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Research Article

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Solvent-Free Green Synthesis of Oximino Esters of Thiophene by Hydrothermal Method and Characterization of their Mesogenic Properties

Mary Anne Anitha[1*], KM Lokanatha Rai[1] and R Somashekar[2]

[1]DOS in Chemistry, University of Mysore, Manasagangotri, Mysore, India
[2]Department of Physics, Regional Institute of Education, Manasagangotri, Mysore, India

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ABSTRACT

Hydrothermal synthesis of a homologous series of thiophene derivatives from 4-(1-(hydroxyimino) ethyl) phenyl 4-alkoxybenzoates and thiophene-2-carboxylic acid using mercuric acetate under solvent-free conditions is described. The liquid crystalline properties of the synthesized compounds were investigated by Polarising Optical Microscopy (POM) and Differential Scanning Calorimetry (DSC). It is observed that all the members of the series exhibited only Nematic phase (N).

Keywords: Phase transfer catalysis; Mercuric acetate; Hydrothermal/Solvothermal method; Nematic phase; Polarising optical microscope (POM); Differential scanning calorimetry

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INTRODUCTION

The five-membered, sulfur containing heterocycle thiophene is widely used as a building block in medicinal chemistry and drug discovery. It constitutes an important class of compounds that are stable, and can be easily synthesized and functionalized. Functionalized thiophenes have found extensive use as precursors for functional materials, natural products and pharmaceuticals. Many heterocyclic compounds containing thiophene have versatile pharmacological activities such as controlling diabetes [1], anticonvulsant [2], antiviral [3], antibacterial [4], anti-inflammatory [5], antioxidant [6], antimicrobial [7], antifungal [8], local anesthetic [9], antiallergy [10], anti-tubercular agents [11], etc. Thiophenes are also used as photosensitive natural insecticide [12]. They are also incorporated into cycloparaphenylenes [13] which exhibit electrochemical and optical properties, in transition metal complexes [14], in covalent organic frameworks [15], in organic solar cells [16], in copolymers [17], in high performance field effect transistors [18], as dyes for probing membranes [19], etc.

Carbonyl compounds form a number of derivatives such as oximes, hydrazones, semicarbazones and N-substituted hydrazones. These nitrogen derivatives are not only synthetic intermediates, but they are extensively used for purification, characterization of carbonyl compounds, etc. Compounds with N-O bonds, such as O-aryloximes ethers, O-alkenyl oxime ethers, nitrones and N-oxides have been used extensively as important starting materials (or) intermediates to synthesize key building blocks in organic synthesis such as the synthesis of heterocyclic compounds such as isoxazolines and oxazines. Oxime and its derivatives are found in a number of commercial drugs such as pralidoxime, pifoxime, cefixime, fluvoxamine, oxiconazole and enviroxime. They are also used as ataraxics [20], anti-inflammatory agents [21], anti-HIV agents [22], etc. Liquid crystals are an intermediate state of matter that exists between crystal and liquid states. Materials in liquid crystalline phase exhibit/s both the fluid and crystalline properties in such a manner, that they are utilized in liquid crystal displays, thermometers, optical imaging, polymers, etc. The general common molecular feature of a liquid crystal is an elongated, narrow molecular frame work which usually is depicted as a rod-shaped or a bent-shaped structure. Semicarbazones, oximes and azines are derivatives of carbonyl compounds which are liquid crystalline. Thiophene and their derivatives are widely used in non-linear optics [23-28]. Majority of the thiophene-based liquid crystalline molecules contain thiophene ring either as a central ring or as a part of fused ring system [29-36]. Hydrothermal/solvothermal method is used for the

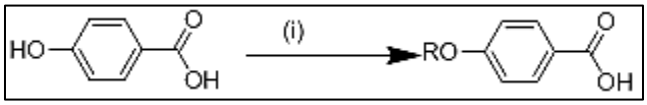
synthesis of 1, 3, 4-oxadiazoles [37], homometallic and heterometallic tetrazole complexes [38,39], and pyrazoles and isoxazoles [40]. There are no reports of alkylation/esterification of oximes by the hydrothermal method. Alkylation or esterification of oximes involves the use of acid chlorides, and this method suffers from disadvantages such as longer reaction time, harsh reaction conditions, lower yield, side products, etc. Many methods have been developed to overcome these conditions [41-45]. Mercuric acetate is used for transetherification of methoxyethene [46]. Thus, we decided to synthesise oximino esters of thiophene from 4-(1-(hydroxyimino)ethyl)phenyl 4-alkoxybenzoates and thiophene-2-carboxylic acid using mercuric acetate under solvent-free conditions, and evaluate their mesogenic properties.

MATERIALS AND METHODS

All reagents and solvents were used as received from the suppliers as given below. 4-hydroxyacetophenone, hydroxylamine hydrochloride and pyridine were bought from Loba Chemie. n-ethyl bromide, n-propyl bromide, n-butyl bromide, n-pentyl bromide, n-hexyl bromide, n-heptyl bromide and n-octyl bromide were bought from Loba Chemie. 1-bromodecane, 1-bromododecane, 1-bromotetradecane and 1-bromohexadecane were bought from Alfa Aesar. Mercuric acetate and thiophene-2-carboxylic acid was bought from Loba Chemie. Ethylacetate, petroleum ether and n-hexane was bought from Rankem. Melting points were determined by using digital melting point apparatus in melting point capillaries and are uncorrected. The purity of the compounds was checked by TLC on silica gel G plates and the spots were identified by iodine chamber and U.V lamp used as visualizing agents. Column chromatrography was performed on silica gel (100-200 mesh) using a gradient of ethyl acetate and petroleum ether as mobile phase. IR spectra were recorded by using KBr pellets on a FTIR Spectrophotometer (Shimadzu 8400S, 4000-400 cm^{-1}). ^{1}H- and ^{13}C-NMR spectra were recorded using $CDCl_3$ as solvent and tetramethylsilane as internal standard using Agilent-NMR 400MHz. ^{1}H-NMR spectral data are given as chemical shifts in ppm followed by multiplicity (s=singlet, d=doublet, dd=doublet of doublet, t=triplet, m=multiplet, and so on). Mass spectra were recorded in a mass spectrometer of Synapt G2 HDMS.

Experimental Procedure

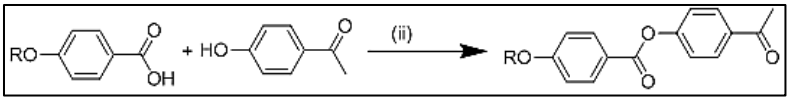
Synthesis of 4-alkoxybenzoic acids: Typical procedure for the synthesis of 4-ethoxybenzoic acid (Scheme 1):
4-hydroxybenzoic acid (4.022 g, 29.1 mmol) and ethyl bromide (3.145 g, 2.14 ml, and 29.1 mmol) were dissolved in anhydrous ethanol (45 ml). Then, powdered potassium hydroxide (3.259 g, 58.2 mmol) was added to the above reaction mixture and refluxed for 6hrs under stirring. After cooling to room temperature, the mixture was acidified with 1 N hydrochloric acid (20 ml) to yield white precipitate. After filtration, the crude product was purified by recrystallization using methanol: water (1:1) to get 4-ethoxybenzoic acid as the pure product (2.959 g, 61.15%).



1 **2b-l**

Scheme 1: RBr, KOH, EtOH, 4-6hrs, reflux, R= C2H5, C3H7, C4H9, C5H11, C6H13, C7H15 C8H17, C10H21, C12H25, C14H29, C16H33

Synthesis of 4-acetylphenyl 4-alkoxybenzoate: Typical procedure for the synthesis of 4- acetylphenyl 4-methoxybenzoate (Scheme 2):
To the reaction mixture of 4-methoxybenzoic acid (2.646 g, 17.4 mmol) and 4-hydroxy acetophenone in 100 ml round bottomed flask (2.367 g, 17.4 mmol) in dichloromethane (60 ml) as solvent, DCC (3.590 g, 17.4 mmol) and DMAP (0.425 g, 3.48 mmol) was added at room temperature and stirred for 20 hrs. The precipitated urea was filtered and was diluted with excess solvent, washed with water (3×20 ml), very dilute sodium hydroxide solution (10 ml), water (2×15 ml) and finally dried over anhydrous sodium sulphate. Evaporation of the solvent gave a crude solid which was purified by tituration using chloroform and n-hexane to give the 4-acetylphenyl 4-methoxybenzoate as a creamish solid (3.198 g, 68.04%)**.**

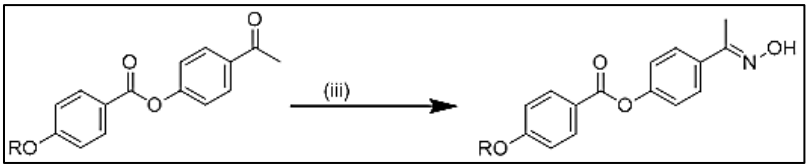


2a-l **3** **4a-l**

Scheme 2: DCC, DMAP, CH2Cl2, stir, 20hrs, R=CH3, C2H5, C3H7, C4H9, C5H11, C6H13, C7H15 C8H17, C10H21, C12H25, C14H29, C16H33

Synthesis of 4-(1-(hydroxyimino) ethyl) phenyl 4-alkoxybenzoate: Typical procedure for the synthesis of 4-(1-(hydroxyimino) ethyl) phenyl 4-methoxybenzoate (Scheme 3):

The reaction mixture of 4-acetylphenyl 4-methoxybenzoate (2.701 g, 10 mmol), hydroxylamine hydrochloride (1.395 g, 20 mmol) and pyridine (1.58 g, 1.60 ml, 20 mmol) in ethanol (80 ml) was refluxed for 18 hours. The excess ethanol was removed by arranging the condenser for downward distillation on a water bath. The residue in the flask was allowed to cool and 40 ml water was added. The residue was extracted into diethyl ether (60 ml), washed with water (2×15 ml), brine, dried over anhydrous magnesium sulphate and evaporated to get crude 4-(1-(hydroxyimino)ethyl)phenyl 4-methoxybenzoate which was futher purified by recrystallization using methanol (1.678 g, 58.88%).

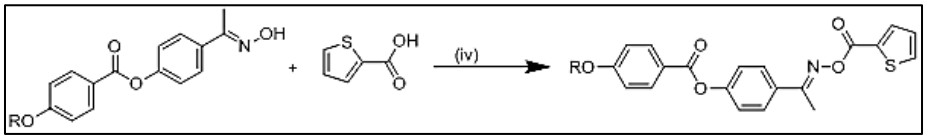


4a-1 **5a-1**

Scheme 3: NH2OH. HCl, pyridine, EtOH, reflux, 12-18hrs, R=CH3, C2H5, C3H7, C4H9, C5H11, C6H13, C7H15, C8H17, C10H21, C12H25, C14H29, C16H33

Synthesis of 4-(1-(((thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-alkoxybenzoate: Typical procedure for the synthesis of 4-(1-(((thiophene-2 carbonyl)oxy)imino)ethyl)phenyl 4-methoxybenzoate (Scheme 4):

4-(1-(hydroxyimino)ethyl)phenyl 4-methoxybenzoate (1.494 g, 5.24 mmol) thiophene-2-carboxylic acid (0.671 g, 5.24 mmol) and mercuric acetate (1.667 g, 5.24 mmol) were taken in a teflon liner. The teflon liner was tightly closed and lowered inside a steel autoclave. The steel autoclave was kept inside a pre-heated oven at 160°- 170°C and heated for 6 to 8 hours. Then the autoclave was taken out of the oven and allowed to attain room temperature. The teflon liner inside the steel autoclave was opened and the residue was extracted into ethyl acetate (60 ml), washed with distilled water, brine, dried over anhydrous sodium sulphate and evaporated to get a crude dark brown solid, which was further purified by recrystallization using ethanol: ethyl acetate (2:3) to get the pure product as a pale brown solid (1.192 g, 57.58%).

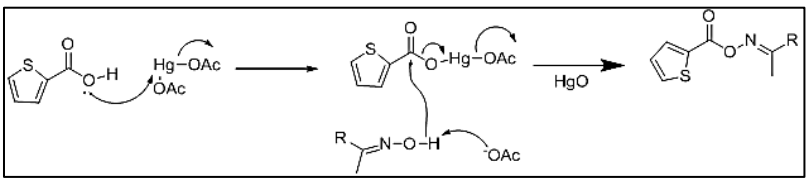


5a-l **6** **7a-l**

Scheme 4: Hg(OAc)2, 1600C, 6-8hrs, R=CH3, C2H5, C3H7, C4H9, C5H11, C6H13, C7H15 C8H17, C10H21, C12H25, C14H29, C16H33

Reaction Mechanism

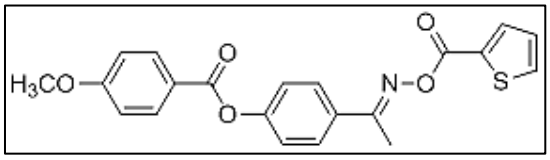
The first step of the reaction involves the attack of the nucleophilic oxygen of the carboxylic acid of thiophene on the mercury ion, followed by elimination of acetate anion. In the second step, the negatively charged acetoxy ion that was expelled in the first step abstracts the hydrogen of the oxime, the negatively charged oxygen of the oxime in turn attacks the carbonyl group of thiophene, resulting in the elimination of another acetate anion and mercuric oxide; and forming the final oximino ester product (Scheme 5).



Scheme 5: Reaction mechanism oximino ester product

Results of Spectral Data

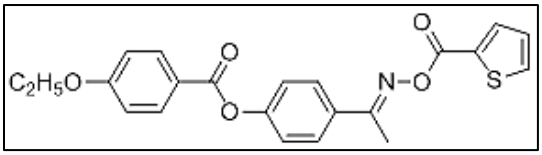
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-methoxybenzoate(7a):



Scheme 6: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-methoxybenzoate(7a)

Obtained from 5a (1.494 g, 5.24 mmol), 6 (0.671g, 5.24 mmol) and $Hg(OAc)_2$ (1.667 g, 5.24 mmol) as a pale brown solid (1.192 g, 57.58%); Molecular formula: $C_{21}H_{17}NO_5S$; ^1H NMR (400MH_z,$CDCl_3$): δ8.11-8.09 (m, 2H, ArH), δ7.99 (dd, 1H, J=4.8 Hz, 10.4 Hz), δ7.85 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.53-7.51 (m, 2H, ArH), δ 7.22-7.18 (m, 3H, ArH), δ7.02-7.00 (m, 2H, ArH), δ3.79 (s, 3H, -OCH_3), δ2.71 (s, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$):165.87, 164.99, 160.34, 154.83, 152.03, 134.91, 134.45, 133.89, 132.34, 131.45, 128.55, 127.99, 122.78, 121.66, 114.39, 56.23, 12.51; IR Analysis: 3099, 3067, 2968, 1737, 1668, 1614, 1595, 1513, 1415, 1345, 1296, 947 cm^{-1}; Elemental analysis: Calculated: C=63.79, H=4.33, N=3.54, O=20.23, S=8.11; Found: C=63.56, H=4.29, N=3.48, O=19.53, S=7.97; Mass Spectra: Actual Mass=395.08, Found=396.78 [M+1], 397.25 [M+2], 398.00 [M+3]; Melting Point=156-158°C (Scheme 6).

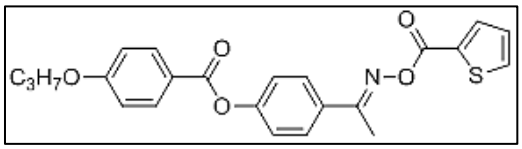
2) 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-ethoxybenzoate (7b):



Scheme 7: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-ethoxybenzoate (7b)

Obtained from 5b (1.396 g, 4.67 mmol), 6 (0.597 g, 4.67 mmol) and $Hg(OAc)_2$ (1.487 g, 4.67 mmol) as a pale brown solid (0.989 g, 51.81%); Molecular formula: $C_{22}H_{19}NO_5S$; ^1H NMR (400 MHz, $CDCl_3$): δ8.12-8.08 (m, 2H, ArH), δ7.99 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.85 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.54-7.51 (m, 2H, ArH), δ 7.23-7.19 (m, 3H, ArH), δ7.02-7.00 (m,2H, ArH), δ4.09 (q, 2H, -OCH_2), δ2.75 (s, 3H, -CH_3), δ 1.45 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$):165.91, 164.01, 159.98, 154.81, 151.73, 135.13, 134.49, 133.71, 132.44, 131.56, 128.66, 128.03, 122.79, 121.61, 115.28, 65.19, 15.03, 12.83; IR Analysis: 3099, 3067, 2970, 1739, 1687, 1665, 1619, 1597, 1513, 1418, 1349, 1299, 949 cm^{-1}; Elemental analysis: Calculated: C=64.53, H=4.68, N=3.42, O=19.54, S=7.83; Found: C=63.86, H=4.61, N=3.41, O=19.19, S=6.99; Mass Spectra: Actual Mass=409.09, Found=410.32 [M+1]; Melting Point=157-159°C (Scheme 7).

4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-propoxybenzoate (7c):

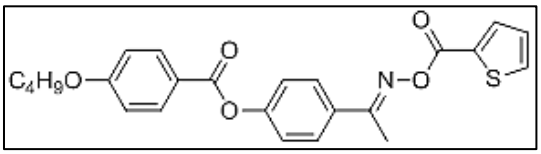


Scheme 8: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-propoxybenzoate (7c)

Obtained from 5c (1.299 g, 4.15 mmol), 6 (0.531 g, 4.15 mmol) and $Hg(OAc)_2$ (1.322 g, 4.15 mmol) as a pale brown solid (0.844 g, 48.08%); Molecular formula: $C_{23}H_{21}NO_5S$; ^1H NMR (400 MHz, $CDCl_3$): δ8.12-8.09 (m, 2H, ArH), δ7.98 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.86 (dd, 1H, J=4.4Hz, J=10.0 Hz), δ 7.54-7.52 (m, 2H, ArH), δ 7.21-7.17 (m, 3H, ArH), δ7.05-7.02 (m,2H, ArH), δ4.08 (t, 2H, -OCH_2), δ2.73 (s, 3H, -CH_2), δ 1.85-1.83 (m, 2H, -CH_2), δ 1.15 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 165.76, 164.95, 160.18, 155.03, 150.98, 135.13, 134.41, 133.77, 132.67, 130.99, 128.64, 127.56, 122.79, 121.61, 114.81, 67.74, 21.64, 12.57, 11.96; IR Analysis: 3094, 3072, 2965, 1739, 1689, 1667, 1613, 1596, 1517, 1418, 1345, 1294, 943 cm^{-1}; Elemental analysis: Calculated: C=65.23, H=5.00,

N=3.31, O=18.89, S=7.57; Found: C=64.96, H=4.92, N=3.29, O=18.78, S=7.47; Mass Spectra: Actual Mass=423.11, Found=424.78 [M+1]; Melting Point=162-164°C (Scheme 8).

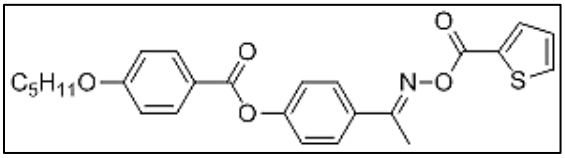
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-butoxybenzoate (7d):



Scheme 9: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-butoxybenzoate (7d)

Obtained from 6d (1.504 g, 4.59 mmol), 7 (0.588 g, 4.59 mmol) and $Hg(OAc)_2$ (1.465 g, 4.59 mmol) as a pale brown solid (1.219 g, 60.65%); Molecular formula: $C_{24}H_{23}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.11-8.09 (m, 2H, ArH), δ7.96 (dd, 1H, J=4.6 Hz, J=10.4Hz), δ7.84 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.55-7.52 (m, 2H, ArH), δ 7.23-7.19 (m, 3H, ArH), δ7.04-7.01 (m, 2H, ArH), δ4.07 (t, 2H, -OCH_2), δ2.72 (s, 3H, -CH_3), δ 1.77-1.74 (m, 2H, -CH_2), δ 1.48-1.43 (m, 2H, -CH_2),δ 0.97 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 166.89, 165.14, 159.91, 155.01, 151.89, 136.21, 135.16, 133.79, 132.58, 131.53, 129.42, 128.13, 122.82, 121.59, 114.67, 67.33, 32.18, 21.05, 14.96, 12.39; IR Analysis: 3091, 3074, 2969, 1741, 1684, 1671, 1619, 1599, 1513, 1415, 1347, 1297, 947 cm^{-1}; Elemental analysis: Calculated: C=65.89, H=5.30, N=3.20, O=18.28, S=7.33; Found: C=64.99, H=5.19, N=3.18, O=18.13, S=6.99; Mass Spectra: Actual Mass=437.13, Found=438.19 [M+1]; Melting Point=161-163°C (Scheme 9).

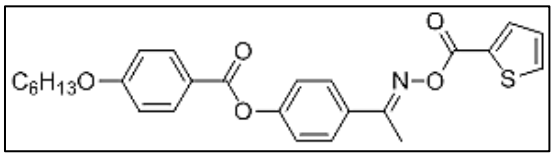
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-pentyloxybenzoate (7e):



Scheme 10: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-pentyloxybenzoate (7e)

Obtained from 5e (1.099 g, 3.22 mmol), 6 (0.412 g, 3.22 mmol) and $Hg(OAc)_2$ (1.027 g, 3.22 mmol) as a pale brown solid (0.873 g, 60.08%); Molecular formula: $C_{25}H_{25}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.11-8.07 (m, 2H, ArH), δ7.99 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.85 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.54-7.50 (m, 2H, ArH), δ 7.21-7.17 (m, 3H, ArH), δ7.04-6.99 (m, 2H, ArH), δ4.11 (t, 2H, -OCH_2), δ2.71 (s, 3H, -CH_3), δ 1.77-1.73 (m, 2H, -CH_2), δ 1.46-1.42 (m, 4H, -CH_2),δ0.98 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 165.99, 164.60, 160.83, 155.09, 151.16, 136.19, 135.72, 133.75, 132.49, 131.83, 129.10, 128.65, 122.73, 121.29, 115.29, 67.88, 29.56, 27.89, 22.66, 14.49, 12.86; IR Analysis: 3094, 3068, 2968, 1748, 1686, 1667, 1614, 1595, 1513, 1415, 1345, 1296, 950 cm^{-1}; Elemental analysis: Calculated: C=66.50, H=5.58, N=3.10, O=17.72, S=7.10; Found: C=65.88, H=5.49, N=3.08, O=17.63, S=6.99; Mass Spectra: Actual Mass=451.15, Found=451.77 [M^{+1}]; Melting Point=163-165°C (Scheme 10).

4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(hexyloxy)benzoate (7f):

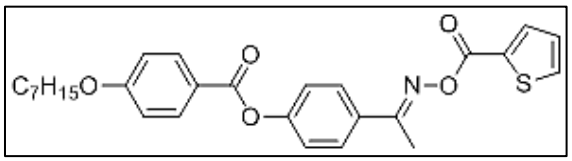


Scheme 11: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(hexyloxy)benzoate (7f)

Obtained from 5f (1.844 g, 5.19 mmol), 6 (0.655 g, 5.19 mmol) and $Hg(OAc)_2$ (1.655 g, 5.19 mmol) as a pale brown solid (1.224 g, 50.68%); Molecular formula: $C_{26}H_{27}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.12-8.09 (m, 2H, ArH), δ7.97 (dd, 1H, J=4.8 Hz, 10.2Hz), δ7.87 (dd, 1H, J=4.6 Hz, 10.4 Hz), δ 7.52-7.49 (m, 2H, ArH), δ 7.20-7.17 (m, 3H, ArH), δ7.05-7.02 (m, 2H, ArH), δ4.08 (t, 2H, -OCH_2), δ2.76 (s, 3H, -CH_3), δ 1.77-1.73 (m, 2H, -CH_2), δ 1.46-1.43 (m, 2H, -CH_2), δ 1.31-1.28 (m, 4H, -CH_2), δ 0.98(t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 165.83, 165.41, 160.84, 154.99, 152.03, 135.01, 134.45, 133.80, 132.39, 131.41 , 128.37, 127.71, 122.79, 121.48, 115.31, 69.21 ,

31.33, 29.85, 25.71, 22.65, 14.29, 13.45; IR Analysis: 3096, 3078, 2972, 1739 ,1689, 1667, 1614, 1601, 1518, 1415, 1346, 1296, 945 cm^{-1}; Elemental analysis: Calculated: C=67.08, H=5.85, N=3.01, O=17.18, S=6.89; Found: C=66.99, H=5.62, N=2.98, O=17.10, S=6.33; Mass Spectra: Actual Mass=465.16, Found=466.79 [M+1]; Melting Point=164-166°C (Scheme 11).

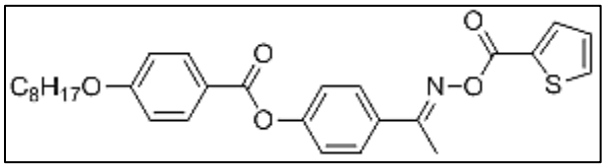
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(heptyloxy)benzoate (7g):



Scheme 12: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(heptyloxy)benzoate (7g)

Obtained from 5g (0.998 g, 2.70 mmol), 6 (0.346 g, 2.70 mmol) and $Hg(OAc)_2$ (0.862 g, 2.70 mmol) as a pale brown solid (0.594 g, 45.87%); Molecular formula: $C_{27}H_{29}NO_5S$; ^1H NMR (400 MHz, $CDCl_3$): δ8.13-8.10 (m, 2H, ArH), δ7.96 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.85 (dd, 1H, J=4.4 Hz, J=10.2 Hz), δ 7.55-7.52 (m, 2H, ArH), δ 7.25-7.23 (m, 3H, ArH), δ7.06-7.02 (m, 2H, ArH), δ4.08 (t, 2H, $-OCH_2$), δ2.76 (s, 3H, $-CH_3$), δ 1.78-1.74 (m, 2H, $-CH_2$), δ 1.32-1.27 (brm, 8H, $-CH_2$), δ0.95 (t, 3H, $-CH_3$); ^{13}C NMR (100 MHz, $CDCl_3$):166.01, 164.46, 160.34, 154.93, 152.47, 135.11, 134.41, 133.69, 132.34, 131.48, 129.31, 127.55, 122.74, 121.60, 114.91, 68.34 , 31.21, 29.95, 29.44, 25.94, 22.85, 14.82, 13.29; IR Analysis: 3093, 3068, 2966, 1735, 1682, 1663, 1621, 1594, 1518, 1420, 1345, 1299, 941 cm^{-1}; Elemental analysis: Calculated: C=67.62, H=6.09, N=2.92, O=16.68, S=6.69; Found: C=67.39, H=5.78, N=2.81, O=16.53, S=6.53; Mass Spectra: Actual Mass=479.18, Found=479.69 [M^{+1}]; Melting Point=167-169°C (Scheme 12).

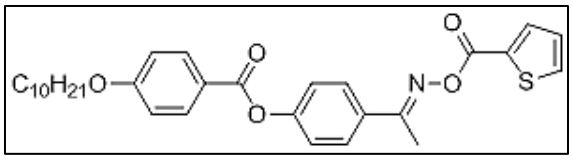
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(octyloxy)benzoate (7h):



Scheme 13: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(octyloxy)benzoate (7h)

Obtained from 5h (1.566 g, 4.09 mmol), 6 (0.523 g, 4.09 mmol) and $Hg(OAc)_2$ (1.302 g, 4.09 mmol) as a pale brown solid (1.003 g, 49.77%); Molecular formula: $C_{28}H_{31}NO_5S$; ^1H NMR (400 MHz, $CDCl_3$): δ8.10-8.07 (m, 2H, ArH), δ7.98 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.87 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.54-7.50 (m, 2H, ArH), δ 7.25-7.22 (m, 3H, ArH), δ7.03-6.99 (m, 2H, ArH), δ4.12 (t, 2H, $-OCH_2$), δ2.72 (s, 3H, $-CH_3$), δ 1.83-1.79 (m, 2H, $-CH_2$), δ 1.35-1.33 (m, 2H, $-CH_2$), δ 1.32-1.29 (brm, 8H, $-CH_2$), δ0.95 (t, 3H, $-CH_3$); ^{13}C NMR (100 MHz, $CDCl_3$): 165.71, 164.91, 160.39, 155.17, 152.55, 135.18, 134.49, 133.61, 132.46, 131.58, 129.05, 128.11, 122.78, 121.69, 114.77, 67.77, 32.09, 29.73, 29.34, 25.99, 25.66, 22.62, 14.18, 12.53; IR Analysis: 3096, 3065, 2972, 1739, 1691, 1667, 1619, 1597, 1517, 1422, 1351, 1298, 942 cm^{-1}; Elemental analysis: Calculated: C=68.12, H=6.33, N=2.84, O=16.21, S=6.50; Found: C=68.09, H=6.17, N=2.70, O=16.19, S=6.45; Mass Spectra: Actual Mass=493.19, Found=495.69 [M+2]; Melting Point=168-170°C (Scheme 13).

4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(decyloxy)benzoate (7i):

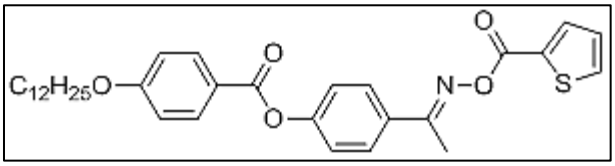


Scheme 14: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(decyloxy)benzoate (7i)

Obtained from 5i (1.119 g, 2.72 mmol), 6 (0.348 g, 2.72 mmol) and $Hg(OAc)_2$ (0.867 g, 2.72 mmol) as a pale brown solid (0.794 g, 55.99%); Molecular formula: $C_{30}H_{35}NO_5S$; ^1H NMR (400MHz, $CDCl_3$): δ8.13-8.11 (m, 2H, ArH),

δ7.99 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.84 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.53-7.49 (m, 2H, ArH), δ 7.24-7.22 (m, 3H, ArH), δ7.04-7.01 (m, 2H, ArH), δ4.08 (t, 2H, -OCH_2), δ2.69 (s, 3H, -CH_3), δ 1.79-1.75 (m, 2H, -CH_2), δ 1.39-1.36 (m, 2H, -CH_2), δ 1.28 (brm, 12H, -CH_2), δ0.97 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 167.07, 165.91, 160.34, 154.77, 151.92, 135.22, 134.25, 133.30, 132.34, 131.46, 129.15, 126.42, 122.72, 121.61, 115.17, 68.23, 31.83, 29.99, 29.64, 29.42, 29.21, 26.05, 24.17, 22.72, 14.24, 12.86; IR Analysis: 3097, 3075, 2965, 1740, 1681, 1669, 1609, 1589, 1513, 1414, 1345, 1298, 948 cm^{-1}; Elemental analysis: Calculated: C=69.07, H=6.76, N=2.68, O=15.33, S=6.15; Found: C=68.89, H=6.58, N=2.63, O=15.26, S=6.09; Mass Spectra: Actual Mass=521.22, Found=522.55 [M^{+1}]; Melting Point=167-169°C (Scheme 14).

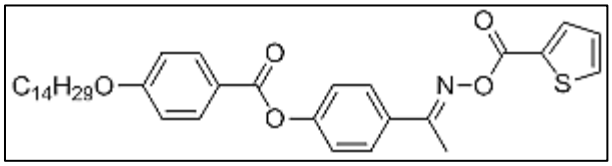
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(dodecyloxy)benzoate (7j):



Scheme 15: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(dodecyloxy)benzoate (7j)

Obtained from 5j (1.339 g, 3.05 mmol), 6 (0.390 g, 3.05 mmol) and $Hg(OAc)_2$ (0.971 g, 3.05 mmol) as a pale brown solid (0.755 g, 45.10%); Molecular formula: $C_{32}H_{39}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.09-8.07 (m, 2H, ArH), δ7.95 (dd, 1H, J=4.4 Hz, J=10.2 Hz), δ7.84 (dd, 1H, J=4.4 Hz, J=10.2 Hz), δ 7.56-7.53 (m, 2H, ArH), δ 7.24-7.21 (m, 3H, ArH), δ7.05-7.03 (m, 2H, ArH), δ4.13 (t, 2H, -OCH_2), δ2.72 (s, 3H, -CH_3), δ 1.75-1.72 (m, 2H, -CH_2), δ 1.34-1.29 (m, 2H, -CH_2), δ 1.26-1.19 (brm, 16H, -CH_2), δ0.87 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 165.87, 163.77, 159.84, 154.77, 152.35, 135.72, 134.45, 133.89, 132.46, 131.45, 128.55, 126.88, 122.78, 121.63, 114.39, 68.71, 31.13, 29.74, 29.62, 29.47, 29.28, 29.01, 28.82, 26.75, 24.51, 22.32, 14.42, 12.73; IR Analysis: 3090, 3075, 2969, 1741, 1688, 1672, 1611, 1603, 1521, 1419, 1350, 1291, 939 cm^{-1}; Elemental analysis: Calculated: C=69.92, H=7.15, N=2.55, O=14.55, S=5.83; Found: C=69.89, H=6.99, N=2.39, O=14.51, S=5.22; Mass Spectra: Actual Mass=549.25, Found=551.15 [M+2]; Melting Point=170-172°C (Scheme 15).

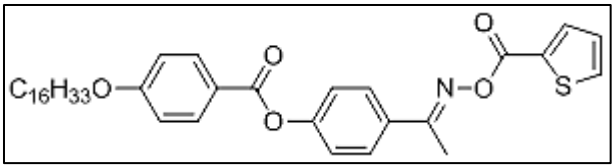
4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(tetradecyloxy)benzoate (7k):



Scheme 16: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(tetradecyloxy)benzoate (7k)

Obtained from 5k (1.383 g, 2.96 mmol), 6 (0.379 g, 2.96 mmol) and $Hg(OAc)_2$ (0.943 g, 2.96 mmol) as a pale brown solid (0.887 g, 51.92%); Molecular formula: $C_{34}H_{43}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.12-8.09 (m, 2H, ArH), δ7.99 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.84 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.54-7.51 (m, 2H, ArH), δ 7.23-7.19 (m, 3H, ArH), δ7.21-7.18 (m, 2H, ArH), δ4.11(t, 2H, -OCH_2), δ2.75(s, 3H, -CH_3), δ 1.72-1.68 (m, 2H, -CH_2), δ 1.48-1.45 (m, 2H, -CH_2), δ 1.33-1.29 (brm, 20H, -CH_2), δ1.03 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$):165.80, 164.69, 160.34, 154.93, 152.46,135.99, 134.41, 133.34, 132.36, 131.61, 128.55, 127.86, 122.87, 121.91, 114.89, 68.71, 32.34, 30.13, 29.86, 29.61, 29.45, 29.30, 28.87, 28.69, 28.55, 26.77, 25.99, 22.61, 14.21, 12.75; IR Analysis: 3093, 3078, 2965, 1736 ,1685, 1672, 1625, 1603, 1518, 1417, 1345, 1296, 947 cm^{-1}; Elemental analysis: Calculated: C=70.68, H=7.50, N=2.42, O=13.85, S=5.55; Found: C=69.88, H=7.47, N=2.33, O=13.81, S=5.11; Mass Spectra: Actual Mass=577.29, Found=579.95 [M+2]; Melting Point=172-174°C (Scheme 16).

4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(hexadecyloxy)benzoate(7l):



Scheme 17: 4-(1-(((Thiophene-2-carbonyl)oxy)imino)ethyl)phenyl 4-(hexadecyloxy)benzoate(7l)

Obtained from 5l (0.949 g, 1.92 mmol), 6 (0.245 g, 1.92 mmol) and $Hg(OAc)_2$ (0.611 g, 1.92 mmol) as pale brown solid (0.598 g, 51.59%); Molecular formula: $C_{36}H_{47}NO_5S$; ^{1}H NMR (400 MHz, $CDCl_3$): δ8.13-8.11 (m, 2H, ArH), δ7.99 (dd, 1H, J=4.8 Hz, J=10.4 Hz), δ7.84 (dd, 1H, J=4.4 Hz, J=10 Hz), δ 7.53-7.48 (m, 2H, ArH), δ 7.25-7.22 (m, 3H, ArH), δ7.05-7.02 (m, 2H, ArH), δ4.08 (t, 2H, -OCH_2), δ2.76 (s, 3H, -CH_3), δ 1.69-1.65 (m, 2H, -CH_2), δ 1.59-1.47 (brm, 26H, -CH_2), δ1.09 (t, 3H, -CH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 166.21, 165.34,160.64, 154.93, 152.39, 134.99, 134.25, 133.72, 132.74, 131.39, 128.55, 127.81, 122.88, 121.69, 115.13, 67.91, 31.04, 29.95, 29.71, 29.65, 29.58, 29.43, 29.31, 29.23, 29.11, 26.89, 26.43, 25.96, 25.71, 22.57, 13.77 , 13.29; IR Analysis: 3091, 3067, 2966, 1743, 1689, 1669, 1619, 1591, 1521, 1420, 1350, 1301, 945 cm^{-1}; Elemental analysis: Calculated: C=71.37, H=7.82, N=2.31, O=13.20, S=5.29; Found: C=71.17, H=6.99, N=2.19, O=13.01, S=4.96; Mass Spectra: Actual Mass=605.31, Found=605.56 [M^{+1}]; Melting Point=174-176°C (Scheme 17).

RESULTS AND DISCUSSION

Differential scanning calorimetry and polarising optical microscope fitted with a hot stage were used to investigate the liquid crystalline properties of the synthesized thiophene compounds. The molecular constitution of organic compounds effects the mesogenic properties. Hence, the transition temperatures and mesophase range as measures of mesomorphism can be correlated with the molecular constitution of the compounds. All the twelve members of the thiophene derivatives (7a-l) exhibit an enantiotropic nematic phase. The smectic C or smectic A phases are not observed along with the nematic phase. The phase transition temperatures and the corresponding enthalpy changes of the synthesized compounds; and a plot of transition temperatures against the number of carbon atoms in the alkoxy chains are given in Table 1 and in Figure 1 respectively. From the Figure 2, it is observed that the nematic to isotropic phase transitions show a smooth rising tendency and does not exhibit an odd-even effect. On cooling the isotropic liquid of the thiophene esters, the compounds form small droplets that coalesce to classical Schlieren textures characteristic of the nematic phase and no smectic phase is observed even in higher homologues.

Table 1: Phase transition temperature (0°C) and associated enthalpy changes

Compound No	Phase transition temperature (0°C) and associated enthalpy changes (J/g) Cr=Crystalline, N=Nematic, I=Isotropic	
	Heating	Cooling
7a	Cr107.78(35.88)N152.18(13.63)I	I154.99(-12.16)N103(-34.29)Cr
7b	Cr109.21(36.55)N153.29 (14.56)I	I156.78(-13.36)N99.32(-33.17)Cr
7c	Cr 110.45(37.44)N154.77(15.36)I	I157.94(-12.99)N97.45(-32.29)Cr
7d	Cr 111.89(38.22)N156.89(16.41)I	I159.24(-14.87)N96.55(-35.61)Cr
7e	Cr112.45(40.01)N158.99(17.34)I	I160.78(-16.88)N94.67(-38.76)Cr
7f	Cr 114.74(41.21)N159.32 (18.31)I	I162.07(-17.19)N92.66(-39.45)Cr
7g	Cr 116.01(43.21)N160.33(19.22)I	I164.45(-18.21)N90.34(41.56)Cr
7h	Cr117.89(45.77)N161.45(21.25)I	I165.37(-20.19)N87.88(-42.66)Cr
7i	Cr119.30(46.99)N163.11(22.88)I	I167.38(-21.47)N85.66(-45.19)Cr
7j	Cr120.45(47.34)N165.91(23.19)I	I168.44(-22.55)N84.09(-43.39)Cr
7k	Cr121.66(49.76)N167.88(25.41)I	I170.67(-24.66)N82.02(-46.78)Cr
7l	Cr123.44(51.23)N169.29(27.12)I	I171.38(-26.32)N79.99(-48.97)Cr

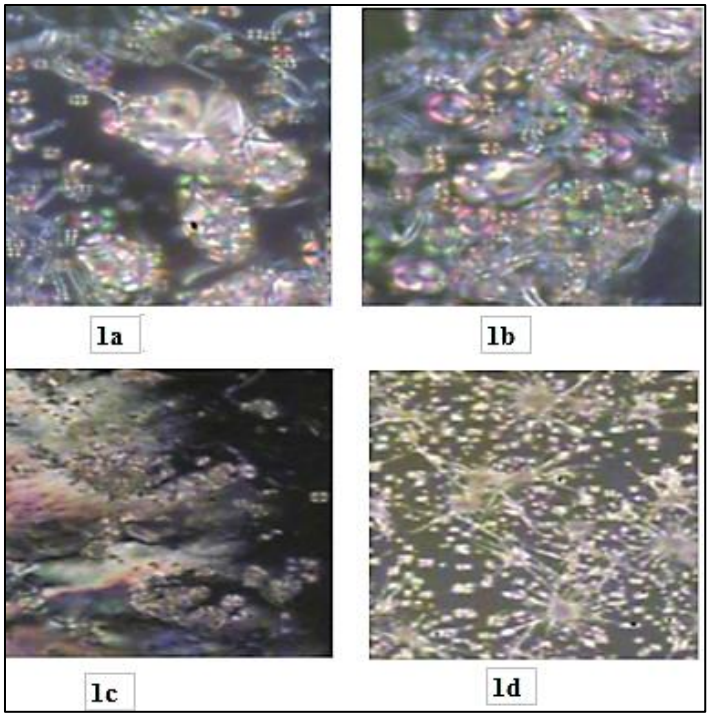


Figure 1: Liquid crystalline properties of thiophenes

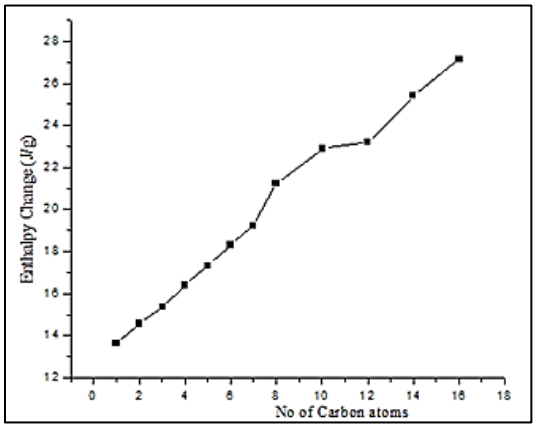


Figure 2: Nematic to isotropic phase transitions

CONCLUSION

O-Arylation, O-alkenylation and O-esterification products are very important intermediates in organic synthesis, and are definitely attractive targets in the synthesis and construction of carbon-heteroatom bonds and heterocycles. Thus, the O- esterification of oximes was achieved by the mercuric acetate- mediated hydrothermal synthesis. The hydrothermal reactions offered better selectivity, higher product yields, enhancement of reaction rates when compared to conventional heating, achieve higher reaction temperatures, handling convenience, improved efficiency, improves temperature homogeneity, improved reproducibility, and so on. Thus the hydrothermal method offered an efficient, clean and economic solvent-free technique for the O-esterification of oximes with better yield and higher purity of prodcuts and avoided the hazards of solution phase reactions and provided an environmentally benign reaction conditions by preventing the release of reaction by-products and solvents into the environment.

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REFERENCES

[1] S Nomura; S Sakamaki; M Hongu; E Kawanishi; Y Koga; T Sakamoto; Y Yamamoto; K Ueta; H Kimata; K Nakayama; MT Tsukimoto. *J Med Chem*. **2010**, 53(17), 6355-6360.
[2] R Kulandasamy; AV Adhikari; JP Stables. *Eur J Med Chem.* **2009**, 44(11), 4376-4384.
[3] CE Stephens; TM Felder; JW Sowell; G Andrei; J Balzarini; R Snoeck; E De Clercq. *Bioorg Med Chem.* **2001**, 9(5), 1123-1132.
[4] YN Mabkhot; NA Kheder; AM Farag. *Molecule.* **2013**, 18, 4669-4678.
[5] K Molvi; M Mansuri; V Sudarsanam; MM Patel; SM Andrabi; N Haque. *J Enzyme Inhib Med Chem.* **2008**, 23(6), 829-838.
[6] E Menteşe; F Yilmaz; N Baltaş; O Bekircan; B Kahveci. *J Enzyme Inhib Med Chem.* **2015**, 30(3), 435-441.
[7] S Yasmeen; SH Sumrra; MS Akram; ZH Chohan. *J Enzyme Inhib Med Chem.* **2017**, 32(1), 106-112.
[8] N Fokialakis; CL Cantrell; SO Duke; AL Skaltsounis; DE Wedge. *J Agric Food Chem.* **2006**, 54(5), 1651-1655.
[9] DE Becker; KL Reed. *Anesth Prog*. **2006**, 53(3), 98-109.
[10] MD Mullican; RJ Sorenson; DT Connor; DO Thueson; JA Kennedy; MC Conroy. *J Med Chem.* **1991**, 34(7), 2186-2194.
[11] MK Parai; G Panda; V Chaturvedi; YK Manju; S Sinha. *Bioorg Med Chem Lett*. **2008**, 18(1), 289-292.
[12] AB Shajan; PA Anooja; VM Mitha; N Paulson; K Sanooja; ST Nair; P Praveena. *J Plant Path Microbiol*. **2013**, 4(1), 1-4.
[13] H Thakellapalli; B Farajidizaji; TW Butcher; NG Akhmedov; BV Popp; JL Petersen; KK Wang. *Org Lett.* **2015**, 17(14), 3470-3473.
[14] D Belo; M Almeida. *Coordination Chem Rev.* **2010**, 254(13-14), 1479-1492.
[15] LA Baldwin; JW Crowe; MD Shannon; CP Jaroniec; PL McGrie. *Chem Mater.* **2015**, 27(18), 6169-6172.
[16] F Zhang; D Wu; Y Xu; X Feng. *J Mater Chem.* **2011**, 21, 17590-17600.
[17] B Pal; WC Yen; JS Yang; WF Su. *Macromolecules.* **2007**, 40(23), 8189-8194.
[18] W Zhang; Y Han; X Zhu; Z Fei; Y Feng; ND Treat; H Faber; N Stingelin; I McCulloch; TD Anthopoulos; M Heeney. *Adv Mater.* **2016**, 28, 3922-3927.
[19] IL Duarte; P Chairatana; Y Wu; JP Moreno; PM Bennett; JE Reeve; I Boczarow; W Kaluza; NA Hosny; SD Stranks; RJ Nicholas; K Clays; MK Kuimova; H Anderson. *Org Biomol Chem.* **2015**, 13(12), 3792-3802.
[20] MM Kochhar; BB Williams. *J Pharm Sci.* **1965**, 54, 1149-1152.
[21] AD Pillai; PD Rathod; PX Franklin; H Padh; KK Vasu; V Sudarsanam. *Biochem Biophys Res Commun.* **2004**, 317, 1067-1074.
[22] A Palani; S Shapiro; H Josien; T Bara; JW Clader; WJ Greenlee; K Cox; JM Strizki; BM Baroudy. *J Med Chem.* **2002**, 45, 3143-3160.
[23] P Poornesh; PK Hegde; G Umesh; MG Manjunatha; KB Manjunatha; AV Adhikari; *Optic Laser Tech.* **2010**, 42(1), 230-236.
[24] X Wang; Y Yan; T Liu; X Su; L Qian; Y Song; H Xu. *J Polymer Sci*. **2010**, 48(23), 5498-5504.
[25] AJ Seed; GJ Cross; KJ Toyne; JW Goodby. *Liq Cryst.* **2003**, 30(9), 1089-1107.
[26] MC Davis; RA Hollins; B Douglas. *Synth Comm.* **2006**, 36(23), 3515-3523.
[27] JM Raimundo; P Blanchard; N Gallego-Planas; N Mercier; I Ledoux-Rak; R Hierle; J Roncali. *J Org Chem.* **2001**, 67(1), 205-218.
[28] PJ Mendes; TJL Silva; AJP Carvalho; JPP Ramalho. *J Mol Structure.* **2010**, 946(1-3), 33-42.
[29] AA Kiryanov; P Sampson; AJ Seed. *J Org Chem.* **2001**, 66, 7925-7929.
[30] LH Wu; YC Wang; CS Hsu. *Liq Cryst.* **2000**, 27, 1503-1513.
[31] J Han; FY Zhang; JY Wang; YM Wang; ML Pang; JB Meng. *Liq Cryst.* **2009**, 36, 825-833.
[32] NL Campbell; WL Duffy; GI Thomas; JH Wild; SM Kelly; K Bartle; MO Neill; V Minter; RP Tuffin. *J Mater Chem.* **2002,** 12, 2706-2721.
[33] K Kishikawa; MC Harris; TM Swager. *Chem Mater*. **1999**, 11, 867-871.

[34] J Han; Q Wang; XY Chang; LR Zhu. *Liq Cryst*. **2012**, 39, 669-674.
[35] T Kitamura; CH Lee; Y Taniguchi; Y Fujiwara; Y Sano; M Matsumoto. *Mol Cryst Liq Cryst.* **1997**, 293, 239-245.
[36] K Cernovska; B Košata; J Svoboda; V Novotnà; M Glogarovà. *Liq Cryst*. **2006**, 33, 987- 996.
[37] KR Mahendra; KM Lokanatha Rai. *Inter J Chem Pharm Sci.* **2016**, 7, 76-83.
[38] YZ Tang; GX Wang; Q Ye; RG Xiong; RX Yuan. *Cryst Growth Des.* **2007**, 7, 2382.
[39] EA Popova; RE Trifonov; VA Ostrovskii. *ARKIVOC*, **2012**, 45-65.
[40] EA Musad; KM Lokanatha Rai; K Byrappa. *Int J Biomedical Sci*. **2010,** 6, 45-48.
[41] TJ Maimone; SL Buchwald. *J Am Chem Soc*. **2010**, 132, 9990-9991.
[42] A Hall; KL Jones; TC Jones; NM Killeen; R Pörzig; PH Taylor; SC Yau; NCO Tomkinson. *Synlett.* **2006**, 3435-3438.
[43] S Bertelsen; P Dinèr; RL Johansen; KA Jorgensen. *J Am Chem Soc*. **2007**, 129, 1536-1537.
[44] H Miyabe; K Yoshida; M Yamauchi; Y Takemoto. *J Org Chem.* **2005**, 70, 2148-2153.
[45] SCS Kumar; NV Kumar; P Srinivas; MK Bettadaiah. *Synthesis*, **2014**, 46, 1847-1852.
[46] C Segura; M Ventura; J Marti; M Duran. *SCIENTIA Gerundensis*, **1996**, 22, 73-77.