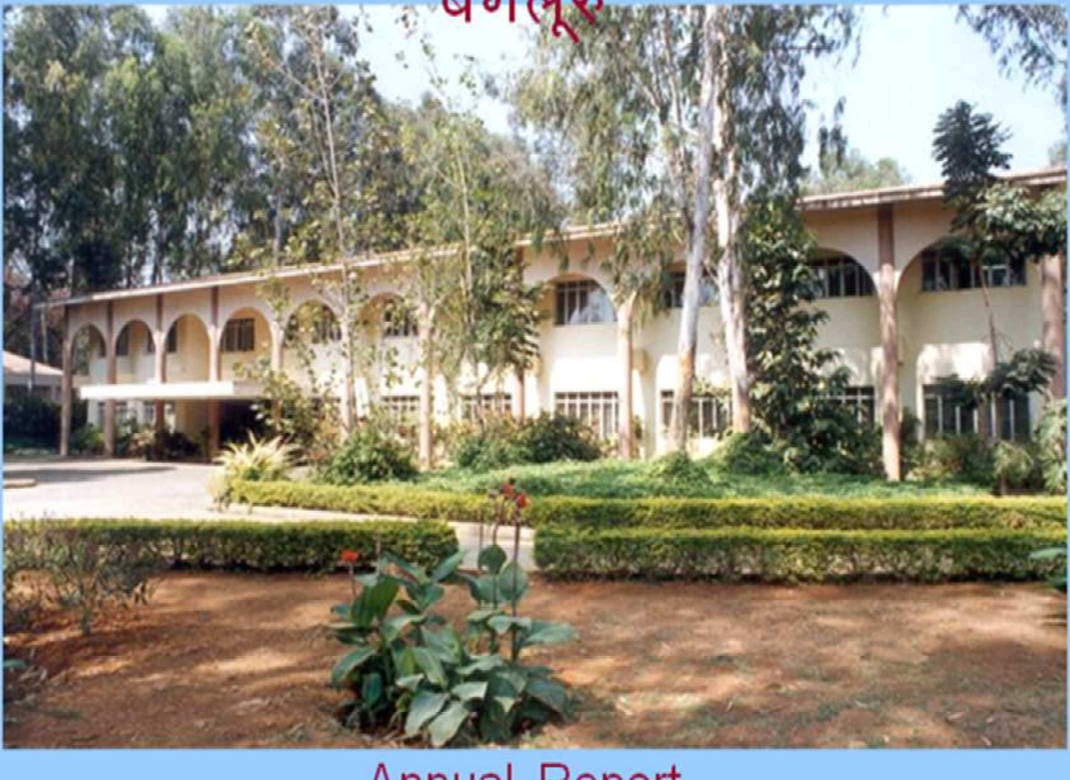
Centre for Liquid Crystal Research
(Centre for Soft Matter Research w.e.f. 01.09.2010)

Bengaluru

तरल क्रिस्ट्ल अनुसंधान केंद्र
(01.09.2010 से मृदु पधार्थ अनुसंधान केंद्र)

बेंगलूरु



Annual Report

2009 - 2010

वार्षिक रिपोर्ट

२००९ - २०१०

COMPOSITION OF GOVERNING COUNCIL (2009-2010)

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Prof. K. A. Suresh **Member-Secretary**
Centre for Liquid Crystal Research
P.B.No.1329, Jalahalli
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FOREWORD

The Centre for Liquid Crystal Research (CLCR) was registered in the year 1991 as a Scientific Society under the Karnataka Societies Act. In the year 2003, the Centre was taken over by the Department of Science and Technology (DST), Government of India. The Centre focuses on basic science with a bias towards technology, conducting research, training students for Ph.D. programme and popularizing science.

This Annual Report for the year 2009-2010, highlights some of the research and development and academic programmes of the Centre. It lists the scientific output of the Centre, academic activities and scientific publications for the period 1 April 2009 -- 31 March 2010.

In a significant development, the Centre has been renamed as "Centre for Soft Matter Research (CSMR)". This was on the following recommendation made by the Research Advisory Board (RAB) of the Centre, in its meeting held on 6.2.2008 :

" i) CLCR may diversify its research programmes into Soft Matter Research – an interdisciplinary area consisting of physics, chemistry, biology and material science, but retaining the emphasis on liquid crystals and other ordered systems.

ii) Steps may be taken to develop the Centre as a true Centre for Soft Matter Research in the country.

The name, Centre for Liquid Crystal Research, is specialized to a relatively “mature” field. Taking into account the current international trend in research and the recommendation of the RAB to expand the scope of the Centre’s programmes, the name of the Centre may be changed to Centre for Soft Matter Research (CSMR) from the present Centre for Liquid Crystal Research (CLCR). This will significantly help attract more candidates for faculty from a wider scientific background, and also attract motivated students interested in the interdisciplinary subject of soft matter."

The recommendation of RAB was approved by the Governing Council of the Centre, General Body of the Society, Department of Science and Technology, Government of India and finally the amendment was registered by the Registrar of Societies, Government of Karnataka on 28.4.2010.

The new name "Centre for Soft Matter Research (CSMR)" has come into effect from 1 September 2010.

Bangalore K. A. SURESH / PRAVEER ASTHANA

1. INTRODUCTION

The Centre for Liquid Crystal Research (CLCR) was functioning as a Scientific Society registered under the Karnataka Societies Act. It was funded by an ad-hoc grant from the Department of Science and Technology, Government of India, project grants from SERC and from the funds made available by the Raman Research Institute Trust. The Centre was taken over in 1995 by the Govt. of India, and converted to an autonomous institution under the administrative control of the Department of Information Technology. In the year 2003, the Centre was brought under the administrative control of the Department of Science and Technology (DST), Ministry of Science and Technology. DST has been providing core support to the Centre in the form of a grant-in-aid for conducting basic and applied research in liquid crystals and related areas. The objective of the Centre is to focus on basic science, and to develop a bias towards technology, in line with the international trends on liquid crystal materials and other soft matter. The Centre is renamed as "Centre for Soft Matter Research" with effect from 1 September 2010.

The Centre is engaged in research and development on a variety of liquid crystal materials and other soft materials like gels and polymers. This is the only centre in the country devoted to research and development in liquid crystals and other soft matter.

The Centre has also entered into an MOU to provide technical advice and characterization services to Bharat Electronics Ltd., a premier industrial organization under the Ministry of Defence.

2. CORE FUNDED PROJECT

The Department of Information Technology, Govt. of India, in its proposal submitted to the Planning Commission provided for CLCR, an outlay of Rs.12.88 crores for the 10th plan period. The grants were received by CLCR from the Department of Information & Technology up to the financial year 2002-03. In 2003, the Centre came under the administrative control of the Department of Science & Technology, Ministry of Science & Technology. From 2004 onwards, the grants were received by CLCR from the Department of Science & Technology. Year wise break up of outlay proposed as per the 11th Plan document, and approved is given in the table.

(Rs. in Lakhs)

Eleventh Plan Outlay	2007-08	2008-09	2009-10	2010-11	2011-12	Total
Proposed & approved Outlay	284.00 (FE 84.00)	415.00 (FE 179.00)	373.00 (FE 111.00)	442.00 (FE 151.00)	586.00 (FE 262.00)	2100.00 (FE 797.00)

During the year 2009-10, a grant of Rs.330 lakhs has been released by DST.

3. RESERVATION AND OFFICIAL LANGUAGE

The Centre follows the national policy on reservation and official language as per rules and orders issued by the Government of India from time to time.

Centre has 1 SC/ST employee working under Group C.

The Centre has observed Hindi Day on 14 September 2009. On this occasion, a talk by Shri Sanjay K.Varshney and a documentary in Hindi have been arranged.

Shri Prem Singh, Joint Director, Hindi Cell, DST, visited the Centre on 20 July 2009 and on this occasion, a talk on Hindi was organized by the Centre.

To popularize Hindi at CLCR, everyday a scientific word is shown on the notice board under "आज का शब्द".

4. RESEARCH ADVISORY BOARD

A Research Advisory Board was formed to advice on the research activities being carried out at the Centre.

1.	Prof. N. Kumar Raman Research Institute	Chairman
2.	Prof. Chandan Das Gupta Indian Institute of Science	Member
3.	Prof. S. Ramakrishnan Indian Institute of Science	Member
4.	Prof. Namita Surolia Jawaharlal Nehru Centre for Advanced Scientific Research	Member
5.	Prof. G. U. Kulkarni Jawaharlal Nehru Centre for Advanced Scientific Research	Member
6.	Dr. A. T. Kalghatgi Central Research Laboratory, Bharat Electronics Limited	Member
7.	Prof. K. A. Suresh Centre for Liquid Crystal Research	Convener

The Committee met on 16 June 2009. On this occasion an In-house meeting was also conducted and the following talks were given.

Collective precession of chiral molecules driven by water evaporation	K. A. Suresh
Fast responding robust nematic liquid crystal gels: Electro-optic and rheological studies	Geetha G. Nair

Unusual dielectric and electrical switching behavior in the de Vries smectic A phase	D. S. Shankar Rao
Discotic tris(N-salicylideneaniline)s with fluorophores: Synthesis and characterization	C.V.Yelamaggad
Molecular architectures conducive to form thermotropic biaxial nematic mesophase	Veena Prasad
Electric-field-assisted fast recovery of the nematic phase from its photo-stimulated state	S. Krishna Prasad
Shear deformation and division of cylindrical walls in free-standing nematic films under high electric fields	K. S. Krishnamurthy

5. FINANCE COMMITTEE

The second meeting of the Finance Committee with the following members was held on 6 August 2009.

1.	Joint Secretary & Financial Advisor, DST	Chairman
2.	Director, CLCR	Member
3.	Prof. K. V. Ramanathan, Indian Institute of Science, Bangalore	Member
4.	Dr. T. G. Ramesh, National Aerospace Laboratories, Bangalore	Member
5.	Administrative Officer, CLCR	Invitee

6. RESEARCH AND DEVELOPMENTAL ACTIVITIES

6.1 KINETICS OF TRANS-CIS ISOMERIZATION IN AZOBENZENE DIMERS AT AN AIR-WATER INTERFACE

We have studied the kinetics of *trans* to *cis* isomerization under the illumination of ultraviolet light, in the Langmuir monolayer of mesogenic azobenzene dimer, bis-[5-(4'-n-dodecyloxy benzoyloxy)-2-(4''-methylphenylazo)phenyl] adipate, at an air-water interface. We find that the *trans* to *cis* isomerization reaction of the molecules in the monolayer shows deviation from the first-order kinetics unlike those reported on Langmuir monolayers of azobenzene molecules. We attribute the deviation from first-order kinetics to the simultaneous photoisomerization of *trans* isomers to form *cis* isomers and the reverse thermal isomerization of *cis* isomers to form *trans* isomers. Our analysis of the rate of change of mole fraction of *trans* isomers to form *cis* isomers indicates a first-order kinetics for *trans* to *cis* photoisomerization reaction and a second-order kinetics for *cis* to *trans* thermal isomerization reaction. This second-order kinetics mechanism is similar to the Lindemann-Hinshelwood mechanism for the unimolecular reactions at low concentration of reactants. The formation of the activated *cis* isomer by collisions is a slow process as compared to the decay of the activated *cis* isomer to *trans* isomer in the liquid expanded phase. This results in the second-order kinetics for the thermal isomerization of *cis* isomers.

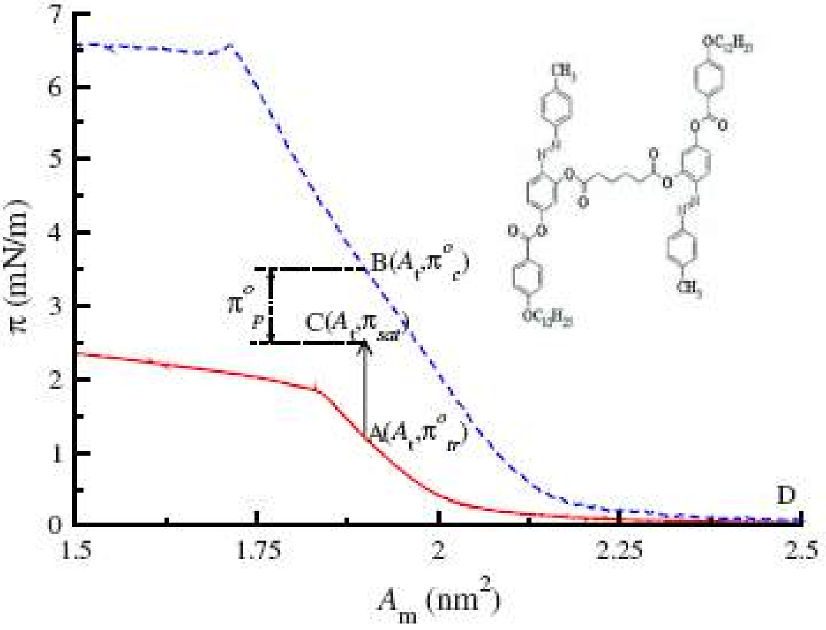


Figure: Surface pressure (π) vs area per molecule (A_m) isotherms of the *trans*-12D1H monolayer (continuous line) and *cis*-12D1H monolayer (dashed line). For the kinetic studies of the *trans* to *cis* isomerization, the *trans*-12D1H monolayer was illuminated with uv light (365 nm) at a target area per molecule, A_t [point $A(A_t, \pi^o_{tr})$]. This results in the increase of surface pressure of the monolayer with time and saturates to a value of π_{sat} [point $C(A_t,\pi_{sat})$]. Molecular structure of 12D1H is shown at top right of the figure.

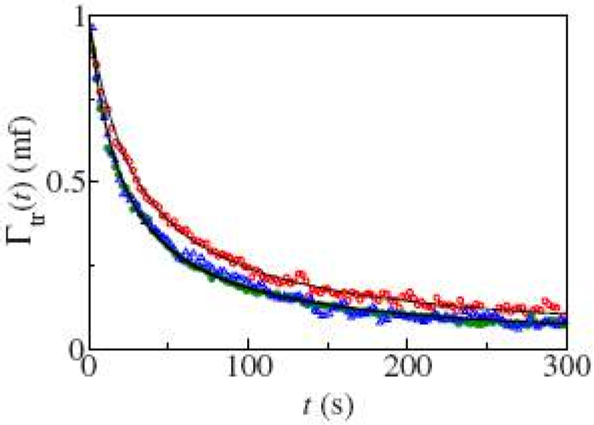


Figure: Calculated mole fraction (mf) of *trans* isomer [Γ_{tr}(t)] plotted as a function of time (t) in seconds for three different values of A_t: (i) 1.87 nm^2 (open circles), (ii) 1.92 nm^2 (filled circles), and (iii) 1.96 nm^2 (open triangles). Solid lines are computed using Eq. (9) to fit the data.

Investigator: K.A. Suresh
Collaborators: Bharat Kumar, Raman Research Institute, Sadashivanagar, Bangalore

6.2 NOVEL MESOGENIC AZOBENZENE DIMER AT AIR-WATER AND AIR-SOLID INTERFACES

We have studied the monolayer film properties of a novel mesogenic azobenzene molecule at air-water interface (Langmuir film) and air-solid interface (Langmuir-Blodgett film). The material, H-shaped dimer bis[5-(4′-*n*-dodecyloxy benzoyloxy)-2-(4″-methylphenylazo)phenyl] adipate (12D1H) exhibits a smectic C phase between 51 and 48 °C on cooling. Surface manometry studies showed the formation of a stable monolayer at the air-water interface. Brewster angle microscopy (BAM) showed that liquid domains coexisting with the gas region at large area transformed to a uniform liquid phase with increasing surface density and finally to a collapsed state. We have carried out atomic force microscope (AFM) studies on Langmuir-Blodgett (LB) films transferred onto freshly cleaved hydrophilic mica substrate. The AFM images showed domains of height of about 3.8 nm, which corresponds to

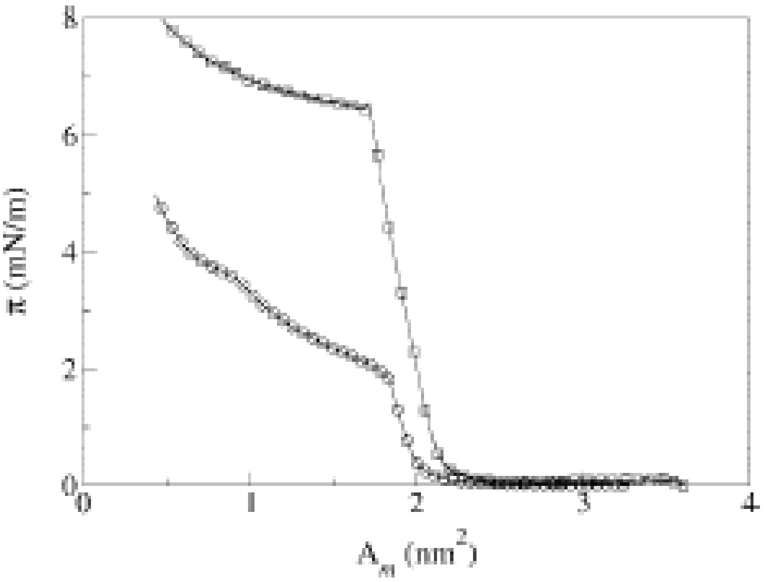


Figure : Surface pressure (π) - area per molecule (Am) isotherm for the monolayer in dark (curve with circles) and for the monolayer in the presence of UV light of wavelength 365 nm (curve with squares).

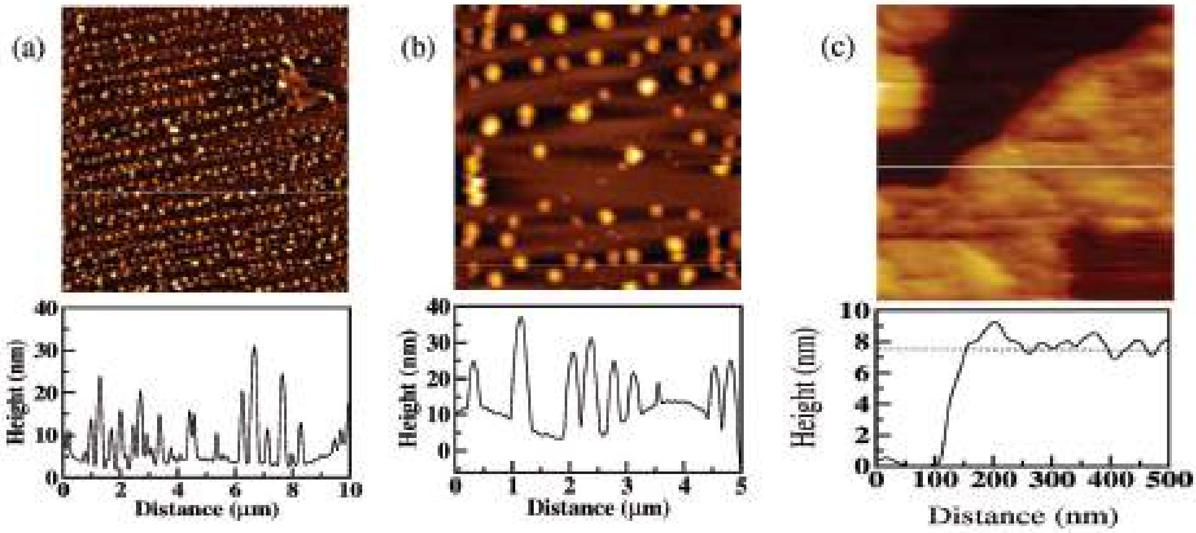


Figure : AFM images of 12D1H transferred at 1.0 mN/m onto hydrophobic silicon substrate. (a) 10μm scan range image showing the coexistence of droplets of uniform size and a bilayer domain (top right). (b) 5 μm scan range image showing droplets of about 100 nm size with height distribution of 10 to 50 nm. (c) 500 nm scan range image showing bilayer film with a height of 7.6 nm.

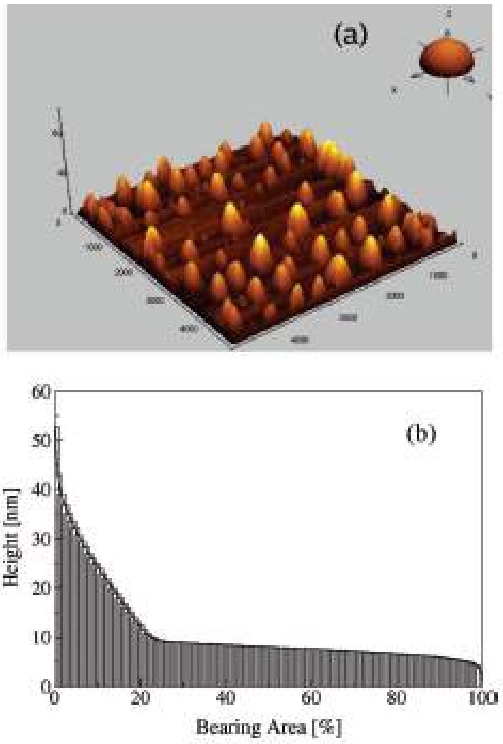


Figure : (a) 3D view of AFM image of small droplets on hydrophobic silicon substrate (*X*, *Y*, and *Z* scales are in nm). (b) Abbot curve showing the surface height as a function of percentage bearing area.

the estimated height of the molecule confirming the formation of monomolecular film. On a hydrophobic silicon substrate, the LB transfer yields a bilayer film, which dewets to form uniform nanodroplets of diameter of about 100 nm and height in the range 10-50 nm. Our analysis indicated that the mechanism involved in the formation of nanodroplets can be attributed to spinodal dewetting. The 12D1H molecule containing an azobenzene group undergoes a trans to cis transformation in the presence of ultraviolet light. Our surface manometry studies showed that the monolayer in the presence of ultraviolet light was more stable with a collapse pressure three times that of the monolayer in the dark.

Investigator: K.A. Suresh
Collaborators: Bharat Kumar, Raman Research Institute, Sadashivanagar, Bangalore
A.K.Prajapati and M.C.Varia, The M.S.University of Baroda, Baroda

6.3 ELECTRIC-FIELD DICTATED PHASE DIAGRAM AND ACCELERATED DYNAMICS OF A REENTRANT NEMATIC LIQUID CRYSTAL UNDER PHOTO-STIMULATION CONDITIONS

In a system consisting of photoactive molecules that exhibit light-driven isomerization transformations, actinic light can diminish or enhance ordering in the medium to the extent that phase transitions from the equilibrium phase to a more ordered/disordered one can be brought about isothermally. This ability of light while enabling it to be used like a thermodynamic-like parameter to investigate phase behaviour of matter, adds a new dimension to the studies owing to the non-equilibrium character of the isothermal transitions. We have carried out experiments which exploit the combination of two recent findings, namely, an applied electric field can accelerate the return to the nematic liquid crystalline phase from a photo-driven isotropic phase, and in a reentrant mesogenic system the photo-induced phase can be more ordered. Unique temperature-electric field phase diagrams mapped out for

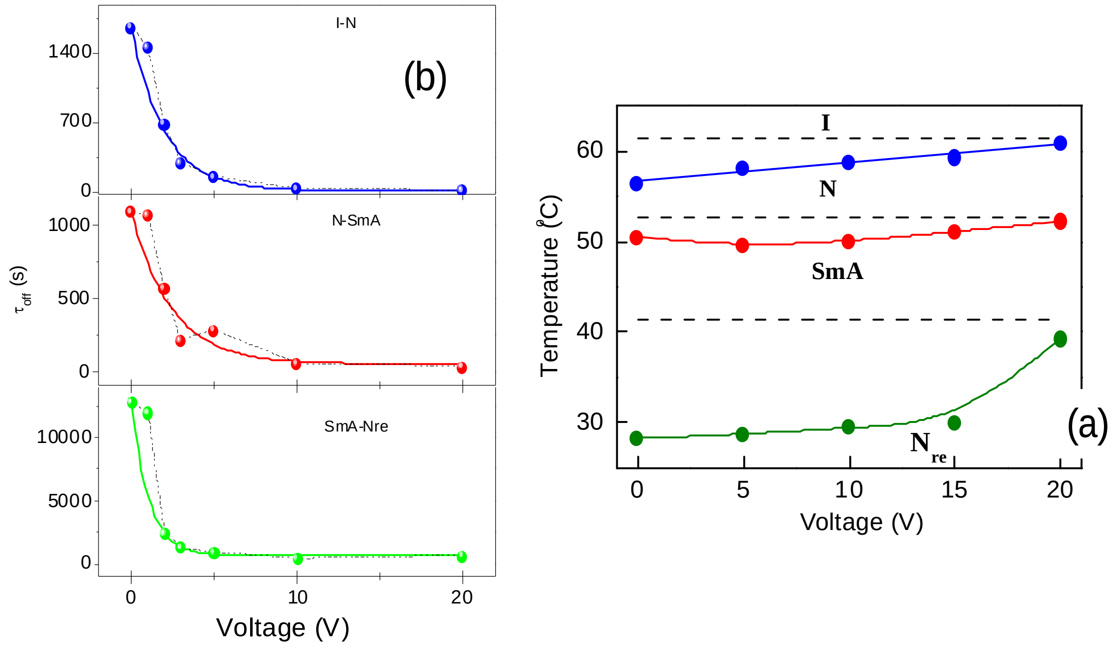


Figure 1: (a) Temperature-voltage phase diagram (b) Voltage dependence of the relaxation time, displaying a strong influence by the electric field.

a liquid crystal exhibiting isotropic-nematic-smectic A-reentrant nematic sequence reveal that the electric field influences all the transitions, but its effect is maximum on the equilibrium re-entrant nematic to the photo-induced smectic A transformation [Figure 1a]. Temporal measurements have been performed to study the dynamics of both the photochemical and back relaxation processes across the different transitions, under non-equilibrium conditions. The electric field is indeed observed to accelerate the thermal back relaxation in each case, and particularly the recovery of the re-entrant phase is hastened by three orders of magnitude in time [Figure 1b]. Possible causes for the acceleration are explored starting from the molecular mechanism involving photoinduced nanosegregation, especially in the case of the reentrant transformation [Figure 2]. This feature, which has been supported by a

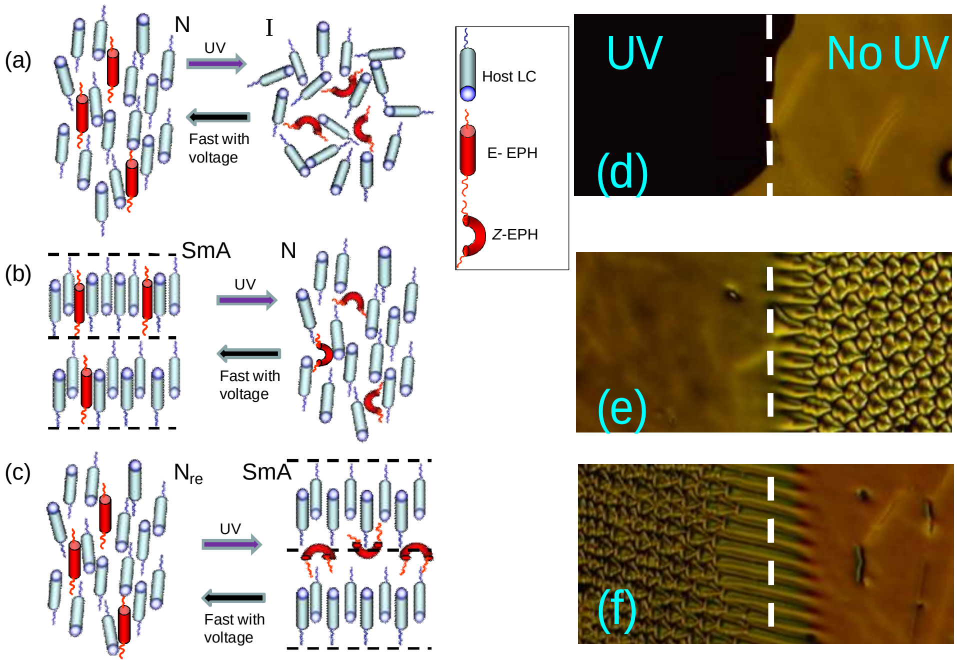


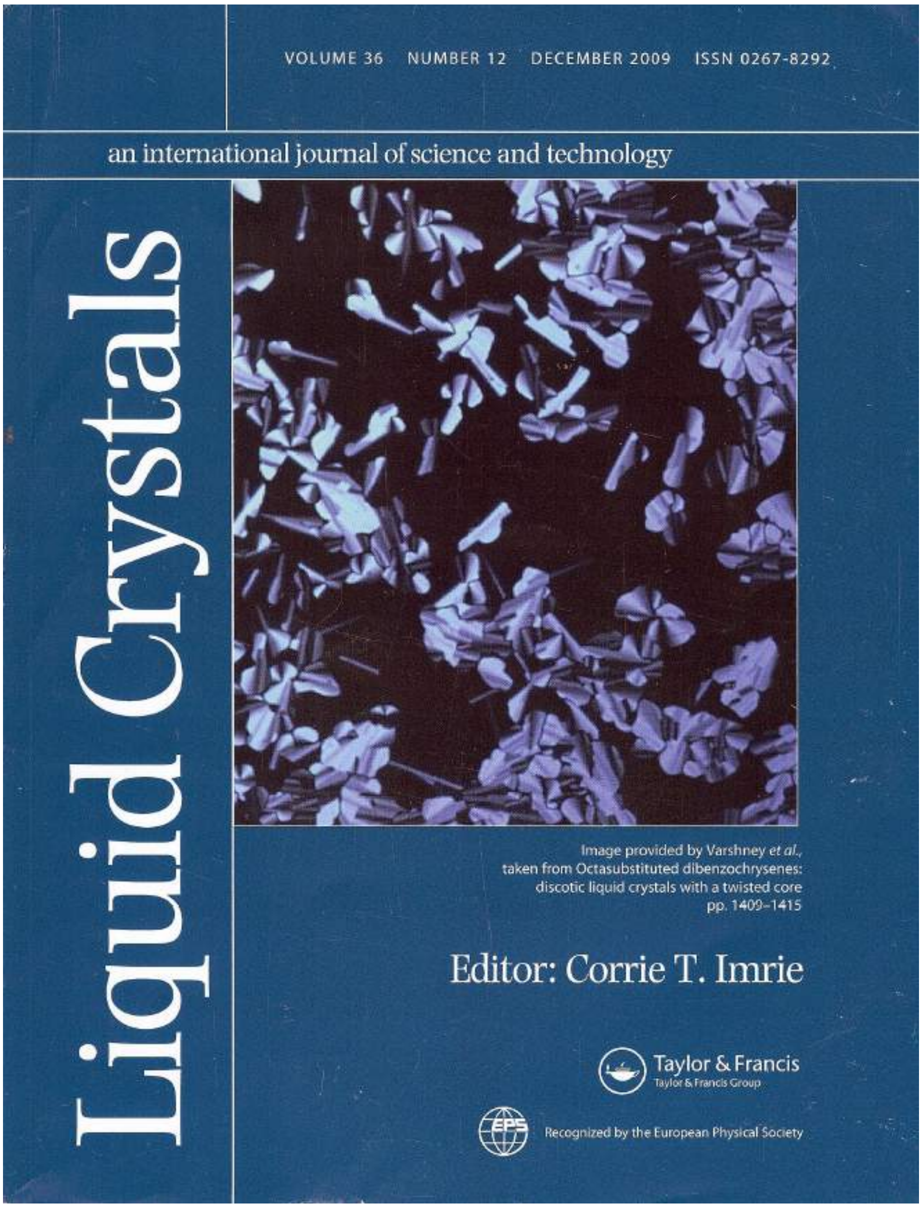
Figure 2: (a,b,c) Schematic representation of the molecular arrangements in the equilibrium (left panels) and photodriven (right panels) states. Notice especially the nanophase segregation in the photo-stimulated SmA phase (panel c). The microphotographs in (d), (e) and (f) exhibit the textural pattern in the non-masked (UV) and masked (No UV) regions corresponding to situations given in (a),(b) and (c).

molecular simulation investigation by the Boulder group, also provides an explanation for the slower response in such systems, in the absence of the electric field. The acceleration due to the electric field, is perhaps due to the lowering of the potential barrier between the *cis* and *trans* isomers by the application of the field. The larger influence of the electric field on the reentrant transition possibly suggests that subtle changes in the molecular environment stabilize/destabilize the reentrant phase. These features provide credence to our earlier observation that even extremely low magnitudes of the UV intensity (few micro watts/cm^2) can bring in a large change for the transformation involving the reentrant phase.

Investigators: S.Sridevi, S. Krishna Prasad and Geetha G.Nair

6.4 DISCOTIC LIQUID CRYSTALS WITH A TWISTED CORE

Our continuing interest in the design and synthesis of new discotics, which are of fundamental importance to organic material science, prompted the design and synthesis of octasubstituted dibenzochrysenes (DBCs). Thus, by following a conventional method, a series of chiral and achiral octasubstituted DBCs are prepared and their liquid crystalline properties are investigated by polarizing optical microscopy and X-ray diffraction studies. The achiral derivatives with long peripheral aliphatic chains exhibit hexagonal and rectangular columnar mesophases over a wide thermal range, whereas those with short chains exhibit only hexagonal or more ordered columnar phases. The chiral derivatives exhibit only the hexagonal columnar mesophase. The MM2 energy minimization of the DBC core shows a twisted structure.



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an international journal of science and technology

Liquid Crystals

Image provided by Varshney *et al.*,
taken from Octasubstituted dibenzochrysenes:
discotic liquid crystals with a twisted core
pp. 1409–1415

Editor: Corrie T. Imrie

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EPS Recognized by the European Physical Society

Cover page of the journal in which a texture of the study is published. (Published in December 2009).

Spontaneous deracemization is among the more important topics in chemistry. Deracemizaton can occur when racemic molecules are crystallized and even in liquid crystalline phases. However, a spontaneous deracemization has never been unambiguously demonstrated in discotic columnar phases consisting of nonchiral or racemic molecules. We have observed for the first time, the spontaneous deracemization (chiral resolution) of disc-like molecules in the columnar phase of one of the DBC compounds synthesized by us. Molecules appear to be flat, but not quite; they are slightly twisted. With the use of electronic and vibrational circular dichroism (ECD and VCD) spectroscopy we found that such racemic disc-like molecules with axial chirality macroscopically segregate into chiral domains. High magnitude ECD signals reveal the formation of chiral superstructures such as aggregated structures of chiral columns with the same handedness and superhelical structures of chiral columns.

Investigators: Sanjay K. Varshney and Veena Prasad
Collaborators: H. Nagayama, M. Goto, F. Araoka, K. Ishikawa and H. Takezoe, Tokyo Institute of Technology, Japan.

6.5 UNDERSTANDING THE OBSERVATION OF LARGE ELECTRICAL CONDUCTIVITIES IN NEMATIC LIQUID CRYSTAL-CARBON NANOTUBE COMPOSITES

Carbon nanotube (CNT) is a multifunctional nanomaterial that possesses extraordinary electrical, thermal, and optical properties. Preparing a well oriented sample to realize in bulk the anisotropic properties has been, however, a challenging task. Attempts have been made to employ liquid crystals (LC) as the dispersing medium for CNTs, and exploit the reorientation of LC molecules using external fields to achieve CNT orientation. The advantage of this procedure is that the external fields need not have any direct influence on CNT. Such a phenomenon is very interesting because of device applications in which parameters like electrical conductivity may be switched from low value to a high value by fields acting on the nematic LC. The motivation for our work was that certain earlier reports describe orders of magnitude enhancement in electrical conductivity of LC-CNT composites when reorienting electric fields are applied. In contrast, however, the increase is very much smaller if a magnetic field is used for reorientation. To understand this puzzling feature we have carried out detailed and systematic measurements on a LC-CNT composite system.

Figure 3 shows the electrical conductivity of the LC-CNT composite σ as a function of the oscillating voltage and applied magnetic field. For comparison the data for the pure LC sample, which essentially behaves like an electric insulator, are also given. For the CNT composite, σ increases by more than four orders of magnitude, in the electric field case, whereas with the magnetic field as the orienting field, the increase is only a factor of two higher than that for zero fields. A possible argument could be that the orientation is incomplete in the magnetic field measurements. Measurements of dielectric constant confirm that the field employed is sufficient, in both the cases, to achieve saturation in the reorientation. More importantly, the dielectric data in the electric field-induced reorientation case, display a large increase in the circuit current value concomitant with conductivity increase, reaching the stage of dielectric breakdown even at moderate voltages. To provide a supporting evidence for this argument, we investigated local heating effects that are known to be associated with such a dielectric breakdown phenomenon. Polarizing optical microscopy optical observations were performed when the electric field is applied to the LC-CNT composite to get a visual proof of the local heating effect.

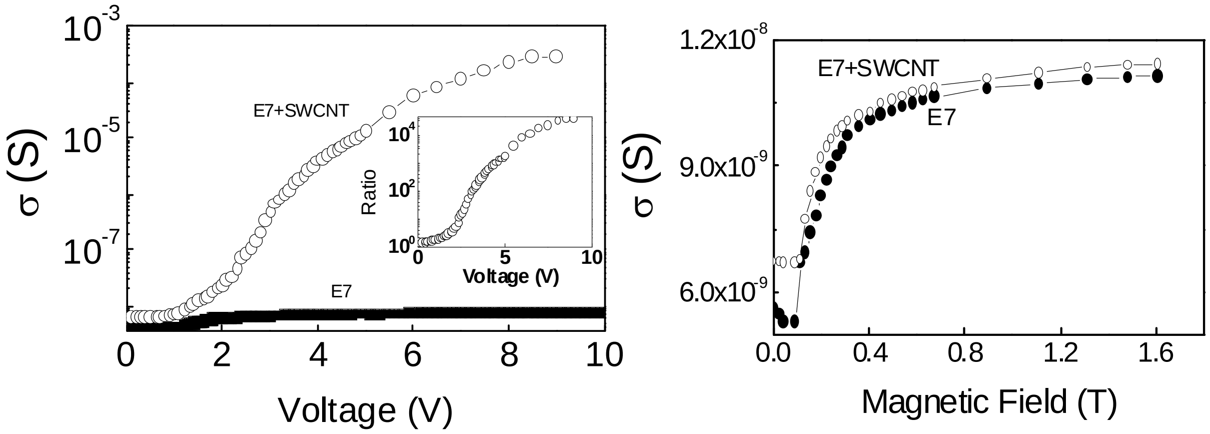


Figure 3: Voltage and magnetic field dependence of the electrical conductivity σ for pure LC (filled symbol) and the LC+SWCNT composite (open symbol). The inset shows the ratio of the

When the voltage reaches a value of 8 V, the local heating becomes so prominent as to drive the material through the nematic to the isotropic transition, providing clear evidence to our argument. Based on these observations we suggest that the large magnitudes of enhancement in the electrical conductivity reported earlier and also seen in the present investigation obtained during the reorientation process is not due to the inherent property of CNTs, and attention must be paid to the phenomenon of dielectric breakdown and consequent local heating effects.

Investigators: V. Jayalakshmi and S. Krishna Prasad

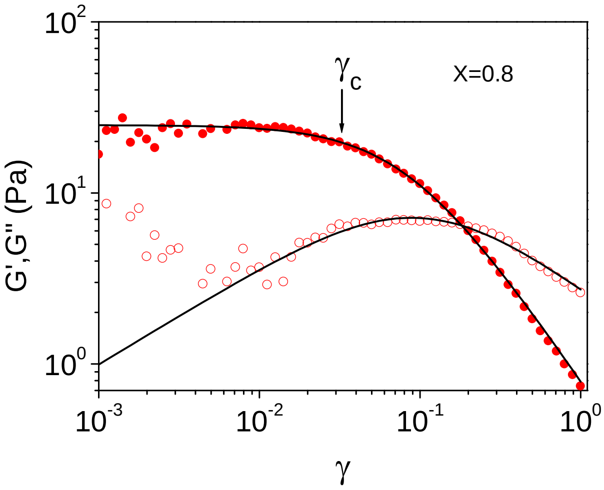
6.6 OBSERVATION OF PHOTOFLEXOELECTRICITY IN PHOTOACTIVE GUEST-HOST NEMATICS

Photoflexoelectricity in nematics requires the presence of three generalized degrees of freedom: electrical, mechanical and optical [3]. We have investigated the flexoelectric effect in guest-host nematic systems featuring an optical degree of freedom based on the trans-cis photoizomerization of the azo-bond. While the host systems are commercially available compounds, the photoactive guest substances with the desired functionality were prepared in our laboratory. In homeotropic nematic layers in horizontal electric fields, subjected to illumination by actinic light (λ ~ 365 nm) a marked, reversible increase of the bend flexoelectrooptic effect (i.e., the increment of transmitted light intensity between crossed polarizers due to an in-plane electric field) was found with relaxation times of the order of 10 s. The back relaxation was promoted by a blue light illumination. The d.c. voltage dependence of both dark and light flexoresponce followed the predictions of the flexotheory. An UV amplitude enhancement of flexo-oscillations excited by an a.c. voltage was also observed. Considering the relative importance of the bulk and surface contributions to the photoflexoresponse, these experimental features suggest large contributions from the surface polarization. Prolonged UV illumination (~a few minutes) of the cell resulted in an anchoring transition from homeotropic to tilted (conical) orientation, suggesting the presence of a command surface.

Investigators: S.Krishna Prasad, Uma S.Hiremath and C.V.Yelamaggad
Collaborators: A.G.Petrov, Y.Marinov and G.Hadjihristov, Institute of Solid State Physics, Bulgaria

6.7 SOFT GLASS RHEOLOGY OF LIQUID CRYSTAL GELS

Extensive rheological characterization of a nematic liquid crystal (NLC) gelated with a novel monodisperse dipeptide, also a liquid crystal, has been carried out. A number of composites with varying concentration of the gelator (X=0.2 to 10, X being the weight % of gelator in NLC) were prepared for the studies. All samples showed shear thinning behavior without a Newtonian plateau region at lower shear rates typical of gels. Dynamic oscillatory measurements in the linear as well as non-linear regime exhibited following features: (i) Small deformation oscillatory data at lower frequencies exhibited a weak power law dependence of the storage (G') and loss (G'') moduli. (ii) Above a critical strain amplitude (γ_c), both G' and G" become strain dependent with G' showing a monotonic decrease, and G" exhibiting a peak before decreasing. (iii) Above the γ_c, in the non-linear viscoelastic regime, the decay



The G' (filled circles) and G" (open circles) data as a function of strain amplitude γ for X=0.8 Above γ_c, G' shows a monotonic decrease and G" exhibits a peak before decreasing, features hallmark of soft glassy materials (SGMs).

in the G' and G" could be described by a power-law behaviour i.e., G' ~ $\gamma^{-\nu'}$ and G" ~ $\gamma^{-\nu''}$. The exponents obtained follows the expression $\nu'' \sim \nu'/2$. (iv) Failure of Cox-Merz superposition. These features are hallmark of soft glassy characters commonly seen in soft materials, such as foams, slurries, etc. Further, the results agree qualitatively with the predictions of a phenomenological model, known as Soft Galss Rheological (SGR) model which was proposed to describe the universal rheological behaviour seen in soft glassy materials (SGMs).

Investigators: Geetha G. Nair, R. Bhargavi, S. Krishna Prasad, V. Jayalaksmi and C.V.Yelamaggad

6.8 DSC AND THERMO-RHEOLOGY OF LC GELS

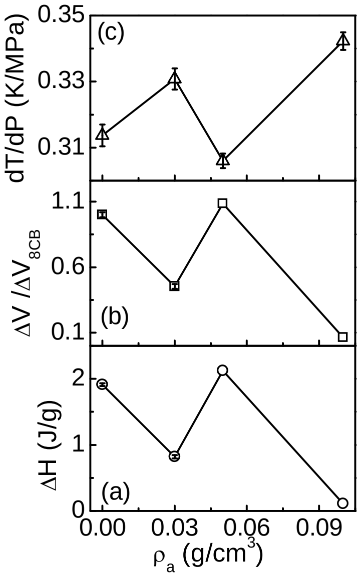
Differential Scanning Calorimetry (DSC) and thermo-rheological measurements have been carried out on some of the gels (X=1,2,4 and 10) of the same system described above. For X=2 and 4, the DSC scans displayed a two-peak profile across the nematic to isotropic (N-I) phase transition, a feature reminiscent of the random-dilution to random-field crossover observed in liquid crystal composites formed with aerosil particles. The G' and G" data measured as function of temperature showed two step-like variation corresponding to the two peaks observed in DSC, albeit, with a temperature anomaly. The two transitions are believed to correspond to gel to nematic sol and nematic sol to isotropic sol phase transitions respectively. Experiments are currently in progress to explore the possibility of associating these changes with transformations from the nematic gel to the isotropic sol through an anisotropic sol phase.

Investigators: Geetha G. Nair, R. Bhargavi, S. Krishna Prasad and C.V. Yelamaggad

6.9 HIGH PRESSURE STUDIES

(i) Confinement effects on liquid crystals are interesting both from fundamental and technological point of view. Investigation of confinement effect on liquid crystals are interesting because (i) liquid crystals (LCs) exhibit variety of phases with different degrees of translational and orientational order, (ii) transition are second order or at best weakly first order (iii) LCs are typical representative of soft materials (iv) response to perturbation induced by confining matrix are long ranged (v) doesn't react chemically with the host matrix. The restricted geometry can be realized by using prefabricated confining matrix such as Anopore, Nuclepore in which the voids are highly regular with well defined pore dimensions or with biological membranes like Millipore, synpore where the large distribution of the pore size and the cavities are interconnected. The geometrically enforced disorder observed in these situations can also be obtained by having the liquid crystal in a network termed as aerosils formed with silica spheres of ∼7 nm diameter whose surfaces are decorated to achieve hydrophilic or hydrophobic interactions. The advantage of the aerosil network is that the random disorder can be controlled and fine tuned by simply varying the concentration of the silica particles. The fragile hydrogen bond network that results from the interactions between the particles permits the disorder to be created in situ, allowing the influence of the quenched randomness on various phase transitions in LC materials to be examined. We have performed first high pressure investigations of the nematic–isotropic transition in the composites of a liquid crystal compound with hydrophilic aerosil particles. The aerosil particles were degassed and dried at a temperature of ∼200 ◦C for 12 h. The aerosil and 8CB mixtures were prepared by the generally employed solvent mixing process.

Based on earlier studies for mixtures with aerosil concentration <0.1 is considered as soft gel, and for >0.1 is considered as stiffer gel. Pressure studies are carried out on pure and mixtures with aerosil concentration ρ_a = 0.03, 0.05 and 0.10 g cm^{-3} in the nematic LC. The pressure–temperature (PT) phase diagram for all the four mixtures and the pure compound showed that the data appears smooth over the entire range of pressure indicating that the network remains intact even at elevated pressures. Quantitative analysis of the pressure–temperature phase diagrams using a simple linear, a second degree polynomial and the Simon–Glatzel equation have been performed which reveal interesting behaviour of parameters such as the transition temperature, slope of the phase boundary and the transition volume. The slope (m) values, enthalpy values measured using differential scanning calorimetry at room pressure, and calculated transition volume ΔV, all of them vary nonmonotonically with increasing aerosil concentration. The high pressure study adds a new dimension,namely, the influence of pressure on liquid crystalline transitions in restricted geometries.



The nonmonotonic dependences of (a)ΔH and (b)ΔV and (c) the slope dT/dP on the aerosil concentration ρ_a in nematic liquid crystal. In panels (b) and (c), the error bars are smaller than the size of the data marker used.

Investigators: D.S. Shankar Rao, S. Krishna Prasad and Prasad N. Bapat

(ii) Detailed optical polarizing microscopy (OPM) Xray diffraction (XRD) studies are carried out on highly luminescent octupolar oxadiazole derivatives. XRD studies confirmed the liquid crystal phase assignments observed using OPM studies. The analysis of the XRD data revealed columnar packing with hexagonal arrangement of the molecules in the high temperature phase, transforms to a low temperature tilted columnar phase(Col_{ob}) with rectangular packing, the tilt angle in the range of 83^o. Xray investigations are also done in the gel state formed for one of the derivative which is found to have Col_{ob} packing.

Investigators: D.S. Shankar Rao and S. Krishna Prasad
Collaborators: Suresh Das, Photosciences and Photonics Section Chemical Sciences and Technology Division National Institute for Interdisciplinary Science and Technology, CSIR Trivandrum

(iii) The phase sequence uniaxial smectic A–biaxial smectic A–uniaxial smectic A (reentrant) phase in a nonsymmetrical liquid crystal dimer which is observed in the polarizing optical microscope, is proved unambiguously through high resolution Xray diffraction studies. The XRD data revealed the orthogonal layered structure with liquid like order within the layer in all the three phases confirming it to be smectic A phase.

Investigators: D.S. Shankar Rao, Geetha G. Nair, S. Krishna Prasad and C.V. Yemaggad

(iv) Detailed high resolution XRD experiments are done on tris(N-salicylideneaniline)s (TSANs) comprised of oxadiazole cores. The results show that all derivatives have the molecules stacked in columns with 2dimensional hexagonal arrangement of the lattice.

Investigators: D.S. Shankar Rao, S. Krishna Prasad and C.V. Yemaggad

(v) Detailed high resolution XRD experiments are done on two triphenylene cores covalently linked via rigid spacer, namely, π-conjugated ethynyl- or butadiynylbridge. The diffraction pattern of all these compounds showed four or more sharp peaks in the low angle region which on indexing fitted to a columnar phase with 2dimensional rectangular arrangement of the lattice. All the peaks were indexed to get appropriate hkl indices, also the lattice parameter. In addition the diffraction pattern showed a strong core-core peak in the wide angle region further supporting for the columnar packing of the molecular cores.

Investigators: D.S. Shankar Rao and Sanjay Kumar Varshney.

6.10 MOLECULAR DESIGN AND SYNTHESIS OF DISCOTIC LIQUID CRYSTALLINE DIMERS AND TRIMERS

The synthesis and mesomorphic properties of novel non-symmetrical discotic dimers have been investigated. These dimers are prepared by the combination of electron deficient (n-type) anthraquinone and electron rich (p-type) triphenylene discotic monomers. The mesophases have been characterized using polarizing optical microscopy, differential scanning calorimetry and X-ray diffraction. Most of the dimers synthesized here, exhibit a rectangular columnar mesophase and one of the compounds exhibit a nematic phase as well. Charge transfer behavior has been studied by UV-Vis spectroscopy.

In addition to the above compounds, we designed and synthesized several functionalized dimers and linear trimes as well. These dimers have either hydroxyl or acetyloxy functional group. Here some of the compounds exhibited nematic / columnar phases at room temperature.

Investigators: Sanjay K. Varshney and Veena Prasad
Collaborators: H. Monobe, Y. Shimizu, National Institute of Advanced Industrial Science and Technology, Osaka, Japan.
H. Takezoe, H. Nagayama, Tokyo Institute of Technology, Tokyo, Japan.

6.11 π–CONJUGATED DISCOTIC TWINS

Novel discotic liquid crystals consisting of two triphenylene mesogenic cores covalently linked via a rigid spacer, *i.e.*, π–conjugated ethynyl- or butadiynyl bridge, (TP twins) are designed and synthesized. Three varieties of TP twins are prepared. These TP twins exhibit a variety of discotic mesophases like nematic, columnar rectangular over a wide range of temperature. It has been found that the length of the rigid spacer and β – substitution are the key factors that govern the molecular self-assembly of triphenylene twins. To the best of our knowledge these are the first examples of TP twins exhibiting polymesomorphism.

Investigators: Sanjay K. Varshney, Veena Prasad and D.S. Shankar Rao
Collaborators: Hideo Takezoe, Tokyo Institute of Technology, Tokyo, Japan.

6.12 DESIGN AND SYNTHESIS OF NOVEL PHASMID – LIKE AZO COMPOUNDS FORMED BY HYDROGEN BONDING

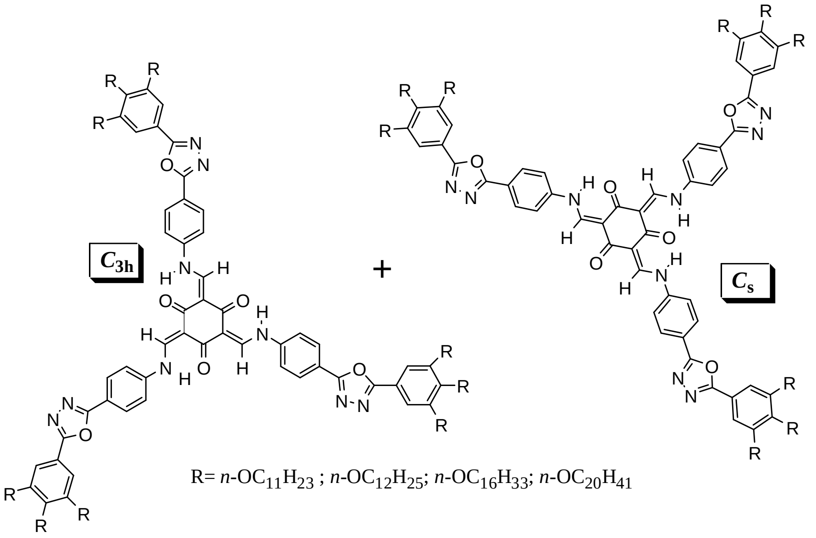
The crucial role of hydrogen bonding in inducing and/or stabilising the liquid crystalline properties has been recognised in certain systems, wherein dimerisation of the molecules imparts enhanced structural anisotropy, which is a paramount factor for a compound to exhibit liquid crystalline properties. In this direction, we designed and synthesized new series of azo carboxylic acids, wherein, the molecules, self – assemble to form dimers through inter-molecular hydrogen bonding, resulting in phasmid-like compounds. The presence of an azo linkage induces photochromism to these compounds in addition to their liquid crystalline properties.

The mesomorphic properties of these compounds were studied using polarising optical microscopy, differential scanning calorimetry and X-ray diffraction. Investigations revealed that these compounds form nematic and columnar mesophases. We obtained unconventional and unique X-ray diffraction patterns in the nematic range of these compounds. To elucidate the exact nature of the nematic phase, a detailed X-ray and other physical studies are in progress. The effect of molecular structure on the mesomorphic properties has also been studied, by changing the linkage group as well as by varying the number of alkoxy chains in these systems.

Investigators: N.G. Nagaveni, S.K. Varshney and Veena Prasad
Collaborators: S-W. Kang, Chonbuk National University, Korea.

6.13 LUMINESCENT, LIQUID CRYSTALLINE TRIS(N-SALICYLIDENEANILINE)S: SYNTHESIS AND CHARACTERIZATION

Tris(*N*-salicylideneaniline)s (TSANs) comprising 1,3,4-oxadiazole fluorophore have been designed and synthesized (Figure 1). Thereby, through the incorporation of fluorophore we have examined the effects on the mesomorphic behaviour and photophysical properties of discotic TSANs. These compounds with 1,3,4-oxadiazole wings exist in an inseparable mixture of two keto-enamine tautomeric forms with C_{3h} and C_s rotational symmetries, and self-assemble into fluid columnar (Col) phase over a wide thermal range as evidenced by several complementary studies. The qualitative photophysical study reveals their emissive characteristics in both solution and fluid Col states (Figure 2). Remarkably, solutions show blue fluorescence (λ = 474 nm), while glassy Col film show preserved emission behaviour and two-dimensional (2D) order. Thus, we have disclosed a simple way of modifying molecular self-assembling and light generating ability of TSANs. Importantly, some novel oxadiazole-based intermediates have been synthesized, which could be useful in the synthesis of light emitting liquid crystals.



R= *n*-$OC_{11}H_{23}$; *n*-$OC_{12}H_{25}$; *n*-$OC_{16}H_{33}$; *n*-$OC_{20}H_{41}$

***Figure 1**: Molecular structure of TSANs bearing 1,3,4-oxadiazole fluorophore*

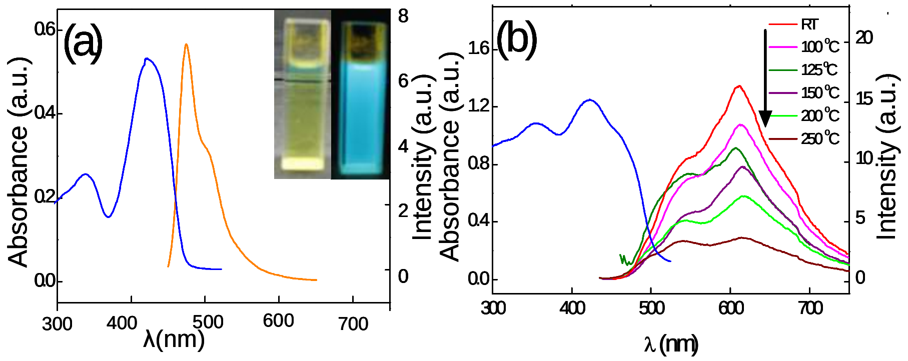
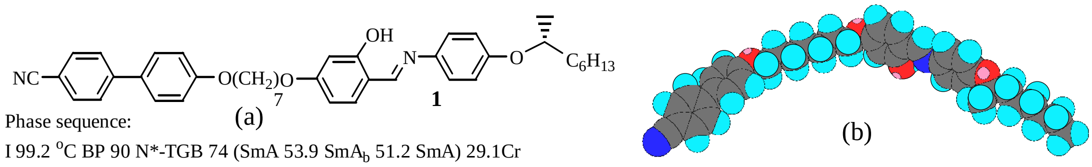


***Figure 2.** Panel (a): absorption spectrum (blue trace) and emission spectrum (orange trace) (excited at 420 nm) obtained for one of the TSANs in THF solution (2.3 × 10^{-6} M); inset shows the pictures of solutions as seen before (LHS) and after the illumination (RHS) of the light of 365 nm; Panel (b): thin film absorption spectrum (LHS) at room temperature and emission spectra (RHS) for thin film as a function of temperature. (LHS = Left hand side; RHS = Right hand side)*

Investigators: C. V. Yelamaggad, A. S. Achalkumar, D. S. Shankar Rao and S. Krishna Prasad

6.14 A NEW THERMOTROPIC REENTRANT BEHAVIOUR IN A CHIRAL LIQUID CRYSTAL DIMER

An optically active liquid crystal dimer comprising cyanobiphenyl and chiral salicyladimine segments interlinked through a heptamethylene spacer (**1**; Figure 1) has been synthesized and characterized. The combination of orthoscopic (Figure 2a-c), conoscopic (Figure 2d-f) and XRD studies (Figure 3) unequivocally establishes remarkable phase behaviour of this new dimer. In particular, it exhibits an unprecedented reentrant phase sequence namely, uniaxial smectic A (SmA)– biaxial smectic A (SmA_b) - uniaxial SmA phase, below the blue phase (BP) - chiral nematic (N*) – twist grain boundary (TGB) phases (Figure 1). It is assumed that the presence of a salicylaldimine core with a chiral centre nearer to the aromatic core in



Phase sequence:
I 99.2 °C BP 90 N*-TGB 74 (SmA 53.9 SmA_b 51.2 SmA) 29.1Cr

***Figure 1**: Molecular structure (a) and a space-filling model of the energy minimized bent-structure (b) of the optically active salicylaldimine-based nonsymmetric dimer.*

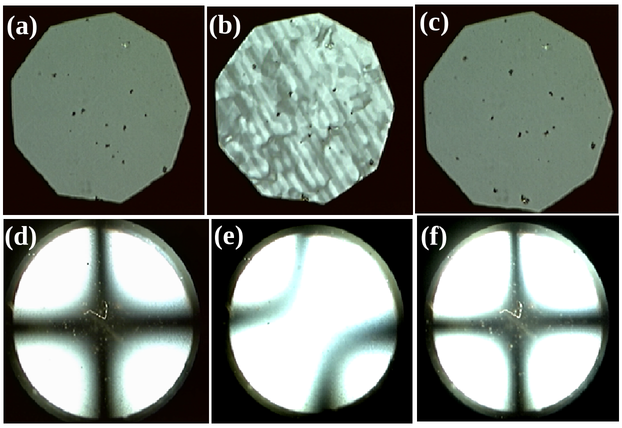


***Figure 2**: Microphotographs of the (a-c) orthoscopic and (d-f) conoscopic patterns observed for the homeotropically aligned sample **1**: (a & d) the SmA phase, (b & e) the SmA_b phase: note that the isogyres are well separated and (c & f) the reentrant SmA phase.*

this dimer is an important structural (perhaps in terms of rigidity/stereochemical) factor for its unique behaviour given the observation that the analogous chiral Schiff's base dimers with the chiral centre one carbon away from the core do not favour such a behaviour.

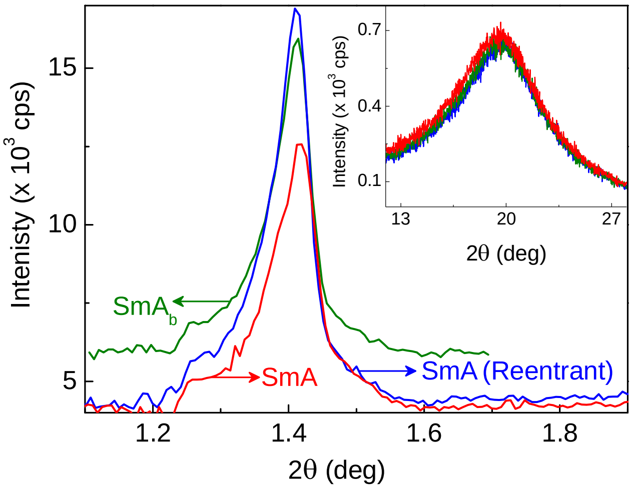


Figure 3: *The low-angle and wide-angle (inset) regions of the XRD patterns obtained for the uniaxial SmA phase at 61 ^{o}C (red traces), the biaxial SmA phase at 53.2 ^{o}C (green traces) and the reentrant uniaxial SmA phase at 48 ^{o}C (blue traces).*

Investigators: C. V. Yelamaggad, V. Padmini Tamilenthi, D. S. Shankar Rao, G. G. Nair and S. Krishna Prasad

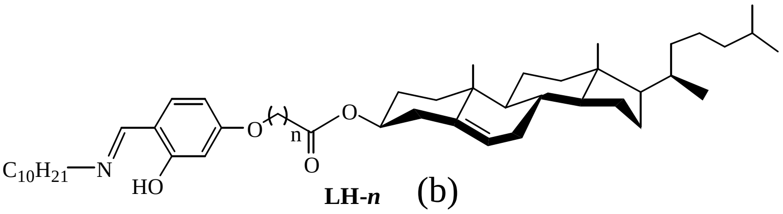
6.15 OPTICALLY-ACTIVE, MESOGENIC LANTHANIDE COMPLEXES: SYNTHESIS AND CHARACTERISATION

A number of lanthanidomesogens with the formula **[LnL(LH)$_2$][X]$_2$** (Figure 1a) have been prepared and investigated for their thermal behaviour. These mesogens are derived from ligands (**LH-*n***) (Figure 1b) formed by covalently linking the pro-mesogenic cholesterol segment with the *N*-(*n*-decyl)salicylaldimine core through either an even-parity (4-oxybutan-oyloxy / 6-oxyhexanoyloxy / 8-oxyoctanoyloxy) or an odd-parity (5-oxypentanoyloxy) spacer. These ligands are designed based on the recently conceived concept of decoupling the anisometric segment from the metal-coordinating site by a flexible spacer to account for the stabilisation of nematic and /

or smectic phases at lower temperatures. The even parity spacer ligands are polymesomorphic whereas the odd parity analogue exhibits only the chiral nematic phase. In contrast, the complexes display solely the smectic A phase (Figure 2a) indicating that the variation in the nature of lanthanide has no influence on the general phase behaviour of the complexes. The clearing temperatures of both the ligands and the complexes display an odd-even effect (Figure 2b); the even members show relatively higher transition temperatures.

$[LnL(LH)_2][X]_2$ (a)

Where X = NO_3 or CF_3SO_3 ; Ln = La, Gd, and Yb
LH = Ligand ; L = Ligand without phenolic proton



LH-*n* (b)

LH-3: n = 3; **LH-4**: n =4; **LH-5**: n = 5; **LH-7**: n = 7

Figure 1 : (a) A general formula of lanthanidomesogens; (b) Molecular structure of ligands

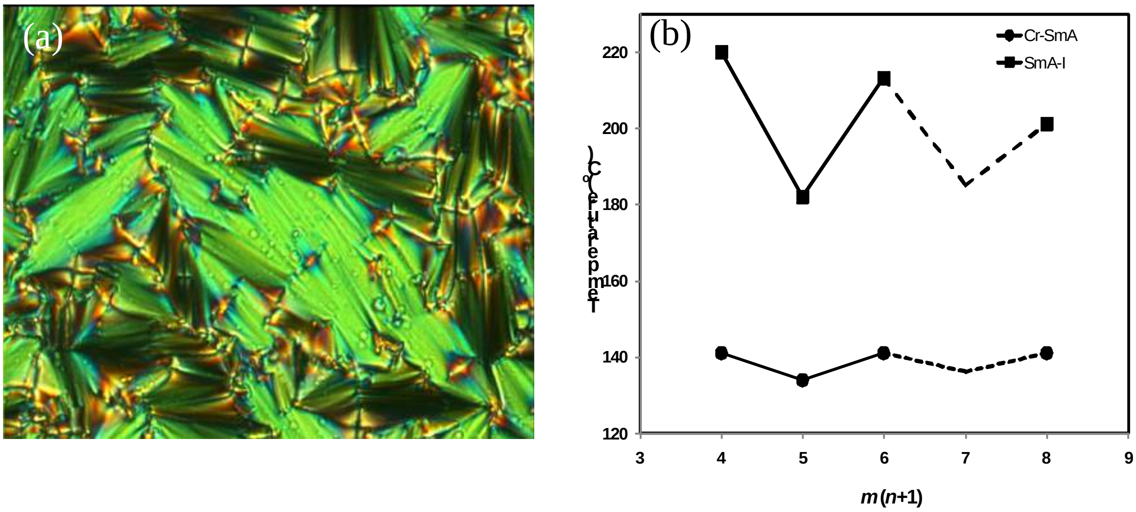


***Figure 2**. (a) Microphotographs of the textures observed for the SmA* phase of one of the complexes (**I-7**): a focal-conic texture of the fully grown SmA phase. (b) The dependence of the transition temperatures on the number of carbon atoms (**m** = **n**+1) in the oxyalkanoyloxy spacers for gadolinium(III) complexes in heating cycle. The dashed lines joining points are suggestive of the general trend.*

Investigators: C. V. Yelamaggad, Rashmi Prabhu and G. Shanker
Collaborators : D. W. Bruce, Department of Chemistry, University of York, UK

6.16 LIQUID CRYSTAL TRIMERS COMPRISING CYANOBIPHENYL AND SALICYLALDIMINE ANISOMETRIC SEGMENTS

The first examples of salicyaldimine-based liquid crystalline trimers (Figure 1) have been synthesized and investigated for their phase behaviour. Particularly, they are formed by covalently tethering nematogenic cyanobiphenyl segments on the either side of salicyaldimine core through flexible spacers. The molecular design was chosen to understand structure-property correlations, and in fact, was originated based on our general observation that the molecular systems consisting of cyanobiphenyl and salicyaldimine favor the stabilization of biaxial mesophase(s). All the homologues, exhibit only the uniaxial nematic phase (Figure 2a) with the exception of an octamethylene-spacer containing member which stabilizes an additional monotropic smectic phase (Figure 2b). This implies therefore that these trimers are more compatible with the molecular assembly in the nematic structure than the layered structure. It can also be seen that this trimeric design, although consisting of favorable mesogenic segments, do not support the stabilization of biaxial mesophase. The effects of odd-parity and even-parity spacers on the transition temperatures, especially the clearing temperatures, are quite apparent (Figure 3); the even-members possess higher value, in a manner reminiscent of other reports. The present investigation may be useful for the better understanding of the relation between chemical structure and physical properties of such mixed trimers.

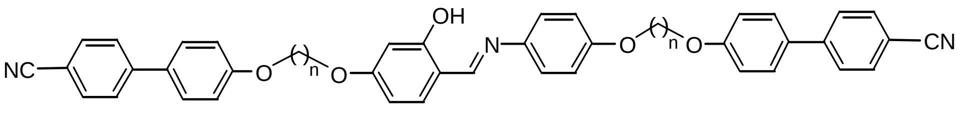


***Figure 1**: Molecular structure of salicyaldimine-based liquid crystalline trimers*

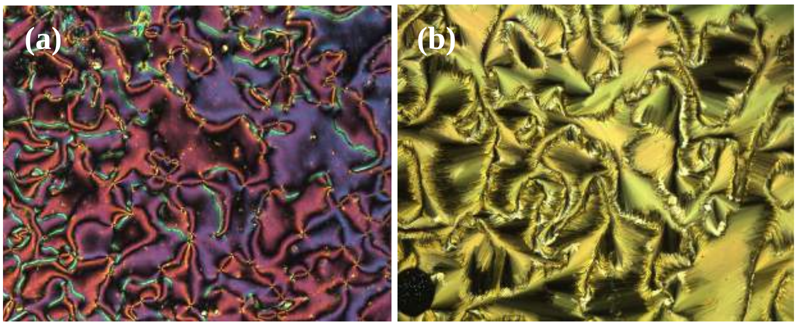


***Figure 2**: Optical microphotographs obtained for (a) the nematic schlieren texture of trimer with heptamethylene spacer and (b) the paramorphotic schlieren texture of the SmX phase occurring below the nematic phase of trimer octamethylene sapcer.*

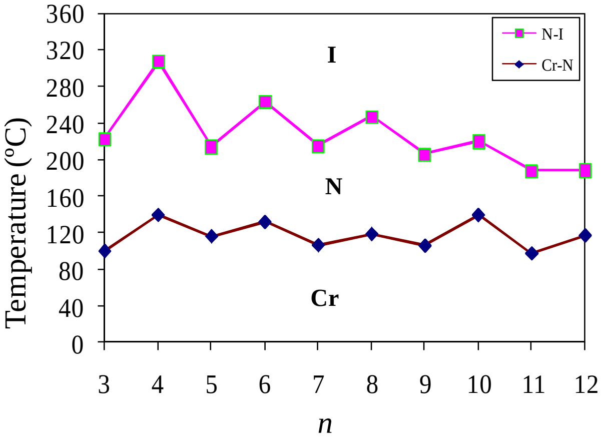


***Figure 3**: Phase diagram of temperature vs number of methylene units in the spacers for the trimer series.*

Investigators: C. V. Yelamaggad and V. Padmini Tamilenthi

6.17 VIBRATIONAL SUM FREQUENCY GENERATION SPECTROSCOPIC INVESTIGATION OF THE INTERACTION OF THIOCYANATE IONS WITH ZWITTERIONIC PHOSPHOLIPID MONOLAYERS AT THE AIR-WATER INTERFACE

Many physico-chemical and biological processes can be influenced by the presence of ions. In recent times, there has been much interest shown towards studying the impact of ions on water, protein and lipid systems by various research groups.

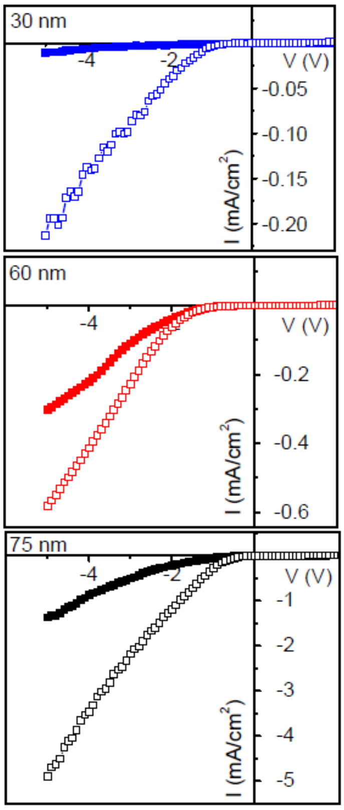
Thiocyanate (SCN(-)) is a highly chaotropic anion of considerable biological significance, which interacts quite strongly with lipid interfaces. In most cases it is not exactly known if this interaction involves direct binding to lipid groups, or some type of indirect association or partitioning. In this study, the interaction of thiocyanate anions with zwitterionic phospholipid monolayers in the liquid expanded (LE) phase is examined using surface pressure-area per molecule (pi-A(L)) isotherms and vibrational sum frequency generation (VSFG) spectroscopy. Both dipalmitoyl phosphatidylcholine (DPPC) and dimyristoyl phosphatidylethanolamine (DMPE) lipids, which form stable monolayers, have been used in this investigation, since their head groups may be expected to interact with the electrolyte solution in different ways. The pi-A(L) isotherms of both lipids indicate a strong expansion of the monolayers when in contact with SCN(-) solutions. From the C-H stretch region of the VSFG spectra it can be deduced that the presence of the anion perturbs the conformation of the lipid chains significantly. The interfacial water structure is also perturbed in a complex way. Two distinct thiocyanate populations are detected in the CN stretch spectral region, proving that SCN(-) associates with zwitterionic phospholipids.

Investigator: Viswanath .P
Collaborators: Aroti A, Leontidis E., Department of Chemistry, University of Cyprus, Cyprus
Motschmann H, Institute of Physical and Theoretical Chemistry, University of Regensburg, Germany

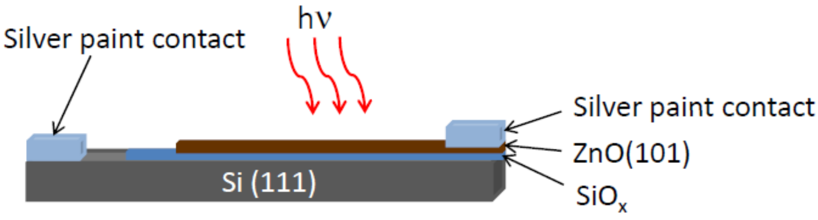
6.18 STATIC AND DYNAMIC PHOTORESPONSE OF ZnO(101)/Si(111) DIODES

We have fabricated ZnO(101)/SiO_x/Si(111) diodes and studied the photoresponse of it. The native oxide, SiO_x layer on Si(111) substrate was prepared by chemical reaction with ‘piranha’ solution and a part of it was etched off using HF solution, to make silver paint contact on Si (111), prior to deposition of ZnO(101) with help of shadow masking. We have employed pulsed reactive crossed-beam laser ablation to deposit (101) oriented ZnO films. We have studied the static and dynamic the photoresponse characteristics of the ZnO(101) based photodiodes for the first time.

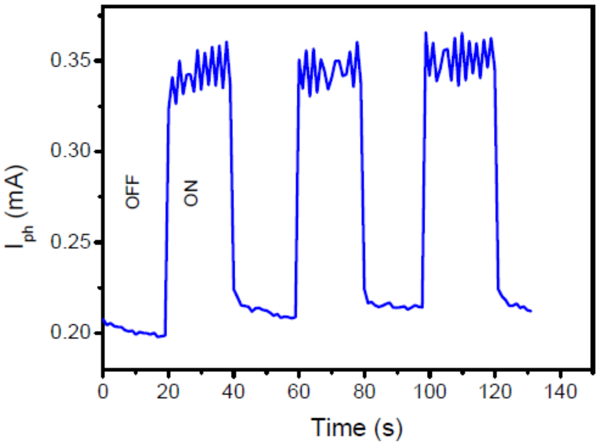
A large photoresponse for the smaller thickness of the ZnO film and decreases upon increasing the thickness thereafter indicate that the (101) crystallographic orientation of the ZnO films is substantially modifying the junction properties. The quantum efficiency is estimated from the *I-V* characteristics and is about 98 % for the 75 nm ZnO(101) film diode. All our ZnO(101)/SiO_x/Si(111) diodes show as well a good dynamical ON/OFF characteristics of the photocurrent.



I-V characteristics in dark (solid symbols) and under illumination (open symbols) for different ZnO(101) film thickness.



Schematic of the ZnO(101)/SiO_x/Si(111) device.

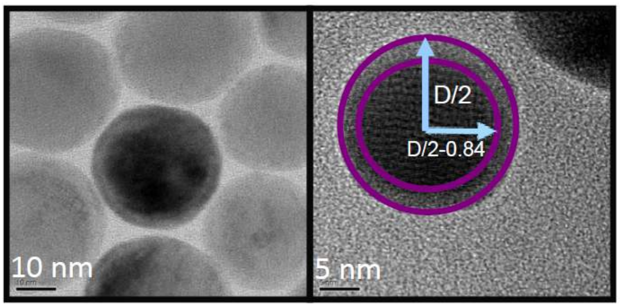


Rise and decay curves of the photocurrent.

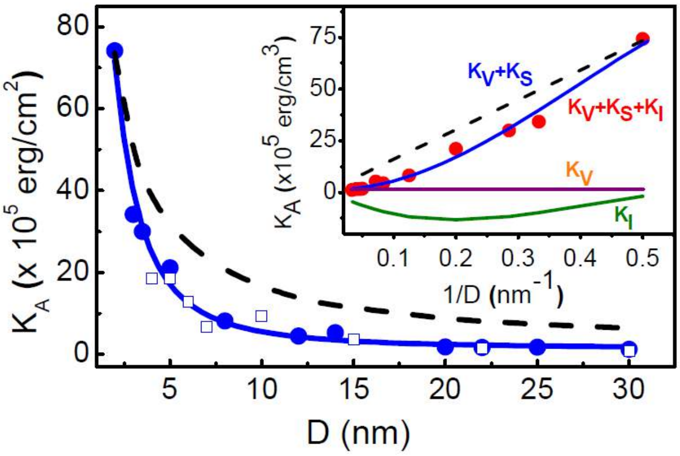
Investigator: S. Angappane
Collaborator: G.U.Kulkani, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore

6.19 NOVEL INTERFACE ANISOTROPY AND EXCHANGE BIAS EFFECTS IN MONODISPERSE $Fe_3O_4/\gamma\text{-}Fe_2O_3$ CORE/SHELL NANOPARTICLES

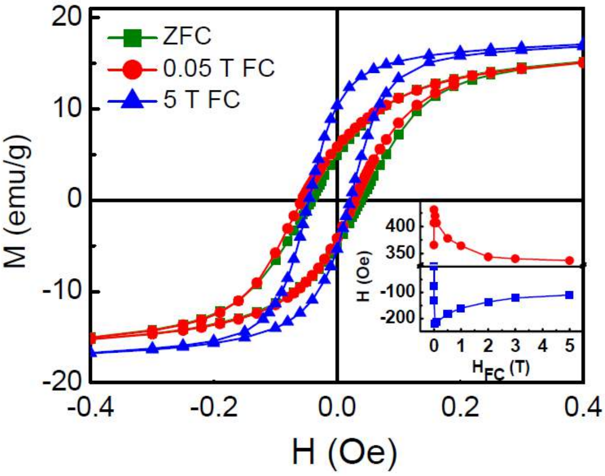
We have investigated the magnetic properties of well-characterized monodisperse $Fe_3O_4/\gamma\text{-}Fe_2O_3$ core/shell nanoparticles having a very narrow size distribution. From the detailed studies of the size dependence of the magnetic properties, we found that there exists novel interface exchange anisotropy, which governs the effective anisotropy of these core/shell Fe_3O_4/γ-Fe_2O_3 nanoparticles in addition to the usual volume and surface magnetic anisotropy. A phenomenological model including the



TEM images of Fe_3O_4/γ-Fe_2O_3 core/shell nanoparticles.



Exchange Anisotropy: Size dependence of anisotropy constant, K_A and fit to contributions of volume, surface and interface anisotropies.



Exchange Bias: Hysteresis curves measured at 10 K after zero-field cooling and field cooling under 0.05 and 5 T for 12 nm Fe_3O_4/γ-Fe_2O_3 core/shell nanoparticles.

interface exchange anisotropy is found to account well for the size dependence of the observed magnetic anisotropy over a very wide range of particle size from 3 to 30 nm. We further discovered that the interface in the core/shell $Fe_3O_4/\gamma\text{-}Fe_2O_3$ nanoparticles gives rise to exchange bias behavior in the magnetization data.

Investigator: S. Angappane
Collaborator: J.-G. Park, Sungkyunkwan University, Korea (Presently in Seoul National University, Korea)

6.20 EXPERIMENTAL DETERMINATION OF INTER PARTICLE DISTANCE IN Fe_3O_4 NANOPARTICLES DISPERSION USING SAXS MEASUREMENTS

Employing small angle x-ray scattering (SAXS), we have experimentally determined the inter-particle distance between the Fe_3O_4 nanoparticles dispersed in different concentrations. We have made SAXS measurements at 4C1 - Small Angle X-ray Scattering beamline of Pohang Accelerator Laboratory, Korea. A unified scattering function for the two structural limits described using a semi-empirical equation proposed by Beaucage et al. was used to analyze the data [J. Appl. Cryst., Vol.29, 134 (1996)]. The structures formed by multiple structural levels described by the global unified scattering function containing exponential form of Guinier's law and structurally limited Porod's power law terms accounting for multiple structural levels which takes into account the correlation effects. For the first time, we showed the inter particle distance, *d*, values calculated from SAXS data matching reasonably with the expected values derived from the fill factor of nanoparticles in the solution and this procedure could be applied to determination of inter particle distance in several other nanoparticle dispersions.

Investigator: S. Angappane
Collaborator: J.-G. Park, Sungkyunkwan University, Korea (Presently in Seoul National University, Korea)

6.21 PATTERNED ELECTROCONVECTIVE STATES IN A BENT-CORE NEMATIC LIQUID CRYSTAL

This study deals with the results of investigations on the anisotropic electrohydrodynamic states arising in a highly conducting, planarly aligned, bent-core nematic liquid crystal driven by ac fields of frequency f in the range 10 Hz-1 MHz. Pattern morphology-wise, two f-regimes are distinguished. The low f regime, wherein the primary bifurcation is to a state of periodic longitudinal stripes (LS), extends to an unprecedentedly large f, in the range 150 kHz–550 kHz, depending on the temperature T. This is followed by the high f regime wherein periodic normal stripes (NS) constitute the primary instability. Both the instabilities involve predominant director modulations and streamlines in the layer plane. The transitional frequency between the two regimes is linear in temperature. The curve $V_c(f)$ shows a nonlinear increase for the LS state and decrease for the NS state. V_c (T) is an ever increasing curve close to the nematic-isotropic point for both the states. The wave number of LS varies directly as V, and that of NS shows nearly the same behaviour. The pattern period versus f is increasing for LS, but decreasing for NS. Both the instability states exhibit complex, light-polarization dependent lens action. Well above the threshold, disclination loops of regular geometry appear along the stripes. They drift in a coordinated manner along the flow lines. At very high voltages, the instability turns strongly time dependent. The current models of anisotropic convection based on static electrical parameters fail to account for the observed instabilities.

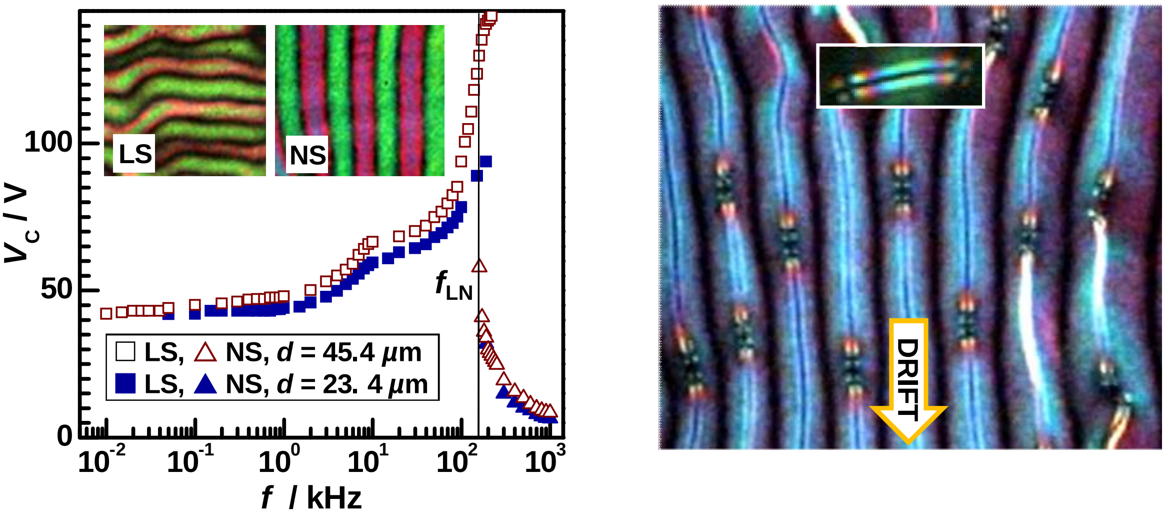


Figure 1: (*Left*) *Frequency dependence of the optical threshold* V_c *at which the primary bifurcation into a patterned state is observed at 110* ^{o}*C in samples of two different thicknesses, d. LS and NS denote longitudinal and normal stripes, respectively;* f_{LN} *is the crossover frequency separating the LS and NS states. (Right) Drifting disclination arrays formed in the NS state at 0.5 MHz, 60 V; crossed polarizers, 110* ^{o}*C, d= 12.7 µm. Inset: Corresponding disclination in the LS state at 1 kHz, 50 V.*

Inveastigators: Pramod Tadapatri, Uma S. Hiremath, C. V. Yelamaggad, and K.S.Krishnamurthy

6.22 PERMITTIVITY, CONDUCTIVITY, ELASTICITY AND VISCOSITY MEASUREMENTS IN THE NEMATIC PHASE OF A BENT-CORE LIQUID CRYSTAL

The work pertains to the measurements of dielectric permittivity ε, electrical conductivity σ, elastic moduli k_{ii} and rotational viscosity γ for a bent-core nematic liquid crystal. The static permittivity anisotropy $\varepsilon_a = \varepsilon_{||} - \varepsilon_{\perp}$ is negative; at a given temperature in the interval 107 ^{o}C-123 ^{o}C, $\varepsilon_{||}$ shows two relaxations falling in the frequency bands 20-200 kHz and 0.9-2 MHz; $\varepsilon_{\perp}$ also shows a relaxation between 0.9-5 MHz. The conductivity anisotropy $\sigma_a = \sigma_{||} - \sigma_{\perp}$ is negative at low frequencies; it changes sign twice at frequencies f_1 and f_2 that increase with temperature, in the range 6.5-10 kHz and 95-600 kHz, respectively. Surprisingly, the splay modulus k_{11} is considerably greater than the bend modulus k_{33} in the entire nematic range. Viscous relaxation is more complex than in calamitic systems involving at least a two-step process. The γ values are an order of magnitude greater compared to calamitics.

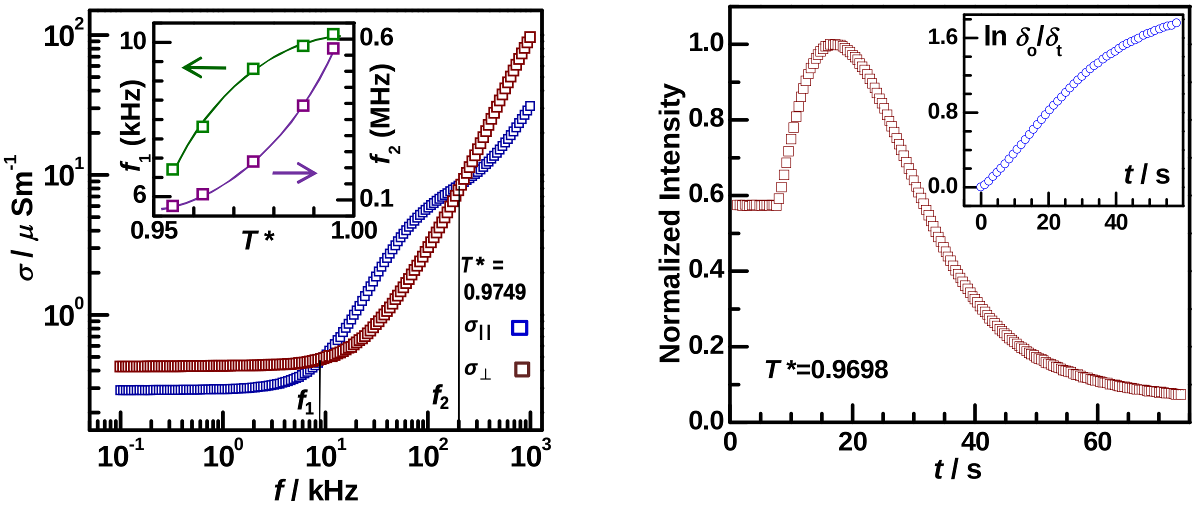


Figure 2. (Left) Frequency dependence of the principal electrical conductivities $\sigma_{||}$ and $\sigma_\perp$ at 115 ^{o}C showing the σ-anisotropy sign reversals at frequencies f_1 and f_2. Inset: Scaled temperature (relative to clearing temperature of 125 ^{o}C) T versus f_1 and f_2. (Right) Time variation of normalized intensity of light transmitted by the initially homeotropic liquid crystal cell of thickness 33 µm. The flat region, which is for an applied voltage of 1.64 V, terminates where the field is turned off. Inset: The nonlinear time dependence of ln δ_o/δ_t, δ_t being the phase change at time t; here t=0 corresponds to the peak position where the phase change $\delta_o = \pi$.*

Inveastigators: Pramod Tadapatri, Uma S. Hiremath, C. V. Yelamaggad, and K.S.Krishnamurthy

7. SPONSORED PROJECTS

- An Indo-Bulgarian research project proposal entitled "Investigations on flexoelectric properties of liquid crystals" was sanctioned in February 2008 costing Rs. 4.98 lakhs. The second year grant of Rs. 1.66 lakhs has been received in March 2010. Under this project, during the year, Dr. S.Krishna Prasad visited Sofia, Bulgaria during November 6-20, 2009. Also Prof. Yordon G.Marinov, Bulgarian Scientist, Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria visited CLCR for 21 days during 6-26 March 2010 under this project. [Indian side: C. V. Yelamaggad, K.S.Krishnamurthy and S. Krishna Prasad; Bulgarian side: A. G. Petrov, Y. G. Marinov and H. P. Hinov]

- A three year Council of Scientific and Industrial Research – CSIR Project # 2162 on “Synthesis and liquid crystal behavior of chiral disc-rod oligomers” has been sanctioned from 1 March 2008. A grant of Rs. 6.25 lakhs being the first year’s was sanctioned during 2008-09 and the work is in progress. [C. V. Yelamaggad, S. Krishna Prasad and D. S. Shankar Rao].

- A three year Department of Science & Technology – SERC (CVY1) Project on “Synthesis and characterization of Tris(N-salicylideneaniline) [TSAN]-based disc-shaped liquid crystals” costing Rs. 33.16 lakhs was sanctioned in November 2007 and first installment of grant of Rs. 20 lakhs was received in January 2008. In addition, Rs.7 lakhs has been received during the year and the work is in progress. [C.V.Yelamaggad, S. Krishna Prasad and D. S. Shankar Rao].

- A SERC Project entitled "Growth on technologically important crystals" costing Rs.6.75 lakhs has been sanctioned during the year. The first instalment of Rs.6 lakhs has been received and a two-day discussion meeting was held during 4-5 February 2010 with Prof. H.L. Bhat as its Coordinator. The main objective of this meeting was to encourage and guide young and upcoming researchers in the field, to submit meaningful project proposals to DST for funding. 24 proposals were presented before the screening committee and all other proposers. Presented proposals were discussed and suggestions for improvement were made during the meeting. The PIs were asked to submit the improvised proposals to the DST in the proper format. [H.L. Bhat].

- Under the ongoing INSA-Hungarian Exchange Programme, Dr. D.S.Shankar Rao visited Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, Budapest, Hungary, for 2 months from 13.07.2009 to 12.09.2009.

  Also under this programme, Prof. Agnes Buka, Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest, Hungary visited the Centre during 22-29 October 2009 under INSA-HAS Exchange of Scientists Programme. During this visit she gave a colloquium entitled “Why is electroconvection still interesting and unavoidable?” on 23 October 2009.

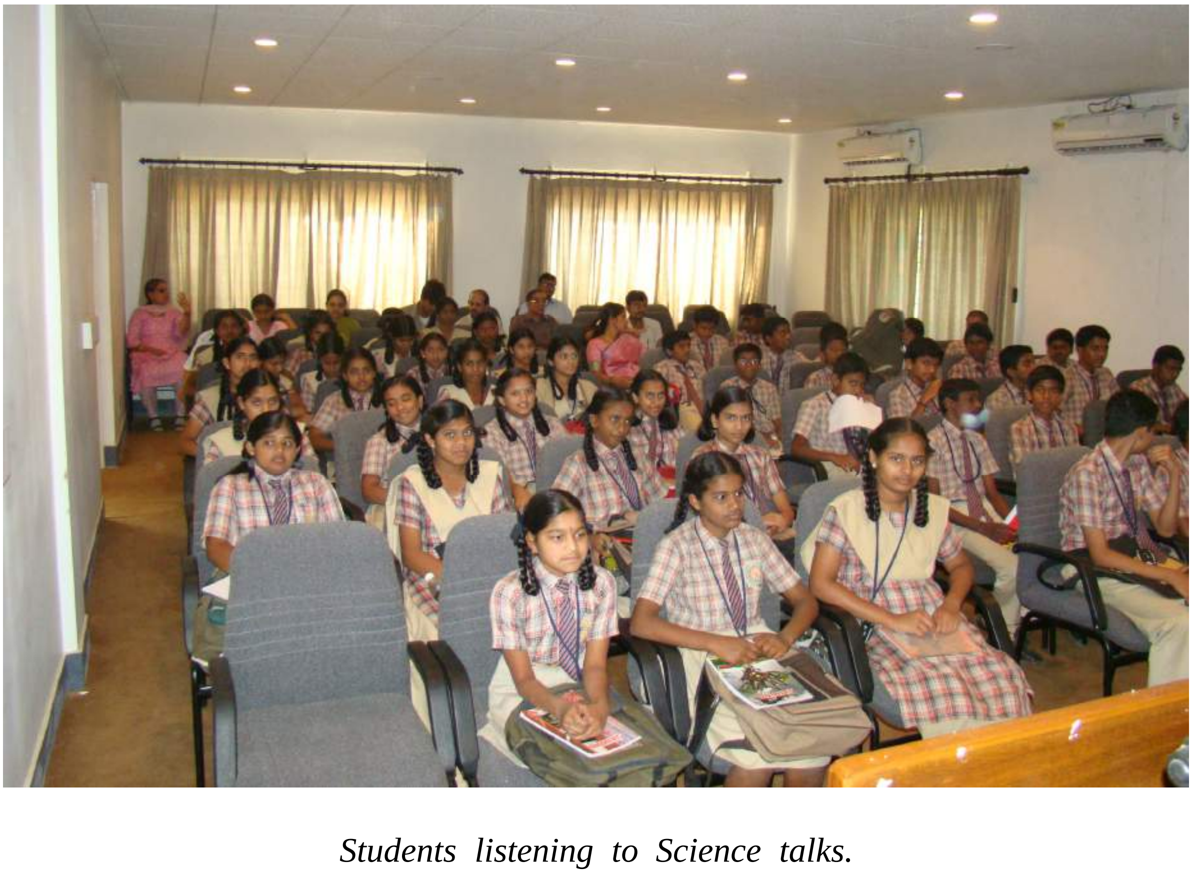
8. NATIONAL SCIENCE DAY

The Centre celebrated the National Science Day on 26 February 2010. The Centre declared that day as Open Day for the public. The Centre invited about 50 children and a few teachers from Raja Rajeshwari High School, Doddabommasandra, Bangalore and arranged for them a series of lectures by the Scientists of CLCR. The lectures were on :

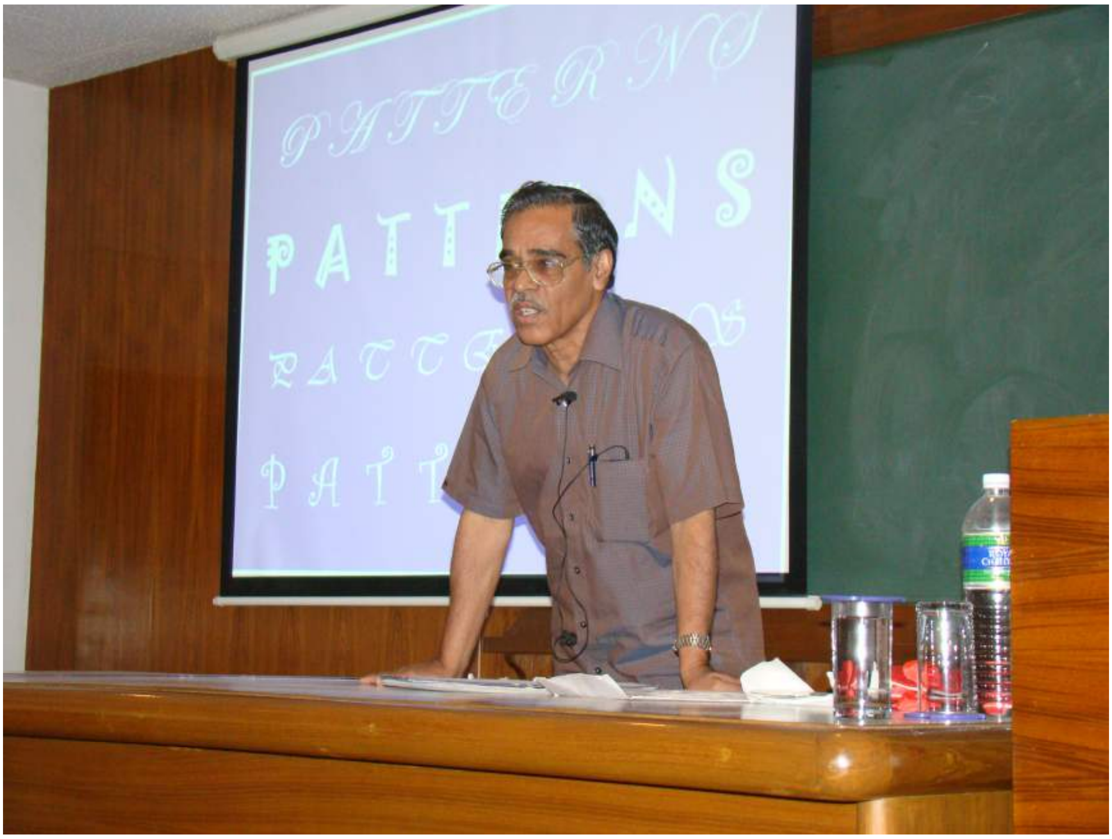
(1) Patterns. (K.S.Krishnamurthy)
(2) Maths and secret writing. (P.Viswanath)
(3) Glimpses of the nano world. (S.Krishna Prasad)
(4) Cyclical motions of the earth. (G.S.Ranganath)
(5) Nuclear energy and crystals. (H.L.Bhat)
(6) Observation, recording, analysis and interpretation in science. (K.A.Suresh)

There were also some demonstrations on science and participation of children in using instruments in the laboratories. The children showed great appreciation of the various programmes conducted at the Centre.

Visiting students waiting for their turn to learn about the research activities at CLCR.



Students listening to Science talks.



Prof. K.S. Krishnamurthy conveying the science of patterns in nature.

Students excitedly observing an experiment by Pramod Tadapatri
on minimum energy surfaces.

Students watching a demonstration by Pramoda Kumar on
the vibration modes of a metal plate excited by sound waves.

Students being exposed to the intricacies of chemical analysis, by Hashambi Dambal.

9. PROF. S. CHANDRASEKHAR MEMORIAL LECTURE

The Centre is observing 6 August of every year as Founder's Day by arranging a Prof.S.Chandrasekhar Memorial Lecture. The sixth lecture in the series was held on 6 August 2009 and the memorial lecture was delivered by Prof. V.S.Ramamurthy, DAE Homi Bhabha Chair Professor, Inter University Acceleration Centre, New Delhi on "Building the Human Resource for Research Intensive Institutions".

Prof. K.A.Suresh welcoming the Speaker, Prof. V.S.Ramamurthy and the Chairman of the Governing Council, Prof. R.Narasimha.

Prof. V.S.Ramamurthy, delivering the 6th S.Chandrasekhar memorial lecture on the importance of human resource for research intensive institutions.

Group photo on the occasion of the 6th S.Chandrasekhar memorial lecture.

10. PROF. G. N. RAMACHANDRAN MEMORIAL LECTURE - MAY 2009

The Governing Council at its meeting held on 13.02.2008 approved the institution of a new series of annual lectures in memory of Professor G.N.Ramachandran. The Series on the Prof. G.N.Ramachandran Memorial Lecture has been initiated with effect from this year. The first lecture in the series was held on 29 May 2009 and the memorial lecture was delivered by Prof. C.N.R. Rao, FRS, National Research Professor, Linus Pauling Research Professor &Honorary President, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore on “Graphene: The New Nanocarbon”.

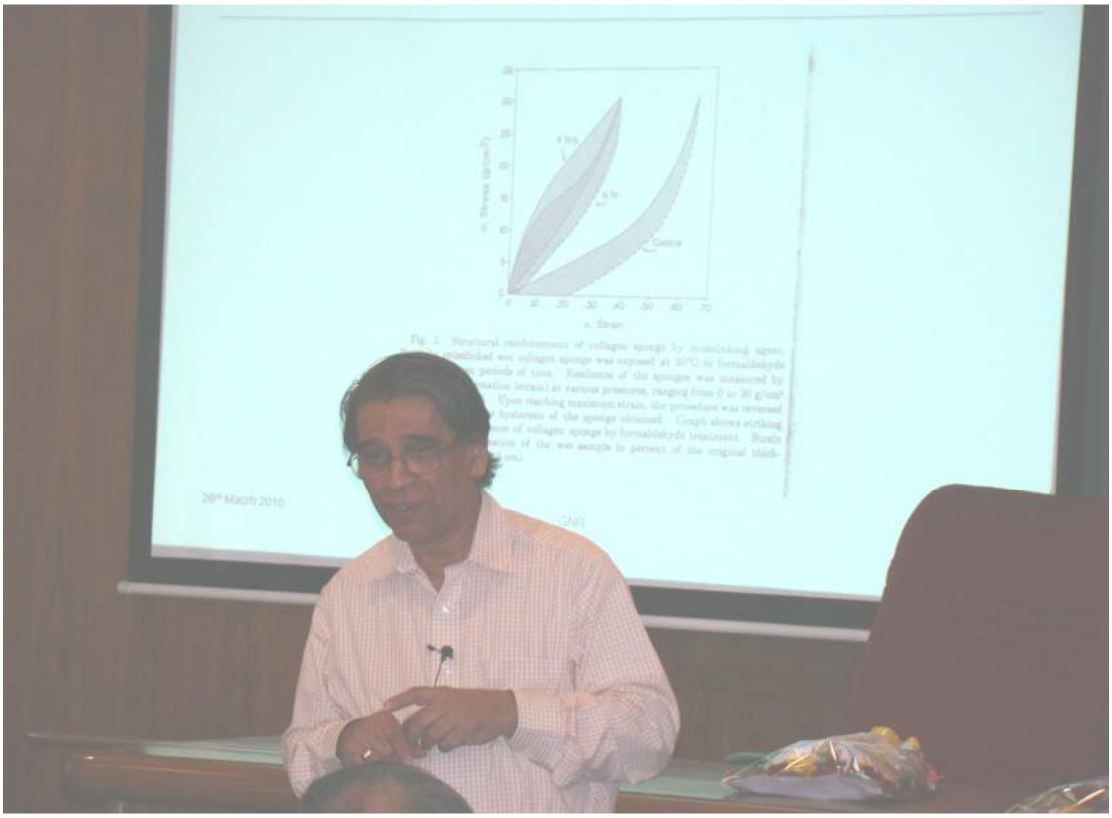
Prof. C.N.R.Rao inaugurating the G.N.Ramachandran Memorial Lecture Series and delivering the first lecture on Graphene: The new nanocarbon.

A brief introduction to the newly instituted G.N.Ramachandran Memorial Lecture Series, by Prof. K.A.Suresh.

11. PROF. G. N. RAMACHANDRAN MEMORIAL LECTURE - MARCH 2010

The second lecture in the series of Prof. G.N.Ramachandran Memorial Lecture was held on 26 March 2010 and the memorial lecture was delivered by Prof. T.Ramasami, Secretary, Department of Science and Technology, New Delhi on “Collagen based Smart Biomaterials".

Welcoming Prof. T.Ramasami, Secretary, Department of Science and Technology.



Prof. T.Ramasami delivering the 2nd G.N.Ramachandran memorial lecture on collagen based smart materials.

Some soft talk on Soft Matter.

Group photo on the occasion of the 2nd G.N.Ramachandran memorial lecture.

12. DISCUSSION MEETING ON “GROWTH OF TECHNOLOGICALLY IMPORTANT CRYSTALS”

The Discussion Meeting on “Growth of Technologically Important Crystals’, sponsored by the Department of Science and Technology, Government of India, New Delhi was held during February 4-5, 2010 at the center with Prof H. L. Bhat as its coordinator. The main objective of this meeting was to encourage and guide young and upcoming researchers in the field, to submit meaningful project proposals to DST for funding. Preliminary proposals received prior to the meeting against an advertisement put up in Current Science (33 in number) were screened and shortlisted by a screening committee.

On the 4th morning, the meeting was inaugurated by the Director of the Centre Prof.K.A.Suresh. Each day there was a lead lecture given by an expert in the field prior to the formal presentation of the proposals .The principal Investigators of the shortlisted proposals (24 in number) made their presentation before the screening committee and all other proposers. Presented proposals were discussed and suggestions for improvement were made during the meeting. The PIs were asked to submit the improvised proposals to the DST in the proper format.

13. POPULARIZING OF SCIENCE

Towards popularization of science the faculty of the Centre gave the following talks

Sl. No.	Name of the faculty	Date	Title of the talk	Place
1.	Prof. H.L.Bhat	04-04-2009	Science and technology of Lasers	J M V College of Engineering, Bangalore
2.		11-05-2009	Science and Technology of Lasers	Visvesvaraya Industrial and Technological museum, Bangalore
3.		26-11-2009	Laser: A powerful Light Source	Shirdi Sai Engg. College, Anekal

4.		09-12-2009	Lasers: Science and Technology	Kolar
5.		12-12-2009	Photoelectric effect	Doddaballapur
6.		15-12-2009	Einstein's connection to Laser	Gadag
7.		17-12-2009	Einstein and Quanta	Regional Institute of Education, Mysore
8.		01-01-2010	Lasers and Applications	NIT, Surathkal
9.		14-01-2010	Einstein and Laser	Internatinal Inst of Information Technology, Pune
10.		29-01-2010	Some aspects of Industrial Crystallization	SIT, Tumkur
11.		31-01-2010	Photoelectric Effect: Einstein's Explanation	IISc, Bangalore
12.		01-02-2010	Laser as a teaching Aid	IISc, Bangalore
13.		24-02-2010	Defects in Crystals	Kuvempu University , Shimoga
14.		20-03-2010	Nonlinear Optical Crystals	BNMIT, Bangalore
15.	Prof. G.S.Ranganath	29-4-2009 and 02-05-2009	Patterns in Nature - 2 lectures	Planetarium, Bangalore
16.		11-05-2009	Engineering concepts in animal design	MVJ College of Engineering, Whitefield, Bangalore
17.		22-05-2009	Strange solids	Planetarium
18.		01-08-2009	Water as a material	Pre-University College, Bangalore North Education Society
19.		29-08-2009, 12-09-2009 and 13-09-2009	Quantum physics - 3 lectures	Planetarium, Bangalore
20.		12-11-2009	Optics and mechanics in animal world - Workshop for teachers	Planetarium, Bangalore
21.		28-02-2010	Thermal physics in everyday life	Karnataka Vigyan Parishat - on occasion of Science Day
22.	Prof.K.S.Krishnamurthy	14-01-2010	Liquid Crystals and Modulation of Light	International Institute of Information Technology, Pune, Talk given under the DST Programme: Innovation in Science Pursuit for Inspired Research (INSPIRE)
23.	Dr.S.Krishna Prasad	02.12.2009	Two lectures on "Liquid Crystals"	At Gulbarga and Bidar under the Karnataka Vigyana Vidya Jaagruti programme organized by Karnataka Rajya Vigyana

				Parishat, Government of Karnataka
24.		17.03.2010	Introductory lecture "Liquid crystals, Laptops and life"	In the " Science and Technology of liquid crystals" workshop held at the SJRC Institutions, Bangalore
25.	Dr. C.V.Yelamaggad	26-12-2009	**Lecture I**: "Introduction to Liquid Crystals" **Lecture II**:" Applications, Physics and Chemistry Aspects of Liquid Crystals"	Sri Suttur Veerashimhasana Math, Sri Kresthra Suttur, Nanjungud Taluk, Mysore. Served as Resource Person for Refresher Course for PU College Lecturers. Delivered two lectures. This was organized by Department of Pre-University Education and Department of Science and Technology, Government of Karnataka.
26.		09-12-2009	How can Crystals be Liquids?	The Bangalore Science Forum A. V. Hall, National High School, Basavanagudi, Bangalore.
27.		4.12.2009	Liquid Crystals –An Unique State of Matter	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, Conducted by Karnataka Rajya Vijnana Parishat (KRVP), and delivered a lecture at Haveri. Venue: Jilla Gurubhavan, Haveri.
28.		26-11-2009	Liquid Crystals –An Unique State of Matter	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, conducted by KRVP, and delivered a lecture at Bagalakot. Venue: Basaveshwar Engineering College, Bagalkot.
29.		26-11-2009	Liquid Crystals –An Unique State of Matter	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, conducted by KRVP and delivered a lecture at Bijapur. Venue: K. C. Patil Science College Engineering College, Bijapur.
30.		18-11-2009	Liquid Crystals – An Unique State of Matter	Vijaya Composite Pre-University College, South End Circle, Bangalore. PUC students, faculty members, administrative staff including Principal of the college attend the same.
31.		18-11-2009	Liquid Crystals	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, conducted by KRVP and delivered a lecture at Bangalore. Venue: H. N.

				Kalakshetra, Jayanagar, Bangalore.
32.		17-11-2009	Liquid Crystals	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, Conducted by KRVP, and delivered a lecture at A. E. S. National College, Gauribidanur, Kolar District.
33.		31-10-2009	Liquid Crystals	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, conducted KRVP and delivered a lecture at Chitradurga Venue: Ta. Ra. Su. Jilla Rangamandira, Chitradurga.
34.		03-10-2009	Liquid Crystals	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, Conducted by KRVP, and delivered a lecture at Madhugiri. Venue: M. N. K. Kalyana Mantap, Madhugiri.
35.		03-10-2009	Liquid Crystals	Participated in Students (SSLC and PUC-I)–Scientists Interactive Program, Conducted by KRVP and delivered a lecture at Tumakur. Venue: Sri Siddaganag College of Pharmacy, Tumakur.

14. STUDENTS PROGRAMME

- Ms. V.Jayalakshmi, SRF has submitted her thesis entitled "Experimental investigations of electric field effects in liquid crystals” to the Mangalore University in December 2009 for the award of Ph.D degree. Has since left CLCR on a post doctoral fellowship at Queen’s Univeristy, Canada.
- Mr. G.Shanker was awarded the Ph. D degree by the Mangalore University in August 2009 for the thesis entitled “Studies of liquid crystals with novel molecular architecture: design, synthesis and characterization”.

- Ms. S.Sridevi visited Zaragoza, Spain to attend the 12 International Conference on Ferroelectric Liquid Crystals, during 31 August to 4 September 2009 under the financial assistance of DST.

- Mr. Sanjay K Varshney, visited the Tokyo Institute of Technology, Japan on an invitation from the Japan Society for the Promotion of Science (JSPS) RONPAKU (Dissertation Ph.D.) Programme for 30 days, beginning from 03 January 2009.

- During the year, five new students were taken under the Ph.D. Programme 2009.

15. HONORS / AWARDS / PRIZES

Prof. K.A. Suresh was elected as Fellow of the Indian National Academy of Sciences (INSA), New Delhi during the year 2009.

16. VISITS ABROAD

- Dr. D.S.Shankar Rao visitied Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, Budapest, Hungary, under the INSA-Hungarian Exchange Programme, for 2 months from 13.07.2009 to 12.09.2009.

- Dr. C.V.Yelamaggad visited Japan to attend 4th Asia Symposium on Functional Dyes at Advanced Materials, held at Osaka, Japan during 2-10 June 2009. During this period he visited (i) Prof. N. Nakatsuji's laboratory, Graduate School of Material Science, University of Hyogo, Hyogo, Japan and gave a talk on "Self-Assembly of Supramolecules into Helical Fluid Columns" and (ii) Prof. Kazuchika

Ohta’s laboratory, Smart Materials Science and Technology, Department of Bioscience and Textile Technology, Interdisciplinary Graduate School of Science and Technology, Shinshu University Ueda, Nagano, Japan and gave two talks entitled “Self-Assembly of Supramolecules into Helical Fluid Columns” and “Luminescent Discotic Tris(salicylideneaniline)s : Synthesis and Mesomorphism”.

- Dr. S.Krishna Prasad visited Institute of Solid State Physics, Bulgarian Academy of Science, Bulgaria under Indo-Bulgarian Joint Research Programme, during 6-20 November 2009. During this visit he gave a talk on “Photo-stimulated Phase Transitions”.
- Dr. S.Krishna Prasad visited China to attend International Symposium on Liquid Crystal Science and Technology held at Kunming, China during 2-6 August 2009 and gave plenary lecture on "Photo-induced and photo suppressed phase transitions". He also chaired a session.

17. SEMINARS / TALKS GIVEN AT OTHER INSTITUTES

- Dr. Veena Prasad attended National Conference on the Emerging Areas in Chemistry (NACEAC-2009) during 31.7.09 to 1.8.09 at Mysore University gave an invited lecture on "Photo-responsive and electrically switchable mesophases: a new dimension to the bent-core liquid crystals".

- Dr. .P.Viswanath visited Ghaziabad to attend the workshop on 'Administrative vigilance for vigilance officers' as Vigilance Officer of CLCR held during 30 November to 3 December 2009.

- Dr. S.Angappane visited Tata Institute of Fundamental Research, Mumbai for technical clarification on SQUID magnetometer during 15 to 20 February 2010

18. INTERNATIONAL WOMEN'S DAY

The Centre celebrated the International Women's Day on 9 March 2009 at CLCR premises. Dr. Geetha G.Nair convened a meeting held at CLCR and the women members of the Centre discussed various issues.

19. VISIT OF SCIENTISTS FROM ABROAD AND COLLOQUIA / SEMINARS GIVEN AT THE CENTRE

- Dr. Santanu Kumar Pal, University of Wisconsin-Madison, USA visited the Centre on 30 June 2009 and gave a seminar on "Chemically-responsive gels prepared from microspheres dispersed in liquid crystals".

- Dr. Christophe Marin, Nanocryogeny Institute, CEA Grenoble, France visited the Centre on 13 October 2009 and gave a seminar on "Growth of novel magnetic crystals ".

- Prof. Agnes Buka, Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest, Hungary visited the Centre during 21-24 October 2009 and gave a colloquium entitled "Why is electroconvection still interesting and unavoidable?" on 23 October 2009.

- Prof. Gerald G. Fuller, Stanford University, California, USA, visited the Centre on 7 January 2010 gave a colloquium on "Liquid Crystalline Collagen: A Self-Assembled Morphology for the Orientation of Mammalian Cells".

- Dr. Yordan G.Marinov, Scientist, Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria visited the Centre during 6-26 March 2010 and gave a colloquium on “Surfactant desorption in homeotropic nematic layers studied by flexoelectric spectroscopy” on 18 March 2010.

20. SEMINARS / COLLOQUIA GIVEN AT THE CENTRE

- Ms. Nagaveni N.G., JRF, gave a seminar on " Unconventional Thermotropic Liquid Crystals Consisting of an Azo Linkage : Synthesis and Mesomorphic Properties" on 19 June 2009.

- Ms. Rashmi Prabhu, JRF, gave a seminar on "Synthesis and Characterization of Thermotropic Liquid Crystals with Novel Molecular Architecture" on 27 July 2009.

- Ms. R.Bhargavi, JRF, gave a seminar on "Rheological studies of liquid crystal gels and composites" on 25 August 2009.

- Mr. Vinaya Kumar K. R., JRF, gave a seminar on "Films of mesogenic amphiphilic molecules at air-water and air-solid interfaces" on 26 August 2009.

- Prof. G.S.Ranganath, Visiting Professor, gave a seminar on "Phases of ice" on 24 September 2009.

- Ms. V. Jayalakshmi, SRF, gave a seminar on " Experimental Investigations of Electric Field Effects in Liquid Crystals" on 14 December 2009.

- Mr. Sanjay K.Varshney, gave a seminar on " Discotic Liquid Crystals as Functional Materials : Synthesis and Mesomorphism" on 24 December 2009.
- Mr. Pramoda Kumar, SRF, gave a seminar on "Field Driven Reorientational and Convective Instabilities in Nematic Liquid Crystals" on 12 January 2010.

21. COURSES GIVEN AT CLCR

Prof. H.L. Bhat gave a course of six lectures on "Defects in Solids" directed towards Ph.D. students.

Dr. S.Krishna Prasad gave a course of seven lectures on "Structure and Properties of Liquid Crystals" directed towards Ph.D. students.

Dr. C.V.Yelamaggad gave a course of five lectures on "Liquid Crystal Chemistry" directed towards Ph.D. students.

Dr. S.Angappane gave a course of ten lectures on "Solid State Physics" directed towards Ph.D. students.

Dr. P.Viswanath gave a course of ten lectures on "Introduction to Scientific Computing" directed towards Ph.D. students.

22. LIST OF SCIENTISTS AND RESEARCHERS

Name		Designation
1.	Prof. K.A.Suresh	Director
2.	Dr. S.Krishna Prasad	Scientist E
3.	Dr. Geetha G.Nair	Scientist C
4.	Dr. D.S.Shankar Rao	Scientist C
5.	Dr. Veena Prasad	Scientist C
6.	Dr. C.V.Yelamaggad	Scientist C
7.	Dr. P.Viswanath	Scientist C
8.	Dr. S.Angappane	Scientist C
9.	Prof. K.S.Krishnamurthy	Emeritus Scientist
10.	Prof. H.L.Bhat	Visiting Professor
11.	Prof. G.S.Ranganath	Visiting Professor
12.	Dr. Uma S.Hiremath	Research Associate
13.	Dr. V.Padmini	Research Associate
14.	Mr. Pramoda Kumar	Senior Research Fellow
15.	Ms. Jayalakshmi	Senior Research Fellow
16.	Ms. S.Sridevi	Senior Research Fellow
17.	Mr. Pramod Tadapatri	Senior Research Fellow
18.	Mr. Prasad N.Bapat	Senior Research Fellow
19.	Ms. Rashmi Prabhu	Junior Research Fellow
20.	Ms. N.G.Nagaveni	Junior Research Fellow
21.	Ms. R.Bhargavi	Junior Research Fellow
22.	Mr. Vinaya Kumar K.R.	Junior Research Fellow
23.	Ms. T. Shilpa Harish	Junior Research Fellow
24.	Mr. M.Vijaykumar	Junior Research Fellow
25.	Ms. R. Rajalakshmi	Junior Research Fellow
26.	Ms. Hashambi K.Dambal	Junior Research Fellow
27.	Ms. K. Gayathri	Junior Research Fellow
28.	Mr. K.R.Sunil Kumar	Project Assistant
29.	Ms. Halley M.Menezes	Project Assistant

23. ADMINISTRATIVE STAFF

Name	Designation
1. Shri Subhod M.Gulvady	Administrative Officer
2. Shri K.R.Shankar	Accounts Officer
3. Shri P.K.Ramakrishnan	Engineer
4. Shri A. Puttaswamy	Maintenance Engineer (16.7.09 to 10.10.09)
5. Shri L. Chandra Sekhar	Maintenance Engineer
6. Smt P.Nethravathi	Office Superintendent
7. Shri Sanjay K.Varshney	Technical Assistant
8. Smt Sandhya D.Hombal	Technical Assistant
9. Shri M.Jayaram	U.D.C.
10. Shri Govindappa	Consultant in Administration

24. PUBLICATIONS DURING 2009-2010

Books

1) Diversity in Materials Science. Editors: S.B Krupanidhi and H.L.Bhat, Indian Academy of Sciences and Materials Research Society of India, Bangalore, 2009

Chapter published in a Book

1) A combined DFT and carbon-13 NMR study of a biaxial bent-core liquid crystal, A. Marini, Veena Prasad and R.Y. Dong, Chapter 13 in the book entitled "*Nuclear magnetic resonance spectroscopy of liquid crystals*" Ed. By R. Y. Dong, World Scientific Publishers, Singapore, 2009.

Papers published

In Journals

1) Nematic biaxiality in a bent-core material, H.G. Yoon, S. Kang, R.Y. Dong, A. Marini, K.A. Suresh, M. Srinivasarao and S.Kumar, *Phys. Rev. E*, **81**, 051706 (1-7) (2010).

2) Soft glass rheology in liquid crystalline gels formed by a monodisperse dipeptide, Geetha G. Nair, S. Krishna Prasad, R. Bhargavi, V. Jayalakshmi, G. Shanker and C.V. Yelamaggad, *J. Phys. Chem.,* **114**, 697(2010).

3) Patterned electroconvective states in a bent-core nematic liquid crystal,

P.Tadapatri, Uma S. Hiremath, C. V. Yelamaggad and K. S. Krishnamurthy, *J. Phy. Chem*. *B*, **114***,* 10 (2010).

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Papers & Posters presented at the Conferences

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17) *Electric-field dictated phase diagram and accelerated dynamics of a reentrant nematic liquid crystal under photo-stimulation,* S.Sridevi, Oral presentation at the 16th National Conference on Liquid Crystals, Oct 26-28, 2009 organised by the University of Lucknow, Lucknow.

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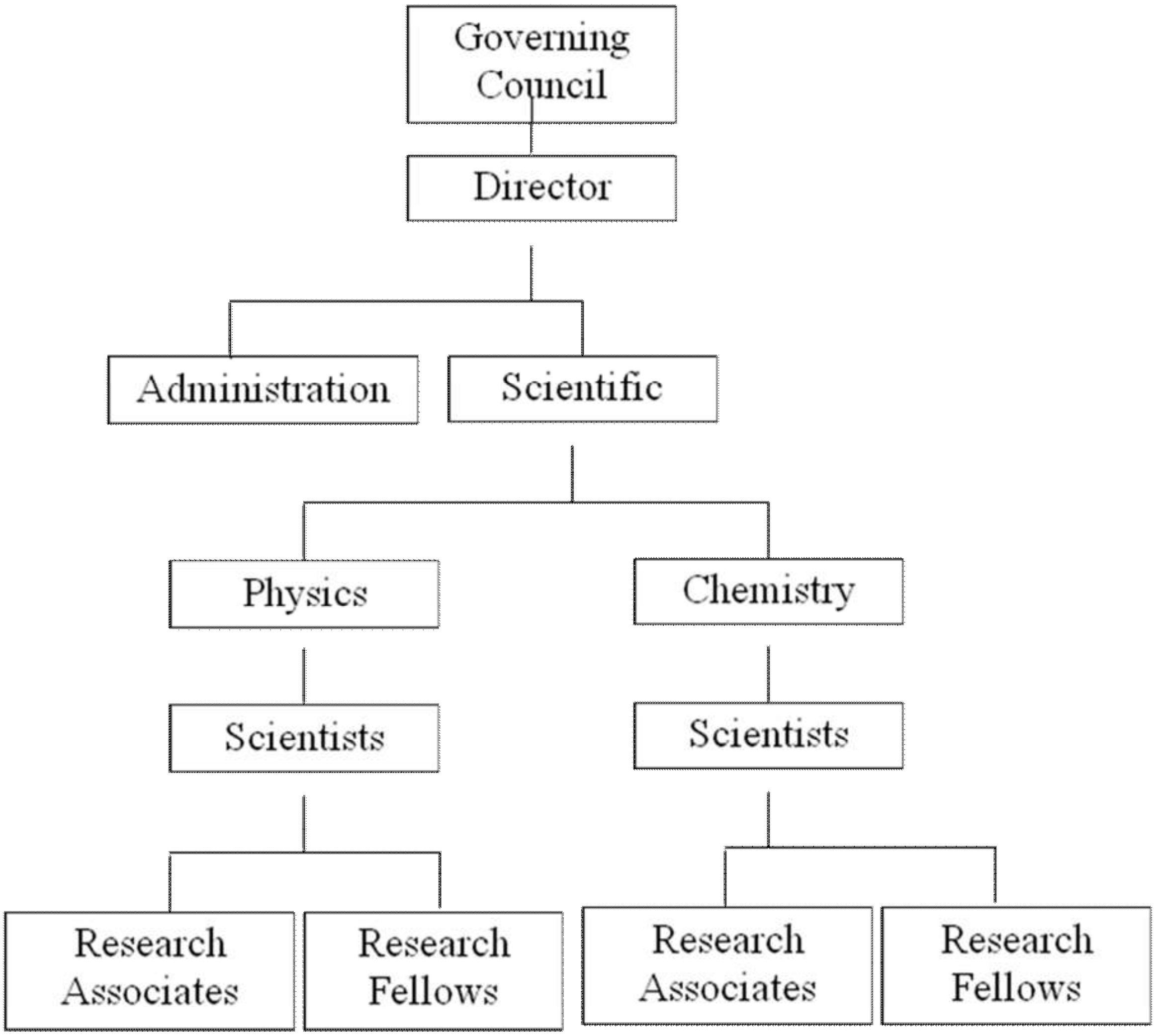

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