Centre for Liquid Crystal Research
Bangalore

तरल क्रिस्ट्ल अनुसंधान केंद्र
बेंगलूर

Annual Report
2008 - 2009

वार्षिक रिपोर्ट
२००८ – २००९

CENTRE FOR LIQUID CRYSTAL RESEARCH
BANGALORE

ANNUAL REPORT
2008 – 2009

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Prof. K. A. Suresh — **Member-Secretary**
Director
Centre for Liquid Crystal Research
P.B.No.1329, Jalahalli
BANGALORE - 560 013

CONTENTS

FOREWORD

The Centre for Liquid Crystal Research (CLCR) is 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 Centre focuses on basic science, and to develop a bias towards technology, conducting research and publishing in high impact journals, training students in its Ph.D. Programme and popularizing science.

This Annual Report for the year 2008-2009, highlights some of the research, development and academic programmes of the Centre, and lists the scientific output of the Centre in its academic activities and scientific publications for the period from 1 April 2008 to 31 March 2009. Among the research publications, an article entitled "Shear deformation and division of cylindrical walls in free-standing nematic films under high electric fields" had some of its figures reproduced on the cover page of the Journal of Physical Chemistry B. Also another article entitled "Optically biaxial interdigitated smectic A phase: liquid crystalline dimeric bidentate ligands and their metal complexes" had one of its figures reproduced on the cover page of the Journal of Materials Chemistry.

The Centre is gradually, broadening its scope in research in Soft Matter, an interdisciplinary area connecting physics, chemistry, biology and material science. However, the Centre plans to keep both thermotropic and lyotropic liquid crystals as its core area of research.

Bangalore

11 September 2009

K. A. SURESH

DIRECTOR

1. INTRODUCTION

The Centre for Liquid Crystal Research (CLCR) was earlier 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. Since December 2002 (effective April 2003), the Centre has come under the administrative control of the Department of Science and Technology, Ministry of Science and Technology. 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, related areas and devices.

CLCR is engaged in research and development on the synthesis and characterization of a host of liquid crystal materials. CLCR is the only centre in the country devoted to research and development in liquid crystals and related areas.

CLCR 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 December 2002, 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 2008-09, a grant of Rs.365 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.

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 twice on 6 February 2008 and 18 December 2008.

5. FINANCE COMMITTEE

The first meeting of the Finance Committee with the following members was held on 5 September 2008.

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 SHEAR DEFORMATION AND DIVISION OF CYLINDRICAL WALLS IN FREE-STANDING NEMATIC FILMS UNDER HIGH ELECTRIC FIELDS

This investigation focuses on the behaviour of cylindrical walls formed in a substrate-free nematic film of PCH5 under the action of an inplane ac field. In the film, with vertical molecular alignment at all the limiting surfaces, annular walls are induced well above the bend-Freedericksz threshold. They exhibit, at high field strengths, a new type of instability not encountered in sandwich, or any other, cell configuration. It manifests as a shearing of the loop-wall between the opposite free-surfaces (Fig. 1). The shear strain is measured as a function of time, field strength, frequency and temperature. Significantly, the strain is linear in field strength. The origin of shear and its dependence on field variables are explained through an adaptation of the Carr-Helfrich mechanism of charge separation. The sheared wall is stable against pincement up to several times the threshold field, and divides itself into two fragments under a large enough strain. With the shear distortion, linear defects

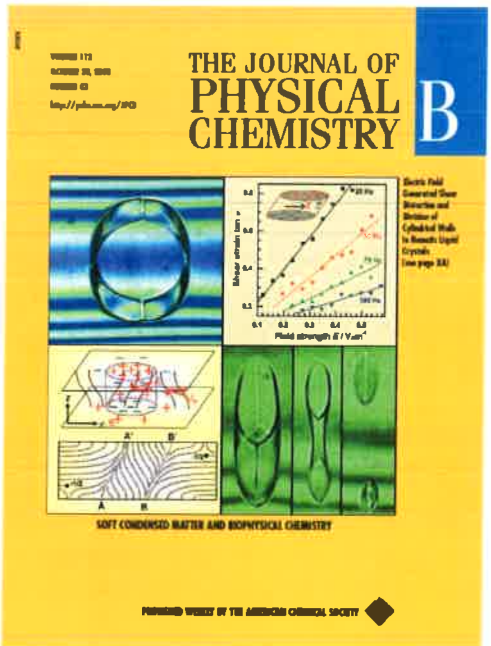


Figure 1. Cover page of the journal in which the results of the study are published. The picture shows the sheared wall (top left), linear relation between the field and strain (top right), mechanism of charge accumulation on the domain faces (bottom left) and division of the loop wall (bottom right).

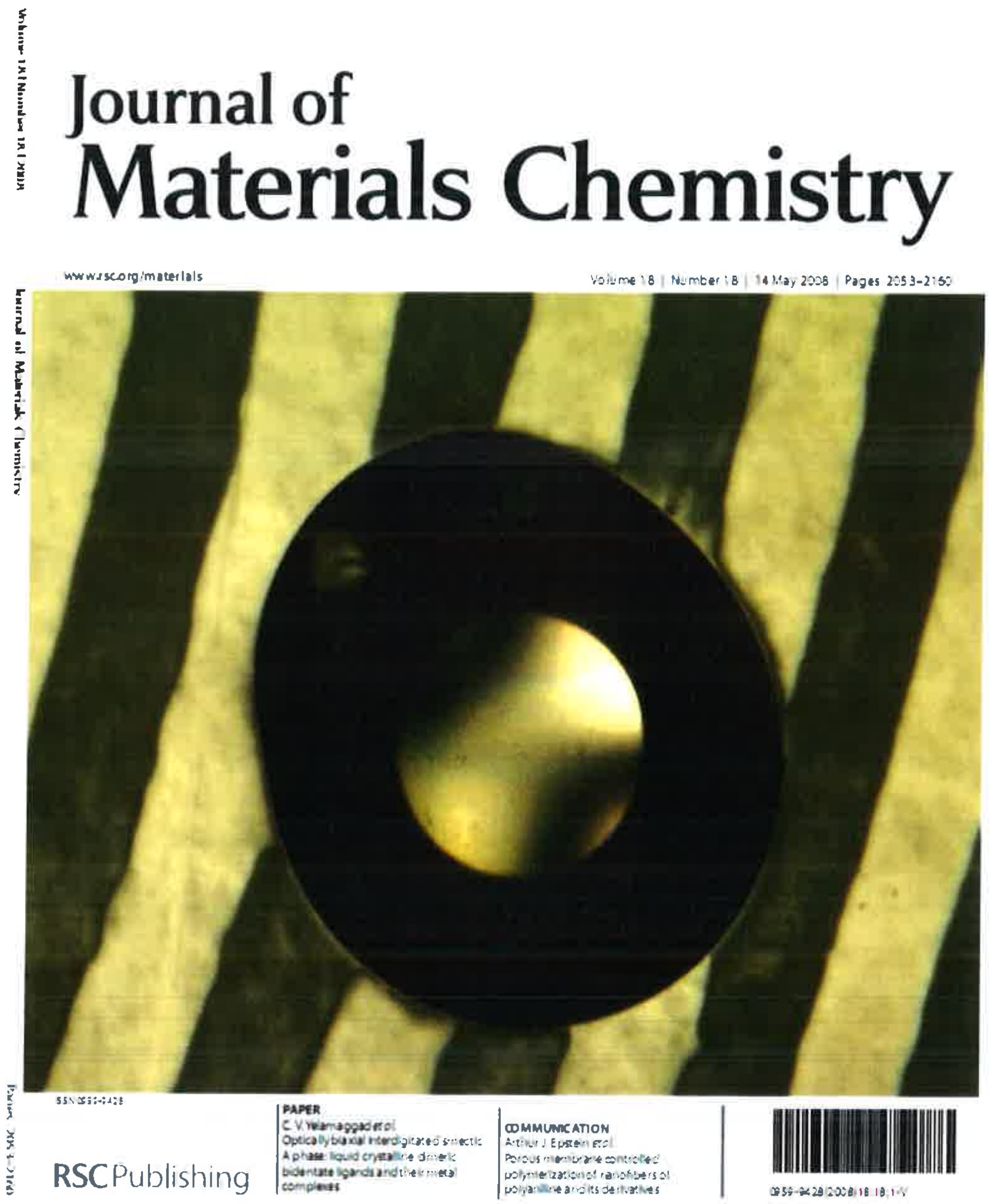
(Published in October 2008)

appear in the opposite splay-bend regions, just as Neel lines in Bloch walls of magnetic systems. At very low frequencies, flexoelectric influence on distortion is revealed.

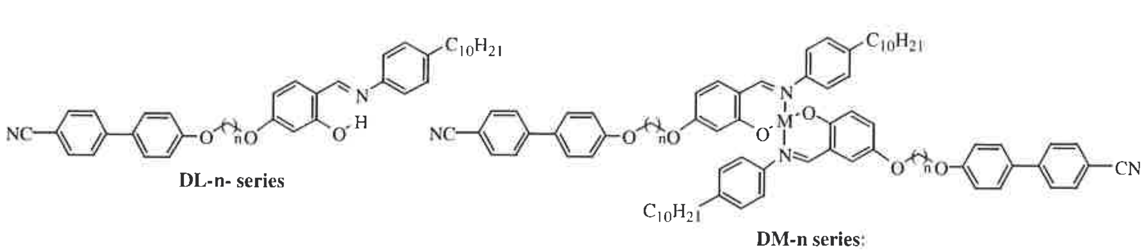
Investigators: Pramod Tadapatri and K. S. Krishnamurthy

6.2 OPTICALLY BIAXIAL INTERDIGITATED SMECTIC A PHASE : LIQUID CRYSTALLINE DIMERIC BIDENTATE LIGANDS AND THEIR METAL COMPLEXES

A series of dimeric bidentate ligands (DL-*n* series) and their Cu(II) and Pd(II) (DM-*n* series) complexes have been designed, synthesized and characterized (see Chart 1). In general, the dimeric bidentate ligands exhibit nematic and/or smectic phase/s. The dimers comprising an odd-parity spacer exhibit an interesting phase sequence viz., nematic (N)-uniaxial smectic A (SmA) SmA- biaxial SmA (SmA_b), see Fig.1. This is remarkable given the fact that mesogens showing the SmA_b phase are rather scarce. As expected, the dimers having an even-parity spacer display different behavior. The dimeric ligand having a short even (hexamethylene) spacer shows a trimesomorphic sequence: N-SmA- anticlinic smectic C (SmC_a) phase; compounds with intermediate (octamethylene) or long (decamethylene) spacers show the N and/or SmA phase only. On the contrary, the Cu(II) and Pd(II) complexes of these ligands are solely nematogens. However, the copper complexes exhibit an odd-even effect for the nematic-isotropic transition temperatures and the associated entropy values, a feature not reported hitherto. Thus, the occurrence of the SmA_b phase in nonsymmetrical liquid crystal dimers comprising two rod-like anisometric segments separated by odd parity spacer has been evidenced unequivocally for the first time. Besides, in the course of this study, we have realized the first examples of metallomesogens derived from achiral nonsymmetrical bidentate dimeric ligands.



Cover page of the journal in which the results of the study are published.
(Published in May 2008)



DL-n- series

DM-n series:

Chart 1: Molecular structures of dimeric bidentate ligands and their Cu(II) and Pd(II) complexes

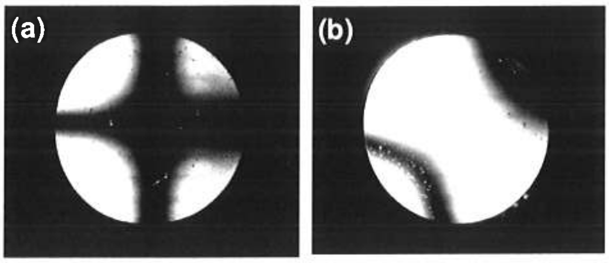


Figure 1: Microphotograph of the conoscopic patterns obtained for the homeotropically aligned dimer having pentamethylene spacer: (a) the SmA phase; (b) the SmA_{db} phase, notice that the isogyres are well separated.

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

6.3 MECHANICAL PROPERTIES OF LANGMUIR–BLODGETT FILMS OF A DISCOTIC LIQUID CRYSTAL–DNA COMPLEX BY ATOMIC FORCE MICROSCOPY

Discotic molecules have drawn lot of attention for their intriguing supramolecular architectures. In addition, because of their potential applications in devices such as light emitting diodes, photovoltaic solar cells, field-effect transistors and gas sensors, researchers have designed and synthesized several types of discotic liquid crystals (discogens). Although aliphatic lipid–DNA complexes are known for decades, the discogen–DNA complexes have been studied recently, and they are expected to have some novel applications.

The successful long-term performance and reliability of these materials in practical devices are usually limited by their mechanical properties. Hence, measurements of the mechanical properties of such materials are of paramount importance. The conventional techniques to measure the mechanical properties are generally restricted to macroscopic length scale, whereas the current trend in miniaturization of products and devices pose the need for characterization of materials at nanoscale. One of the convenient and reliable techniques for the precise

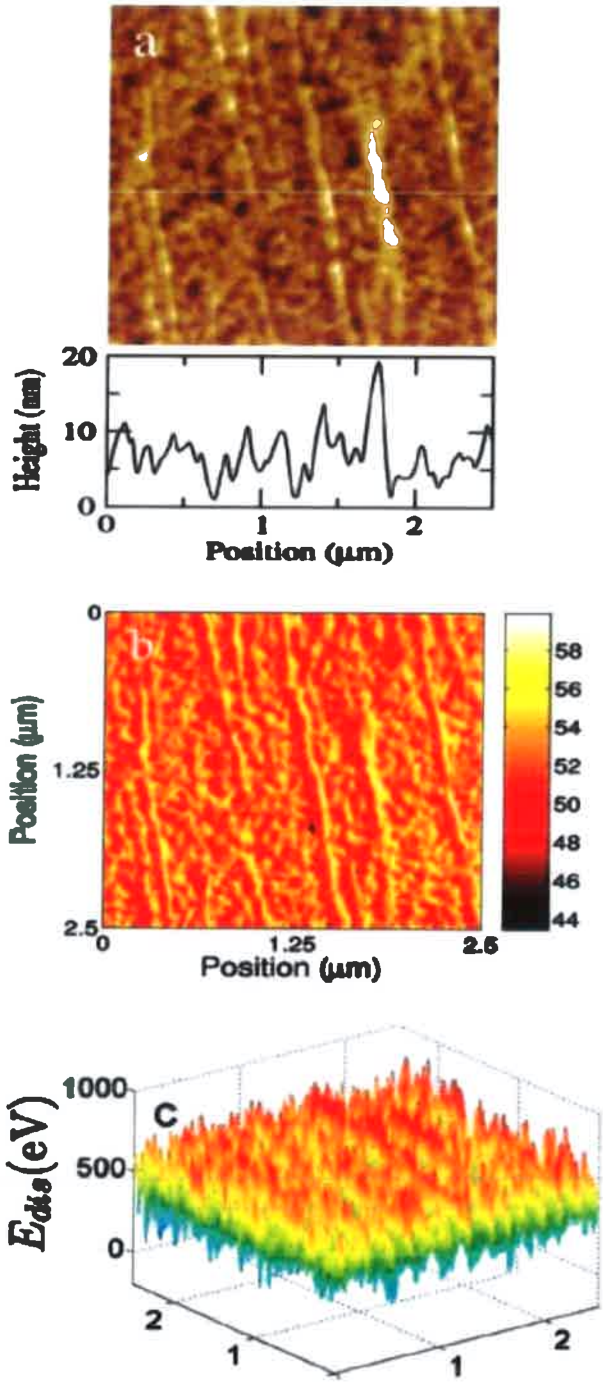


Figure : Tapping mode AFM images of the PyTp–DNA complex LB film with 20 layers: (a) topography image, showing height profile; (b) simultaneously acquired phase image, the scale bar shows phase shift in degrees; (c) corresponding energy dissipation (E_{dis}) map constructed from the phase image.

measurement of mechanical properties of nanostructures is to employ an atomic force microscope (AFM).

We have studied the mechanical properties of films of a novel ionic discogen, pyridinium tethered with hexaalkoxytriphenylene (PyTp) and its complex with DNA (PyTp–DNA) using atomic force microscope (AFM). The PyTp and PyTp–DNA complex monolayer films were first formed at air–water interface and then transferred onto silicon substrates by Langmuir–Blodgett (LB) technique. For the mechanical properties, particularly to obtain elastic modulus, we have carried out nanoindentation measurements on the LB films of PyTp and also PyTp–DNA complex. The load versus indentation curves from the nanoindentation measurements were analyzed quantitatively using Hertz model. Our analysis yields Young's modulus values of 54 and 160 MPa for the PyTp and PyTp–DNA complex films, respectively. In addition, the LB films were imaged in the tapping mode AFM to obtain topography and phase images simultaneously (Figure). The energy dissipation maps were constructed from the phase images to determine qualitatively the variation in stiffness on the film surfaces. We find that the complex film exhibits a nonuniform surface with varying stiffness while the pure film exhibits a uniform surface.

Investigator: K. A.Suresh
Collaborator: Alpana Nayak, Raman Research Institute, Bangalore

6.4 MONOLAYER OF AMPHIPHILIC FUNCTIONALIZED GOLD NANOPARTICLES AT AN AIR-WATER INTERFACE

The properties of the materials change drastically when its dimensions scale down to nanometer length scale. Nanoparticles can be forced to assemble on superlattices whose optical and electronic properties are tunable. One of the important parameters determining the properties of nanoparticle crystals is the interparticle separation. The interparticle separation can precisely be manoeuvred by forming the monolayer of the nanoparticles at an interface and changing the surface density. A stable monolayer films at the air-water (*A-W*) interface is known as a Langmuir monolayer. The Langmuir monolayer is an ideal system for studying the thermodynamics of two-dimensional (2D) systems and the nature of interactions involved between the particles. Changing the interparticle distances by the lateral compression of the monolayer, different 2D phases can be obtained. These phases can be transferred layer by layer onto different substrates by the Langmuir-Blodgett (LB) technique. A few attempts have been made to study the Langmuir monolayer of the functionalized metal nanoparticles at the *A-W* interface. However, the particles studied so far did not show a stable Langmuir monolayer. Accordingly, we synthesized amphiphilic gold nanoparticles (AGNs) functionalized with hydroxy-terminated alkyl-thiol and studied the Langmuir film of the particles by surface manometry and microscopy techniques (Figures 1 and 2). We find a stable Langmuir monolayer of the AGNs at the *A-W* interface.

Langmuir films at the air-water interface exhibit a variety of surface phases which arise primarily due to the molecular interaction governed by intermolecular separation. We have studied the thermodynamical aspects of Langmuir monolayers of amphiphilic functionalized gold nanoparticles at the air-water interface. Interestingly, the AGN monolayer exhibits phases like gas, a low-ordered liquid *L*1, a high-ordered liquid *L*2, and a collapsed state. We find that the first-order phase transition between *L*1 and *L*2 vanishes above a critical temperature of 28.4°C.

Surprisingly, for a range of higher temperatures >=29.4 °C and <=36.3 °C, the *L*1 phase undergoes a transition to a bilayer of the *L*2 phase before entering into the collapsed state.

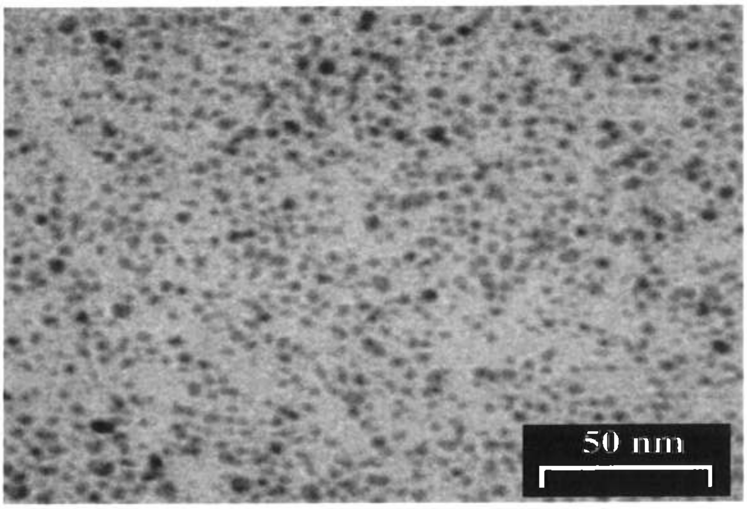


Figure 1: Transmission electron microscope (Hitachi, H7000, 100 kV) image of the AGN. The solution of the sample of AGN was spread on a carbon-evaporated copper grid, and the image was scanned after 2 hours.

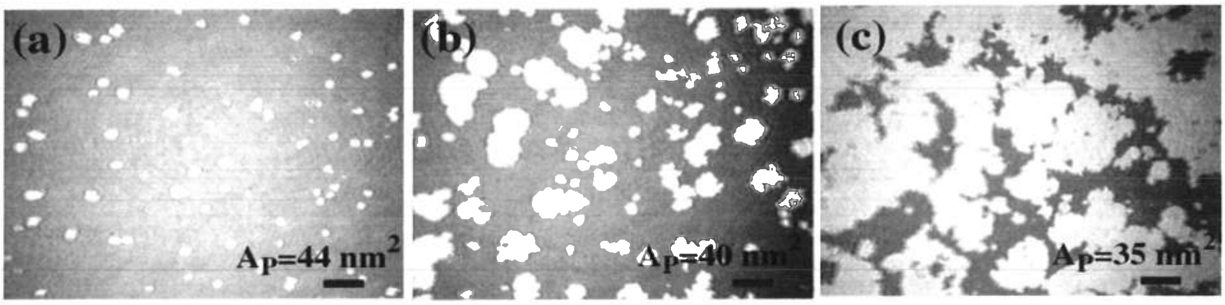


Figure 2: The BAM images of the monolayer of AGNs at 31 °C taken at different area per molecule (AP). Figures a to c show the nucleation and growth of bright domains on the gray background. Scale bar=500 micro metre.

<u>Investigator :</u> K. A. Suresh
<u>Collaborators:</u> Raj Kumar Gupta, Birla Institute of Technology, Pilani and Sandeep Kumar, Raman Research Institute, Bangalore.

6.5 UNUSUAL DIELECTRIC AND ELECTRICAL SWITCHING BEHAVIOUR IN THE DE VRIES SMECTIC A PHASE OF TWO ORGANOSILOXANE DERIVATIVES

Smectic A (SmA) and smectic-C (SmC) liquid crystals are layered phases possessing quasi-long-range positional order in one dimension represented by a mass-density wave, whose wave vector is either along the director (SmA), or tilted (SmC). Owing to the tilt, the layer thickness is shorter in the SmC phase than in the orthogonal SmA phase. A phase that has certain features of these two phases and termed de Vries Sm A has the molecules substantially tilted, but with only short-range azimuthal coherence. The chiral version of this phase has particularly attracted much attention owing to the non-observation of zigzag defects as a direct consequence of the associated minimal layer shrinkage across the SmA-SmC(rather chiral SmC or SmC*) phase transition. Various aspects of the de Vries SmA phase have been reported in a number of papers yet the structural aspects of this phase are not yet completely understood. We have investigated the layer spacing,

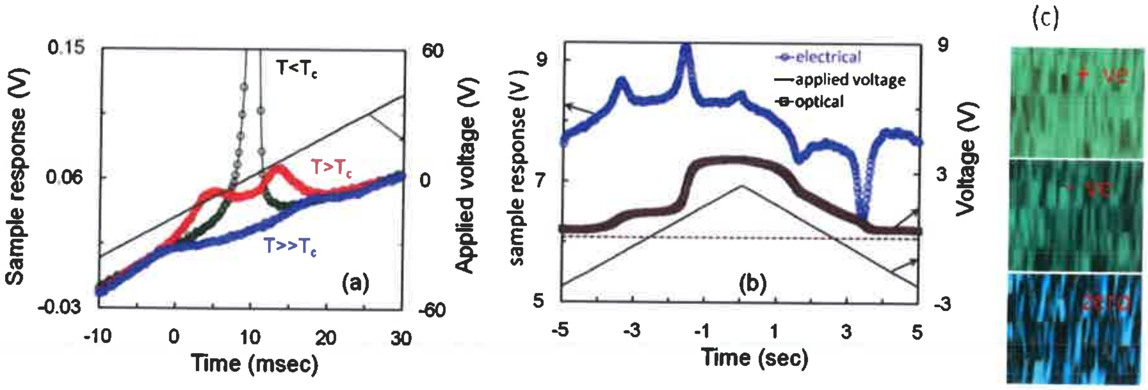


Figure 1: (a) Current response (open circles) of ETSi sample upon application of a triangular wave field in the SmC (data set $T<T_c$) and SmA phases. Notice the double peak profile in the SmA phase, whose magnitude decreases with increasing temperature. (b) The optical response obtained simultaneously with the $T>T_c$ data set and the applied triangular wave form. The zero of the applied voltage is indicated as dashed line. (c) Polarizing textures in the SmA phase in the absence of, and when ±60V is applied. The vertical arrow indicates the SmA-SmC* transition temperature*

electrical, electro-optical and low frequency dielectric behavior of two organosiloxane derivatives exhibiting the de Vries SmA phase. While one of the materials exhibits a clear first order transition with coexistence of Xray peaks and a jump in the layer spacing, the second compound shows a near-first order character. But in both the cases a pretransitional decrease in the layer spacing is seen on the SmA side, which we suggest is a direct proof of the de Vries character of the phase. The surprising result of the present studies is that the electrical and electro-optical switching profiles show features that are characteristic of an antiferroelectric structure (Figure 1) as opposed to the standard electroclinic response. The magnitude of the antiferroelectric response diminishes on approaching the isotropic phase. The DC bias field dependence of the low frequency dielectric constant corroborates these results. To explain these novel observations we have proposed a structural model (Figure 2) in which two neighbouring smectic layers form an antiferroelectric block and the de-correlation of the tilt direction, a characteristic of the de Vries phase occurs between such blocks.

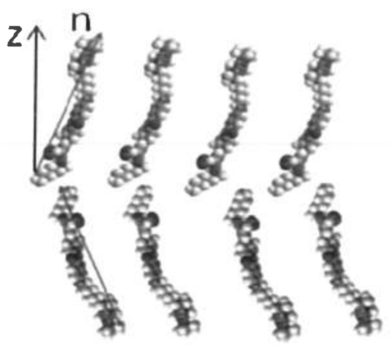


Figure 2: Proposed structure to explain the antiferroelectric (AF) switching in the de Vries phase. Notice that the molecules are shown tilted as expected for the de Vries phase and the tilting direction of the director (n) with respect to the layer normal (z) is opposite in the neighbouring layers to support the AF character of the medium.

<u>Investigators</u> : S.Krishna Prasad, D.S.Shankar Rao, S.Sridevi and C.V.Lobo
<u>Collaborators</u>: B.R.Ratna and J.Naciri, Naval Research Laboratory, Washington D.C., USA
R.Shashidhar, Polestar Technologies, Mass, USA

6.6 PRETRANSITIONAL BEHAVIOUR IN THE VICINITY OF THE ISOTROPIC-NEMATIC TRANSITION OF STRONGLY POLAR COMPOUNDS

The isotropic-nematic transition, being weakly first order, exhibits pretransitional effects signifying the appearance of the nematic-like regions in the isotropic phase. In the isotropic phase, strongly polar liquid crystals, such as the popular alkyl and alkoxy cyano biphenyl behave in a non-standard fashion: whereas far away from the transition the dielectric constant ε_{iso} has a 1/T dependence (a feature commonly seen in polar liquids also), on approaching the nematic phase the trend reverses resulting in a maximum in $\varepsilon_{iso,}$ at a temperature slightly above the transition, an effect explained on the basis of short-range correlations with an antiparallel association of the neighbouring molecules. Recently, there has been a revival in studies on this behaviour to possibly associate it with the order of transition. We have conducted dielectric measurements on a number of liquid crystalline systems of varied molecular structures and exhibiting the isotropic-nematic transition with a view to understand the dielectric anomaly seen immediately above the nematic-isotropic transition in, generally, cyanobiphenyl compounds. The central feature of our studies is that the convex shape of the thermal variation of ε_{iso} is more an exception, than a rule. In materials that exhibit such an anomaly we find a linear correlation between the $\delta\varepsilon = (\varepsilon_{peak} - \varepsilon_{IN})/ \varepsilon_{IN}$ and $\delta T = T_{peak} - T_{IN}$, where ε_{peak} is the maximum value of the dielectric constant in the isotropic phase and ε_{IN}, the value at the transition, and T_{peak} and T_{IN} the corresponding temperatures. These results demonstrate that there is no single factor that controls the convex-shaped anomaly. Instead, several factors, such as the magnitude of the dipole moment along the molecular axis, the order of the transition and most importantly, the stiffness/flexibility of the core part of the constituent molecules decide the appearance as well as the magnitude of this anomaly. The stiffness/flexibility parameter can also be looked at from the point of soft repulsions that can be caused by the presence of lateral dipoles present in the central portion of the molecule.

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

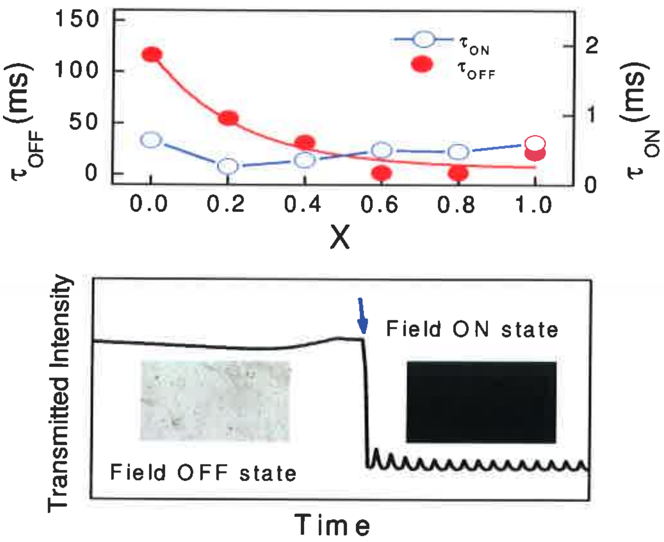
6.7 FAST RESPONDING ROBUST NEMATIC LIQUID CRYSTALLINE GELS FORMED BY A MONODISPERSE DIPEPTIDE: ELECTRO-OPTIC AND RHEOLOGICAL STUDIES

Liquid crystals contained in a network are promising materials for display devices. An especially attractive material property aimed at is the faster electrical response. A popular matrix in this regard is a gel, which is made of solid network swollen by a liquid. Substituting the liquid with a liquid crystal yields a liquid crystal gel, which is either irreversible in nature (termed chemical gel) or reversible (physical gel). Recently there has been lot of interest in the electro-optic properties of such gels formed by physical processes such as hydrogen bonding due to anisotropy, thermo-reversibility and are mechanical robustness. We have used a novel liquid crystalline monodisperse homomeric dipeptide (GSC98) for creating the gel matrix and the nematic liquid crystal used is E7. The electro-optic and rheological measurements of liquid crystal gels formed by mixtures of these two showed that the gelation improves the dynamic characteristics of the electro-optic switching of the device employing these gels, by as much as two orders of magnitude. Concomitantly, a huge increase (by three orders of magnitude) is seen in the zero shear viscosity of the material. The combination of these properties results in a robust fast responding liquid crystal display device.

In this study we have used gels formed with X= 0.2, 0.4, 0.6, 0.8 and 1, where X is the concentration of GSC98 by weight% in E7.

Left: Pure E7 Right: X=0.6 gel. Note the immobility of the gel due its high viscosity as against the freely flowing pure E7.

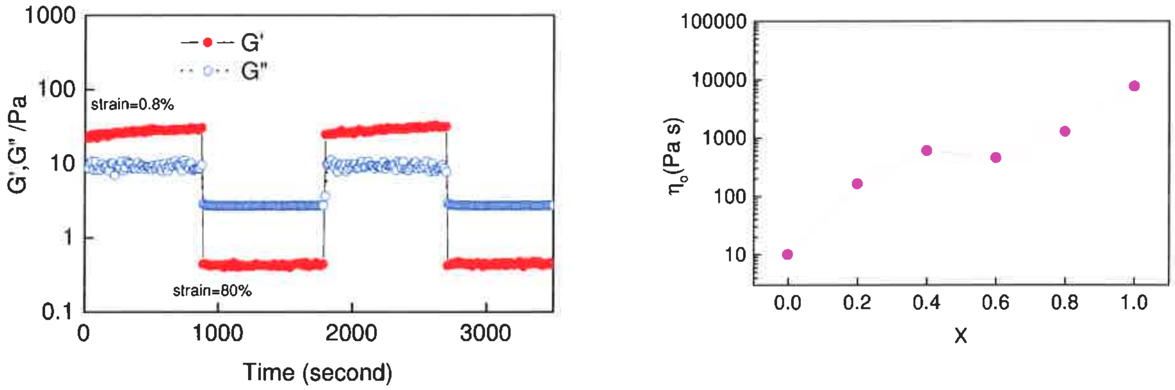
The electro-optic measurements show that the Freedericksz threshold voltage for the gels up to about 0.8% of GSC98 in E7 is comparable to the pure E7. The switch ON time, (τ_{ON}) is almost independent of the gel concentration and the switch OFF time (τ_{OFF}) decreases drastically compared to that of pure E7. For example, X=0.6% shows nearly two orders of magnitude faster response, with hardly any change in the threshold voltage.



Top panel: Decrease of the switch OFF time (τ_{OFF}) in the low concentration gel composites.

Bottom panel: Electro-optic response curve and photomicrographs of field OFF "bright" and field ON "dark" states obtained for the gel X=0.6.

In order to characterize the mechanical properties of the gels, rheological measurements were performed. More important from the device point of view is the rapid recovery of the collapsed gel seen in the transient measurements. Therefore, while monitoring storage and loss moduli, G' and G", the gels were subjected to large oscillatory strains ($\gamma > \gamma_o$) to break the gel structure and then abruptly reduce the strain amplitude to a very small value ($\gamma < \gamma_o$). For X=0.8, shown in the figure, upon application of a large strain, G' decreases by two orders of magnitude. While G" also shows a decrease, its variation is much smaller which also leads to a change in the relationship from G'>G" to G'<G". When γ is reduced to a small value, the recovery to the elastic state takes place instantaneously. The recovery is indeed reproducible over repeated cycles of measurement.



Left: *Step strain measurements of X=0.8 gel showing the rapid recovery of gel structure when the gel is subjected to a large oscillatory strain of 80%. The recovery to the gel state takes place within ~ 20 seconds and is reproducible over repeated cycles of measurement.*

Right: *The gel concentration dependence of low shear rate ($\dot{\gamma}$ = 5x10^{-4} s^{-1}) viscosity (η_o) obtained from fitting the viscosity vs. shear rate data in each case to Carreau model. η_o increases, for example, by nearly three orders of magnitude for X=0.8 as compared to pure NLC.*

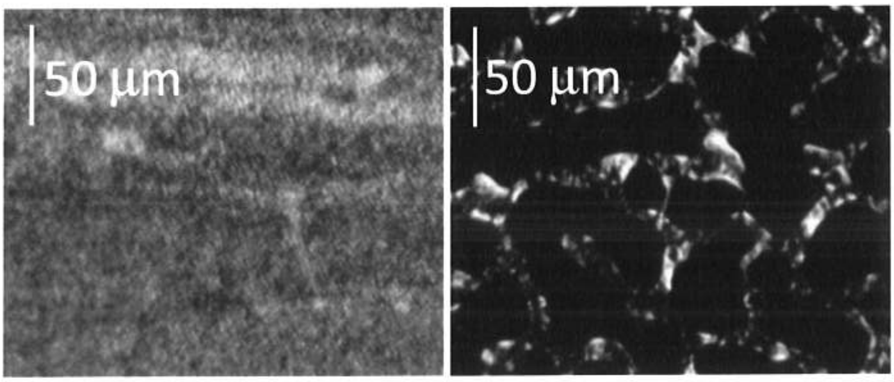
The bulk viscosity of the gels measured as a function of shear rates show that the low shear rate viscosity increases, for example, by nearly three orders of magnitude for 0.8% gel compared to pure E7, making the gels more robust compared to pure E7.

Investigators : Geetha G. Nair, S. Krishna Prasad, V. Jayalakshmi, G.Shanker and C.V. Yelamaggad

6.8 PHOTO-CONTROLLED CONFORMATION-ASSISTED PERMANENT OPTICAL STORAGE DEVICE EMPLOYING A POLYMER NETWORK LIQUID CRYSTAL

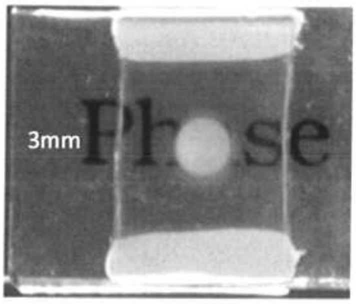
A new type of optical storage device is described employing a material consisting of a host nematic liquid crystal, a photoisomerisable azobenzene component and a photopolymerizable monomer. The principle of image storing involves selectively controlling the birefringence of the medium immediately prior to photopolymerization of the monomer. We also suggest that grey-shades can be created in this device using the recently discovered phenomenon of electric-field acceleration of reverse isomerisation.

The material investigated consisted of E7 doped with 5 wt% of a photoisomerisable azobenzene based mesogen (EPH). This mixture (LC) in turn was mixed with a photo-polymerizable monomer, RM82 in the ratio 60:40, by weight. The polymerization of RM82 and the *trans-cis* isomerization of EPH were carried out using a UV lamp of 1 mW/cm^2 at 365 nm wavelength at room temperature. The sample when viewed under an optical polarizing microscope immediately after this process, showed a birefringent planar texture that was essentially identical to that of the pristine sample and more importantly exhibited strong nematic director fluctuations. It was observed that subsequently, about 30 minutes after the UV illumination the director fluctuations got quenched. We exploited this duration to control the orientation of LC molecules, which gets irreversibly frozen after the quenching of the director fluctuations and to create regions of different contrast.

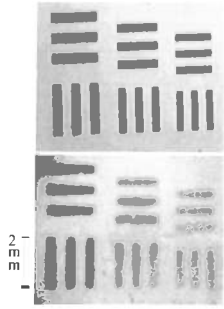


Photomicrographs in the (left) region exposed to white light (right) unexposed to white light while cooling the sample to room temperature.

The cell illuminated with UV light at room temperature was heated to the clearing temperature keeping it inside a hot stage and illuminating with microscope lamp. On cooling back to room temperature and taking out of the hot stage, the cell showed a striking contrast between the regions exposed and not exposed to the white light (WL) of the microscope lamp; The WL-non-exposed region was a clear transparent one whereas the WL-exposed region was highly scattering resulting in a large contrast between the two regions. Under the microscope, the WL-exposed region showed grainy texture, whereas the WL-non-exposed region showed a texture with narrow birefringent networks separated by large isotropic-like regions. A photograph of the sample cell with such a "stored pattern" is shown below demonstrating the quality of the scattering and transparency of the two regions. No noticeable degradation in the contrast was observed even after several months of creation of the pattern.



Photograph of a sample cell with a "stored pattern".



Top: USAF pattern mask, Bottom: Pattern stored using the mask.

Investigators : Geetha G. Nair, S. Krishna Prasad and V. Jayalakshmi

6.9 FORMATION OF HIGHLY LUMINISCENT SUPRAMOLECULAR ARCHITECTURES POSSESSING COLUMNAR MESOPHASE

The spontaneous self-assembly of molecules to form soft materials is currently a topic of great interest in areas that range from chemistry and biology to materials science. Of the various soft materials, liquid crystals and gels have attracted special attention because of their ability to form highly ordered superstructures with specific functional properties. Xray diffraction (XRD) measurements are carried out on newly synthesized novel octupolar oxadiazole derivatives. Results showed that the 12th homologue exhibit at high temperature, a columnar phase with two dimensional hexagonal ordering (Col_h) of the lattice. On lowering the temperature it transformed to columnar phase with an oblique lattice (Col_{ob}). The measured tilt angle is 83 degrees. At ambient temperature the compound remained in the Col_{ob} phase with increased lattice spacing. The higher homologue (16th) exhibit Col_h phase at higher temperature, transformed to columnar phase with 2-dimensional rectangular ordering of the lattice at lower temperature. The change from a Col_h to Col_{ob} or Col_r phases require strong interaction between the cores of neighboring columns, since the core of one column has to selectively tilt with respect to the others. The tilted column reduces the interactions between bulky side chains and allows closer contact between the cores, as also suggested by the appearance of a wide angle peak corresponding to core-core interactions. The strong core-core interactions resulted in supramolecular assemblies leading to the formation of highly luminescent gels in nonpolar solvents. The gels were found to posses a hexagonal columnar organization revealed by XRD studies. Absorption spectra and luminescence studies were performed to understand the formation of gels. This paper is accepted for publication in Advanced Functional Materials.

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

6.10 X-RAY, ELECTRICAL AND ELECTRO-OPTIC STUDIES IN THE COLUMNAR MESOPHASE

Detailed XRD study, electrical switching and electro-optic studies has been carried out on functionalized homomeric dipeptides. The dipeptides derived from l-/d-alanines form columnar phase with oblique lattice. Electrical studies showed ferroelectric switching of the columnar state with measured spontaneous polarization being as high as 440 nC/cm^2. Microphotographs showed two bistable states. Electro- optic response show a sharp change in the intensity associated with a change in the state of the phase. The XRD revealed that dipeptide derived from l-/d-leucines, another derivative show columnar phase with 2-dimensional rectangular ordering.

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

6.11 BIAXIAL NEMATIC MATERIALS:

Bent-Core Compounds:

We have been pursuing the above topic, since 2003. During the above mentioned period, we undertook the following studies on biaxial nematic phase.

(i) A combined DFT and Carbon-13 NMR study of a biaxial bent-core mesogen:

Here, we have undertaken a detailed study of a bent-core molecule, A131, by means of density functional theory (DFT). The aim is to seek the most probable conformational states within its bent-shaped core. The conformers found in the Potential Energy Surface (PES) of the 5-ring model of A131 mesogen belong to two distinct structural groups, namely the banana-shaped and the hockey stick-shaped form. Moreover, the Chemical Shielding Tensors (CSTs) of the aromatic carbons, for the four prevalent conformers, have been quantum mechanically (QM) calculated using GIAO-DFT approach. The derived CSTs can be related to chemical shift anisotropy (CSA) tensors and then compared with those previously measured by means of Solid State 2D NMR SUPER technique. The agreement between the experimental and calculated CSA tensors is found to be satisfactory, especially if taking into account the complexity of the system under investigation. The verified CSA tensors for A131 are used to ascertain the assignment of carbon peaks, and to interpret the ^{13}C chemical shifts in the NMR spectra from the uniaxial and biaxial nematic phases, in order to give more reliable structural and local orientation order parameters. Implications of the new ordering information are discussed in light of the conformational states found by in vacuo-DFT calculations. The local order parameters *S* and *D* of the aromatic rings are found to be useful, particularly with the aid of DFT results, in postulating the preferred conformers in the two nematic phases of A131.

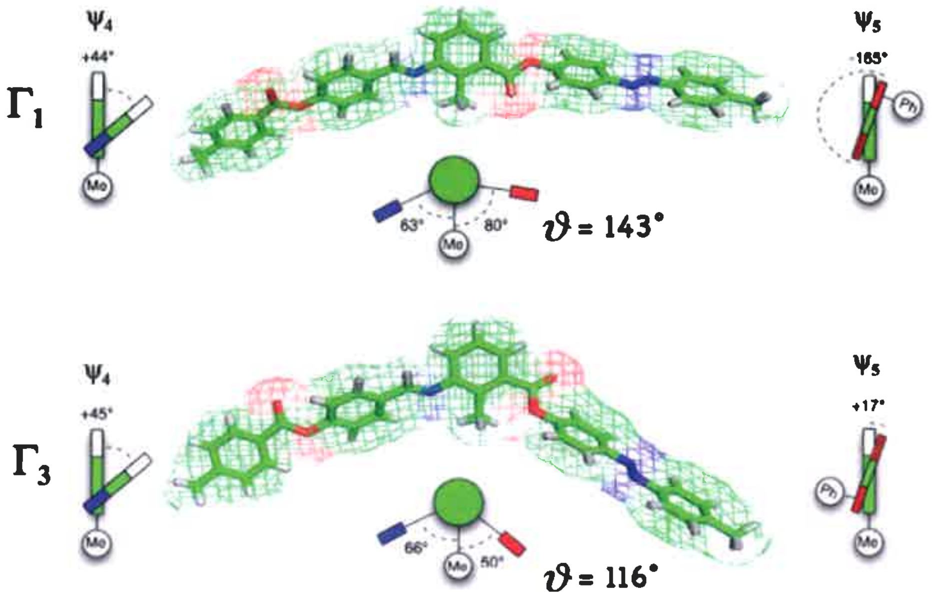


Figure: Molecular structures and principal geometrical parameters of Γ_1 and Γ_3 conformers of A131. The lateral side views are shown on the left and right sides of the molecular models.

Investigator: Veena Prasad
Collaborators: R.Y. Dong, University of British Columbia, Vancouver, Canada, and Alberto Marini, Universita di Pisa, Italy.

(ii) XRD study:

Here, we have undertaken *ab-initio* calculations of X-ray diffraction patterns in the isotropic, uniaxial nematic and biaxial nematic phases of bent-core mesogens. The calculations provide satisfactory semi quantitative interpretations of experimental results. These calculations should provide a pathway to more redefined and quantitative analysis of X-ray diffraction data from the biaxial nematic phase.

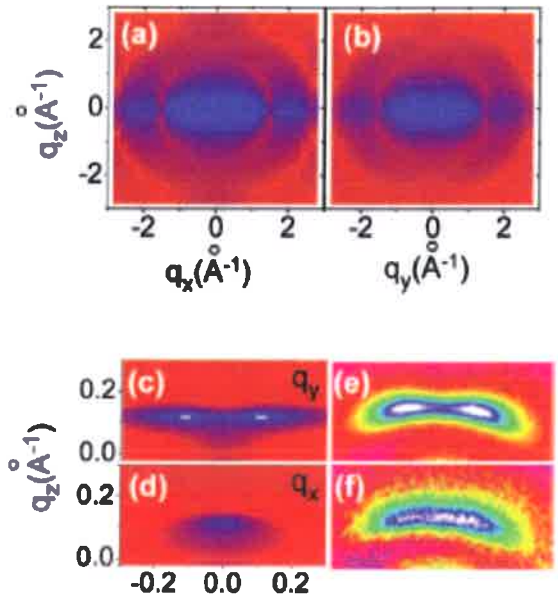


Figure: Variation of the scattered intensity $I(\vec{q})$ on two orthogonal planes in q-space for near-perfect alignment of bent-core molecules ($\gamma = \beta = 5$) in (a) q_x-q_z and (b) q_y-q_z planes. Panels (c) and (d) depict the corresponding enlarged views of the diffraction patterns at a small angle. The panels on the right show the observed scattered intensity from a bent-core liquid crystal supported between two beryllium substrates (e) without and (f) with a square-wave voltage of amplitude 5 V applied between them.

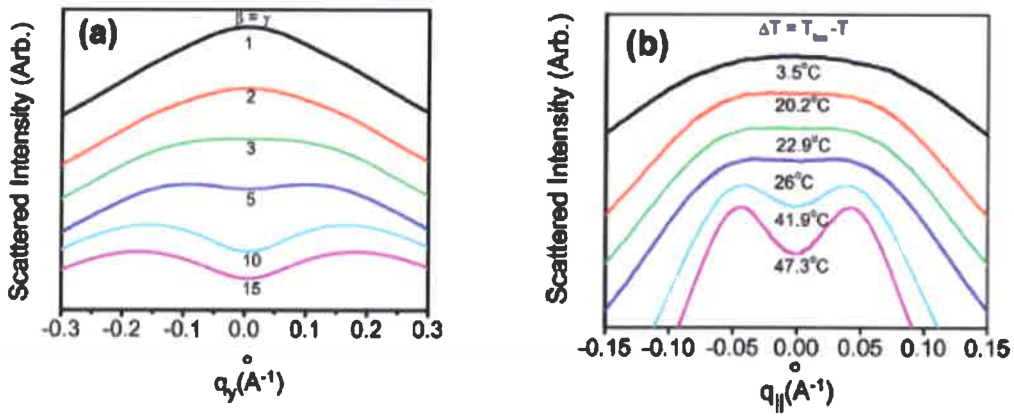


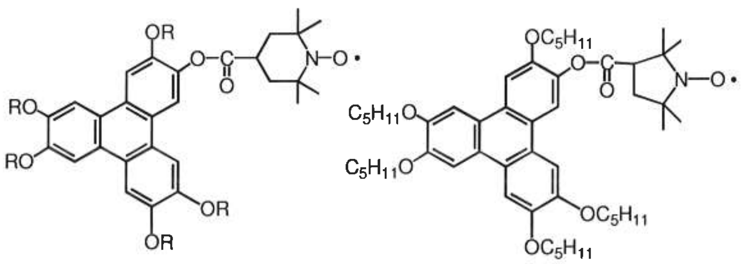
Figure: **(a) Variation of the calculated integrated intensity as a function of q_y for different values of $\beta = \gamma$. (b) Variation of the integrated intensity as a function of the wave vector for azo-substituted bent-core liquid crystals for different reduced temperatures ΔT. We note that the sample was in a capillary tube with an external magnetic field and that no attempt was made to align the secondary director.**

<u>Investigator</u>: Veena Prasad

<u>Collaborators</u>: Bharat Acharya, Platypus Technologies, Madison, USA.
Satyendra Kumar and Shin-woong Kang, Kent State University, USA.

6.12 THE FIRST EXAMPLES OF DISCOTIC RADICALS: THE COLUMNAR MESOMORPHISM IN SPIN-CARRYING TRIPHENYLENES

The magneto-responsive discotics (Chart 1) formed by covalently linking triphenylene with TEMPO or PROXYL molecular radicals have been reported for the first time. The columnar mesomorphism of these new compounds has been established unequivocally with the aid of several complementary studies (Fig. 1a and 1b). The nature (ring-size) of the peripheral radical entity attached to triphenylene, rather than the exterior *n*-alkoxy tails, seems to influence the general phase behavior and the structure of the columnar phase. The TEMPO discotics exhibit fluid/glassy hexagonal columnar phase over wide thermal range; while the discogen derived from PROXYL radical displays a transition from the hexagonal columnar phase to plastic rectangular columnar phase, the first of its kind. The magnetic susceptibility measurements of these radical discotics in their fluid columnar, frozen columnar and solid states revealed that the antiferromagnetic intermolecular interactions of Curie-Weiss behaviour are preserved irrespective of the phase changes. Thus, the radical discotics described here are early examples of what could be a vast family of novel materials that may prompt increased attention of many researchers and, thus find application in different fields.



1a: R=C_5H_{11}, **1b**: R=C_6H_{13}

2

Chart 1: Molecular structures of radical discotics synthesized and studied.

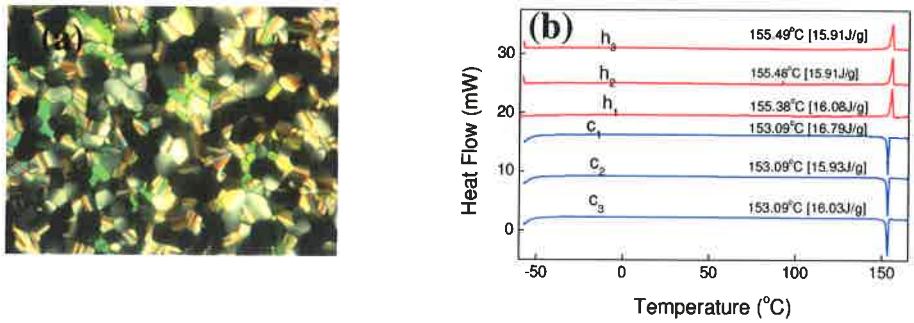
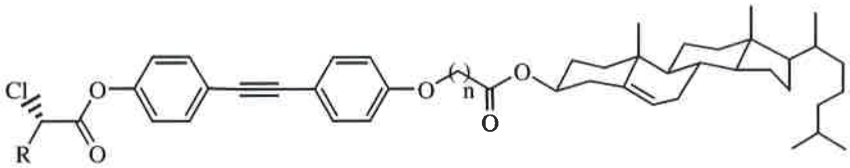


Figure 1: (a) Microphotograph of the optical texture of the Col phase of discotic 2. (b) DSC thermograms of three heating and cooling cycles obtained for the radical discotic 2 (at a rate of 5 °C/min).

Investigators: C.V.Yelamaggad, A. S. Achalkumar and D. S. Shankar Rao
Collaborators: M. Nobusawa, H. Akutsu, J. Yamada and S. Nakatsuji, Graduate School of Material Science, University of Hyogo, Japan

6.13 LIQUID CRYSTAL DIMERS DERIVED FROM NATURALLY OCCURRING CHIRAL MOIETIES: SYNTHESIS AND CHARACTERIZATION

Naturally occurring cholesterol and α-chloro alkanoyl units derived from natural α-amino acids (L-valine, L-leucine and L-isoleucine) have been utilized to prepare three different series of non-symmetric liquid crystal dimers. Tolane (diphenylacetylene) core has been chosen as the other mesogenic segment to covalently tether with cholesterol through a flexible spacer. In each series, the terminal α-chloro ester group attached to the tolane unit is kept constant, while the length and parity of the spacer have been varied; specifically, three dimers comprising even-parity spacer of varying length, and one compound with an odd-parity spacer constituted a series. Except one, all the eleven dimers display enantiotropic mesomorphism. Within the series, clearing temperatures exhibit a dramatic odd-even effect wherein the even-parity dimers possess higher values. In general, the dimers comprising α-chloro ester group derived from L-valine and L-leucine stabilize chiral nematic and /or smectic phase/s, while the compounds with terminal group resulting from L-isoleucine show twist grain boundary phase additionally; this implies that the nature of the α-chloro ester group influences the phase behavior. Notably, an odd-parity dimer with a α-chloro ester group derived from L-valine exhibits a transition from an intercalated smectic A phase to a monolayer (unknown) smectic phase (see Fig. 1), as evidenced by optical, calorimetric and by X-ray diffraction studies.



TDV-3 : n = 3; R = *i*-Pr **TDL-3** : n = 3; R = *i*-Bu **TDI-3** : n = 3; R = (*S*)-*sec*-Bu
TDV-4 : n = 4; R = *i*-Pr **TDL-4** : n = 4; R = *i*-Bu **TDI-4** : n = 4; R = (*S*)-*sec*-Bu
TDV-5 : n = 5; R = *i*-Pr **TDL-5** : n = 5; R = *i*-Bu **TDI-5** : n = 5; R =(*S*)-*sec*-Bu
TDV-7 : n = 7; R = *i*-Pr **TDL-7** : n = 7; R = *i*-Bu **TDI-7** : n = 7; R = (*S*)-*sec*-Bu

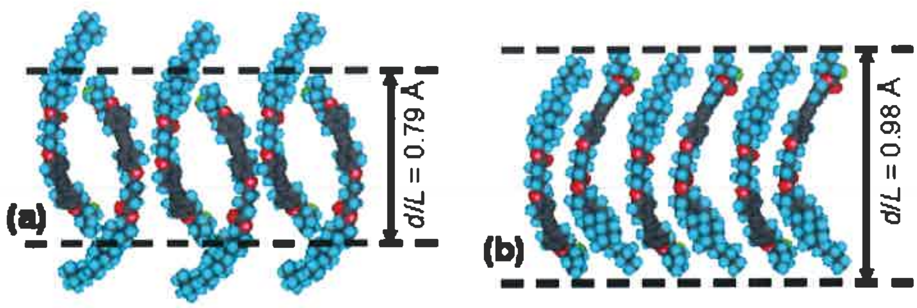
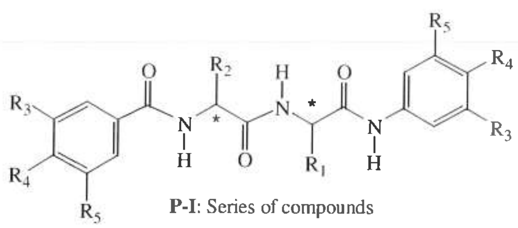


Figure 1. Schematic representation of molecular organizations in an intercalated SmA phase (a) and a fluid monolayer SmX phase (b) formed by the dimer TDV-4

Investigators: C.V.Yelamaggad and G. Shanker.

6.14 EVALUATION OF MESOMORPHISM OF HOMOMERIC DIPEPTIDES

Supramolecular homomomeric dipeptides (here after referred to as **P-I** series) have been investigated for their mesomorphic behavior with the aid of UV-Vis, chiroptical (CD spectral), microscopic, calorimetric, electrical switching and X-ray studies. These studies have shown that two pairs of enantiomers and their respective diastereomers derived from amino acids self-organize into a helical columnar phase through H-bonding. The CD and X-ray studies, respectively, have revealed that the form chirality (handedness) and the magnitude of out-of-plane fluctuations of the lattice planes of the fluid supramolecular columnar structures are solely directed by the stereochemistry encoded in the spacer. Notably, the less frequently found oblique helical columnar phase formed by a pair of enantiomers derived from L- & D-alanines, unlike others, exhibit ferroelectric behavior; the measured spontaneous polarization is as high as 440 nC cm^{-2}. Besides, all these supramolecules form stable organogels in ethanol; the CD and SEM studies on a representative gel suggest the presence of helical structure.



P-I: Series of compounds

1 : $R_2 = R_1$ = (*S*)-Isobutyl; $R_3 = R_5$ = H; $R_4 = OC_{10}H_{21}$ (L-Leu-L-Leu)
2 : $R_2 = R_1$ = (*S*)-Isobutyl; R_3 = H; $R_4 = R_5 = OC_{10}H_{21}$ (L-Leu-L-Leu)

3a : $R_2 = R_1$ = (*S*)-Methyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (L-Ala-L-Ala)
3b : $R_2 = R_1$ = (*R*)-Methyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (D-Ala-D-Ala)
3c : R_2 = (*R*)-Methyl; R_1 = (*S*)-Methyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (D-Ala-L-Ala)

4a : $R_2 = R_1$ = (*S*)-Isobutyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (L-Leu-L-Leu)
4b : $R_2 = R_1$ = (*R*)-Isobutyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (D-Leu-D-Leu)
4c : R_2 = (*R*)-Isobutyl; R_1 = (*S*)-Isobutyl; $R_3 = R_4 = R_5 = OC_{10}H_{21}$ (D-Leu-L-Leu)

Chart : Molecular structure of homomeric dipeptides synthesized and studied.

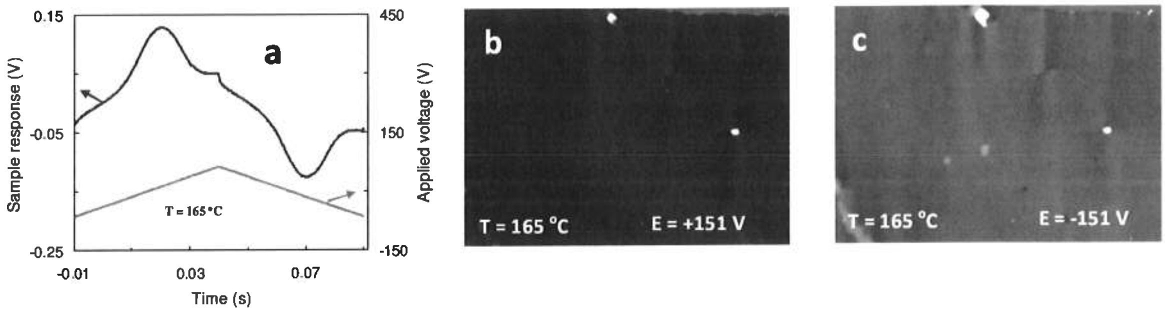


Figure : (a) Ferroelectric switching current response trace obtained for the Col_{ob} phase of one of the enantiomers (triangular-wave field, 64 V, 10 Hz). (b) & (c) Microphotographs of the two bistable states.

Investigators: C.V.Yelamaggad, G. Shanker, D. S. Shankar Rao and S. Krishna Prasad

Collaborators: R. V. Raman Rao and V. V. Suresh Babu, Department of Studies in Chemistry, Bangalore University, Bangalore.

6.15 ELECTROCONVECTION IN A HOMEOTROPIC BENT-ROD NEMATIC LIQUID CRYSTAL BEYOND THE DIELECTRIC INVERSION FREQUENCY

This study deals with the structural transitions in an initially homeotropically aligned bent-rod nematic liquid crystal excited by ac fields of frequency f well above the dielectric inversion point f_i. From the measured principal dielectric constants and electrical conductivities of the compound, the Carr-Helfrich conduction regime is anticipated to extend into the sub-MHz region. Periodic patterned states occur through secondary bifurcations from the Freedericksz distorted state (Fig. 1, Right). An anchoring transition between the bend Freedericksz (BF) and degenerate planar (DP) states is detected (Fig. 1, Left).

The BF state is metastable well above the Freedericksz threshold and gives way to the DP state which persists in the field-off condition for several hours. In the BF regime, not far from f_i, periodic Williams-like domains form around the umbilics; they drift along the director easy axis right from their onset. With increasing *f*, the wave vector of the periodic domains switches from parallel to normal disposition with

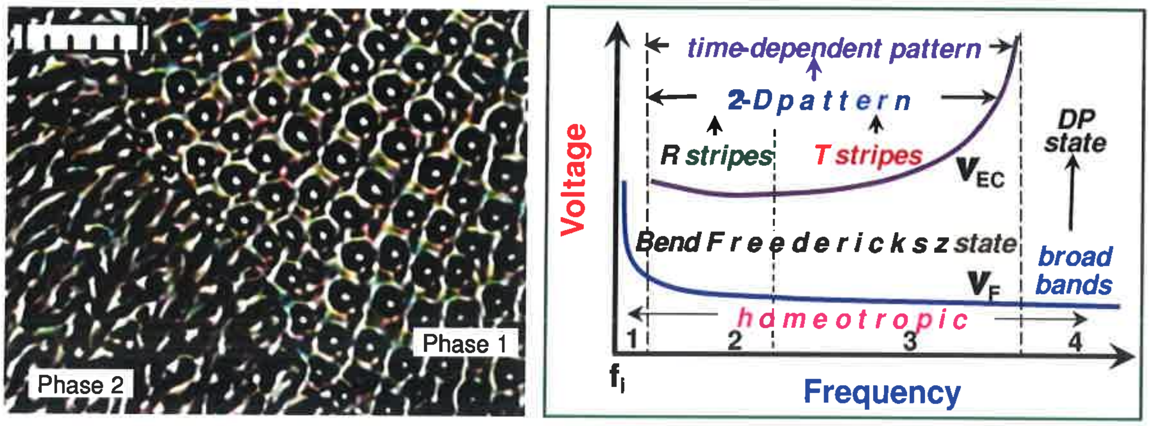


Figure 1: (Left) Phase 1 showing a 2-D pattern at a +1 umbilic while Phase 2 is in the Chevron state. 135 °C, 150 kHz, 17.7 V. Scale division 10 μm. (Right) Schematic of the bifurcation states in the voltage-frequency space inside the conduction regime, above the dielectric isotropy point f_i for BCCB. V_F and V_{EC} denote the critical voltages for the onset of the BF and EC instabilities, respectively. The BF and EC states in regions 2 and 3 are metastable and, over an extended time, give way to the degenerate planar (DP) state or a patterned state arising out of it. In region 4, the BF state is unstable to the formation of broad bands.

respect to the **c** vector. Well above f_i, a broad-band instability is found.

Investigators: Pramoda Kumar, S. H. Uma, C. V. Yelamaggad and K. S. Krishnamurthy

Collaborator: A. G. Rossberg, International Institute for Applied Systems Analysis, Laxenburg, Austria

6.16 DRIFTING PERIODIC STRUCTURES IN A DEGENERATE-PLANAR BENT-ROD NEMATIC LIQUID CRYSTAL BEYOND THE DIELECTRIC INVERSION FREQUENCY

The study dwells on the electric field generated effects in the nematic phase of a twin mesogen formed of bent-core and calamitic units, aligned homeotropically in the initial ground state and examined beyond the dielectric inversion point. We focus here on the degenerate planar (DP) configuration which establishes itself at the expense of the bend Freedericksz (BF) state, in the course of an anchoring transition. In the DP regime, normal rolls, broad domains, and chevrons (both defect mediated and defect free types) form at various linear defect-sites, in different regions of the frequency-voltage plane. A significant novel aspect common to all these patterned states is the sustained propagative instability which does not seem

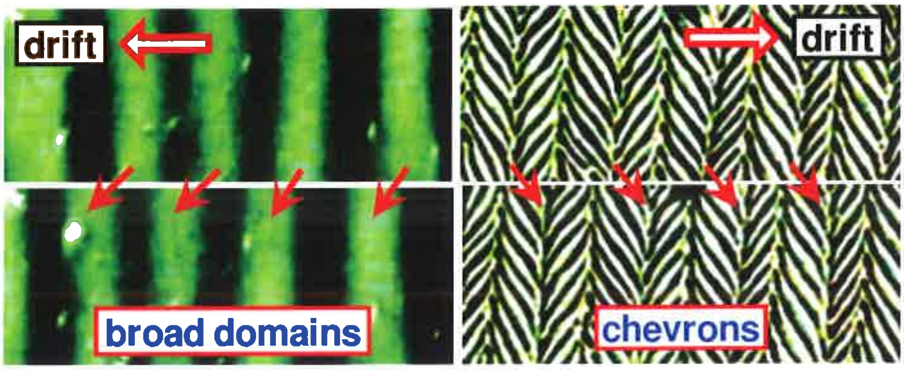


Figure 1. Phase propagation observed in the broad domain (left) and chevron (right) states formed in the bent core nematic liquid crystal BCCB.

explicable on the basis of known driving mechanisms (Fig.1).

Investigators: Pramoda Kumar, S. H. Uma, C. V. Yelamaggad, and K. S. Krishnamurthy
Collaborator: A. G. Rossberg, International Institute for Applied Systems Analysis, Laxenburg, Austria

6.17 EXCHANGE BIAS EFFECTS IN Fe_3O_4/γ-Fe_2O_3 CORE/SHELL NANOPARTICLES

Exchange bias effects in monodisperse and core/shell structured Fe_3O_4/γ-Fe_2O_3 nanoparticles, synthesized by thermal decomposition iron oleate complex, are studied for the first time here. The narrow size distribution and the well defined core/shell structure of our nanoparticles are very well established by transmission electron microscope (TEM) and X-ray magnetic circular dichroism (XMCD) studies. The interface exchange anisotropy, in addition to the surface anisotropy, is found to dominate the effective anisotropy of these core/shell Fe_3O_4/γ-Fe_2O_3 nanoparticles, calculated from the blocking temperature (T_B). A phenomenological model including the interface exchange anisotropy parameter is found to fit very well with the effective anisotropy data. Unlike the exchange bias in conventional ferromagnetic (FM)/antiferromagnetic (AFM) systems, the unusual ferrimagnetic/ferrimagnetic interface of the core/shell structure gives exchange bias in our Fe_3O_4/γ-Fe_2O_3 nanoparticles. In these core-shell structured nanoparticles, a spin glass state in the γ-Fe_2O_3 shell might play the role of AFM layer to bring about the exchange bias effect or possibly the uncompensated spins of γ-Fe_2O_3 shell could couple ferromagnetically with the Fe_3O_4 core to show the exchange bias effect.

Investigator: S. Angappane
Collaborators: T.Hyeon, SNU, Korea and J.-G.Park, SKKU, Korea

6.18 ZnO(101) FILMS BY PULSED REACTIVE CROSSED-BEAM LASER ABLATION

Pulsed reactive crossed-beam laser ablation (PRCLA) was employed to deposit a (101) oriented ZnO film. In this method, a supersonic jet of oxygen pulse is made to cross the laser plume from a zinc metal target while being carried to the Si(111) substrate. The obtained deposit was nanocrystalline ZnO as confirmed by a host of characterization techniques. When the substrate was held at varying temperatures, from room temperature to 900 °C, the crystallinity of the obtained films increased as expected, but importantly, the crystallographic orientation of the films was varied. High substrate temperatures produced the usual (001) oriented films, while lower substrate temperatures gave rise to increasingly (101) oriented films. The substrate held at room temperature contained only the (101) orientation. The film morphology also varied with the substrate temperature, from being nanoparticulate to rod-like deposits for higher deposition temperatures. Surprisingly, the ZnO(101) surfaces showed reactivity with acetone forming carbonaceous nanostructures on the surface.

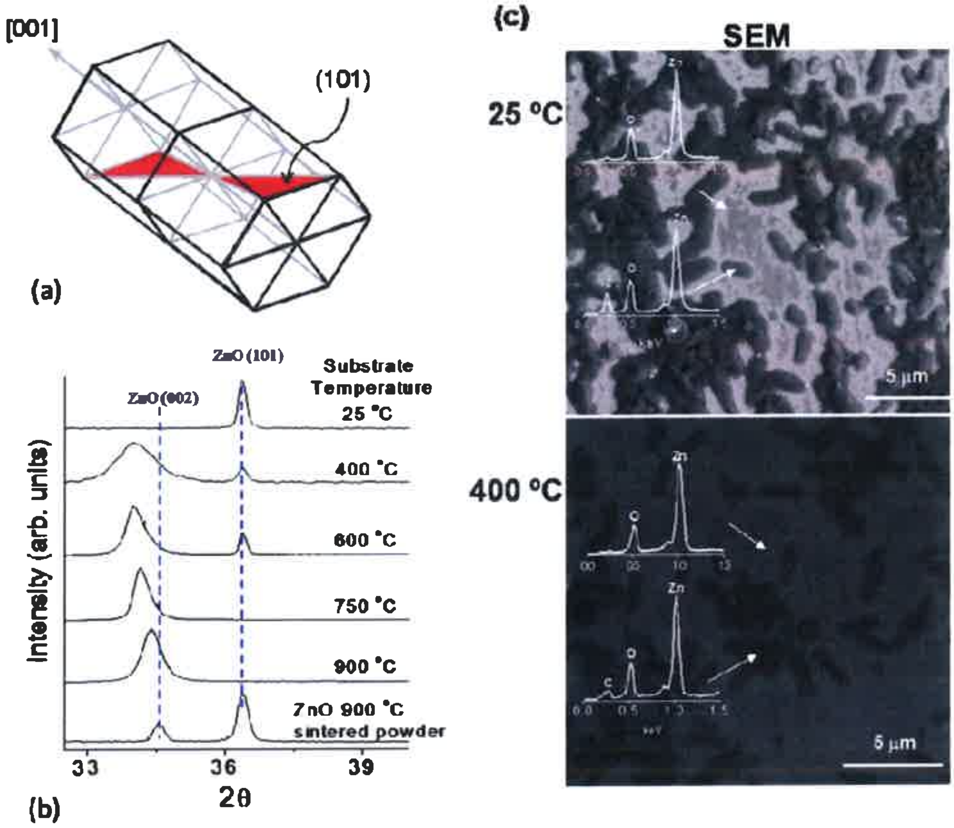


Figure : (a) ZnO unit cell showing the (101) plane and (b) XRD pattern of ZnO prepared by pulsed reactive crossed-beam laser ablation at various substrate temperatures. (c) SEM images of the surfaces of ZnO films after being treated with acetone; bunches of carbon nanostructures are found on the surface. Insets of show the EDX analysis of the surface chemical species.

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

7. SPONSORED PROJECTS

- A three year Department of Science & Technology – SERC (2004-05) Project on "Photo induced effect in liquid crystals" costing Rs. 12.94 lakhs was sanctioned in November 2004 came to an end in July 2008. [S. Krishna Prasad, Geetha G. Nair and D. S. Shankar Rao].

- A three year project entitled "Investigations of the photo-stimulated phenomena in liquid crystals" between CLCR, Bangalore and Instituto Nazionale di Fisica della Materia (INFM), Italy was selected by the Department of Science & Technology as a joint research project within the framework of the Indo-Italian Program of Cooperation in Science & Technology 2005-07 in August 2005. A grant of Rs. 1.18 lakhs being the first year's allocation was received during the year 2006-07. As per the directions of DST, the project was closed in December 2008 and an unspent balance of Rs. 1.13 lakhs has been refunded to DST. [Indian side: S.Krishna Prasad, Geetha G.Nair and D.S.Shankar Rao; Italian side: Domenico Paparo, Enrico Santamato, Giancarlo Abbate, Lorenzo Marrucci]

- 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 first year grant of Rs. 1.66 lakhs has been received in April 2008. Under this project, Prof. K. S. Krishnamurthy, Indian Scientist visited Sofia, Bulgaria during 27.8.2008 to 17.09.2008. Also Prof. Alexander G.Petrov, Bulgarian Scientist, Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria visited CLCR for 16 days from 16.10.08 to 31.10.08 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 grant has been received during the year 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 and the work is in progress. [C. V. Yelamaggad, S. Krishna Prasad and D. S. Shankar Rao].

8. NATIONAL SCIENCE DAY

The Centre celebrated the National Science Day on 27 February 2009. The Centre declared that day as Open Day for the public. The Centre invited about 45 children and a few teachers from Mother Theresa School, M.E.S.Road, Jalahalli, Bangalore to the Centre and arranged for them a series of lectures by the Scientists of CLCR. The lectures were on :

(1) Nanoscience in nature.

(2) Chunky liquids and sloppy solids.

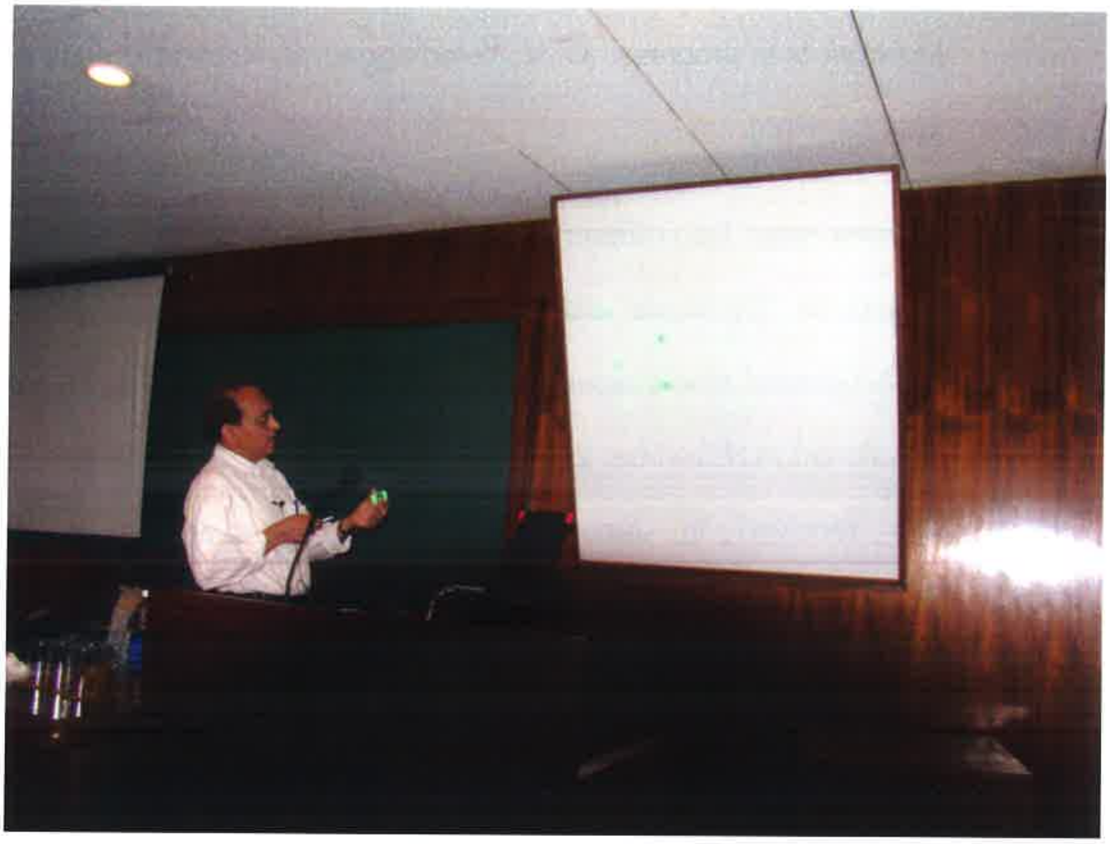
(3) Laser : A learning aid.

(4) The science of mummification.

(5) Chemistry and the human body.

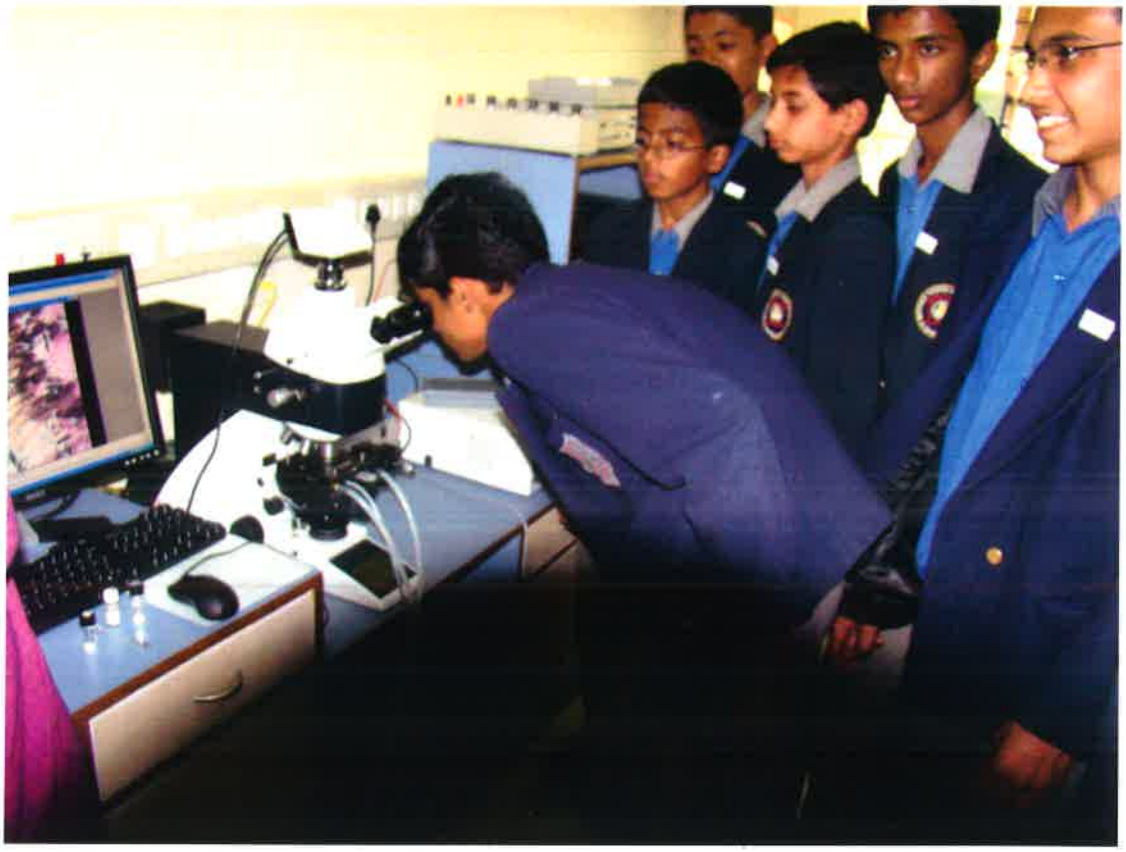
(6) Supercritical fluids and other intermediate phases.

There were also some demonstrations on science and participation of children in



Prof. H.L.Bhat conveying the beauty of science through a simple demonstration using a laser pointer.

Audience in full attention at the demonstration and lecture.



Budding scientists unraveling the liquid crystal textures using a polarizing microscope.

Dr. Geetha G.Nair demonstrating that soft matter has both viscosity and elasticity.
It can flow but yet it could be rigid!

An ideal setting (at CLCR) for contemplating science.

using instruments in the laboratories. The children showed great appreciation of the various programmes conducted at the Centre.

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 fifth in the series was held on 6 August 2008 and the memorial lecture was delivered by Prof. M. Vijayan, President, Indian National Science Academy, New Delhi on "Form and function of proteins: The global scenario and the Indian effort". On this occasion, Prof. S. Chandrasekhar's Portrait was unveiled by Capt. S. Prabhala, Former Chairman & Managing Director, Bharat Electronics Limited, Bangalore.

10. POPULARIZING OF SCIENCE

- Prof. G. S. Ranganath, gave a talk on "Wonders in the Sky" at the B. M. S. College for Women, Basavanagudi, Bangalore on 7 February 2009.

- Prof. H. L. Bhat, gave a talk on "Photoelectric effect" at the High School Science Teachers' Training Programme (DSERT), Bijapur, on 24 December 2008.

- Prof. H. L. Bhat, gave a talk on "Lasers and applications" at the High School Science Teachers' Training Programme (DSERT), Bijapur, on 25 December 2008.

- Prof. H. L. Bhat, gave a talk on "Laser as a teaching aid" at the Regional Institute of Education, Mysore, on 8 January 2009.

Welcome by Prof. K.A.Suresh at the "Prof. S.Chandrasekhar memorial lecture and unveiling of his portrait". The function was presided over by Prof. R.Narasimha, Chairman, Governing Council, CLCR.

Prof. M. Vijayan, President, Indian National Science Academy, New Delhi, delivering the Prof. S.Chandrasekhar memorial lecture.

Unveiling the portrait of Prof. S.Chandrasekhar by Capt. S.Prabhala, Former Chairman & Managing Director, Bharat Electronics Limited, Bangalore. Prof. R.Narasimha, Chairman, Governing Council, CLCR, presided over the event.

11. STUDENTS PROGRAMME

- Mr. A. S. Achalkumar was awarded the Ph. D degree by the Mangalore University in August 2008 for the thesis entitled "Self-Assembly of anisometric conventional and non-conventional molecules into liquid crystal phases".

- Mr. Pramoda Kumar, SRF visited the Research Institute for Solid State Physics and Optics of the Hungarian Academy of Sciences, Hungary under INSA-Hungarian bilateral exchange programme for 3 months from 3.5.2008 to 31.7.2008. He collaborated with Prof. Agnes Buka and Dr. Nandor Eber of the Hungarian Academy of Sciences on the research work "Electroconvection in nematic liquid crystals".

- Mr. Pramoda Kumar gave an oral presentation on "Electric field generated instabilities in nematics beyond the dielectric inversion point" at the Conference on Mesogenic & Ferroic Materials (CMFM-09) held at Banaras Hindu University, Varanasi during 9-11 January 2009.

- Ms. S. Sridevi gave an oral presentation on "Unusual dielectric and electrical switching behaviour studies in the de Vries SmA phase of three organosilaxone derivatives" at the Conference on Mesogenic & Ferroic Materials (CMFM-09) held at Banaras Hindu University, Varanasi during 9-11 January 2009.

- During the year, four new students were taken under the Ph.D. Programme-2008.

12. HONORS / AWARDS / PRIZES

Dr. S. Krishna Prasad was awarded in August 2008, the Sir C. V. Raman Young Scientist State Award for the year 2007 instituted by the Government of Karnataka.

13. VISITS ABROAD

- Prof. K.A. Suresh visited Korea for attending the 22nd International Liquid Crystal Conference held at Jeju Island, Korea during June 29 to July 9, 2008.

He gave an invited talk on "Discotic mesogen-DNA complex films at interfaces" (1 July), chaired a session (30 June) during the conference and also attended the Executive Board Meetings of International Liquid Crystal Society (1 July and 3 July). During this visit he also gave a talk at Seoul National University, Seoul on 7 July 2008.

- Dr. S. Krishna Prasad visited Korea for attending the 22nd International Liquid Crystal Conference held at Jeju Island, Korea during June 29 to July 4, 2008.
  He gave an invited talk entitled "Photo-stimulated and photo suppressed phase transitions" and contributed oral (1) and posters (6) presentations.

- Prof. K. S. Krishnamurthy visited Institute of Solid State Physics, Sofia, Bulgaria for 22 days during 27 August to 17 September 2008 under the Indo-Bulgarian Joint Project between CLCR and Institute of Solid State Physics, Sofia, Bulgaria.
  He gave an invited talk on 'Competing modes of electrically excited instabilities in nematics' and participated in the 15th International School on Condensed Matter Physics held at Varna from August 31-Sept. 5, 2008.

- Dr. Veena Prasad visited the Kent State University, Kent, USA during 21 October to 22 November 2008 to work on an ongoing collaboration on bent-core molecules.
  She participated in the International Symposium on Thermotropic Biaxial Nematic Materials held at Kent, USA during 27-28, October 2008 and gave an invited talk on "Molecular architectures to obtain novel thermotropic biaxial nematic materials".

14. SEMINARS / TALKS GIVEN AT OTHER INSTITUTES

- Prof. K. A. Suresh gave a Plenary Talk on "Electrical conductivity of Langmuir-Blodgett films of a discotic mesogen-DNA complex by atomic force microscopy" and also chaired a session at the Conference on Disorder, Complexity and Biology-II (DISCOMB-09) held at Banaras Hindu University, Varanasi during 5-8 January 2009.

- Prof. K. A. Suresh gave an invited talk on "Mechanical properties of discotic mesogen-DNA complex films at solid-air interfaces by atomic force microscopy" at the International Conference on Functional Materials during 27-29 November 2008 at the Indian Institute of Technology, Madras, Chennai.

- Dr. S. Krishna Prasad gave an invited talk on "Photo-induced phase transitions in smectic liquid crystals" at the Conference on Mesogenic & Ferroic Materials (CMFM-09) held at Banaras Hindu University, Varanasi during 9-11 January 2009.

- Dr. Veena Prasad gave an invited talk on "Photo controlled electro-optical properties: Introduction of a new dimension to the exotic bent-core liquid crystals" at the International Conference on Frontiers in Chemical Research held at Mangalore University, Mangalore during 29-31 December 2008.

- Dr. S. Angappane gave an invited talk on "Interparticle interaction and exchange bias in ferromagnetic nanoparticles" at the Workshop on 'Advances in Science and Technology' held at Anna University, Tirunelveli on 13 March 2009.

- Dr. S. Angappane attended the Workshop on 'Low temperature and high magnetic field facilities at UGC-DAE Consortium for scientific research, Indore' held at Indore during 6-7 March 2009.

15. INTERNATIONAL WOMEN'S DAY

The Centre celebrated the International Women's Day on 9 March 2008 at CLCR premises. A meeting was held at CLCR and the women of the Centre discussed various issues.

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

- A colloquium was given by Prof. Hideo Takezoe, Tokyo Institute of Technology, Tokyo, Japan on "Liquid Crystal Photonic Devices" on 17 October 2008.

- Prof. Alexander G.Petrov, Scientist, Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria visited CLCR for 16 days from 16 October 2008 to 31 October 2008 Indo-Bulgarian Joint Project. During this period he also gave a colloquium on "Stochastic and deterministic membrane sensing" on 24 October 2008.

17. SEMINARS / COLLOQUIA GIVEN AT THE CENTRE

- Ms. S. Sridevi, JRF, gave a seminar on "Experimental investigations on strongly polar liquid crystalline molecules" on 28 May 2008.

- Mr. G. Shanker, SRF, gave a seminar on "Studies of liquid crystals with novel molecular architecture: Design, synthesis and characterization" on 4 December 2008.

- Mr. Prasad N. Bapat, JRF, gave a seminar on "High pressure studies on phase transitions in liquid crystals" on 23 December 2008.

- Mr. Pramod Tadapatri, JRF, gave a seminar on "Electric field generated instabilities in thermotropic liquid crystals" on 29 December 2008.

18. LIST OF SCIENTISTS AND RESEARCHERS WORKING IN THE CENTRE AS ON 31.03.2009

	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. G.Shanker	Senior Research Fellow
15.	Mr. Pramoda Kumar	Senior Research Fellow
16.	Ms. Jayalakshmi	Junior Research Fellow

17.	Ms. S.Sridevi	Junior Research Fellow
18.	Mr. Pramod Tadapatri	Junior Research Fellow
19.	Mr. Prasad N.Bapat	Junior Research Fellow
20.	Ms. Rashmi Prabhu	Junior Research Fellow
21.	Ms. R.Bhargavi	Junior Research Fellow
22.	Mr. Vinaya Kumar K.R.	Junior Research Fellow
23.	Mr. N.G.Nagaveni	Junior Research Fellow
24.	Ms. Hashambi K.Dambal	Project Assistant
25.	Mr. K.R.Sunil Kumar	Project Assistant

19. ADMINISTRATIVE STAFF AS ON 31.03.2009

	Name	Designation
1.	Shri K.P.N.Rao	Administrative Officer (upto 31.5.2008)
2.	Shri Subhod M.Gulvady	Administrative Officer (w.e.f. 5.2.2009)
3.	Shri K.R.Shankar	Accounts Officer
4.	Shri P.K.Ramakrishnan	Engineer
5.	Smt P.Nethravathi	Office Superintendent
6.	Shri Sanjay K.Varshney	Technical Assistant
7.	Smt Sandhya D.Hombal	Technical Assistant
8.	Shri M.Jayaram	U.D.C.
9.	Shri Govindappa	Consultant in Administration

20. PUBLICATIONS DURING 2008-2009

Patents

1) A method of electric field assisted fast erasing of the stored optical information. Prasad, Subbarao Krishna; Nair, Geetha Gopinathan; Jayalakshmi, Vallamkondu. (Centre for Liquid Crystal Research, India). Indian Pat. Appl. (2008), Indian patent has been granted vide No. IN 2007CH00545 on 26.12.2008.

Chapter published in a Book

1) DFT and carbon-13 NMR in a biaxial bent-core mesogen, A. Marini, V.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] (in press).

Papers published

In Journals

1) Mechanical properties of Langmuir-Blodgett films of a discogen-DNA complex by atomic force microscopy, Alpana Nayak and K.A.Suresh, *J. Phys. Chem. B*, **113**, 3669 (2009). (An invited article for P.G. De Gennes Memorial Issue).

2) Phase transitions and rare-earth magnetism in hexagonal and orthorhombic $DyMnO_3$ single crystals, S.Harikrishnan, S.Rößler, C.M.Naveen Kumar, H.L.Bhat, U.K. Rößler, S.Wirth, F.Steglich and Suja Elizabeth, *J. Phys. Condens. Matter,* **21**, 096002 (2009).

3) Development of a versatile high temperature top seeded solution growth unit for growing cesium lithium borate crystals, J.N.B.Reddy, S.Elizabeth, H.L.Bhat, A.K.Karnal, *Review of Scientific Instruments,* **80**, Article No.013908 (2009).

4) Dielectric spectroscopy of unsymmetrical liquid crystal dimers showing wide temperature range TGBA and TGBC* phases, A. S. Pandey, R. Dhar, M. B. Pandey, A. S. Achalkumar and C. V. Yelamaggad, *Liq. Cryst.*, **36**, 13 (2009).

5) Role of molecular structure on x-ray diffraction in uniaxial and biaxial phases of thermotropic liquid crystals, B.R. Acharya, S-W. Kang, V. Prasad and S. Kumar, *J. Phys. Chem. B.*, **113**, 3845 (2009). (An invited article for P.G.De Gennes Memorial Issue).

6) Shear deformation and division of cylindrical walls in free-standing nematic films under high electric fields, Pramod Tadapatri and K. S. Krishnamurthy, *J. Phys. Chem. B* **112**, 13509 (2008). [Front Cover]

7) Optically biaxial interdigitated smectic A phase: liquid crystalline dimeric bidentate ligands and their metal complexes, C. V. Yelamaggad, I.S. Shashikala, V. Padmini Tamilenthi, D. S. Shankar Rao, Geetha G. Nair and S. Krishna Prasad, *J. Mater. Chem.*, **18**, 2096 (2008). [Front Cover]

8) Spatiotemporal patterns in a Langmuir monolayer due to driven molecular precession, R.K.Gupta, K.A.Suresh, S.Kumar, L.M.Lopatina, R.L.B.Selinger and J.V.Selinger, *Phys. Rev. E.*, **78**, 041703 (1-7) (2008).

9) Monolayer of amphiphilic functionalised gold nanoparticles at an air-water interface, Raj Kumar Gupta, K.A. Suresh and Sandeep Kumar, *Phys. Rev. E*, **78**, 032601 (1-4) (2008).

10) Supramolecular helical fluid columns from self-assembly of homomeric dipeptides, C. V. Yelamaggad, G. Shanker, R. V. Ramana Rao, D. S. Shankar Rao, S. Krishna Prasad, V. V. Suresh Babu, *Chem. Eur. J.,* **14**, 10462 (2008).

11) Pretransitional behaviour in the vicinity of the isotropic–nematic transition of strongly polar compounds, S Sridevi, S Krishna Prasad, D S Shankar Rao and C V Yelamaggad, *J. Phys.: Condens. Matter*, **20**, 465106 (2008).

12) Effect of the C-2 hydroxyl group on the mesomorphism of alkyl glycosides: synthesis and thermotropic behavior of alkyl 2-deoxy-d-arabino-hexopyranosides, M. K. Singh, N. Jayaraman, D.S. Shankar Rao, S. Krishna Prasad, *Chemistry and Physics of Lipids,* **155**, 90 (2008).

13) Cholesterol-based nonsymmetric liquid crystal dimers: an overview, C. V. Yelamaggad, G. Shanker, Uma S. Hiremath and S. Krishna Prasad, *J. Mater. Chem.,* **18**, 2927 (2008) Invited Article

14) Manifestation of chiral smectic C phase in diphenylbutadiene cored bolaamphiphilic sugars, Suresh Das, N. Gopinathan, S. Abraham, N. Jayaraman, M. K. Singh, S. Krishna Prasad, D. S. Shankar Rao, *Adv. Func. Mater.*, **18**, 1632 (2008).

15) Electrically tunable color using mixtures of bent-core and rod-shape molecules, Geetha.G. Nair, C. A. Bailey, S.Taushanoff, K. Fodor-Csorba, A. Vajda, Z. Varga, A. Bóta, A. Jákli, *Adv. Mater.,* **20**, 3138 (2008).

16) Electric-field assisted acceleration of the photostimulated nematic-isotropic transition, S. Krishna Prasad, Geetha G. Nair and V. Jayalakshmi, *Adv. Mater.*, **20**, 1363 (2008)

17) The first examples of discotic radicals: Columnar mesomorphism in spin-carrying triphenylenes, C. V. Yelamaggad, A. S. Achalkumar, D. S. Shankar Rao, M. Nobusawa, H. Akutsu, J. Yamada and S. Nakatsuji, *J. Mater. Chem.*, **18**, 3433 (2008).

18) Liquid crystal dimers derived from naturally occurring chiral moieties: Synthesis and characterization, C. V. Yelamaggad and G. Shanker, *Tetrahedron*, **64**, 3760 (2008).

19) Drifting periodic structures in a degenerate-planar bent-rod nematic liquid crystal beyond the dielectric inversion frequency, P. Kumar, Uma S. Hiremath, C. V. Yelamaggad, A. G. Rossberg and K. S. Krishnamurthy, *J. Phy. Chem. B*, **112**, 9270 (2008).

20) Electroconvection in a homeotropic bent-rod nematic liquid crystal beyond the dielectric inversion frequency, P. Kumar, Uma S. Hiremath, C. V. Yelamaggad, A. G. Rossberg and K. S. Krishnamurthy, *J. Phy. Chem. B*, **112**, 9753 (2008).

21) Frequency and temperature dependence of the dielectric parameters of wide temperature range TGBA and TGBC* phases of unsymmetrical liquid crystal dimers, M.B. Pandeya, R. Dhar, A. S. Achalkumar and C.V. Yelamaggad, *Phase Transitions*, **81**, 449 (2008).

22) Crystal structure of cholesteryl 5-(4'-(n-decyloxy)-2',3'-difluoro-biphenyl-4-yloxy)-pentanoate - a liquid crystalline non-symmetric dimer, R. K. Sharma, V. Gupta, Manoj Mathews and C. V. Yelamaggad, *Liq. Cryst.*, **35**, 1161 (2008).

23) Discotic liquid crystals: Synthesis and characterization of radial polyalkynylbenzene derivatives, Sanjay Kumar Varshney,Hideo Takezoe and D. S. Shankar Rao, *Bull. Chem. Soc. Jpn.*, **81**, 163 (2008)

In Press

1) Novel mesogenic azobenzene dimer at air-water and air-solid interfaces, Bharat Kumar, A.K.Prajapati, M.C.Varia and K.A.Suresh, *Langmuir* (in press).

2) Unusual dielectric and electrical switching behavior in the de Vries smectic *A* phase of twoorganosiloxane derivatives, S. Krishna Prasad, D. S. Shankar Rao, S. Sridevi, Chethan V. Lobo, B. R. Ratna, Jawad Naciri, and R. Shashidhar, *Phys. Rev. Lett.* (in press)

3) Understanding the observation of large electrical conductivity in liquid crystal-carbon nanotube composites, V.Jayalakshmi and S. Krishna Prasad, *Appl. Phys. Lett.* (in press)

4) Discotic mesogen-DNA complex films at interfaces, K.A.Suresh, and Alpana Nayak, *Mol. Cryst. Liq. Cryst.* (in press) Invited Article

5) Effect of high pressure on the nematic-isotropic transition in aerosil-liquid crystal composites, Prasad N. Bapat, D.S. Shankar Rao and S. Krishna Prasad, *Thermochimica Acta* (in press)

6) Photo-controlled conformation-assisted permanent optical storage device employing a polymer network liquid crystal, V. Jayalakshmi, G. Hegde, Geetha G. Nair and S. Krishna Prasad, *Physical Chemistry Chemical Physics* (in press)

7) Fast responding robust nematic liquid crystalline gels formed by a monodisperse dipeptide: electro-optic and rheological studies, Geetha G.

Nair, S. Krishna Prasad, V. Jayalakshmi, G. Shanker, and C.V. Yelamaggad, *J. Phys. Chem. B,* (in press)

8) A new thermotropic reentrant behaviour in a chiral liquid crystal dimer: the occurence of SmA-SmA_b-SmA phase sequence, C. V. Yelamaggad, V.Padmini, D. S. Shankar Rao, Geetha G. Nair and S. Krishna Prasad, *J. Mater. Chem.* (in press)

9) Formation of highly luminescent supramolecular architectures possessing columnar order from octupolar oxadiazole derivatives: Hierarchical self-assembly from nanospheres to fibrous gels, Shinto Varghese, N. S. Saleesh Kumar, Anjali Krishna, D. S. Shankar Rao, S. Krishna Prasad, and Suresh Das, *Adv. Func. Mater.,* (in press)

10) Luminescent, liquid crystalline tris(N-salicylideneaniline)s: Synthesis and characterization, C. V. Yelamaggad, A. S. Achalkumar, D. S. Shankar Rao and S. Krishna Prasad, *J. Org. Chem.* (in press)

11) Photoinduced phase transitions, S. Krishna Prasad, Geetha G. Nair and D.S. Shankar Rao, *Liquid Crystals* (in press) Invited Article

12) Photo-stimulated and photo-suppressed phase transitions, S.Krishna Prasad, Mol. Cryst. *Liq. Cryst.* (in press)

13) Liquid crystalline phase transitions in confined geometries, S. Krishna Prasad, D.S. Shankar Rao and Geetha G. Nair, *Journal of the Indian Institute of Science* (in press)

14) Electric-field dictated phase diagram and accelerated dynamics of a reentrant nematic liquid crystal under photo-stimulation, S. Sridevi, S. Krishna Prasad* and Geetha G. Nair, *Advanced Functional Materials (submitted)*

15) Optically-active, mesogenic lanthanide complexes: Design, synthesis and characterisation, C. V. Yelamaggad, Rashmi Prabhu, G. Shanker and D. W. Bruce, *Liq. Cryst.* (in press)

16) Crystal structure of an optically active nonsymmetric liquid crystal dimer: cholesteryl 5-[4-(4-*n*-heptylphenylethynyl)phenoxy]pentanoate, R. K. Sharma, V. K. Gupta, Manoj Mathews and C. V. Yelamaggad, *Liq. Cryst.* (in press)

17) Converse flexoelectric effect in bent-core nematic liquid crystals, Kumar, Y. Marinov, H. P. Hinov, Uma S. Hiremath, C. V. Yelamaggad, K. S. Krishnamurthy, and A. G. Petrov, *J. Phy. Chem. B.* (in press)

18) Crystal structure of bis(cholesteryl)4,4'-(1,2-phenylenebis(oxy))dibutanoate - an oligomesogen, V. K. Gupta, R. K. Sharma, M. Mathews and C. V. Yelamaggad, *Liq. Cryst.* (in press)

19) Observation of flexo-dielectric walls in a bent-core-calamitic nematic liquid

crystals, H. P. Hinov, Y. G. Marinov, A. G. Petrov, Uma S. Hiremath, C. V. Yelamaggad, *J. Opt. Adv. Mater.* (in press)

20) π–conjugated triphenylene twins exhibiting polymesomorphism including the nematic phase, Sanjay K. Varshney, H. Takezoe, V. Prasad, and D.S.S. Rao, *Mol. Cryst. Liq. Cryst.* (in press).

Papers & Posters presented at the Conferences

1) *Evidence of worm-like micellar behaviour in chromonic liquid crystals: Rheological, x-ray and dielectric studies*, S.Krishna Prasad, Oral paper presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea, June 29 – July 4, 2008.

2) *Dielectric measurements of the pretransitional behaviour in the vicinity of the isotropic-nematic transition of strongly polar compounds*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea, June 29 – July 4, 2008.

3) *Manifestation of chiral smectic C phase in Bolaamphiphilic sugars*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea June 29 – July 4, 2008.

4) *Dielectric and elastic constant measurements under high pressure on strongly polar liquid crystals*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea June 29 – July 4, 2008.

5) *Electrical conductivity and dielectric constant measurements of liquid crystal - gold nanoparticles composites*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea June 29 – July 4, 2008; The paper (contributed) also presented by Geetha G.Nair at the 15th National Conference on Liquid Crystals, October 13-15, 2008 organized by Indian Institute of Science, Bangalore.

6) *Photo-controlled conformation assisted permanent optical storage device*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea June 29 – July 4, 2008.

7) *Unusual dielectric and electrical switching behaviour studies in the de Vries smectic A phase of three organosiloxane derivatives*, S.Krishna Prasad, Poster presented at the 22nd International Liquid Crystal Conference, Jeju Island, Korea June 29 – July 4, 2008.

8) *Influence of photo-isomerization on the polarization-tilt coupling in an antiferroelectric liquid crystal,* S.Krishna Prasad**,** Oral presentation at the 15th

National Conference on Liquid Crystals, October 13-15, 2008 organized by Indian Institute of Science, Bangalore.

9) *Biaxial smectic and uniaxial nematic phases of mixtures of bent-core and rod-shape molecules,* S. Taushanoff, C. A. Bailey, K. Fodor-Csorba, A. Vajda, Geetha G. Nair, A. Jakli, Presented at International Symposium on Biaxial Nematic Liquid Crystals, Kent State University, October 27 - 28, 2008.

10) *Thermally-induced mesophase transitions in alkyl-substituted pentathienoacenes,* C.M. Shaw, X. Zhang, L. S. Miguel Rivera, Geetha G. Nair, A. Jakli, A.J. Matzger and D.C. Martin, Presented at APS March Meeting, Monday–Friday, March 16–20, 2009; Pittsburgh, Pennsylvania, USA. http://meetings.aps.org/link/BAPS.2009.MAR.D18.8

11) *Flexoelectrically driven instabilities in liquid crystals*, K.S.Krishnamurthy, Paper presented for the Proc. of the 15th National Conf. on Liquid Crystals, in the J. Indian Institute of Science, (under revision).

12) *Unusual dielectric and electrical switching behaviour studies in the de Vries smectic A phase of three organosilaxone derivatives,* D.S.Shankar Rao, Oral presentation at the 15th National Conference on Liquid Crystals, October 13-15, 2008 organized by Indian Institute of Science, Bangalore.

13) *Electroconvection in a homeotropic bent-rod nematic liquid crystal beyond the dielectric inversion frequency*, Pramoda Kumar, Uma S. Hiremath, C. V. Yelamaggad, K. S. Krishnamurthy and A. G. Rossberg. Poster presented at the 15th National Conference on Liquid Crystals, Oct. 13-15, 2008, organized by the Indian Institute of Science, Bangalore.

14) *Shear deformation and division of cylindrical walls in free-standing nematic films under high electric fields*, Pramod Tadapatri and K. S. Krishnamurthy. Poster presented at the 15th National Conference on Liquid Crystals, Oct. 13-15, 2008, organized by the Indian Institute of Science, Bangalore.

CENTRE FOR LIQUID CRYSTAL RESEARCH
BANGALORE

STATEMENT OF ACCOUNTS
FOR THE YEAR 2008 – 2009
AND
THE BALANCE SHEET AS ON 31.03.2009

B. R. V. Goud & Co.
Chartered Accountants

'Sai Complex', 1st Floor
1/1, Museum Road
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Telefax : 25586042
E-mail: brvg6204@gmail.com
www.brvg.co.in

Date: 20.07.2009

AUDITORS' REPORT

1. We have audited the attached Balance Sheet of **Centre for Liquid Crystal Research, Jalahalli, Bangalore,** as at 31st March 2009 and the Income and Expenditure Account and Receipts & Payments Account for the year ended on that date, annexed thereto. These Financial Statements drawn up by the Centre are the responsibility of the Centres' Management. Our responsibility is to express an opinion on these Financial Statements based on our Audit.

   We have conducted our audit in accordance with Auditing standards generally accepted in India. Those Standards require that we plan and perform the audit to obtain reasonable assurance about whether the Financial Statements are free of material misstatement. An Audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the Financial Statements. An audit also includes assessing the accounting principles used and significant estimates by Management, as well as evaluating the overall Financial Statement presentation. We believe that our audit provides a reasonable basis for our opinion.

2. We have obtained all the information and explanations, which to the best of our knowledge and belief were necessary for the purpose of our Audit.

3. In our opinion, proper Books of Accounts as required by law have been kept by the Management so far as appears from our examination of such books.

4. The Balance Sheet and the Income and Expenditure Account dealt with by this report are in agreement with the books of account.

5. It is the policy of the Centre to prepare its financial statements on the Cash receipts and disbursements basis. On the basis, revenue and related assets are recognized when received rather than when earned. The expenses are recognized when paid rather than when the obligation is incurred.

6. In our opinion and to the best of our information and according to the explanations given to us, the said accounts read with the schedules thereon give a true and fair view:

   a) In the case of the Balance Sheet, of the state of affairs of the Centre as at 31st March 2009,

   A N D

   b) In the case of Income and Expenditure Account, of the **DEFICIT** for the year ended on that date.

for B.R.V. GOUD & CO.,
Chartered Accountants,

(A.B.SHIVA SUBRAMANYAM)
PARTNER

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.

BALANCE SHEET AS AT 31ST MARCH, 2009

(Amount in Rupees)

I. CORPUS / CAPITAL FUND AND LIABILITIES	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	**108126054**	46434537
RESERVES AND SURPLUS	2	**N I L**	N I L
EARMARKED / ENDOWMENT FUNDS PROJECTS	3	**6436092**	7778785
SECURED LOANS AND BORROWINGS	4	**N I L**	N I L
UNSECURED LOANS AND BORROWINGS	5	**N I L**	N I L
DEFERRED CREDIT LIABILITIES	6	**N I L**	N I L
CURRENT LIABILITIES AND PROVISIONS	7	**248706**	49682
DEFERRED GOVT. GRANTS	8	**N I L**	46543632
TOTAL		**114810852**	100806636
II. ASSETS			
FIXED ASSETS	9	**59389626**	38674745
INVESTMENTS - FROM EARMARKED/ENDOWMENT FUNDS	10	**N I L**	N I L
INVESTMENTS - OTHERS	11	**N I L**	N I L
CURRENT ASSETS, LOANS, ADVANCES ETC.,	12	**55421226**	62131891
MISCELLANEOUS EXPENDITURE (to the extent not written off or adjusted)		**N I L**	N I L
TOTAL		**114810852**	100806636
NOTES ON ACCOUNTS	25		

As per our report of even date,
for BRV Goud & Co.,
Chartered Accountants,

(K.A.SURESH)
DIRECTOR

(K.R.SHANKAR)
ACCOUNTS OFFICER

(A B SHIVASUBRAMANYAM)
PARTNER

PLACE: BANGALORE
DATE : 20.07.2009

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 2009

(Amount in Rupees)

A - INCOME	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
Income from Sales / Services	13	N I L	N I L
Grants / Subsidies:	14	38000000	31728861
Fees / Subscriptions	15	N I L	N I L
Income from Investments(income on investments from		N I L	N I L
earmarked / endowment Funds)	16	N I L	N I L
Income from Royalty, Publications etc.,	17	N I L	N I L
Interest earned	18	3052176	2552504
Other Income	19	277441	5489084
Increase / (decrease) in stock of finished goods and work-in-progress	20	N I L	N I L
TOTAL (A)		41329617	39770449
B - EXPENDITURE			
Establishment Expenses	21	6295442	3316415
Other Administrative Expenses etc.,	22	10524684	8411457
Expenditures on Grants, Subsidies etc.,	23	29156285	N I L
Interest	24	N I L	N I L
Depreciation (Net Total at the year end corresponding to schedule 9 (A)		0	5434462
TOTAL (B)		45976411	17162334
BALANCE BEING SURPLUS / (DEFICIT) CARRIED TO CORPUS / CAPITAL FUND (A-B)		(4646794)	22608115
NOTES ON ACCOUNTS	25		

As per our report of even date,
for BRV Goud & Co.,
Chartered Accountants,

(K.A.SURESH)
DIRECTOR

(K.R.SHANKAR)
ACCOUNTS OFFICER

(A.B.SHIVA SUBRAMANYAM)
PARTNER

PLACE: BANGALORE
DATE : 20.07.2009

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.

RECEIPTS AND PAYMENTS FOR THE PERIOD / YEAR ENDED 31ST MARCH, 2009

(Amount in Rupees)

	RECEIPTS	Current Year	Previous Year
I	**Opening Balances**		
	a) Cash in Hand	**7660**	7727
	b) Bank Balances	**2714318**	549876
II	**Grants Received**		
	a) From Govt.of India	**38000000**	40000000
	b) From Other Sources		
	i) CSIR (1931_CVY) Project	**0**	288731
	ii) SERC (2004-05) Project	**2168**	600000
	iii) SERC (CVY1) Project	**0**	2000000
	iv) CSIR (2162_CVY3) Project	**624667**	N I L
	v) Indo-Bulgarian Project	**166000**	N I L
III	**Income on Investments from**		
	a) Earmarked/Endownment Funds	**N I L**	N I L
	b) Own Funds	**N I L**	N I L
IV	**Interest Received**		
	a) On Bank Deposits (S.B)	**23495**	18054
	b) Loans, Advances, Deposits etc.,	**3028681**	2534450
	Other Income		
V	a) Miscellaneous Receipts, CHSS	**32045**	12350
	b) Miscellaneous Income	**231640**	35987
	c) Licence Fee	**13756**	6285
VI	**Amount Borrowed**	**N I L**	N I L
VII	**Any Other Receipts**		
	a) EMD	**221926**	14576
	b) Advances	**224579**	41720
	c) Income Tax	**743407**	252409
	d) Contributions recovered & rem	**16000**	12450
	e) CPF	**428338**	201389
	f) NSC	**0**	1000
	g) IT refund received	**0**	281018
	h) National Relief Fund	**14990**	0
VIII	**Investments & Deposits Matured**	**78207137**	104687578
	TOTAL	**124700807**	151545600

	PAYMENTS	Current Year	Previous Year
I	**Expenses**		
	a) Establishment Expenses	**6295442**	3316415
	b) Administrative Expenses	**10524684**	8342130
II	**Payments made against Funds for various Projects**	**3055730**	634168
III	**Investments and Deposits**		
	a) Made out of own Funds	**50912699**	128674106
	b) Capital Work in Progress	**0**	
IV	**Expenditure on Foxed assets**	**29156285**	7390555
V	**Refund of Surplus money/Loans**	**N I L**	N I L
VI	**EMD / Security Deposit**	**22902**	N I L
VII	**Finance Charges (Interest)**	**N I L**	N I L
VIII	**Other Payments:**		
	a) Income Tax	**743407**	252409
	b) Contributions recovered & remitted to RRI	**16000**	12450
	c) CPF	**428338**	201389
	d) National Relief Fund	**14990**	0
	e) Advances	**235917**	0
IX	**Closing Balances**		
	a) Cash in Hand	**0**	7660
	b) Bank Balances	**23294413**	2714318
	TOTAL	**124700807**	151545600

As per our report of even date,
for BRV Goud & Co.,
Chartered Accountants,

(K.A.SURESH)
DIRECTOR

(K.R.SHANKAR)
ACCOUNTS OFFICEI

(A.B. SHIVA SUBRAMANYAM)
PARTNE

PLACE: BANGALORE
DATE : 20.07.2009

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

(Amount in Rupees)

		CURRENT YEAR	PREVIOUS YEAR
SCHEDULE 1 - CORPUS / CAPITAL FUND			
Balance as at the beginning of the year		**46434537**	23826422
ADD: Deferred Grant (See Note)		**46543632**	0
Fixed Assets Purchased during the year		**29156285**	0
Surplus (Deficit) for the year		**(4646794)**	22608115
		117487660	46434537
LESS: Depreciation for the year		**9361606**	0
	TOTAL	**108126054**	46434537
SCHEDULE 2 - RESERVES AND SURPLUS		**N I L**	N I L
SCHEDULE 3 - EARMARKED / PROJECT FUNDS	TOTAL	6436092	7778785
(See Annexure A for details)			
SCHEDULE 4 - SECURED LOANS AND BORROWINGS		**N I L**	N I L
SCHEDULE 5-UNSECURED LOANS AND BORROWINGS		**N I L**	N I L
SCHEDULE 6-DEFERRED CREDIT LIABILITIES		**N I L**	N I L
SCHEDULE 7-CURRENT LIABILITIES & PROVISIONS			
A) CURRENT LIABILITES:			
1) Statutory Liabilites - Professional Tax		**0**	0
2) Other Liabilities - Security Deposit		**248706**	49682
	TOTAL (A)	**248706**	49682
B) PROVISIONS:		**N I L**	N I L
	TOTAL (B)	**N I L**	N I L
	TOTAL (A+B)	**248706**	49682
SCHEDULE 8 - DEFERRED GRANT			
Balance as at the beginning of the year		**46543632**	43706955
ADD: Grants received during the year		**0**	8271139
		46543632	51978094
LESS: Transferred to Capital Fund		**46543632**	5434462
	TOTAL	**0**	46543632

CENTRE FOR LIQUID CRYSTAL RESEARCH, ALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

Annexure A to Schedule 3

(Amount in Rupees)

SCHEDULE 3 - EARMARKED / PROJECTS FUNDS	SERC	SERC (2004-05)	SERC (CVY1)	PROJECT / WISE BREAKUP INDO-US	INDO-US (SKP)	INDO - JAPAN	CSIR (NMITLI)	CSIR (SK)	CSIR (CVY)	CSIR (2162_CVY3)	INDO-ITALIAN	INDO-BULGARIAN	TOTAL CURRENT YEAR	PREVIOUS YEAR
a) Opening Balance of the Funds	2603883	564382	1977989	454357	242332	175319	1468481	162779	24928	-8665	113000	0	7778785	6222335
b) Additions to the Funds:														
i) Grants	0	2168	0	0	0	0	0	-124237	0	624667	-113000	166000	555598	2888731
ii) Incomefrom Investments made on Account of India														
iii) Other Additions (Specify nature)														
TOTAL (a+b)	2603883	566550	1977989	454357	242332	175319	1468481	38542	24928	616002	0	166000	8334383	9111066
c) Utilisation/Expenditure towards objective of Funds:														
i) Capital Expenditure														
Fixed Assets														
Others														
ii) Revenue Expenditure														
Salaries, Wages and Allowances etc.,	0	28000	265319	0	0	0	0	0	0	194486	0	115876	603681	585101
Consumables	0	133706	94804	0	0	0	0	0	0	0	0	0	228510	33332
Overheads	0	206479	0	0	0	0	0	0	0	0	0	0	206479	0
Depreciation	292245	29755	236287	19880	36358	0	220348	5781	3782	15187	0	0	859621	713848
TOTAL (c)	292245	397940	596410	19880	36358	0	220348	5781	3782	209673	0	115876	1898291	1332281
NET BALANCE AT THE YEAR END (a+b-c)	2311638	168610	1381579	434477	205974	175319	1248133	32761	21146	406329	0	50124	6436092	7778785

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

SCHEDULE - 9 : FIXED ASSETS **(Amount in Rupees)**

DESCRIPTION	W.D.V. as on 31.03.2008	Additions/deletions during the year				Total	Rate	Depreciation for the year	W.D.V. as on 31.03.2009
		Before Sept.	After Sept.	Total additions	Total Deletions				
A. C L C R : 52060									
Equipment	2092540	225439	62461	287900	0	2380440	15	352381	2028059
Furniture & Fixtures	745750	66707	37435	104142	0	849892	10	83117	766775
Scientific Equipment	26554021	24084628	909776	24994404	0	51548425	15	7664031	43884394
Workshop Equipment	248592	0	0	0	0	248592	15	37289	211303
Generator Set	334278	0	0	0	0	334278	15	50142	284136
Air Conditioner	228013	48000	0	48000	0	276013	15	41402	234611
Annexe Building	1065002	0	2396668	2396668	0	3461670	10	226334	3235336
Carpentary Works	464661	55944	0	55944	0	520605	10	52060	468545
Vinyl Flooring	141139	8415	0	8415	0	149554	10	14955	134599
Fume Cupboard	92327	0	0	0	0	92327	10	9233	83094
Aluminium Partitions	322304	76393	0	76393	0	398697	10	39870	358827
Brick Base(Partitions)	29178	0	0	0	0	29178	10	2918	26260
Other Miscellaneous Works	1991737	100699	242711	343410	0	2335147	10	221379	2113768
Construction of Shed	64691	19757	0	19757	0	84448	10	8445	76003
Construction of Cycle Stand	81946	0	0	0	0	81946	10	8195	73751
Computers	166844	677913	143339	821252	0	988096	60	549856	438240
Total (A) Rs.(Carried Forward)	34623023	25363895	3792390	29156285	0	63779308		9361606	54417702

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

SCHEDULE - 9 : FIXED ASSETS **(Amount in Rupees)**

DESCRIPTION	W.D.V. as on 31.03.2008	Additions/deletions during the year Before Sept.	After Sept.	Total additions	Total Deletions	Total	Rate	Depreciation for the year	W.D.V. as on 31.03.2009
SCHEDULE - 9 : FIXED ASSETS									**(Amount in Rupees)**
DESCRIPTION	W.D.V. as on 31.03.2008	Additions/deletions during the year Before Sept.	After Sept.	Total additions	Total Deletions	Total	Rate	Depreciation as on 1.4.2008	W.D.V. as on 31.03.2009
Total (A) Rs.(Brought Forward)	34623023	25363895	3792390	29156285	0	63779308		9361606	54417702
B. SERC PROJECT:									
Electrical Installation	177185	0	0	0	0	177185	15	26578	150607
Equipment	1770513	0	0	0	0	1770513	15	265577	1504936
Cycle	596	0	0	0	0	596	15	89	507
Total (B) Rs.	1948294	0	0	0	0	1948294		292244	1656050
C. INDO US PROJECT:									
Equipment	111641	0	0	0	0	111641	15	16746	94895
Temperature Controller	8524	0	0	0	0	8524	15	1279	7245
Cell Fabrication	12368	0	0	0	0	12368	15	1855	10513
Total (C) Rs.	132533	0	0	0	0	132533		19880	112653
D. INDO US (SKP) PROJECT:									
Equipment	242378		0	0	0	242378	15	36357	206021
Total (D) Rs.	242378	0	0	0	0	242378		36357	206021
E. CSIR (NMITLI) PROJECT:									
Equipment	1468310	0	0	0	0	1468310	15	220247	1248064
Computers	170	0	0	0	0	170	60	102	68
Total (E) Rs.	1468480	0	0	0	0	1468480		220349	1248132
F. CSIR (SK) PROJECT:									
Equipment	38541	0	0	0	0	38541	15	5781	32760
Total (F) Rs.	38541	0	0	0	0	38541		5781	32760
G. CSIR (CVY) PROJECT:									
Equipment	25216	0	0	0	0	25216	15	3782	21434
Total (G) Rs.	25216	0	0	0	0	25216		3782	21434
H. SERC (2004-05) PROJECT:									
Equipment	181725	16640	0	16640	0	198365	15	29755	168610
Total (H) Rs.	181725	16640	0	16640	0	198365		29755	168610
I. SERC (CVY1) PROJECT:									
Equipment	14555	1560683	0	1560683	0	1575238	15	236286	1338952
Total (I) Rs.	14555	1560683	0	1560683	0	1575238		236286	1338952
J. CSIR (2162_CVY3) PROJECT:									
Equipment	0	0	202500	202500	0	202500	15	15188	187313
Total (J) Rs.	0	0	202500	202500	0	202500		15188	187313
Grand Total(A+B+C+D+E+F+(	**38674745**	**26941218**	**3994890**	**30936108**	**0**	**69610853**	**0**	**10221227**	**59389626**

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

(Amount in Rupees)

		CURRENT YEAR	PREVIOUS YEAR
SCHEDULE 10 - INVESTMENTS FROM EARMARKED / ENDOWMENT FUNDS		NIL	NIL
SCHEDULE 11 - INVESTMENTS - OTHERS		NIL	NIL
SCHEDULE 12-CURRENT ASSETS,LOANS, ADVANCES			
A) CURRENT ASSETS:			
1) Inventories		NIL	NIL
2) Sundry Debtors:		NIL	NIL
3) Cash Balances in Hand(including Cheques/Drafts and Imprest)		NIL	7660
4) Bank Balances:- Scheduled Banks			
Current Account		NIL	NIL
Deposits Account (includes margin money)		31632391	58926829
Savings Accounts		23294413	2714318
5) Post Office Savings Account - NSC		0	0
	TOTAL (A)	54926804	61648807
B) LOANS,ADVANCES AND OTHER ASSETS:			
1) Loans		NIL	NIL
2) Advances and Other amounts recoverable in Cash or in kind or for value to be received:		55568	44230
a) K P T C L Deposit (SERC/CLCR)		347740	347740
b) Telephone		76000	76000
c) Income Tax		15114	15114
	TOTAL (B)	494422	483084
	TOTAL (A+B)	55421226	62131891

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE - 560 013.
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

(Amount in Rupees)

		CURRENT YEAR	PREVIOUS YEAR
SCHEDULE 13-INCOME FROM SALES / SERVICES		NIL	NIL
SCHEDULE 14 - GRANTS / SUBSIDIES			
(Irrevocable Grants & Sbusidies Received)			
Central Government Plan DIT		38000000	31728861
SCHEDULE 15 - FEES / SUBSCRIPTIONS		NIL	NIL
SCHEDULE 16 - INCOME FROM INVESTMENTS		NIL	NIL
SCHEDULE 17 - INCOME FROM ROYALTY, PUBLICATIONS ETC.,		NIL	NIL
SCHEDULE 18 - INTEREST EARNED			
1) On Term Deposits - Scheduled Bank		3028681	2534450
2) On Savings Accounts - Scheduled Bank		23495	18054
	TOTAL	3052176	2552504
SCHEDULE 19 - OTHER INCOME			
Miscellaneous Income		277441	54622
Deferred Grant Income		0	5434462
		277441	5489084
SCHEDULE 20 - INCREASE (DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS		NIL	NIL
SCHEDULE 21 - ESTABLISHMENT EXPENSES			
1) Salaries and Wages		6282543	3304683
2) Others - Medical Expenses		12899	11732
	TOTAL	6295442	3316415

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2009

(Amount in Rupees)

	CURRENT YEAR	PREVIOUS YEAR
SCHEDULE 22-OTHER ADMINISTRATIVE EXPENSES, ETC.,		
PLAN:		
Journals & Books	**1380791**	741897
Seminars and Conferences	**352814**	83063
Fellowship	**1793850**	1120696
Repairs & Maintenance of Building	**989893**	403900
Repairs & Maintenance of Equipment	**854783**	952021
Postage	**25613**	33255
Telephones	**135129**	111458
Printing & Stationery	**218319**	215139
Electricity & Water	**1015151**	1013796
Travelling and Conveyance	**585969**	696913
Audit fee	**33708**	0
Advertisement charges	**57533**	83449
Packing and forwarding	**180893**	54460
Miscellaneous Expenses	**141694**	112688
Consumables	**1459909**	1430179
Bank Charges	**27885**	22669
Hospitality	**40163**	32001
Customs Duty (statutory minimum)	**63330**	63205
Samples Analysis Charges	**119200**	150518
Professional Charges	**93945**	271104
Annual Fee/Internet Charges	**27000**	12000
Security & House Keeping	**638442**	411606
Insurance	**40670**	107132
Rates & Taxes	**8,000**	18500
Rent	**240,000**	200000
Loss on Sale of Asset	**0**	69327
Miscellaneous expenditure	**0**	481
TOTAL	**10524684**	8411457
SCHEDULE 23-EXPENDITURE ON GRANTS, SUBSIDIES ETC.,	29156285	0
SCHEDULE 24- INTEREST	NIL	NIL

CENTRE FOR LIQUID CRYSTAL RESEARCH, JALAHALLI, BANGALORE

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2009

SCHEDULE 25: SIGNIFICANT ACCOUNTING POLICIES

1. **Accounting Conventions:-** The financial statements are drawn up in accordance with historical accounting conventions and on the going concern concept. Cash system is followed to record the Income and Expenditure.

   - According to the decision taken by the Governing Council for accounting treatment of Grants- in –aid received from Department of Science and Technology to defray the expenses of the Centre, no bifurcation has been made between Revenue Grant and Capital Grant. The total amount of Grant received from the DST during the Fiscal Year 2008-09 has been credited to the Income and expenditure account of the Institute.

   - Consequent to the change in the Accounting Policy as stated above, the Deferred Grant Account created to the extent of Rs.46543652/-During the years 2005-2006 to 2007-2008 has been transferred to Capital Fund, during the year ended 31st March,2009.

2. **Investments:** - Investments are stated at cost. Interests from Investments are accounted on "cash basis".

3. **Fixed assets:** - Fixed assets shown under Gross Block are recorded at cost of acquisition, inclusive of inward freight, duties, taxes and incidental expenses related to acquisition.

4. **Depreciation:** - Depreciation on Fixed assets has been provided on Written Down Value Method at rates as per Income Tax Rules. Depreciation for the year amounting to Rs1, 02, 21,227/- has been debited to the Capital Fund account and not to the Income and Expenditure Account, since the entire cost of acquisition of Fixed assets acquired by the Centre has been charged off to the Income & Expenditure Account, and the same is brought into books by debiting to the assets account and crediting to the Capital Fund account, as a matter of accounting policy, as stated in Note No. 5 below.

5. **Capital Expenditure:-** All Capital Expenditure incurred during the year amounting to Rs.2,91,56,285 for purchase of Fixed Assets is charged to Income & Expenditure Account., under the head "Expenditure on Grants/ Subsidy". The same is again reflected in Fixed assets schedule by crediting to Capital Fund account.

SCHEDULE 25: CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS

CONTINGENT LIABILITIES

1.1 Claims against the Entity not acknowledged as debts- Rs. **Nil**	(Previous year Rs. **Nil**)
1.2 In respect of:	
Bank guarantee given by/on behalf of the Entity – Rs. **Nil**	(Previous year Rs. **Nil**)
Letter of Credit opened by Bank on behalf of the Entity-Rs. **Nil**	(Previous year Rs. **Nil**)
Bills discounted with bands Rs. **Nil**	(Previous year Rs. **Nil**)
1.3 Disputed demands in respect of:	
Income tax Rs. **Nil**	(Previous year Rs. **Nil**)
Sales tax Rs. **Nil**	(Previous year Rs. **Nil**)
Municipal taxes Rs. **Nil**	(Previous year Rs. **Nil**)
1.4 In respect of claims from parties for non-execution of orders, but contested by the Entity Rs. **Nil**	(Previous year Rs. **Nil**)
CA PITAL COMMITMENTS	
Estimated value of contracts remaining to be executed on capital account and not provided for (net of advances) Rs. **Nil**	(Previous year Rs. **Nil**)
LEASE OBLIGATIONS	
Future obligations for rentals under finance lease arrangements for plant and machinery amount to Rs. **Nil**	(Previous year Rs. **Nil**)

CURRENT ASSETS, LOANS AND ADVANCES

In the opinion of the management, the current assets, loans and advances have a value on realisation in the ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

6. **TAXATION:** No provision for Income Tax has been considered necessary as Centre for Liquid Crystal Research has been registered under Sec. 10(21) and Sec. 12A of Income Tax Act, 1961.

7. **FOREIGN CURRENCY TRANSACTIONS**

7.1 Value of Imports Calculated on C I F Basis"

- Capital goods	Rs. 2,65,55,087/-
- Stores. Spares and consumables	Rs. 6,87,790/-

7.2 Expenditure in foreign currency:

a) Travel	Rs. 4,82,152/-
b) Remittances and interest payment to Financial Institutions/Banks in Foreign Currency	Nil

7.3 Earnings:

Value of exports on FOB basis	Nil

Presentation of Accounts: The Financial Statements are presented in the format prescribed by the Department of Science and Technology for all Central Autonomous Organizations, vide their letter No. A1/Misc/004 /2002 dated 26.03.2002.

All the paise are rounded off to the nearest rupee.

Previous year's figures have been regrouped wherever necessary to suit this year's groupings.

Schedules 1-25 are annexed to and form an integral part of the Balance Sheet as at 31st March 2009 and the Income and Expenditure Account for the year ended on that date.

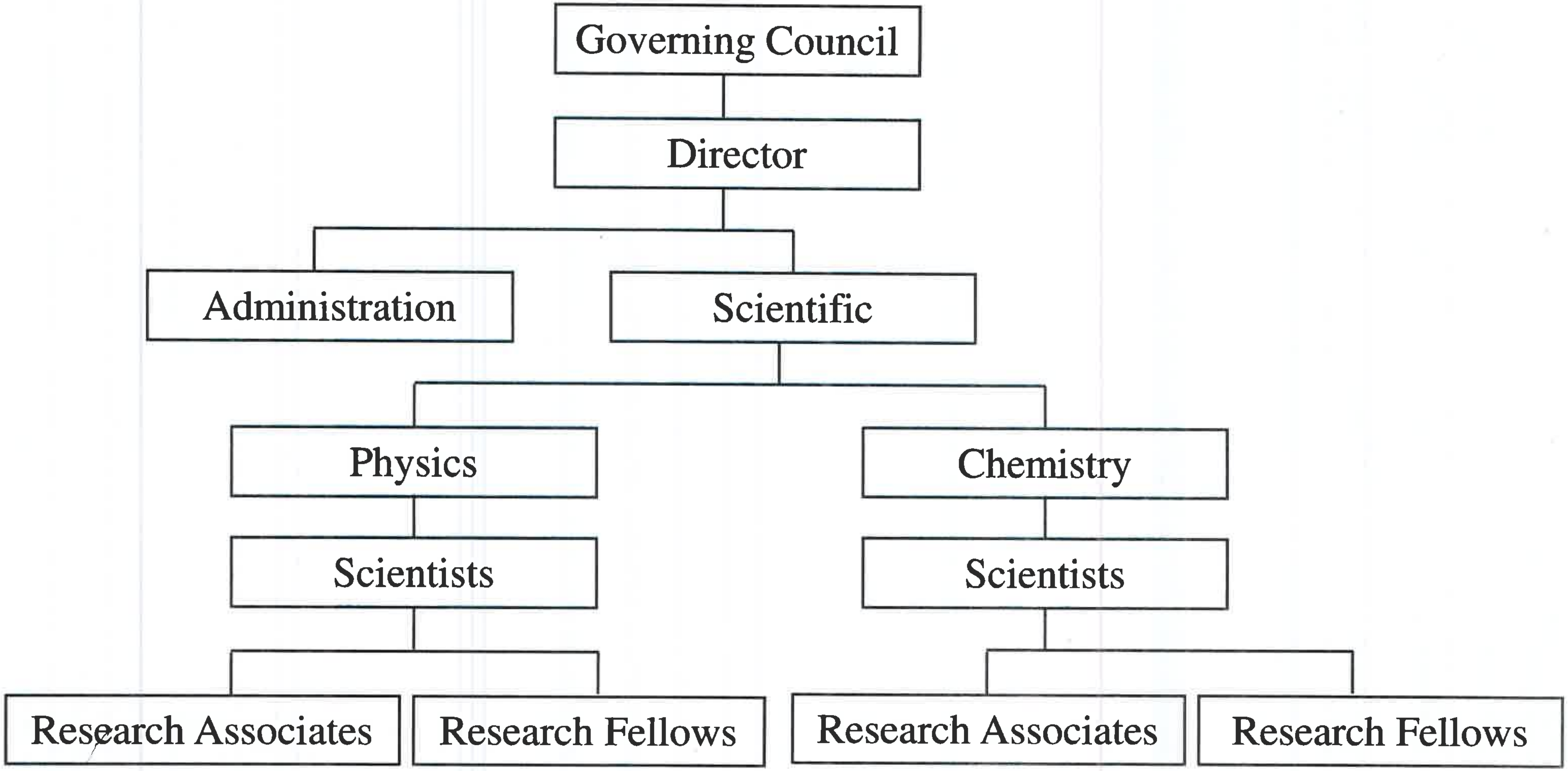
As Per out report of even date,
For B.R.V. Goud & Co.,
Chartered Accountants

PLACE: Bangalore
DATE : 20/07/2009

(A.B. SHIVA SUBRAMANYAM)

PARTNER

Centre for Liquid Crystal Research (CLCR)
Organisation Chart



CENTRE FOR LIQUID CRYSTAL RESEARCH
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