Synthesis and study the liquid crystalline properties of new compounds containing 5-methyl-2,4-dihydro-3H-pyrazol-3-one

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Abstract. The new compounds of pyrazolines were synthesized from the reaction of different acid hydrazide with ethylacetoacetate and ethanol under reflux. These compounds were obtained from many sequence reactions. The 4-acetyl-5-methyl-2,4-dihydro-3H-pyrazol-3-one compounds synthesized from the reaction of 5-methyl-2,4-dihydro-3H-pyrazol-3-one with acetyl chloride in calcium hydroxide and 1,4-dioxane. Finally, Schiff bases were prepared via condensation reaction of products of mono- and tri ketone derivatives [IV]a,b with phenyl hydrazines as presented in (Scheme 1, 2). The synthesized compounds were identification by using FTIR, NMR and Mass spectroscopy (of some of them). The mesomorphic behaviour of these derivatives were examined under OPM. The compound [IV]a exhibited enantiotropic liquid crystal (Smectic A on heating and Nematic on cooling) while the compound [V]c showed Smectic A and nematic phases only on cooling (monotropic). Also the two compounds [V]b and [VI]b exhibited nematic mesophase on cooling. The compound [IV]b, [V]b,d and [VI]a,c,d did not show any mesomorphic properties.

Keywords: Pyrazolines, hydrazines, Schiff bases, heterocyclic liquid crystal.

1. Introduction
Five membered lactam ring containing two nitrogen and presence of carbonyl group at position five gives pyrazolone [1,2]. Pyrazolones are best classified as 3-pyrazolin-5-one (1), 2-pyrazolin-5-one (2) and 2-pyrazolin-4-one (3). Within each class of pyrazolones many tautomeric forms are possible; for simplicity only one form is shown [3,4].

3-Amino-1-nicotinoyl-pyrazol-5(4H)-one synthesized by the reaction of acid hydrazide with ethylacetoacetate in ethanol using glacial acetic acid as a catalyst (equation. 1) [5].

Equation 1
Also, Kumar et al [6] prepared 1-[3-(4-chlorophenyl sulfonyl(propanoyl)-3-methyl-pyrazol-5(4H)-one from condensation reaction of acid hydrazide compound with ethyl acetoacetate in ethanol under reflux (equation 2).

![Equation 2]

While, 3-methyl -5-pyrazolone(10) synthesized by the reaction of acetoacetate with hydrazine hydrate in ethanol [7] (equation 3).

![Equation 3]

Hydrazones belong to the Schiff base family containing azomethine(-NHN=CH-). Hydrazones are the condensation products of hydrazine derivatives with carbonyl compounds (aldehydes or ketones) [8,9], as in (equation 4).

![Equation 4]  

Many series of liquid crystalline compounds contain heterocyclic groups have been synthesized because of their interesting properties [10]. A wide variety of liquid crystalline compounds containing five-member heterocycles the subject of much investigation [11]. Therefore, various mesomorphic heterocyclic compounds have been reported [12,13]. Thermotropic liquid crystals are of great technological importance [14]. Pyrazole-containing liquid crystals have been also described [15]. The majority of these compounds are 3,5-di-substituted pyrazoles [16]. Indeed, some 3,5-disubstituted pyrazoles and 4-substituted pyrazoles have demonstrated their ability to show liquid crystalline behavior [17], pyrazole and terminal substituents has proven to be very efficient as a starting material for various kinds of mesogenic compounds. Some of these groups are strongly polar and others are slightly polar [18]. The aim of our present work is the synthesis and study the liquid crystalline behavior of pyrazoline-2-one derivatives.

2. Experimental

2.1. Materials:
All of chemicals were supplied from sigma and Aldrich chemicals co. and used as received.

2.2. Instrumental
The FTIR spectra were recorded by 600 FTIR spectrometer, (UK). $^1$H-NMR spectra were obtained with Bruker spectrophotometer model ultra shield at 400 MHz using tetramethylsilane (TMS) as internal standard and DMSO-d$_6$ as solvent. Uncorrected melting point were determined by using Hot-Stage Gallen Kamp melting point.

2.3. Synthesis:
The new compounds were synthesized according to Scheme 1 and 2 by the following general procedure.

![Scheme 1](image_url)
Methyl 4-methoxybenzoate [I]a, trimethyl benzene-1,3,5-tricarboxylate [I]b, 4-methoxybenzohydrazide [II]a and benzene-1,3,5-tricarbohydrazide [II]b were prepared according to reference [19].

2-(4-methoxybenzoyl)-5-methyl-2,4-dihydro-3H-pyrazol-3-one [III]a
A mixture of acid hydrazides [II]a (1gm, 0.0028 mol) and ethyl acetoacetate (0.5ml, 0.0028 mol) in absolute ethanol (20 mL) was refluxed for (3 hrs) [20]. The cured product was allowed to cool and formed precipitate on cooling, filtered and recrystallized from methanol to give compounds [III]a. The brown precipitate yield 93%, m.p = 174-178 °C. FTIR (cm⁻¹): 3068 (CH aromatic); 2981, 2956, 2841 (CH aliphatic); 1732 (C=O Pyrazolone ring); 1657 (C=O amid); 1608 (C=N); 1502 (C=C benzene ring); 1257 (C-O); 845 (para substituted benzene ring).

2,2',2''-(benzene-1,3,5-tricarbonyl)tris(5-methyl-2,4-dihydro-3H-pyrazol-3-one) [III]b
was synthesized by using the same method except mixture of acid hydrazides (1gm, 0.001 mol) and (1.56gm, 0.003 mol) of ethyl acetoacetate and (30mL) of ethanol. The brown precipitate yield 73%, m.p = 116-118 °C. FTIR (cm⁻¹): 3163 (CH aromatic); 2985, 2900 (CH aliphatic); 1728 (C=O Pyrazolone ring); 1657 (C=O amid); 1643 (C=N); 1519 (C=C benzene ring); 1242 (CO); 866 (para substituted benzene ring). ¹H NMR (DMSO-d₆), (δ ppm): 3.40 (s, 6H, CH₂), 2.28 (s, 9H, CH₃), 8.34-8.73 (m, 3H, Ar-H).

4-acetyl-2-(4-methoxybenzoyl)-5-methyl-2,4-dihydro-3H-pyrazol-3-one [IV]a
The solution from 1,4-Dioxane (25 mL), compounds [III]a (3.016gm, 0.013mol) and acetyl chloride (1.03ml, 0.013 mol) was refluxed for 4 hrs in oil bath with calcium hydroxide (0.962gm, 0.19 mol) and cooled to room temperature. The resulted reaction mass was added to the dilute hydrochloric acid (4.5mL of Conc. HCl in 20 mL water). The crude product was collected by filtrations [21]. The brown precipitate yield 80%, m.p = 222-224 °C. FTIR (cm⁻¹): 3039 (CH aromatic); 2920, 2843 (CH aliphatic); 1760 (C=O 4-acetyl pyrazolones); 1685 (C=O...
ketone); and 1643 (C=O amid); 1612 (C=N); 1573 (C=C benzene ring); 1261 (C-O); 840 (para substituted benzene ring). ^1H NMR (DMSO-d6, (δ ppm): 1.91 (s, 3H, CH3), 3.57 (s, 3H, COCH3), 3.66 (s, 1H, CH), 3.84 (s, 3H, OCH3), 7.05-7.93 (d-d, 4H, Ar-H).

The compound 2,2',2''-(benzene-1,3,5-tricarbonyl)tris(4-acetyl-5-methyl-2,4-dihydro-3H-pyrazol-3-one) [IV]b was synthesized by using the same method except (75mL) of 1,4-Dioxane solution, (0.45g, 0.013mol) of compound (IIb), (0.04g 0.039mol) of acetyl chloride and (0.55g, 0.57mol) of calcium hydroxide. The brown precipitate yield 74%, m.p = 310 °C decompose. FTIR (cm⁻¹): 3003 (CH aromatic), 2933, 2866 (CH aliphatic), 1788 (C=O 4-acetyl pyrazolones); 1716 (C=O ketone); 1654 (C=O amid); 1633 (C=N); 1575 (C=C benzene ring); 1223 (C-O); 874 (para substituted benzene ring). The mass spectrum exhibited parent ion [M+]+ at m/z=576.

General procedure for synthesis of hydrazones [V]a-d and (VI)a-d
A mixture of compound [IV]a (0.5g, 0.0018 mol) and phenyl hydrazine or substituted phenyl hydrazine (0.2ml, 0.0018mol) in ethanol (5mL) was refluxed for (6hrs). Cool, pour onto cold water [22], a precipitate was formed which collected by filtration then washed several times with cold water and recrystallized from ethanol. The compounds [VI]a-d were synthesized by using the same method except (0.003) of phenyl hydrazine or substituted phenyl hydrazine in (15mL) of ethanol.

2-(4-methoxybenzoyl)-5-methyl-4-(1-(2-phenylhydrazono)ethyl)-2,4-dihydro-3H-pyrazol-3-one [V]a. Orange yield 60%, m.p.108-110 °C. FTIR (cm⁻¹): 3284 (NH); 3026 (CH aromatic); 2935, 2928, 2864 (CH aliphatic); 1725 (C=O Pyrazolone ring); 1647(C=O amid); 1601 (C=N); 1545 (C=C); 1250 (C-O); 852 (para substituted benzene ring).

4-(1-(2,4-di-nitrophenyl)hydrazono)ethyl)-2-(4-methoxybenzoyl)-5-methyl-2, 4-dihydro-3H-pyrazol-3-one [V]b
Orange yield 60%, m.p. 186.188 °C. FTIR (cm⁻¹): 3321 (NH); 3093, 3016 (CH aromatic); 2935, 2873 (CH aliphatic); 1639(C=O amid); 1612 (C=N); 1577(C=C); 1496, 1327 (NO₂); 1246 (C-O); 852 (para substituted benzene ring).

2-(4-methoxybenzoyl)-5-methyl-4-(1-(2-(4-nitrophenyl)hydrazono)ethyl)-2,4-di-hy2-(4-methoxybenzoyl)-5-methyl-4-(1-(2-di-nitrophenyl)hydrazono)ethyl)-2,4-di-hydro-3H-pyrazol-3-one [V]c
Orange yield 63%, m.p.214-216°C. FTIR (cm⁻¹): 3419 (NH); 3035, 3012 (CH aromatic); 2943, 2846 (CH aliphatic); 1690(C=O amid); 1601 (C=N); 1562 (C=C); 1512, 1308 (NO₂); 1254 (C-O); 843 (para substituted benzene ring).

N'-(1-(1-(4-methoxybenzoyl))-3-methyl-5-oxo-4,5-dihydro-1H-pyrazol-4-yl)ethylidene)-4'-(5-(4-methoxy phenyl)-1,3,4-oxadiaoloz-2-yl)-(1,1'-biphenyl)-4-carbohydrazide [V]d
Off white yield 77%, m.p.198-200 °C. FTIR (cm⁻¹): 3290 (NH); 3059 (CH aromatic); 2981, 2935, 2873 (CH aliphatic); 1685(C=O amid, exocyclic); 1600 (C=N); 1562 (C=C); 1242 (C-O); 867 (para substituted benzene ring). ^1H NMR (DMSO-d6), (δ ppm): 1.24 (s, 6H, CH3), 3.34 (s, H, CH), 3.84 (s, 6H, OCH3), 7.05-7.90 (d-d, 16H, Ar-H), 10.31 (s, 1H, NH).

2,2'-((5-(3-methyl-5-oxo-4-(1-(2-phenylhydrazono)ethyl)-4,5-dihydro-1H-pyrazol-1-carbonyl)isophthaloyl)bis(5-methyl-4-(1-(2-phenylhydrazono)ethyl)-2,4-dihydro-3H-pyrazol-3-one) [VI]a:
Brown yield 60%, m.p.320 °C decompose. FTIR (cm⁻¹): 3427 (NH); 3080 (CH aromatic); 2943, 2873 (CH aliphatic); 1651(C=O amid); 1610 (C=N); 1560 (C=C). ^1H NMR (DMSO-d6),(δ ppm): 1.26 (s, 6H, CH3), 1.80 (s, 6H, CH3C=N), 2.60 (s, 3H, CH pyrazol ring). 6.86-7.83 (m, 18H, Ar-H), 9.60 (s, 1H, NH).
In addition, the absorption bands for C═O at position C₁ of the pyrazole-1-carbonylisophthaloyl bis(4-(1-(2-(4-nitrophenyl) hydrazono) ethyl)-5-methyl-2,4-dihydro-3H-pyrazol-3-one) [VI]ₐ. Red yield 63%, m.p. 200-202 °C. FTIR (cm⁻¹): 3321 (NH); 3099 (CH aromatic); 2925, 2850 (CH aliphatic); 1645 (C=O amid); 1604 (C=N); 1577 (C=C); 1515, 1331 (NO₂).

2,2'-(5-(3-methyl-4-(1-(2-(4-nitrophenyl)hydrazono)ethyl)-5-oxo-4,5-dihydro-1H-pyrazole-1-carbonylisophthaloyl)bis(5-methyl-4-(1-(2-(4-nitrophenyl)hydrazono)ethyl)-2,4-dihydro-3H-pyrazol-3-one) [VI]ₐ. Brown yield 82%, m.p. >320 °C. FTIR (cm⁻¹): 3271 (NH); 3022 (CH aromatic); 2929, 2875 (CH aliphatic); 1650 (C=O amid); 1608 (C=N); 1595 (C=C benzene ring); 1519, 1321 (NO₂); 826 (C-O); 850 (para substituted benzene ring).

N',N'',N'''-(benzene-1,3,5-tricarbonyl)tris(3-methyl-5-oxo-4,5-dihydro-1H-pyrazole-1,4-diy)tris(ethan-1-yl-1-ylidene)tris(4'-(5-(4-methoxy-phenyl)-1,3,4-oxadiazol-2-yl)-[11,1'-biphenyl]-4-carboxyhydrazide) [V]Iₐ. Brown yield 60%, m.p. 320 °C decompose. FTIR (cm⁻¹): 3336 (NH); 3085 (CH aromatic); 2925, 2840 (CH aliphatic); 1655 (C=O amid); 1608 (C=N); 1566 (C=C benzene ring); 1257 (CO); 845 (para substituted benzene ring).

3. Result and Discussion

Synthesis

The routes synthetic of pyrazoline compounds[[Va]|ₐ,a] and [[Vb]|ₐ,a] are outlined in Scheme (1) and (2). All of the synthesized compounds gave satisfactory analysis for the proposed structures, which were confirmed on the basis of their Fourier transform Infrared (FT-IR) and ¹H nuclear magnetic resonance (NMR). The ester and hydrazide acid compounds [[I]|ₐ] and [[II]|ₐ] were prepared based on the methods mentioned in the reference [19] The third step in Scheme (1) is the synthesis of compounds [[III]|ₐ] and [[III]|ₐ] by the reaction hydrazide acid [[I]|ₐ] or [[II]|ₐ] with ethyl acetocetate in absolute ethanol under refluxed for (3 hrs). The FTIR spectrum for these compound, showed the disappearance of absorption bands due to NHNH₂ and exhibit new stretching vibration bands at due to C=O Pyrazoline and C=N (endocyclic). In addition, the ¹H NMR exhibited signal for protons of CH₃ attached to heterocyclic ring (at C-5) and a signal for protons CH₂ of pyrazoline ring with absence the signals related to protons of NHNH₂ unit. The compounds [IV]ₐ, and [IV]ₐh was synthesized via reflux a mixture from 1,4-Dioxiane, compounds [III]ₐ and acetyl chloride with calcium hydroxide for 4 hrs in oil bath, then cooled to room temperature. The resulted reaction mass was added to the dilute hydrochloric acid. The crude product was collected by filtrations [21], to produce the 4-acetyl pyrazoline derivatives. The FTIR spectrum for these compound, appearance of new stretching bands for C═O at position C-4 from pyrazoline ring, beside to the ¹H NMR spectrum exhibited signal for a proton of CH of pyrazoline ring (at C-4) with absence the signals related to protons of CH₂ unit at the same position. The reaction of compounds (IV)ₐ and (IV)ₐh with phenyl hydrazines leads to the formation of the Schiff base (V)ₐₐd and (VI)ₐₐd about 60-77% yields. The FTIR spectra showed the appearance two new absorption bands due to C=N and NH groups. The ¹H NMR exhibited signal for NH proton with absence the signals related to protons of NHNH₂ unit.

4. Liquid crystal properties

The transition temperatures and mesophase type (texture identity) of all compounds were investigated by using hot-stage polarizing optical microscopy (POM). The phase transition temperatures were summarized in Table (1), the compounds [IV]ₐ, [V]ₐₐc, and [VI]ₐ display liquid crystal properties and the compound [[III]|ₐ, [III]ₐc, [V]ₐₐd, [IV]ₐh, and [VI]ₐₐc didn’t show any mesomorphic behavior.
Table (1) Liquid crystalline transition temperatures (°C) of compounds [III]ₐ-[VI]ₐ.

| Comp. No. | Transition temperatures | Comp. No. | Transition temperatures |
|-----------|-------------------------|-----------|-------------------------|
| [III]ₐ    | Cr 176°C → I           | [III]ₐ    | Cr 118°C → I           |
| [IV]ₐ     | Cr 220°C → Sₐ 240°C → I | [IV]ₐ     | Cr 300°C → dec.       |
|           | I 224°C → N            |           |                         |
| [V]ₐ      | Cr 260°C → I           | [VI]ₐ     | Cr 310°C → dec.       |
|           | I 250°C → N            |           |                         |
| [V]ₐ      | Cr 200°C → I           | [VI]ₐ     | Cr 210°C → I           |
|           | I 125°C → N            |           |                         |
| [V]ₐ      | Cr 270°C → I           | [VI]ₐ     | Cr 305°C → dec.       |
|           | I 240°C → N 200°C → Sₐ |           |                         |
| [V]ₐ      | Cr 204°C → I           | [VI]ₐ     |                         |

Cr = Crystal; S= Smectic; N = Nematic; I = Isotropic Transition; dec.= decomposition

The compounds ([III]ₐ, [IV]ₐ, and [V]ₐₐ) did not showed any mesogens properties this attitude can be related to effect of interaction forces and the molecule geometrical shape. The compound [IV]ₐ showed Smectic A on heating and a nematic mesophase on cooling, The change one of the hydrogen atom at position C-4 from pyrazoline ring (compound IIIₐ) by a bulky group (COCH₃) as in compound [IV]ₐ, lead to change in interaction forces of terminal groups and change in the molecule geometrical shape, see Figures (1), for this reason the emergence of a liquid crystalline phase.

![3D structure of compound [III]ₐ and [IV]ₐ](image)

Figure (1) 3D structure of compound [III]ₐ and [IV]ₐ
The compound [V], showed monotropic Smectic A and Nematic mesophases, the nitro group which have dipole moment (M=5.73D) and planer structure (sp² hybrid orbital) then the dipole-dipole interactions between this group would favour the Smectic A of mesophase [23]. While the phenyl group may be play a good role to the formation only monotropic Nematic phase as in compound [V].

The compounds ([III]b, [IV]b, and [V]a,d) did not showed any mesogens properties this attitude can be related to the two effects: the first effect is presence of many adjacent aromatic rings and the continuation of resonance along these rings leads to a very large increase in the rigidity of the molecule and difficulty of melting it, and this causes lack of access to the liquid crystal phase because no solid matter melts. On the other hand, the compound [VI]b display mesophases propraties while the compound [V]b did not show the same behavior that may be due to the presence two NO₂ groups which are enhances the disk shape of the compound [VI]b and give discotic nematic mesophase.
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