ALCOM Update

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

VOL. 9, NO. 1 APRIL 1999

ALCOM scientists collaborate with small college to create new liquid crystalline compound

Last summer, the ALCOM Education Outreach program began a collaboration between members of the ALCOM Center and a chemistry professor from Wheaton College. The collaboration has resulted in new liquid crystalline compounds which may be useful for cholesteric displays or optical beamsteerers. The new compounds will be mixed with known compounds to create a mixture having better properties.

The collaboration began with a phone call to the ALCOM Center from Prof. George Lorenzo at Wheaton College in Illinois. He was in search of a way to rekindle his research in liquid crystal chemistry which began almost thirty years ago when he was a postdoctoral fellow. Many small colleges such as Wheaton are not strongly oriented toward research and typically do not have all the resources needed to complete the entire process of design, synthesis and characterization of liquid crystalline compounds.

The ALCOM Center provided financial suppport for a Wheaton College student majoring in chemistry to spend eight weeks during the summer working with Prof. Lorenzo to synthesize several new liquid crystalline compounds. The Center will also provide support for the design, synthesis and characterization of these compounds.

Dr. Mary Neubert (center) explains to student Dena Burrows how to remove a solvent from the product while Professors Petschek (left) and Lorenzo (right) watch.

Prof. Lorenzo collaborated with two ALCOM scientists, Dr. Mary E. Neubert (Kent State University) and Prof. Rolfe G. Petschek (Case Western Reserve University) to design a cyclopropyl modification of a diphenyl-diacetylene. Neubert and Petschek work closely together to make liquid crystals that have high optical birefringence and large dielectric anisotropy, properties that are desirable for certain liquid crystal displays and optical beam steerers. Dr. Petschek's expertise in theory and Dr. Neubert's expertise in structure property relationships helped guide Prof. Lorenzo in designing the compound's structure. They thought that the cyclopropyl group, whose chemistry is well known to Lorenzo, would increase the conjugation range and therefore the birefringence of a diacetylene compound. The cyclopropyl group is also of interest as it can be made chiral; a chiral synthesis could lead to a useful cholesteric dopant.

Prof. Lorenzo and his student, Dena Burrows, synthesized three new compounds all of which had nematic phases. The compounds were sent to the Liquid Crystal In-

Wheaton *continued on page 6*

ALCOM technology information on web

A fundamental mission of Kent State University is to enhance the quality of life through research and creative activity which may result in patentable inventions or copyrightable materials.

The primary mission of Kent's Office of Technology Transfer and Outreach Coordination (OTTOC) is to seek protection of the University's intellectual property and to make these results available to the public by actively seeking business partners, collaborators and licensees. A key to this mission is to seek ways to connect Kent with external groups and organizations through the outreach initiative, especially working with economic development organizations throughout Northeast Ohio.

As director of OTTOC, Greg Wilson works with the university community and

Technologies *continued on page 6*

In This Issue:

From the Director

by John L. West

ALCOM made a good start in 1999, extending our collaborations and developing new technologies while continuing to build on our strong foundation of basic and applied research. A quick glance at this newsletter reveals the extensive collaborations that are a hallmark of ALCOM and our success.

The most recent ALCOM symposium, *Chiral Materials and Applications*, was co-sponsored by the Japanese Liquid Crystal Society and attracted speakers from around the world. ALCOM principal investigator, Chuck Gartland, will co-chair the International Congress on Industrial and Applied Mathematics mini-symposium, *Applications of Mathematical Models of Liquid Crystals*, to be held in Scotland in June.

Our long collaboration with the University of the Philippines and new collaboration with Wheaton College are fine examples of how ALCOM helps to educate students around the nation and the world and how this outreach supports our research programs. The collaborative grant with Finotello, Crawford and Zumer expands well established relationships to enhance our research into alignment and heterogeneous systems. These are but a few examples of ALCOM's extensive collaborations.

The new technologies featured in this newsletter demonstrate the application of ALCOM research. Satyen Kumar's recent announcement of phase separated composite films adds to ALCOM's well established reputation in developing new combinations of polymers. Peter Palffy-Muhoray and colleagues demonstrated lasing in cholesteric materials. Both of these technologies open up exciting new areas of basic and applied research and offer many potential applications.

A quick glance at the research notes and ALCOM publications listed in this newsletter shows the breadth and continued strength of ALCOM research. It has been a good start to what I fully expect to be a great year. We will continue to build on the strong foundation required for ALCOM's continued success in the next decade.

Publication on new ALCOM technique generates interest on web and in print media

Kent State University physics professor, Satyendra Kumar, has been receiving a lot of attention lately because of an article he and Dr. Valery Vorflusev published in *Science* magazine.

A team of three Kent scientists, Kumar, Vorflusev, and Jae-Hoon Kim, has developed a new technique for making liquid crystal display screens with a much thinner film of liquid crystal. The technology, named phase separated composite films (PSCOF), promises to simplify the fabrication of high-end displays with lighter weight, improved performance, and lower cost.

The article has generated several print media and on-line reviews such as those in the *Los Angeles Times Science Watch*, Academic Press *Daily in*Sci*ght* and *Microelectronics Technology Alert*.

The team has produced a very flexible display only slightly thicker than a piece of paper. With this technology it now appears possible to fabricate a new generation of high-information content displays for operation at flicker- and distortion-free high speeds that will be used in computer displays and high-definition television.

"Lightweight and flexible thin displays finally may become a reality with the use of this technology," Kumar said. The PSCOF technology has demonstrated the capability to produce microstructures such as one- and two-dimensional gratings as well as microlens arrays.

The article, "Phase-Separated Composite Films for Liquid Crystal Displays," *Science* **283**, March 1999, can be downloaded in portable document format (pdf) from Prof. Kumar's website: http://xray.kent.edu/~guest/ICCE/Science.pdf.

For more information, contact Prof. Kumar by telephone: (330) 672-2566 or e-mail: satyen@xray.kent.edu.

ALCOM

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J.E. Fulghum, E.C. Gartland,
J.R. Kelly, S. Kumar, O.D. Lavrentovich,
M.E. Neubert, P. Palffy-Muhoray, S. Sprunt,
R.J. Twieg, J.L. West, D.K. Yang

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Chiral materials and applications topic of recent ALCOM/JLCS symposium

The ALCOM Center held its eleventh symposium, *Chiral Materials and Applications*, February 18-19, 1999. The meeting marked the second time ALCOM has joined with the Japanese Liquid Crystal Society to hold a symposium.

The first meeting was held in Tokyo, Japan, November 1997. Two ALCOM scientists, Jack R. Kelly and Oleg D. Lavrentovich, traveled to Tokyo to participate. Dr. Nobuyuki Kobayashi represented the Japanese Liquid Crystal Society at the February meeting.

The symposium was co-chaired by ALCOM scientists Dr. Robert J. Twieg and Dr. John L. West, both from Kent State University.

The one and one-half day symposium included sessions on materials, nonlinear optics, and applications. Fifteen oral presentations were made by invited speakers and ALCOM researchers.

Guest speakers were scientists representing six countries:

• **John W. Goodby**, University of Hull, England, *Chirality at the Extremes in Liquid Crystals*

• **Mark M. Green**, Polytech Institute of New York, USA, *The Amplification of Chirality and Other Studies in Chiral Synthetic Polymers Lead to New Points of View and New Materials*

• **Nobuyuki Kobayashi**, Minolta Co., Japan, *Reflective Color Cholesteric LCDs: The Relationship Between Chemical Structures of LC Materials and Characteristics of LCDs*

• **Robert P. Lemieux**, Queens University, Canada, *Induction of a Ferroelectric Smectic C* Liquid Crystal Phase Using Atropiso-meric Dopants*

• **Andre Persoons**, University of Leuven, Belgium, *Nonlinear Optics, Chirality, Supramolecular Organization: A World of Twisted Symmetries*

• **Slobodan Zumer,** University of Ljubljana, Slovenia, *Instability of Double Twisted Helix in a Banana-Shaped Liquid Crystal and Isoregic Chiral Smectic C Polyester*

A poster session was held during which 41 presentations were made on ALCOM research. A complete list of poster presentations can be found on the ALCOM website: http://alcom.kent.edu/ALCOM/symposia.html.

The meeting concluded with a forum on chiral materials and applications. The panel, comprised of the invited speakers, answered questions from the audience on the topic of chiral materials.

"The symposium demonstrated the effectiveness of international collaborations," according to Dr. West. "We brought some of the best scientists from around the world to speak and share their expertise in the area of chiral materials which complemented the research being conducted in the ALCOM Center," West added.

Dr. Nobuyuki Kobayashi, representing JLCS, speaks on reflective color cholesteric liquid crystal displays

Panel members (l-r) A. Persoons, R. Lemieux, M. Green, and J. Goodby listen to a question from the audience.

Doctoral student, Ruiquing Ma (center) explains his research to speaker Slobodan Zumer (right) during the poster session.

ALCOM research part of mini-symposium to be held in Scotland

ALCOM scientist and Kent State University Professor Eugene C. Gartland, Jr., is co-chair of a mini-symposium, *Applications of Mathematical Models of Liquid Crystals*, to be held during ICIAM '99. The mini-symposium is co-chaired with Professor Frank Leslie, University of Strathclyde, Scotland.

The International Congress on Industrial and Applied Mathematics (ICIAM) conference will be held July 5-9, 1999, in Edinburgh, Scotland.

The mini-symposium talks will focus on the diversity of behavior that anisotropic liquids exhibit with special emphasis on aspects of interest for display applications.

For details on the mini-symposium, contact Prof. Gartland at (330) 672-4004 ext. 362 or gartland@mcs.kent.edu.

The conference web site can be found at www.ma.hw.ac.uk/iciam99/.

New Philippines liquid crystals lab linked to collaborations with ALCOM

The history of liquid crystal research in the Philippines began with a doctoral student's interest in the subject and resulted in a new liquid crystals laboratory under the direction of that same student, now a physicis professor at the National Institute of Physics (NIP) at the University of the Philippines.

In the early 1980's, Zenaida B. Domingo wanted to conduct doctoral research on liquid crystals. Weekly seminars were organized and materials obtained from various international sources, one of which was the Liquid Crystal Institute at Kent State University. That initial contact led to a scholarship to conduct her doctoral research at the LCI.

During Domingo's three years of research and collaboration at the LCI, the possibility of starting a liquid crystals lab gained momentum. Her goal to expand liquid crystal research in the Philippines focused on starting a new research laboratory.

Dena Agra and Larry Manuel are currently conducting their doctoral research at Kent State University's Physics Department and Liquid Crystal Institute.

The laboratory was dedicated February, 1998. In special recognition of the LCI's influence, Dr. Domingo invited Mrs. Jesse Brown, widow of the LCI's founder, Dr. Glenn H. Brown, to visit the Philippines for the dedication.

From a handful of students during its conception, the laboratory now boasts a roster of 6 graduate students, 18 undergraduate students and 9 alumni who have chosen to pursue careers in industry or further studies abroad.

The Liquid Crystals Lab at NIP became interdisciplinary with the addition of Dr. Leonorina G. Cada. She provides expertise in the chemical aspects of liquid crystals.

The group's long-term goal is to improve their country's research and development capabilities in liquid crystals. In pursuit of that goal, scientists research a variety of topics such as liquid crystal polymer synthesis, formulations and polymer dispersed liquid crystals, optical characterization, biological applications and lyotropic liquid crystals.

The laboratory also offers services such as consulting, sample analysis, contract research, training, and lectures to companies, academic and research institutions.

True to its legacy of maintaining international collaborations, the lab continues to interact with Kent State University and the ALCOM Center. Dr. Domingo has returned several times to interact with ALCOM scientists and she has invited ALCOM scientists to visit the lab and give seminars on their research.

Currently, two doctoral students from the Philippines are conducting research at Kent State University. Larry Manuel arrived at the Liquid Crystal Institute in March, 1998, to research ferroelectric liquid crystals. He is studying under the guidance of ALCOM scientist and Chemical Physics Professor L.-C. Chien.

"Conducting my doctoral research at the LCI has been very beneficial," Manuel said. "It has enabled me to learn and use equipment not available in the Philippines."

Ms. Dena Mae Agra is currently studying under the guidance of Prof. Satyendra Kumar, who is an ALCOM principal investigator and physics professor. Kumar visited the Philippines last year to teach a month-long liquid crystals course. While there he advised undergraduate and graduate students on research and identified possible areas of collaborative research.

"Dr. Kumar encouraged me to come to Kent for my doctoral research because I could obtain specialized training not available elsewhere," Ms. Agra said. She is conducting x-ray reflectivity and optical measurements on LC alignment layers.

The Philippines Liquid Crystals Lab website is http://nip.upd.edu.ph/lcg.

Synthesis and Characterization of Polar Ultra-thin Langmuir Blodgett films for Nonlinear Optical Applications

T. Srikhhirin, A.B. Phillips, O. Ostroverkhova, K.D. Singer, P.L. Taylor, J.A. Mann, Jr., D.E. Schuele, and J.B. Lando, Physics, Chemical Engineering, and Macromolecular Science Department, Case Western Reserve University

1) Synthesis of Side Chain Liquid Crystalline Copolymers and Characterization of their Polar Structure

A series of side chain liquid crystalline copolymers having a different spacer length, copolymer composition, and chromophore type were synthesized and characterized both in the bulk and at the gas-water interface. The liquid crystalline properties were identified by differential scanning calorimetry (DSC), optical microscopy, and X-ray diffraction (XRD). Copolymers with spacer lengths of 4, 5, 10, and 11 show smectic A (S_A) phases with a bâtonnet texture. The liquid crystalline (LC) phase is stabilized as the spacer is increased. Copolymers with different copolymer compositions were investigated both as monolayers and transferred films.

2) Application of Dielectric Relaxation Spectroscopy to Ultra-Thin Langmuir Blodgett Films

The dynamics of ultrathin Langmuir-Blodgett (LB) films were studied by dielectric relaxation spectroscopy (DRS). The technique is sensitive to detecting the relaxation and transition of the multilayers. The activation energy (E_a) and dielectric strength ($\Delta\varepsilon$) of β-relaxation of the copolymer with different spacers, copolymer composition, and chromophore were shown. A copolymer with a shorter spacer behaves similar to the long spacer at high frequency. The nitrobiphenyl (NBP) acts as a plasticizer to the multilayer which was observed as a reduction of the activation energy. The nature of an anomalous peak was shown. The modification of the NBP with the nitrostilbene (NSB) and methoxy ethoxy methoxy biphenyl (MEMBP) with methoxy biphenyl (OMe) results in a change in the relaxation spectra which is related to the difference in the packing of the multilayer films.

Research Notes, *continued on page 5*

Scientists from U.S. and Slovenia collaborate in research on liquid crystal films

Scientists from three different universities half a world apart were recently awarded a National Science Foundation international grant to study orientational phenomena in homeotropic liquid crystal films.

The three scientists are ALCOM principal investigator Daniele Finotello (Kent State University, Physics Department), Gregory Crawford (Brown University, Division of Engineering and a KSU Ph.D. graduate), and Slobodan Zumer (University of Ljubljana, Physics Department).

Collaborations between Kent State University and the University of Ljubljana, Slovenia, date back to the early 1970's. Dr. Crawford began research with Dr. Zumer in 1987 when Crawford was a doctoral student. All three physicists have collaborated since 1991 when Prof. Zumer spent a sabbatical year at the Liquid Crystal Institute.

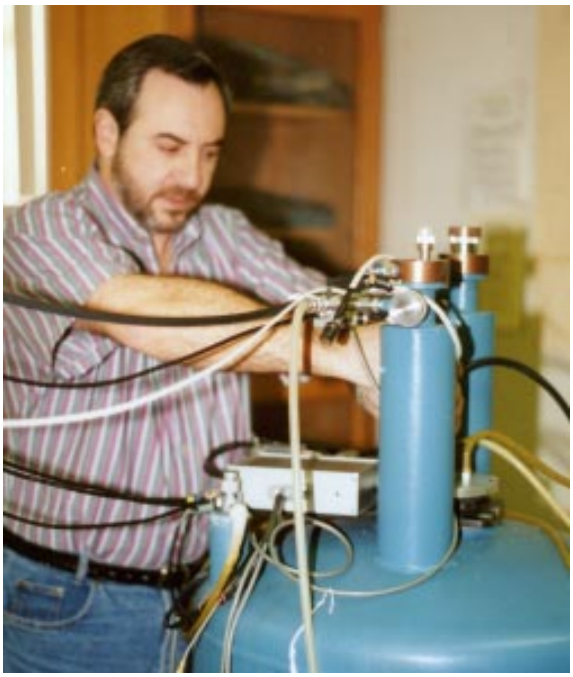
"That work produced many important publications in the area of confined liquid crystals and our collaboration has continued ever since," according to Prof. Finotello. "This grant essentially ensures our continuing work on a higher and more formal level."

The three-year project in solid state chemistry will advance scientific knowledge by enabling experts in the United States and Central Europe to combine complementary talents and share research resources in areas of strong mutual interest and competence.

The grant examines homeotropically-aligned liquid crystals in micropores and thin films. Some of its objectives are to explore the fundamental physical chemical properties behind self assembled layers on surfaces for liquid crystal alignment and to establish ways in which the aligning layers can be modified and manipulated to influence the liquid crystal alignment directions.

The scientists are investigating the surface induced ordering for configurations with homeotropic boundary conditions by using nuclear magnetic resonance techniques to probe alignment layers and the liquid crystal. This will permit direct investigation of the ordering of the alignment layer in both nematic and isotropic phases.

The researchers selectively deuterate molecules useful in alignment layers and attach them to the walls of porous membranes possessing the appropriate surface-to-volume ratio for nuclear magnetic resonance experiments. Additional microcalorimetry and optical techniques will complement the NMR studies.



Prof. Finotello tunes the NMR probe to increase its sensitivity to the confined film's behavior.

"Our focus is to understand the physics of the alignment layer itself, using direct experimental probes, with the underlying goal to systematically control homeotropic alignment for a host of new devices that rely on this type of anchoring. New types of display configurations that utilize homeotropic anchoring are easier to process and do not require the archaic rubbing process," according to Dr. Crawford.

The results should improve the fundamental understanding of ordering in these systems and may be applicable in novel flat liquid crystal display devices.

3) Functionalized Diacetylenes for Nonlinear Optical Applications: Synthesis, Characterization and the Properties of their Monolayers

Synthesis and characterization of DA(8/1)OMe (14-{4'-((methoxy)methoxy) biphenyl}-10,12-tetradecadiynoic acid and DA(8/1)NBP (14-{4' -((nitro) methoxy) biphenyl}-10,12-tetradecadiynoic acid are presented. Monolayers of DA(8/1)OMe at the gas-water interface were investigated. It does not form a stable monolayer nor does it undergo polymerization at the gas-water interface; however, the Ba^{2+} and Cd^{2+} salts form a polymerized stable monolayer. Polymerization was confirmed by Raman spectroscopy. The diacetylene analog with the more polar tail group, DA(8/1)NBP, does not form a monolayer and does undergo polymerization regardless of the subphase condition. A mixed monolayer of DA(8/1)OMe and DA(8/1)NBP forms a true monolayer if the composition of DA(8/1)NBP is 50% or less.

"Synthesis and Mesomorphic Properties of Some Asymmetrical Pyrimidinylphenyldiacetylenes," C.M. Hudson, R.A. Shenoy, M.E. Neubert, R.G. Petschek, *Liq. Cryst.* **26**, 241-250 (1999).

"Infrared and Dielectric Investigation of Curing in a Polymer Stabilized Liquid Crystal System," B. Wall, D. Schuele, J.L. Koenig, *Appl. Spectrosc.* **53**, 164-169 (1999).

"Optimizing the Performance of Fast FTIR Imaging," C. Snively, J.L. Koenig, *Appl. Spectrosc.* **53**, 170-177 (1999).

"Optimization of Stacks of Reflective Cholesteric Films for Full Color Displays," J.L. West, V. Bodnar, *ASID '99*, pp. 29-32 (1999).

"Infrared Spectroscopic Studies of the Mechanism of Orientation of Polarized UV-exposed Polyimide Films for Liquid Crystal Alignment," K. Ha, J.L. West, *Mol. Cryst. Liq. Cryst.* **323**, 129-143 (1998).

Publications, *continued on page 7*

Wheaton, *from page 1*

stitute at Kent State University for evaluation. The Wheaton team designed and carried out the synthesis which is the most time consuming part of creating a new compound. Many structural modifications are needed to find useful new liquid crystalline compounds. Through collaboration, the work is divided and the knowledge is multiplied.

"I am very impressed with their results and the amount of work that they accomplished," Dr. Neubert said. "This is a good opportunity to expose people in small colleges to liquid crystals and it also benefits us by having additional people making compounds that we don't have time to make," she added.

The Wheaton College team visited the Liquid Crystal Institute in March to see the facilities and talk to scientists and technicians. Burrows, Lorenzo, Neubert and Petschek also met to discuss results to date and what possible modifications of the current promising compounds would be of most interest.

While visiting, Burrows and Lorenzo were able to watch a purity analysis being conducted on their compounds by LCI technicians. Gas chromatography was used to determine how pure the compounds are. Characterization of compounds, consisting of determining the mesomorphic properties, enthalpy values, preliminary birefringence, and dielectric anisotropy is underway. Comparison of mesomorphic properties with those of similar compounds shows where additional modifications need to be made.

Dr. S.T. Wu, a scientist at Hughes Laboratories in California, will also be involved in the collaboration. Interesting compounds will be sent to Dr. Wu for evaluation of their usefulness in mixtures for use in devices.

"Dr. Neubert and her group have been very helpful with experimental information which has facilitated our progress greatly," said Prof. Lorenzo. "We didn't have to 'reinvent the wheel' as it were."

"I am gratified by this collaboration," said Petschek. "I am confident that these promising compounds would not have existed without all its members."

Dena Burrows explains the final step in the synthesis of the new compound to (l-r) Prof. Lorenzo, Prof. Petschek and Dr. Neubert.

Ms. Burrows will graduate in Spring 1999 and plans to begin a graduate degree in education.

"My work last summer gave me a better 'feel' and more natural understanding of organic chemistry and it strengthened my confidence in my lab technique," said Burrows. Her career goal is to teach high school chemistry. She will take into the classroom her knowledge of liquid crystal design and synthesis to share with her students. "I can give them an accurate description of what this type of research is like," she added.

Prof. Lorenzo plans to continue his liquid crystal research. "I value the association with members of LCI and ALCOM as an educational opportunity for me personally," said Lorenzo. "Beyond that it is helping to bring awareness to the Chemistry Department here about the field of liquid crystals which was little known before this."

The ALCOM Center has agreed to provide Summer 1999 funding for another undergraduate student. The Center will also cover the cost of some of the materials needed for the project.

Since the collaboration with Wheaton College was so successful, Dr. Neubert would like to see the collaborative program expanded to include several colleges. She sees the need for more students to understand how to design and synthesize materials. Industrial chemists knowledgeable in such syntheses are in short supply and the program would be an excellent way to introduce chemistry majors to the field of materials design and synthesis.

Technologies, *from page 1*

industries to create a bridge between the technology created at Kent and the industries which can transform the technology into applications that will affect our everyday lives.

"Coming from a corporate background into academia has given me unique insight into forging mutually beneficial public-private partnerships, moving Kent's technology from the lab to real life applications and promoting University alliances through outreach," Wilson said.

To further expand its information outreach, OTTC has established a site on the world wide web: **www.techtrans.kent.edu**. The site lists liquid crystal, biomedical, and software technologies including issued patents, patent applications, and invention disclosures. The site also includes confidentiality and sponsored research forms that can be viewed by interested parties and then downloaded to begin the collaborative agreement process.

Members of the ALCOM Industrial Partnership Program are given first refusal on any technology created through the Center. The technologies are then made available to the general public.

Each university in the ALCOM consortium, Kent, Case Western Reserve and the University of Akron, has offices to promote ALCOM and other university technologies.

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Lasing in cholesteric liquid crystals

Lasing in materials whose structure gives rise to distributed cavity effects was proposed some time ago. Cholesteric liquid crystals (CLC), with their periodic helical structure and selective reflection band are expected to exhibit strong distributed cavity effects.

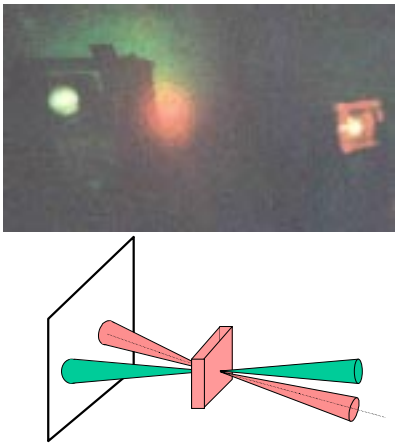
The possibility of lasing in CLC was proposed by Goldberg and Schnur [1] in1973, and experimental investigations have been carried out subsequently [2].

Lasing in dye doped CLC was unambiguously demonstrated for the first time during the past year by A. Genack, et al., at Queen's College at CUNY [3], and by B. Taheri, P. Palffy-Muhoray and KSU graduate student H. Kabir at the Liquid Crystal Institute (LCI) [4].

The LCI team's initial efforts focused on modification of the fluorescent spectrum of dyes dissolved in CLC by distributed cavity effects. The salient feature was the alteration of the emission spectrum and an enhancement of emission at the reflection band edges.

Mixtures of CLC and dyes were then studied in lasing experiments. Twenty micron-thick samples between glass slides were pumped by single 33ps pulses from a frequency doubled Q-switched and mode-locked NdYAG laser; low threshold lasing was observed in a variety of samples.

An interesting related topic concerns microcavity effects of cholesterics on the emissive properties of light emitting materials. Palffy-Muhoray's group plans to study the emissive properties of systems consisting of combined thin film organic light emitting materials and CLC. In addition to tailoring the emission spectrum and enhancing the efficiency, this could lead to realizing the first large area, flat, electrically driven all-organic laser. Such systems are expected to have a great potential in emissive display applications.



Far field pattern showing cholesteric laser spot (center) and schematic diagram. Note the diffraction rings.

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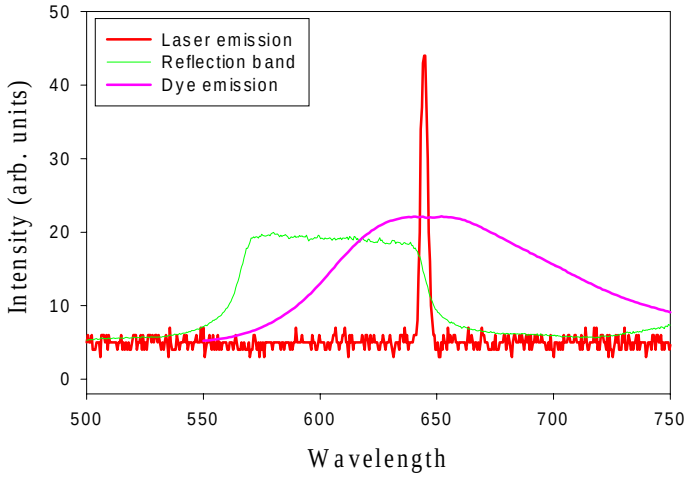
2. I.P. Il'chishin, E.A. Tikhonov, V.G. Tishchenko and M.T. Shpak, *JETP Lett.* **32**, 27 (1980).
3. V.I Kopp, B. Fan, H.K.M. Vithana and A.Z. Genack, *Opt.Lett.* **23**, 1709 (1998).
4. B. Taheri and P. Palffy-Muhoray (unpublished; presented at ALCOM Symposium on Chirality, Cuyahoga Falls, February 18, 1999).



Dye emission above lasing threshold. In addition to nonlinear gain and line narrowing, strong directional emission was observed.

"Phase-Separated Composite Films for Liquid Crystal Displays," V. Vorflusev, S. Kumar, *Science* **283** (1999).

"Instability of Radial Hedgehog Configurations in Nematic Liquid Crystals Under Landau-de Gennes Free-Energy Models," E.C. Gartland, Jr., S. Mkaddem, *Phys. Rev. E* **59**, 563-567 (1999).

"Multidimensional Director Modeling Using the Q Tensor Representation in a Liquid Crystal Cell and its Application to the Pi Cell with Patterned Electrodes," H. Mori, E.C. Gartland, Jr., J.R. Kelly, P.J. Bos, *Jpn. J. Appl Phys.* **38**, Part 1 No. 1A, 135-146 (1999).

"Photo- and Electroluminescence Studies of 2,5-bis[2'-(4"-(6-hexoxybenzyl))-1'-ethenyl]-3,4-dibutyl thiopenes," S. Blumstengel, I. Sokolik, R. Dorsinville, D. Voloshchenko, M. He, O. Lavrentovich, L.C. Chien, *Synth. Metals* **99**, 85-90 (1999).

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"Multidimensional Director Modeling Using the Q Tensor Representation in a Liquid crystal Cell and its Application to the p Cell with Patterned Electrodes," H. Mori, E.C. Gartland, Jr., J.R. Kelly, P.J. Bos, *Jpn. J. Appl. Phys.* **38**, 135-146 (1999).

" Modulated Structures with Field-Controlled Direction and Periodicity in SmC* Liquid Crystals," D. Subacius, D. Voloshchenko, P. Bos, O.D. Lavrentovich, *Liq. Cryst.* **26**, 295-298 (1999).

"Studies of Holographic Gratings Formed in Polymer-dispersed Liquid crystal Films and their Dynamical Behavior," A.Y.-G. Fuh, T-C. Ko, M-S. Tsai, C.-Y. Huang, L.-C. Chien, *Mol. Cryst. Liq. Cryst.* **321**, 365-381 (1998).

"Fast FT-IR Imaging: Theory and Applications," C.M. Snively, J.L. Koenig, *Spectrosp.* **13**, 22-28 (1998).

Conferences - ILCC 2000

Preliminary registration is underway for the 18th International Liquid Crystal Conference, *ILCC 2000*. The meeting will be held July 24-28, 2000, in Sendai, Japan.

Pre-registration (deadline Aug. 13 1999) may be made on the web at www.ecei.tohoku.ac.jp/~ilcc2000/. The second circular is due for distribution in late October. Deadline for submitting abstracts is February 15, 2000.

Inquiries should be directed to Prof. Tatsuo Uchida, Executive Chair, *ILCC 2000*; email: ilcc2000@ecei.tohoku.ac.jp.

Degrees

Sami Mkaddem, Ph.D. in Applied Mathematics, Kent State University, Dec. 1998, "Numerical Modeling of Confined Liquid Crystal Systems."

Christopher Snively, Ph.D. in Macromolecular Science and Engineering, Case Western Reserve University, Jan. 1999, "Fast FTIR Imaging of Complex Polymer Systems." Dr. Snively is a postdoctoral fellow at Purdue University.

Calendar

KSU Alumni dinner party during SID Conference, May 19 (Wednesday)
Contact Deng-Ke Yang during conference for information.

European Conference on LCs 99
April 25-30, 1999 Crete, Greece
www.physics.upatras.gr/ecle99/

6th International Symposium on Metallomesogens (ISMM 99)
June 8-11, 1999 Rotenburg, Germany

7th International Conference on Ferroelectric Liquid Crystals (FLC 99)
Aug. 29-Sept. 3, 1999
Darmstadt, Germany

Web Sites

ALCOM Home Page
http://alcom.kent.edu/ALCOM/ALCOM.html

Liquid Crystal Institute, KSU
http://www.lci.kent.edu

Dept. Macromolecular Science, CWRU
http://k2.scl.cwru.edu/cse/emac/

Department of Physics, CWRU
http://erebus.phys.cwru.edu/phys/physdept.html

Polymer Science, University of Akron
http://www.polymer.uakron.edu/

On-Line Polymer Liquid Crystal Tutorial
http://plc.cwru.edu

Experiment at a Distance
http://olbers.kent.edu/alcomed/Experiment/eo.html

Optics of Cholesteric Liquid Crystals
http://alcom.kent.edu/~tik/choles.html

ALCOM Education Home Page
http://olbers.kent.edu/alcomed/k12.html

Edison Polymer Innovation Corporation
http://www.epicpoly.org

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