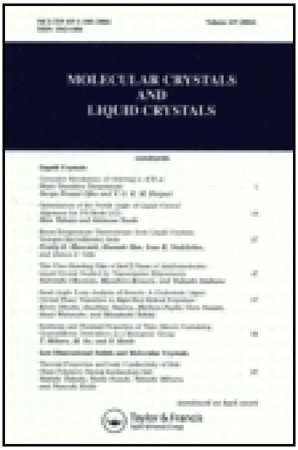

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Liquid Crystal Phenomena in Cellulose-NMMO-H_2O System

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Liquid Crystal Phenomena in Cellulose-NMMO-H_2O System

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In research programme realized was carried out analysis of the properties of the spinning solutions of cellulose in NMMO-H_2O system. Based on rheological properties of cellulose solutions and measurements useing FTIR and NMR methods was confirm that liquid crystals of cellulose appear in NMMO-H_2O system. Liquid crystal phenomena was observed not only in the high concentrated cellulose solutions in stationary state but also in cellulose solutions in dynamic state when spinning cellulose solutions flow across spinneret hole. In this last case existence of the liquid crystals in stimulated by preasure and ingredients.

Keywords: cellulose; liquid crystals; cellulose fibres

Since the start-up of the first Courtauld's Tencel fibre mill only seven years have passed, but within this period of time much experience has been collected allowing for the evaluation of this technology. The fact that the technology of cellulose fibre manufacture by the NMMO process a technology of the future has been proven by the plans of erecting next mills. Already at the end of 1992, Courtaulds Ltd, reached the assumed production capacity of 18,000 tons/a at the Mobil mill (USA). In 1994 Courtaulds Ltd. produced 43,000 tons/a of Tencel fibres [1,2]. At the same time Courtaulds Ltd. continues the technology improvement. Due to the increase in the spinning rate, in 1995, 55,000 tons of Tencel fibres were produced, mainly for Japan. Courtaulds Ltd. makes next

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investment to build the first Tencel fibre mill in Europe at Grimsby, England, with a capacity of 42,000 tons/a. The start-up take place in 1998, and the full capacity will be reached in end of 1999. According to available information, within nearest years Courtaulds Ltd. will produce 100,000 tons/a of Tencel fibres.

Lenzing AG erect a mill of Lyocell fibres at Heiligenkreuz, Austria, which start to produce in the mid 1997 with a capacity of 10,000 tons/a. In 1998 Lenzing produced twice as much, i.e. 20,000 tons/a of Lyocell fibres. The third world manufacturer of cellulose fibres by the NMMO process is Akzo Nobel. After a 20-year period of research works, Akzo Nobel is going to erect a large-scale commercial plant of filament fibres. Courtaulds and Akzo Nobel have been co-operated since 1994 on the improvement of the continuous fibre technology. A trilateral agreement has been signed by Courtaulds, Akzo Nobel and Asahi to promote the continuous fibres Lyocell in Japan [3,4]. The partners consider the Japanese market to be an excellent place to carry out tests of demand for such fibres. At the same time Asahi has decided to carry out research on sophisticated dyeing of fabrics from these fibres and to develop a process for their finishing.

From the above given data it follows clearly that the production of cellulose fibres by the NMMO process is under further development. It seems that the assumed increase in the manufacture of these fibres to a volume of 100,000 tons/a will be exceeded in the year of 2000. At the some time one can be observe a considerable concentration of research potential by the world companies to improve the technology of cellulose fibres by the NMMO process, as well as the marketing of textile fabrics from these fibres. It is clear now that the manufacture of cellulose fibres from the cellulose/NMMO systems is going to be a predominating technology of the 21st century. Despite many adventages, this technology requires, however, some improvement concerning practically all the technological stages to such extent which would allow one to produce staple or continuous fibres with required and programmable properties.

In order to accomplish this task in our laboratory we carried out examination of the liquid crystal phenomena in cellulose-NMMO-H_2O system, through technological stages of the fibres preparation.

As the effect of the crystal swelling of cellulose in NMMO, the increase of the distance between net crystal plane was observed, and layer intracrystal complex coming to existence. After unreversible swelling of the cellulose in NMMO stechiometrical complex is observed. It can be expresed in the form:

$$C_6H_{10}O_5 \cdot C_5H_{11}NO_2 \cdot H_2O$$

which contains 54,5% of cellulose.

Liquid crystal phase of cellulose in NMMO solution was observed in our laboratory under 20% concentration of cellulose. Rheological experiments shown it very clearly (Fig. 1).

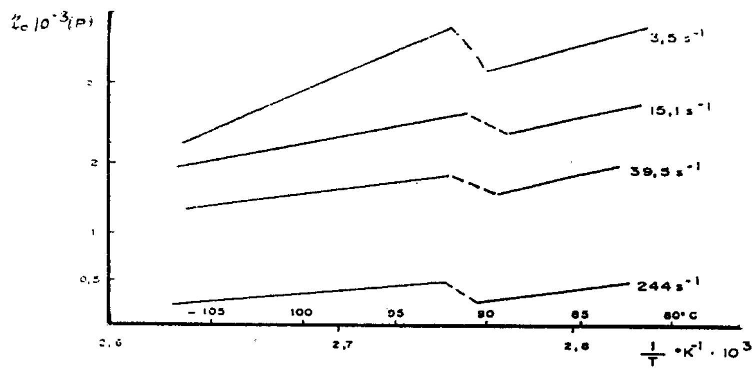

FIGURE 1 Cretical temperature of phase changes isotropic to anisotropic solution of cellulose in NMMO, with fifferent shear rate.

FIGURE 1 Critical temperature of phase changes isotropic to anisotropic solution of cellulose in NMMO, with different shear rate.

Spinning solution of cellulose in NMMO has rather isotropic form with sporadic anisotropic liquid crystal domains. Therefore, can be say that in spinning conditions of the fibres, e.g. at 90-120°C, liquid crystal phase almost disappear but appears in spinneret hole, and in air gape under spinning head, when spinning solution leaves out the hole of the spinneret (Fig.2).

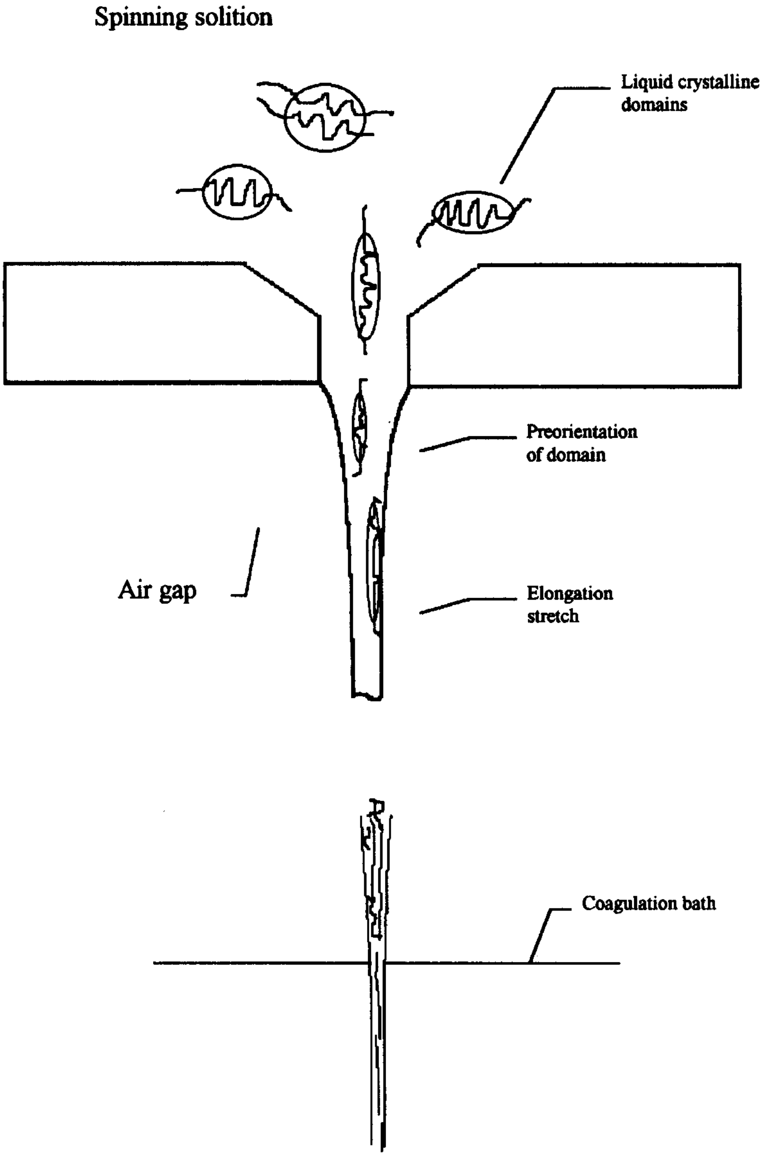

FIGURE 2 Schematic explanation of the structural changes of the liquid crystalline solution in the air gape and in the spinning bath

Appear of the liquid crystal domain in NMMO solution of cellulose in spinneret hole is as effect of increasing of the preasure, lowering the temperature, shearing effect, and memory of the cellulose structure. Above phenomena which take place in the spinning time of the cellulosic fibres by NMMO process, play very important role in technology, and decided about the fibre properties, especially about susceptibility of the fibres for fibrilization and about their elasticity [7].

References

[1] Chemical Fibres International, vol. 46 April 1996.
[2] Chemical Fibres International, vol. 45 Oct. 1995.
[3] Textile World, vol. 146 (6), 90, 1996.
[4] F.W. Fröhlich, Int. Fibre J. vol 12 (3), 4, 1997.
[5] E.F. Thode, R.G. Guide, TAPPI J., vol. 42, 35, 1959.
[6] W. Berger, M. Keck, Cellulose Sources and Exploitation, Ed. J.F. Kennedy, G.O. Phillips, P.A. Williams, Ellis Horwood, Chichester 1990, p. 69–78.
[7] B. Laszkiewicz, Technical University of Lodz, Reports 1995–99.