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# Synthesis of new liquid crystalline isoxazole-, pyrazole- and 2-isoxazoline-containing compounds

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The syntheses of new liquid crystalline 3-aryl-5-alkylisoxazoles, 3-aryl-5-alkyl-1H-pyrazoles and 3-aryl-5-alkyl-2-isoxazolines with ether or ester bridges are reported. The key stage in the synthesis is the oxidation of the 2-isoxazoline ring to isoxazole. The influences of core-heterocycle type and bridging group on the mesomorphic properties for the prepared compounds are discussed.



## 1. Introduction

A wide varity of liquid crystalline compounds containing five-member heterocycles have been synthesized to date [1–5]. Isoxazole- and pyrazole-containing liquid crystals have been also described [6–19]. The majority of these compounds are 3,5-diarylisoxazoles and 3,5-diarylpyrazoles [6–17]. By comparison, liquid crystalline 3-aryl-5-alkylisoxazoles and 3-aryl-5-alkyl-1H-pyrazoles are unknown, and the aim of our present work is the preparation of such compounds.

Normally the key stage in the synthesis of liquid crystalline isoxazoles and pyrazoles is the reaction of the corresponding β-diketones with hydroxylamine hydrochloride or hydrazine hydrate, respectively [7–15]. In the case of isoxazoles, however, such methodology is limited to the synthesis of symmetrical 3,5-disubstituted isoxazoles. A mixture of two regiomers is obtained when unsymmetrical β-diketones are reacted with hydroxylamine hydrochloride. Better results were obtained when 1,3-dipolar cycloaddition [13, 16] and oxidation of α,β-unsaturated ketone oximes [17] or 2-isoxazolines [6] were employed.

Recently the synthesis and properties of 2-isoxazoline-containing liquid crystals were reported [20–22]. Several of these compounds are 2-isoxazolines with 3-aryl and 5-alkyl substitutients [20]. It is well known that 2-isoxazolines have a versatile synthetic application [23]. Reductive cleavage of the 2-isoxazoline heterocycle could lead to different 1,3-difunctional compounds. Recently we used this transformation for the synthesis of liquid crystals with a modified terminal chain [24]. In the present work we have used the oxidation of the 3-aryl-5-alkyl-2-isoxazoline ring as the key stage for the preparation of the desired mesomorphic 3-aryl-5-alkylisoxazoles. It is also well known that the cleavage of the isoxazole ring leads to the corresponding β-diketones [25]. We planned to use this transformation of 3-aryl-5-alkylisoxazoles for the preparation of liquid crystalline 3-aryl-5-alkyl-1H-pyrazoles.

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## 2. Results and discussion

### 2.1. *Synthesis*

The synthetic route to the new liquid crystalline compounds **7**–**10** is shown in scheme 1. The 2-isoxazoline **2** was chosen as the key intermediate. The preparation of this compound from 4-hydroxybenzaldehyde **1** was reported previously [24]. The corresponding oxime was synthesized from compound **1**. Following nitrile oxide generation from the oxime, the subsequent 1,3-dipolar cycloaddition to heptene-1 led to the 2-isoxazoline **2**. The phenolic hydroxy group in this compound provides the possibility for designing liquid crystalline molecules with ether or ester bridges.

There are several preparative methods for the conversion of 2-isoxazolines into isoxazoles [25–27]. One of these includes the reaction of 2-isoxazolines with *N*-bromosuccinimide (NBS) and subsequent dehydrobromination of the 4- and 5-bromo derivatives by the action of basic reagents [26]. We used this method for preparation of isoxazole **4** from 2-isoxazoline **2**. It is well known that phenols are very sensitive to the action of oxidizing reagents. Thus we started the synthesis with the protection of the OH group in compound **2**. Acetate **3** was obtained by reaction of this phenol with

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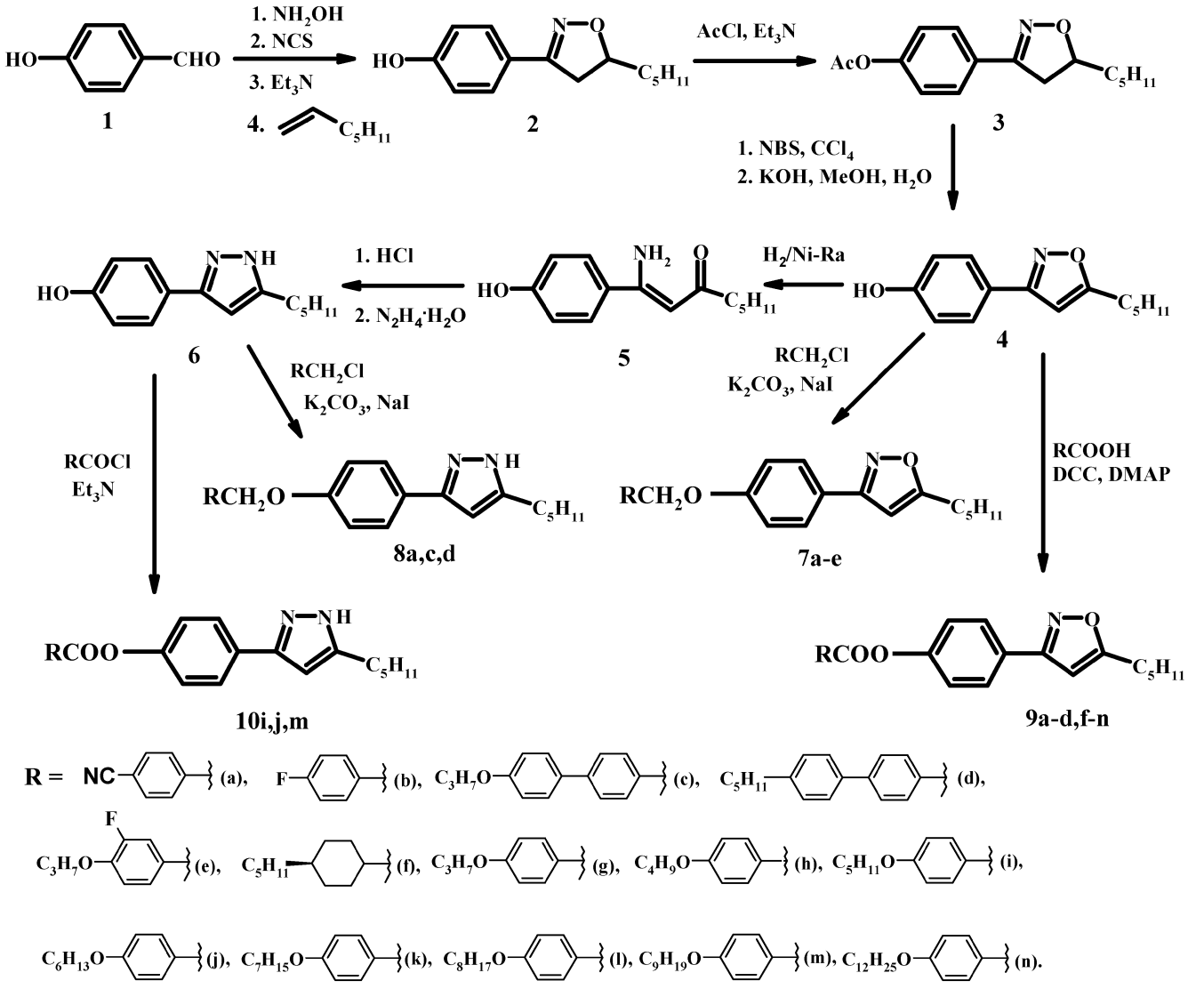
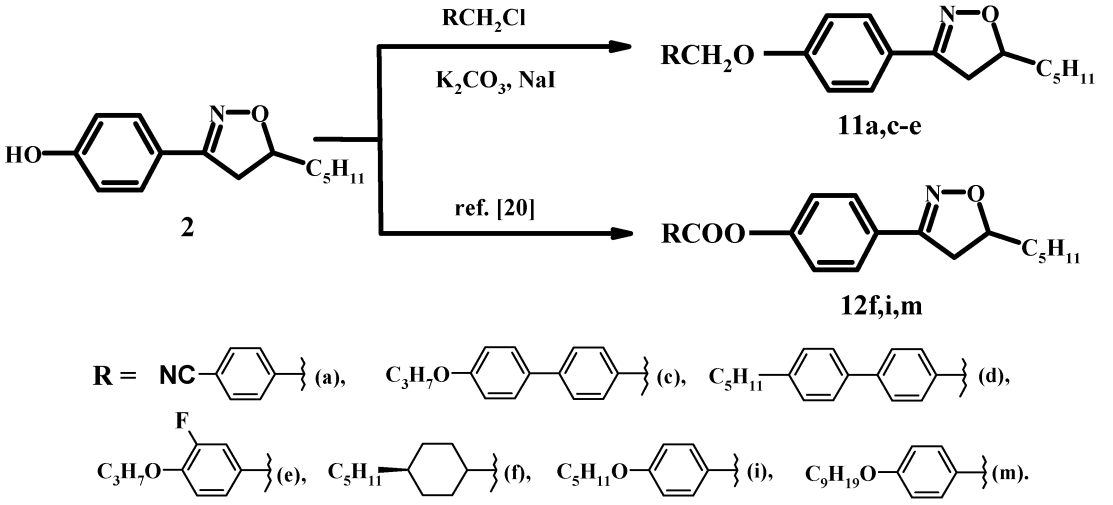



Scheme 1.

acetyl chloride. Reaction of acetate **3** with NBS under UV-irradiation and subsequent dehydrobromination of intermediate 4- and 5-bromo-2-isoxazolines with potassium hydroxide in aqueous methanol furnished the target isoxazole **4** in 50% yield. Deprotection of the phenol group also took place at this stage. Enaminoketone **5** was obtained from isoxazole **4** by hydrogenolysis over Raney nickel catalyst with 92% yield. Hydrolysis of the enamino function in compound **5** to the corresponding β-diketone was carried out by the action of dilute hydrochloric acid. Cyclization of this β-diketone with hydrazine hydrate led to pyrazole **6** in 96% overall yield.

The liquid crystalline 3-aryl-5-alkylisoxazoles **7a**–**e** and 3-aryl-5-alkylpyrazoles **8a**,**c**,**d** with an ether group, were synthesized by the reaction of phenols **4** and **6** with the corresponding benzyl chlorides. The target compounds were obtained in 76–98% yields. Esterification of phenol **4** by the corresponding carboxylic acids in the presence of *N*,*N*′-dicyclohexylcarbodiimide (DCC) and 4-*N*,*N*-dimethylaminopyridine (DMAP) gave the liquid crystalline 3-aryl-5-alkylisoxazoles **9a**–**d**,**f**–**n** in 63–86% yields. These reaction conditions for the esterification of compound **6** were unsuccessful. The liquid crystalline 3-aryl-5-alkylpyrazoles **10i**,**j**,**m** were prepared in 39–52% yields by benzoylation of phenol **6** with the corresponding acyl chlorides.

Liquid crystalline 3-aryl-5-alkyl-2-isoxazolines **11** and **12**, with the ether and ester linkages required to compare the heterocycle type influence on mesomorphic properties in these series, were synthesized from the phenol **2** (scheme 2). Benzylic ethers **11a**,**c**–**e**




Scheme 2.

were obtained by reaction with the corresponding benzyl chlorides. The synthesis and properties of esters **12f**,**i**,**m** were described previously [20].

The structures of all intermediates and final products were confirmed by IR, UV and $^1$H NMR spectra (see § 3).

### 2.2. *Mesomorphic properties*

The phase transition temperatures of the novel synthesized compounds **7**–**11** and previously described esters **12** [20] are summarized in table 1. Almost all of the synthesized isoxazoles, pyrazoles and 2-isoxazolines with 3-aryl and 5-alkyl substitutes are mesomorphic. Of the ethers **7**,**8**,**11**, differing in heterocycle type, compounds **7a** and **11a** with a terminal cyano group form an enantiotropic nematic phase, and **7a,** a monotropic smectic phase. Smectic behaviour is typical for all other ethers with isoxazole, pyrazole and 2-isoxazole rings.

Isoxazole- and pyrazole-containing esters **9** and **10** form nematic phases only, or smectic and nematic phases for long chain homologues **9k**–**n**. The smectic C phase temperature range in the 4-alkoxybenzoates **9k**–**n** increases with increasing alkoxy chain length, and SmC is the dominant phase for the dodecyloxybenzoate **9n**. Replacement of the ether linkage by the more rigid ester group for isoxazoles and pyrazoles leads to nematic mesomorphism. The nematic phase is more stable in isoxazoles **9** than in pyrazoles **10**.

In general, the benzylic ethers **7**,**8** form smectic phases while compounds **9**,**10** with an ester linkage exhibit the nematic phase. The same bridging group influence was found for liquid crystalline 2-aryl-5-alkylthiadiazoles and 2-aryl-5-alkyloxadiazoles with ether and ester linkages [3]. Smectic phases are more typical for 2-isoxazoline-containing esters **12** [20] in contrast to the corresponding isoxazoles **9**. Probably this difference in mesomorphic behaviour is caused by the non-planarity of the 2-isoxazoline ring.

It should be noted that the nematic phase, or a nematic phase in addition to a smectic phase, were found for liquid crystalline 3,5-diarylisoxazoles [7–12]. The liquid crystalline 3,5-diarylpyrazoles described previously in the literature exhibit smectic phases only [7, 8, 14]. These 3,5-diaryl-substituted isoxazoles and pyrazoles have bent-core structures. The 3-aryl-5-alkyl-substituted isoxazoles and pyrazoles described here have a sufficiently flexible 5-alkyl chain to give a more rod-like shape rather than a bent-core structure.

## 3. Experimental

UV spectra were recorded with a Specord M40 spectrometer. IR spectra were obtained using a Specord 75IR instrument. $^1$H NMR spectra were recodered on a Bruker Avance 400 (400 MHz) spectrometer with hexamethyldisiloxane ($\delta$ 0.055 ppm) as internal standard. The spectra were recorded using ethanol (UV) and chloroform (IR) solvents unless otherwise indicated. Reaction progress and product purity were checked using a TLC on Kieselgel 60 $F_{254}$ (Merck). Phase transition temperatures were measured using a heating stage in conjugation with a polarizing microscope. The transition temperatures were measured at a heating rate of $1^\circ C\,min^{-1}$ and correspond to the begining of phase changes. The errors in the transition temperatures are estimated as $\pm 0.5^\circ C$. Phase identification was made by comparison of the observed textures with those reported in the literature [28].

Table 1. Transition temperatures (°C) of isoxazoles **7**,**9**, pyrazoles **8**,**10**, and 2-isoxazolines **11**,**12**.

| Compound | *R* | Cr | | SmC | | SmA | | N | | I |
|---|---|---|---|---|---|---|---|---|---|---|
| **7a** | 4-CN-$C_6H_4$ | ● | 86 | — | — | ● | (72.5) | ● | 102 | ● |
| **8a** | | ● | 136 | — | — | — | — | — | — | ● |
| **11a** | | ● | 86 | — | — | — | — | ● | 107.5 | ● |
| **7b** | 4-F-$C_6H_4$ | ● | 99.5 | ● | 105.5 | ● | — | — | 109.5 | ● |
| **7c** | 4′-$C_3H_7O$-$C_6H_4$-$C_6H_4$ | ● | 187 | — | — | ● | — | — | 224 | ● |
| **8c** | | ● | 182 | — | — | ● | — | — | 234 | ● |
| **11c** | | ● | 186.5 | — | — | ● | — | — | 243.5 | ● |
| **7d** | 4′-$C_5H_{11}$-$C_6H_4$-$C_6H_4$ | ● | 160 | — | — | ● | — | — | 210 | ● |
| **8d** | | ● | 153 | ● | 207 | ● | — | — | 224 | ● |
| **11d** | | ● | 157.5 | — | — | ● | — | — | 226.5 | ● |
| **7e** | 3-F-4-$C_3H_7O$-$C_6H_3$ | ● | 94 | ● | (90) | ● | — | — | 102.5 | ● |
| **11e** | | ● | 122.5 | ● | 132 | ● | — | — | 133.5 | ● |
| **9a** | 4-CN-$C_6H_4$ | ● | 111.5 | ● | (106.5) | — | — | ● | 174 | ● |
| **9b** | 4-F-$C_6H_4$ | ● | 126.5 | — | — | — | — | — | — | ● |
| **9c** | 4′-$C_3H_7O$-$C_6H_4$-$C_6H_4$ | ● | 180 | — | — | — | — | — | — | ● |
| **9d** | 4′-$C_5H_{11}$-$C_6H_4$-$C_6H_4$ | ● | 143.5 | — | — | — | — | — | — | ● |
| **9f** | 4-$C_5H_{11}$-$C_6H_{10}$ | ● | 72 | ● | — | — | 117 | ● | 144 | ● |
| **12f** | | ● | 124 | — | — | ● | — | — | 155 | ● |
| **9g** | 4-$C_3H_7O$-$C_6H_4$ | ● | 118.5 | — | — | — | — | ● | 149 | ● |
| **9h** | 4-$C_4H_9O$-$C_6H_4$ | ● | 110.5 | — | — | — | — | ● | 153.5 | ● |
| **9i** | 4-$C_5H_{11}O$-$C_6H_4$ | ● | 114.5 | — | — | — | — | ● | 144.5 | ● |
| **10i** | | ● | 143.5 | — | — | — | — | ● | (139) | ● |
| **12i** | | ● | 137.5 | — | — | ● | 146.5 | ● | 160 | ● |
| **9j** | 4-$C_6H_{13}O$-$C_6H_4$ | ● | 104 | ● | (95.5) | — | — | ● | 148 | ● |
| **10j** | | ● | 146 | — | — | — | — | ● | (146) | ● |
| **9k** | 4-$C_7H_{15}O$-$C_6H_4$ | ● | 106 | ● | — | — | 113 | ● | 143.5 | ● |
| **9l** | 4-$C_8H_{17}O$-$C_6H_4$ | ● | 105.5 | ● | — | — | 114 | ● | 143 | ● |
| **9m** | 4-$C_9H_{19}O$-$C_6H_4$ | ● | 108 | ● | — | — | 121.5 | ● | 142 | ● |
| **10m** | | ● | 116.5 | — | — | — | — | ● | 126.5 | ● |
| **12m** | | ● | 118 | ● | 154 | ● | — | — | 162 | ● |
| **9n** | 4-$C_{12}H_{25}O$-$C_6H_4$ | ● | 105 | ● | — | — | 129 | ● | 135 | ● |

### 3.1. *3-(4-Acetoxyphenyl)-5-amyl-2-isoxazoline (3)*

Acetyl chloride (4.5 ml, 63.3 mmol) was added dropwise with stirring to a solution of 3-(4-hydroxyphenyl)-5-amyl-2-isoxazoline **2** (4.9 g, 21.0 mmol) (synthesis described in [24]) in toluene (35 ml) and triethylamine (35 ml). The mixture was stirred for 3 h 15 min at room temperature and then water (100 ml) was added. The separated aqueous layer was washed with toluene (30 ml), and the combined organic layers with 20% sulphuric acid (100 ml) and brine (2 × 40 ml) and dried ($MgSO_4$). The solvent was removed *in vacuo* and the residue recrystallized (methanol) to give a white crystalline solid. Yield 5.1 g (87%), m.p. 78–80°C ($CH_3OH$). IR, $cm^{-1}$: 3035, 3025 (C–$H_{arom.}$), 2970, 2945, 2870 (C–$H_{alkyl}$), 1765 (C=O), 1605, 1510 (C=$C_{arom.}$), 925 (N–O). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.89 (3H, t, $J$=7 Hz, $CH_3$), 1.25–1.53 (6H, m, $CH_2$), 1.55–1.65 (1H, m, $CH_2$), 1.72–1.82 (1H, m, $CH_2$), 2.30 (3H, s, $CH_3COO$), 2.85 (1H, dd, $J_1$=8 Hz, $J_2$=16.5 Hz, 4-$CH_2$), 3.35 (1H, dd, $J_1$=10.4 Hz, $J_2$=16.5 Hz, 4-$CH_2$), 4.68–4.76 (1H, m, 5-CH), 7.11 (2H, d, $J$=9 Hz, arom. protons), 7.67 (2H, d, $J$=9 Hz, arom. protons).

### 3.2. *3-(4-Hydroxyphenyl)-5-amylisoxazole (4)*

A mixture of 2-isoxazoline **3** (4.892 g, 17.79 mmol) and NBS (3.438 g, 19.32 mmol) in $CCl_4$ (90 ml) was heated under reflux and UV-irradiation for 2 h. The mixture was allowed to cool, and the precipitate was filtered off and washed with $CCl_4$ (20 ml). The filtrate was washed with water (2 × 50 ml) and the solvent removed *in vacuo*.

The resulting residue was dissolved in methanol/water mixture (1/1, 60 ml) and potassium hydroxide (3.0 g, 53.6 mmol) was then added. The resulting reaction mixture was stirred under reflux for 1 h. It was allowed to cool and dilute hydrochloric acid (1/4, 25 ml) was added. The product was extracted with ethyl acetate ($3 \times 50$ ml), and the combined organic extracts were washed with brine ($4 \times 30$ ml) and dried ($MgSO_4$). The solvent was removed *in vacuo* and the residue recrystallized from toluene/petroleum ether. The product was purified by column chromatography (silica gel, ethyl acetate/petroleum ether, 1/3) and recrystallized from toluene/petroleum ether. Yield 2.037 g (50%), m.p. 82°C (toluene/petroleum ether). UV ($\lambda_{max}$, nm): 260, 264. IR, $cm^{-1}$: 3590, 3500–3050 (O–H), 3005 (C–$H_{arom.}$), 2960, 2935, 2865 (C–$H_{alkyl.}$), 1605, 1525 (C=$C_{arom.}$), 1260, 1175 (C–O). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.90 (3H, t, $J$=7 Hz, $CH_3$), 1.32–1.40 (4H, m, $CH_2$), 1.73 (2H, quintet, $J$=7 Hz, $CH_2$), 2.76 (2H, t, $J$=7 Hz, $CH_2$), 6.23 (1H, s, 4-CH), 6.71 (1H, br. s, OH), 6.89 (2H, d, $J$=8.8 Hz, arom. protons), 7.64 (2H, d, $J$=8.8 Hz, arom. protons).

### 3.3. *1-Amino-1-(4-hydroxyphenyl)-oct-1-en-3-one (5)*

A solution of isoxazole **4** (2.30 g, 9.96 mmol) in methanol (55 ml) was hydrogenated over Raney Ni catalyst. After the reaction was complete the catalyst was filtered off and washed with methanol (30 ml). The solvent was removed *in vacuo* and the residue purified by column chromatography (silica gel, ethyl acetate petroleum ether, 1/3 to 2/1). Yield 2.13 g (92%), m.p. 120–121°C (toluene/petroleum ether). UV ($\lambda_{max}$, nm): 268, 329 ($CH_3OH$); 256, 320 (dioxane). IR, $cm^{-1}$: 3580, 3480, 3425–3015 (O–H, N–H), 2995 (C–$H_{arom.}$), 2950, 2925, 2855 (C–$H_{alkyl}$), 1600, 1570, 1530, 1485 (C=O, C=C, C=$C_{arom.}$). IR, $cm^{-1}$ (THF): 3500–3030 (O–H, N–H), 1600, 1575, 1530, 1485 (C=O, C=C, C=$C_{arom.}$). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.87 (3H, t, $J$=7 Hz, $CH_3$), 1.26–1.38 (4H, m, $CH_2$), 1.58–1.72 (2H, m, $CH_2$), 2.37 (2H, t, $J$=7.5 Hz, 4-$CH_2$), 5.44 (1H, s, 2-CH), 6.91 (2H, d, $J$=8.5 Hz, arom. protons), 7.45 (2H, d, $J$=8.5 Hz, arom. protons), 5.25 (1H, br. s, $NH_2$), 6.90–7.02 (1H, m, OH), 10.04 (1H, br. s, $NH_2$).

### 3.4. *3-(4-Hydroxyphenyl)-5-amyl-1H-pyrazole (6)*

A mixture of enaminoketone **5** (0.726 g, 3.116 mmol) and dilute hydrochloric acid (1/10, 5.5 ml) in THF (20 ml) was heated under reflux for 1 h. The mixture was allowed to cool and chloroform (20 ml) and brine (30 ml) were added. The separated aqueous layer was washed with chloroform ($2 \times 10$ ml), and the combined organic layers were washed with brine (15 ml). The solvent was removed *in vacuo* and the resulting residue dissolved in methanol (10 ml); hydrazine hydrate (0.3 ml, 6.18 mmol) was then added. The solution was heated under reflux for a further 1 h, and water (50 ml) was added. The precipitate was filtered off and washed with water (100 ml) and cold petroleum ether (5 ml). After the drying *in vacuo* a yield of 0.688 g pyrazole **6** (96%) was obtained, m.p. 150–151°C (toluene). UV ($\lambda_{max}$, nm): 258.5 ($CH_3OH$). IR, $cm^{-1}$ (THF): 3650–3050 (O–H, N–H), 1610, 1525, 1500 (C=$C_{arom.}$). $^1H$ NMR ($(CD_3)_2CO$, $\delta$, ppm): 0.88 (3H, t, $J$=7 Hz, $CH_3$), 1.28–1.40 (4H, m, $CH_2$), 1.67 (2H, quintet, $J$=7.5 Hz, $CH_2$), 2.64 (2H, t, $J$=7.5 Hz, $CH_2$), 6.32 (1H, s, 4-CH), 6.84 (2H, d, $J$=8.5 Hz, arom. protons), 7.63 (2H, d, $J$=8.5 Hz, arom. protons).

### 3.5. *3-[4-(4-Cyanophenyl)methyloxy]phenyl-5-amylisoxazole (7a)*

Sodium iodide (0.123 g, 0.82 mmol) and potassium carbonate (0.28 g, 2 mmol) were added to a solution of phenol **4** (0.100 g, 0.43 mmol) and 4-cyanobenzyl chloride (0.062 g, 0.41 mmol) in acetone (10 ml). The resulting reaction mixture was stirred under reflux for 9.5 h. The solution was allowed to cool and was then diluted with water (35 ml). The solid was filtered off and washed with water. After the dryning *in vacuo* a yield of 0.138 g of benzylic ether **7a** (97.5%) was obtained. An analytical sample was obtained by double recrystallization from 2-propanol. UV ($\lambda_{max}$, nm): 231, 256. IR, $cm^{-1}$: 3000 (C–$H_{arom.}$), 2925, 2860 (C–$H_{alkyl}$), 2225 (C≡N), 1600, 1520 (C=$C_{arom.}$), 1240, 1170 (C–O). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.81 (3H, t, $J$=7 Hz, $CH_3$), 1.18–1.26 (4H, m, $CH_2$), 1.61 (2H, quintet, $J$=7 Hz, $CH_2$), 2.70 (2H, t, $J$=7 Hz, $CH_2$), 5.19 (2H, s, Ar′–$CH_2$–O–Ar), 6.62 (1H, s, 4-CH), 7.23 (2H, d, $J$=9 Hz, arom. protons), 7.57 (2H, d, $J$=9 Hz, arom. protons), 7.72 (2H, d, $J$=9 Hz, arom. protons), 8.09 (2H, d, $J$=9 Hz, arom. protons).

Compounds **7b–e**, **8a**,**c**,**d** and **11a**,**c–e** were prepared by a similar procedure to that described for **7a**.

### 3.6. *3-[4-(4-Cyanophenyl-1-methyloxy)phenyl)]-5-amyl-1H-pyrazole (8a)*

Yield 88%. UV ($\lambda_{max}$, nm): 234, 259 ($CH_3OH$). IR, $cm^{-1}$: 3445 (N–H), 2950, 2920, 2850 (C–$H_{alkyl}$), 2225 (C≡N), 1605, 1570, 1550, 1515, 1495 (C=$C_{arom.}$). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.89 (3H, t, $J$=7 Hz, $CH_3$), 1.29–1.40 (4H, m, $CH_2$), 1.67 (2H, quintet, $J$=7.5 Hz, $CH_2$), 2.64 (2H, t, $J$=7.5 Hz, $CH_2$), 5.14 (2H, s, Ar′–$CH_2$–O–Ar), 6.29 (1H, s, 4-CH), 6.96 (2H, d, $J$=9 Hz, arom. protons), 7.55 (2H, d, $J$=9 Hz, arom. protons), 7.64–7.70 (4H, m, arom. protons).

### 3.7. *3-[4-(4-Cyanophenyl-1-methyloxy)phenyl]-5-amyl-2-isoxazoline (11a)*

Yield 61%. IR, $cm^{-1}$: 3020, 3000 (C–$H_{arom.}$), 2950, 2925, 2855 (C–$H_{alkyl}$), 2225 (C≡N), 1600, 1505 (C=$C_{arom.}$). UV ($\lambda_{max}$, nm): 272.5. $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.88 (3H, t, $J$=6.8 Hz, $CH_3$), 1.25–1.80 (8H, m, $CH_2$), 2.91 (1H, dd, $J_1$=8.4 Hz, $J_2$=16.4 Hz, 4-$CH_2$), 3.34 (1H, dd, $J_1$=10 Hz, $J_2$=16.4 Hz, 4-$CH_2$), 4.65–4.73 (1H, m, 5-CH), 5.14 (2H, s, Ar′–$CH_2$–O–Ar), 6.95 (2H, d, $J$=8.8 Hz, arom. protons), 7.53 (2H, d, $J$=8 Hz, arom. protons), 7.60 (2H, d, $J$=8.8 Hz, arom. protons), 7.67 (2H, d, $J$=8 Hz, arom. protons).

### 3.8. *4-Cyanobenzoic acid 4-(5-amylisoxazol-3-yl)-phenyl ester (9a)*

To a solution of phenol **5** (0.085 g, 0.37 mmol), 4-cyanobenzoic acid (0.060 g, 0.41 mmol) and DCC (0.085 g, 0.41 mmol) in dichloromethane (10 ml) was added a catalytic amount of DMAP. The reaction mixture was stirred for 25 h and than filtered through aluminum oxide. The sorbent was washed with dichloromethane (40 ml); the solvent was removed and the crude product recrystallized from 2-propanol; yield 0.83 g of ester **9a** (63%). UV ($\lambda_{max}$, nm): 243. IR, $cm^{-1}$: 3000 (C–$H_{arom.}$), 2950, 2925, 2855 (C–$H_{alkyl.}$), 2230 (C≡N), 1730 (C=O), 1600, 1505 (C=$C_{arom.}$), 1250, 1065 (C–O). $^1H$ NMR ($C_5D_5N$, $\delta$, ppm): 0.74 (3H, t, $J$=7 Hz, $CH_3$), 1.15–1.19 (4H, m, $CH_2$), 1.53 (2H, quintet, $J$=7 Hz, $CH_2$), 2.63 (2H, t, $J$=7 Hz, $CH_2$), 6.57 (1H, s, 4-CH), 7.50 (2H, d, $J$=9 Hz, arom. protons), 7.80 (2H, d, $J$=9 Hz, arom. protons), 8.10 (2H, d, $J$=9 Hz, arom. protons), 8.19 (2H, d, $J$=9 Hz, arom. protons).

Compounds **9b–d,f–n** were prepared by a similar procedure to that described for **9a**.

### 3.9. *4-Amyloxybenzoic acid 4-(5-amyl-1H-pyrazol-3-yl)phenyl ester (10i)*

A mixture of 4-amyloxybenzoic acid (0.055 g, 0.264 mmol), thionyl chloride (0.2 ml, 2.78 mmol) and one drop of dimethylformamide in dichloromethane (5 ml) was heated under reflux for 1 h. The solvent was then removed and the crude acid chloride dissolved in dry tetrahydrofyran (5 ml). Triethylamine (0.35 ml, 2.52 mmol) and pyrazole **6** (0.060 g, 0.261 mmol) were then added with stirring. The mixture was stirred for a further 2.5 h and then chloroform (15 ml) and water (15 ml) were added. The separated aqueous layer was washed with chloroform (2 × 10 ml), and the combined organic layers were washed with water (20 ml) and dried ($Na_2SO_4$). The solvent was removed *in vacuo* and the residue recrystallized (2-propanol) to give a white crystalline solid; yield 0.055 g (50%). UV ($\lambda_{max}$, nm): 263 ($CH_3OH$). IR, $cm^{-1}$: 3475 (N–H), 3005 (C–$H_{arom.}$), 2955, 2930, 2870, 2855 (C–$H_{alkyl.}$), 1725 (C=O), 1600, 1570, 1555, 1515, 1500 (C=$C_{arom.}$), 1250, 1200, 1165, 1070 (C–O). $^1H$ NMR ($CDCl_3$, $\delta$, ppm): 0.90 (3H, t, $J$=7 Hz, $CH_3$), 0.94 (3H, t, $J$=7.5 Hz, $CH_3$), 1.30–1.50 (8H, m, $CH_2$), 1.69 (2H, quintet, $J$=7.5 Hz, $CH_2$), 1.82 (2H, quintet, $J$=7 Hz, $CH_2$), 2.67 (2H, t, $J$=7.5 Hz, $CH_2$), 4.04 (2H, t, $J$=7 Hz, $OCH_2$), 6.35 (1H, s, 4-CH), 6.96 (2H, d, $J$=9 Hz, arom. protons), 7.23 (2H, d, $J$=9 Hz, arom. protons), 7.77 (2H, d, $J$=9 Hz, arom. protons), 8.14 (2H, d, $J$=9 Hz, arom. protons).

Compounds **10j,m** were prepared by a similar procedure to that described for **10i**.

## 4. Conclusion

New liquid crystalline 3-aryl-5-alkylisoxazoles and 3-aryl-5-alkyl-1H-pyrazoles with ether and ester linkages have been prepared. The key step in the synthesis of these materials is the oxidation of the 2-isoxazoline ring to isoxazole. Further reductive cleavage of the isoxazole cycle led to β-enaminoketone. Subsequent chemical transformations of the latter substance gave the intermediate pyrazole. The target liquid crystalline compounds were prepared by benzylation and esterification of isoxazole- and pyrazole-containing phenols. Liquid crystalline 3-aryl-5-alkyl-2-isoxazolines with an ether linkage were also synthesized to compare the heterocycle type influences on mesomorphic properties.

Smectic phases are typical for liquid crystalline ethers with isoxazole, pyrazole and 2-isoxazoline rings. The mesophase ranges are similar for pyrazoles and 2-isoxazolines, and larger than for the corresponding isoxazoles. Isoxazole-containing liquid crystals with ester linkages exhibit the nematic phase only, or the smectic C and nematic phases for long chain homologues. Pyrazole-containing esters form monotropic or enantiotropic nematic phases. Mesophase ranges for isoxazoles with ester linkages are larger than for corresponding pyrazoles.

## References

[1] V.F. Petrov. *Liq. Cryst.*, **28**, 217 (2001).
[2] L.A. Karamysheva, S.I. Torgova, I.F. Agafonova, V.F. Petrov. *Liq. Cryst.*, **27**, 393 (2000).
[3] O. Madelung (Ed). *Liquid Crystals,* in Landolt-Börnstein, New Series, Group IV, Vol. 7d, Springer-Verlag, Berlin (1992).
[4] A.J. Seed, G.J. Cross, K.J. Toyne, J.W. Goodby. *Liq. Cryst.*, **30**, 1089 (2003).
[5] R. Mcdonald, D. Lacey, P. Watson, S. Cowling, P. Wilson. *Liq. Cryst.*, **32**, 319 (2005).
[6] S. Sugimori. Japanese Patent, JP60-54375 (1985).
[7] J. Barbera, C. Cativiela, J.L. Serrano, M.M. Zurbano. *Liq. Cryst.*, **11**, 887 (1992).

[8] J. Bartulin, R. Martinez, H.J. Müller, Z.X. Fan, W. Haase. *Mol. Cryst. liq. Cryst.*, **220**, 67 (1992).
[9] C.G. Seguel, B. Borchers, W. Haase, C. Aguilera. *Liq. Cryst.*, **11**, 899 (1992).
[10] J. Bartulin, R. Martinez, H. Gallardo, H.J. Müller, T.R. Taylor. *Mol. Cryst. liq. Cryst. Sci. Technol., A.*, **225**, 175 (1993).
[11] R. Iglesias, J.L. Serrano, T. Sierra. *Liq. Cryst.*, **22**, 37 (1997).
[12] J. Barbera, R. Gimenez, J.L. Serrano, R. Alcala, B. Villacampa, J. Villalba, I. Ledoux, J. Zyss. *Liq. Cryst.*, **22**, 265 (1997).
[13] A. Sakaigawa, A. Miyazaki, M. Koden. U.S. Patent 60 077 399 (1999).
[14] M.C. Torralba, M. Cano, J.A. Campo, J.V. Heras, E. Pinilla, M.R. Torres. *J. Organomet. Chem.*, **654**, 150 (2002).
[15] D.H. Brown, P. Styring. *Liq. Cryst.*, **30**, 23 (2003).
[16] T. Haino, M. Tanaka, K. Ideta, K. Kubo, A. Mori, Y. Fukazawa. *Tetrahedron Lett.*, **45**, 2277 (2004).
[17] H. Gallardo, C. Zucco. *Mol. Cryst. liq. Cryst.*, **373**, 181 (2002).
[18] J. Bartulin, M.L. Ramos, H. Zunza. *Bol. Soc. Chil. Quím.*, **44**, 375 (1999).
[19] W. Schmidt, B. Hornung, R. Wingen. U.S. Patent 6 616 989 (2003).
[20] V.S. Bezborodov, M.M. Kauhanka, V.I. Lapanik. *Vesti NAN Belarusi. Ser. Chim. Navuk*, **3**, 76 (in Russian) (2003).
[21] V.S. Bezborodov, N.N. Kauhanka, V.I. Lapanik, C.J. Lee. *Liq. Cryst.*, **30**, 579 (2003).
[22] V. Bezborodov, N. Kauhanka, V. Lapanik. *Mol. Cryst. liq. Cryst.*, **411**, 103 (2004).
[23] S. Kanemasa, O. Tsuge. *Heterocycles*, **30**, 719 (1990).
[24] U.M. Kauhanka, M.M. Kauhanka. *Liq. Cryst.*, **31**, 1547 (2004).
[25] P.G. Baraldi, A. Barco, S. Benetti, G.P. Pollini, D. Simoni. *Synthesis*, 857 (1987).
[26] G. Bianchi, P. Grünanger. *Tetrahedron*, **21**, 817 (1965).
[27] A. Barco, S. Benetti, G.P. Pollini, P.G. Baraldi. *Synthesis*, 837 (1977).
[28] D. Demus, L. Richter. *The Texture of Liquid Crystals*. VEB Deutcher Verlag fur Grandstoff Industrie, Leipzig (1978).