CHAPTER-1

Introduction
1.1. General Introduction to Liquid Crystals Applications:

Liquid crystal have unique properties both isotropic liquid nature and anisotropic solid nature. It has sensitivity towards changes in temperature, concentration, pressure and presence of electric and magnetic fields. The liquid crystals exhibit the property of birefringence when they are subjected to crossed polarizers under the polarizing optical microscope. They exhibit different textures at different temperatures as the molecules behave differently at each phase. Such liquid crystals are called thermotropic liquid crystals. Phase transition temperatures are significant for application point of view and can be determined through several techniques.

Liquid crystals compounds exhibit non-covalent interaction between the molecules. These interactions include hydrogen bonding, metal coordination, vanderwall forces, electrostatic forces, etc. Hydrogen bonding focused great many features such as the rates of dynamic equilibrium, new phases and their thermal stability with low bond activation energies having wide applications in electro-optic displays, photo voltaic cells, fibre communication and flourscent films etc.

In general liquid crystals are broadly classified in to two types

1. Lyotropic liquid crystals
2. Thermotropic liquid crystals.

1. Lyotropic Liquid Crystals:

This type of liquid crystal phase is formed by dissolving some materials in suitable isotropic solvent. The transition of mesophases which occur with the change in the concentration of solute [3]. Even though the temperature is changed, there is no change in the mesophases. These are of great interest biologically and appear to play an important role in living systems.
2. Thermotropic Liquid Crystals:

The transitions involving in these mesophases are most naturally effected by changing temperature [4,5]. These are of interest both from the stand point of basic research and also for application in electro-optic display, temperature and pressure sensors etc. Organic compounds which are able to form thermotropic as well as lyotropic mesophases are termed as “Amphotropic” liquid crystals. The thermotropic liquid crystals are further classified in to 1. Discotics 2. Sandics 3. Bowlics 4. Calamitics.

Discotics (6): These are mesogens with disc like molecules
Sandics (7): These are the mesogens with lath like molecules.
Bowlics (8): These are the mesogens with bowl like (bent like) molecules.
   These are also called as banana type liquid crystals.
Calamitics (9): These are the mesogens with rod like molecule. These are further classified in to 3 types. a. Nematic b. Cholesteric
   c. Smectic

a. Nematic:

There is long range orientational order i.e. the molecules tend to align parallel to each other to some common axis labeled by unit vector (or director) but the direction of \( \hat{n} \), is arbitrary in space. The centers of gravity of molecules have long-range order. In fact nematics do flow like liquids.

b. Cholesteric (Or) Spontaneously twisted nematic:

The nematic phase exhibited by an optically active compound is called the spontaneously twisted nematic. The phase is characterized by a continuous twist of the direction of the director which forms a helix as one traverses through the sample along the optic axis. As the first reported compounds of this type of the liquid crystals are the derivatives of cholesterol, these are also called as cholesteric liquid crystals. These are uniaxial crystals and exhibit focal conic with Grandjean [10,11], homogenous and pseudo isotropic textures under crossed polars.
c. Smectic:

These are characterized by both long range orientational order as well as short range positional orders with simple changes in mutual arrangement of the layers and also with changes in the state of order inside the layers. All the smectics are layered structures with a well-defined interlayer spacing and these are more ordered than nematics. For a given material the smectic phase always occurs at a temperature below that of nematic domain. The degree of order and structural arrangement of molecules define the smectic phases thermotropically in the following order with increasing temperature...\(S_H, S_G, S_F, S_E, S_B, S_C, S_D, S_A\).

So far no single compound is found to exhibit all the phases from A to X as given below

**Sub Classification of Smectic Liquid Crystal Phases**

Smectic -A phase:

In SmA phase, the long axis of the molecules (rod type) are aligned parallel and arranged with their ends in line to form layers. The molecular long axes tend to be orthogonal to the layer planes. It is described as a solid in the direction of director and as a fluid normal to the director \(\hat{n}\). There is no long range packing of centre of gravity of the molecules within the plane. The molecule can diffuse from one layer to the other. The phase usually adopts [12] either homeotropic black appearance or the homeogenous focal conic fan texture, which separates (on cooling the isotropic liquid) in the form of batonnets (which themselves consist of growing focal conic domains).

Smectic – B phase:

The molecules with in the Smectic layer in this phase are arranged [12] in hexagonally close packed array with the molecular long axis perpendicular to the layer planes. There are two types of smectic-B (SmB) phases viz, the crystal SmB of (SmB\(_{\text{cryst}}\)) and the hexatic S\(_B\) (SmB\(_{\text{Hex}}\)). In crystal SmB phase, the molecules are orthogonal to the layer planes and the layer spacing is equal to molecular length. The molecules in the layers are relatively more ordered than those in SmA phase. The molecular centres from a hexagonal net, whose parameters are comparatively smaller than the constituent molecules.
However, their rotation is regarded as hardly free, though possibly cooperative. In SmB crystal molecules have three dimensional correlations (for over thousand layers). In hexatic SmB\textsubscript{Hex}, the molecules have short range in plane positional ordering in addition to the long – range bond – orientational order in layers and over the layers. If a compound exhibits both the crystal and hexatic S\textsubscript{B} phases, the crystalline S\textsubscript{B} phase occurs \cite{12} at a low temperature than that of hexatic SmB phase. It exhibits two natural textures i.e apart from homeotropic mosaic and a paramorphotic focal conic fan textures. The paramorphotic change is accompanied by the appearance of transient bars across the focal conic fan texture during the SmA – SmB transition. This phase is more viscous than SmA phase, but still exhibits shear flow.

\textbf{Smectic C:}

Since, molecules on an average are constituted in two equivalently tilted directions to the layer normal in smC phase, this phase is optically biaxial \cite{12,13}. In smectic layers the molecular long axis of constituent molecules is found tilted with respect to the normal to the layer planes. Further, molecules packed in an unstructured way with in the layers and layers having liquid like nature and hence described as tilted analogue of S\textsubscript{A} phase. The molecules in layers are free to slide over one another i.e there is no long range correlation for molecules except in the tilt direction. The molecules rotates about their long axis (with no associated processional rotation) and thus the phase is biaxial. Thus it is a two dimensional unstructured phase with a finite molecular tilt. The tilt angle varies from compound to compound and it is found to be temperature dependent in some compounds while it is independent in other compounds. Three types of tilt angles are exhibited by smC phase viz one, associated with central hard core and remaining two with that of the alkyl end chains. Tilted anti phase is also reported as SmC\textsubscript{A}.

\textbf{Smectic – D phase:}

The phase \cite{12} is optically isotropic. It nucleates from S\textsubscript{C} in the from of straight edged squares, rhombus, hexagon and rectangles. It also nucleates in a fern plant type of pattern growing in schlieren texture.
**Smectic – E phase:**

Semectic E phase posses high degree of molecular ordering in smectic layers with distinct non-hexagonal lattice. They possess an orthorhombic unit cell. This phase \([12]\) is usually obtained by cooling \(S_A\) or \(S_B\). It is identified with its arcs paramarphotic focal conic fan texture, which appears in column ranging from grey blue to yellowish.

**Smectic – F phase:**

This phase occurs \([12,14]\) at a room temperature below smecticC phase and has a hexagonal close packed quasi two dimensional structure. Hexagon tilts towards one side of the hexagon. The phase formed by the cooling isotropic liquid exhibits \([12]\) the mosaic schlieren texture or the textures of cylindrical spherulite or fan type. The paramarphotic texture of SmF phase contain the focal conic fan with L shaped patches. The Schlieren mosaic texture is also observed.

**Smectic –G phase:**

X-ray diffraction \([15]\) studies reveal that smectic G phases possess highly ordered structure similar to that of SmE phase. The smectic G phase is identified with the molecules having a pseudo hexogonal close packing with in the smectic plane aligned at right angles to the tilt direction. The close packing arrangement is of hexagonal kind. These layers are well correlated to give \([12]\) a 3D structure. A considerable dynamic disorder of molecules is known to exist in smectic G phase. The inter layer correlations are well established with AAA----- mono layer stacking. The molecules have cooperative oscillatory movement about their long axes, the local structure is chevron packing (or herring bone). The SmG phase exhibits natural mosaic texture. It is formed through dendritic growth of elongated platelets (or splinters) as the mesophase separates from the preceding one. The resulting mosaic texture consists of elongated platelet areas that have an almost rectangular shape. The para morphotic textures formed in the SmG phase are arced broken focal conic fan mosaic with (small poorly defined platelets) weakly coloured textures. But the texture formed by SmG phase grown from
SmC or SmF phase exhibits the broken fan texture with a patch work appearing like checkered board. The mosaic texture is often made up of large rounded platlet areas that are highly coloured.

**Smectic – H phase:**

The structure of this phase is equivalent to $S_E$ except that the molecules have long axes tilted with respect to the normal of the layer planes. Because of the tilt, the pseudo–hexagonal net becomes more disordered and the phase has monoclinic structure. This phase does not exhibit any other natural texture. The SmH phase obtained from SmC phase (Which in turn is from isotropic and nematic phases) exhibits a clear, but strained focal conic fan texture. If SmH phase is obtained from SmA phase, it exhibits broken focal conic fan texture. This phase also shows a number of mosaic textures. Sakagmi et al [16] have first differentiated the SmG and SmH phases in Terphathalylidine bIS-p–n–butylaniline (TBBA) and its higher homologues.

**Smectic – I phase:**

The molecular structure of SmI phase is similar to that of SmF phase. The difference between the two phases is due to the tilt direction of the pseudo–hexagonal molecular net i.e towards the apex of the hexagon in SmI phase. The in–plane correlation length is greater in SmI phase than in SmF phase. Thus, this phase is formed on cooling the homeotropic texture of the preceding SmA phase or Schlieren texture of the preceding SmC phase. The resulting texture is of schlieren type, which is difficult to bring into microscopic focus. The SmI phase also exhibits bubbled texture. The bubbles change their size with temperature and flow.

**Smectic – J phase and Smectic – K phases:**

These two phases are disordered crystal phases and are related in crystal structure and characteristics of SmG and SmH phases, respectively. They differ only in the direction of tilt. Both the phases have monoclinic symmetry (with $b > a$) and pseudo hexagonal packing of molecules with tilt towards the apex of the hexagon. The distortion from the hexagonal packing is greater [17,18] in the lower temperature phases.
Smectic – M phase:

G. Hepp ke. et al in 1992 reported [19] the existence of new smectic phase (SmM). The new phase belongs to the group of tilted smectic phases with short range positional order. Presumably SmM belongs to the group of hexatic phases exhibiting long range bond orientational order.

Smectic – O phase:

The existence of smectic O phase is established [19 – 22] by A.M. Levelut et al in chiral as well as racemic 1–methyl heptyl - terphathalyldene - bis - aminocinnamate (MHTAC). X-ray investigations showed that this phase has a tilted smectic structure without positional order within the layers. Conoscopic investigations on this compound indicate that the optical axes is parallel to the layer normal for zero field state and tilted for the two other states induced by electric field.

Smectic – Q phase:

A.M.Levelut. et al discovered [19] a new type of liquid crystalline phase, which occurs in chiral but not in recemic 1- methyl heptyl terphathalyldene – bis – Amino Cinnamate (MHTAC) which was also the source [23] of first SmO phase. Recently only other compounds exhibiting this phase are reported.

Smectic – X phase:

H.R.Brand and P.E.cladis reported [24] this phase and named it as SmX phase which exhibited a finite spontaneous polarization. The in – plane structure of this phase was predicted to be similar as a non helicoidal SmG or SmK phases. Chiral smectic phases are uniaxial because of the helix structure, where as SmX phase is biaxial.
1.2. Hydrogen Bond:

Hydrogen bonding is a donor–acceptor interaction specifically involving hydrogen atoms. A hydrogen bond is a link of the form A-H-----B as shown in the Figure.1 where A and B are electro negative atoms and B has a lone pair of electron. The most significant hydrogen bonding occurs where A and B are atoms of Nitrogen [N] Oxygen [O] and Fluorine [F]. Weak hydrogen bonding can also be formed between the less electronegative atoms. The simplest hydrogen bond is an electrostatic interaction between the proton of A-H and the lone pair of B

![Hydrogen bond](image)

Figure.1

The atom A needs to be electronegative in order to polarize the A-H bond and hence leaves the charge of the proton partially unshielded. The atom B needs to be the electronegative such that it has restrained a high electron density in the molecule of which it may be a part and hence can reasonably interact strongly with the protons of exposed charge. In molecular orbital terms, a hydrogen bond consists of four electrons in the three molecular orbitals that can be built from the appropriately directed atomic orbitals of A, H and B. Hydrogen bond energies extended from about 15-40 Kcal/mol for strong hydrogen bond 4-15 Kcal/mol for moderate bonds,1-4 Kcal/mol for weak hydrogen bonds respectively. Strong hydrogen bonds are formed by groups in which there is a deficiency of electron density in the donar group like O^+, N^+ or an excess of electron density in the acceptor group like F^-, O^- and N^-. This is to be expected since a deficiency of electrons of the donar group further deshields the proton there by increasing the positive charge. On the other hand while an excess of electrons on the acceptor group increases its negative charge and interact with deshielded proton. These bonds are also referred as ionic hydrogen bonds.

The intermolecular hydrogen bonds due to their significant low bond activation energies which are considered to be the basis for the origin of new
stable mesophases with wide thermal spans. These non covalent systems show a profound impact on melting points, heats of vaporization and heats of enthalpies. Following the well established example of liquid crystal formation through the dimerisation of aromatic carboxylic acids, several classes of compounds formed by interaction of complementary molecules have been reported and the liquid crystalline behaviour is crucially dependent on the structure of the resulting supra molecular system. This motivated to synthesize complex liquid crystal via hydrogen bond consisting of the type mesogenic and non-mesogenic namely p- n- Alkyl benzoic acid (n=5 to 10) and heptyl-p-hydroxy benzoate and p-n-Alkoxy benzoic acid (n=5 to 10) and nonyl-p-hydroxy benzoate. \`The charactization, phase transition temperatures and the formation of the hydrogen bond in the system are studied through synthesis of the above novel compound.

1.3. Types of Hydrogen Bond:

Hydrogen bonds are classified in to two types

(i). Intermolecular hydrogen bonds

(ii). Intra molecular hydrogen bonds.

(i). Inter molecular hydrogen bond:

In such type of linkages, two or more than two molecules of the same compound combine together to give a polymeric aggregate. Example: HF molecules.

When a number of HF molecules are brought together, the positive end of one dipole $H^+ - F^-$ attracts the –ve end of the other similar dipole $H^+ - F^-$ and these molecules associated together to form a cluster, $[HF]_n$ shown as

$(-H^+ - F^- - H^+ - F^- - H^+ - F^- - H^+ - F^-) \_n$

In case of $[NH_3]_n$ and $[H_2O]_n$ molecules are associated together to form as clusters.
(ii). **Intra molecular Hydrogen bond:**

This type of hydrogen bonding occurs with in two atoms of the same molecule. Generally, this type of bonding is known as chelation. This is possible in ortho substituted compounds.

Example: O- nitro phenol furnished as an important example of a molecule having intra molecular H- bonding. The O- Nitro phenol boils at 214°C while O- and O- isomer boil at 290°C and 270°C respectively. Thus we see that O- form has the minimum boiling point which is accounted for the assumption that O- form contains an intra molecular (internal) hydrogen – bonding which can be represented as shown below.

Intra molecular – hydrogen bonding in O-nitro phenol is not possible in m and P-isomers because of the size of the ring. Thus in m and p forms inter – molecular hydrogen-bonding takes place and this results in some degree of association among a number of m and p-forms. It is this association which accounts for the higher boiling points of m and p – isomers.

![Diagram](image)

1.4 . **Detection of Hydrogen Bond:**

The following methods have been used for the detection of hydrogen bond in different compounds.

(i). **Infra –red spectroscopy:**

When a complex of the type A-H-B containing hydrogen bond is formed, several changes are observed in the infrared region.
(a) The absorption bands due to the A-H stretching vibrations (Fundamental and overtones) are shifted to lower frequencies. These shifts range from 30 cm\(^{-1}\) to several hundred cm\(^{-1}\) or more. This shifting is due to the weakening of the force constant for A-H stretching mode which is caused by the formation of hydrogen-bond.

(b) New vibrational modes which correspond to hydrogen bond stretching and deformation are observed at low frequencies in the far infrared region. The fundamental frequency which is associated with O-H stretching is found at 3600 cm\(^{-1}\). If the O-H group forms inter-molecular hydrogen bond an additional band appears at 3300 cm\(^{-1}\).

Increase in temperature (or) in dilution of the solution weakness the intensity near 3300 cm\(^{-1}\) and increase the same near 3600 cm\(^{-1}\). This shows that hydrogen bond formation is diminished with the increase of temperature and dilution of the solution. (i.e decrease in concentration). If an intra–molecular hydrogen-bond is formed, as in salicylaldehyde, suppression of free O-H group is so complete that the band at 3600 cm\(^{-1}\) is absent the only band which is observed is at 3300 cm\(^{-1}\).

(ii). Proton –Magnetic Resonance method:

The formation of a hydrogen-bond A–H –B in liquids and solutions modifies the electron density round the proton of A-H group and hence it’s shielding. In most of the cases Proton Magnetic Resonance (PMR) is displaced to down field (i.e. towards lower magnetic field) causing a hydrogen bonding shift which is added to the existing chemical shift. Therefore, with the exception of some cases involving aromatic molecules, the hydrogen bonding shift is usually negative. PMR method is useful for the cases with small shifts and overlapping bands in their infrared spectra.
(iii). **Electron Absorption Spectroscopy** :

Visible and UV spectroscopy in the visible region from 6000-2000’Å involves excitation of electronic energy levels. Experimentally it has been observed that electronic transitions are shifted to the blue [hypso–chromic shifts] when the chromophore is involved in hydrogen as an acceptor and are shifted to red (batho–chromic shifts) when the chromophore serves as donor.

(iv). **X-ray method** :

When the distance between certain pairs of atoms are usually short and the number of these short distances corresponds to the number of hydrogen bonds required by the formula, the short distances may be considered to indicate the position of the hydrogen bonds. As an example in the crystal of sodium hydrogen carbonate, two of the each planar carbonate group are only 2.55° A from the nearest oxygen’s of adjacent groups, while the third is separated from its nearest neighbours. It is thus assumed that the short distances indicate the positions of the hydrogen-atoms and the resulting structure is an infinite chain ion in which discrete carbonate ions are linked through hydrogen bonds. In order to explain nature of hydrogen bond several theories have been suggested. The theories are based on (i) Electrostatic approach (ii) Valance Band Theory (VBT) treatment and (iii) Molecular Orbital Theory (MOT) treatment.

1.5: **Image Analysis**: Image processing and analysis is a field of research in which the properties of liquid crystals are extracted from their textures. In most of the cases the image of an object is treated as a two dimensional signal. To extract useful information from the images some standard techniques are applied. The basic concept is an image is treated as a matrix of intensity values which has a particular quantized brightness and is a large array of sampled points from the continuous image. Now these points are called as pixels. Each pixel in a region is similar with respect to some computed property like colour, intensity or texture. The adjacent pixels differ with respect to same proportion.

The intensity of each pixel is variable. In a colour image, colour is typically represented by three component intensities red, green and blue that
maeans in a colour image each pixel has 3 intensity values. But in case of monochrome image it has one value per pixel represented by gray in colour. Each image pixel has its own gray level (dynamic range). The number of bits per pixel (bpp) is 1bpp=2colours for monochrome 2bpp=4colours and 3bpp=8colours. The image signal is coded in a two dimensional special domain. In image analysis feature extraction is a special form of dimensionality reduction. Transforming input data into a set of features is called “feature extraction”. Features often contain information relative gray shade texture shape or context.

Digital images are classified in to 4 types. The binary scale image each pixel is just black or white and possible values for each pixel is [0,1]. So one bit per pixel is needed. These are efficient in terms of storage. The second type is gray scale image contain the brightness information. It is a data matrix whose values represent shades of gray. When the elements of gray scale image are of class unit 8 or unit 16, they have integer values in the range [0,255] or [0,65535] respectively. Mostly the gray value of each pixel of an 8-bit image is considered. The range 0-255 is selected due to the fact that human eye is not sensible enough to make the difference between more than 256 levels of intensity for colour. Further the value of 255 is convenient for computer storage. The third type colour image or RGB image, each pixel has 24 bits. These are converted in to binary or gray colour image to reduce the time consumption and difficulty in image analysis the white colour is coded as [255,255,255] and black as [0,0,0] and bright pink as [255,0,255]. In the last type of indexed colour image, a small subset of more than sixteen million possible colours.

To extract features from images, some of the commonly used methods are (1) spatial (2) transform features (3) shape feature (4) edges and boundaries (5) moments and (6) textures. The spatial features of an object may be characterized by its gray levels, histogram features, amplitude features etc. Some of the common histogram features are dispersion, kurtosis and other features are median and mode.

Regarding the texture analysis it refers to a class of mathematical procedures and models that characterize a spatial variations with in imagery as a means of extracting information. If the texture primitive sizes are
comparable with pixel sizes statistical approach or stochastic approach is suitable. These methods can be used to analyse the spatial distribution of gray value. Based on the number of pixels defining the local feature statistical methods using various algorithms can be classified into first order (one-pixel) second order (two pixels) and higher order (three or more pixels). The first order statistics (histogram of intensities) estimate properties like mean, variance, skewness, kurtosis, energy and entropy of individual pixel by waiving the spatial interaction between image pixels.

The most popular second order statistical features for texture analysis are derived from the co-occurrence matrix which is covered in the next chapter.

**Advantages of Image Analysis:**

In medical field interpretation of images obtained from X-ray, MRI or CAT scans and also analysis of chromosome karyotypes. Satellite/ aerial views of land to investigate the suitability of different regions of different crops. Distinguishing good and fresh produce of fruits and vegetables from old in agricultural field. The inspection of paper samples in industry and to sharpen or de-blurring of speed camera images and finger print analysis in law enforcement. Finally the image analysis has great advantages in the designing of LCD’s.

1.6. Literature Survey:

To support my research work on “Image Analysis and Hydrogen bond studies of p-n-alkyl (oxy) Benzoic Acids” I have selected the latest journals at international level where the latest research findings on liquid crystals were noted by internationally reputed scientists and used them as highly valuable tools for my thesis.

Since the work is related with preparation and characterization of supramolecular liquid crystals of p-n-alkyl(oxy) benzoic acids with hydroxy benzoates using thermal techniques, spectroscopic methods, structural studies with 1H NMR and X-Ray diffraction a large span of literature survey which includes V.N.Vijayakumar etal [25] P.A.Kumar etal [26] for the crystallization
studies of hexadecylaniline used with Alkoxy benzoic acids A.V.Doshi etal [27] for the study of benzoate derivatives in ortho hydroxy-n-propyl benzoate is non mesomorphic but on condensing it with p-n-alkoxy benzoic acid gives rise to new ester homologous series with mesomorphic which are used in biological studies. A.Nahla etal[28] for estrification of alkoxy benzoic acids with hydroxyl propyl cellulose results the liquid crystal properties which are useful in electro optic applications Kavita etal [29] pongali N.Satya Prabhu etal [30], V.N.Vijaya Kumar etal[31,32] for alkoxy benzoic acid separately with p-n-alkyl benzoic acid chloro / hydroxy benzaldehyde, succinic acid levo tartaric acid used in optical shuttering and light modulation.


Maher A Qaddoura etal [43] in the study of liquid crystalline dimer of 4-(4pentenyloxy) benzoic acid, a member of the n-alkoxy benzoic acid homologus series was synthesized using potassium carbonate supported on alumina as catalyst which exhibits three mesophases, Pongali Satya Prabhu etal [44] Subha Priya etal [45] for rich poly morphism and T.Chitravel etal [46] for lowering the transition temperature to ambient temperature and reentrant liquid crystal smectic phase when applied stimulus is with drawn orginal nematic texture is observed ordering in intermolecular hydrogen bonding between alkyl aniline and alkoxy benzoic acids. V.N.Vijaya Kumar etal [47] for optical, thermal and dielectric measurement in linear hydrogen bonded liquid crystals, a new smectic ordering which is refered as smectic R is characterized which exhibits a ribbon like phase. H.M.P.Chen etal [48] in


1.7. Statement of the Research Problem:

The liquid crystalline materials are themselves unique as they posses dual [1] property namely the flow property of liquid (Isotropic) and geometrical property of solid (anisotropy). This dual property makes the model system to study one, two and three dimensional crystal melting. A varity of liquid crystal molecules with different molecular structures have been designed and synthesized. Their viability has been tested for application aspects as passive devices [2] mainly in display device.

Liquid crystal research involves the design and synthesis of novel materials. The process of self organization of liquid crystal molecules has been a highly interesting area. In this, modification to the traditional rod like liquid crystalline molecules is done by adding additional functional groups like azobenzene, dicarboxylic acids, dicayl amino pyridins palladium, platinum, lanthanide, hydroxy benzoates, pyridine, phenol etc in an efficient way to obtain noval liquid crystals phases due to intra and inter molecular interactions. The role of hydrogen bonding interactions in the formation of liquid crystal and stabilization of crystalline phases has been recognized and significant work has been turned out. The synthesis and characterization of supra molecular liquid crystal obtained through hydrogen bonding interaction of complimentary molecules has been extensively studied in the last 20 years. The field started with systematic investigation in the early 1990s. The first
hydrogen bonded complexes exhibiting liquid crystalline behaviour resulted from the dimerisation of aromatic carboxylic acids. Lengthening of rigid rod segments occurs as a property of liquid crystalline behaviour. The recent attention has been focused on the mesomorphizm induced by the non covalent electrostatic interaction involving inter molecular hydrogen bonding. The significance of hydrogen bond liquid crystal materials is all together highly realized. Surprisingly it was found that hydrogen bonds are successfully employed for the formation of new mesophases. The hydrogen bond has a striking influence on the phase behaviour as well as transition temperatures.

The hydrogen bonded liquid crystals has been synthesized with the combination of liquid crystal + liquid crystal, liquid crystal + non liquid crystal and non liquid crystal + non liquid crystal. This motivated the author to prepare hydrogen bonded liquid crystalline compound consisting of the type of liquid crystal + non liquid crystal namely a series of p-n- Alkyl benzoic acid: hyptyl-p-hydroxy benzoate (5BA:7HB to 10BA:7HB) and also p-n-alkoxy benzoic acid : nonyl–p-hydroxy benzoate (5OBA:9HB to 10OBA: 9HB). Further detailed study for confirmation of hydrogen bond formation has taken up using FTIR and HNMR. It is also planned to do x-ray diffraction studies to confirm the crystalline structure further and to check the even–odd effect.

In the entire series the induced smectic G phase and quenching of nematic phase may be due to the inter molecular hydrogen bond. It is also noted that induced smectic G phase is observed in both heating and cooling cycles in addition to quenching of nematic phase. The phase transition temperatures observed through polarizing microscopic studies are in reasonable agreement with the transition temperatures obtained from differential scanning calorimetry. Further the phase transition temperatures of p-n-alkoxy benzoic acid and p-n-alkyl benzoic acid, p-n-alkyl benzoic acid-hyptyl-p-hydroxy benzoate mesogens are determined using statistical image analysis.
The statistical parameter contrast, energy, homogeneity and correlation of the textures were computed using MATLAB as a function of temperature. The statistical parameter show abrupt changes as a function of temperature which relates the phase transition of the sample. Statistical image analysis results are in good agreement with the literature values. Statistical image analysis is reliable, more efficient and very sensitive to identify transition temperatures in mesophases.

References:


