ALCOM Update

NSF Science and Technology Center for Advanced Liquid Crystalline Optical Materials | Consortium of Kent, Case Western Reserve, and Akron

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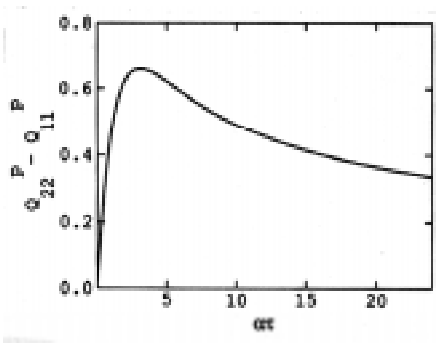
Researchers Investigate Anchoring on Photoreactive Polymer Films

Hristina Galabova and David Allender

The ability of some photoreactive polymers to homogeneously orient a liquid crystal after being exposed to linearly polarized UV light has been of great interest during the last several years. Two types of materials have been studied. In the case of polyimides, exposure to UV light causes breaking of the polymer backbone, while in the case of poly(vinylcinnamate) (PVCN) and poly(vinyl-4-methoxy cinnamate) (PVMC), the exposure causes crosslinking of side groups.

Dave Allender and Hristina Galabova examine computer data.

In our work we have theoretically investigated the liquid crystal alignment on irradiated PVCN or PVMC films. We have assumed that the alignment is due to interaction of the liquid crystal molecules with the polymer side groups and their photoreaction products, and by using the model developed by J. Chen for the angular dependence of the probability for a photoreaction, we have derived the angular distribution of what we call ordering sites, that is, side groups and photoreaction products able to orient the liquid crystal. To describe their orientational order, we have introduced a tensor order parameter for the polymer film, similar to the order parameter used for the description of liquid crystalline order. The order parameter is determined by averaging over the angular distribution of the ordering sites and thus, it depends on the exposure time. When no pretilt angle exists, the order parameter tensor is diagonal and its in-plane anisotropy follows behavior similar to the experimental observation for optical anisotropy of PVCN films as a function of exposure time (see Fig. 1).



Liquid crystals in the nematic phase in contact with a surface favoring planar (with no in-plane easy axis) order have some inherent in-plane anisotropy. We assume that when the liquid crystal is in contact with an irradiated polymer film, the film not only introduces an in-plane easy axis but also increases the inherent anisotropy of the liquid crystal by an amount equal to the anisotropy of the film. We also assume that the eigenvalue of the liquid crystal order parameter corresponding to an eigenvector perpendicular to the surface is the same as that of the polymer film. Using these assumptions we have calculated the behavior of the azimuthal and polar surface coefficients as a function of exposure time

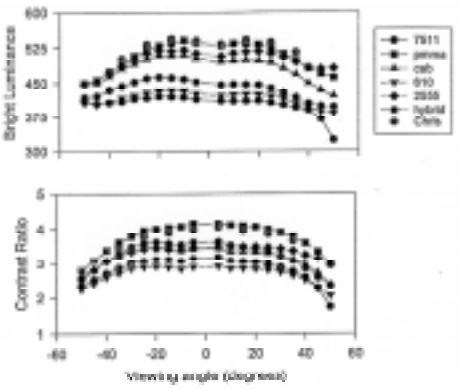
POLYMER FILMS, *continued on page4*

RESEARCH NOTES

New Polyimide Alignment Film for LCDs

Uniform alignment of liquid crystal molecules is important for most liquid crystal displays (LCDs). Rubbed polyimide films (PFs) are common alignment layers used in the fabrication of LCDs. Polyimide films which require curing temperatures above 250°C are not suitable for use in the fabrication of full color LCDs because of the poor stability of dyes or organic pigments above 200°C. In addition, PFs requiring high-temperature curing are not suitable for LCDs using plastic substrates. Therefore, it is important to have PFs which can be processed at low temperature.

Chien's group (C. Hudson) has developed a series of soluble polyimide alignment films for low temperature curing (below 120°C). A representative polyimide, "Chris", is soluble in organic solvents such as acetone, dichloromethane, 2-butanone, etc. The new PF has shown good alignment characteristics with a pretilt angle larger than 2° for TN LCD as determined by the ALCOM Characterization Center (R. Klouda). The Chris PF was also evaluated as the alignment film for a surface-stabilized bistable reflective cholesteric display (BRCD) by D. Davis and B. Taheri. The comparison shown below was made for luminescence at reflective and scattering states with BRCDs against other alignment films, Nissan 610 and 7511, Dupont 2555 poly(methylmethacrylate) (PMMA) and cellulose acetate butyral (CAB).



RESEARCH NOTES, *continued on page 3*

FROM THE DIRECTOR

A Year of Change and Growth

by John L. West, Interim Director

1996 has been a year of change and growth for ALCOM. At the annual retreat in January, Bill Doane announced that he would retire in June. Shortly thereafter the search for his replacement began. The search continues and a permanent replacement should be announced before the next newsletter.

Bill's term as director ended with the 16th International Liquid Crystal Conference, held the last week of June on the Kent Campus. ALCOM was a major sponsor of the conference and ALCOM principal investigators made up the entire organizing committee.

In October ALCOM established a formal collaboration with the Japanese Association of Liquid Crystal Scientists (JALCS). Through this collaboration, ALCOM and JALCS plan to exchange students and senior scientists. Two members of JALCS, S. Kobayashi and M. Hasegawa, gave presentations at the ALCOM symposium on *Non-Rub Alignment Techniques*, held October 21-22 at Cuyahoga Falls, Ohio.

I am writing this message on the ShinKansen, on my way to give the keynote address at a JALCS meeting in Kobe. This new collaboration will strengthen both organizations. We hope to add scientists from other countries in the Pacific Rim to this collaboration.

The year ends as the LCI and headquarters for ALCOM move to a new building. In addition to doubling the research space of the current LCI, the new building will provide an auditorium, expanded conference space, classrooms, and over 3,000 square feet of clean room space. The clean room will house the ALCOM prototype facility and a display pilot line donated by Lucent Technologies.

1997 promises to see continued growth and change. The year begins with the annual retreat to be held January 8-10 at Sawmill Creek. This retreat will be especially important as we begin the process of preparing the renewal proposal to NSF for ALCOM funding from 1998 through 2001. The written proposal will set the direction for ALCOM research; it will be submitted to NSF in April. The on-site review is scheduled for mid-July. Finally, I hope to see you at the ceremony to dedicate the new Liquid Crystal Institute building in early June.

Symposium Held on Non-Rub Alignment Techniques

Chuck Rosenblatt, Chair; John West, Co-chair

ALCOM's Alignment Layer Project has focused heavily on non-invasive techniques to achieve planar and near-planar alignment. Although rubbing of a polymer-treated surface has been a useful method in the past, manufacturers have long sought a more reliable method which does not entail unwanted dust and charge buildup. Several years ago it was realized that exposure of appropriate polymers to polarized ultraviolet light can establish an easy axis for the director orientation without the unwanted artifacts associated with surface rubbing. Although still in its infancy, such a technique holds the promise of consistent results with high manufacturing yield.

To better familiarize both ALCOM members and our industrial partners with the current technology, a symposium was held October 21-22, 1996 at the Sheraton Suites, Cuyahoga Falls, Ohio. Of the 148 participants, 43 were from academia and industry including representatives from 19 companies in the ALCOM Industrial Partnership Program.

Four invited pioneers delivered plenary talks; W. Gibbons, Alliant Techsystems; M. Hasegawa, IBM Research Japan; S. Kobayashi, Science University of Tokyo in Yamaguchi; and Y. Reznikov, Ukrainian Academy of Sciences. Their talks covered a wide range of topics, including an introduction to UV alignment treatments of polyimides, the effects of polarized UV on the ultimate director orientation, the effects of magnetic fields during polymerization, the generation of pretilt, the effects of polyimide structure, and optical and electrical properties of UV-prepared cells. Additionally, fourteen talks presented by ALCOM principal

SYMPOSIUM, *continued on page 3*

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NSF Science and Technology Center
for Advanced Liquid Crystalline Optical Materials
Consortium of Kent, Case Western Reserve and Akron

Interim Director
J.L. West

Associate Director
J.L. Koenig

ALCOM PIs

Kent State University
D.W. Allender, L. Bartolo, P.J. Bos, L.-C. Chien, J.W. Doane, P. Farrell, D. Finotello, J.E. Fulghum, C. Gartland, J.R. Kelly, S. Kumar, O.D. Lavrentovich, M.E. Neubert, P. Palffy-Muhoray, A. Ruttan, S. Sprunt, J.L. West, D.K. Yang

University of Akron
S.Z.D. Cheng, P. Han, F.W. Harris, T. Kyu

Case Western Reserve University
W.L. Gordon, S.D. Hudson, A.M. Jamieson, J.L. Koenig, J.B. Lando, J.A. Mann, R.G. Petschek, C. Rosenblatt, D.E. Schuele, K.D. Singer, P.L. Taylor, S.Q. Wang

John Carroll University
M.R. Fisch

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ALCOM Newsletter Editors
Elaine Landry and Brenda Buck

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Mailing Address: Liquid Crystal Institute
Kent State University, Kent, OH 44242-0001
Tel: (330) 672-2654; Fax: (330) 672-2796
e-mail: brenda@scorpio.kent.edu

FEATURE

ALCOM Joins Trade Mission to Asia

Samsung executives show Cartwright and West their new 22" diagonal, full-color active matrix liquid crystal display.

Representatives from ALCOM were invited by Ohio Lt. Governor Nancy Hollister to join her and the Ohio Department of Development on a trade mission to Asia in September. The mission centered around the Midwest U.S./Japan Trade Association meeting held in Tokyo and included visits to five major Japanese liquid crystal display (LCD) manufacturers.

Kent representatives President Carol Cartwright and LCI Associate Director John West were asked to be part of the trade delegation because of Kent's Liquid Crystal Institute, which has already helped to build relationships with Japanese companies. The trade mission allowed all parties to sit down and discuss opportunities available in Ohio.

"The meetings with these companies stressed the importance of building long-term relationships with the ultimate goal of expanding the established base of liquid crystal display manufacturing in Northeast Ohio," said West.

Cartwright and West then left the Lt. Governor's delegation and traveled to South Korea to visit Samsung Electronics Corporation. While there, they toured Samsung's active matrix LCD production line and met with company executives to discuss continuing interactions.

The trade mission broadened the reputation of ALCOM as well as testing the economic potential of science and technology center collaborations with government and industry.

"The trade trip to Japan represented a new partnership model for state government and universities interested in pursuing cooperative economic development efforts in Ohio," Cartwright stated. "We were able to communicate Ohio's commitment to basic science support, the applications of research conducted at the Liquid Crystal Institute, and the business development opportunities that exist in Ohio," she added.

SYMPOSIUM, *from page 2*

investigators, postdoctoral fellows, and students covered a wide range of topics being explored by investigators from the participating ALCOM universities.

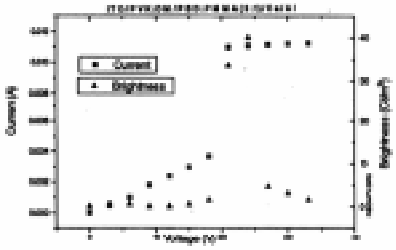
The symposium concluded with a panel discussion, the first time such an open-ended discussion was incorporated into an ALCOM symposium. Participants were P. Bos (Liquid Crystal Institute), S. Kobayashi (Science University of Tokyo), A. Lien (IBM), and J. Stroh (LXD). John West (Liquid Crystal Institute) served as moderator.

Although several scientific and technological issues were addressed, perhaps the most contentious issue was the ultimate viability of UV-alignment. Whether the technique, in the long run, will be as reliable as claimed, or if the retooling cost will be prohibitively expensive are still unanswered, but it is clear that participants left with a firm foundation for future work.

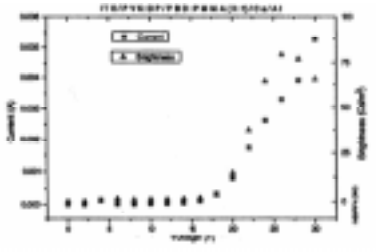
RESEARCH NOTES, *from page 1*

Thiophene-Based Liquid Crystals in a Electroluminescence Device

Thiophene-based compounds are known for such properties as thermochromism and solvatochromism. They have attracted much attention recently because of their use as emitters and singlet exciton confinement layers in fabrication of effective organic light-emitting diodes (LEDs). Bright electroluminescence throughout the whole visible spectrum might be obtained by changing conjugation length in a thiophene compound. Recently, Chien's group (D. Voloshchenko and M. He) has been working on the preparation of liquid crystal electroluminescence (EL) devices using thiophene-based liquid crystalline materials. These materials combine the properties, namely anisotropy and electroluminescence, which make them attractive for EL devices. In collaboration with Professor Sokolik (Dept. of Elec. Eng. of the City University of New York), they fabricated EL devices using a nematic thiophene liquid crystal and a polyurethane containing thiophene moieties both of which emit blue light. The liquid crystal EL device gives a stable blue electroluminescence with a luminescence of 40 Cd/m^2 while a polymer EL device yields a stable blue light with brightness around 80 Cd/m^2. The results are shown in Figures 1 and 2.



Electroluminescence of a nematic thiophene-based LC (Fig 1) and Electroluminescence of a polyurethane containing thiophene-moieties (Fig. 2).



Xerox Launches Company to bring New Image Capture and Display Technologies to Market

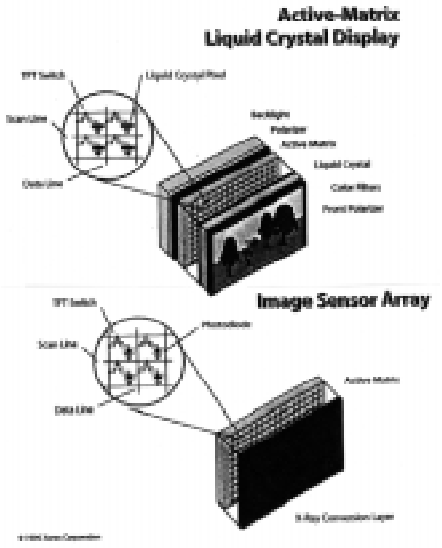
Demands on digital viewing environments have rapidly increased as knowledge workers discover more applications where digital information has practical value. Vast amounts of complex and detailed data are being digitized and used at a rapidly increasing pace. A wide variety of information forms, such as animation, sound, video and object links, are being incorporated into electronic documents. This multimedia enrichment of documents has created a need for a far more versatile and detailed digital viewing environment.

On March 11, 1996, Xerox Corporation launched *dpiX, A Xerox Company,* a business that will develop and market high-fidelity digital viewing environments which represent a quantum leap in the collection and viewing of detail-critical information. The new company (pronounced "depicts") will deliver Palo Alto Research Center (PARC) - developed, ultra-high resolution, image sensor and display products enabling visual computing professionals to work with a wider variety of information than ever before. PARC researchers have demonstrated page-size flat panel displays with seven million pixels, far exceeding the half million pixel displays now commonly found in laptop computers.

Initially, the new company will provide customized, application-specific solutions for OEM customers. dpiX will deploy a manufacturing strategy similar to that used by application specific integrated circuit (ASIC) manufacturers, making it possible to tailor manufacturing processes to accommodate different panel designs and specific performance requirements. This strategy will allow dpiX to better serve customers with lower volume or custom products. Although it will first address the military avionics and medical imaging markets, dpiX plans to apply its technology advances to products which address broader visual markets including workstation, document imaging, publishing and prepress, computer aided design, mapping systems, multisystems, multimedia production and non-destructive testing.

"We are opening the window to the digital world in a dramatically vivid way that brings combined forms of visual communication to the individual."

dPix plans to introduce state-of-the-art AMLCD display products for the growing U.S. military avionics market in late 1996. dpiX is working together with display manufacturer Planar Advance, Inc., of Beaverton, OR, to jointly develop rugged, high-performance AMLCDs which will provide improved viewing for digital maps, tactical situations, radar data and flight information.



For the medical industry, dpiX provides large-format sensor arrays which have the potential to replace film in a variety of diagnostic imaging applications, thereby eliminating the need for bulky hardware, expensive chemical processing and space-consuming archives. With all the clarity of X-ray film, images can be captured using dpiX sensor arrays and transmitted electronically.

"When you actually see the technologies we've created, you'll immediately visualize the myriad applications that are possible," said Dr. Malcom J. Thompson, chief executive officer of the new Xerox business. "We are opening the window to the digital world in a dramatically vivid way that brings combined forms of visual communication to the individual. We've created a dynamic medium that communicates with more richness and dimension than a paper document and with more definition than today's digital documents on the desktop."

dpiX flat-panel display and image sensor arrays are compelling technologies which have immediate and far-reaching applications. By offering excellent image quality and supporting application-specific imaging requirements, each technology has powerful implications for improving the efficiency and accuracy with which we work.

dpiX is located at 3406 Hillview Ave., Palo Alto CA. Xerox Corporation is a global company serving worldwide document processing markets. Xerox joined the ALCOM industrial partnership program in 1995.

POLYMER FILMS, *from page 1*

of the film, and we have found that both coefficients follow behavior similar to the anisotropy of the film having a maximum at the same exposure time as the anisotropy of the film; however, the change in the polar coefficient is much smaller than that of the azimuthal one.

In order to relate our results to experimental observations, we have calculated the behavior of the twist angle in a twist cell with two polymer layers oriented in such a way that a 90° twist is favored. According to the calculations, a PVCN film exposed for more than 5 seconds but less than a few hours will strongly anchor the liquid crystal. Experimental observations show that the quality of alignment is decreased on film exposed for a long time, but no quantitative results are available. A systematic experimental study of the behavior of a twist cell with polymer layers exposed for different periods of time will give an indication of exactly how the liquid crystal order at the surface is related to that of the polymer film.

In our work we have investigated only the case where no pretilt angle exists on the irradiated polymer film. Pretilt angle generation is certainly a major issue, and currently we are concentrating our efforts on describing the pretilt angle generation on doubly exposed polyimide films.

Polymers and Liquid Crystals Tutorial

In 1993, Jack Koenig recognized the growing potential of a multimedia approach to instruction in the form of an electronic textbook available through both the internet and CD ROM, for self study and as supplementary material for classroom use.

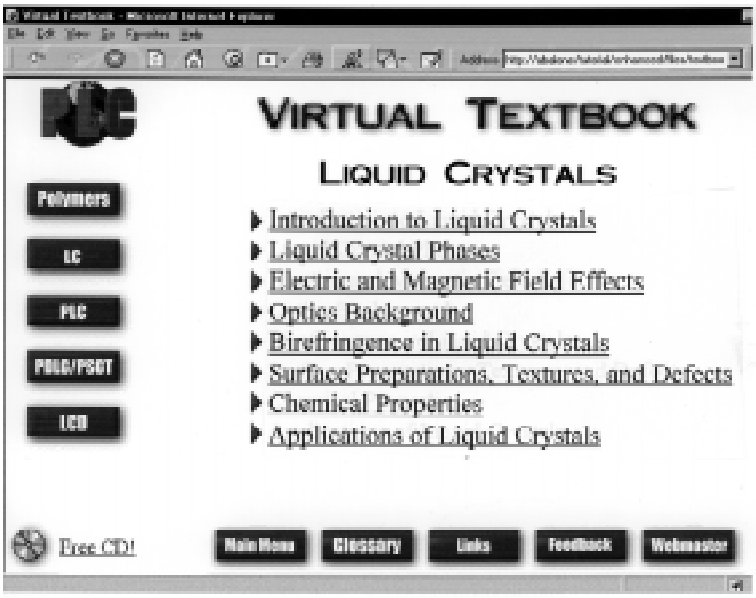


Fig. 1 - User interface of the tutorial

Koenig proposed, with Bill Gordon, a joint effort between the departments of Macromolecular Science and Physics to develop a prototype module for use in the ALCOM Outreach Program. This was to include introductory material on polymers, liquid crystals and their applications at the level of college undergraduates with a basic knowledge of chemistry and physics. They enlisted Peter Cramer, a specialist in educational computing in the Physics Department to assist.

Work started with the construction of two simulations describing polymer growth; one was based on a linear chain model and the other included conformation dependence in a 2D representation. Two undergraduates working with Cramer developed the simulations along with one illustrating the mesophases of liquid crystalline materials. Undergraduates also participated in preparing related text material.

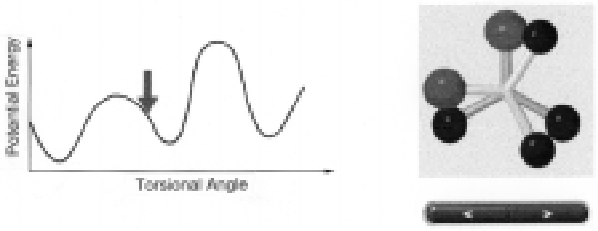


Fig. 2 - User can adjust torsion angle of the carbon-carbon bond.

Rapid developments in technology permitted the use of HTML (hypertext markup language) documents available through the World Wide Web using an on-campus server scheduled to open to the Internet by the end of Summer, 1995. Fig. 1 illustrates the user interface showing the Liquid Crystal Section. Buttons on the left present the main section topics.

In 1996, the tutorial moved from a static book-like format to a true dynamic multimedia application through the availability of new software. Acquisition of Ray Dream Studio made possible the preparation of 3D images and animations and with Director Studio, Shockwave-embedded interactive applications were created. Web users were then able to interact with page content to experiment or clarify particular elements of the accompanying text (Fig. 2).

In order to expand availability of the tutorial, a CD version was developed that does not require users to be connected to the internet. It has the same look and feel as the on-line version and is capable of running on both Mac and PC platforms.

The CD is currently being evaluated by representative groups including some CWRU freshmen, interested members of ChemLinks Coalition (chemistry faculty, primarily in liberal arts colleges) and some public school teachers in the ALCOM SAM-Net Workshop.

The Web version can be accessed at http://abalone.cwru.edu.

PUBLICATIONS

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"Morphology of Polymer Networks Polymerized in Highly Ordered Liquid Crystalline Phases," D.S. Muzic, C.V. Rajaram, L.C. Chien, S.D. Hudson, *Polym. Adv. Technol.* **7**, 737 (1996).

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"Kinetic Theory and the Flory-Huggins Approximation," P.L. Taylor, Y.-K. Yu, X.Y. Wang, *J. Chem. Phys.*, **105**, 1237 (1996).

"Kinetic Theory of Phase Separation Induced by Nonuniform Photopolymerization," X.Y. Wang, Y.-K. Yu, P.L. Taylor, *J. Appl. Phys.*, **80**, 3285 (1996).

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"Optically Aligned Liquid Crystals: Physics and Applications," T. Kosa, P. Palffy-Muhoray, *Pure Appl. Opt.*, **5**, 595 (1996).

In Brief

NRC Announces Associateship Programs

The National Research Council has announced the 1997 Resident, Cooperative, and Postdoctoral Research Associateship Programs which provide opportunities for Ph.D. scientists and engineers of unusual promise and ability to perform research on problems largely of their own choosing. The host laboratory will provide the associate with programmatic assistance including facilities, support services, necessary equipment, and travel necessary for the conduct of the approved research program.

Approximately 350 new full-time associateships will be awarded on a competitive basis in 1997 for research in areas of science, engineering, and computer science. Annual stipends for recent Ph.D.s for the 1997 program year range from $30,000-$45,000 depending upon the sponsoring laboratory and will be appropriately higher for senior associates.

Information on specific research opportunities and participating federal laboratories, as well as application materials may be obtained from the National Research Council, Associates Programs (TJ 2114/D2), 2101 Constitution Avenue NW, Washington DC, 20418. Information is also on the internet at: http://www.nas.edu/rap/welcome.html.

Koenig receives ACS Award

Professor Jack L. Koenig from the Department of Macromolecular Science at Case Western Reserve University has won the 1997 ACS Phillips Award in Applied Polymer Science. A symposium in his honor will be held at the Spring ACS meeting in San Francisco, April 15, 1997.

Calendar

- ALCOM Annual Retreat, January 8-10, 1997, Sawmill Creek Resort
- S&T/SPIE Symposium on Electronic Imaging: Science & Technology San Jose, CA, February 8-14, 1997.
- European Conference on Liquid Crystals '97, Zakopane, Poland, March 3-8, 1997.
- American Chemical Society, San Francisco CA, April 13-17, 1997

Web Sites

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http://alcom.kent.edu/ALCOM/ALCOM.html
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Dept. of Macromolecular Science, CWRU
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Polymer Science, University of Akron
http://www.polymer.uakron.edu/
On-Line Polymer Liquid Crystal Tutorial
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