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# Study the effects of terminal side chain and –nitro group on mesomorphic behaviour of cinnamate-chalconyl based liquid crystal

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#### ABSTRACT

The influence of the terminal side chain and lateral nitro on mesomorphism due to the flexibility and polarity of lateral group is investigated. A new homologues series is synthesized to accomplish this aim. The  $C_1$  to  $C_3$  homologue are nonmesomorphic, while the rest of the homologues exhibit enantiotropic nematic and smectic properties. The texture of the nematic mesophase is of threaded, Schlieren and droplets type. All these compounds were characterized by elemental analyses and spectroscopic techniques of FTIR and <sup>1</sup>H Nuclear magnetic resonance (NMR). The phase behaviour was studied by polarizing optical microscopy (POM), differential scanning calorimetry (DSC), and X-ray diffraction techniques.

#### **KEYWORDS**

Enantiotropic; liquid crystal; nematic; smectic

#### **GRAPHICAL ABSTRACT**



# Introduction

Liquid crystal (LC) is an intermediate state of a matter in between the liquid and the crystal behaving with some typical properties of a liquid as well as some crystalline properties. There are many kinds of LC materials with different molecular structures, based on which LC can be divided into three categories, that is, calamitic liquid crystal, bent-shape liquid crystal, and discotic liquid crystal. Calamitic LC materials are widely used in a flat-panel displays, smart windows, laser, and other photonics. Liquid crystalline (LC) chalconyl ester derivatives play dual role useful in LC devices and pharmaceutical preparation and therapeutical treatment to

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cure diseases within definite range of concentration in solution state [1–10]. Liquid crystals in the nematic group are most commonly used in production of liquid crystal displays (LCD) due to their unique physical properties and wide temperature range. In the nematic phase, liquid crystal molecules are oriented on average along a particular direction. By applying an electric or magnetic field the orientation of the molecules can be derived in a probable approach [11–17]. This mechanism provides the basis for LCDs.

In our previous work, we have proposed homologous series that consist of three phenyl rings bonded through vinyl carboxy and chalconyl central groups as well as varying left n-alkoxy terminal end group and a fixed tail part at right side ended group [18]. Therefore, in present investigation is planned with a view to understand and establish the effects of tail group  $(-OC_{16}H_{33})$  and lateral group  $(-NO_2)$  on molecular structure of LC properties of thermotropic mesomorphism. Number of homologous series or LC materials have been reported in which ester-chalconyl linkage group is present to date [19–24], Group efficiency order and structure relation with mesomorphism will be derived.

# **Experimental**

# **Synthesis**

Trans 4-n- alkoxy cinnamic acids (A) prepared by modified method of Dave et al. and Vora et al. [25]. (E)-3-(4-(hexadecyloxy) phenyl)-1-(4-hydroxy-3-nitrophenyl) prop-2-en-1-one (B) was prepared by usual established method [26]. Esters were synthesized by a method reported in literature [27]. Thus, the Chalconyl - Ester homologue derivatives were filtered, washed with sodium bicarbonate solution, dried and purified till constant transition temperatures using an optical polarizing microscope equipped with a heating stage. Alkyl halides (R-Br), 4-hydroxy benzaldehyde, 4-hydroxy 3-nito acetophenone, dicyclohexyl carbodimide (DCC), Dimethyl amino pyridine (DMAP), Anhydrous  $K_2CO_3$ , Malonic acid, KOH, DCM, Ethanol, Acetone required for synthesis were used as received except solvents which was dried and distilled prior to use. The synthetic route to a series is shown in Scheme 1.

## Characterization

Representative homologues series were characterised by elemental analysis, Infrared spectroscopy, <sup>1</sup>H NMR spectra. IR spectra were recorded by Perkin-Elmer spectrum GX, <sup>1</sup>HNMR spectra were recorded on Bruker using CDCl<sub>3</sub> as solvent. Microanalysis was performed on Perkin-Elmer PE 2400 CHN analyzer (Table 1). Transition temperature and LC properties (Textures) were determined using an optical polarising microscopy equipped with heating stage (Table 2). Texture image of some homologues for nematic phase were determined by miscibility method (Table 3). Decomposition temperatures (Table 4) were determined using of Shimadzu DSC 60 differential Scanning Calorimeter with a heating rate of 5 to 10.0°C min<sup>-1</sup>. Thermodynamic quantities enthalpy ( $\Delta$ H) and entropy ( $\Delta$ S =  $\Delta$ H/T) are qualitatively discussed.

# Analytical data

# IR spectra in cm<sup>-1</sup> for butyloxy, hexadecyloxy & octadecyloxy derivatives

**Butyloxy**: 640 Polymethylene  $(-CH_2-)n$  of  $-OC_{10}H_{21}$ , 823(-C-H- def. m di-substituted-Para), 734 Polymethylene  $(-CH_2-)$  of  $-OC_{16}H_{33}$ , 937 (-C-H- def. hydrocarbon), 1510-1450 (N-O Str bands) 1056 and 1018(-C-O-) Str, 1373 and 1303 and 1249, 1165 (-C-O Str in



Scheme 1. Synthesis route of series-1.

-(CH<sub>2</sub>)n chain, 1427 and 1465 (-C-H- def. in CH<sub>2</sub>), 1512 (-C=C-)str, 1602 (-C=O group), 1728 (-COO- ester group), 2848 and 2914 (-C-H str in CH<sub>3</sub>).

**Hexadecyloxy**: 740 Polymethylene ( $-CH_2-$ )n of  $-OC_{16}H_{33}$ , 648 Polymethylene ( $-CH_2-$ )n of  $-C_{16}H_{33}$  817(-C-H- def. m di-substituted-Para), 972 (-C-H- def. hydrocarbon), 1530-1470 (N-O Str. bands), 1064 (-C-O-) Str, 1365 and 1249, 1165 (-C-O str in  $-(CH_2)$ n chain, 1365 and 1450 (-C-H- def. in CH<sub>2</sub>), 1510 (-C=C-)str, 1604 and 1681 (-C=O group), 1735 (-COO- ester group), 2854 and 2924(-C-H str in CH<sub>3</sub>).

**Octadecyloxy:** 734 Polymethylene ( $-CH_2-$ )n of  $-OC_{18}H_{37}$ , 831(-C-H- def. m disubstituted-Para), 941 (-C-H- def. hydrocarbon), 1540- 1460 (N–O Str bands), 1056 (-C-O-) Str, 1373 and 1303 and 1249, 1165 (-C-O str in  $-(CH_2)$ n chain, 1388 and 1468 (-C-H- def. in CH<sub>2</sub>), 1512 (-C=C-)str, 1604 and 1681 (-C=O group), 1735 (-COO- ester group), 2850 and 2920 (-C-H str in CH<sub>3</sub>).

Table 1. Elemental analysis for (1) pentyloxy (2) hexyloxy (3) decyloxy, and (4) dodecyloxy derivatives.

		Ele	ements % foun	ıd	Elements % Calculated			
Sr. no.	Molecular formula	С	Н	Ν	С	Н	Ν	
1	C45H50NO7	74.43	8.10	1.88	74.48	8.13	1.93	
2	$C_{46}H_{61}NO_7$	74.66	8.23	1.82	74.69	8.25	1.89	
3	$C_{50}H_{69}NO_7$	75.40	8.63	1.74	75.47	8.67	1.76	
4	C <sub>52</sub> H <sub>73</sub> NO <sub>7</sub>	75.78	8.82	1.66	75.82	8.86	1.70	





4-(3-(4-(hexadecyloxy)phenyl)acryloyl)-2-nitrophenyl 3-(4-(n-alkoxy)phenyl)acrylate

		Transition temperatures in °C						
Sr.no	R = n-alkyl group	Cr	Smectic		Nematic		lsotropic	
1	C1		_	_	_	_	212.0	
2	Ċ,		_	_	_		208.0	
3	C,	•		_	_	_	198.0	
4	C_4		_	_	_	_	184.0	
5	$C_{5}$		_	_	182.0		192.0	
6	C <sub>6</sub>		162.0	•	181.0		198.0	
7	C <sub>7</sub>		157.0		167.0		190.0	
8	C's		160.0		172.0		184.0	
9	C <sub>10</sub>		152.0		166.0		178.0	
10	C12		148.0		164.0		182.0	
11	C14		132.0	•	148.0		168.0	
12	C16		112.0	•	138.0		154.0	
13	C <sub>18</sub>	•	108.0	•	120.0	•	132.0	•

## Table 3. Texture of nematic phase of $C_7$ , $C_{10}$ , $C_{14}$ , $C_{16}$ by miscibility method.

Sr. no.	Homologue	Texture
1	C <sub>7</sub>	Threaded
2	C <sub>10</sub>	Schlieren
3	C <sub>14</sub>	Threaded
4	C <sub>16</sub>	Schlieren

Table 4. Transition temperature (°C) and enthalpy (J  $g^{-1}$ ) and entropy change (J  $g^{-1}k^{-1}$ ) by DSC measurement.

Homologues or Comp.	Transition	Heating scan (°C)	Cooling scan (°C)	$\Delta$ H (-Jg <sup>-1</sup> )	$\Delta H (Jg^{-1})$	$\Delta$ S(J g <sup>-1</sup> k <sup>-1</sup> )	$\Delta$ S(J g <sup>-1</sup> k <sup>-1</sup> )
C₅	Cr-SmC	_	_	_	_	_	_
	SmC-N	168	155	9.34	8.18	0.0211	0.0191
	N-I	>178	_	—	_	_	_
C <sub>14</sub>	Cr-SmC	110	105	32.31	33.08	0.0843	0.0875
	SmC-N	140	132	7.28	5.90	0.0176	0.0145
	N-I	>150	—	_	—	—	_
C <sub>16</sub>	Cr-SmC	105	102	33.50	39.12	0.0886	0.1043
	SmC-N	132	125	8.84	7.40	0.0182	0.0185
	N-I	>140	—	_	—	—	_
C <sub>18</sub>	Cr-SmC	110	104	34.58	33.18	0.0902	0.0880
	SmC-N	138	132	6.45	5.35	0.0156	0.0132
	N-I	>142	_	—	—	_	—

# 1HNMR spectra in CDCl<sub>3</sub> in $\delta$ ppm for methoxy, pentyloxy, octyloxy, decyloxy, and dodecyloxy derivative

**Methoxy**: 0.88 (t, 3H,  $-CH_3$  of  $-C_{16}H_{33}$ ), 1.26 (m, 2H n-poly methylene groups of  $-OC_{16}H_{33}$ ), 1.75 (m, 2H, n-poly methylene groups of  $-OC_{16}H_{33}$ ), 1.29 (P, 10 H of  $-OC_{16}H_{33}$  group), 3.81 (s,  $-O-CH_2-CH_3$ -of  $-OCH_3$ ), 4.06 (t, 3H,  $-O-CH_2-CH_2$ -of  $-OC_{16}H_{33}$ ), 6.93-6.95 (d, 1H, -CO-CH=CH-), 7.53-7.55 (d, 1H, -CO-CH=CH-), 7.28-7.31 (d, 2H)

-CH=CH-COO-), 6.50 (d, 1H, -CH=CH-COO-), 6.94-6.92 & 7.62-7.62 (d, 4H, left side phenyl ring), 7.74 & 8.58, 8.41 (3H, central phenyl ring), 7.62-7.61 & 6.95-6.92 (d, 4H, terminal phenyl ring).

**Pentyloxy:** 0.88-0.90 (t, 6H,  $-CH_3$  of  $-OC_5H_{11}$  &  $-OC_{16}H_{33}$ ), 1.26 (m, n-poly methylene groups of  $-OC_{16}H_{33}$ ), 1.31 (q, 8H,  $-CH_2$  of  $-OC_5H_{11}$  &  $-OC_{16}H_{33}$ ), 1.29 (P, 10 H of  $-OC_5H_{11}$  &  $-OC_{16}H_{33}$  group), 1.75 (m, n-poly methylene groups of  $-OC_5H_{11}$ ), 3.5-3.6 (s,  $-OCH_2-CH_2$ -of  $-OC_{12}H_{25}$ ), 4.06 (t, 6H,  $-O-CH_2-CH_2$ -of  $-OC_5H_{11}$  &  $-OC_{16}H_{33}$ ), 7.54-7.56 (d, 1H, -CO-CH=CH-), 8.30-8.32 (d, 1H, -CO-CH=CH-), 7.62-7.64 (d, 1H, -CH=CH-COO-), 6.30 (d, 1H, -CH=CH-COO-), 6.94-6.91 & 7.60-7.62 (d, 4H, left side phenyl ring), 7.72 & 8.58, 8.41 (3H, central phenyl ring), 7.60-7.61 & 6.95-6.92 (d, 4H, terminal phenyl ring).

**Octyloxy:** 0.88 (t, 6H,  $-CH_3$  of  $-OC_8H_{17} & -OC_{16}H_{33}$ ), 1.2-1.3 (m, n-poly methylene groups of  $-OC_8H_{17} & -OC_{16}H_{33}$ ), 1.29 (P, 10 H of  $-OC_8H_{17} & -OC_{16}H_{33}$  group), 1.74-1.76 (m, n-poly methylene groups of  $-OC_8H_{17} & -OC_{16}H_{33}$ ), 4.06 (t, 6H,  $O-CH_2-CH_2$ -of  $-OC_8H_{17} & -OC_{16}H_{33}$ ), 6.92-6.95 (d, 1H, -CO-CH=CH-), 7.52-7.55 (d, 1H, -CO-CH=CH-), 7.28-7.31 (d, 1H, -CH=CH-COO-), 6.50 (d, 1H, -CH=CH-COO-), 6.94-6.90 & 7.61-7.62 (d, 4H, left side phenyl ring), 7.74 & 8.58, 8.41 (3H, central phenyl ring), 7.62-7.60 & 6.95-6.92 (d, 4H, terminal phenyl ring).

**Decyloxy:** 0.88 (t, 6H,-CH<sub>3</sub> of  $-OC_{10}H_{21} \& -OC_{16}H_{33}$ ), 1.2-1.5 (m, n-poly methylene groups of  $-OC_{10}H_{21} \& -OC_{16}H_{33}$ ), 1.29 (P, 10 H of  $-OC_{10}H_{21} \& -OC_{16}H_{33}$  group), 1.31 (q, 8H of 1.80 (m, n-poly methylene groups of  $-OC_{10}H_{21} \& -OC_{16}H_{33}$ ), 4.06 (t, 6H,-O-CH<sub>2</sub>-CH<sub>2</sub>-of  $-OC_{10}H_{21} \& -OC_{16}H_{33}$ ), 6.93-6.95 (d, 1H, -CO-CH=CH-), 7.53-7.55 (d, 1H, -CO-CH=CH-), 7.28-7.31 (d, 1H, -CH=CH-COO-), 6.50 (d, 1H, -CH=CH-COO-), 6.94-6.92 & 7.62-7.62 (d, 4H, left side phenyl ring), 7.74 & 8.58, 8.40 (3H, central phenyl ring), 7.62-7.61 & 6.94-6.92 (d, 4H, terminal phenyl ring).

**Dodecyloxy:** 0.87 (t, 6H,  $-CH_3$  of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$ ), 1.2-1.5(m, n-poly methylene groups of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$ ), 1.80 (m, n-poly methylene groups of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$ ), 1.29 (P, 10 H of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$  group), 1.31 (q, 8H of 1.80 (m, n-poly methylene groups of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$ ), 4.06 (t, 6H,  $-O-CH_2-CH_2$ -of  $-OC_{12}H_{25} \& -OC_{16}H_{33}$ ), 6.93-6.95 (d, 1H, -CO-CH=CH-), 7.53-7.55 (d, 1H, -CO-CH=CH-), 7.28-7.31 (d, 1H, -CH=CH-COO-), 6.50 (d, 1H, -CH=CH-COO-), 6.94-6.92 & 7.62-7.62 (d, 4H, left side phenyl ring), 7.74 & 8.58, 8.41 (3H, central phenyl ring), 7.62-7.61 & 6.95-6.92 (d, 4H, terminal phenyl ring).

## **Result and discussion**

## **POM investigation**

From the POM measurements, we have found that the 4-hydroxy nitro derivative of chalcone (m.p. 71°C, yield 74%) do not possess liquid crystalline phase however by the linking with trans cinnamic acid that display mesomorphism property. Mesomorphic character commences at  $C_5$  homologue and continued up to last  $C_{18}$  homologue as enantiotropically manner and shows smectic as well as nematic mesophase.  $C_1$  to  $C_4$  homologues are does not show LC phase due to their high crystallising tendency. This compounds are directly converted from solid phase to liquid phase without exhibit liquid crystalline property. In present case, we have represents the effect of polarity or polarizability of laterally nitro group ( $-NO_2$ ) and flexibility due to end side chain ( $-OC_{16}H_{33}$ ) in liquid crystalline behaviour. The phase diagram is shown in Fig. 1, which is plotted against the number of carbons atoms present in n-alkyl



Figure 1. Phase diagram of series by POM.

chain of left n-alkoxy terminal end groups versus the transition temperatures of homologues as observed and determined using an optical polarizing microscope equipped with a heating stage. Solid-isotropic curve follows a zigzag way of rising and falling as series is increased with number of methylene unit linked in it and inclusive descending and slightly increases at dodecyloxy homologue of the present homologues series. The smectic to nematic transition curve drop away with slightly ascends at  $C_{12}$  homologue and descends continue with  $C_{18}$  homologue, respectively. Nematic-isotropic phase transition curve shows descending tendency and ascending at  $C_{12}$  homologue, it behaves due to fairly abnormality from dodecyloxy to octadecyloxy derivative. Both the transition curve indicated odd-even effect. The mesomorphic properties are varying from homologue to homologue in same series because of added methylene group in left side of the n-alkyl chain containing n-alkoxy terminal side chain. The presence of odd-even effect diminishes as series is ascended beyond octyloxy derivatives.

Texture image shown in Fig. 2, for  $C_{10}$  homologue, the schlieren texture image at 166°C, (b) Smectic C phase for  $C_{12}$  homologue at 148°C, (c) Smectic C phase for  $C_8$  homologue at 160°C, (d) Threaded type nematic phase of  $C_{18}$  homologue at 120°C during heating and cooling conditions respectively.  $C_{16}$ ,  $C_{14}$ ,  $C_5$  homologue display nematic phase mention in Fig. S1 (Supplementary data).



Figure 2. POM image of (a) C<sub>10</sub> homologue, (b) C<sub>12</sub> homologue, (c) C<sub>8</sub> homologue, (d) C<sub>18</sub> homologue.

The absence of lamellar packing of molecules in their solid crystal lattices at solid form  $(C_1)$ to  $C_4$ ) due to unsuitable magnitudes of intermolecular anisotropic forces of lateral attractions which hinders to maintain sliding moving layered of molecules in their floating condition on the surface under exposed thermal vibrations. As increasing the chain which sliding moving the arrangement of molecules closeness to each other to cause smectic mesophase  $(C_6 \text{ to } C_{18})$  homologue. The exhibition of nematic mesophase formation for definite range of temperature by C<sub>5</sub> to C<sub>18</sub> homologue is attributed to the suitable magnitudes of anisotropic forces of intermolecular attractions due to fittest magnitudes of molecular polarity and polarizability, permanent dipole-moment across long molecular axis with increasing chain, dispersion forces etc. as a consequence of favourable molecular rigidity and flexibility which facilitated statistically parallel orientational order of molecules in floating condition on the surface to cause nematic mesophase (threaded and Schlieren type) in the presence of thermal energy. The changing magnitudes of mesogenic properties from homologue to homologue in the same series is due to the changing number linked methylene unit which made variations in the gradual variations in molecular rigidity and flexibility due to long chain at terminal side. The phase sequence of  $comp.C_{10}$  during cooling condition shown in Fig. 3. The nematic phase starts at 166°C from isotropic mass, than it cooled to convert into nematic droplets and applying further cooling, movement of sliding layer and it transform into smectic mesophase which on more cooling switch into solid crystal phase.

Textures of nematic phase in presently prepared series are threaded, schlieren, while the smectic phase are of the type of smectic C. Thermal stabilities for smectic and nematic are 157.0°C and 175.33°C, respectively, whose observed total mesophaselength (Sm+N) at 10–42°C.



Figure 3. Phase sequence of  $C_{10}$  homologue at heating condition by POM

# **DSC** study

The thermal behaviour of novel homologues series were examined by using DSC measurement. In Fig. 4,  $C_{18}$  homologue, heating condition first endothermic peak at 110°C, which indicates the presence of SmC. That was further confirmed by POM. While second peak observed at 138°C shows nematic phase. However, at cooled condition, the endothermic peak observed at 104°C and 132°C. In  $C_{14}$  homologue, first endothermic peak at 110°C and second peak at 140°C during heating stage, while in cooling stage two peak trace at 132°C and 105°C. That was confirmed by POM analysis and that indicates the mesophase obtained enantiotropically.  $C_{16}$  homologue, during heating first endothermic peak observed at 105°C confirmed the



Figure 4. DSC measurement (A) C<sub>18</sub> homologue, (B) C<sub>14</sub> homologue, (C) C<sub>16</sub> homologue, (D) C<sub>5</sub> homologue.



**Figure 5.** (a) DSC measurement of  $C_{16}$  homologue.

presence of SmC and second endothermic at 132°C, that confirm the nematic mesophase, At cold condition mesophase confirm by POM investigation that shows two peaks are at 125°C and 102°C which confirmed the presence of mesophase smectic as well as nematic that was also confirmed by POM study enantiotropically manner. (D)  $C_5$  homologue, one endothermic peak observed at 168°C, that indicates the presence of only nematic phase, again at cooled condition, the single peak was traced at 155°C, which was confirmed by POM at late commencement of mesophase at 182°C, heating and cooling condition.

Transition temperature obtained by DSC analysis at heating and cooling condition and the value of enthalpy and entropy is mention in Table 4. Molecules of every homologue randomly oriented in all possible directions with high order of disorder or entropy ( $\Delta S = \Delta H/T$ ) beyond isotropic temperature and the enthalpy value ( $\Delta H$ ). But, at cooled condition, the same from and below isotropic temperature, the mesophase is persisted to appear reversibly at the high temperature at observed during heating condition. The mesophase obtained in this present series is enantiotropically smectogenic and nematogenic manner respectively. In Fig. 5, LC phase is confirmed by DSC analysis with trace two endothermic peak which confirmed the presence of smectic and nematic phase at heating and cooling condition.

#### Powder X-ray diffractometer study

In order to correlate the results of the DSC and POM, we have performed powder X-ray diffraction. The molecular arrangement and the presence of smectic phase is confirmed by using XRD measurement. Heated compound at its transition temperature. In Fig. 6, the graphical representation of proposed molecular packing of smectic C phase. The XRD of  $C_7$  homologue at 148°C. Two diffraction peaks are obtained at low angles (d: 33.08 A° and 6.92A°) show in Fig. 7.

The changing mesogenic behaviours from varying left side chain in the same series is attributed due to changing number of methylene units linked with it, which causes variations in the magnitudes of the total molecular part including tailed group with presence of  $-NO_2$  group at lateral side with effect of its polarity and polarizability to induce mesophase and molecular rigidity unaltered because rest of the molecular part including tailed end remains unchanged throughout the novel synthesized homologues series. Some LC properties evaluated from thermotropic data of presently investigated novel series-1 with compared with structurally similar analogues series X [28] as mentioned below Fig. 8.



Figure 6. Proposed molecular packing of the Sm C phase in present series.



**Figure 7.** XRD diffractogram of Compound C<sub>7</sub> homologue at 148°C.



Figure 8. Structurally similar analogous series.

In Fig. 8, the homologous series-1 is presently investigated and series-X is taken for comparison, same in linearity except series-1 contain one more vinyl linkage group and nitro group at lateral side. Therefore the magnitudes of molecular rigidity and flexibility differing from homologue with presence of vinyl carboxy (-CH=CH-COO-) in series-X and lateral side ( $-NO_2$ ), however, in series-X, carboxy linkage group (-COO-) and no any lateral



Figure 9. Space filling diagram of series-1 and series-X.

group. Thus, variations in mesomorphic properties like thermal stability and mesophaselengths, commencement of mesophase etc. will depend upon the magnitudes of changing features of homologous series 1, and series X taken under comparative study. Figure 9 shows the space filling diagram of series 1 and series X respectively. Series 1 is more linear as compare to series X, it is differ with ethylene linkage with carboxy linking group in cinnamates with middle phenyl ring, while in series X carboxy group linked with first and second phenyl ring with absence of nitro group.

Nematic thermal stability of present series-1 is the greater than series-X under comparison. Nematic mesophase instigates from  $C_6$  homologue for a series-X, while smectic property is totally absent. The exhibition of nematic mesophase in addition to smectic phase in case of present synthesized series-1 is attributed to the ortho substituted  $-NO_2$  lateral group, which rises molecular polarity and polarizability. Though broaden of molecule in which, reducing at end to end fascinations, but, the magnitudes of intermolecular attractions through polarizability increases to such an extent that, the environmental situation favours sliding layered molecular arrangement at Cr-Sm transition temperature and then, statistically parallel orientational order of molecules in fluctuating condition between Sm-N and N-I transition temperatures. Thus, the more polarizable series-1 and X are missing smectogenic character and additional polarizable series-1 to convince with lateral substitution facilitated exhibition of smectic property in addition to nematic property.

#### Conclusions

In summary, we have synthesized a series of chalconyl esters linked groups with flexible aliphatic side chain with benzene core, which exhibit smectogenic and nematogenic property enantiotropically manner, the mesomorphism was confirmed by POM, DSC, and powder XRD. The degree of mesomorphism is higher with introduced lateral side by nitro group as compare to series-X.

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