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George W. Gray

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Reminiscences from a life with liquid crystals

by GEORGE W. GRAY*

Liquid Crystal Institute, The University of Southampton,
Southampton SO17 1BJ, UK

*Presented at the Capri Symposium in Honour of George W. Gray, FRS held at the
Hotel Palatium, Capri, 11–14 September 1996*

The author looks back over a scientific career of almost 50 years spent mainly in research on liquid crystals (LCs) and carried out largely in University service and latterly for about five years in Industry. In this review, the development of UK LC research is traced mainly through its rapid escalation starting in the early 1970s and stemming from the development of applications for LCs in electro-optical displays, itself set on course by the author's own discovery of the first materials enabling the production of commercially viable, long life twisted nematic displays. The author's other contributions in the field are discussed and widened into a general review of current trends and activities in the field, with some emphasis being placed on threats to fundamental research posed by diminished funding and the current pressures on researchers to engage heavily in short term, 'wealth creating' projects.

1. Introduction

I would like to thank all who attended this meeting which was of course of very special significance to me. It is with particular warmth that I record my personal gratitude to Professor Sven Lagerwall who conceived the idea of the Capri Meeting and through his own efforts made it happen. I am also indebted to Dr Bengt Stebler of Chalmers University who actively assisted in the organization, together with Professor Eugenio Amendola, from Naples, and Professor Francesco Simoni, from Ancona. When events like this are brought into being, the early spirit of liquid crystals is clearly still very much alive. I do thank you the organizers and all of you for creating what was a happy and a scientifically significant meeting.

The meeting was of course to mark my seventieth birthday and at the same time approaching 50 years of involvement in research in the field of LCs. My birthday occurred on 4 September 1996 and I must say that leaving the sixties behind was made easier for me by the pleasant anticipation of coming to this lovely island of Capri and being with you all. My wife and I have decided that while we ought to grow old gracefully, it might be more fun to do it disgracefully, and I might suggest that Professor Alfred Saupe, shown here with me in Pisa (figure 1), who some time ago achieved 70, might form the nucleus of an Over 70 LC Club, whose aim would be to think up exciting things for us and up-and-coming LC septuagenarians to do.

2. The early years in research

The title proposed for this talk seemed clearly enough defined, but its content caused me a lot of heart searching, mainly because there was so much about which to reminisce. Selectivity rules are however very helpful, and one of these was that while reminiscing, anyone or anything that gave me less than pleasure would be omitted.

In 1946, I graduated from the University of Glasgow at the age of 20, but my father's illness dictated that I find work. No years in the PhD or post-doctoral cocoon were for me. The work I found was as a temporary Laboratory Demonstrator at Hull, then at University College of London. In 1947 I was promoted to Assistant Lecturer and given the opportunity to register for a doctoral degree of the University of London. This was my beginning in the field of LCs, as I chose to work on the mesomorphism of aromatic carboxylic acids supervised by the Head of Department, Professor Brynmor Jones later to become Sir Brynmor Jones and Vice-Chancellor of the University. I was teaching about 15 hours per week, and supervising the work of one to three Masters students, so it took me until 1953 to submit my own PhD thesis. The University of Hull has of course grown in size and strength over the years, but in the late 1940s and early 1950s, things were less easy and I did most of my research in prefabricated laboratories and with many shortages of equipment. But it was a challenging environment in which to work, perhaps more so than in some better heeled institutions—everyone was keen to succeed, to help one another, and to recover after the lost war-time years. Indeed, I owe a

*Author for correspondence.



Figure 1. Professor Alfred Saupe (left) and the author; 14th International Liquid Crystal Conference, Pisa, 1992.

great debt to the University of Hull, giving me as it did freedom to do research, develop my own ideas, gain promotion and work in a steadily improving environment supported by many excellent colleagues. Because of this, I remained at Hull for over 40 years before leaving in 1990, after serving as Head of Chemistry and senior Professor.

My doctoral research up to 1953 was followed in the years up to about 1965 with extensions to the earlier studies of the relationships between molecular structure and LC properties. Studies of alkoxy-aromatic carboxylic acids derived from benzene, biphenyl, naphthalene, fluorene, fluorenone and anthracene and in several cases of their methyl, halogeno and nitro substituted analogues established that, within families LC behaviour trends sensibly with structural change allowing the development of working rules concerning:

- (1) regular trends in LC transition temperatures within homologous series;
- (2) the dependence of nematic thermal stability on molecular breadth and lateral substituent size;
- (3) the more subtle dependence of smectic thermal stability on a combination of lateral group size and dipole moment;
- (4) the strong influence of steric twisting by a lateral group in depressing mesophase thermal stability;
- (5) the role of aromatic core size and type on phase type and phase stability;
- (6) core shielding effects in diminishing the depressing effects of lateral groups;
- (7) the important nematic terminal group efficiency order.

3. The 1960s

In the years 1960–1968, it was becoming difficult to attract support for niche research like liquid crystals,

seemingly without importance or technical value. Already, the doctrine of pursuit of that which will be quickly wealth creating was having an influence. Indeed, my PhD examiner, the eminent Professor M.J.S. Dewar wrote in 1967 in one of his books ‘Whilst liquid crystals are uncommon and of no practical importance, they are of interest for the light they throw on the conflict between order and disorder’. For two or three years, my work was in fact unsupported by money or students, and my own hands alone kept new results coming. To preserve my research profile, I had to venture into other areas and for some years was supervising industrially funded research on bacterial cell wall chemistry. This broadened my experience, but seeing the end of my LC work as a real possibility, I decided to write up what I knew about liquid crystals in the book *Molecular Structure and the Properties of Liquid Crystals*, published [1] in 1962 by Academic Press. This proved to be a good thing to have done, because a change in attitudes was due to occur starting in 1965, and the book got me and my work recognized nationally and internationally. In relation to the research that went into that book, I would like to acknowledge the help of Professor Pierre Chatelain of the University of Montpellier who gave me access to invaluable theses, literature and other publications on LCs. The review article by Glenn Brown published [2] in 1957 was also a strong motivating influence. Indeed it might be good if some of today’s researchers were to read both these works and realize that some things are being discovered for the second time.

The reawakened interest in LCs was, however, primarily due to Glenn Brown’s organization of the First International Liquid Crystal Conference in Kent State University in 1965. Attended by just 90 delegates, it created a liquid crystal brotherhood (or is it mafia?) and gave that small internationally distributed group a focal point and hope for exciting things to come. Realizing that a full reawakening needed time, Glenn Brown succeeded in obtaining support for a Second International LC Conference (ILCC) in 1968, again at Kent State. This meeting was attended by George Heilmeyer and others from Radio Corporation of America in Princeton, NJ, where his group was opening the door and people’s eyes to the possibility of display applications of LCs. Two years later we met again in Berlin, this ILCC being organized by Professor Hosemann—shown here (figure 2) at the opening ceremony. Applications of LCs were now being discussed very openly.

Then it was back to KSU in 1972 and discussion on display applications dominated the meeting, and just two years later in Stockholm at the 4th ILCC, I remember lecturing about materials prospects for devices of five types: (1) dynamic scattering devices, (2) Fréedericksz



Figure 2. Opening Ceremony of the 3rd International Liquid Crystal Conference, Berlin, 1970; extreme left, Professor R. Hosemann, Conference Organizer.

devices, (3) twisted nematic devices, (4) cholesteric memory devices and (5) cholesteric–nematic phase change devices.

4. Discovery of the cyanobiphenyls

Around that time, it became a little scientifically awkward. The cyanobiphenyls had already been made and evaluated in my group and at DRA, Malvern, but they could not be discussed publicly or fully until all patents were secure. We did not publish until March 1973 in *Electronics Letters* [3] and later revealed more details in August 1973 in a paper [4] presented by Ken Harrison at a symposium of the American Chemical Society in Chicago, published later in 1974.

The discovery of the cyanobiphenyls was the outcome of a contract obtained from the UK Ministry of Defence in October 1970. The object was to seek substances exhibiting LC phases at room temperature, specifically of course for LC display device applications. These had been recognized as the possible desirable alternative to the cathode ray tube (CRT) as early as 1968 by Professor

Cyril Hilsum then a very senior, special merit scientist at DRA, Malvern, and later to be Research Director at GEC. His forward vision, awareness that the UK paid more in royalties to RCA for the CRT than the development costs of Concorde, and knowledge of the work going on at RCA provided him with the strength of argument to secure the MoD funding [5]. When the patents of Ferguson, and of Schadt and Helfrich came into the public domain and we were able to move thinking away from materials of negative dielectric anisotropy to positive dielectric anisotropy systems, we progressed swiftly at Hull. Based on our knowledge of Schiff's bases and the nematic terminal group efficiency order, i.e. on results of earlier fundamental studies of structure/property relations of LC materials, we knew that eliminating the two atom linkage from a Schiff's base or an azoxy compound would not eliminate the LC properties if a terminal cyano group, which would also generate the positive dielectric anisotropy, were used. And so the now familiar 4-alkyl- and 4-alkoxy-4'-cyano biphenyls were conceived, synthesized, shown to

be excellent materials for direct drive TN displays, and put into commercial production and the marketplace by BDH Ltd (now Merck UK Ltd).

The consequences of all this are well known and need not be elaborated here. The materials were quickly successful—good performance in TN displays allowing manufacture of quality, long life devices, and as has been very often said, providing the secure base from which the embryonic LC display industry could grow and generate today's multibillion dollar international markets.

These results are often said to be my claim to fame, but there are those (mainly non-performers) who like to stress the negative aspect that no European Display Production of any consequence developed from our materials chemistry success. I think this is supposed to upset me, and indeed the English do love to knock success and the successful. Frankly, I cared very little that UK Ltd did not benefit device-wise from the work and that this area was exploited to the full in Japan and the Far East. I was happy to see that society in its widest international sense was benefiting by my science, and was not too troubled that the coffers of Electronic Companies did not profit thereby. It did however please me that the UK chemical industry benefited financially from my work—a conveniently forgotten fact. Also, I would like to emphasize some other much wider and to me equally important advantages and consequences that stemmed from our simple discovery of the cyanobiphenyls.

- (1) Cyanobiphenyl analogues—the PCHs of E. Merck in Germany and the cyanophenylpyrimidines of Hoffmann-La Roche in Switzerland naturally developed and were by 1977 in the marketplace, contributing by extending the valuable range of physical parameters available in room temperature LC materials.
- (2) The success quickly escalated my research funding, and my group grew in size, being well over 20 when I left Hull in 1990. MoD contracts are also very good in allowing a percentage of blue sky research to be done, in recognition that it is very often that commercially viable products emerge from such research.
- (3) The MoD funded work developed into the UK Consortium on LCs, still in existence today and involving, in the 1970s–1980s, the University of Hull, BDH Ltd, DRA Malvern, The University of Exeter (Professor A.J. Leadbetter) and the University of Sheffield (Professor D. A. Dunmur). This of course helped greatly to develop activity and strength in LC research in the UK.

- (4) The success also attracted very good people to work in the Hull LC Group, and probably the most able and exciting group of young researchers that I was ever privileged to work with was created—John Goodby, now back leading my old group at Hull after spending over 10 years at AT and T Bell Laboratories in New Jersey, Ken Harrison now in a senior position at DRA, Malvern after several years in LC display work in the USA, David Coates now Research Manager at Merck UK Ltd after a period with Standard Telecommunication Laboratories in Harlow, Alan Mosley, now a senior scientist at GEC Hirst Research Laboratories, Steve Kelly, now back in Hull after periods at Brown Boveri et Cie and F. Hoffmann-La Roche in Switzerland and Damien McDonnell now a senior scientist in charge of the electronics sector at DRA, Malvern, which embraces the LC research.

Satisfaction accrued too from external recognition of the work over the years—Queen's Award for Technological Achievement in 1979, Personal Professorship in 1979, Rank Prize for Opto-electronics in 1980, Fellowship of the Royal Society in 1983, Leverhulme Gold Medallist of the Royal Society in 1987, Fellowship of the Royal Society of Edinburgh in 1989, CBE in 1991, Kyoto Prize Laureate in Advanced Technology in 1995 and SID Karl Ferdinand Braun Prize in 1996.

I am somewhat saddened at times that the only aspect of a life's work that gains any general recognition, apart from that of one's peers, seems to be the fact that you developed a group of materials on which a thriving industry has been based. Personally I take most satisfaction from the catalysis of research stemming from these materials and the results that have flowed from studies of the physics and physical chemistry of the cyanobiphenyls, because they are stable, room temperature LC systems and available highly pure. Understanding of the physics and dynamics of LCs has developed enormously from them—understanding of order parameter, elastic properties, re-entrant phenomena, etc. The biphenyls also produced room temperature smectics and chiral phases, and they too have enhanced the fundamental knowledge base.

5. Other good work done

While developments of the biphenyls and their mixtures were going on, the increased research funding enabled research on a wider front to be undertaken in the Hull group, leading to:

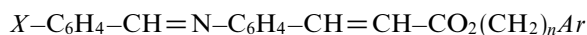
- (a) a fuller understanding of smectics and their polymorphism consequent upon the synthesis and

study of new materials exhibiting SmB, SmF and SmI phases—work [6] with John Goodby in collaboration with Alan Leadbetter;

- (b) rationalization of smectic nomenclature—achieved at a meeting in Halle involving John Goodby, myself, Horst Sackmann and Dietrich Demus, resolving the serious problem of the same phases being assigned different code letters by different groups [7];
- (c) development of new alicyclic mesogens (bicyclooctanes, cubanes)—work [8] with Steve Kelly;
- (d) molecular factors determining SmC formation—with John Goodby [9];
- (e) development of phase identification by optical microscopy—with John Goodby [10];
- (f) synthesis of deuterio-mesogens for neutron studies—work [11] with Alan Mosley in collaboration with Alan Leadbetter;
- (g) development of novel chiral mesogens and high order parameter dyes—work with Damien McDonnell in the former of which the position of a chiral centre of given optical configuration in a chiral alkyl group was shown [12] to determine the helical twist sense in an alternating way dependent on parity (Gray/McDonnell Rules)—

all building up a more secure picture of structure/property relationships in LC systems, and underlining the need to regard mesogens as sensitive, subtle molecules in which flexibility and conformation play a vital role [13]. Much has been done in more recent times on, in particular, understanding of the conformer populations in systems having flexible alkyl or polymethylene chains. By and large, however, molecules with a potential to form mesophases do the sensible thing and adopt the most suitable rod-like conformation consistent with optimizing packing and ensuring that space is filled efficiently. Examples of this sort of thing in fact go back a long way to the work at Hull of David Coates on systems [14] showing very high chain length related fluctuations or alternations in mesophase thermal stability, nicely developed in more recent studies [15] by Luckhurst and colleagues on flexibly linked dimers and trimers.

Examples from the early work in the period 1970–1975 are provided by:



where $X = CN$ and Ar may be phenyl, *m*-tolyl, *p*-tolyl, etc. and in which as n (0, 1, 2, etc.) changes from even to odd, the terminal aryl group moves from on-axis to off-axis and the behaviour of the system changes from strongly mesomorphic to non-mesomorphic— T_{N-1}

changing from 278 to <40 [virtual]°C to 155 to <40 [virtual]°C for $n=0, 1, 2, 3$, for the system with $Ar = \text{phenyl}$.

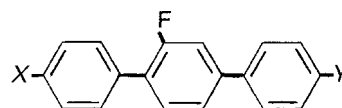
A less well-known example showing a similar dramatic effect on T_{N-1} , but demonstrating that such alternating deviations from linearity caused by changes in chain parity influence smectic thermal stability to a much smaller extent were given by a similar system where



Again (figure 3) the nematic phase fails to appear in the alternate odd chain members and the opposite chain alternation effect on SmA and SmB phases leads or almost leads to the extinction of SmA phases in favour of the SmB phase in the same odd members. The smectic phases can therefore accommodate the bent shapes of the odd homologues more readily than the nematic phase.

6. Later developments

As time passed and the group grew in size, the research diversified, sometimes under external pressure to engage in commercially oriented projects—for example into liquid crystal polymers [16] and even into Langmuir–Blodgett thin films. Particular pressure was mounted in the 1980s for us to work in the field of materials for ferroelectric LC displays. It is often the case that fundamental research projects generate important results by accident. One example is provided by one of the more successful families of ferroelectric LC materials that we produced in a programme originally directed at alternative materials of high T_{N-1} . The systems were 4,4''-disubstituted *p*-terphenyls of structure:



where $X, Y = \text{alkyl and/or alkoxy}$.

In the event [17], a limited degree of SmC behaviour was noted in certain homologues of the series where $X = \text{alkyl}$ and $Y = C_3H_7$ (figure 4). We decided to pursue this in the hope of obtaining some interesting materials with the phase sequence:



needed for FLC devices. In addition there were other interesting features: the dialkyl materials had no terminal lateral dipoles (once thought to be a requirement for SmC behaviour) and in the homologous series of dialkyl materials, the members with $X = C_5$ and C_7 had no SmA phases. But the progress of the work was limited by the poor Grignard coupling reactions available to build up the terphenyl ring system.

Illustrating the iterative nature of research, this led us

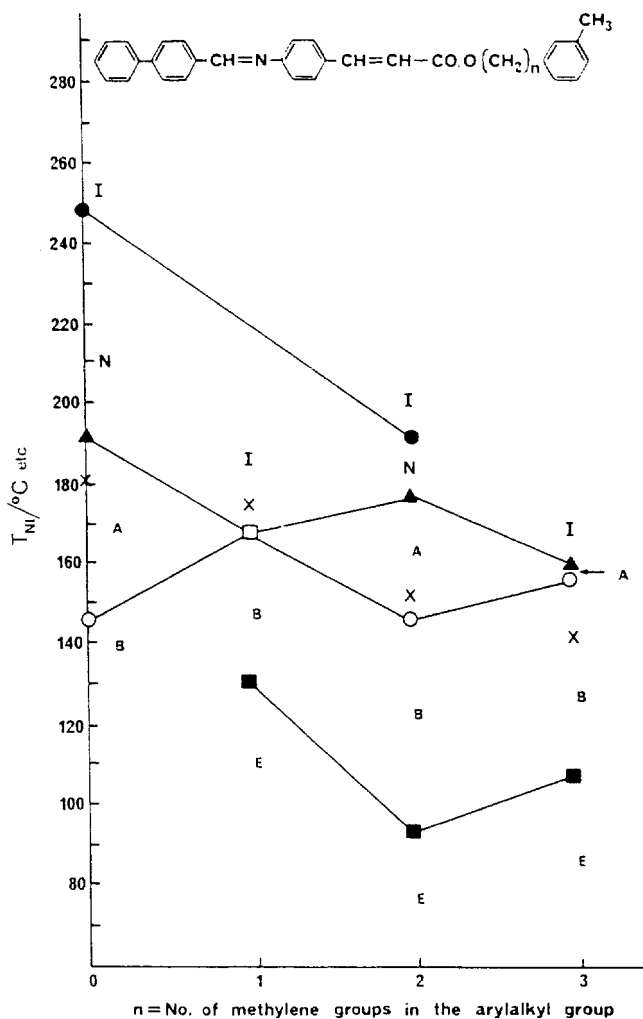


Figure 3. Alternation effects in a homologous series resulting from the movement on- and off-axis, respectively, of a terminal aryl group as the number of methylene groups changes from even to odd. Note the exceptionally high degree of alternation of the N–I transition temperatures, resulting in the $n=1$ and 3 members having no N phase. Smectic transition temperatures are less affected and the opposite alternation of the SmA and SmB thermal stability results in the extinction or near extinction of SmA properties in the $n=$ odd homologues. X denotes the melting point of each homologue. A, B and E = SmA, SmB and crystal E (from [14] with permission).

into the optimization [18] of palladium catalysed boronic acid cross coupling reactions to achieve efficient aryl–aryl coupling to form the terphenyl system from simpler benzene and biphenyl fragments. These procedures have become very successful and are now used extensively for the laboratory and commercial synthesis of a wide range of terphenyl and other mesogens that were hitherto quite unavailable.

The availability of materials from the boronic acid processes allowed essential mixture work to be under-

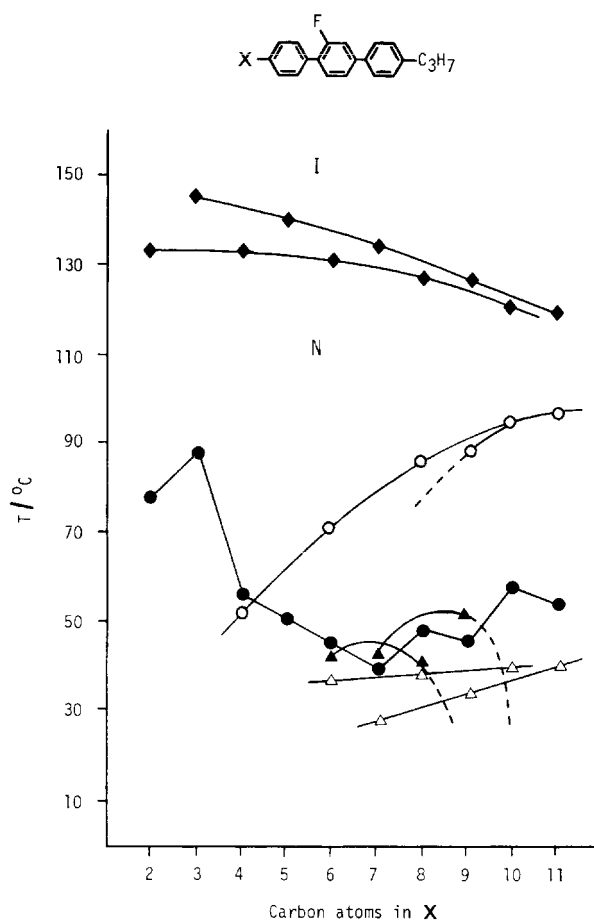


Figure 4. Plot of transition temperatures against the number of carbon atoms in the normal alkyl group X in the terphenyl system shown. \blacktriangle = SmC–SmA or N; \triangle = SmB–SmA or SmC; \circ = SmA–N; \bullet = Cr-mesophase. Note: SmA phase absent in the 5 and 7 members (redrawn from [17]).

taken in order to suppress melting points and underlying SmB properties to give mixtures doped with chiral cyanhydrin esters [19] that were very good hosts for FLC devices. In the course of this work, the missing SmA peculiarity arose again, as shown [20] in this simple binary case (figure 5). The C9 homologue has an I–N–SmA–SmC–SmB sequence, and the C7 homologue has an I–N–SmC–SmB sequence. However, at about 60 wt % of C7 homologue, the SmA phase vanishes with the appearance of re-entrant nematic behaviour. The dotted line shows the extrapolation to a hypothetical N–SmA transition at about 55°C which fits with where the SmA–N transition ought to be but is not in the plot for the homologous series (figure 3). Similar behaviour with re-entrance occurred with mixtures of 7/3 with 6/3 and with 10/3 and for 5/3 with 4/3. The absence of the SmA phase for some members suggests that for the earlier homologues there may be a very high degree of

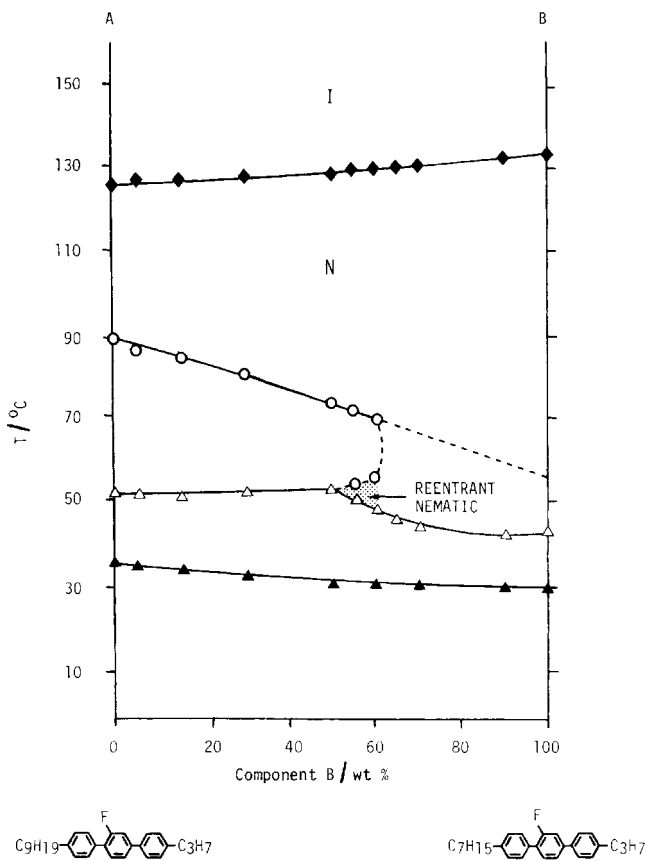


Figure 5. Phase diagram for the binary system of components A and B shown. \circ = SmA–N or N_{re} ; \triangle = SmC–SmA, N or N_{re} ; \blacktriangle = SmB–SmC. Dashed line is an extrapolation to a hypothetical SmA–N transition temperature for the heptyl homologue B (redrawn from [20]).

alternation of the SmA–N transition temperatures and that we only see this when the alternation becomes damped later in the homologous series. This is a well publicized result from 1987 which remains without a firm explanation, reminding us that unanswered riddles do exist in the literature.

7. The late 1980s and on

In the latter half of the 1980s, with the end of my academic career becoming visible on the horizon (I would be 65 in 1991), much of my thinking went into preserving the future of the Liquid Crystal Group at Hull University. The man whom I wanted to lead the group was John Goodby, and I am pleased to say that he was persuaded away from AT & T Bell Laboratories in New Jersey, first under an industrially supported Readership, soon converted into a full University post and Personal Professorship. As I knew he would, John accepted inheritance of the Hull Group and has carried it forward most successfully since I left with a clear

conscience in 1990 to join Merck Ltd as Research Coordinator and Consultant.

The industrial experience at Merck Ltd has been interesting, but came at the start of a recessionary period involving large staff losses and tightening up at all levels from R and D to general management. Business-led philosophies of necessity led to the pursuit of short term projects with markets in view. This was very understandable, but does limit in-house capability to do fundamental research having longer business possibilities—the kind of research which provides the seed corn for future businesses. Speaking nationally, the consumption everywhere of existing seed corn at a high rate without anything going back into the bag has to be regarded with grave concern.

These last few years working with Merck Ltd and E. Merck in Darmstadt have unquestionably been most interesting, and educative to one hitherto steeped in the academic environment, albeit involving many collaborations with industry over the previous 20 years. I am indeed most grateful to Merck for the opportunity given me to stay active in the field until the age I am now, and I will always be appreciative of the obvious pleasure of its staff when I received the Kyoto Prize Laureate in 1995.

If I have regrets at all, they probably relate to the period of the mid-1980s when I should possibly have resisted pressures to accept research funding for some projects. But one is under considerable obligation in the Universities to bring in all the funding that you can. Of course I quote no examples, but some projects merely diluted the group's research and increased its size, to no great scientific purpose.

8. Today

Now in 1996, my activities are of course much less frenetic—some interaction still with Merck, some consultancy with DERA, Malvern and with an American company, a lot of effort as Editor of the journal *Liquid Crystals*, and a considerable amount of time on editorial work connected with the new VCH *Handbook of Liquid Crystals* and with the new Taylor & Francis series on Liquid Crystals—specifically here with John Goodby—launched through the book by P. J. Collings and M. Hird. I am also very involved as Chairman of the Advisory Board of the newly inaugurated Southampton Liquid Crystal Institute involving the research groups in the Departments of Chemistry, Mathematics and Physics and having as senior staff the following names well known and respected in the LC community—H. J. Coles, G. R. Luckhurst, T. J. Sluckin, J. W. Emsley, and G. Attard. In its infancy still, the Institute will I feel sure grow, develop and flourish because of the quality of its researchers and its interdisciplinary nature. I am

certain that this is the way forward. In the face of reduced funding opportunities for fundamental research, strong units are more likely to be successful in their grant applications, and survive because they have that interdisciplinarity required to generate top ranking proposals and be excellent in the field of LC research.

The motivation and the injection of funding that have stemmed from the successful applications of LCs have of course been essential factors in the sharply escalating levels of research in the field over the past several years. Whether this can continue is hard to predict. Existing LC displays, whether they be of the supertwisted nematic type or the active matrix addressed type look very good indeed, and if they are to be replaced, it has to be by a display that is considerably better or cheaper or easier to produce, or all three. The ferroelectric LC display has been slow to mature, and the antiferroelectric display, deeply interesting as it is, has yet to prove itself in the marketplace. PDLC systems too have their own problems and have not yet been the big marketing success envisaged by the gurus before they moved on out of sight to predict about something else. Related systems like cholesteric gel displays may have a lot to offer, and polymer stabilized LCs are interesting too, as are aligned LC polymers and LC polymer networks derived from so-called mono- and di-reactive mesogens, or speaking more exactly from low molar mass materials that are liquid crystalline, alignable and contain within their molecules one or two functional groups permitting polymerization to be effected and produce aligned LC polymers. Merck's 'Brightlight' or 'Transmax' cholesteric LC polymer film, coupled to a quarter-wave plate, is an example [21] which should have an important impact as a brightness enhancement film for existing STN and TN devices. Piezoelectric and pyroelectric devices and detectors, and also spatial light modulators may well provide application outlets for LCs, but the big new development requiring tonnage capacity production of new LC materials is not at present obvious. Perhaps it is hidden away and requires some long term fundamental research to bring it to the fore.

But will the support for that fundamental research be forthcoming [22]? At present funding seems to be diminishing. Yet there is so much to be done, and so many interesting projects to be developed—to mention only some, research on metallomesogens, on carbohydrate based LCs, on understanding the full role of chirality in LCs, on the role of LCs in biological systems, on the theory of LC phases and phase transitions, on harnessing polymer chemistry to the needs of LCs, on simulation and molecular modelling, etc.

And we should not forget that there are competitors to LCs in the displays field—electroluminescent displays, plasma displays, field emission displays, improved CRT

display systems and of course light emitting polymers which are receiving much current news coverage. No doubt some or all of these will find at least niche markets in the display industry and gain some business from LC materials. However, no single display device system can be all things to all men, and, for example, light emitting polymer materials may be at their best if in fact they are liquid crystalline and alignable, since they can then give linearly polarized electroluminescence, so enabling their use as good backlights for LC displays.

9. In conclusion

I am so pleased to have had this opportunity to reminisce in this way, to look back with hindsight and to emphasize that you do not publish over 360 scientific papers and patents in your career by achieving only the preparation of the cyanobiphenyls, important as they have of course been, and still are.

The pleasures of working in this field have been very great indeed, through the friendships and interactions developed over the years with so many people, many there at Capri. The International Liquid Crystal Conferences have preserved these friendships and interactions over the years through the warm family of liquid crystallographers that these conferences have fostered—we even have a multilingual Liquid Crystal song. At this stage in the lecture on which this article is based, I showed a number of slides of people with whom I have established particularly close friendships, had particularly important interactions or done especially exciting things scientifically over the years. Space does not allow me to reproduce these here. I will simply mention the names and photographic contexts, and hope I cause no offence to those not included—in such a long career there have been too many to include more than a selection—Professor S. Chandrasekhar and his wife, who together have hosted such very special conferences in Bangalore, Professor G. Scherowsky and his family on the occasion of his 60th birthday Fest Colloquium earlier this year, Professor E. Chiellini at the particularly excellent ILCC at Pisa, Dr P. Cladis and Professor Harry Coles at the Pisa banquet, Professor Alan Leadbetter at Budapest, Professor Duncan Bruce and the group of people who attended my 'retirement' meeting at the Royal Society of Chemistry in London, the meeting being organized by Duncan. Other slides shown were of Professor John Goodby now at Hull University, Dr Ken Harrison who worked on the biphenyls with me at Hull and Professor Cyril Hilsum to whom I owe an especial debt of gratitude regarding my own career development. I asked that just one picture from that stage of my talk be included. A scientist who gives a lot to science sacrifices a lot of his life and time to that process, and he needs behind him a very good woman.



Figure 6. The support team behind the author; my wife Marjorie seated second from the right and my daughters—left to right Elizabeth, Veronica and Caroline.

I was very lucky to have that in my wife Marjorie shown second from the right of figure 6, together with our daughters, from left to right Elizabeth, Veronica and Caroline, who have always been so supportive to us both.

Finally, I want to say that in organizing this birthday celebratory meeting in my honour in Capri, Professor Sven Lagerwall and his colleagues and friends have shown that the very important spirit of the Liquid Crystal Community is very much alive today. For all that they have done, I record my deepest thanks, particularly of course to you Sven for conceiving the idea and making it happen.

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