Water Sorption of Nylon 6 Microfibers Studied by Inverse Gas Chromatography

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1. Introduction

Microfibers were developed as result of the attempts to obtain the comfort characteristics of cotton and the fineness of natural silk. Microfiber technologies have reached the ranges of fineness of natural silk (10 μ m), and moreover in recent years even fibers of diameter below 1 μ m were developed and are extensively taking their place in various fields of application other than production of garments with high comfort. Microfibers are used in the production of filters for chemical industry and for medical use, high oil absorbability wiping materials; as ion exchange, conductive or supportive materials in paper and other industries, and have numerous of other applications [1]. The present research is dealing with water sorption characteristic of microfibers of various diameters, on which there are still considerably few reports.

2. Experimental

Water sorption by nylon 6 fibers was measured by means of inverse gas chromatography. Five samples, used in order to investigate relationship between the water sorption characteristics and fiber diameters, are specified in Table 1.

Table 1. Characteristics of samples

Sample name	Diameter [μ m]	Method of production	Crystallinity [%]
N22	21.9	Conventional melt spinning	22
N10	9.8	High speed spinning	25
N8	8.1	High speed spinning	27
N3	3.4	"Islands-in-a-sea"	31
N2	2.5	"Islands-in-a-sea"	32

One sample of conventional melt-spun fibers, two of high speed-spun and two samples spun by Umishima ("Islands-in-a-sea") method were used. The diameter values measured by scanning electron microscopy on 500 fibers were statistically analyzed. The crystallinity was evaluated from the density data, which were determined by the density column method. Fibers were purified in hexane, methanol and distilled water before use in order to prevent any influence of impurities on measured water sorption. Prior to the placement in a gas chromatograph column, dry mass of the fibers was determined.

The water sorption was measured by gradually increasing the volume of water sample injected. Temperature was changed in every following series respectively. Huber and Keulemans method was used in determination of diffusion front of the chromatogram [2].

3. Results and discussion

Obtained sorption data were plotted as the regain e.g. amount of water sorbed by dried fiber, against the relative water vapor pressure. Isotherms for all samples have shown sigmoidal shape treated as an indicative of multilayer sorption [3]. From the linear parameters of B.E.T. multilayer adsorption theory it was found that obtained data seem to fit the theory very well. Isotherms show that sorption of moisture increases with decrease in fiber diameter (Figure 1).

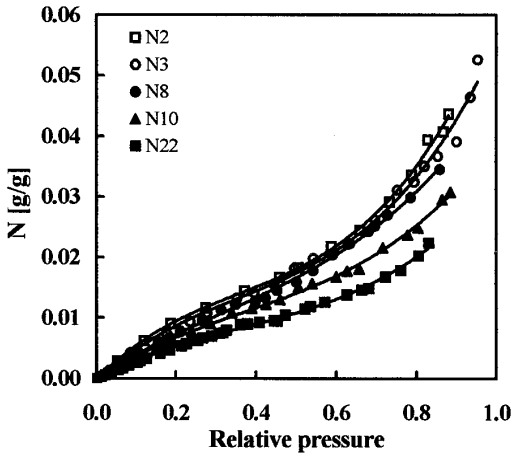

Figure 1 Water sorption isotherms at 80℃

If the whole amount sorbed is considered like the water adsorbed only on the surface of the fiber, simple explanation of such behavior could be that the increase in sorbed amount is proportional to increase in specific surface of the samples at microfibers comparing to the conventional fibers. However, the term 'surface' is not clearly distinguished in the case of nylon 6 polymers. It is well known that nylon 6 is a hydrophilic polymer and appreciably enough reports pointed out that certain number of water molecules are diffusing through the thickness of polymer [4]. This process depends on the structure of the polymer and it could be the reason why samples of nylon 6 fibers with various diameters show different sorption character.

Deviation of sorption behavior is observed on sorption isotherm at 50 ℃ of N2 and N3 microfibers. Beyond the relative pressure values of approximately 0.5, sorption of water by these fibers appears to be less than those for N8 and N10 samples (Figure 2).

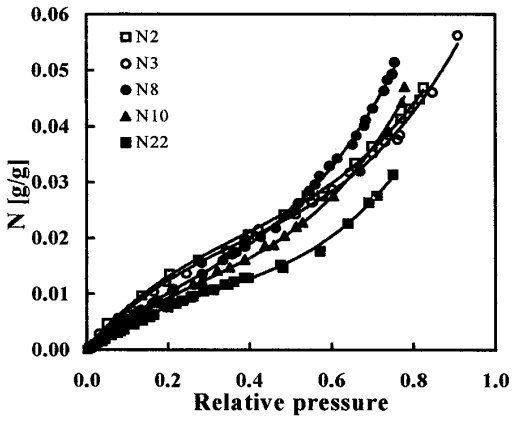

Figure 2 Water sorption isotherms at 50℃

There might exist some structural differences between the samples, due to different production methods. It was shown on the conventionally spun nylon 6 fibers of 25.4 μ m diameter, that water acts as the plasticizer increasing the amount of crystalline phase and the size of crystals [5]. The probability that this process occurs is highest at, what is relatively considered the surface of the polymer. The values of degrees of crystallization for the samples in the present study are not particularly high. Nevertheless, it is possible that the distribution of existing crystallites varies and their influence on water sorption changes consequently. Crystalline phase of the conventionally spun fibers is concentrated mainly on the surface while the structure of high-speed spun fibers differs due to sudden change of temperature in the zone under spinneret [6]. As for the "Islands-in-a-sea" fibers, there are yet no reports on their crystalline structure.

4. Conclusion

The present research is dealing with water sorption by microfibers which was found to be increased comparing to the fibers of higher diameters. Since there are no reports about the similar species up to now, it is necessary to make additional measurement of sorption by means of some experimental technique other than inverse gas chromatography and make a comparison with present results. It is also desirable to find out more about the structure formation in microfibers spun by advanced spinning methods in order to explain the change in sorption behavior.

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List of publications

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