below on the future of new cellulose fibres, including comparing them with natural fibres (cotton), some generalizations can be made. The constant increase in the demand for cellulose-based textile fibres is not only due to the tendency toward a higher standard for clothing and satisfaction of the needs of the growing population, but also to the specific features of the properties of cellulose fibres (natural and man-made), especially hygroscopicity and hygiene: in this respect, the new fibres for linen clothing are significantly better than synthetic fibres, second to the latter only in fabrics for water-repellent clothing; an analysis of the possibilities of solving the problem of the increasing demand for cellulose fibres by expanding production of cotton and increasing production of man-made cellulose fibres leads to the following conclusions: the increase in areas planted with cotton could be slowed by an increase in the demand for fields for grains and the limited possibilities of restoring previous catastrophically destroyed sources of irrigation water; while preserving or expanding production of cotton, primarily by increasing productivity, it is necessary to significantly increase production of man-made fibres; for this reason, the main restriction which had previously not permitted adding new HC fibre enterprises primarily produced by the viscose process, which does not meet current ecological requirements, has been removed; for this reason, the advances in spinning of cellulose fibres from solutions in "direct" solvents (primarily MMO) make this method fundamental in solving the problem of satisfying the demand for cellulose fibres; in using the new method of manufacturing HC fibres, one of the serious conditions for increasing total production of chemical fibres should also be considered; this does not eliminate the need for progress in the synthetic fibre field, although with respect to some physical, particularly strength, properties, MMO fibres can partially take on the function of textile materials which synthetic, basically polyester, fibres currently fulfill; some properties of the new fibres, in particular, their capacity for surface fibrillation, require improvement, but although this is difficult, it is nevertheless a totally solvable problem. The questions discussed in the present article require further elaboration and more precise definition, but they undoubtedly constitute an important part of the overall prognosis for production and correspondingly scientific studies of fibres.

Data on scientific and pilot-industrial studies to create new methods of fabrication of hydrated cellulose (HC) fibres and especially methods based on the use of a "direct" solvent of cellulose — N-methylmorpholine N-oxide (MMO) — were published in Khimicheskie Volokna, No. 1 (1996) [1].

It is useful to briefly analyze the following basic aspects of this problem:
— the special importance of HC fibres in the textile industry;
— ways of increasing production of HC fibres and correspondingly changing the ratio between them and natural fibres, primarily cotton;
— ecological problems of production of HC fibres;
— the ratio between HC and synthetic fibres in their use in the textile industry and technology.

Some of these questions were examined in the review issue of the journal published by Lenzing [2], but in individualizing them, it is useful to consider the specific features of solving such problems in Russia (and in CIS countries) in comparison to other regions of the world. This comparison is complicated by the fact that the overall state of the economies in CIS countries has led to a significant drop in production in many branches of industry, including production of chemical fibres.
fibres. Nevertheless, it would not be justified to not conduct a preliminary analysis of future predictions concretely related to the HC fibre industry while awaiting the next upswing in the economy.

We will discuss the aspects of the problem of HC fibres noted above.

The special importance of HC fibres in the textile industry is primarily determined by the fact that cellulose sorbs a large number of water molecules due to the three hydroxyl groups on each elementary unit of the macromolecular chain in its chemical structure, and this ensures absorption of atmospheric moisture by the cloth, and blocking of other segments of the macromolecule by molecules of water strengthens the degree of wetting of the cloth (the contact angle of wetting with water is below 90°, while \( \cos \varphi > 0 \)). For this reason, favorable conditions are created for penetration of moisture from the space under the clothing through the pores in the cloth onto the outside of the cloth. Evaporation of moisture on the surface of clothing, which requires expenditure of the heat of evaporation, decreases the temperature of the entire system and creates more comfortable conditions in wearing the clothing [3]. This is the advantage of textile materials made of HC fibres for clothing in comparison to cloth made of synthetic fibres, where the angle of wetting with water is greater than 90°, which determines their water-repellent properties. For this reason, synthetic fibres are more suitable for fabrication of outer clothing, but not for underwear which lies next to the skin.

High wettability with water is characteristic of both natural cellulose fibres (cotton, flax, etc.) and for cellulose-based man-made fibres, with the exception of cellulose acetate fibres in which the hydroxyl groups are blocked by acetyl groups. Wool and silk also have high wettability with water, but in contrast to HC fibres, they cannot be mass produced due to the high cost and relatively limited availability. The solution to the problem of satisfying the textile industry demand for fibres for clothing fabrics (especially for fabric in contact with the body — of the type of fabric for underwear, nightwear, etc.) can thus only be solved by natural or man-made cellulose fibres. If we consider the constantly increasing demand for such fabrics and correspondingly fibres, then a reasonable combination of ways of satisfying the demand for these fibres must be found: increasing cotton plantings and expanding production of man-made cellulose fibres. More precisely, this concerns an economic and technical evaluation of both methods and the definition of reasonable ratios between them.

Not having sufficient data on the production volumes of both cotton and HC fibres, on zoning of these plants and their specific volumes, on outlays for equipment and provision of labor resources, and due to the lack of a coherent economic policy for the regions producing these materials, it is difficult to perform a detailed analysis and form a definitive conclusion concerning the advantages of one method or another. At the same time, an objective examination of several concrete questions should be an important factor in preparing to solve this problem.

Let us begin with problems related to production of cotton. One of the first special problems is the distribution of cotton and food grain crops. It should be noted that the problem of a shortage of grain products will probably be more properly solved by increasing productivity in the grain-growing regions of CIS. At the same time, the possibility of increasing the yield of cotton per hectare of planting by intensifying plant protection, selection and cultivation of genetically controlled varieties of cotton, and especially important, rational irrigation, should also not be overlooked. The use of fertilizers is also correlated with an increase in production of cotton, particularly fine-fibre varieties, and this in turn requires a simultaneous analysis of the economics of the part of the chemical industry engaged in production of rational kinds of fertilizers.

According to some data, the cost of viscose fibre has been higher than the cost of cotton in the last ten years. Departing from the economic complexities characteristic of recent times, we can assume that in the very near future, the difference in the cost of these fibres will hardly be very sharp if restoration of a sufficient water supply is economically and technically acceptable.

After examining the economic aspect of the cotton—man-made cellulose fibre problem, it is especially necessary to stop at one of the important impediments for development of production of HC fibres — the negative ecological consequences: emission of harmful gases (carbon disulfide and hydrogen sulfide) into the atmosphere and heavy metal salts into wastewaters. This is due to the fact that HC fibres are basically fabricated by the viscose process. The cuprammonium process, less harmful with respect to emission of gases into the atmosphere, requires a very painstaking and very expensive method of removing copper salts, which poison living and plant organisms, from water dumped in natural bodies of water. However, the outlays for making viscose fibre production harmless are also very important. This situation has significantly inhibited or even halted development of viscose production. In many countries, attempts have been made to partially transfer this production to so-called "developing" countries, where the standards in the environmental protection laws still allow such emissions into the atmosphere and natural bodies of water.

Ecological factors have stimulated especially intense searches for methods of processing cellulose into fibres by other ways in the past ten years, in particular, by preparation of the starting spinning solutions not from cellulose derivatives.