Centre for Soft Matter Research

Bengaluru

मृदु पदार्थ अनुसंधान केन्द्र

बेंगलूरु

ANNUAL REPORT

2013 – 2014

वार्षिक रिपोर्ट

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P.B. No.1329, Jalahalli
BENGALURU – 560 013

CONTENTS

FOREWORD

The Centre for Soft Matter Research (CSMR) is an autonomous institute under the Department of Science and Technology (DST), Ministry of Science and Technology, Government of India. The Centre is registered as a Scientific Society under the Karnataka Societies Act.

The Annual Report for the year 2013-2014 highlights the research and development activities, scientific programmes of the Centre, and lists the output of the Centre such as the academic activities and research publications for the period 1 April 2013 to 31 March 2014.

In recent times, exploration of matter, including soft matter, at nano scale has emerged as another knowledge frontier revolutionizing materials science and technology. There is hardly any branch of materials science and technology, including soft matter, which has been left unaffected by the emerging knowledge frontiners of nano science.

In view of the above, the Governing Council in its 22nd meeting held on March 6, 2013 decided to change the name of the Centre from "Centre for Soft Matter Research" to "Centre for Nano and Soft Matter Sciences" (CNSMS) to allow for this changing reality of research and development in materials science and engineering. This would also greatly enrich the research and development strengths of the Centre in liquid crystals and soft matter research.

The new name was approved by the higher bodies and also the Department of Science and Technology, Government of India. The amendment was registered by the Registrar of Societies, Government of Karnataka on 9 January 2014. It was decided to adopt the new name with effect from 1 April 2014.

Bengaluru

PRAVEER ASTHANA

1. INTRODUCTION

The Centre, formerly known as Centre for Liquid Crystal Research (CLCR), started 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 was brought under the administrative control of the Department of Information Technology. In the year 2003, the Centre was converted to an autonomous institution under the administrative control of the Department of Science and Technology (DST), Ministry of Science and Technology. The Centre was renamed as "Centre for Soft Matter Research (CSMR)" with effect from 1 September 2010 in order to expand the scope of its research programmes keeping in view the current international trends in research. The new name was approved by DST and the amendment was registered by the Registrar of Societies, Government of Karnataka on 28 April 2010. DST has been providing core support in the form of grant-in-aid for conducting basic and applied research in soft matter and related areas. The objective of the Centre is to focus on basic science, and to develop a bias towards technology, in line with the international trends in research on Soft Matter including liquid crystal materials.

The Centre is engaged in Research and Development (R&D) on a variety of liquid crystal materials and other soft materials like gels, polymers, membranes and so on. This is the only centre in the country devoted to Research and Development in soft matter.

The Centre has also entered into an MOU to provide technical 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, provided funds for CLCR. The grants were received by CLCR from the Department of Information Technology up to the financial year 2002-03. From 2004 onwards CLCR has been getting grants from the Department of Science and Technology (DST), Ministry of Science & Technology. The year-wise break-up of the outlay proposed by the Centre, as per the 12^{th} Plan document, is given below.

Table: Proposed Outlay as per the Twelfth Plan document (Rs. in Lakhs)

2012-13	2013-14	2014-15	2015-16	2016-17	Total
1044.00* (FE 560.00)	1205.00 (FE 540.00)	1393.00 (FE 600.00)	1308.00 (FE 460.00)	1267.00 (FE 380.00)	6217.00 (FE 2540.00)

* During the year 2013-14, a grant of Rs. 560 lakhs was released by DST.

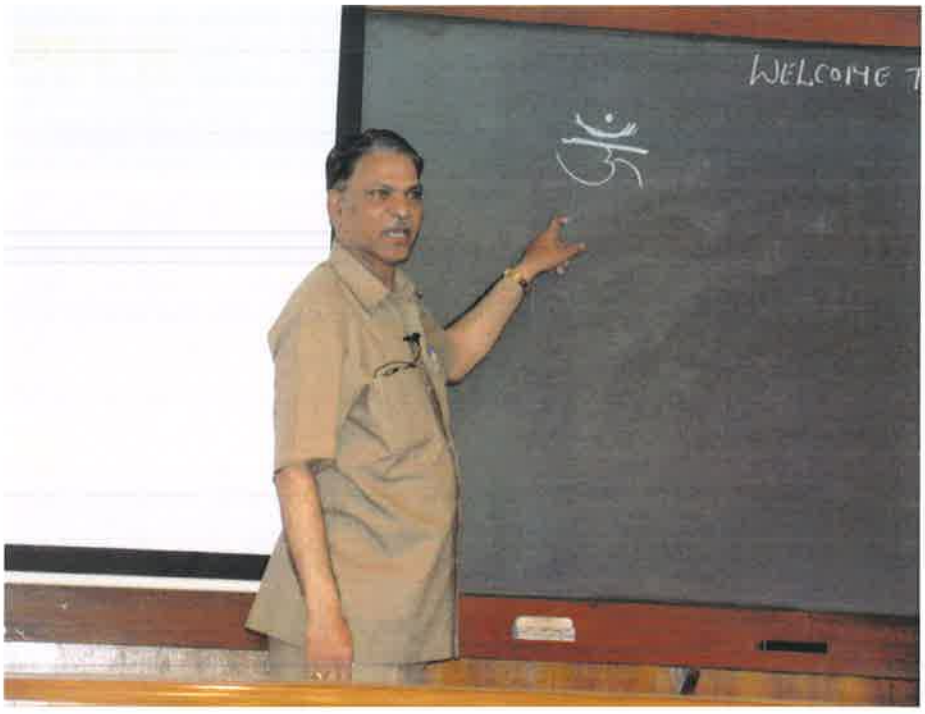
3. RESERVATION AND OFFICIAL LANGUAGE

The Centre follows the national policies on Reservation and Official Language as per the rules and orders issued by the Government of India from time to time.

The Centre has one SC/ST employee working under Group C.

HINDI DAY

The Centre observed the Hindi Divas on 16 September 2013. On this occasion, Shri M.G.Savadatti, Assistant Director (Retd), Central Hindi Training Institute, Bangalore gave a lecture entitled **हिन्दी के स्वरूप वर्तमान स्थिति में.**



Shri M.G.Savadatti, Assistant Director (Retd), Central Hindi Training Institute, Bangalore delivering a talk.

To popularize usage of Hindi at CSMR, everyday a scientific word is displayed on the Notice Board under "आज का शब्द".

4. RESEARCH ADVISORY BOARD

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

1.	Prof. N. Kumar Raman Research Institute	Chairman
2.	Prof. Chandan Dasgupta 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 Presently, Director (R&D), Bharat Electronics Limited	Member
7.	Prof. K. A. Suresh Centre for Soft Matter Research	Convener

5. FINANCE COMMITTEE

The sixth meeting of the Finance Committee was held on 5 November 2013 with the following members

1.	Dr. Praveer Asthana, Acting Director, CSMR, Bengaluru	Chairman
2.	Prof. K. V. Ramanathan, Former Chairman, NMR Centre, Indian Institute of Science, Bengaluru	Member
3.	Dr. T. G. Ramesh, Former Head, Materials Science Division, National Aerospace Laboratories, Bengaluru	Member
4.	Prof. K. A. Suresh, Scientist of Eminence, CSMR	Invitee
5.	Shri S. Gulvady, Administrative Officer, CSMR	Invitee

The Finance Committee was reconstituted by the Governing Council at its meeting held on 6 November 2013 with the following members

1.	Director, CSMR	Chairman
2.	Financial Advisor, DST, New Delhi	Member
3.	Prof. K.S. Narayan, JNCASR	Member
4.	Prof. S.B.Krupanidhi, IISc	Member
5.	Administrative Officer, CSMR	Invitee

6. RESEARCH AND DEVELOPMENT ACTIVITIES

6.1 *A PHOTO-DRIVEN DUAL-FREQUENCY ADDRESSABLE OPTICAL DEVICE OF BANANA-SHAPED MOLECULES*

A new type of photonic device driven by the photoisomerization of azobenzene in a bent-core nematic environment has been demonstrated the principle of which is the reorientation of the molecules exhibiting a dual-frequency switching property by unpolarized UV light (Figure 1A). The resulting large changes in the birefringence can be employed to fabricate optically-addressed display devices and image-storage systems. The main advantage of the bent-core environment is the orders of magnitude faster back relaxation even in the absence of a visible wavelength radiation, obviating the need for additional optical components, and thus simplifying the device. Concomitant with the birefringence and permittivity changes, conductivity of the material, exhibiting a two-fold increase upon irradiation, can also be

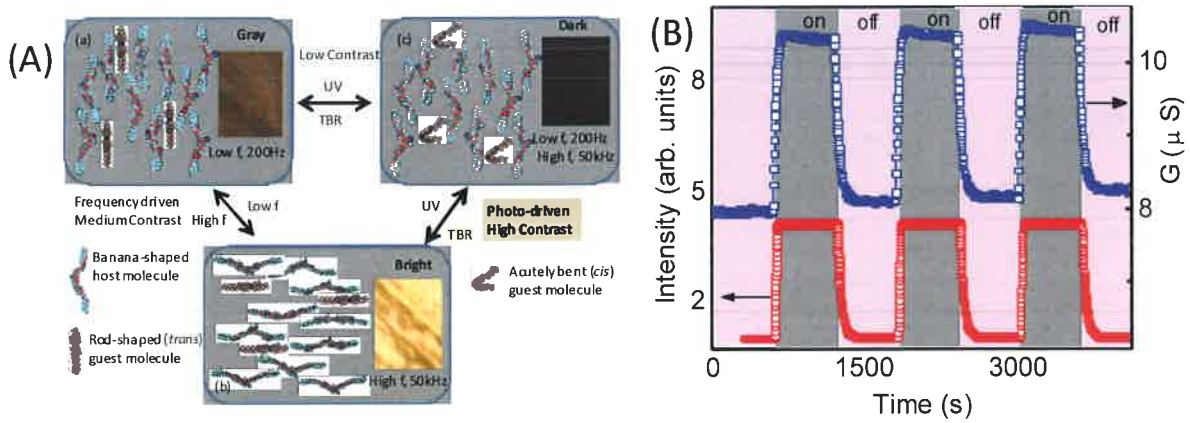


Figure 1: (A) Principle of the device showing molecular conformation and field of view in the polarizing microscope under (a) equilibrium and (b) & (c) photodriven conditions. Panels (b) and (c) are for low and high frequency driving situations, respectively.

photo-controlled (Figure 1B). The fatigue-limit of the device seems to be quite high, as the observed effects were highly reproducible over many cycles between the photo-driven and no-UV states. In this demonstration of the principle the host bent-core material has a small positive dielectric anisotropy. With an improved design of the molecule it is possible to further improve the dynamic characteristics of the device.

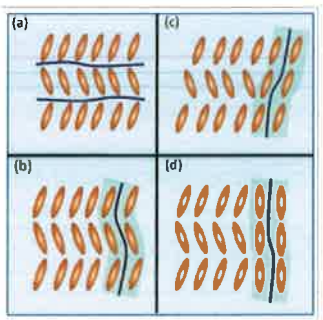
This work has been published: S. Krishna Prasad, P. Lakshmi Madhuri, Uma S. Hiremath, and C.V. Yelamaggad, *Appl. Phys. Lett.*, **104,** 111906 (2014)

Investigators : S. Krishna Prasad, P. Lakshmi Madhuri, Uma S. Hiremath, and C. V. Yelamaggad

6.2 *DYNAMICS OF THE ANTIFERROELECTRIC SMECTIC PHASE CONFINED IN A POLYMER NETWORK*

Dielectric spectroscopic investigations have been performed on an antiferroelectric liquid crystal in its pristine form and when stabilized by a polymer network without and on application of a DC bias field. While the in-phase mode associated with the helix distortion is hardly affected, the high frequency mode connected with the antiphase fluctuations shows a large decrease with increasing concentration of the photoactive monomer used to generate the polymer stabilization. Employing data obtained as a function of DC bias, several parameters, including the antiferroelectric coupling coefficient, the relevant elastic constant, and the viscosities have been extracted. Particularly interesting is the substantial reduction of the antiferroelectric coupling coefficient which should be responsible for the decrease in the

Figure 2



antiphase mode frequency. The analysis of the data also shows that the quadratic coefficient of the Landau free energy decreases by a factor of 5 for the polymer stabilized system. The Hookean elastic constant representing the elastic interaction between the liquid crystalline molecules and the strands of the polymer network, is quite large and argued to play an important role for the observed behaviour. These findings are expected to open up a new way

to understand collective modes in restricted geometries. The polymer stabilization can lead to different molecular arrangements (see figure 2) with respect to the polymer strands. The results favour the situation shown in the panel (d).

This work has been published: P. Lakshmi Madhuri, S. Krishna Prasad and Geetha G. Nair, *RSC Advances*, **4,** 3121 (2014).

Investigators : P. Lakshmi Madhuri, S. Krishna Prasad and Geetha G. Nair

6.3 *FASTER DIELECTRIC RELAXATION, AND ENHANCEMENT OF ELECTRICAL CONDUCTIVITY, DIELECTRIC ANISOTROPY IN COMPOSITES OF GOLD NANOPARTICLE AND A WEAKLY POLAR NEMATIC LIQUID CRYSTAL*

Detailed calorimetric, frequency-dependent anisotropic conductivity and permittivity measurements have been performed on composites of gold nanoparticles (GNP) and a weakly-polar nematic liquid crystal possessing a low frequency director relaxation. The presence of the nanoparticles substantially lowers the nematic-isotropic transition temperature and also the associated transition entropy. The conductivity of the composites is enhanced by two orders of magnitude, with a concentration dependence described by a percolation scaling law usually observed in mixtures of metal particles and polymers. The exponent determined is much smaller, which could be due to the presence of thermal fluctuations characteristic of the fluid-like nematic medium. The frequency dependence of the AC conductivity exhibits a critical frequency that increases with concentration of GNP; the high frequency response is not in agreement with Jonscher's Universal Response principle. The low frequency of the director relaxation mode enabled detailed dielectric relaxation spectroscopy studies, the first of its kind. While the value of the relaxation frequency depends strongly on the concentration of GNP, the activation energy remains essentially the same. We compare the observations with those predicted by the dilution theory, and find a general agreement.

This work has been published: S. Krishna Prasad, M. Vijay Kumar, T. Shilpa and C. V. Yelamaggad, *RSC Advances,* **4,** 4453 (2014).

Investigators : S. Krishna Prasad, M. Vijay Kumar, T. Shilpa and C. V. Yelamaggad

6.4 *PERIODICALLY CLICKABLE POLYESTERS: STUDY OF INTRACHAIN SELF-SEGREGATION INDUCED FOLDING, CRYSTALLIZATION, AND MESOPHASE FORMATION*

A series of polyesters have been quantitatively "clicked" with a fluoroalkylazide , to yield polyesters carrying longchain alkylene segments in the backbone and either one or two perfluoroalkyl segments located at periodic intervals along the polymer chain (Figure 3). The immiscibility of the alkylene and fluoroalkyl segments causes the polymer chains to fold in a zigzag fashion to facilitate the segregation of these segments; the folded chains further organize in the solid state to form a lamellar structure with alternating domains of alkyl (HC) and fluoroalkyl (FC) segments. Evidence for the self-segregation is provided by DSC, SAXS, WAXS, and TEM studies; in two of the samples, the DSC thermograms showed two distinct endotherms associated with the melting of the individual domains, while the WAXS patterns (see Figure 4) confirm the existence of two separate peaks (whose relative strength is dependent on the site of clicking) corresponding to the interchain distances within the crystalline lattices of the HC and FC domains. SAXS data, on the other hand, reveal the formation of an extended lamellar morphology with an interlamellar spacing that matches reasonably well with those estimated from TEM studies. Interestingly, a smectic-type liquid crystalline phase is observed at temperatures between the two melting transitions. These systems present a unique opportunity to develop interesting nano-structured polymeric materials with precise control over both the domain size and morphology; importantly, the

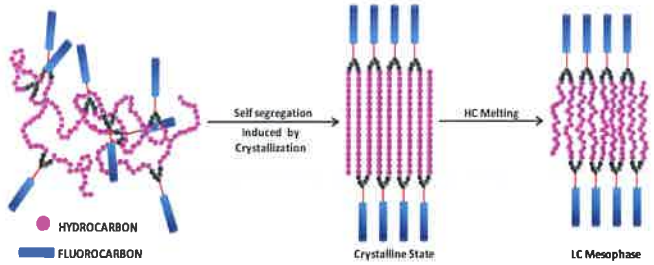


Figure 3

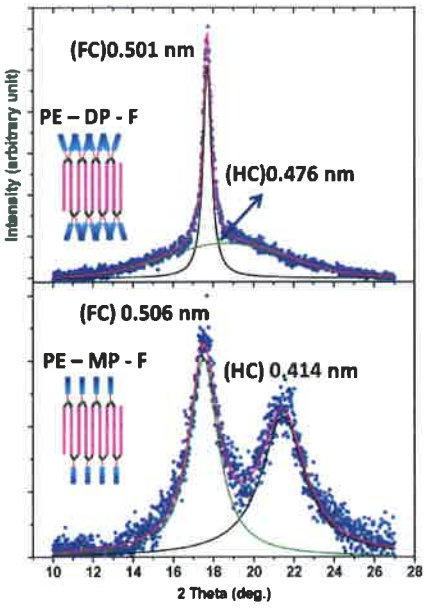


Figure 4

domain sizes are far smaller than those typically observed in traditional block copolymers.

This work was carried out in collaboration with Joydeb Mandal and Prof. S. Ramakrishnan and has been published: Joydeb Mandal, S. Krishna Prasad, D. S. Shankar Rao, and S. Ramakrishnan, *J. Am. Chem. Soc.*, **136,** 2538 (2014).

Investigators: D.S. Shankar Rao and S. Krishna Prasad

6.5 INFLUENCE OF POLARIZATION-TILT COUPLING ON THE FERROELECTRIC PROPERTIES OF SMECTIC GELS

Physical gels are soft materials formed by weak interactions between fibrous aggregation of low molecular weight gelators and the surrounding liquid medium. Since non-covalent interactions such as a van der Waals forces or hydrogen bonds are involved in the gelation process, these systems are generally thermally reversible. If the liquid is replaced by a liquid crystal (LC), it brings in the dimension of anisotropy. The thermal reversibility of the LC gel is an advantage although, as far as confinement of LC in a network is concerned, these systems resemble a polymer dispersed LC material. The mesophase involved in the investigations on LC organogels has mostly been the nematic. In the current study, experiments have been carried out on composites of a ferroelectric liquid crystal (FLC), exhibiting smectic mesophases, with a simple organic gelating agent. Structural, thermal, electrical and mechanical probes have been employed to investigate the influence of the coupling between the polarization and tilt angle on the ferroelectric properties of smectic gels. The importance

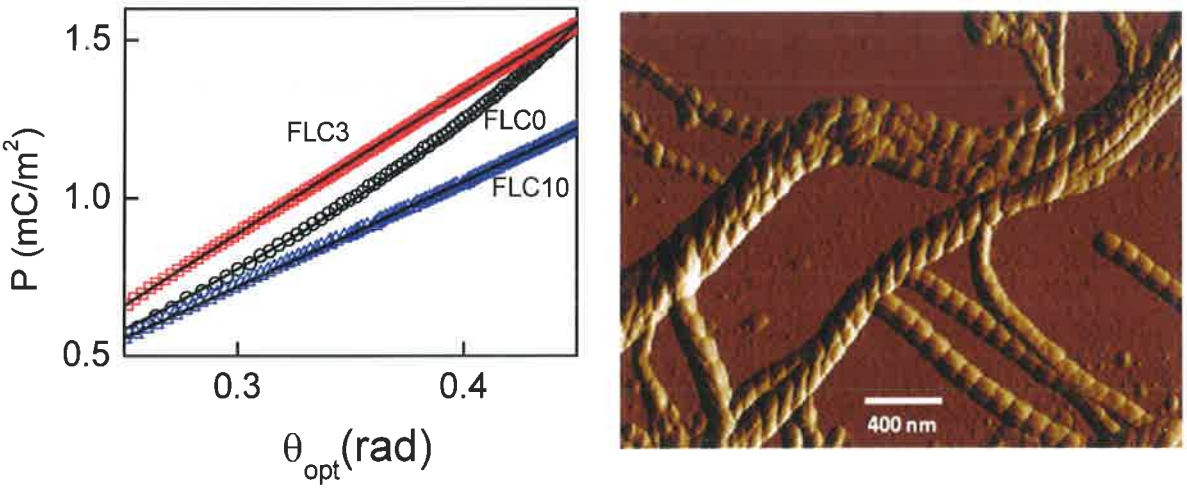


Figure 1: *Left: Dependence of polarization P on the electro-optic tilt angle (θ). While the host mixture(FLC0) shows a noticeable nonlinear variation, the composites (FLC 3 and FLC10) have essentially a linear behaviour suggesting that the importance of the biquadratic polarization-tilt coupling is reduced upon gelation. Right: AFM image of the fibre strands exhibiting a twisted stripe pattern with a periodicity of ~ 100 nm for FLC10*

of this study is due to the potential application of these soft materials in memory devices.

The calorimetric data, presenting clear signatures of the gelation occurring in the smectic A (Sm A) phase or the isotropic phase, depending on the concentration of the gelator, help in constructing a rich diagram in the temperature-gelator concentration space. The atomic force microscopy (AFM) imaging brings out the interesting feature of the transfer of chirality from FLC to the gel strands, as exemplified by the creation of nano-rope structures which have attracted much attention in recent times. The influence of gelation on the magnitude of the

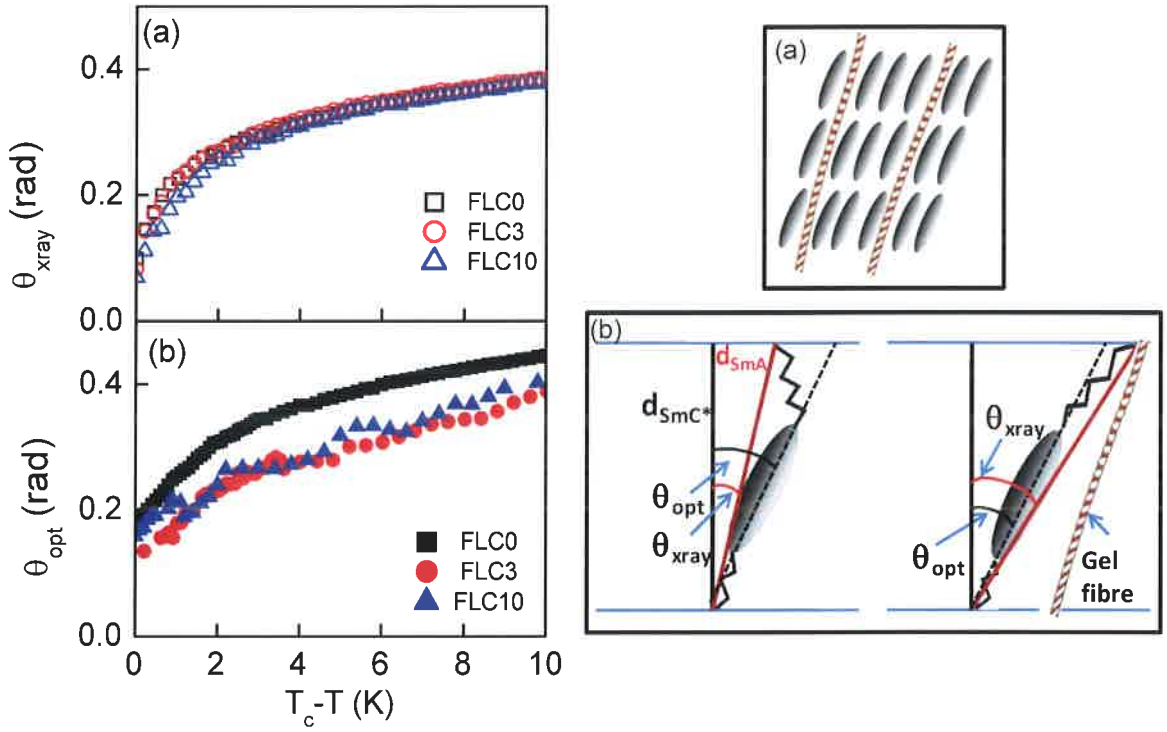


Figure 2: Left: Thermal variation of the tilt angle in the SmC phase determined from (a) XRD and (b) electro-optic methods for the host mixture and two composites. The values from XRD are nearly identical for the different materials, unlike the electro-optics ones. Right: Schematic diagram to illustrate (a) that the HSA fibres run through the smectic layers creating intralayer segregation of the fibres and LC molecules, and (b) the origins of the tilt angle as measured by the XRD (θ_{xray}) and electro-optic (θ_{opt}) techniques. Notable is the feature that for the non-gel system (left panel) θ_{opt} is greater than θ_{xray}, a feature that gets reversed upon gelation. Lowering of θ_{opt} is attributed to anchoring caused by the gel fibres.*

tilt angle appears to be dependent on the probe employed: There is no change in the values obtained by Xray diffraction (XRD), which looks at the projection of the entire molecular length on to the layer normal. In contrast, the value from the electro-optic method, wherein the molecular-core is responsible for the results, diminishes with gelator concentration. The latter feature is copied by the magnitude of the polarization also. Dielectric spectroscopy shows that gelation weakly influences the soft mode in the SmA phase. However, the

Goldstone mode behaviour is strongly dependent on the gelator concentration, with the appearance of two modes in the smectic C* (SmC*) phase of higher gel concentrations. The data analyzed in terms of the predictions of the Landau model proposed for the ordinary (non-gel) SmA-SmC* transition show that the gel network enhances the linear polarization-tilt coupling over the biquadratic one. Upon gelation the system becomes mechanically strong with a large increase in the elastic moduli.

Investigators : Geetha G. Nair, S. Vimala, S. Krishna Prasad, Uma S. Hiremath and C.V.Yelamaggad

6.6 NOVEL COLUMNAR–CALAMITIC PHASE SEQUENCES IN A BINARY SYSTEM OF BENT-CORE AND ROD-LIKE MESOGENS

We have performed X-ray, electrical switching and dielectric measurements on a binary system comprising achiral bent-core and chiral rod-like components. While the pure bent-core compound exhibits a single mesophase, namely the B2 phase, the rod-like compound shows smectic A and smectic C* mesophases. A particular mixture, studied in detail here, exhibits a novel sequence involving three different columnar phases (the B1 phases being of the $B1_{rev}$ type), whose thermal range is enclosed at the higher and lower temperature range by fluid smectic phases of the upright and tilted types, respectively (Sm A–$B1_{OPAF1}$–$B1_{OPAF2}$–$B1_{TPAF}$–Sm C* phase, the subscripts O, T, P, F and AF indicate orthogonal, tilted, polar, ferroelectric and antiferroelectric properties, respectively. The structural studies (see Figure 1) revealed that all the columnar phases show a rectangular lattice, with the lowest temperature phase having tilted molecules. In the electrical switching measurements (Figure 2) a twin peak profile – characteristic of an antiferroelectric structure – is seen for the $B1_{OPAF}$ phases, but with no textural change except on a transient scale. On the other hand the $B1_{TPAF}$ phase, which also shows antiferroelectric-type switching, exhibits clear changes between the field-off and field-on states, as well as for the two signs of the field. This phase also possesses a three-fold higher value of polarization than the smectic C* phase, indicating the stronger influence of the polar ordering. Dielectric studies (Figure 3) show the presence of a soft mode of relaxation in the vicinity of the $B1_{OPAF2}$–$B1_{TPAF}$ transition, with the relaxation frequency of the mode exhibiting behavior similar to that seen for the smectic A–smectic C* phase transition. Mean field coefficients determining the soft mode behavior as well as the thermal variation of the tilt angle have been determined. We suggest that the chiral interactions are augmented by the presence of polar ordering of the bent-core molecules, and the polar interaction of the minority concentration bent-core molecules is also affected by the rod-like molecules. In fact,

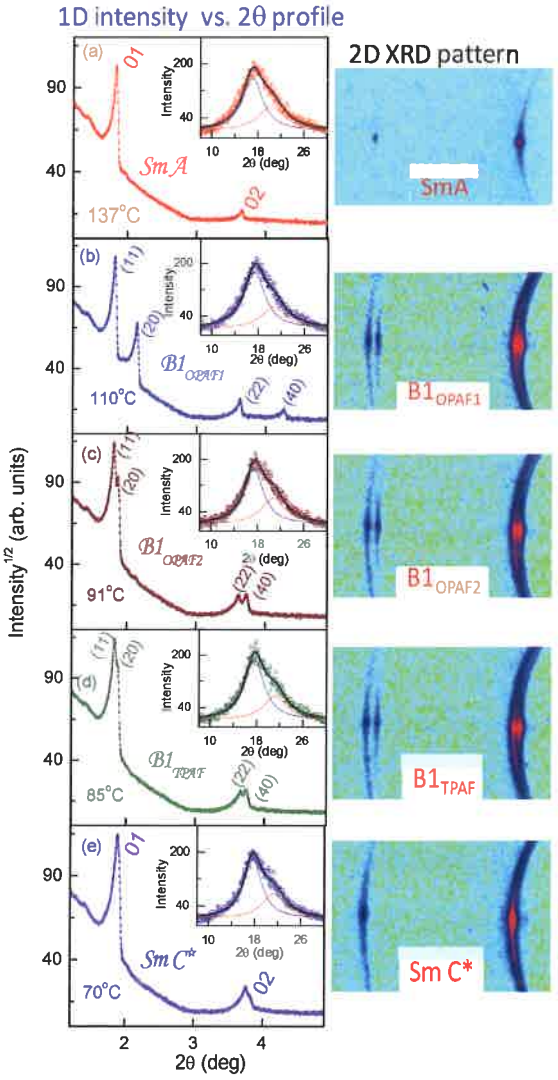


Figure 1: X-ray images (right panel) and the extracted intensity vs. angle (2θ) profiles (left panel). The fitting of the data helps in resolving the diffuse maximum into contributions from the cholesterol (lower angle portion, blue line) and the hydrocarbon parts (larger angle, red line) of the molecules. Notice the presence of two sets of twin-spots in the images for the B1 phases and a single set of spots for the smectic phases.

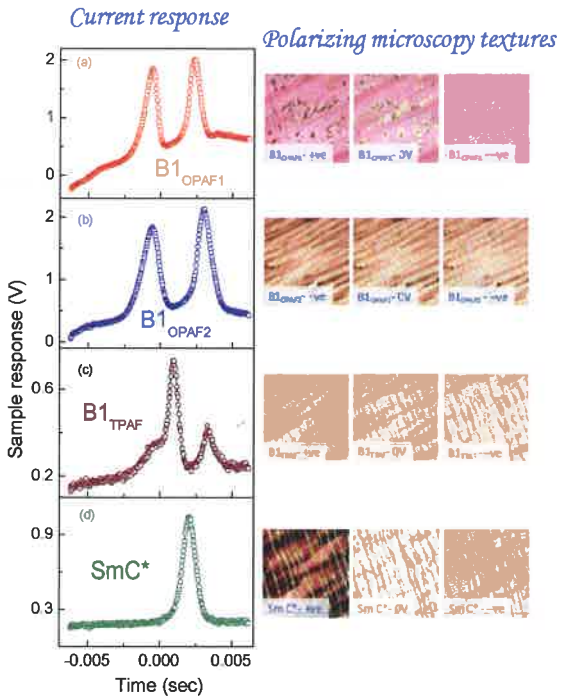


Figure 2: Current response (left panels), and polarizing microscopy textures with no field and upon application of a field with -ve or +ve sign (right panels).

it is possible that the competition between the two types of forces in the mixture leads to the

appearance of the columnar structure, which is not present in either of the pure compounds. The transition from the columnar phase with upright molecules to that with tilted molecules is accompanied by the softening of relaxation frequency connected with the tilt.

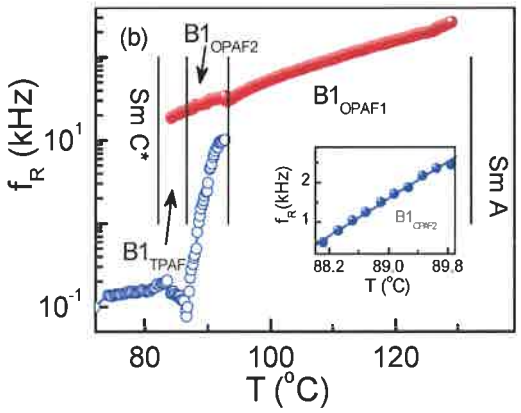


Figure 3: The temperature dependence of the relaxation frequency in the different mesophases. The data shown as filled symbols correspond to the polar ordering of the bent-core molecules, whereas the open symbols represent the soft mode (connected with the tilting of the molecules) in the $B1_{OPAF}$ and $B1_{TPAF}$ phases, and the Goldstone mode in the SmC phase. The inset in the bottom panel shows the fitting of the soft mode (in the $B1_{OPAF2}$ phase) frequency to the Landau model expression.*

This work was carried out in collaboration with M. Sarvamangala and S. Basavaraja of Department of Physics, Gulbarga University.

This work has been published: D. S. Shankar Rao, M. Vijay Kumar, S. Krishna Prasad, U. S. Hiremath, M. Sarvamangala and S. Basavaraja, *J. Mater. Chem. C*, **1**, 7488 (2013)

Investigators: D. S. Shankar Rao, M. Vijay Kumar, S. Krishna Prasad, U.S. Hiremath

6.7 XRAY DIFFRACTION STUDIES ON FLUORESCENT UNSYMMETRICAL FOUR-RING BENT-CORE MESOGENS

Xray diffraction measurements have been carried out on unsymmetrical four-ring bent-core compounds with unequal chain lengths and reversing the ester linkage in the molecule. Figure 4 shows the diffraction pattern for a representative compound. The compound shows four sharp reflection in the low angle region in addition to diffuse scattering in the wide angle region. The indexing carried out fitted very well (with low χ^2 value) for the tilted columnar phase (Col_r) with the lattice parameters a = 43.60 Å; b = 82.24 Å; V = 16386 $Å^3$. The Xray results on compounds with slight modifications in the structure showed that it forms a columnar phase with 2D columnar oblique lattice.

This work was carried out in collaboration with N. V. S. Rao, Chemistry Department, Assam University, Silchar.

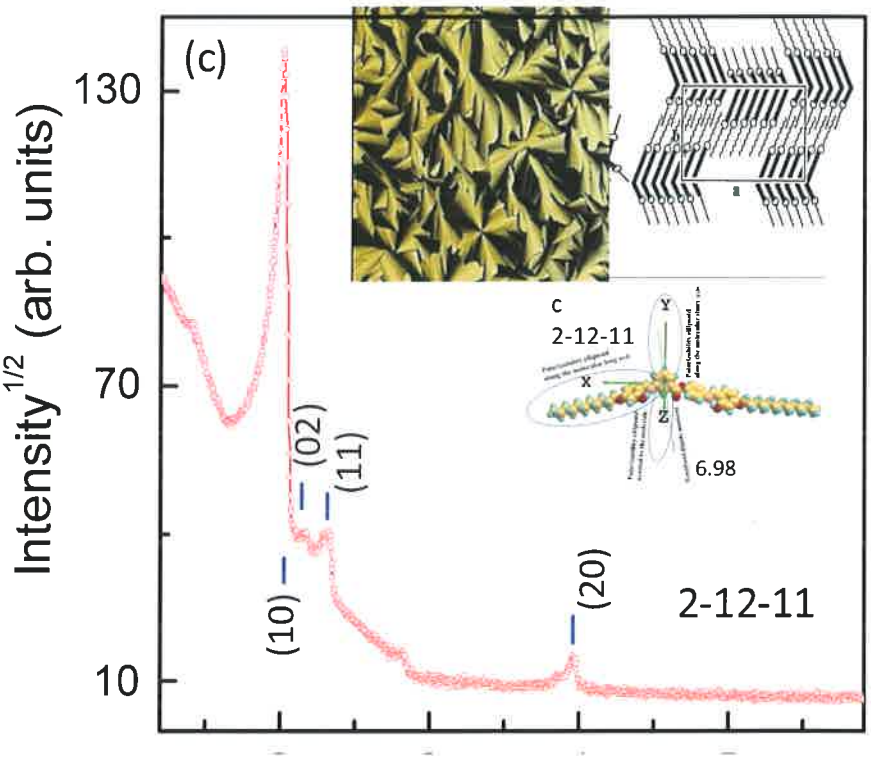


Figure 4: The X-ray intensity versus 2θ profile in the low angle region at 95 °C. The number indicates the miller indices of the peak which fits into a 2D rectangular lattice. Also shown are the microscopic texture, minimised energy conformation of the molecular structure.

This work has been published: R. Deb, A. R. Laskar, D. D. Sarkar, G. Mohiuddin, N.Chakraborty, S. Ghosh, D. S. Shankar Rao and N.V.S Rao, *Cryst Eng Comm,* **15**, 10510 (2013)

Investigators: D. S. Shankar Rao

6.8 XRAY DIFFRACTION STUDIES ON LANTHANIDOMESOGENS COMPLEX

Figure 5 top panel shows diffraction pattern for the ligand 6ae at room temperature in the mesophase. In the wide-angle region, a diffuse intensity maximum centered at around 4.2 Å is observed, associated with the short-range liquid-like positional ordering of the hydrocarbon chains within the layer plane. In the low-angle region, sharp peaks observed corresponding to d spacings of 47.7, 28.2, and 23.8 Å in the ratio 1:0.59:0.5 suggest a columnar phase with 2D hexagonal lattice. We proposed a tubular columns, generated by the stacking of the discs, and the mutual organization of these columns into a hexagonal lattice. Figure 4 bottom panel shows XRD pattern for the complex with three peaks observed in the small-angle region, one strong peak and two weak peaks corresponding to the Miller indices (100), (200), and (300) with a d-spacing ratio of 1:2:3, respectively. The presence of these equidistant reflections

shows that the molecules are arranged in regularly spaced layers with a layer distance of 37.61Å. Two other less intense but relatively sharp reflections were assigned to (120) and (130) reflections, which indicate 2D columnar ordering of the mesophase. The presence of broad halos in the wide-angle region at 4.3 Å confirm the fluid nature of the mesophase. The

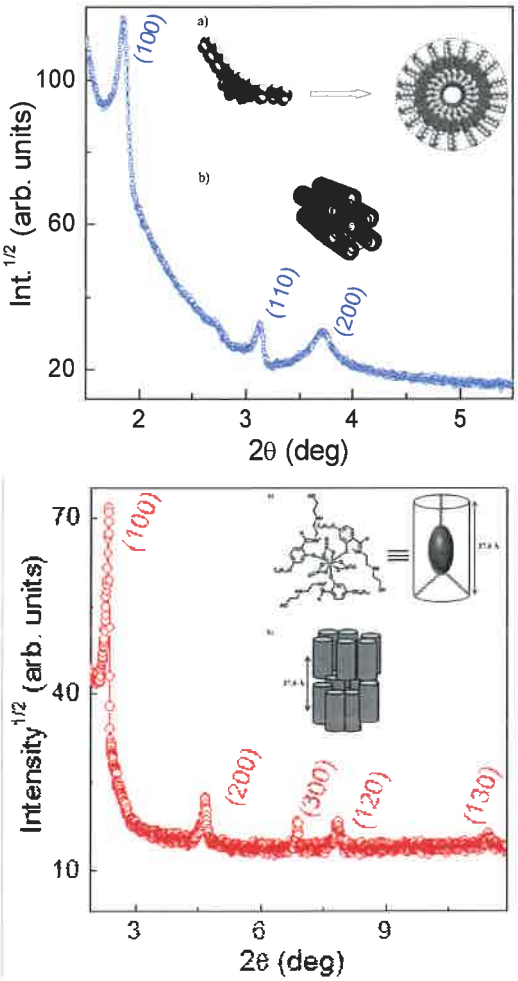


Figure 5: The X-ray intensity versus 2ϑ profile in the low angle region for the ligand (top panel) and the metal complex (bottom panel). Also shown in the graph are the molecular organization, which organize into columnar phase with 2D hexagonal lattice in the case of ligand whereas into a lamellar phase with short range columnar order.

XRD analysis that the observed mesophase may more appropriately be branded as a lamellar phase with short-range columnar order within the layers (Col_L). As such, the phase is more akin to a smectic type phase. The Col_L mesophase can be imagined to form smectic layers made of broken lamellae with some interdigitation of the peripheral alkoxy chains in the layer molecules.

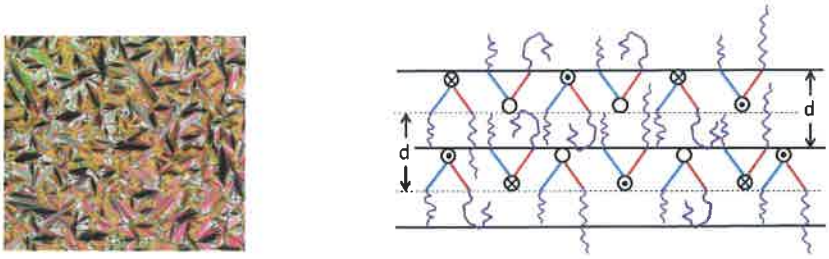
This work was carried out in collaboration with G. Das and C. R. Bhattacharjee, Department of Chemistry, Assam University, Silchar.

This work has been published: H. A. R. Pramanik, Gobinda Das, C. R. Bhattacharjee, P. C. Paul, P. Mondal, S. Krishna Prasad, and D. S. Shankar Rao, *Chem. Eur. J.* **19**, 13151 (2013).

Investigators: D. S. Shankar Rao and S.Krishna Prasad

6.9 V- SHAPED LIQUID CRYSTALLINE AZO COMPOUNDS

The first examples of V-shaped liquid crystalline materials composed of non-symmetrical molecules are designed and synthesised. They belong to a homologous series of azo substituted compounds wherein the two arms attached to the 1,2-positions of the benzene ring are different. The new compounds are characterised by the spectroscopic methods. The liquid crystalline properties are investigated using polarising optical microscopy, differential scanning calorimetry and X-ray diffraction studies. All the compounds synthesised here are found to be liquid crystalline. They exhibit nematic and smectic A mesophases, which are uniaxial in nature. The preliminary qualitative experiments showed that the compounds are photo-sensitive. Based on the X-ray results, we have made an effort to illustrate the molecular arrangement of these compounds in their mesophases as shown in the following figure.



(a) **(b)**

Figure: (a) Focal conic texture of SmA mesophase of the compound ***A-12*** *and (b) the molecular arrangement in SmA . The empty, crossed and dotted circles indicate the bend-plane of the molecules oriented in all the possible directions.*

This work has been published: N.G. Nagaveni and Veena Prasad, *Phase transitions*, **86**, 1227 (2013).

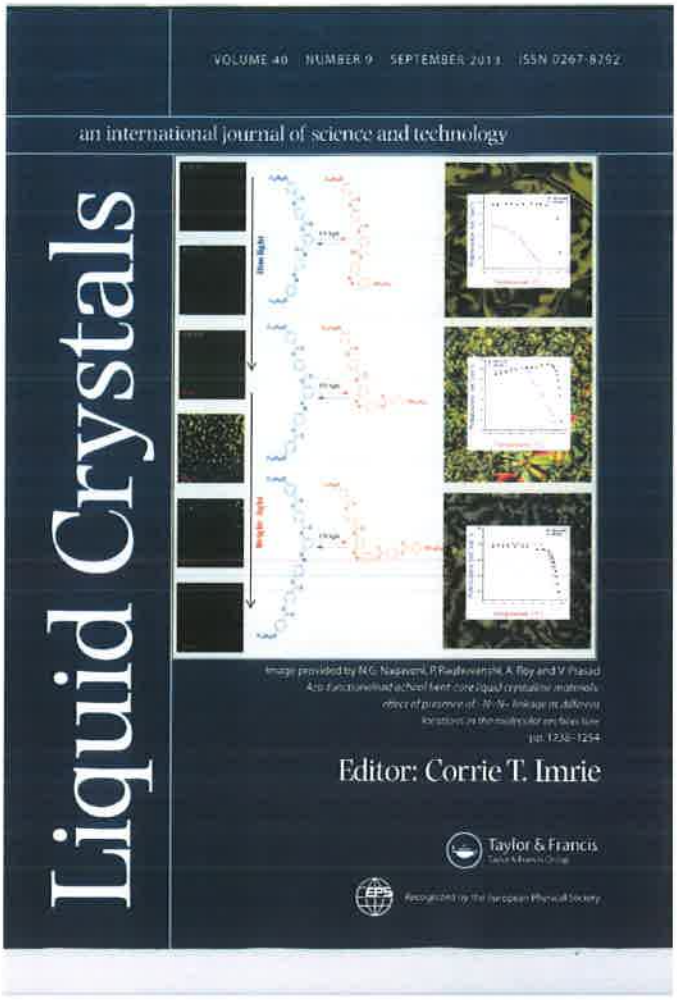
Investigators: N.G. Nagaveni and Veena Prasad.

6.10 AZO FUNCTIONALIZED ACHIRAL BENT-CORE LIQUID CRYSTALLINE MATERIALS

Azo functionalized materials are of special interest due to their photochromic properties which can be exploited for optical and optoelectronic devices. From this point of view, we

have been working on such smart materials and have synthesized several new photochromic materials and studied the photo-induced effects in such systems.

(i) We investigated the effect of presence of –N=N- linkage, at different locations in the molecular architecture, on the mesomorphic properties. The molecular structures of all the newly synthesized compounds are established using the organic spectroscopic methods. The liquid crystalline properties are investigated using polarizing optical microscopy (POM), differential scanning calorimetry (DSC), X-ray diffraction and electro-optical studies. They exhibit B_1 (col_r) and B_2 (SmC_AP_A) mesophases. We observed that the presence of –N=N- linkage at different locations in the molecular architecture does not have much effect on the mesogenic behaviour of such compounds. However, we clearly see a profound effect of the location of the –N=N- linkage, on the photo-induced electro-optical properties of these compounds.



Cover page of the journal in which a texture of the study is published. (Published in 2013).

This work was carried out in collaboration with P. Raghuvanshi and Arun Roy, Raman Research Institute, Bangalore.

This work has been published : N.G. Nagaveni, P. Raghuvanshi, Arun Roy and Veena Prasad, *Liq. Cryst.*, **40**, 1238 (2013).

Investigators: N.G. Nagaveni and Veena Prasad

(ii) Three structural variants of azo substituted achiral bent-core compounds are synthesised. Here, the effect of symmetrical and non-symmetrical arms at 1,3- positions of the central phenyl ring on the mesogenic properties of the resulting bent-core azo compounds is studied. The structures of all the compounds synthesised are confirmed by the organic spectroscopic methods. The liquid crystalline properties are investigated using polarising optical microscopy (POM), differential scanning calorimetry (DSC) and X-ray diffraction (XRD) studies. It was found that the non-symmetrical molecules are more conducive to mesomorphism than the symmetrical ones. We observed B_1 (Col_r), B_2 (SmC_AP_A) and B_7 mesophases in these compounds. The B_7 mesophase was found to have a modulated layer structure. Interestingly, a reversible field induced transition from the B_7 – like structure to the racemic SmC_AP_F was also observed. We also performed the photo-induced studies in the B_7 mesophase and compared the results with those obtained in a B_2 mesophase. From our studies, we observed that the phot-induced effects are more profound in the case of B_7 mesophase when compared to the B_2 mesophase, in such systems as shown in the following figure.

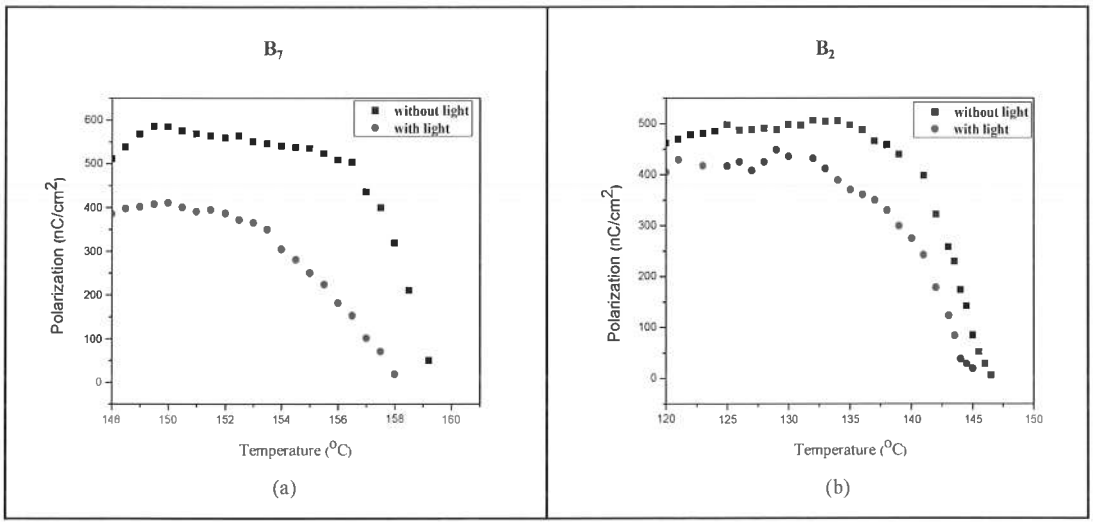


*Figure: The variation of the measured spontaneous polarization in the (a) **B_7** mesophase of the sample **A-12** and (b) **B_2** mesophase of the sample **B-12**, as a function of temperature, both in the presence and absence of UV light.*

This work was carried out in collaboration with Arun Roy, Raman Research Institute, Bangalore.

This work has been published : N.G. Nagaveni, Veena Prasad and Arun Roy, *Liq. Cryst.*, **40**,1405 (2013).

Investigators: N.G. Nagaveni and Veena Prasad.

6.11 AZO FUNCTIONALIZED LIQUID CRYSTALLINE DIMERS

Three new series of azo functionalised dimers composed of banana (bent-core) and rod- like moieties connected via flexible alkylene spacer have been synthesised and characterised. Here, the molecular structure – liquid crystalline property relationship has been studied, mainly by varying the spacer chain length in addition to the effect of polar –CN end group. All the compounds synthesised are characterised by the organic spectroscopic methods. The thermal behaviour of these dimers is investigated by the polarising optical microscopy, differential scanning calorimetry, electro-optical and X-ray diffraction studies. Interestingly, we observed a variety of mesophases in these dimers viz., N, SmA, SmC, SmX, SmY, Col_x, and Col_y. We even observed a re-entrant phenomena of the mesophases in one of these dimers. The nematic phases of some of these dimers exhibit electric field induced textural patterns, shown in the following figure. The dimers are photosensitive and the T_{NI} was found to decrease as the illuminated light intensity was increased.

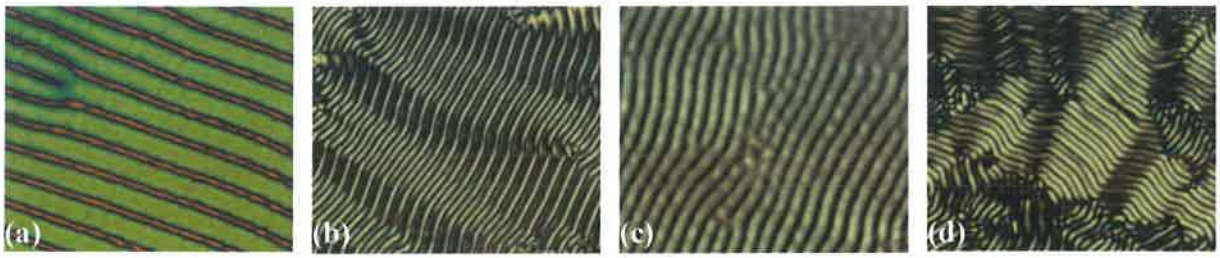


Figure: Field-induced textural changes of the nematic phase of dimer ***A-6*** *(a) 6 Vμm^{-1}, 120Hz (b) 20 Vμm^{-1}, 1KHz at 145 °C and (c) 6 Vμm^{-1}, 120Hz (d) 16 Vμm^{-1}, 500Hz at 161 °C.*

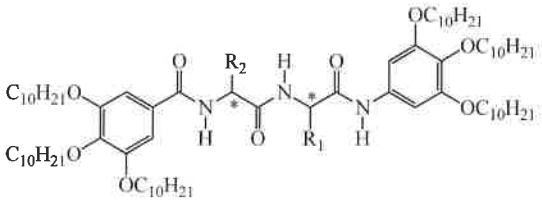
This work was carried out in collaboration with Arun Roy, Raman Research Institute, Bangalore.

This work has been published : N.G. Nagaveni, Veena Prasad and Arun Roy, *Liq. Cryst.*, **40**, 1001 (2013).

Investigators: N.G. Nagaveni and Veena Prasad

6.12 LIQUID CRYSTAL BEHAVIOR OF HOMERIC DIPEPTIDES

Optically active, liquid crystal (LC) homomeric dipeptides (Chart 1), in particular a pair of enantiomers and a diastereomer formed by joining two hexacatenar (half-disk like) entities through a dipeptide spacer comprising L-L, D-D and L-D valine residues, have been characterized systematically using optical polarizing microscope and differential scanning calorimeter. Hydrogen-bond directed self-assembly of these nondiscoid supramolecules results in the formation columnar (Col) LC phase (Fig.1a-b). They form a stable organo gel in polar organic solvents through intermolecular hydrogen bond (Fig. 2a); their scanning electronic microscopy (SEM) images reveal the presence of entangled network (Fig. 2b-c). The interaction of these dipeptides with nanaoparticles (silica species) has also been studied by SEM images and UV-visible experiments; thus, a net work has been assigned as shown in Fig. 2d.



1 : $R_1 = R_2 =$ (*S*)-Isopropyl; **2** : $R_1 = R_2 =$ (*R*)-Isopropyl;**3**: $R_1 =$ (*S*)-Isopropyl; $R_2 =$ (*R*)-Isopropyl

Chart 1: Molecular structure of homomeric dipeptides

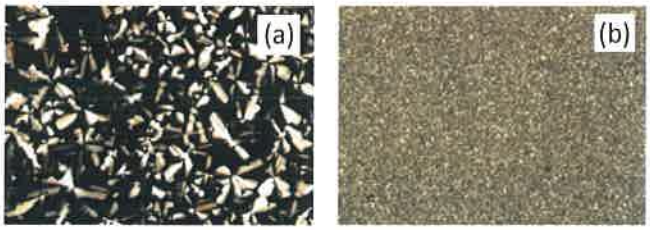


*Figure 1: (a) Microphotographs of the optical textures seen for (a) Col phase at 255 °C of compound **1**, (b) sandy texture Col phase formed by compound **3** at 80 °C*

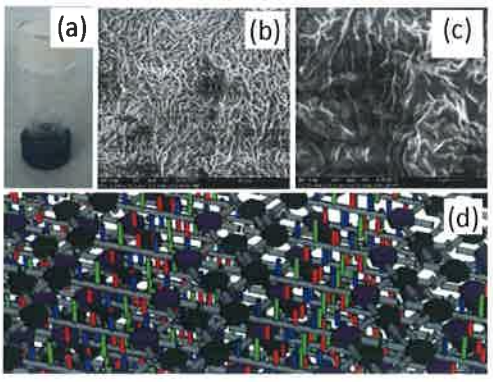


*Figure 2: (a) Test tube inversion method confirming gel formation of dipeptide **1**, (b-c) SEM images of gel showing entangled morphology in different micro meter sizes and (d) schematic representation of 3D network in gel.*

This work has been accepted for publication : Rashmi Prabhu, C. V. Yelamaggad and G. Shanker, *Liq. Cryst.*, 2014 (in press).

Investigators: Rashmi Prabhu, G. Shanker and C. V. Yelamaggad.

6.13 NONSYMMETRIC DIMERS COMPRISING CHALCONE AND CHOLESTEROL ENTITIES: AN INVESTIGATION ON STRUCTURE-PROPERTY CORRELATIONS

Thirty-two new optically active nonsymmetric dimers belonging to four series have been investigated for their thermal behavior by polarizing optical microscope, differential scanning calorimeter, X-ray diffraction and electrical switching studies. These dimers comprise pro-mesogenic cholesterol and short bent-core chalcone, interlinked covalently through an ω-oxyalkanoyl spacer of varying length and parity. Fundamentally, these four series of compounds differing in the structure of the chalcone have been investigated with the aim of comparing their thermal behavior with that of the known dimers of identical nature. Our study clearly illustrates the complex interplay of the different molecular sub-units of the dimers in stabilizing mesophases such as blue phase(s), chiral nematic, twist grain boundary, smectic A and chiral smectic C phases. XRD study suggests that cholesterol-based dimers

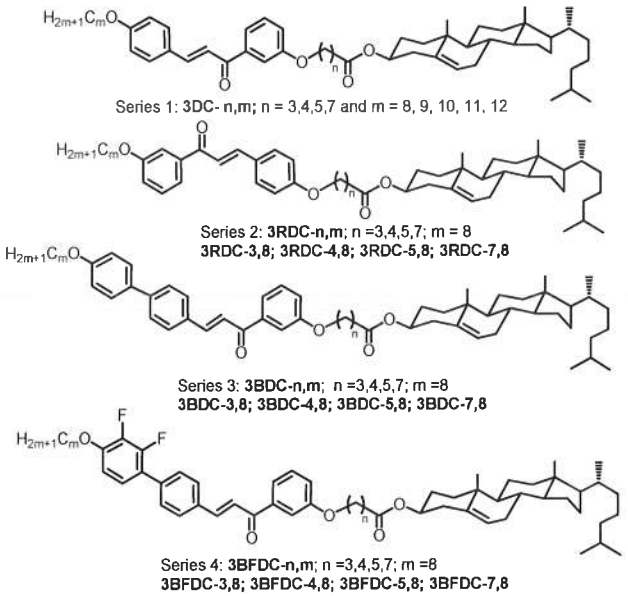


Chart 1: Molecular structure of the four series of non-symmetric dimers investigated

stabilize an intercalated SmA phase (Fig. 2) if they possess terminal tail and flexible spacer of equal length.

This work has been accepted for publication : A. S. Achalkumar, D. S. Shankar Rao and C. V. Yelamaggad. *New J. Chem.*, 2014 (in press))

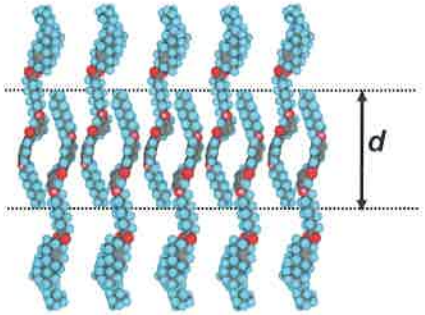


*Figure 4. A schematic representation of the self-assembly of dimer **3DC-7,8** into an intercalated SmA phase.*

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

6.14 OBSERVATION OF DOUBLE EXCHANGE DRIVEN ELECTRORESISTANCE OF $La_{0.67}Ca_{0.33}MnO_3$ THIN FILM

We have prepared single phase polycrystalline $La_{0.67}Ca_{0.33}MnO_3$ (LCMO) thin film on n-type Si (100) substrate using chemical solution deposition. The deposited LCMO thin film was annealed at 800 °C for one hour in oxygen atmosphere. The X-ray diffraction measurement on the film indicates the polycrystalline nature and orthorhombic crystal structure with lattice parameters, a = 5.460, b = 7.740 and c = 5.456 Å. The scanning electron microscopy images confirm the good grain connectivity and the thickness of the film is about 260 nm. We have measured the electrical resistance with varying temperature from 15 to 300 K in in-plane (*IP*) and out-of-plane (*OP*) configurations using the two probe method. In *OP* configuration, the Si substrate itself serves as an electrode. In both *IP* and *OP* configurations, the film shows the metal insulator transition. The peak temperature, T_p for *OP* and *IP* configurations are 214 and 220 K respectively for the applied current of 100 μA. The resistance of the LCMO thin film decreases with increase of the applied currents for both configurations. For *IP* configuration, when the applied current increases, the T_p shifts towards low temperatures. Strikingly, in *OP* configuration, the T_p shifts towards high temperatures for increase of the applied currents.

In *IP* configuration, the shift of T_p towards lower temperatures is attributed to the Joule heating effect of the sample which becomes predominant at large applied currents. For *OP* configuration, the shift of T_p towards high temperatures with increasing applied currents can be explained by the double exchange theory, which is used to explain the magnetoresistance in manganites. Possibly, the increase in the applied current imparts higher ordering to Mn ions which results in decrease of resistance and shifts the peak temperature towards higher temperatures, similar to that observed in magnetoresistance. We have showed the negligible role played by LCMO/Si interface on the *OP* electroresistance measurement using nearly symmetric with slightly non-linear *I-V* curves for the entire temperature range. Undoubtedly, the larger value of electric field for out-of-plane configuration could give rise to the observed double exchange driven electroresistance of LCMO film. This study strongly supports that the mechanism responsible for electroresistance is same as that of magnetoresistance of manganites. Hence, we have exploited a simple measurement technique to observe the double exchange driven proper electroresistance of $La_{0.67}Ca_{0.33}MnO_3$ thin film.

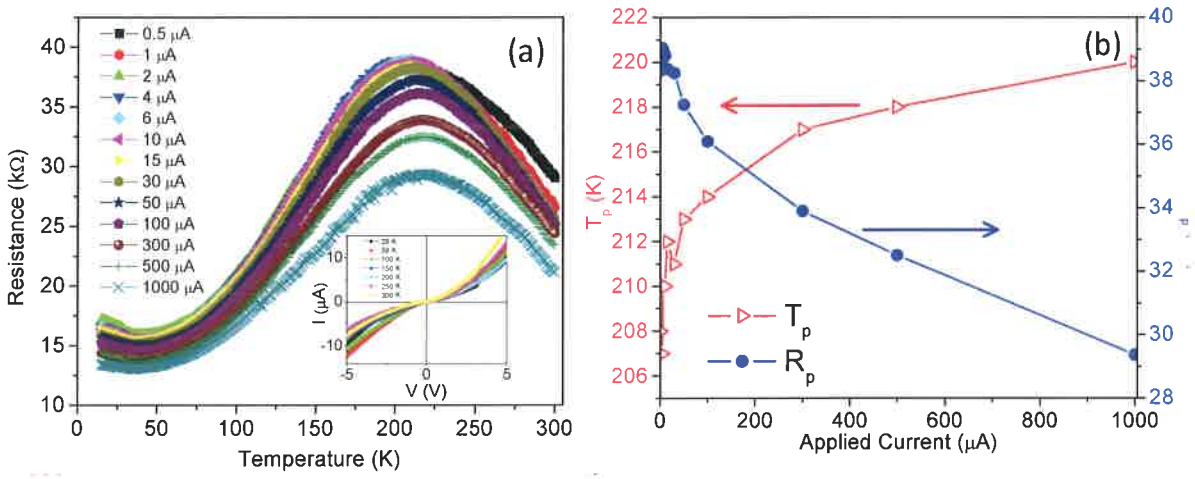


Fig. 1.1: (a) R-T data of LCMO film for different applied currents and (b) the metal-insulator transition temperature (T_p) and peak resistance (R_p) with function of applied currents. The inset of (a) shows the I-V curves measured at different temperatures.

This work has been published: Nagaiah Kambhala, P. Viswanath, and S. Angappane, *Appl. Phys. Lett.* **103**, 102408 (2013).

Investigators: Nagaiah Kambhala, P. Viswanath, and S. Angappane

6.15 EFFECTS OF THICKNESS OF SPUTTERED ZnO AND ZnO:Mn THIN FILMS

The effects of thickness of undoped and Mn doped ZnO (ZnO:Mn) thin films deposited by RF magnetron sputtering is studied systematically. We have prepared ZnO and ZnO:Mn thin films of different thicknesses varying between 45 and 190 nm. The deposited films were characterized by a host of characterization techniques, such as, x-ray diffraction, scanning electron microscopy, UV-visible transmittance and photoluminescence. The x-ray diffraction measurements on all the films show a preferential growth along *c* axis and the intensity of *(002)* peak is found to increase with increase of thickness upto 80 and 90 nm for ZnO and ZnO:Mn films respectively and decreases thereafter. The FESEM images of the films illustrate a hexagonal granular surface morphology for lower thickness and a growth of pyramidal nanostructures for higher thickness. The calculated values of the optical band gaps are found to decrease upon increasing the film thickness. The optimum deposition time is found to be 60 min, which yielded a thickness about 80 and 90 nm for ZnO and ZnO:Mn films respectively. Remarkably, we found that for the thickness of 80 nm, our ZnO films show a high crystalline quality with sharp band edge emission. Similarly, our ZnO: Mn film of thickness 90 nm shows a good crystallinity and prominent band edge emission. Interestingly, the band edge emission disappears above the critical thickness. The minimum stress of 3.9 and 2.7 GPa is observed at the thickness value of 80 and 90 nm respectively for ZnO and ZnO: Mn thin films. Hence, our thickness dependence study of sputtered ZnO and ZnO: Mn films indicate the optimum thickness for the better structural and optical properties. We believe that these sputtered

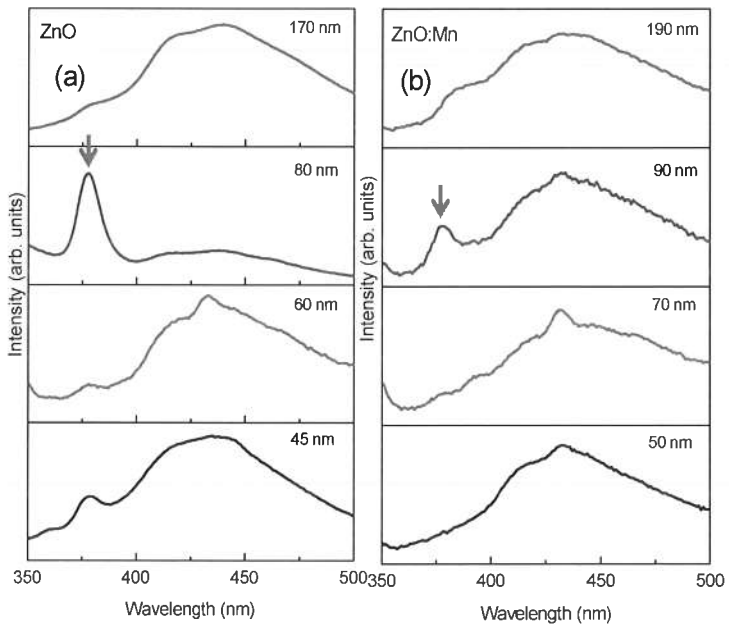


Figure 1.2: Photoluminescence spectra obtained for (a) ZnO and (b) ZnO:Mn thin films for different thicknesses excited using the light of wavelength 315 nm. The arrow indicates the band edge emission band.

undoped and doped films ZnO films would find its feasible applications in memristive and optoelectronic devices.

Investigators: R. Rajalakshmi, and S. Angappane

6.16 *ANISOTROPIC ELECTRICAL TRANSPORT AND MAGNETIC PROPERTIES OF $La_{0.67}Sr_{0.33}MnO_3$ THIN FILM*

We study the anisotropic electrical transport and magnetic properties of $La_{0.67}Sr_{0.33}MnO_3$ thin film deposited on Si substrate by chemical solution deposition. A large value of low field magnetoresistance was observed for current parallel to applied magnetic field compared to current perpendicular to field. Similarly, a large magnetization is observed when the magnetic field applied parallel to film plane. From magnetotransport and magnetic measurements, it is evident that our polycrystalline $La_{0.67}Sr_{0.33}MnO_3$ thin film deposited on Si substrate exhibits in-plane anisotropy. The higher values of low temperature MR and AMR observed in our polycrystalline $La_{0.67}Sr_{0.33}MnO_3$ thin film arises from polycrystalline grain boundaries for the application of small magnetic field. The angular dependence of magnetoresistance deviating from the sinusoidal behaviour indicates the role played by grain boundary and small applied magnetic field. Evidently, the analysis of the resistivity data indicates the increase in charge delocalization even with the small applied magnetic field and the existence of in plane anisotropy of the film.

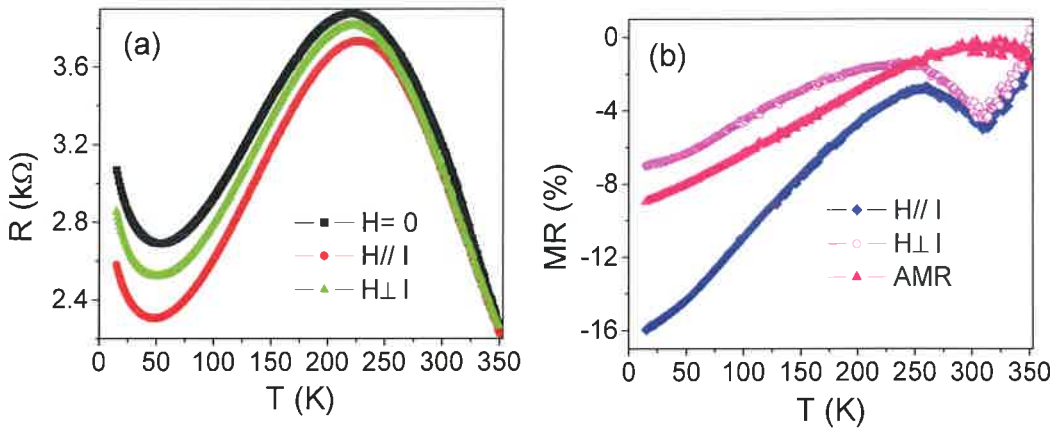


Fig. 1.3: (a) Temperature dependence of resistance with and without applied magnetic field; (b) Magnetoresistance and anisotropic- magnetoresistance versus temperature with applied magnetic field (H=1000 G).

Investigators: Nagaiah Kambhala, and S. Angappane

6.17 THREE DIMENSIONAL BRANCHED GOLD NANOSTRUCTURES ON REDUCED GRAPHENE OXIDE FILMS FORMED AT A LIQUID/LIQUID INTERFACE

Gold nanostructures with anisotropic geometries such as rods, wires, plates, pods, polyhedrons, stars and dendrites hold immense potential in sensing, optical imaging and catalysis as they exhibit interesting optical and physiochemical properties. The localized surface plasmon resonance (LSPR) of gold nanoparticles depends greatly on the shape and as the spherical shape transforms to elongated and branched structures, the transverse and longitudinal components of the dipole LSPR becomes non-equivalent and multipole resonances emerge in the near infra-red region (NIR). Moreover, the corners or tips of anisotropic structures show enhanced electric fields that are particularly useful in the surface enhanced effects including surface enhanced Raman scattering (SERS) useful for the identification of biomolecules. Interfacing anisotropic gold nanostructures with graphene, the wonder 2D material, can open up new avenues for modifying the light-matter interaction of graphene.

We have explored a chemical route to synthesize branched gold nanostructures on reduced graphene oxide (rGO) layers by *in situ* reduction assisted by binary surfactant mixtures containing tetraoctylammonium bromide (TOABr) with cetyltrimethylammonium bromide (CTAB) or sodium dodecylsulfate (SDS) or sodium citrate (SC). The hybrid material self-assembles at a liquid/liquid interface forming a free-standing film. Electron microscopy studies have revealed the morphology, microstructure and crystallinity of the hybrids. The gold nanostructures are branched in three dimensions possessing various shapes such as irregular stars, multi-pods and spiky features interspersed with rGO layers (Figure 1). When TOABr-CTAB mixture is used, most regions on rGO film show irregular shaped, possibly twinned, particles of gold with stunted tip growth (Fig.1a) along with psuedopods. For TOABr-SDS mixture, mostly multi-pod nanostructures are observed as indicated in Figure 1c. In the case of TOABr-SC surfactant mixture, rGO film is covered with irregular star shaped gold nanostructures having elongated spiky features randomly protruding from the surface (Figure 1d). High resolution images of the tips of the nanocrystals (Fig. 1b and 1e) revealed lattice fringes corresponding to (111) planes of gold.

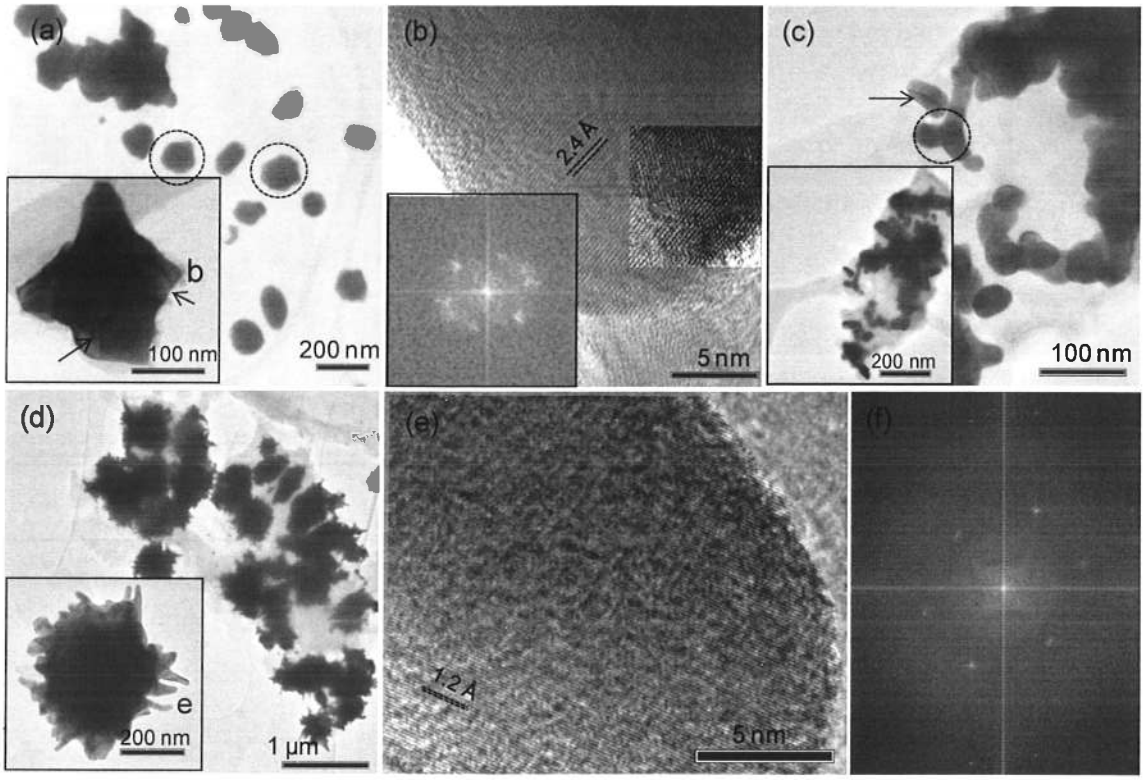


Figure 1. Transmission electron microscopy images of the branched gold nanostructures on rGO obtained in various surfactant mixtures (a) TOABr-CTAB; irregular shapes are marked. Inset gives a magnified view of one such nanostructure with twinning lines indicated by arrows. (b) High resolution image of the tip marked b in the inset of (a). Inset gives the FFT of the highlighted region of (b). (c) TOABr-SDS mixture; a pod shape is marked and twinning line is indicated by an arrow. Inset gives zoomed out view of the particles entrapped in rGO film. (d) TOABr-SC mixture; spiky structures of various sizes are seen. Inset gives the magnified view of a particle. (e) High resolution image of the elongated tip marked e in (d). (f) FFT of (e).

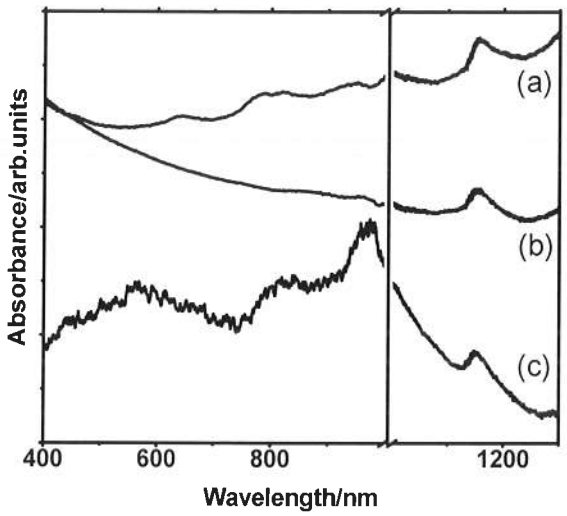


Figure 2. Vis-NIR spectra of the aqueous suspension of rGO films with branched gold nanostructures obtained in various surfactant mixtures (a) TOABr-CTAB (b) TOABr-SDS (c) TOABr-SC.

The hybrids exhibit plasmon modes in visible and NIR due to the shape anisotropy (Figure 2). Several broad peaks around 550 nm, 830 nm, 950 nm and 1150 nm are observed, which could be contributed by the dipole resonances of the core and the elongated spikes and also by the

multipole resonances of the spike features. Interparticle interactions in aggregated assemblies can also contribute to broad peaks around 800 nm. The enhancement effect of the spiky features is also observed as intensity enhancements of graphene bands in Raman spectra. In order to understand the formation of branched gold nanostructures on rGO at an aqueous/organic interface, kinetic studies have been performed in TOABr-SC surfactant mixture by following the morphology and UV-Vis-NIR spectra at various time intervals. These studies revealed that the branching is promoted by the multiple twinning lines in the initially formed seed crystals stabilized on GO and the final shapes of the nanostructures could be driven by the competitive interaction of TOABr and the second surfactant.

This work was carried out in collaboration with Dr. V. N. Singh, National Physical Laboratory, New Delhi (TEM studies).

This work has been accepted for publication : K. Bramhaiah, V.N.Singh and Neena S. John, *Particle and Particle Systems Characterization* 2014 (In press).

Investigators : K. Bramhaiah and Neena S. John

6.18 REDUCED GRAPHENE OXIDE BASED SEMICONDUCTOR NANOPARTICLE HYBRIDS: rGO-Ag_2S AND rGO-ZnO

i. Films of rGO-silver sulfide hybrids formed at a liquid/liquid interface

Ag_2S is a mixed ionic and electronic conductor with a narrow band gap and possesses excellent optoelectronic properties and chemical stability. We have devised a simple chemical strategy to obtain free-standing, ultra-thin films of silver sulfide and rGO based silver sulfide hybrids at a water/toluene interface employing *in situ* chemical reaction in a one step or two step sequential process. Ag_2S and rGO-Ag_2S hybrid films are characterized by various techniques such as UV-visible and photoluminescence spectroscopy, X-ray diffraction and scanning electron microscopy. The morphology of hybrid films consists of Ag_2S nanocrystals on rGO surface while plain Ag_2S films contains branched network of dendritic structures (Fig.1). In both cases, Ag_2S possess a monoclinic α-Ag_2S structure. rGO-Ag_2S exhibit interesting optical and electrical properties. The hybrid films absorb in the region 500-650 nm and show emission in the red region (Fig.2). A higher conductance is observed for the hybrid films arising from the rGO component (Fig.3). This simple low cost method can be extended to prepare other rGO based metal sulfides.

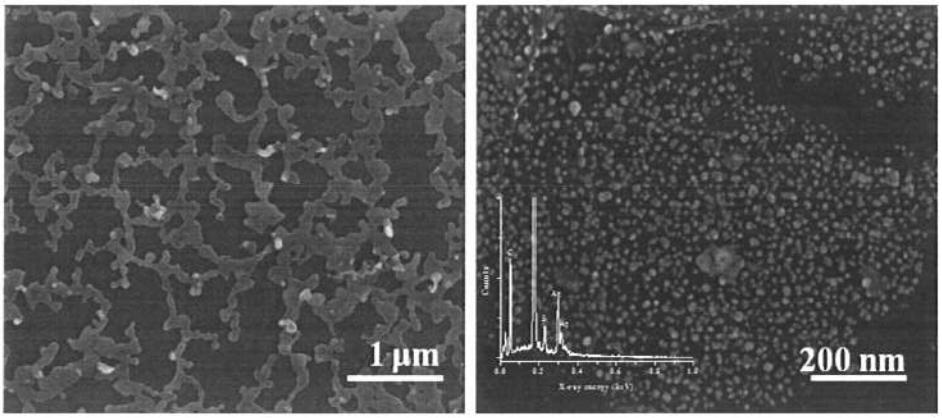


Figure 1. FESEM images a) nanocrystalline plain Ag_2S film (b) hybrid rGO-Ag_2S film, obtained at a liquid/liquid interface. The inset in (b) gives the EDS spectra showing the presence of both Ag and S.

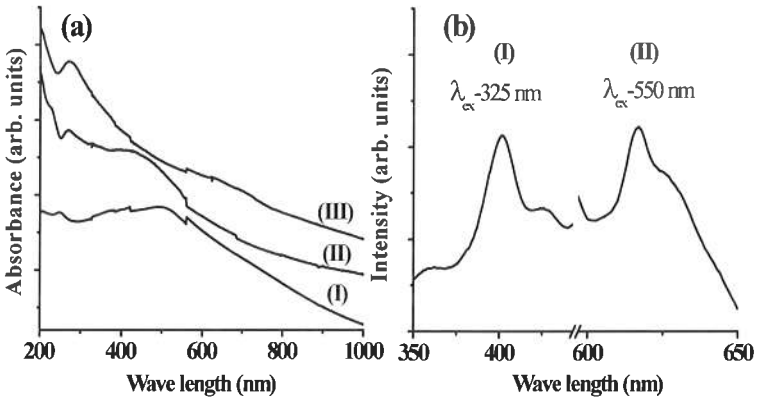


Figure 2. (a) UV-visible spectra of (I) plain Ag_2S (II) hybrid rGO-Ag_2S film by one step method (III) rGO-Ag_2S by two-step method. (b) PL spectra (I) plain Ag_2S film (II) hybrid rGO-Ag_2S film by two-step method.

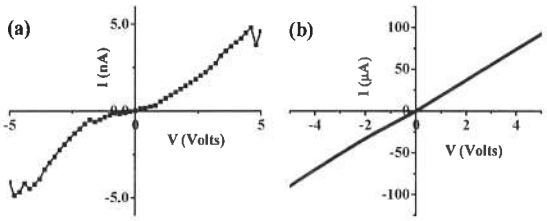


Figure 3. I-V characteristics (a) Ag_2S film (b) rGO-Ag_2S film by two-step method.

This work has been accepted for publication : K. Bramhaiah and Neena S. John, *AIP conf. Proc.* (2014) (In press).

Investigators : K. Bramhaiah and Neena S. John

ii. rGO-ZnO and rGO-Au-ZnO hybrid materials and their photocatalytic activity

ZnO is a II-VI semiconductor with wide band gap and large excitation binding energy at room temperature and hence its nanomaterials have been explored as potential UV sensors, photocatalysts and photodetectors. Heterogeneous catalysts based on ZnO are found to be efficient for the photodegradation of dye pollutants. Coupling ZnO with graphene or gold can further improve the photocatalytic efficiency. We have synthesized rGO-ZnO and rGO-Au-ZnO by the hydrolysis of zinc acetylacetonate in ammonia in the presence of rGO and rGO

preloaded with gold nanoparticles under hydrothermal conditions and solution based deposition, respectively. The hybrid materials were characterized by X-ray diffraction, UV-Visible spectroscopy, photoluminescence spectroscopy and electron microscopy. The morphology shows rod shaped ZnO nanocrystals embedded on rGO layers in the case of rGO-ZnO prepared by hydrothermal conditions (Fig.1a). In the case of rGO-Au-ZnO, hybrid particles consisting of Au and ZnO are observed on rGO layers (Fig.1b). UV-Vis spectra of these materials exhibited absorptions at 275 nm due to rGO, 360 nm due to ZnO bandgap and 550 nm due to SPR from Au nanoparticles (Fig. 2). The bandgap absorption of ZnO nanocrystals is slightly blue-shifted when compared to bulk ZnO (380 nm) due to the quantum confinement effect.

The photocatalytic efficiency of these hybrids is studied by monitoring the photodegradation of rhodamine B dye molecules in the time evolution UV-Vis spectra. The photodegradation was performed ex-situ by irradiating a 40µm dye solution (UV line-365 nm, power-110 mW/cm^2) with 10 mg of the hybrid material. The dye absorption at 555 nm is found to decrease with time and is found to be faster for rGO-Au-ZnO when compared to rGO-ZnO (Fig. 3)and much faster than ZnO. The rate studies are in progress.

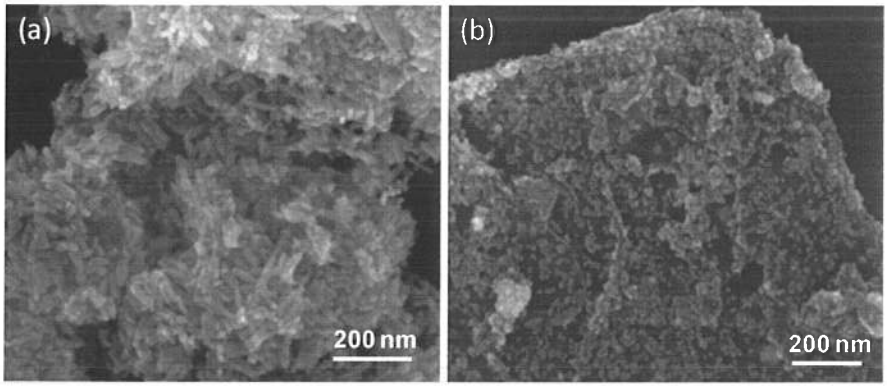


Figure 1. FESEM images of (a) rGO-ZnO by hydrothermal preparation (b) rGO-Au-ZnO by solution deposition.

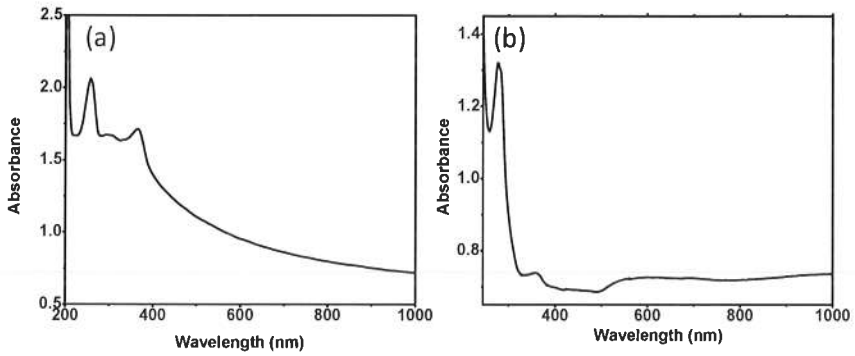


Figure 2. UV-Vis absorption spectra of (a) rGO-ZnO (b) rGO-Au-ZnO hybrids

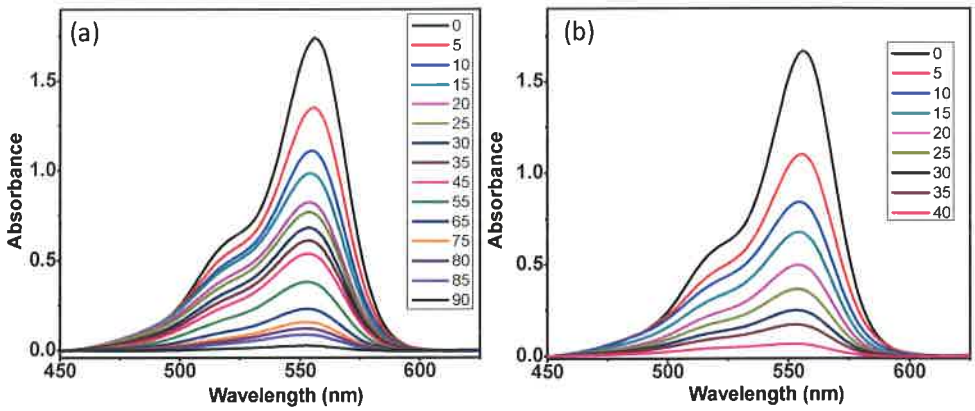


Figure 3. Time evolution UV-Vis spectra of rhodamine B dye solution under UV irradiance in the presence of (a) rGO-ZnO (b) rGO-Au-ZnO. Time is indicated in minutes.

Investigators : K. Bramhaiah and Neena S. John

6.19 ATOMIC FORCE MICROSCOPY STUDIES OF COPPER(II) PHTHALOCYANINE AND PB(II)PHTHALOCYANINE FILMS BY VACUUM DEPOSITION ON VARIOUS SUBSTRATES

Metal-phthalocyanines are promising materials for molecular materials due to their intrinsic electronic properties arising from the delocalized pi- cloud on the macrocycle that may be improved further by doping. We have successfully prepared films of copper phthalocyanine

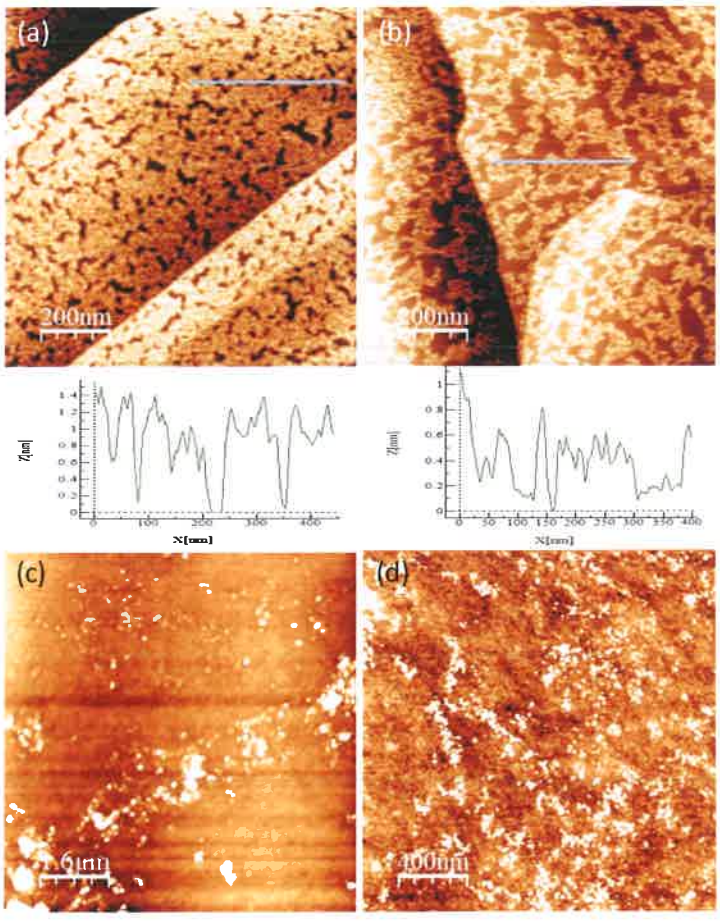


Figure 1. AFM topography of (a) CuPc film on HOPG (b) PbPc film on HOPG and their corresponding section profiles are given below. (c) CuPc on Si (d) PbPc on Si

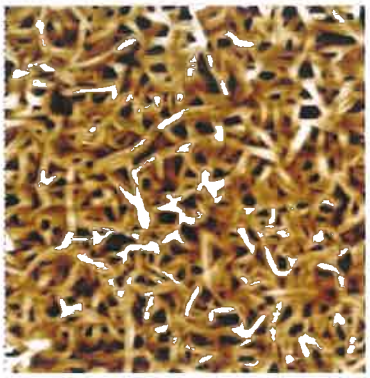


Figure 2: AFM topography of CuPc film on Si with longer duration of deposition (~ 35 nm thickness). Scan area 5x 5 μm^2.

(CuPc) and lead phthalocyanine (PbPc) on silicon (100) and highly oriented pyrolytic graphite (HOPG) substrates by physical vapour deposition in a vacuum chamber. The morphology of the films is studied using AFM in noncontact mode under ambient conditions. On HOPG, both CuPc and PbPc formed thin films consisting of interconnected islands with a few layer thicknesses for a short time scale of deposition (Fig. 1a, b). Under identical conditions, the films obtained on Si are discontinuous consisting of isolated clusters of the molecules (Fig. 1c,d). However for larger deposition times, CuPc formed a continuous film on Si consisting of fibrous features. (Fig.2). Electrical studies on these films are in progress.

Investigators : Priya Madhuri and Neena S. John

6.20 INHOMOGENEOUS FREEDERICKSZ EFFECT IN A QUARTER TURN TWISTED ACHIRAL SMECTIC C LIQUID CRYSTAL

This experimental work concerns the electric Freedericksz instability in an achiral, dielectrically slightly negative, 90°-twisted smectic C liquid crystal. In the base state, the smectic layers are perpendicular to the confining electrodes, with the c director sweeping through 180° across the sample thickness (Fig. 1, Left). Thresholdless reorientation is inferred from a continuous variation of cell capacitance with voltage. Above a few volts, in the first instance of its kind, the periodic nature of the equilibrium Freedericksz state reveals itself in

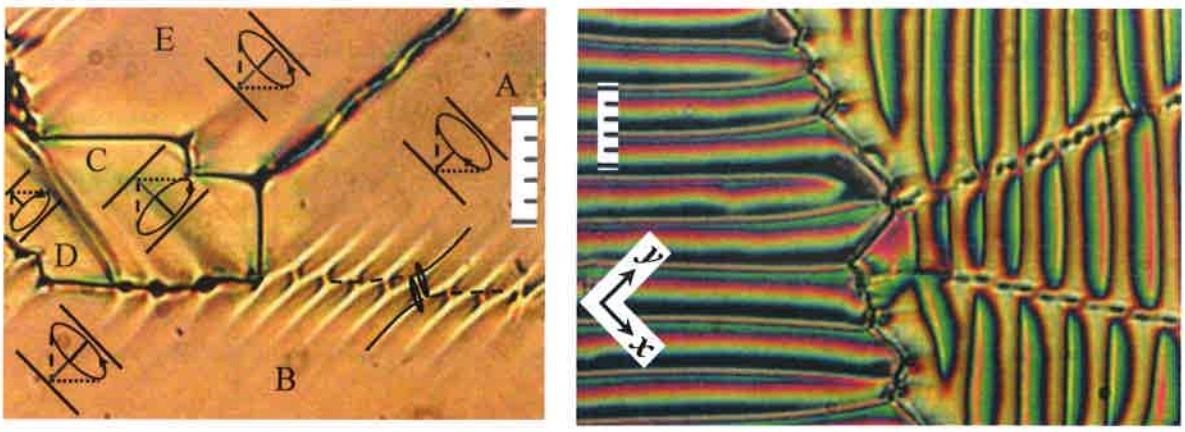


Fig. 1: (Left) Texture of the base state in a 5 μm thick sample of 4,4'-diheptyloxyazoxybenzene (HOAB), showing oriented domains of four types, A-D. The dark parallel lines drawn within the domains A-E indicate the smectic layers; the dotted and dashed lines represent the molecules at the bottom and top substrates, respectively; the in-between inclined line indicates the director at the midplane; arrows attached to the dotted lines indicate the rotational sense. (Right) Optical appearance of the periodic Freedericksz state observed in transmission with partially crossed polarizers. 5 μm thick sample acted on by a 15 V, 1 kHz, square wave field. The left side domain is oppositely twisted compared to the three right side domains of like handedness. The interference colour sequence in the central right domain is reversed relative to the top and bottom domains flanking it. Scale: 5 μm/div.

the stripe morphology (Fig. 1, Right). The pattern period increases with applied voltage, and decreases with increasing field frequency. These changes are brought about through creation and movement of edge dislocations. Homogeneous reorientational state is not recovered at increased fields even up to dielectric break down. A model involving an undulatory band which has the twist localized within it and is flanked by two uniformly and transversely aligned regions, accounts for the optical features of the periodic state.

This work, carried out in collaboration with Dr. Pramoda Kumar, Weizmann Institute of Science, Israel. This work has been published: K. S. Krishnamurthy and Pramoda Kumar, *Europhys. Lett.*, **102**, 66001 (2013).

Investigator : K. S. Krishnamurthy

6.21 POLARITY SENSITIVE ELECTRIC RESPONSES IN A TWISTED SMECTIC C LIQUID CRYSTAL

The investigation reveals the first observation of two polarity sensitive electrical responses found in the low frequency (<1 Hz) regime of a square wave field in an achiral rodlike SmC liquid crystal with negative dielectric and conductivity anisotropies, and in the 90◦-twisted configuration. The first, involves a transient director modulation appearing at each polarity reversal and vanishing under steady field conditions. The instability is polarity sensitive, with the maximum distortion localized near the negative electrode, instead of the sample midplane. This is inferred from the wave vector orientation alternating in the two halves of the driving cycle between the alignment directions at the two substrates (Fig. 2). Various electro-optic characteristics of this temporal phenomenon are also described. Following a similar observant- ion in nematics, we associate the transient periodic order with the Carr-Helfrich mechanism assisted by quadrupolar flexoelectric polarization obtaining under electric field gradients. The second polarity sensitive effect reveals itself in the relative shift of the periodic Freedericksz pattern upon field reversal. The shift, which is linear in field for low fields, tends to saturate for large fields. It is interpreted as due to flexoelectric polarization associated primarily with the **c** director twist about the layer normal. A model involving a periodic wedgelike band, which has the twist localized within it and is flanked by two uniformly and transversely aligned regions, accounts for the flexoelectric shift of the optical pattern.

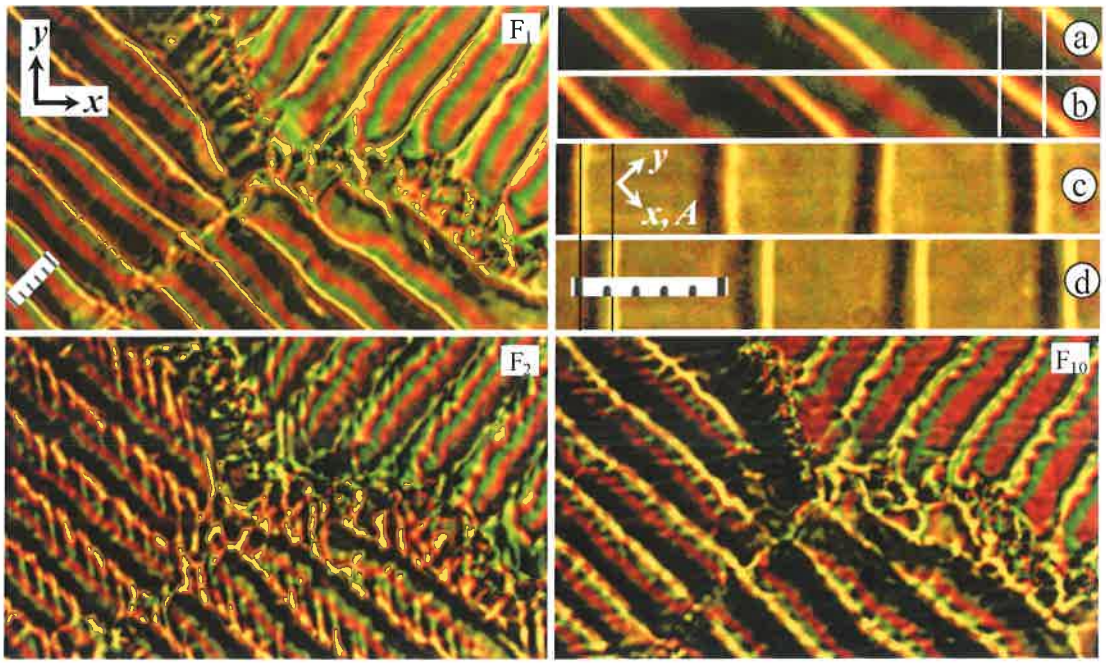


Fig. 2. Hybrid instability states observed at higher voltages in SmC HOAB. F_1, F_2 and F_{10} are frames 1, 2 and 10 of a time series recorded under partially crossed polarizers, at a rate f_R=16 f, with the field frequency f=0.226 Hz. Frames corresponding to successive polarity reversals (eg., F_2 and F_{10}) showing competing periodic Freedericksz (PF) and gradient flexoelectric (GFE) modes are separated by 7 frames, such as F_1, wherein the GFE is absent. Focal lines of the PF state for the two directions of the field are relatively shifted (flexoeffect), as evident from Panels (a-d); (a) and (b), showing the same region, are extracted from frames F_1 and F_3 (not shown), respectively; marker white lines indicate the focal line shift. (c, d) Micrographs for opposite field directions, recorded with only the analyzer, and the sample rotated by 45°. Scale: 5 μm / div.; larger scale applies to (a-d). 16.7 V, 91.4 °C.

This work has been published: k. S. Krishnamurthy, *Phys. Rev. E* **88**, 062503 (2013).

Investigator: K. S. Krishnamurthy

7. SPONSORED PROJECTS

- A three year project entitled "Molecular design, synthesis and characterization of thermotropic liquid crystals with novel molecular architecture" under the DST Women Scientist Scheme A (WOS-A) was sanctioned in January 2011. The project came to an end in January 2014. [Investigator: Uma S. Hiremath and Project Mentor: Geetha G. Nair].
- A three year project entitled "Optically active supramolecular liquid crystals, photochromic trimers and functional trimer-lke mesogens: Synthesis and characterization" under the DST Women Scientist Scheme A (WOS-A) was sanctioned in January 2014. The project is under progress. [Investigator: Uma S. Hiremath and Project Mentor: Geetha G. Nair].

- A three year SERB project proposal "Charge transport and calorimetric studies on liquid crystals and plastic crystals doped with metal nanoparticles" in collaboration with B.L.V.Prasad, NCL, Pune, was sanctioned in 2012. The first instalment of grant has been received. The project is under progress. [Investigator: S.Krishna Prasad]

- A three year SERB Fast Track project titled "Magnetic studies on magnetic ion doped ZnO thin films and resistive switching applications", was sanctioned in 2012. Two instalments of grant have been received. The project is under progress. [Investigator: S. Angappane]

- A three year SERB fast-track project proposal entitled "Local conductance, gas sensing and molecular magnetism studies of electroactive systems based on Metal –Phthalocyanines" was sanctioned in 2012. Two instalments of grant have been received. The project is under progress. [Investigator: Neena Susan John].

- A three year SERB project proposal "Electro-optic and rheological investigations on liquid crystal gels" has been sanctioned in 2013. The first instalment of grant has been received. The project is under progress. [Investigator: Geetha G. Nair and C.V.Yelamaggad]

- A three year SERB project titled "Synthesis and characterization of novel thermotropic liquid crystals: Functional discotics, dimmers and dimer-like mesogens" has been sanctioned in 2013. The first instalment of grant has been received. The project is under progress. [Investigators: C.V.Yelamaggad and S. Krishna Prasad]

- An Indo-Bulgarian research project proposal entitled "Investigation of photostimulation effects in nano-structured liquid crystals" was sanctioned by DST in February 2013. The first instalment of grant has been received. The project is under progress. [Investigators: Indian side - S.Krishna Prasad, Geetha G.Nair, D.S. Shankar Rao and C. V. Yelamaggad; Bulgarian side – Y. G. Marinov, A. G. Petrov, G. B. Hadjichristov, L. Todorova and M. Dencheva-Zarkova]

  As a part of the project, Prof. Alexander G. Petrov, Institute of Solid State Physics, Sofia, Bulgaria visited the Centre during 3-24 February 2014.

- Under the ongoing INSA-Hungarian Exchange Programme, Prof. Nandor Eber and Prof. Tamasne Fodor from the Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest, Hungary visited the Centre during 9-22 December 2013.

8. WOMEN'S DAY

The International Women's Day was celebrated on 7 March 2014. On this occasion, the women staff members of the Centre made a donation to People for Animals (PFA), Kengeri, Bangalore, a non-profit organization to rescue animals. They had a meeting at the Centre to discuss matters of common interest.

Women members of CSMR having a discussion on research facilities in the country.

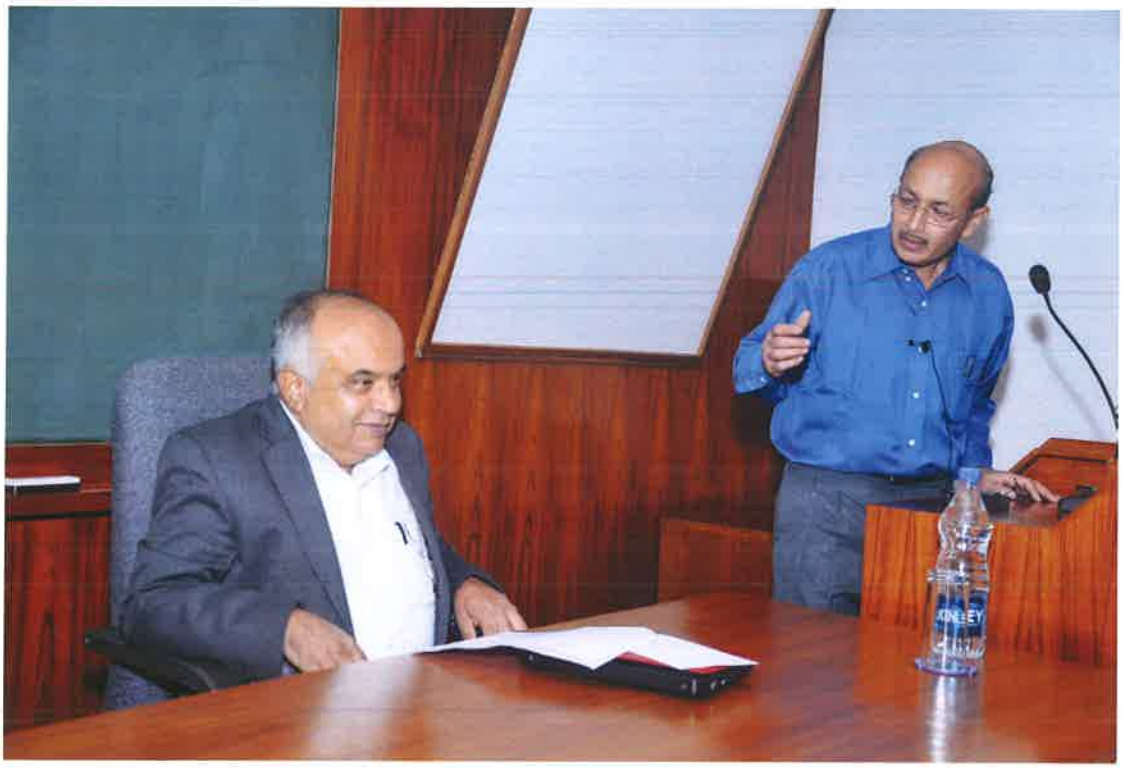
Participants at the conclusion of women's day at CSMR.

9. NATIONAL SCIENCE DAY

The Centre celebrated the National Science Day on 27 February 2014, declaring it the Open Day for the public. The occasion was celebrated by organizing a series of lectures by the CSMR scientists for an invited audience consisting of about 50 students and a few teachers of the Cauvery School, Indiranagar II Stage, Bangalore. Science Day was inaugurated by Prof. B. Thimme Gowda, Vice-Chancellor, Bangalore University and gave a keynote address. The talks were on :

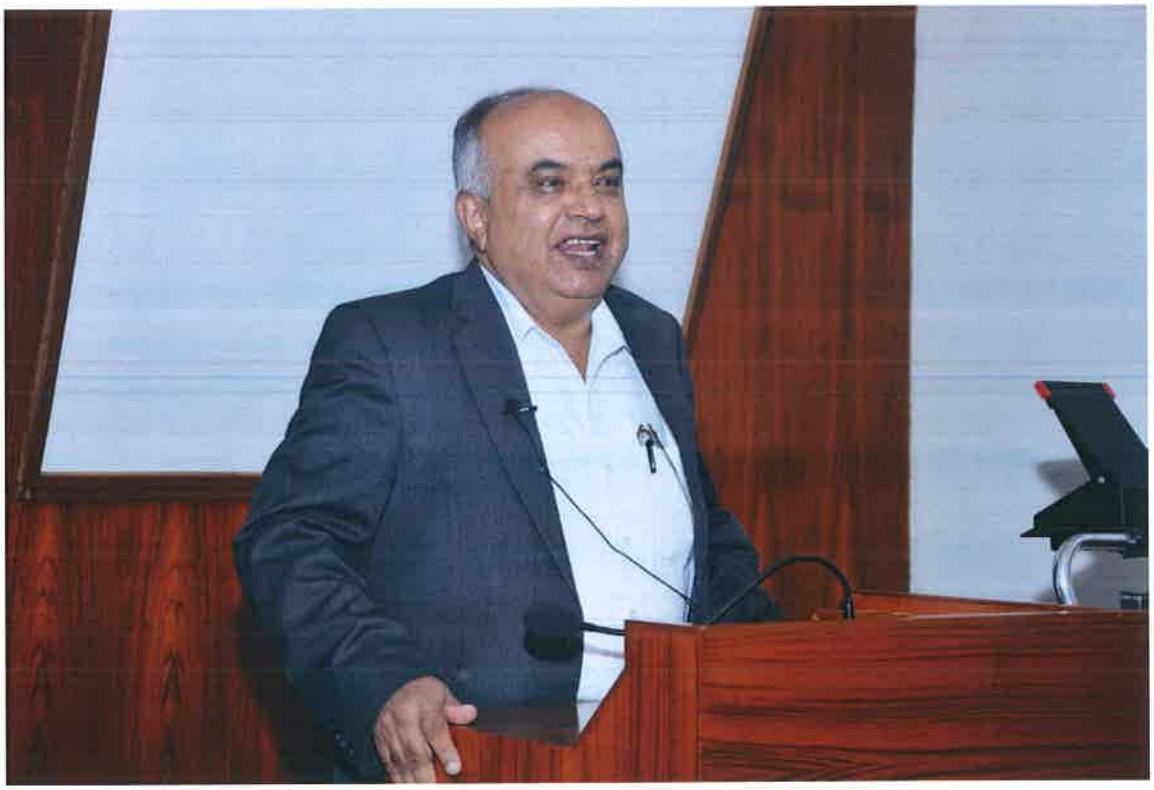
Title	Speaker
Milestones in chemistry	Prof. B. Thimme Gowda
Visual illusions	Prof. K. S. Krishnamurthy
The science of pencil traces	Dr. Neena S. John
Chemical bonding and materials	Dr. S. Angappane
Deceptively simple experiments in mechanics	Prof. G. S. Ranganath
The richness of soft matter	Prof. K. A. Suresh

The students held a question and answer session after the lectures. After lunch, the students visited the laboratories and interacted with the researchers. Some special demonstrations were conducted to explain the research activities of CSMR.



Prof. K.A. Suresh introducing the speaker, Prof. B.Thimme Gowda, Vice-Chancellor, Bangalore University.

Felicitation to Prof. B.Thimme Gowda, Vice-Chancellor, Bangalore University.



Prof. B.Thimme Gowda delivering the Keynote address on "Milestones in chemistry".

Prof. Thimme Gowda explaining the various facets of chemistry.

A Talk on "Visual illusions" by Prof. K. S. Krishnamurthy.

Dr. Neena S. John explaining the "The science of pencil traces".

Dr. S. Angappane speaking on "Chemical bonding and materials".

Illustrations on "Deceptively simple experiments in mechanics" by Prof. G.S. Ranganath.

Audience observing the demonstration of a deceptively simple experiment.

Prof. K. A. Suresh elucidating with examples "The richness of soft matter".

Students observing a demonstration on photoluminescence by P.L.Madhuri, P.Srividya and B. Kamaliya.

Nagaiah Kambhala explaining the study of magnetic properties of soft matter using a Squid Magnetometer.

R. Bhargavi demonstrating gelation of liquid crystals.

Students watching a chemical reaction being demonstrated by K. Bramhaiah.

Veerabhadraswamy B.N. explainging some aspects of synthesizing bent-core molecules.

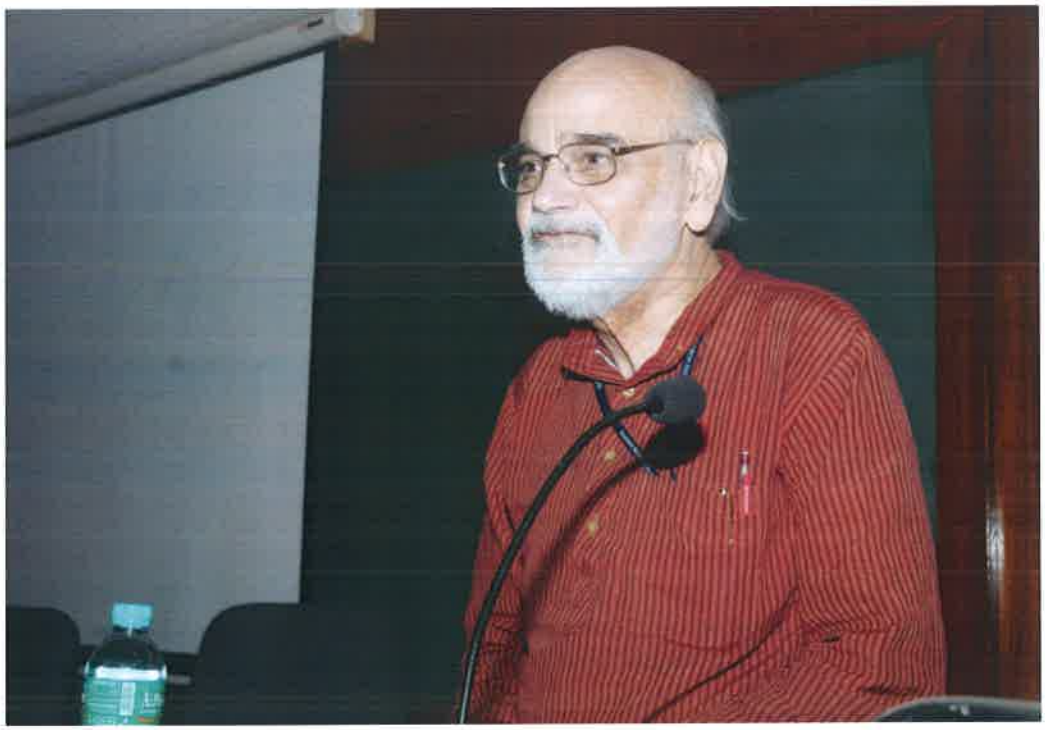
Illustration of a thin film experiment using Closed Circuit Refrigerator by R. Rajalakshmi.

Students and staff of Cauvery School, Indiranagar, Bangalore along with Research Scholars of CSMR who arranged various demonstration experiments.

10. PROF. S. CHANDRASEKHAR MEMORIAL LECTURE

The 10th Prof. S. Chandrasekhar Memorial Lecture was delivered by Prof. Sriram R. Ramaswamy, TIFR Centre for Interdisciplinary Sciences, Hyderabad on 6 August 2013. The lecture was on "Living liquid crystals".

Prof. K.A.Suresh introducing the Speaker, Prof. Sriram Ramaswamy, Director, TIFR Centre for Interdisciplinary Sciences, Hyderabad.



Prof. N. Kumar making a few introductory remarks.

Felicitation to Prof. Sriram Ramaswamy.

Prof. Sriram Ramaswamy delivering a talk on "Living liquid crystals".

Prof. Sriram Ramaswamy elaborating a point on liquid crystal materials and living liquid crystals.

Exchanging views on soft condensed matter and molecular biophysics.

11. STUDENTS' PROGRAMME

- Mr. Pramod Tadapatri, SRF submitted his Ph.D. thesis entitled "Electric field generated instabilities in thermotropic liquid crystals" to Mangalore University during the year.
- Mr. Prasad N. Bapat, SRF submitted his Ph.D. thesis entitled "Influence of pressure on phase transitions in liquid crystals" to Mangalore University during the year.
- Mr. Prasad N.Bapat, has been awarded Ph.D degree for his thesis entitled "Influence of pressure on phase transitions in liquid crystals" under guidance of Dr. S.Krishna Prasad from Mangalore University in February 2014.
- Ms. Vimala S., attended seminar on "Viscosity, rheology, texture-analysis" organized by M/s. BRK Instruments India LLP at Chennai on September 20, 2013.
- Ms. Srividhya Parthasarathy attended 20th National Conference on Liquid Crystals (NCLC-2013), held at Manipal Institute of Technology Manipal, Karnataka during December 16–18, 2013 and made a poster presentation entitled "High pressure dielectric studies on columnar mesophase exhibited by homomeric dipeptides".
- Mr. B.N. Veerabhadraswamy, attended 20th National Conference on Liquid Crystals (NCLC-2013), held at Manipal Institute of Technology Manipal Institute of Technology, Manipal, Karnataka during December 16–18, 2013 and made a poster presentation entitled "Optically active, three-ring Schiff bases and salicylaldimines: synthesis and mesomorphism of ten pairs of enantiomers".
- Mr. Nagaiah Kambhala attended the International Conference on Magnetic Materials and Applications (MagMA-2013) held at Department of Physics, IIT Guwahati during 5-7 December 2013 and presented a poster on "Anisotropic magnetic and electrical properties of $La_{0.67}Sr_{0.33}MnO_3$ thin film".
- Ms. R. Rajalakshmi attended the International Union of Materials Research Societies-International Conference in Asia-2013 (IUMRS-ICA-2013) held at the Indian Institute of Science, Bangalore, during 16-20 December 2013 and presented a poster on "Optimization of RF sputtering deposition of ZnO and ZnO:Mn films".
- Mr. Nagaiah Kambhala attended the International Union of Materials Research Societies-International Conference in Asia-2013 (IUMRS-ICA-2013) held at Indian Institute of

Science, Bangalore, during 16-20 December 2013 and presented a poster on "Proper electroresistance of $La_{0.67}Ca_{0.33}MnO_3$ thin film".

- Mr. Nagaiah Kambhala attended the DST-SERC School on "Advanced functional magnetic materials", held at Goa University, Goa during 3-21 February, 2014.
- Mr. K. Bramhaiah attended 6th Bangalore Nano-2013, held at Bangalore during 04-06 December 2014, and presented a poster entitled "Ultra-thin films of reduced graphene oxide based noble metal nanoparticles and metal sulphide hybrids".
- Mr. K. Bramhaiah attended Winter School-2013, held at Jawaharlal Nehru Centre for Advanced Scientific Research, Jakkur, Bangalore during 02-06 December 2013 and presented a poster entitled "Reduced graphene oxide based silver sulfide hybrid films formed at a liquid/liquid interface".
- Mr. K. Bramhaiah attended 58th DAE Solid State Symposium-2013, held at Thapar University, Patiala, Punjab during 17-21 December 2013 and presented a poster entitled "Reduced graphene oxide based silver sulfide hybrid films formed at a liquid/liquid interface".
- Ms. P. Lakshmi Madhuri attended the International Conference on Advanced Polymeric Materials held at Kottayam, Kerala during 11-33 October 2013 and made an oral presentation entitled "Influence of polymer stabilization on the dielectric relaxations of an antiferroelectric liquid crystal".
- Mr. Nagaiah Kambhala received the best poster award from the International Union of Materials Research Societies during the International Conference in Asia-2013 (IUMRS-ICA-2013) held at Indian Institute of Science, Bangalore, during 16-20 December 2013.

12. POPULARIZATION OF SCIENCE

PROF. K. A. SURESH

	Name of the Institute	Date	Title of talk
1.	Inaugurated the Science Camp under Inspire Internship Scheme of DST at the K.S.Rangaswamy College of Technology, Tiruchengode, Tamil Nadu and gave a Keynote address on 'Path to Science'.	17-21 July 2013	Path to Science

	Name of the Institute	Date	Title of talk
2.	Joint Science Educational Panel of Three Academies at the S.B.Arts and K.C.P. Science College, Bijapur, Karnataka. Convener of the "Lecture Workshop on Physics".	20-22 January 2014	(i) Recent milestones in physics (ii) Liquid crystals, membranes, gels and thin films

Prof. K A Suresh Key note address to Gathering

DR. KRISHNA PRASAD

	Name of the Institute	Date	Title of talk
1.	Vijaya composite pre- university and VEIT degree college, Bangalore	23.11.2013	Many facets of soft matter
2.	Agasthya Science Foundation, Bangalore	11.12.2014	Glimpses of nanoscience and technology

DR. C.V.YELAMAGGAD

1.	Shri Shivayogi Murughendra Swami College, Athani. Presented a talk at the "One Day state level workshop on Nano Science and LCD Technology" conducted to popularize science.	14.02.2014	Liquid crystal for display technology

	Name of the Institute	Date	Title of talk
2.	Shri Adichunchanagiri First Grade College Channarayapatna. Presented an invited talk at the "National Science Day" Jointly Organized by Physics and Chemistry Departments of the college and Karnataka Science and Technology Academy, Bangalore.	29.03.2014	Liquid crystals: Science and Technology
3.	Department of Chemistry, NITTE Meenakshi Institute of Technology. Presented an invited talk in a "Two days workshop on Advances in Material Research" 24-25, October 2013.	25.10.2013	Advanced Soft Materials

DR. P. VISWANATH

1.	Annual Physics Symposium, National Institute of Technology, Tiruchirapalli, Tamilnadu	14.03.2014	Dynamics of liquid drops at interfaces

PROF. K. S. KRISHNAMURTHY

	Name of the Institute	Date	Title of talk
1.	Physics Department, Karnatak University, Dharwar	28.05.2013	(i) Liquid Crystals–An Introduction (ii) Field effects in Liquid Crystals

13. VISITS ABROAD AND TALKS GIVEN

- Dr. Veena Prasad participated in the international conference, 2014 EMN Spring Meeting, held at Las Vegas, USA, from 27 of February 2014 to 2 of March 2014 and gave an Invited talk entitled "Novel phasmidic liquid crystals exhibiting unusual properties".

14. SEMINARS / TALKS GIVEN AT OTHER INSTITUTES

- Prof. K.S.Krishnamurthy attended in the 20th National Conference on Liquid Crystals, held at Manipal Institute of Technology, Manipal University, Manipal during December 16-18, 2013 and delivered the Keynote address titled "Electrical responses in the smectic C phase of calamitic liquid crystals—some recent results".

- Prof. K. A. Suresh attended in the 20th National Conference on Liquid Crystals, held at Manipal Institute of Technology, Manipal University, Manipal during December 16-18, 2013 and delivered an Invited talk on "Electrical and mechanical properties of films of discotic mesogenic molecules at interfaces".

- Dr. S. Krishna Prasad attended the Workshop on Powder, nano and thin film characterization using Xray diffraction held at Anna University, Chennai during 29-30 August 2013 and delivered an Invited Lecture titled "Some examples of Xray diffraction studies on liquid crystalline materials in their bulk and nano-confined geometries".

- Dr. D.S. Shankar Rao attended 20th National Conference on Liquid Crystals (NCLC-2013), held at Manipal Institute of Technology Manipal Institute of Technology, Manipal University, Manipal, Karnataka during December 16–18, 2013 and gave a talk titled "Novel columnar–calamitic phase sequences in a binary system of bent-core and rod-like mesogens".

- Dr. Veena Prasad attended the National Symposium on Recent Advances in Chemical Sciences (NSRACS-2013) held at Mangalore University, Mangalore on 30 April 2013 and delivered an Invited Talk (Resource Person) .

- Dr. Veena Prasad visited Mangalore University and gave Invited Guest Lecture entitled "Physics and Chemistry of Liquid Crystals (6 hours) at Industrial Chemistry Department, Mangalore University, Mangalore during 11-12 November 2013.

- Dr. C.V.Yelamaggad attended the Regional Science Conference on "Science and technology for harnessing natural resources towards sustainable development" held at University of Agricultural Sciences, Raichur on 5 January 2014 and presented an invited talk titled "Liquid crystals for solar cells".

- Dr. C.V.Yelamaggad participated in the 20th National Conference on Liquid Crystals, held at Manipal Institute of Technology, Manipal University, Manipal during December 16-18, 2013 and gave a talk titled "Chirality directed self-assembly of supramolecular liquid crystals: facile synthesis and characterization of dipeptides derived from α-amino acids".

- Dr. P. Viswanath attended the workshop on "Soft matter: self assembly and dynamics" jointly hosted by University of Hyderabad and TIFR centre for interdisciplinary sciences, Hyderabad, during 9-10 January 2014 and gave an Invited Talk entitled 'Specific ion effects at interfaces'.

- Dr. S. Angapane attended the DST Autonomous Bodies Conclave (DST-ABC-2014) held at S. N. Bose National Centre for Basic Sciences, Kolkata during 28-29 January, 2014 and delivered a talk on "Magnetic and magnetotransport phenomena in some novel oxide materials".
- Dr. Neena S. John attended a workshop "New directions in materials" held at JNCASR, Bangalore, during November 30 – December 1, 2013.
- Dr. Neena S. John attended 6th Bangalore Nano-2013 held in Bangalore during 04-06 December 2014.

15. LECTURES BY VISITORS

- Prof. Jung-Il Jin, KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul, Korea visited the Centre on 16 May 2013 and gave a seminar titled " Materials science of DNA".
- Dr. Taku Ozawa, Multi Scale Analysis Engineering Technology Division, JSOL Corporation, Japan visited the Centre on 16 May 2013 and gave a seminar titled "Modelling and simulation of soft materials from molecular characteristics to material properties"
- As a part of ongoing INSA-Hungarian Exchange Programme, Prof. Nandor Eber Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences, Budapest, Hungary visited the Centred during 9-22 December 2013 and gave a colloquium titled "Competition between electric field induced equilibrium and non-equilibrium patterns at low frequency driving in nematics" on 11 December 2013.
- As a part of ongoing INSA-Hungarian Exchange Programme, Prof. Tamasne Fodor visited the Centred during 9-22 December 2013 and gave a colloquium titled "Structure property relationship in bent-core liquid crystals" on 13 December 2013.
- Prof. Jagadish K. Vij, Trinity College, University of Dublin, IreJand visited the Centre on 16 January 2014 and gave a colloquium titled "Twist bend nematic phase : Recent discovery"
- As a part of the Indo-Bulgarian project, Prof. Alexander G. Petrov, Institute of Solid State Physics, Sofia, Bulgaria along with his wife visited the Centre during 3-24 February 2014. He gave a colloquium entitled "Bioflexoelectricity in biological systems" on 19 February 2014.

16. SEMINARS GIVEN AT THE CENTRE

- Mr. Pramod Tadapatri gave a Seminar titled "Electric field generated instabilities in thermotropic liquid crystals" on 22 May 2013.
- Mr. Prasad N.Bapat gave a Seminar titled "Influence of pressure on phase transitions in liquid crystals" on 24 July 2013.

17. LIST OF SCIENTISTS AND RESEARCHERS

	Name	Designation
1.	Prof. K. A. Suresh	Scientist of Eminence
2.	Dr. S. Krishna Prasad	Scientist F
3.	Dr. Geetha G. Nair	Scientist D
4.	Dr. D. S.Shankar Rao	Scientist D
5.	Dr. Veena Prasad	Scientist D
6.	Dr. C. V. Yelamaggad	Scientist D
7.	Dr. P. Viswanath	Scientist C
8.	Dr. S. Angappane	Scientist C
9.	Dr. Neena Susan John	Scientist C
10.	Prof. K. S. Krishnamurthy	Emeritus Scientist
11.	Prof. H. L. Bhat	Visiting Professor
12.	Prof. G. S. Ranganath	Visiting Professor
13.	Dr. Uma S. Hiremath	Research Associate
14.	Dr. Nani Babu Palakurthy	Research Associate (w.e.f. 03.03.2014)
15.	Mr. Pramod Tadapatri	Senior Research Fellow*
16.	Mr. Prasad N.Bapat	Senior Research Fellow*
17.	Ms. Rashmi Prabhu	Senior Research Fellow
18.	Ms. N. G. Nagaveni	Senior Research Fellow
19.	Ms. R. Bhargavi	Senior Research Fellow
20.	Ms. T. Shilpa Harish	Senior Research Fellow
21.	Mr. M. Vijaykumar	Senior Research Fellow
22.	Ms. R. Rajalakshmi	Senior Research Fellow
23.	Mr. Nagaiah Kambhala	Senior Research Fellow
24.	Ms. H. N. Gayathri	Senior Research Fellow
25.	Ms. P. Lakshmi Madhuri	Senior Research Fellow

26.	Ms. S. Vimala	Senior Research Fellow
27.	Mr. K. Bramhaiah	Senior Research Fellow
28.	Ms. M. Monika	Junior Research Fellow
29.	Ms. P. Srividya	Junior Research Fellow
30.	Mr. B. N. Veerabhadraswamy	Junior Research Fellow
31.	Mr. Chandan Kumar	Junior Research Fellow
32.	Mr. Arup Sarkar	Junior Research Fellow
33.	Ms. Priya Madhuri	Junior Research Fellow
34.	Mr. Nivedh Jayanth	Project Assistant
35.	Ms. Usha Parvathi .M.	Project Assistant
36.	Mr. B. Kamaliya	Project Assistant

** Since submitted the thesis and left.*

18. ADMINISTRATIVE STAFF

	Name	Designation
1.	Shri Subhod M. Gulvady	Administrative Officer
2.	Shri Vivek Dubey	Accounts Officer
3.	Shri K. R. Shankar	Consultant in Accounts
4.	Shri L. Chandra Sekhar	Maintenance Engineer
5.	Smt . P. Nethravathi	Office Superintendent
6.	Dr. Sanjay K. Varshney	Technical Assistant
7.	Smt. Sandhya D. Hombal	Technical Assistant
8.	Shri M. Jayaram	U.D.C.
9.	Dr. Pradeep V. Hegde	Library Assistant

19. PUBLICATIONS DURING 2013-2014

Publications in Refereed Journals

1. Periodically clickable polyesters: Study of intrachain self-segregation induced folding, crystallization, and mesophase formation, Joydeb Mandal, S. Krishna Prasad, D. S. Shankar Rao, and S. Ramakrishnan, *J. Am. Chem. Soc.*, **136**, 2538 (2014).

2. A photo-driven dual-frequency addressable optical device of banana-shaped molecules, S. Krishna Prasad, P. Lakshmi Madhuri, Uma S. Hiremath, and C. V. Yelamaggad, *Appl. Phys. Lett.*, **104**, 111906 (2014).

3. Effect of cations on condensation of a mesogenic amphiphilic molecule at the air–aqueous electrolyte interface, Shilpa Harish T and P Viswanath, *Phys. Chem. Chem. Phys.* **16**, 1276 (2014).

4. Spreading and retraction dynamics of smectic liquid crystal domains at interfaces, P Viswanath and K A Suresh, *Liquid Crystals*, **41**, 320 (2014).

5. Influence of polymer stabilization on the dielectric relaxations of an antiferroelectric liquid crystal, P. Lakshmi Madhuri, S. Krishna Prasad and Geetha G. Nair, *RSC Advances*, **4**, 3121 (2014).

6. Enhancement of electrical conductivity, dielectric anisotropy and director relaxation frequency in composites of gold nanoparticle and a weakly polar nematic liquid crystal, S. Krishna Prasad, M. Vijay Kumar, T. Shilpa and C.V. Yelamaggad, *RSC Advances*, **4**, 4453 (2014).

7. Inhomogeneous Freedericksz effect in a quarter turn twisted achiral smectic C liquid crystal, K. S. Krishnamurthy and Pramoda Kumar, *Europhys. Lett.* **102**, 66001 (2013).

8. Observation of double exchange driven electroresistance of $La_{0.67}Ca_{0.33}MnO_3$ thin film, Nagaiah Kambhala, P. Viswanath, and S. Angappane, *Appl. Phys. Lett.* **103**, 102408 (2013).

9. Polarity sensitive electric responses in a twisted smectic C liquid crystal, K. S. Krishnamurthy, *Phys. Rev. E* **88**, 062503 (2013).

10. Novel columnar–calamitic phase sequences in a binary system of bent-core and rod-like mesogens, D. S. Shankar Rao, M. Vijay Kumar, S. Krishna Prasad, U. S. Hiremath, M. Sarvamangala and S. Basavaraja, *J. Mater. Chem. C* **1**, 7488 (2013).

11. Dual frequency conductivity switching in a carbon nanotube/ liquid crystal composite, S. Krishna Prasad, M. Vijay Kumar and C.V. Yelamaggad, *Carbon* **59**, 512 (2013)

12. Effect of pressure on the dielectric behavior of a bent-core liquid crystal, Prasad N. Bapat, D. S. Shankar Rao, S. Krishna Prasad, U. S. Hiremath, and C. V. Yelamaggad, *Phys. Rev. E*, **87**, 042504 (2013).

13. Excited state electron transfer from aminopyrene to graphene: a combined experimental and theoretical study, H. Chakraborti, K. Bramhaiah, Neena S. John and Suman K. Pal, *Phys. Chem. Chem. Phys.*,**15**, 19932 (2013).

14. Azo functionalized achiral bent-core liquid crystals: observation of photo-induced effects in B_7 and B_2 mesophases, N.G. Nagaveni, Veena Prasad and Arun Roy, *Liquid Crystals*, **40**,1405 (2013).

15. Azo functionalized achiral bent-core liquid crystalline materials: the effect of presence of –N=N- linkage at different locations in the molecular architecture, N.G. Nagaveni, P. Raghuvanshi, A. Roy and Veena Prasad, *Liquid Crystals*, **40**, 1238 (2013).

16. Observation of a chiral smectic C phase over a wide thermal range with novel phase sequences in rigid, bulky chiral dimers, Uma S. Hiremath, Halley M. Menezes, Geetha G. Nair, D. S. Shankar Rao and S. Krishna Prasad, *J. Mater. Chem. C*, **1,** 5799 (2013).

17. Tunable emissive lanthanidomesogen derived from a room-temperature liquid-crystalline Schiff-base ligand, H. A. R. Pramanik, Gobinda Das, C. R. Bhattacharjee, P. C. Paul, P. Mondal, S. Krishna Prasad, and D. S. Shankar Rao, *Chem. Eur. J*, **19**, 13151 (2013).

18. Photoluminescent columnar zinc(II) bimetallomesogen of tridentate [ONO]-donor Schiff base ligand, C. R. Bhattacharjee, C. Datta, Gobinda Das, D. Das, P. Mondal, S. Krishna Prasad and D.S. Shankar Rao, *Liquid Crystals*, **40**, 942 (2013).

19. Confinement driven effects in a room temperature ferroelectric liquid crystal: X-ray, linear and non-linear dielectric investigations, M. Vijay Kumar, S. Krishna Prasad, D.S. Shankar Rao and E.P. Pozhidaev, *Phase Transitions*, **86**, 323 (2013).

20. Anomalous dielectric behavior in the nematic and isotropic phases of a strongly polar–weakly polar binary system, M. Sarvamangala, M. Vijay Kumar, S.M. Khened, S. Basavaraja, D.S. Shankar Rao and S. Krishna Prasad, *Phase Transitions*, **86,** 454 (2013).

21. Proton and alpha particle induced changes in thermal and mechanical properties of Lexan polycarbonate, K. Hareesh, Pintu Sen, Ravishankar Bhat, R. Bhargavi, Geetha G. Nair, Sangappa, Ganesh Sanjeev, *Vaccum*, **91**, 1-6 (2013)

22. Fluorescent unsymmetrical four-ring bent-core mesogens: 2D modulated phases, R. Deb, A. R. Laskar, D. D. Sarkar, G. Mohiuddin, N.Chakraborty, S. Ghosh, D. S. Shankar Rao and N.V.S Rao, *Cryst Eng Comm.*, **15**, 10510 (2013)

23. Azo substituted V-shaped liquid crystalline compounds: synthesis and mesophase characterisation, N. G. Nagaveni and Veena Prasad, *Phase transitions*, **86**, 1227 (2013).

24. Azo functionalized liquid crystalline dimers composed of bent-core and rod-like moieties: synthesis and mesomorphic properties, N.G. Nagaveni, Veena Prasad and Arun Roy, *Liquid Crystals*, **40**, 1001 (2013).

25. Structural characterization and molecular order of rod-like mesogens with three and four ring core by XRD and 13C NMR spectroscopy, M. K. Reddy, S.K. Kalluru, K.Yoga, M. Prakash , T. Narasimhaswamy , A. B. Mandal , N. P. Lobo , K. V. Ramanathan , D. S. Shankar Rao and S. Krishna Prasad, *J. Phys. Chem. B*, **117**, 5718 (2013).

26. Crystal growth and nonlinear optical properties of sodium D-isoascorbate monohydrate, K. Raghavendra Rao, H. L.Bhat, Suja Elizabeth, *Crystengcomm*, **15**, 6594 (2013)

27. Glassy dielectric response in Tb2NiMnO6 double perovskite with similarities to a Griffiths phase, Hariharan Nhalil, Harikrishnan S.Nair, H. L. Bhat, Suja Elizabeth, *Europhys. Lett.*, **104**, 67002 (2013).

In press

1. Competition between anisometric and aliphatic entities: An unusual phase sequence with the induction of a phase in an n-alkane–liquid crystal binary system, M. Vijay Kumar, S. Krishna Prasad, D. S. Shankar Rao and P. K. Mukherjee, *Langmuir* (in press).

2. Supergelation via purely aromatic π-π^* driven self-assembly of pseudodiscotic oxadiazole mesogens, A. P. Sivadas, N. S. S. Kumar, D. D. Prabhu, S. Varghese, S. Krishna Prasad, D. S. Shankar Rao and Suresh Das, *J. Am. Chem. Soc.*, (in press).

3. Self-organization properties of homomeric dipeptides derived from valine. Rashmi Prabhu, C. V. Yelamaggad and G. Shanker. *Liquid Crystals*, 2014. (in press)

4. Non-symmetric dimers comprising chalcone and cholesterol entities: An investigation on structure-property correlations. A. S. Achalkumar, D. S. Shankar Raob and C. V. Yelamaggad, *New J. Chem.*, 2014 (in press)

5. Three dimensional branched gold nanostructures on reduced graphene oxide films formed at a liquid/liquid interface, K. Bramhaiah, V.N.Singh, Neena S. John, *Particle and Particle Systems Characterization*, 2014 (in press)

Publications in Conference Proceedings

1. Composites of single walled carbon nanotubes and liquid crystals as switchable conductors, M. Vijay Kumar and S. Krishna Prasad, *Nanosystems: Physics, chemistry, mathematics,* **4**, 425 (2013)

2. Anisotropic magnetotransport properties of $La_{0.67}Sr_{0.33}MnO_3$ thin film, Nagaiah Kambhala, S. Angappane, Proceedings of International Conference on Magnetic Materials and Applications, MagMA 2013, to appear in Physics Procedia (2014) (in press).

3. Reduced graphene oxide based silver sulfide hybrid films formed at a liquid/liquid interface, K. Bramhaiah, Neena S. John, AIP Conf. Proc. (2014) in press.

Books

1. Glittering facets of physics, G.S.Ranganath (2014), Publisher: Bangalore Association for Science Education, Jawaharlal Nehru Planetarium, Bangalore.

CENTRE FOR SOFT MATTER RESEARCH

BENGALURU

STATEMENT OF ACCOUNTS

FOR THE YEAR 2013 – 2014

AND

THE BALANCE SHEET AS ON 31.03.2014

G.R. VENKATANARAYANA
CHARTERED ACCOUNTANTS
Partners :
CA. G.R. Venkatanarayana, B.Com., F.C.A.,
CA. G.S. Umesh, B.Com., F.C.A.,
CA. Venugopal N. Hegde, B.Com., A.C.A.,

No. 618, 75th Cross, 6th Block
Rajajingar, Bangalore-560 010.
Ph: 23404921 / 64537325
Fax: 23500525
Email: grvauditor@gmail.com
grvenkat@sify.com

AUDITOR'S REPORT TO THE MEMBERS OF THE GOVERNING BODY OF CENTRE FOR SOFT MATTER RESEARCH, BANGALORE

We have audited the attached Balance Sheet of **Centre for Soft Matter Research** as at March 31, 2014, the Income & Expenditure Account for the year ended on that date and the Receipts and Payment account for the year ended on that date annexed thereto. These financial statements are the responsibility of the management of Centre for Soft Matter Research. Our responsibility is to express an opinion on these financial statements based on our audit.

We 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 made by Management as well as evaluating the overall financial statements presentation. We believe that our audit provides reasonable basis for our opinion.

We report that:

1. 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.

2. In our opinion proper books of accounts as required by law have been kept by the Centre for Soft Matter Research so for as it appears from our examination of those books.

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

4.The Balance Sheet and Income and Expenditure Account dealt with by this report are prepared in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India subject to the following observations:

(i) Non-Provisions of accrued liability in respect of leave encashment which is not in conformity with the Accounting, Standard 15 [Accounting for retirement benefits

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G.R. VENKATANARAYANA Chartered Accountants BANGALORE

in the financial statements of Employers] issued by the Institute of Chartered Accountants of India.

(ii) The amount spent on acquisition of fixed assets has been deducted from the total grants/ subsidies received in the Income & Expenditure account. This is not in conformity with the Accounting Standard- 5 issued by the Institute Of Chartered Accountants of India. It has been explained that this format has been consistently used to present the accounts before the authority who grant the funds.

5. In our opinion and to the best of our information and according to the explanations given to us and subject to notes on accounts and our qualifications in para 4 above, the said accounts give a true and fair view in conformity with the accounting principles generally accepted in India:

(a) in the case of Balance Sheet, of the state of affairs of the Centre for Soft Matter Research as at March 31, 2014; and

(b) in the case of Income and Expenditure Account, of the excess of Expenditure Over Income for the year ended on that date.

For M/s G R Venkatanarayana
Chartered Accountants

(G R Venkatanarayana)
Partner
Membership No. 018067
Firm Regn. No. 004616S

M/s G.R. VENKATANARAYANA
Chartered Accountants
618, 75th Cross, 6th Block
Rajajinagar, BANGALORE-560 010

Place : Bangalore
Date: 19.07.2014

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

BALANCE SHEET AS AT 31ST MARCH, 2014

(Amount in Rupees)

I. CORPUS / CAPITAL FUND AND LIABILITIES	SCH	As at 31.03.2014	As at 31.03.2013
CORPUS / CAPITAL FUND	1	15,98,63,630	14,88,94,731
RESERVES AND SURPLUS	2	-	-
EARMARKED PROJECTS FUNDS	3	1,28,45,073	89,68,596
SECURED LOANS AND BORROWINGS	4		-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	22,16,464	20,63,311
TOTAL		**17,49,25,167**	15,99,26,638
I I APPLICATION OF FUNDS/ASSETS			
FIXED ASSETS	8	10,61,65,204	8,73,00,214
INVESTMENTS - FROM EARMARKED/ENDOWMENT FUNDS	9	-	-
INVESTMENTS - OTHERS	10	-	-
CURRENT ASSETS, LOANS, ADVANCES ETC.,	11	6,87,59,963	7,26,26,424
TOTAL		**17,49,25,167**	15,99,26,638
NOTES ON ACCOUNTS	24		

As per our report of even date,
for M/s. G.R.VENKATANARAYANA,
Chartered Accountants,

(PRAVEER ASTHANA)
DIRECTOR

(VIVEK DUBEY)
ACCOUNTS OFFICER

(G.R.VENKATANARAYANA)
PARTNER
M. No. 018067
M/s. G.R. VENKATANARAYANA
Chartered Accountants
619, 7th Cross, 6th Block
Rajajinagar, BANGALORE-560 010

PLACE :BANGALORE
DATE 19.07.2014

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 2014

(Amount in Rupees)

A - INCOME	SCH	2013-14	2012-13
Income from Sales / Services	12	-	-
Grants / Subsidies:	13	5,60,00,000	6,00,00,000
Fees / Subscriptions	14	-	-
Income from Investments(income on investments from earmarked / endowment Funds)	15	-	-
Income from Royalty, Publications etc.,	16	-	-
Interest earned	17	45,47,627	59,00,479
Other Income	18	7,03,190	1,38,551
Increase / (decrease) in stock of finished goods and work-in-progress	19	-	-
TOTAL (A)		**6,12,50,817**	**6,60,39,030**
B - EXPENDITURE			
Establishment Expenses	20	2,01,89,426	1,85,87,623
Other Administrative Expenses etc.,	21	1,41,29,955	1,24,32,396
Expenditures on Grants, Subsidies etc.,	22	3,16,43,171	78,82,451
Interest	23	-	-
TOTAL (B)		**6,59,62,552**	**3,89,02,470**
C.BALANCE BEING SURPLUS / (DEFICIT) (A-B)		(47,11,735)	2,71,36,560
D. Add:- Prior Period Income		-	**5,50,114**
E. Less: Prior Period Adjustment		**1,790**	**3,501**
F. SURPLUS / (DEFICIT) CARRIED TO CORPUS / CAPITAL FUND (C+D-E)		**(47,09,945)**	**2,76,83,173**
NOTES ON ACCOUNTS	24		

As per our report of even date,
for M/s. G.R.VENKATANARAYANA,
Chartered Accountants,

(PRAVEER ASTHANA)
DIRECTOR

(VIVEK DUBEY)
ACCOUNTS OFFICER

(G.R.VENKATANARAYANA)
PARTNER
M. No. 018067

M/s. G.R. VENKATANARAYANA
Chartered Accountants
618, 75th Cross, 6th Block
Rajajinagar, BANGALORE-560 010

PLACE :BANGALORE
DATE 19.07.2014

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

RECEIPTS AND PAYMENTS FOR THE PERIOD / YEAR ENDED 31ST MARCH, 2014

(Amount in Rupees)

RECEIPTS		As at 31.03.2014	As at 31.03.2013	PAYMENTS		As at 31.03.2014	As at 31.03.2013
I Opening Balances				**I. Establishment Expenses**		1,79,43,726	1,65,43,703
1) Cash in Hand		Nil	Nil				
				II Administrative Expenses		1,42,36,337	1,22,68,800
2) Bank Balances		58,46,336					
a) Indian Bank	5,63,293		1,216	**III Fixed Assets (Additions)**		3,12,33,386	78,82,451
b) State Bank of India	36,30,953		9,65,186				
c) State Bank of Mysore 1	16,44,506		19,89,748	**IV A) Remittances/Refunds etc.,**			
d) State Bank of Mysore 2	4,945		5,498	a) Earnest Money Deposit & Security Deposit		4,37,391	4,64,706
e) Bank of India	1,584		1,000				
f) Union Bank of India	1,055		1,000	b) CPF Advance and other		49,980	83,301
II Grants-in-aid from DST, Govt of India		5,60,00,000	6,00,00,000	**B) Remittances/Refunds etc.,**		73,18,773	0
				a) C.P.F. Employees Contribution	4,51,039		4,22,675
III Interest Earned		45,47,627		b) C.P.F. CSMR Contribution	2,69,376		2,61,504
a) On Savings Bank Accounts	5,75,099		2,39,948	c) Income Tax Deducted at source			
b) On Fixed/Term Deposits	39,72,528		62,10,645	from staff, contractor & rent and Professional Tax	16,49,774		12,72,294
IV Other Income		1,05,336		d) Duties & Taxes	2,56,897		71,977
a) Stale cheque	75,784		13,136	e) Advance to suppliers/others etc.,	17,61,766		8,23,648
b) License Fee	20,600		17,734	f) Staff Advances	5,24,251		7,36,680
c) Miscellaneous Receipts	8,952		20,817	g) New Pension Scheme Tier 1	9,31,994		7,60,954
				V h) Telephone Deposit	25,500		0
				i) Provisions for last year paid	14,35,040		13,16,339
				j) Stale cheque	13,136		
				Investments			
				VI Fixed/Term Deposits made		4,65,33,157	10,31,02,506
V Other Recoveries etc.,		3,61,645					
A) Earnest Money Deposit & Security Deposit	3,61,645		6,69,082	**VII Earmarked Project Expenses**		60,89,669	44,38,200
B)		41,79,360		**Closing Balance**			
i) C. P. F. Employees Contribution	4,51,039		4,22,675	1) Cash in Hand		Nil	Nil
ii) Income Tax Deducted at source				2) Bank Balances		2,41,58,925	
from staff, contractor & rent and Professional Tax	16,49,774		12,70,983	a) Indian Bank	87,337		5,63,293
iii) Advance to suppliers/others etc.,	10,10,077		2,21,362	b) State Bank of India	2,10,14,220		36,30,953
iv) Staff Advance Recovery	5,52,493		7,53,222	c) State Bank of Mysore (RMV)	30,49,777		16,44,506
v) CPF Advance Recovery	49,980		83,300	d) State Bank of Mysore (Vyalik)	4,845		4,945
vi) New Pension Scheme Tier -1	4,65,997		3,80,477	e) Bank of India	1,648		1,584
C)		7,58,801		f) Union Bank of India	1,098		1,055
i) Establishment Receipts	1,11,900		57,629				
ii) Other Administrative Receipts	6,46,901		53,821				
VI Investments							
a) Fixed/Term deposits matured		6,87,61,239	7,67,34,595				
b) Sale of Fixed Asset		40,000	8,000				
VII Grants/Financial Assistances received for Earmarked Projects as per Schedule- 3		74,01,000	61,75,000				
TOTAL		**14,80,01,344**	**15,62,96,074**	**TOTAL**		**14,80,01,344**	**15,62,96,074**
						0	0

As per our report of even date,
for M/s. G.R.VENKATANARAYANA,
Chartered Accountants,

(PRAVEER ASTHANA)
DIRECTOR

(VIVEK DUBEY)
ACCOUNTS OFFICER

(G.R.VENKATANARAYANA)
PARTNER
M. No. 018067

PLACE :BANGALORE
DATE 19-07-2014

M/s. G.R. VENKATANARAYANA
Chartered Accountants
618, 75th Cross, 6th Block
Rajajinagar, BANGALORE-560 010

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2014

(Amount in Rupees)

		As at 31.03.2014	As at 31.03.2013
SCHEDULE 1 - CORPUS / CAPITAL FUND:			
As Per Previous Balance Sheet		**148894731**	126698360
ADD: Fixed Assets purchased during the year		**31643171**	7882451
		180537902	134580811
ADD: Excess of Income over Expenditure for the year		**-4709945**	27683173
LESS: Depreciation for the year		**15964327**	13369253
	TOTAL	**159863630**	148894731
SCHEDULE 2 - RESERVES AND SURPLUS:	**TOTAL**	-	-
SCHEDULE 3 - EARMARKED / PROJECT FUNDS: (See Annexure A for details)	**TOTAL**	**12845073**	8968596
SCHEDULE 4 - SECURED LOANS AND BORROWINGS:	**TOTAL**	-	-
SCHEDULE 5 - UNSECURED LOANS AND BORROWING	**TOTAL**	-	-
SCHEDULE 6 - DEFERRED CREDIT LIABILITIES:	**TOTAL**	-	-
SCHEDULE 7-CURRENT LIABILITIES & PROVISIONS:			
A) CURRENT LIABILITES:			
1) Statutory Liabilities		-	-
2) Other Liabilities - Creditors/SD /Amount Withhold		**569353**	568135
3) Stale Cheque		**75784**	13136
	TOTAL (A)	**645137**	581271
B) **PROVISIONS:**			
Salaries & Allowances		**1571327**	1459568
Audit Fee		-	22472
	TOTAL (B)	**1571327**	1482040
	TOTAL (A+B)	**2216464**	2063311
SCHEDULE 8 - FIXED ASSETS	**TOTAL**	**106165204**	87300214
SCHEDULE 9- INVESTMENTS FROM EARMARKED / ENDOWMENT FUNDS:		-	-
SCHEDULE 10 - INVESTMENTS - OTHERS:		-	-
SCHEDULE 11 - CURRENT ASSETS,LOANS, ADVANCES:			
A) CURRENT ASSETS:			
1) Inventories		-	-
2) Sundry Debtors:		-	-
3) Cash Balances in Hand(including Cheques/Drafts and Imprest)		-	-
4) Bank Balances:- Nationalised Banks			
a. Term Deposit Receipts (includes margin money)		**43398198**	65626280
b. Current Account : SBM Vyalikaval		**4845**	4945
c. Savings Accounts:			
Bank of India (Malleswaram)		**1648**	1584
Union Bank of India (Malleswaram)		**1098**	1055
Indian Bank (BEL Road)		**87337**	563293
SBI (Jalahalli)		**21014220**	3630953
SBM (RMV Extn)		**3049777**	1644506
	TOTAL (A)	**67557123**	**71472616**

B) LOANS,ADVANCES AND OTHER ASSETS:			
1) Loans		-	-
2) Advances and Other amounts recoverable in Cash or in kind or for value to be received:		**484705**	461023
a) K P T C L Deposit (SERC/CLCR)		**362590**	347740
b) Telephone		**87000**	76500
3) Claims Receivable from SERB		**268545**	268545
	TOTAL (B)	**1202840**	**1153808**
	TOTAL (A+B)	**68759963**	**72626424**
SCHEDULE 12 - INCOME FROM SALES / SERVICES:	**TOTAL**	-	-
SCHEDULE 13 - GRANTS / SUBSIDIES:			
(Irrevocable Grants & Subsidies Received)			
Dept of Science & Techonolgy Government of India	**TOTAL**	**56000000**	**60000000**
SCHEDULE 14 - FEES / SUBSCRIPTIONS:	**TOTAL**	-	-
SCHEDULE 15 - INCOME FROM INVESTMENTS:	**TOTAL**	-	-
SCHEDULE 16 - INCOME FROM ROYALTY, PUBLICATIONS ETC.:	**TOTAL**	-	-
SCHEDULE 17 - INTEREST EARNED:			
1) On Term Deposits - Nationalised Banks		**3972528**	5660531
2) On Savings Accounts - Nationalised Bank		**575099**	239948
	TOTAL	**4547627**	**5900479**
SCHEDULE 18 - OTHER INCOME:			
Licence Fee/Hostel Room rent recovery		**20600**	17734
Miscellaneous Income		**61590**	20817
Project Overhead Recovered		**621000**	100000
Electricity & Water Charges Recovery		-	-
	TOTAL	**703190**	**138551**
SCHEDULE 19 - INCREASE (DECREASE) IN STOCK OF FINISHED GOODS & WORK IN PROGRESS:		-	-
SCHEDULE 20 - ESTABLISHMENT EXPENSES:			
1) Salaries, Allowance and Wages to Staff		**15730447**	13164799
2) Medical Expenses Reimbursed		**61572**	11911
3) Salaries-Allowances,bonus & Awards		**37006**	33650
4) Fellowship & Book Grant		**4360401**	5377263
	TOTAL	**20189426**	**18587623**
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES,ETC:			
Chemicals, Glasswares & Consumables etc.,		**2319514**	2857467
Duties & Taxes		**155571**	71977
Electricity & Water Charges		**1867058**	1804111
Fees & Professional charges		**197957**	235338
Foreign Travel		**139139**	298893
Fuel Charges for Genset		**99789**	43568
Hospitality Charges		**136133**	86062
House Keeping Charges		**1216234**	1062180
Journals & Periodicals		**924049**	1497863
Lab Tools & Implements		-	1200
Liveries		**20049**	12566
Local Conveyance		**418171**	411150

N.M.R. Recording & Sample analysis charges		**279987**	196735
Other Miscellaneous Charges / Bank Charges		**165168**	79553
Advertisement and Pulbilcity Charges		**623254**	173636
Printing & Stationery		**383861**	267741
Registration & Renewals		**127260**	46700
Rent & Insurance		**476125**	371123
Repairs & Maintenance		**2641912**	1085343
Security Charges		**1036360**	929072
Seminar and Conferences		**118428**	70622
Telephone Charges		**272889**	157681
Travel Expenses		**511047**	671815
	TOTAL	**14129955**	**12432396**
SCHEDULE 22 - EXPENDITURE ON GRANTS, SUBSIDIES ETC: (Fixed assets)		**31643171**	**7882451**
SCHEDULE 23 - INTEREST:		-	-

As per our report of even date,
for M/s. G.R.VENKATANARAYANA,
Chartered Accountants,

(PRAVEER ASTHANA)
DIRECTOR

(VIVEK DUBEY)
ACCOUNTS OFFICER

(G.R.VENKATANARAYANA)
PARTNER
M. No. 018067

M/s. G.R. VENKATANARAYANA
Chartered Accountants
618, 75th Cross. 6th Block
Rajajinagar, BANGALORE-560 010

PLACE :BANGALORE
DATE 19-02-2014

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2014

Annexure - A to Schedule 3

(Amount in Rupees)

SCHEDULE 3 - EARMA FUNDS	PROJECT / WISE BREAKUP																			CURRENT YEAR TOTAL	PREVIOUS YEAR
	SERC	SERC (2004-05)	SERC (CVY1)	INDO-US	INDO-US (SKP)	INDO - JAPAN	CSIR (NMITLI)	CSIR (SK)	CSIR (CVY)	CSIR 2162_CVY3	SERC HL Bhat	WOS-A-1 (USH)	SERB (SKP)	SERB (SA)	SERB (NSJ)	INDO-Bulgerian (SKP)	SERB (GGN)	SERB (CVY)	WOS-A-2 (USH)		
a) Opening Balance of	1520056	88015	698939	380630	107497	175319	651499	17104	10901	97779	176462	-455886	3030328	1044953	1150000	275000	-	-	-	8968596	4326483
b) Additions to the Fun																					
i) Grants	-	-	-	-	-	-	-	-	-	-	-	900000	-	160000	350000	-	4650000	700000	641000	7401000	6175000
ii) Income from Investments made on Account of In	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (a+b)	1520056	88015	698939	380630	107497	175319	651499	17104	10901	97779	176462	444114	3030328	1204953	1500000	275000	4650000	700000	641000	16369596	10501483
c) Utilisation/Expenditure towards objectives of Funds:																					
i) Capital Expenditure											-		-	-							
Fixed Assets	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Others											-		-	-							
ii) Revenue Expenditure											-		-	-							
Salaries, Wages ar	-	-	-	-	-	-	-	-	-	-	-	422001	133397	5000	93629	58220	23715	22835	44032	802829	519403
Consumables	-	-	-	-	-	-	-	-	-	-	-	190659	182295	4351	61841	-	-	24210	44138	507494	161990
Depreciation	129671	13202	104841	8820	16132	-	97726	2565	1678	14667	-	-	366153	153344	39401	-	645000	-	-	1593200	836330
Overheads	-	-	-	-	-	-	-	-	-	-	-	-	100000	200000	-	-	150000	100000	71000	621000	0
Grant Refunded	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15164
TOTAL (c)	129671	13202	104841	8820	16132	0	97726	2565	1678	14667	-	612660	781845	362695	194871	58220	818715	147045	159170	3524523	1532887
NET BALANCE AT THE YEAR END (a+b-c)	1390385	74813	594098	371810	91365	175319	553773	14539	9223	83112	176462	-168546	2248483	842258	1305129	216780	3831285	552955	481830	12845073	8968596

CENTRE FOR SOFT MATTER RESEARCH
JALAHALLI, BANGALORE - 560 013

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH, 2014

SCHEDULE - 8 : FIXED ASSETS (Amount in Rupees)

DESCRIPTION	W.D.V. as on 01.04.2013	Additions during the year >180 days	Additions during the year <180 Days	Additions during the year Total additions	Total	Assets sold / replaced during the	Total as on 31.03.2014	Rate of Dep.	Depreciation Full Rate	Dep. For Addition o <180 Days	Total Depreciation for the year	W.D.V. as on 31.03.2014
A. CLCR:												
CIVIL WORKS												
Aluminium Partitions	13,76,491	-	-	-	13,76,491	-	13,76,491	10	1,37,649	-	1,37,649	12,38,842
Brick Base(Partitions)	1,22,638	-	-	-	1,22,638	-	1,22,638	10	12,264	-	12,264	1,10,374
Construction of Cycle Stand	48,388	-	-	-	48,388	-	48,388	10	4,839	-	4,839	43,549
Construction of Shed	49,866	-	-	-	49,866	-	49,866	10	4,987	-	4,987	44,879
Vinyl Flooring	2,38,641	-	-	-	2,38,641	-	2,38,641	10	23,864	-	23,864	2,14,777
Other Miscellaneous Works	15,81,901	-	-	-	15,81,901	-	15,81,901	10	1,58,190	-	1,58,190	14,23,711
BUILDING (Main & Annexe)	65,12,874	-	-	-	65,12,874	-	65,12,874	10	6,51,287	-	6,51,287	58,61,587
ELECTRICAL INSTALLATIONS												
Air Conditioner	7,09,167	-	-	-	7,09,167	-	7,09,167	15	1,06,375	-	1,06,375	6,02,792
Computers	1,96,692	-	1,54,636	1,54,636	3,51,328	-	3,51,328	60	1,18,015	46,391	1,64,406	1,86,922
Fume Cupboard	1,63,867	-	-	-	1,63,867	-	1,63,867	10	16,387	-	16,387	1,47,480
Generator Set	6,07,033	-	-	-	6,07,033	-	6,07,033	15	91,055	-	91,055	5,15,978
FURNITURE & FIXTURES												
Carpentary Works	4,23,018	28,969	34,771	63,740	4,86,758	-	4,86,758	10	45,199	1,739	46,938	4,39,820
Furniture & Fixtures	13,75,241	10,133	36,380	46,513	14,21,754	-	14,21,754	10	1,38,537	1,819	1,40,356	12,81,398
GENERAL EQUIPMENTS												
Equipment	58,13,645	50,392	8,12,423	8,62,815	66,76,460	40,000	66,36,460	15	8,73,606	60,932	9,34,538	57,01,922
Workshop Equipment	1,10,302	-	-	-	1,10,302	-	1,10,302	15	16,545	-	16,545	93,757
SCIENTIFIC EQUIPMENTS	6,19,11,791	2,50,16,248	55,39,219	3,05,55,467	9,24,67,258	-	9,24,67,258	15	1,30,39,206	4,15,441	1,34,54,647	7,90,12,611
Total - (A)	**8,12,41,555**	**2,51,05,742**	**65,77,429**	**3,16,83,171**	**11,29,24,726**	**40,000**	**11,28,84,726**		**1,54,38,005**	**5,26,322**	**1,59,64,327**	**9,69,20,399**
B. SERC PROJECT:												
Electrical Installation	78,618	-	-	-	78,618	-	78,618	15	11,793	-	11,793	66,825
Equipment	7,85,586	-	-	-	7,85,586	-	7,85,586	15	1,17,838	-	1,17,838	6,67,748
Cycle	264	-	-	-	264	-	264	15	40	-	40	224
Total - (B)	8,64,468	-	-	-	8,64,468	-	8,64,468		1,29,671	-	1,29,671	7,34,797
C. INDO US PROJECT:												
Equipment	49,536	-	-	-	49,536	-	49,536	15	7,430	-	7,430	42,106
Temperature Controller	3,782	-	-	-	3,782	-	3,782	15	567	-	567	3,215
Cell Fabrication	5,488	-	-	-	5,488	-	5,488	15	823	-	823	4,665
Total - (C)	58,806	-	-	-	58,806	-	58,806		8,820	-	8,820	49,986
D. INDO US (SKP) PROJECT:												
Equipment	1,07,544	-	-	-	1,07,544	-	1,07,544	15	16,132	-	16,132	91,412
Total - (D)	1,07,544	-	-	-	1,07,544	-	1,07,544		16,132	-	16,132	91,412
E. CSIR (NMITLI) PROJECT:												
Equipment	6,51,497	-	-	-	6,51,497	-	6,51,497	15	97,725	-	97,725	5,53,772
Computers	2	-	-	-	2	-	2	60	1	-	1	1
Total - (E)	6,51,499	-	-	-	6,51,499	-	6,51,499		97,726	-	97,726	5,53,773
F. CSIR (SK) PROJECT:												
Equipment	17,101	-	-	-	17,101	-	17,101	15	2,565	-	2,565	14,536
Total - (F)	17,101	-	-	-	17,101	-	17,101		2,565	-	2,565	14,536
G. CSIR (CVY) PROJECT:												
Equipment	11,189	-	-	-	11,189	-	11,189	15	1,678	-	1,678	9,511
Total - (G)	11,189	-	-	-	11,189	-	11,189		1,678	-	1,678	9,511
H. SERC (2004-05) PROJECT:												
Equipment	88,015	-	-	-	88,015	-	88,015	15	13,202	-	13,202	74,813
Total - (H)	88,015	-	-	-	88,015	-	88,015		13,202	-	13,202	74,813

I. SERC (CVY1) PROJECT:												
Equipment	6,98,941	-	-	-	6,98,941	-	6,98,941	15	1,04,841	-	1,04,841	5,94,100
Total - (I)	6,98,941	-	-	-	6,98,941	-	6,98,941		1,04,841	-	1,04,841	5,94,100
J. CSIR (2162_CVY3) PROJECT:												
Equipment	97,779	-	-	-	97,779	-	97,779	15	14,667	-	14,667	83,112
Total - (J)	97,779	-	-	-	97,779	-	97,779		14,667	-	14,667	83,112
K. SERB (SKP) PROJECT:												
Equipment	24,41,022	-	-	-	24,41,022	-	24,41,022	15	3,66,153	-	3,66,153	20,74,869
Total - (K)	24,41,022	-	-	-	24,41,022	-	24,41,022		3,66,153	-	3,66,153	20,74,869
L. SERB (SA) PROJECT:												
Equipment	10,22,295	-	-	-	10,22,295	-	10,22,295	15	1,53,344	-	1,53,344	8,68,951
Total - (L)	10,22,295	-	-	-	10,22,295	-	10,22,295		1,53,344	-	1,53,344	8,68,951
M. SERB (NSJ) PROJECT:												
Equipment	-	46,000	4,33,346	4,79,346	4,79,346	-	4,79,346	15	6,900	32,501	39,401	4,39,945
Total - (M)	-	46,000	4,33,346	4,79,346	4,79,346	-	4,79,346		6,900	32,501	39,401	4,39,945
N. SERB (GGN) PROJECT:												
Equipment	-	43,00,000	-	43,00,000	43,00,000	-	43,00,000	15	6,45,000	-	6,45,000	36,55,000
Total - (N)	-	43,00,000	-	43,00,000	43,00,000	-	43,00,000		6,45,000	-	6,45,000	36,55,000
Total - B to N	**60,58,659**	**43,46,000**	**4,33,346**	**47,79,346**	**1,08,38,005**	-	**1,08,38,005**		**15,60,699**	**32,501**	**15,93,200**	**92,44,805**
Grand Total (A to N)	**8,73,00,214**	**2,94,51,742**	**70,10,775**	**3,64,62,517**	**12,37,62,731**	**40,000**	**12,37,22,731**		**1,69,98,704**	**5,58,823**	**1,75,57,527**	**10,61,65,204**

(PRAVEER ASTHANA)
DIRECTOR

PLACE :BANGALORE
DATE 19.07.2014

(VIVEK DUBEY)
ACCOUNTS OFFICER

As per our report of even date,
for M/s. G.R.VENKATANARAYANA,
Chartered Accountants,

(G.R.VENKATANARAYANA)
PARTNER
M. No. 018067

M/s. G.R. VENKATANARAYANA
Chartered Accountants
618, 75th Cross, 6th Block
Rajajinagar, BANGALORE-560 010

CENTRE FOR SOFT MATTER RESEARCH, JALAHALLI, BANGALORE

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31ST MARCH 2014

SCHEDULE 24: NOTES ON ACCOUNTS

A.SIGNIFICANT ACCOUNTING POLICIES:

01. **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 , Grants and expenditure except Salary for Month of March ,which is recorded as rule no 64 of Central Government Account Receipts and Payment Rules 1983 .

As per 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 year is credited to the Income and Expenditure account of the Centre.

02. **Investments** : Investments are stated at cost, Interest from Investments are accounted on cash basis.

03.**Fixed assets** : Fixed assets are stated at written down value. Fixed assets are accounted at cost of acquisition, inclusive of inward freight, duties, taxes and incidental expenses related to acquisition.

04. **Depreciation** : Depreciation on Fixed assets has been provided on Written Down Value Method at rates as per Income Tax Rules 1962. Out of the total amount of Depreciation on fixed assets of ₹ 1,75,57,527/-, depreciation of ₹ 1,59,64,327/- on general fixed assets of the Centre has been debited to capital fund account and the depreciation on assets pertaining to projects amounts to ₹ 15,93,200/- has been debited to the Projects fund account. This system is being followed by the centre in the respective years of acquisition of fixed assets acquired and has been treated as Expenditure on Grants in the Income & Expenditure Account, as a matter of accounting policy, as stated in Note No.6 below.

05. **Government Grants/other Grants** : The Grants received are recognized in the accounts on realization basis. The total amount of grant received from DST during the year has been credited to the Income & Expenditure account of the Centre. The conditions stipulated for utilization of Grants-in-aid have been strictly adhered to by the Centre.

06. **Capital Expenditure :** All Capital Expenditure incurred during the year for purchase of Fixed Assets is charged to Income & Expenditure Account, under the head "Expenditure on Grants/Subsidy". The same is again reflected in Schedule 1 by credit to Capital Fund account.

B.NOTES ON ACCOUNTS:

07. **Contingent Liabilities:** Letters of Credit outstanding as on 31.03.2014 ₹ Nil and ₹ 1,75,18,147 was outstanding at the end of previous year.

08. Claims against the Centre not acknowledged as debts ₹ Nil (₹ Nil).

09. Foreign currency transactions are translated at the rates prevailing on the date of transaction.

10. Balance shown under Saving Bank Accounts Include amounts held by Bank under " Auto Sweep Accounts".

11. Prior period adjustment represents adjustments of ₹ 484/-certain advances remaining un-adjusted during earlier years and adjustment of ₹ 2,274/- from stale cheque account .

12. Current liabilities and provisions includes ₹ 34086/- as sundry creditor and ₹ 42878/- withhold from various employees and ₹ 4,92,389/-earnest money deposit and Security deposit .

13. Figures are rounded off to the nearest rupee and figures of previous year have been regrouped and reclassified to conform to that of the current year.

14. Schedules 1 to 24 are annexed to and form an integral part of the Balance Sheet as at 31st March 2014 and the Income and Expenditure Account for the year ended on that date.

As per our report of even date
For M/s G.R.Venkatanarayana
Chartered Accountants

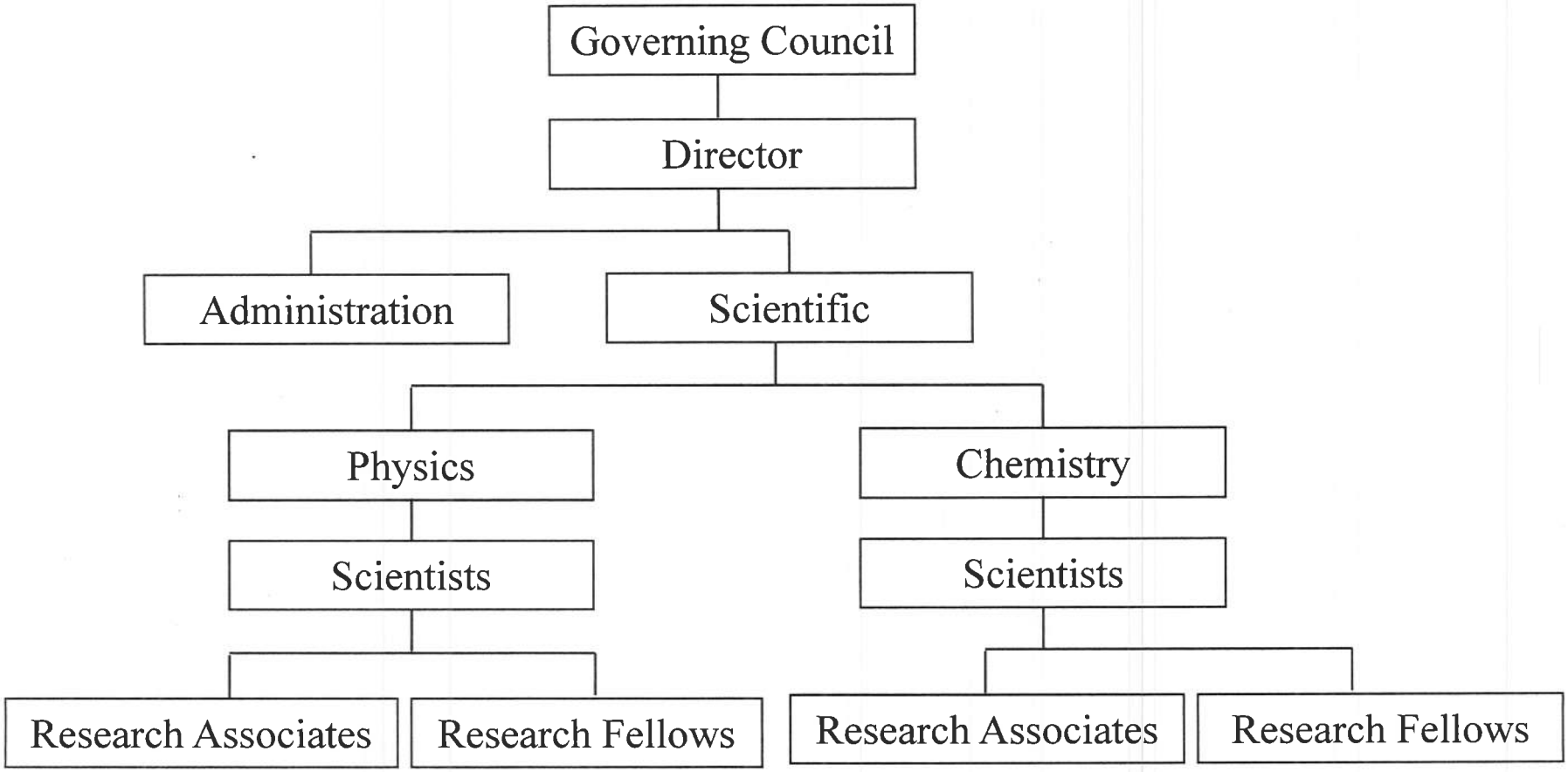
(PRAVEER ASTHANA)
DIRECTOR

(VIVEK DUBEY)
ACCOUNTS OFFICER

(G.R.VENKATANARAYANA)
PARTNER
M.No. 018067
M/s. G.R. VENKATANARAYANA
Chartered Accountants
616, 7th Cross, 6th Block
Rajaji... BANGALORE-560 010

PLACE : BANGALORE
DATE : 19-07-2014

Centre for Soft Matter Research (CSMR)
Organisation Chart



CENTRE FOR SOFT MATTER RESEARCH
P.B.No.1329, Prof. U.R.Rao Road
Jalahalli
Bengaluru – 560 013
Tel: 080-2838 1119, 2308 4200, 2838 6582
Fax: 080-2838 2044
E-mail: admin@csmr.res.in
Website: http://www.csmr.res.in

मृदु पदार्थ अनुसंधान केंद्र
डाक बॉक्स १३२९
प्रो। यू । आर । राव मार्ग
जालहल्ली
बेंगलूरू – ५६० ०१३
फोन: 080-2838 1119, 2308 4200, 2838 6582
टेलीफाक्स : 080-2838 2044
ईमेल : admin@csmr.res.in
वेब : http://www.csmr.res.in