INTRODUCTION

The field of liquid crystals (LC) is a new area of chemical and technological research. Its ability of producing devices has revolutionized the technological market products. As a result of the success of the knowledge already known about liquid crystals and their properties, and there is yet unexplored potential for synthesizing new LC materials.

The liquid crystalline state is independent physically distinct state of matter intermediate to molecular ordering between a crystalline solid and an ordinary isotropic liquid. Upon heating the solid first melt to a turbid cloudy viscous liquid which at higher temperature become optically clear isotropic liquid. Thus in liquid crystals state the molecules still possess a certain degree of order. The transitions are definite and precisely reversible or irreversible called as enantiotropic or monotropic LC substance respectively. Such substances are called the liquid crystalline (LC) or mesomorphic or anisotropic or mesogenic or mesomorphs in general. The phenomenon is known as mesomorphism.

Botanist [1], for the first time observed that, cholesteryl benzoate, had two “Melting Points”, one at 145.5 °C and the other at 178.5 °C when it melted to a normal isotropic clear liquid like other substances.

Friedel [2, 3] led to the conclusion that, the actual state is neither really crystalline nor true liquid.

It has been established by a number of scientists [4, 5] that liquid crystalline state is an ordered phase having mechanical properties of a liquid and optical properties of a crystalline solid.
Liquid crystals are classified on the basis of the manner in which they are obtained. They are classified into two groups.

(1) Thermotropic liquid crystals
(2) Lyotropic liquid crystals

Liquid crystalline property is exhibited either by action of heat or by action of solvents. In thermotropic liquid crystals the change in the molecular ordering is brought about by changing temperature whereas in lyotropic liquid crystals this change is brought about by the effect of solvent on substrates.

Gray and Winsor [6] suggested the terms “amphiphilic” and “nonamphiphilic” for lyotropic and thermotropic liquid crystals, respectively.
On the basis of the molecular arrangements Friedel [7] classified liquid crystals into two broad types, smectic and nematic, often the cholesteric phase described separately as twisted nematic or modified nematic mesophase.

Normally the smectic mesophase occurs at a lower temperature than the nematic mesophase. Existence of a nematic and cholesteric phase together in a mesogen has not been reported till now. Therefore cholesteric mesophase is called as modified nematic or twisted nematic mesophase.

The word “Smectic” is derived from the Greek word “Smectose” for soap. Smectic mesophase is the most ordered one, which is turbid and viscous.

Homologous series exhibiting reentrant phenomenon in smectic mesophases have been studied by Destrade et al [8, 9]. Bennemann et al. [10] have reported some mesogenic chiral compounds showing smecticQ phase just below the clearing point. Structural investigation of smectic Q phase has been carried out by Bennemann, Heppke and Lotzsch [11].

Nematic Liquid Crystal is the simplest mesophase. Calamitic or discotic mesophases produce nematic liquid crystal phase. Nematic mesophase is less ordered than a smectic mesophase. The word “Nematic” is derived from a Greek word “Nema” meaning threads as the phase exhibits threaded schlieren texture.

The optical effect of the nematic threads have been studied by Zocher and Birstein [12]. De Vries [13] proposed classification of nematic phases based on X-ray diffraction pattern.

The cholesteric phase was observed in cholesterol derivatives and hence derived this name viz. cholesteric phase.

Chiral smectic C* or ferroelectric liquid crystal is a modification of smectic C phase which has twist axis normal to the layers. The smectic C* phase of liquid crystal first find out in 1933. This was discovered by Robert Meyer [14].
Discshaped mesogens are called discotic. The liquid crystalline phases formed by disc shaped molecules are referred to as the discotic phases. They were first synthesized and identified in 1977 [15] by Indian scientists S. Chandrasekhar et al.

Compounds between the rodlike and disc like molecules are the lathlike species. The term is derived from Greek word meaning board like and these phases were first observed in polymeric liquid crystals by Ringsdorf et al. in 1986 [16]. They are called Sanidic Liquid Crystals.

Cubic mesophase is optically isotropic and its structure has been derived from X-ray investigation, which indicates a cubic lattice. There is threedimensional long-range order with respect to the position of the lattice unit [17].

Lyotropic liquid crystals are a part of substances called amphiphilic compounds.

Lyotropic liquid crystals produced by the molecules which are surfactants, consisting of two distinct parts (1) a polar, often ionic head and a nonpolar, often hydrocarbon tail. The polar end is attracted towards water (hydrophilic) while the nonpolar end is attracted towards hydrocarbons (lipophilic). Typical hydrophilic groups are -OH, -COOH, -COONa, -SO3K, -NMe3Br, -PO4-Ch2-Ch2-NH3 and typical lipophilic group are –CnH2n+1, –CnH2n+1-O2CCH3CH2COO–CnH2n+1.

Metallomesogens are metal containing liquid crystals. Vorlander [20] found the first thermotropic metal containing liquid crystal.

Liquid crystals play an important role in nature. The biological mesomorphism was first observed in the myelin forms by Virchow [21]. M Perutz et al. [22] studied the structure of haemoglobin and concluded that it could assume liquid crystalline form in the red blood cell. Knapp and Nicholas [23] first reported, mesomorphism in plants, which was observed in esters from banana peels and seeds of strychnine producing plants. A mesomorphic state of nucleic acid is proven by Evdokimov et al. [24].
For a homologous series, when the mesomorphic transition temperatures e.g. nematic-isotropic, smectic-isotropic, smectic-nematic, or smectic-smectic are plotted against the number of carbon atoms in the n-alkyl chain of alkoxy group, smooth curves may be drawn for like or related transitions. Usually the crystal mesomorphic transitions do not exhibit regular trends. The mesomorphic isotropic temperature lie on two falling curves, the upper one for even and lower one for odd number of carbon atoms in the n-alkoxy chain. The odd-even effect usually becomes less marked as the series is ascended and the two curves merge for later homologues of the series. The smecticnematic transition temperature usually do not alternate and lie on a smooth curves, which rises steeply at first, then levels off and may or may not merge with the falling nematicisotropic, smecticisotropic curves.

There exist a close relationship between molecular structure and the mesomorphism of a compound. Considerable interest has been shown from the very beginning to find out the correlation between chemical constitution and mesomorphism. Gray [25, 26] and Demus et al. [27, 28] have given quite a detailed account of effect of chemical constitution on mesomorphism.

The majority of thermotropic liquid liquid crystals are aromatic in nature consisting of polarisable and planar rigid aromatic rings linked with one another through linking groups like: -N=N-, -CH=N-, -CH=CH-, -COO-, -CH=CH-COO-, -CH=CH-CO-, -CO-CH=CH-, etc.

The increase in number of phenyl rings, increases the stability and rigidity [29, 30,31]of the mesophases. The chemical structure of many mesogens can be represented as follows.

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\text{Here L is linking group} 
\]

The molecule may have terminal substituents (R) and lateral substituents (Z), O = Aromatic/ Alicyclic / Heterocyclic rings. Merely suitable structural geometry may not turn the
compound to behave as a liquid crystal. Intermolecular forces also play a very important role.

These intermolecular forces are of three types:

(1) Dipole-dipole attractions – the direct interaction between permanent dipoles in the molecules
(2) Induced dipole attraction arising from the mutual polarization of the molecules by their permanent dipole moments.
(3) Dispersion forces the interaction between instantaneous dipoles produced by spontaneous oscillations of the electron clouds of the molecules.

Terminally or laterally unsubstituted compounds exhibit less stable mesophase compared to substituted mesogenic compounds. However for smectic liquid crystals, certain terminal groups reduce the thermal stability. As the carbon chain of alkoxy or alkyl group is lengthened, the tendency of depressing the melting point is increased. Liquid crystals of moderate chain lengths are normally purely nematic and increasing further length of the carbon chain may give both smectic and nematic mesophases and very long chain length usually exhibits only smectic phases.

Gray and Winsor [32] have reviewed and compared the effects of terminal substituents on the mesogenic systems. The average terminal group efficiency order for smectic phase is

-Ph > -Br > -Cl > -F > -NMe₂ > -Me > -H > -NO₂ > -OMe > -CN

and the average terminal group efficiency order for nematic phase in rod like aromatic system is

-Ph > -NHCOC(CH₃)₂ > -CN > -OCH₃ > -NO₂ > -Cl > -Br > -NMe₂ > -Me > -F > -H.

These orders give a broad idea about the probability of obtaining a particular type of mesophase.

In most cases, lateral substituents broaden the molecules. Thus lowering smectic and nematic phase stability is depending on the reducing lateral attraction [33]. The nature, size, polarity and position of the substituent group have a significant effect on the liquid crystalline
properties.

The lateral group efficiency order [34] for smectic phase is
-I >-Me >-NO$_2$=-Br >-Cl >-F >-H and

The nematic group efficiency order is
-NO$_2$ = -I > -Br > -Cl > -Me > -F > -H

The increased molecular breadth has three pronounced effects.
(i) Lowering of the temperature at which mesophase appears.
(ii) Decreasing the stabilities of the mesophases.
(iii) Destroying any smectogenic property regardless of alkoxy or alkyl group chain length.

Gardlund et al. [35] have studied the effect of lateral methyl group on benzylidene anilines. Laterally chloro substituted homologous series has been studied by Dave et al. [36]. Griffin et al. [37] and Doshi et al. [38] have studied the lateral methyl group effect and found that it decreases all mesophase transitions.

Vora et al. [39, 40] have studied number of homologous series with bulky methoxy group as a lateral substituent. They have found that contrary to common observations lateral methoxy group does not depress the crystal mesomorphic transition temperatures but the mesomorphic-isotropic transitions are drastically reduced.

Doshi and Patel, Chauhan [41,42,43,44] reported the three ring mesogens having a lateral aromatic branch.

Polymers have been used in almost every necessity of life. New polymers with better properties are developed for new application.

After the initial discovery of liquid crystallinity in polymeric solutions by Oster [45] and Robinson [46], number of liquid crystalline polymers have been reported.
Polymer liquid crystals (PLCs) which are combine the properties of polymers with those of liquid crystals.

These “hybrids” show the same mesophase characteristics as that of ordinary liquid crystals yet retain many of the useful and versatile properties of polymers. In order for normally, flexible polymers to display liquid crystalline characteristics, rodlike or disclike elements must be incorporated into their chain. Conversely, sidechain liquid crystal polymers are formed when the mesogens are connected as sidechain to the polymer by a flexible “bridge” which is called the Spacer.

The molecular structure and mesomorphic character of liquid crystal polymers are discussed in detail by Finklemann [47] and Ober [48].

Vora and Patel [49] have reported mesogenic polymers having symmetrically substituted triazine heterocyclic moiety and evaluated the effects of chemical structure on mesomorphism.

New chiral liquid crystals possessing ferro, antiferro and ferrielectric properties. Distinct ferroelectric smectic liquid crystals, new homologous series of racemic symmetric and non symmetric, liquid crystal dimmers with branched alkyl chain, α-halogenated triphenylene based discotic liquid crystals to prepare attractive devices application.

Doshi and Bhoya, Doshi and Ganatra, Doshi and Chauhan, Doshi and Prajapati, Doshi and Makawana, Doshi and V.Patel & D.Patel studied Liquid Crystal state with azoester central group with reference to three phenyl rings and their binary system with the effect of benzoate cinnamates and chalconyl derivatives on liquid crystal behavior [50].

Doshi and Lohar, Doshi and Joshi, Doshi and Odedara, Doshi and Vyas, Doshi and Travadi studied Liquid Crystal with two phenyl ring and their binary system [51].

Doshi and M.L.Chauhan, Doshi and R.B.Patel, Doshi and H.N.Chauhan, Doshi and Suthar, Doshi and Chaudhari, studied Liquid Crystal state using Benzoxyloxy and Cinnamoyloxy double ester central group in addition to central group (–CH=CH-COO- group) linking three phenyl
ring. Novel homologous series of liquid crystals studied with an effect of molecular structure on mesomorphic properties of substances which may be useful to the different fields of uses. [52].

Presently unexploited central group linking middle and third phenyl ring as $-\text{CH}=\text{CH}-\text{CO}-$ and $-\text{CO}-\text{CH}=\text{CH}-$ are selected and their homologous series having three phenyl rings with different lateral and terminal groups are planned to investigate their liquid crystal properties.

Thus from critical survey of the literature on synthesis of novel liquid crystal material through homologous series, it is clear that geometrical shape, size, molecular polarity and polarizability constituting the suitable degree of molecular rigidity and flexibility [53,54,55] which can induced liquid crystal property in a novel compound should be taken into account while synthesizing novel compound.

1.15 APPLICATIONS OF LIQUID CRYSTALS:

Liquid crystal technology has a major effect in many areas of science and engineering, as well as device technology. Applications to this special kind of materials are still being discovered and continue to provide effective solutions to many different problems.

Liquid crystal is used in display devices (LCDs). A major contribution to the growth of LCD technology has come from the development in addressing techniques used for driving matrix LCDs.

Liquid crystals are applied in many non-display applications. Some of the most developed application that currently being researched is in optical correlators, wavelength, optical interconnections, filters and optoelectronic neural networks.

- **Liquid crystal lenses** [56]
- **Three Dimensional Video** [57]
• Medical thermography [58-61]

• High strength fibers [62]

• Radiation Detection [63,64]

• Liquid crystals as solvents in spectroscopy [65,66]

• Liquid crystals as solvents in chemical reactions [67,68]

• Liquid crystals in gas liquid chromatography (GLC) [69-79]

• Thermal mapping and Nondestructive testing [80,81].

• General applications:

  Liquid crystal paintings have been used on fabrics like T-shirts etc. Certain cosmetics containing liquid crystals are also now available.

  They change colour depending on body temperature and atmospheric temperature. Mood jewellery also contains liquid crystals. The body temperature varies according to the mood of a person. Thus the change of the colour of the jewellery [81] or LC BINDIA is useful to decide the mood of person concern. Electronic LC screens are also available to maintain privacy of dealing in the business office or house. LC cloths are available with different colours which are changing their colours with changing intensity of light. Thus same cloth ware show different colours in morning, noon, evening and night. In such case the LC dyes used to colour original cloth are photo sensitive.