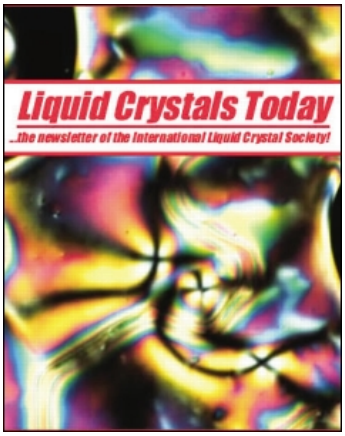

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Liquid Crystals in China

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Liquid Crystals in China

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This article follows that by Dr L. Lam [*Mol. Cryst. Liq. Cryst.* **91** (1983) 77] which briefed on the liquid crystal activities in China for the period of 1970–1982. Research on liquid crystals in China started in 1970, two years after the discovery of the dynamic scattering mode by Heilmeier *et al.* The Liquid Crystal Society, a sub-panel of the Physical Society of China, was founded in 1980. In addition, biennial meetings on liquid crystal polymers have been held since 1987 under the auspices of the Chinese Chemical Society. Up to now, a few hundred scientists and engineers have joined in the fast growing field. A few books written by Chinese authors, covering physics, chemistry, displays, biology and polymers have been published, and in the past decade a number of scientists and engineers well trained in liquid crystals from home and abroad are playing an important role in liquid crystal research and industry in China

As a result of the significant development in liquid crystal applications such as liquid crystal television and liquid crystal notebook computers, and the encouragement of Professor P. G. de Gennes' award of the Nobel Prize in Physics, liquid crystal research in China has been inspired and has obtained increased funding from government and industry. More people from various disciplines are interested and involved in this area. Following the maturing of liquid crystals and the reform of China's economy, Chinese scientists in recent years have actively joined in the world community of liquid crystals. More scientists and engineers than ever have participated in world meetings on liquid crystals. Seventeen Chinese delegates are full members of the International Liquid Crystal Society. X. J. Wang (previously Tsinghua University, now Peking University) and Q. F. Zhou (Peking University) are the Editorial Board members of the journal *Liquid Crystals* and the magazine *Liquid Crystals Today*, respectively.

In 1988 the China Liquid Crystal Society held the Centenary Conference of Liquid Crystal Discovery at Beijing. About 20 noted overseas scientists attended the conference and it was the first meeting of this kind which attracted so many overseas scientists in this area. In 1993 the Sino-Japanese Bilateral meeting on Liquid Crystal Displays and China Winter Symposium on Liquid Crystals were held in Changchun and Shenzhen, respectively; both attracted a few liquid crystal experts from abroad. An event worthy of special mention is the IUPAC sponsored International Conference on Liquid Crystal Polymers which was held in 1994 in Beijing; the first official international conference in the field of liquid crystals ever held in China. One hundred and twelve papers written by 295 authors from 17 countries were presented, for details please see the articles from *Liquid Crystals Today* **4** (3) (1994) and *Macromolecular Symposia* **96** (1995). The activities in China associated with liquid crystals are described under two headings: science, and technology and industry.

Science

About 20 groups in universities and research institutes carry out research on liquid crystals, covering almost all topics within physics, chemistry, biology, and applications.

J. X. Wen and Q. Chen at Shanghai Institute of Organic Chemistry, synthesized fluorinated liquid crystals with 2,3,5,6-tetrafluoro-1,4-phenylene units with and without chiral end groups, which show ferroelectric smectic C phase, cholesteric or smectic A and nematic phases. M. G. Xue at Sichuan University is engaged in research on ion transport through crown ether LC/PVC binary component membranes. The thermo-control of transport of ions (Li^+, Na^+, K^+) through the membranes was selectively operative and the permeation of ions suggests that molecules of crown ether liquid crystal could align to form ionic channels. The organometallic ferroelectric liquid crystals, cholesteryl *trans*, *trans*-2,4-hexadienate tricarbonyl-iron, were synthesized by Chengdu Institute of Organic Chemistry and Sichuan Normal University. They found that one of its diastereoisomers possesses a mesogenic phase while the others do not. Beijing institute of Chemical Reagents synthesized wide temperature range cholesteric liquid crystals with good stability and bright colour, which are good emulsifying agents and can be used in cosmetics and handicrafts. East-China University of Science and Technology, led by G. Z. Li reported syntheses of chiral thermotropic colour liquid crystals which are more stable and more colourful than cholesterol liquid crystals. The black dyes for liquid crystal displays have been

prepared by Dalian University of Science and Technology, which consist of dichroic anthraquinone dyes. The dyes in liquid crystal hosts have flat absorption from 450 to 650 nm. These dyes possess high order parameters, photochemical stability and good solubility.

Researchers of the Third Military Medical College observed a mucilage produced by Gram-negative bacillus and found the evolution of dendritic liquid crystal, and thus proposed liquid crystals action in biological control. L. X. Cao at Wuhan University studied the phase transition of liquid crystals in yolk sac, liver, gonad and adrenal gland during development of the chick embryo.

The bowlic liquid crystals, hexa-*n*-alkylcarboxytribenzocyclononene series, were synthesized by L. Y. Wang at Tsinghua University and were examined by X. J. Wang at Peking University by X-ray diffraction; the bowlic compounds form a triclinic system. X. J. Wang also carried out X-ray diffraction experiments using a position sensitive detector to investigate smectic C phases, the conformation of liquid crystal polymers and X. J. Wang joined Professor A. J. Leadbetter's group at Rutherford Appleton Laboratory (UK) in 1984–85 to investigate the cubic S_D phase. Experiments such as X-ray diffraction, SHG and modelling unambiguously revealed the cubic structure of the S_D phase.

G. Z. Yang at Hebei College of Technology has calculated the thermodynamic properties of liquid crystals using cell theory that took into account short-range positional correlations in liquid crystals. The attenuated total reflection method or half-leaky guiding mode method has been applied to examine surface alignment, optic constants and response of liquid crystals to applied fields by J. A. Zhao, Tsinghua University and X. J. Wang, Peking University. The method is now applied in Changchun Institute of Physics to study the alignment of liquid crystals. The anchoring transition of liquid crystal on crown ether monolayers was studied by Y. Wei at Southeast University. Progress in non-linear optics of nematics has been made at the Physics Institute, Beijing, and enhanced non-linear diffraction effect in the presence of alternating electric fields and thermal oscillation of optical four-wave mixing, were reported.

Q. F. Zhou at Peking University has proposed the Mesogen-Jacket Model for laterally attached side chain liquid crystal polymers. The jacket effect has been proved by Hardouin (France) in terms of neutron scattering experiments. Q. F. Zhou and co-workers have shown that mesogen-jacketed liquid crystal polymers have properties very similar to that of rigid and semi-rigid main chain type liquid crystal polymers. They also found that a monotropic liquid crystalline polymer may transfer into an enantiotropic one simply by increase of the molecular weight or by copolymerization. High strength singularities were observed by Q. F. Zhou for polymeric nematics. R. Qian and S. X. Chen at the Chemistry Institute, Beijing, are interested in disclinations in liquid crystal polymers including the banded textures. Y. L. Yang at Fudan University calculated by means of computer simulation the rheologic behaviour of liquid crystal polymers under shear and demonstrated that the first normal stress difference is negative at middle shear rate. A few groups are studying the application of side chain liquid crystal polymers as NLO materials and cover layers for optical fibres.

X. J. Wang at Peking University, jointly with Dr M. Warner (Cambridge University), has carried out research since 1984 on semi-flexible liquid crystal polymers including main and side chain liquid crystal polymers and cross-linked networks and gels in both conventional and mesogenic solvents. They proposed the classification of side chain liquid crystal polymers, i.e. N_I, N_{II} and N_{III} phases which have been observed by neutron and X-ray, dichroism and NMR experiments. Details of research on liquid crystal polymers in China can also be found in the *Proceedings of International Conference on Liquid Crystal Polymers*, 1994, Beijing.

Technology and Industry

A 7 inch black/white STN-LCD prototype of pixel number 160×320 has been fabricated by X. M. Huang's group, Changchun Institute of Physics. The contrast ratio reached 7:1. Similar kinds of STN prototypes have been fabricated in several other institutions. Nankai University and Huazhong University of Science and Technology are pilot-manufacturing amorphous silicon TFT panels of up to 3 inches. The reasonable quality performance of a moving picture was observed. A thermally addressed, electrically erased, high resolution smectic light valve was produced by East-China University of Science and Technology and Shanghai Institute of Organic Chemistry, the contrast being 10:1; resolution 100 lines/mm; scanning rate 105 pixels/s. Peking University, Tianma Electronics Co. (Shenzhen) and Changchun Institute of Physics are modelling the performance of LCDs by means of the 4×4 matrix method. J. A. Zhao has studied the electro-hydrodynamic instability in chiral nematics of negative dielectric anisotropy. X. J. Wang (Peking University) has used Auger Electron Spectroscopy to assess the quality of ITO-coated glass plates and studied obliquely evaporated SiO on ITO/glass substrates. It was shown that the composition of SiO_x varies, SiO_2 dominant at the

surface-to-air interface, SiO rich in the bulk and SiO_2 accumulated again at the interface to ITO. Liquid crystal film thermograph diagnoses for patients have become a preliminary screening technique in mass screening programme of breast cancer in some hospitals.

China imported five LCD production lines in the middle 80s, manufacturing TN displays. Up to 1990 the number of LCD producers increased to 13, with the output increasing 40 fold. Now there are 20 more LCD producers, mainly distributed in the Pearl River delta, South China. They are state-owned, or joint-venture, or owned by foreign investment. Most of them manufacture TN products, e.g. games, calculators, watches, meters, controls, etc. In the last couple of years, several companies have joined these and are capable of producing STN displays. Now China becomes a key world LCD producer, especially in the low-end or medium-end products. New LCD factories are under construction, and a batch of state standards on LCDs has been drafted to monitor the LCD industry. In addition, some enterprises manufacture non-display products such as optical shutters, thermochromic cholesteric products, etc. Liquid crystal materials for the LCD industry are now available commercially in China, and there are several factories in China producing ITO-coated glass plates for LCD use.

The above overview is not complete: we hope when the 21st Century dawns Chinese scientists and engineers will contribute more to the field of liquid crystals in both science and technology. Chinese liquid crystal people are working together with the liquid crystal community in the world to make liquid crystals more beautiful and less mysterious.