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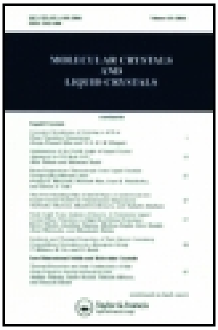

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Discussion of Nomenclature of Liquid Crystals

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Discussion of Nomenclature of Liquid Crystals

August 19, 1965

Chairman: As a result of opinions obtained through prior discussion with a cross-section of participants at the conference, the meeting was asked to consider the advisability of standardizing nomenclature and symbols relating to liquid crystals, particularly with regard to achieving an unambiguous means of recording the number of crystalline and liquid crystalline states exhibited by a compound and the temperatures at which transitions between these states occurred.

The symbols proposed were:

C_1, C_2, C_3 etc.	Crystalline States
S_1, S_2, S_3 etc.	Smectic States
N	Nematic State
I	Isotropic Liquid
$\rightleftarrows$	An enantiotropic transition between two states
$\rightarrow$	A monotropic transition between two states

To put things into perspective, the hypothetical case was considered of a compound exhibiting six states (two crystalline, two smectic, one nematic, and one isotropic) between which enantiotropic transitions occurred, and one additional, monotropic smectic state.

The scheme finally accepted and summarized below contains two amendments to the original scheme proposed by the Chairman.

1. *J. L. Fergason* (Westinghouse Electric Corporation, Pittsburgh, Pa.) proposed that the sequence of crystalline states etc. observed on heating should be represented ----- C_3, C_2, C_1, so that a more natural-looking order of the numerals resulted for monotropic states obtained on cooling.

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2. *P. K. Watson* (Xerox Corporation, Rochester, N.Y.) proposed the use of a sub-subscript letter (M) to emphasize the monotropic nature of a particular state.

$$\begin{tikzcd}
C_2 \arrow[r, shift left] & C_1 \arrow[l, shift left] \arrow[r, shift left, "T"] & S_2 \arrow[l, shift left] \arrow[r, shift left] \arrow[dl, shift left, "T'"] & S_1 \arrow[l, shift left] \arrow[r, shift left] & N \arrow[l, shift left] \arrow[r, shift left] & I \arrow[l, shift left] \\
 & S_{3_M} \arrow[u] \arrow[ur, shift left] & & & &
\end{tikzcd}$$

where T′ < T

Temperatures associated with these transitions would be put along the appropriate arrows. In the case of enantiotropic changes, the temperatures would be recorded above and below the arrows if these had been determined both on heating and cooling the samples.

The above scheme represents clearly that the crystal (C_1) on heating will give the smectic state (S_2) and that S_2 on cooling may either crystallize (giving C_1) or supercool to give the monotropic smectic state (S_{3_M}) followed by the crystalline solid (C_1), but that heating of C_1 will not give the monotropic liquid crystal (S_{3_M}). Although it was pointed out that this particular triangular sequence of double and single arrows is not thermodynamically permissible, the general simplicity and utility of the scheme led to its adoption by the meeting, at least until a more sophisticated scheme became essential.

Before taking matters further, the Chairman invited comments from the meeting concerning views on the desirability of continuing to describe the third liquid crystalline state as the cholesteric state.

G. T. Stewart (University of North Carolina) represented the views of those who were dissatisfied with the term, pointing out that cholesteric is a confusing adjective, particularly as certain systems which give this type of liquid crystal bear no structural relationship to cholesterol, not the least of these being the lyotropic polypeptide systems discovered by C. Robinson.

J. F. Dreyer (Polacoat Inc., Ohio) supported this view, and alternative names based on certain of the unique aspects of this liquid crystalline state were suggested. However the terms "photochromic state" (J. F. D.) and "nematic twisted state" received

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little support, and G. T. Stewart suggested that perhaps the task of settling this should be given to a future meeting. The Chairman added that he would be happy to receive by post any ideas on naming the cholesteric state.

A considerable proportion of those attending were however in favour of retaining the old term cholesteric, at least for the present time. This was eventually agreed, as was the proposal by H. Kelker (Farbwerken Hoechst, Frankfurt) that the abbreviation Ch be used in sequences of transitions involving the cholesteric state, e.g.

$$C_2 \rightleftarrows C_1 \rightleftarrows S \rightleftarrows Ch \rightleftarrows I$$

It should however be pointed out that, after the meeting, a crystallographer expressed some concern to Professor G. H. Brown (Kent State University, Ohio) that the symbol Ch could be confused with a structure symbol used in crystallography.

Referring to the mixtures of certain cholesteryl esters whose unique properties and uses were described earlier in the conference by J. L. Fergason, J. Goldmacher (RCA Laboratories, Princeton, N.J.) then asked what nomenclature was proposed for these systems with particular reference to their composition. G. T. Stewart took up this comment from the medical standpoint, expressing the view that systems of such obvious significance to medicine should be fully described in order to facilitate the exploration of their uses in the medical field. J. L. Fergason said in reply that a range of mixtures was soon to be marketed and gave their qualitative composition as cholesteryl benzoate, cholesteryl nonanoate and cholesteryl myristate. (In fact, samples of these mixtures can now be purchased from the Westinghouse Electric Corporation, Pittsburgh, Pa.—Chairman's note, September 1965.)

Reverting to the general discussion, M. J. Vogel (IBM Corporation, San Jose, California) noted that the general scheme made no allowance for polymesomorphic nematic states.

The Chairman replied that in his experience he had never observed transitions to occur at a precise temperature between different states, both of which were nematic. He emphasized the need for caution in case less well defined changes in the texture of a given

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liquid crystal should become confused with the precisely reversible transitions occurring between liquid crystals and at present under discussion. He suggested that to date there was no real evidence for polymesomorphism of the nematic state, as there was for polymesomorphism of the smectic state. If anyone did produce such evidence in the future, it was stressed that the general scheme was flexible enough to absorb the necessary states N_1, N_2, N_3 etc., but that until these states were proved beyond doubt, the single symbol N for the nematic state would appear to be adequate.

Up to this point, the meeting had concerned itself with problems of nomenclature in relation to thermotropic liquid crystalline systems, i.e., to systems which manifest changes in liquid crystalline behaviour on heating or cooling. The Chairman then invited comments on the applicability of the points so far decided to lyotropic liquid crystals. Whilst the symbols would appear to be all right, and the arrows would represent processes involving the addition or removal of solvent, certain difficulties did become obvious. Thus, both A. J. Mabis (Procter and Gamble Company, Cincinnati, Ohio) and F. B. Rosevear (Procter and Gamble Company, Cincinnati, Ohio) stressed that certain lyotropic liquid crystals did not fit in with the accepted smectic or nematic states. Others agreed with this view, and the Chairman summed up the situation by saying that, whilst the system agreed upon at this discussion was probably fairly adequate at the moment, developments in the field might quickly require a radical alteration in nomenclature. For the time being he thought that we should at least ensure when we refer to a liquid crystal as smectic that it has indeed the true characteristics of the smectic state, and likewise that systems we call nematic are in fact truly nematic. That is, the simple existing terms must not be wrongly applied. In relation to a more precise form of nomenclature, R. Hosemann (Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin) pointed out that X-ray crystallographers in Moscow had recently shown an interest in extending their precise form of space group nomenclature to systems with lower degrees of order than the crystalline state, and he suggested that developments in this area should be watched.

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A. J. Mabis and L. Heaton (Argonne National Laboratory, Argonne, Illinois) also referred to the possibility of using more precise systems of nomenclature for states involving two-dimensional order.

A. Pace (Olin Mathieson Chemical Corporation, New Haven, Conn.) proposed that a committee might profitably be constituted to deal with problems of nomenclature as and when these cropped up. The Chairman invited R. Hosemann to form and act as Chairman of such a Committee, and this he agreed to do.

Afterthoughts by Chairman (2nd September, 1965)

An unrehearsed and relatively unprepared discussion session of the kind held was not expected to make a great deal of headway, and it is gratifying on looking back to realize that three points of progress were in fact achieved.

1. The agreement of a simple system of recording the liquid crystalline properties of compounds and their transition temperatures —a system which, although possibly only of temporary value, it is hoped will be adhered to by authors in the field.
2. A stressing of the fact that problems of nomenclature *do* exist and may become of greater significance particularly as work on lyotropic liquid crystals develops further.
3. The constitution of a nomenclature committee, under the guidance of R. Hosemann, to which research workers can refer particular problems of nomenclature. If we are fortunate enough to be able to hold a further symposium on liquid crystals in three years' time, this committee could be invaluable in reporting to the meeting the most-up-to-date situation regarding nomenclature and the problems of nomenclature in the field of liquid crystals.

January 1966

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