The phase transition is most easily brought about by changes of temperature. The use of Peltier elements seems to be of particular interest for low power devices. For many types of devices it would be useful to have high viscosities at high temperatures and low viscosities at low temperatures, i.e. the opposite of the usual situation. Leaving aside the possibility in principle of using liquid crystals with re-entrant phases,[6] there is no solution to this problem under isobaric conditions. In these cases phase transitions induced by changes of pressure are a possibility. At constant temperature the more highly ordered phase appears at higher pressure.[7] Thus, changes in effective viscosity can be expected at pressures much lower than those used with transmission fluids and oils, e.g. in gear-transmissions.[8] Unfortunately, kinetic data on transitions between the isotropic phase and a smectic phase, or between a nematic phase and a smectic phase, are not yet available. From isobaric microscopic observations it can be estimated that in compounds such as 4,4'-dialkylbiphenyls the molecular rearrangement will take place within a small fraction of a second at room temperature.

To be applicable in engineering many tribological conditions must be fulfilled. Obviously the compounds tested so far wet metals very well. There are many compounds of low molecular weight that are apparently resistant to hydrolysis and oxidation by air at not too high temperatures. A lucky circumstance is the fact that many stable and relatively easily synthesized compounds have an S_B phase, a highly ordered phase within the smectic layers. The occurrence of such a phase was undesirable in compounds synthesized for electrooptical displays. One can predict that, because of the low molecular weight, the resistance to molecular cleavage by shear forces should be good. The role of cavitation forces in highly stressed layers needs to be investigated by long-term tests. The point to be careful about seems to be the presence of organic impurities in the friction layer, which can cause a shift of the transition temperature.

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Conference Reports

Liquid Crystals Centenary

The 12th International Liquid Crystals Conference, held in Freiburg, FRG, on 15-19 August 1988, was attended by over 700 scientists from 31 countries; it is especially noteworthy that these included delegates from the German Democratic Republic and other eastern block countries. The conference, which was sponsored this time by the Deutsche Bunsen-Gesellschaft für Physikalische Chemie, is one of a series that began in 1965 in Kent, Ohio, USA; it is held bienially, the preceding one having been in Berkeley, California. One of the reasons for holding this year's conference in the Federal Republic of Germany is that the discovery of liquid crystals by *Friedrich Reinitzer* took place there 100 years ago. German scientists in Karlsruhe, Freiburg and Halle/Saale became closely involved in further studies of this fourth state of aggregation of matter, whose existence did not at first go unchallenged.

The scientific program of the conference included eight plenary lectures (45 min), 17 invited lectures (30 min), 58 short contributions (15 min), and 420 poster presentations. Apart from the plenary lectures, the meeting was divided into two parallel sessions covering the following main topics:

1. Synthesis and molecular properties (SY)
2. Polymer liquid crystals (PO)
3. Lyotropic liquid crystals (LY)
4. Chiral liquid crystals, blue phases (CH)
5. Ferroelectric liquid crystals (FE)
6. Applications (AP)
7. Surfaces and interfaces (SU)
8. Phase structure and transitions (PH)
9. Molecular dynamics and molecular theory (DY)
10. Instabilities, defects and fluctuations (IN)
11. Nonlinear optics in liquid crystals (NO)

During the course of the twelve conferences held since 1965 the number of scientific contributions has grown in an approximately linear fashion (Fig. 1). The Scientific

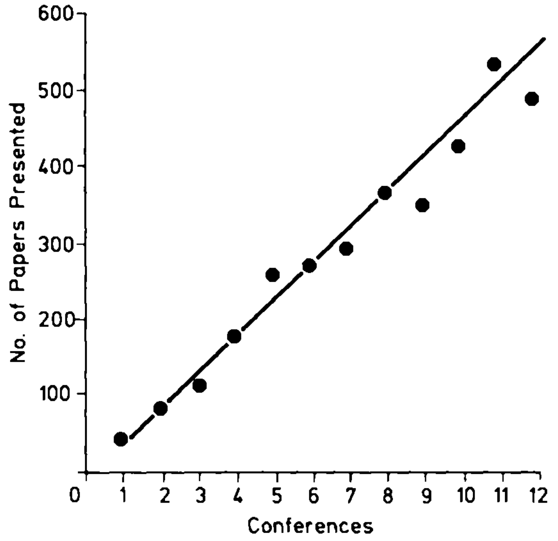

Fig. 1. Total number of papers presented at the International Liquid Crystals Conferences.

Committee of the Freiburg conference applied exacting standards to the papers submitted, and found it necessary to reject about 100 papers to maintain the required high level of scientific quality.

The 100th anniversary of the discovery of liquid crystals was acknowledged in a *historical session* with additional plenary lectures on the history of liquid crystals by *H. Kelker* (Frankfurt) and *H. Sackmann* (Halle/Saale), and in an exhibition entitled "100 Years of Liquid Crystal Research", prepared by *H. Kelker, G. Baur* and *M. Schadt.*

The conference's principal organizers were *G. Meier* of the Fraunhofer-Institut IAF, Freiburg (Conference Chairman), *H. Stegemeyer* of the University of Paderborn (Chairman of the Scientific Committee), *G. Baur* of the Fraunhofer-Institut IAF, Freiburg (Chairman of the Organizing Committee), and *H. Kelker* of the University of Frankfurt/Main (Treasurer).

Session SY was concerned with the synthesis of new types of liquid crystalline materials, and the relationship between molecular structure and physical chemical behavior. The main objective of these investigations is to develop materials with greater "intelligence" for applications in liquid crystal display devices, an area in which there are increasingly stringent demands from applications engineers with regard to switching by electric fields, image resolution, and information storage density. The contributions here emphasized the special importance not only of substances which contain polar and chiral groups and form ferroelectric liquid crystalline phases, but also of classical nematogenic compounds with high multiplexing capability.

Session PO was devoted to the chemistry of *polymer liquid crystals.* The number of groups working in this field and the volume of publications continue to grow, and closer contacts between these groups and those working on low molecular weight liquid crystals proved again very fruitful scientifically at this conference. The upward trend in research on polymer liquid crystals is clearly seen from the large increase in the numbers of papers on this topic over the last five conferences (Fig. 2, ×). While polymers with main chain liquid crystalline behavior have for some time had an established place in applications, e.g. in the manufacture of high tensile strength fibers, the prospect of a technical breakthrough for liquid crystalline side chain polymers is only just emerging. The results reported at the conference suggest that we may expect this to occur in the area of thin films made from high molecular weight liquid crystals frozen in a glassy phase, and having special optical and dielectric properties; these could be used as ultra-high density data storage media. Another area where significant progress can be seen is the development of ferroelectric liquid crystalline polymers.

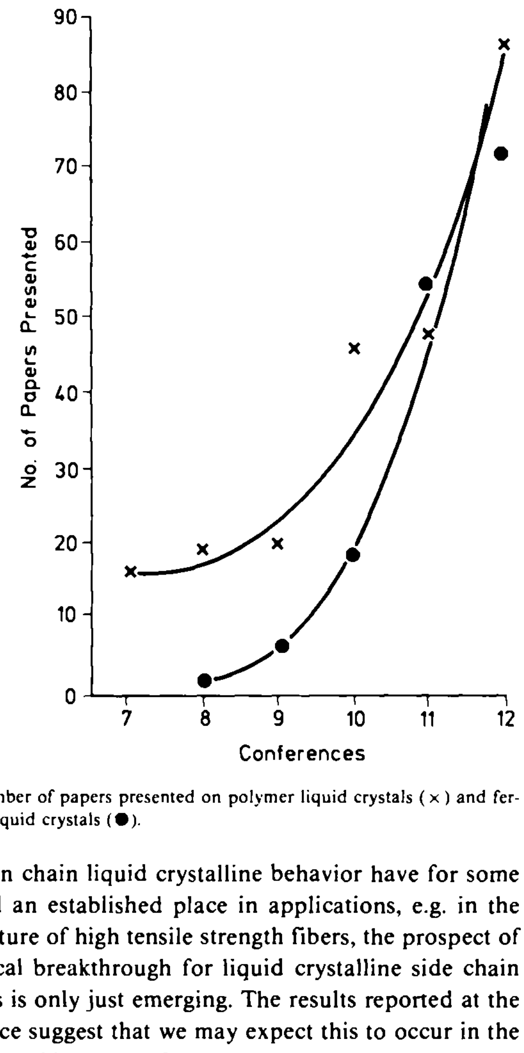

Fig. 2. Number of papers presented on polymer liquid crystals (×) and ferroelectric liquid crystals (●).

In *Session LY* the Scientific Committe aimed to direct special attention to *lyotropic liquid crystals* as an area with potential for further development. Liquid crystals of this type, which occur especially in aqueous solutions of surface active substances, have been studied with regard to their structures and their relationship to classical liquid crystals. As lyotropic liquid crystals have an important role in biological systems such as membranes and cell tissues, there is increasing research activity on this topic, which deserves a greater input of resources than in the past.

Nearly all the papers in *Session CH* were concerned with the *blue phases* observed in some *cholesterogenic liquid crystals,* perhaps still at present no more than a scientific curiosity, but now attracting increasing attention, both experimentally and theoretically. Studies are in progress aimed at discovering how nature, starting from disordered systems of optically active molecules, builds up highly ordered cubic lattice structures in phases of extremely high chirality, with the result that one even observes liquid single crystals; studies have been made of the distortion of such single crystals in applied electric fields. These studies have led to the discovery of a number of distinct blue phases that are only stable in the presence of an electric field, and whose structures are in some cases still a subject of controversy.

Session FE was of particular importance, being devoted to the highly topical theme of *ferroelectric liquid crystals.* From the materials standpoint the preparation of these types of liquid crystals had already been covered in Session SY, and this session was therefore concerned mainly with physical processes in an applied electric field. In an electric field these ferroelectric systems can be switched between two stable states, and by suitably immobilizing these on surfaces in thin cells (up to 2 μm) they can be preserved after the field is removed. The switching times in these processes are extremely short, resulting in switching that is several orders of magnitude faster than can be achieved using nematic phases. It may therefore be possible to use these materials to make faster optical information storage devices, which accounts for the enormous interest shown by applications engineers. Because of this overwhelming interest in applications, the physics of dynamic field effects in ferroelectric liquid crystals has unfortunately been rather neglected. The conference illustrated that much basic research still remains to be done in order to elucidate, for example, the detailed mechanism of switching between the bistable states, and how molecular structural features such as chirality and polarity influence the spontaneous polarization. This area of ferroelectric materials is now clearly emerging as an important direction in liquid crystal research, as is evident from Figure 2 (●) which also shows the growth in the numbers of scientific contributions on this theme over the last five conferences.

In *Session AP, applications* were the theme. Improvements in the LC display devices which have now been in common use for some years are aimed at increasing the information storage density,and improving switching times and multiplexing capability. Important developments here are supertwist cells and active matrix displays. Developments in LCD technology now in progress in Japan, making it possible to produce TV screens with a higher information density, were especially impressive.

The papers in *Session SU* dealt with surface and interface effects in liquid crystals. The binding of liquid crystal molecules on surfaces prepared by vapor plating with inorganic materials or coating with amphiphilic monolayers was described. These techniques, and orientation effects on liquid crystals near to interfaces, also attracted much attention from applications engineers, since such processes are very important in the formation of ultrathin LCD films. Liquid crystal structures at free surfaces were also discussed, including the use of nonlinear optical effects to investigate these systems. The theoretical treatment of smectic layer structures consisting of only a few molecular layers requires an entirely new approach in contrast to the bulk behavior.

Session PH was mainly concerned with theories of *phase transitions* between polymorphic liquid crystal phases, and with experimental testing of such theories. The discussions included insights into the detailed topology of smectic layer structures (e.g. sub-types of the classical S_A phase); multicritical behavior and new types of phase structures were also discussed.

In *Session DY* the *dynamic behavior* of liquid crystals was discussed. An interesting aspect of this was the flow properties of liquid crystals, which one needs to know in order to understand the reorientation processes that occur during switching in a field. Molecular dynamics in monomeric, and more especially polymeric, liquid crystals have also been intensively studied; by using nuclear spin methods it has been possible to study the dynamic behavior of individual molecular segments. This has led to a deeper understanding of motional and relaxation processes in the different liquid crystal phases, the earlier considerations based on rigid rod-like molecules having been shown to be insufficiently detailed for this.

The papers in *Session IN* were again of predominantly theoretical interest, being concerned with *instabilities, defects and fluctuations* in liquid crystals. In this case, however, the results based on considerations of electrohydrodynamic instabilities have also turned out to have practical implications, since it is only thus that a deeper understanding of some of the long familiar processes involved in the switching of liquid crystals is now emerging.

Session NO was arranged by the Scientific Committee to allow a discussion of problems in *nonlinear optics* of liquid crystals. This was the smallest of the sessions, with only seven poster contributions, though by no means least in importance. It became evident that more efforts of research groups should be directed to this field. First of all, a number of problems related to the materials must be solved. Nevertheless, the possibility of using liquid crystalline components in integrated optics where nonlinear optical effects are important is now beginning to emerge.

In summary one can conclude from the results reported at this conference that polymeric liquid crystals, lyotropic systems and ferroelectrics are especially important topics for future research, with corresponding implications for applications technology, in some cases with a direct bearing on applications. The conference papers will be published in *Liquid Crystals 5* early in 1989.

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