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Short Note

2-(5-Chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene

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Abstract: As a consequence of one-pot, three-component reaction of *trans*-2-benzoyl-3-(4-nitrophenyl)aziridine with 5-chloro-3-methyl-1-phenyl-1*H*-pyrazole-4-carbaldehyde and ammonium acetate, 2-(5-chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene was achieved in good yield. The desired photochromic compound display interesting photochromic behavior in the crystalline and solution phase. The structure of the newly synthesized photochromic compound was characterized by elemental analysis, ^{1}H-NMR, ^{13}C-NMR and UV-Visible spectral data.

Keywords: pyrazole; photochromism; bicyclic aziridine; Vilsmeier-Haack reaction

Introduction

Molecules that show reversible, light-induced changes between two isomers with different absorption spectra *i.e.* two different colors are known as photochromes and the associated phenomenon is well-known photochromism [1–6]. This phenomenon provides an appropriate approach to the development of light-sensitive eyewear [7], optical memory [8], molecular devices [9], optical sensing applications [10], molecular photonics as well as more integrated technologies [2].

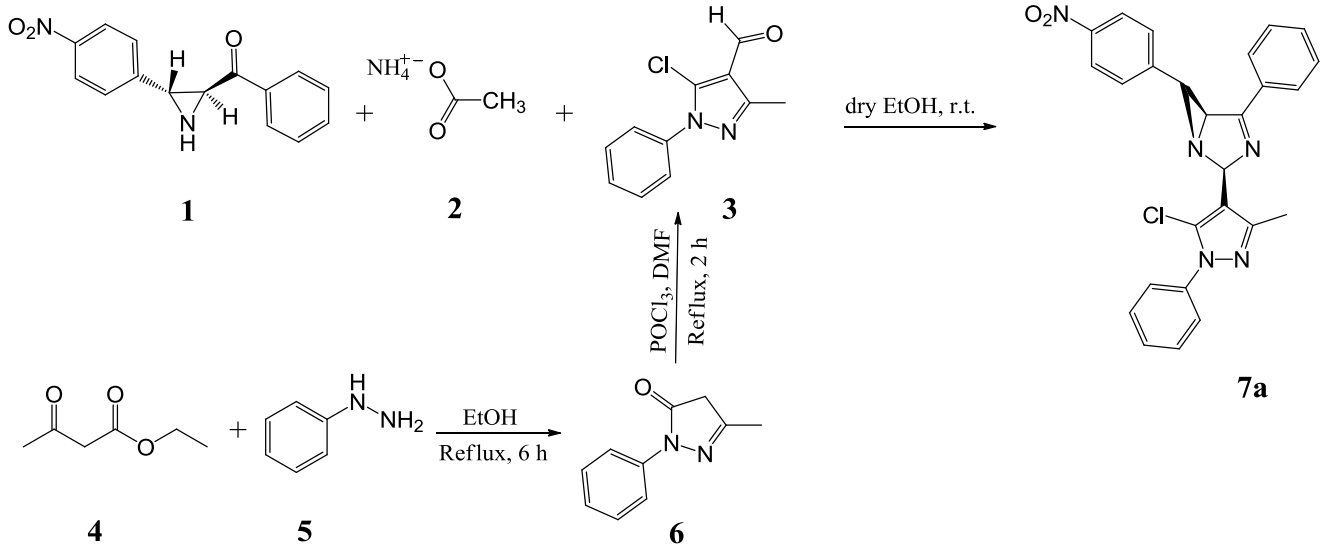
Polyaromatic bicyclic aziridine derivatives constitute an interesting class of organic photochromic compounds have special photochromic properties. These intelligent photochromes exhibit a noticeable color change as a result of the photochromic reaction in the solid and solution state. This property lets us to study them as nominees in the exploration for intelligent photochromic materials [11–37].

Depending on the particular structure, 1,3-diazabicyclo[3.1.0]hex-3-ene derivative crystals showed different colors upon UV irradiation [11–32]. For this reason, synthesis of these compounds has gained great attention in the area of organic photochromism chemistry.

On the other hand, the pyrazole ring is important class of heterocyclic compounds in pharmaceutical field and synthetic chemistry. Pyrazoles and their derivatives have been known to exhibit a wide range of physiological and pharmacological activities, such as anti-inflammatory [38], antibacterial [39,40], anti-convulsant [41], anticancer [42,43], anti-depressant [44], anti-hyperglycemic [45], antiviral [46], antipyretic [47], antioxidant [48], antitubercular [49], fungicides [50], and analgesic activities [51]. These heterocycles have also found applications in transition-metal chemistry as an analytical reagent [52], ligand used for complexation with metals and as antioxidant additives to fuels [53,54].

The desired pyrazolyl-1,3-diazabicyclo[3.1.0]hex-3-ene **7a** was prepared by the one-pot reaction of equimolar amounts of ketoaziridine compound **1** and chloropyrazole aldehyde **3**, in the presence excess amount of NH_4OAc in dry ethanol at room temperature (scheme 1).

Scheme 1. Synthesis of 2-(5-chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene (**7a**).



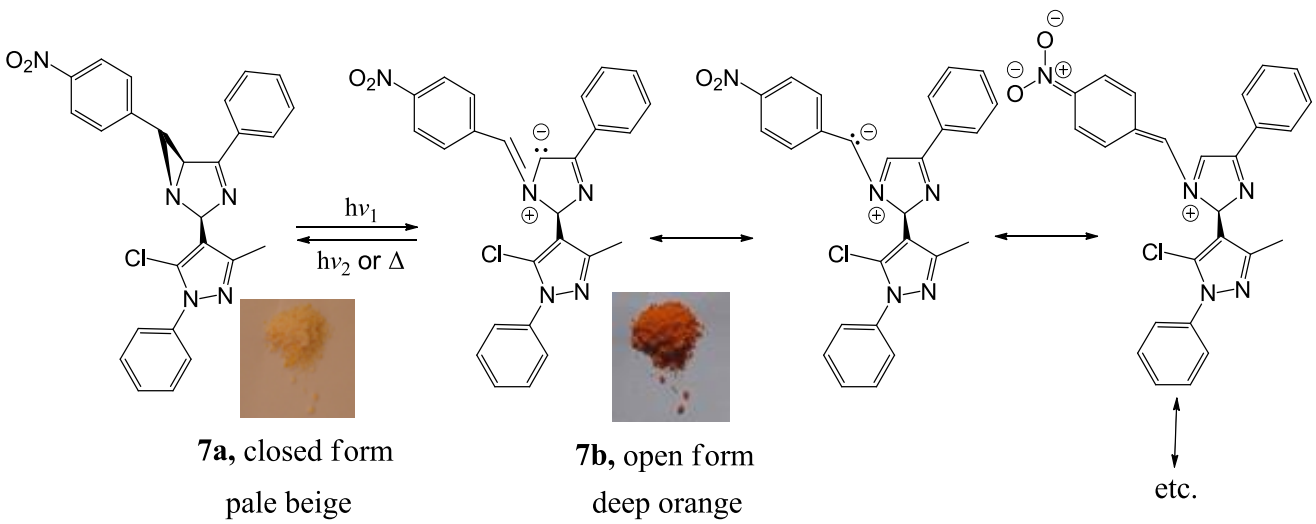
Results and Discussion

Scheme 1 shows the synthesis of the 1,3-diazabicyclo[3.1.0]hex-3-ene derivative **7**. In the first step, the desired intermediate 3-methyl-1-phenyl-1*H*-pyrazol-5(4*H*)-one (**6**) was obtained by cyclo-condensation reaction of ethyl acetoacetate and phenyl hydrazine. Then, the Vilsmeier-Haack reaction of the resulted product pyrazolon derivative lead to chloroformylation to obtain required 5-chloro-3-methyl-1-phenyl-1*H*-pyrazole-4-carbaldehyde (**3**). The starting ketoaziridine **1** was prepared according previously to the described method [13–16]. The structure of **7a** is supported by spectral data. Accordingly, the IR spectrum of **7a** revealed the presence of the nitro group at 1,508 and 1,345 cm^{-1}, as well as the presence of absorption band at 1,599 cm^{-1}, attributed to the C═N double bond. Moreover, in the IR spectrum, absorption bands belonging to the carbonyl and aziridine NH groups in the ketoaziridine **1**, as well as aldehyde functional group in the compound **3** disappeared. While in the

^{1}H-NMR spectrum of the newly formed compound, revealed one singlet at δ = 2.43 ppm for the pyrazole CH_3 protons. The protons of aziridine ring displayed two signals at δ = 2.74 and 3.78 ppm as singlet which attributed to H-6 and H-5, respectively. The signal attributable to the H-2 proton of the imidazoline ring is found at δ = 6.66 ppm as a singlet. The signal doublet at δ = 8.20 ppm belongs to two protons in the *ortho* position relative to the nitro group. The resonances of the two protons belong to two protons in the *ortho* position of the phenyl ring located in right-hand, appeared at 8.02 ppm as a doublet of doublets. The multiplets signal appeared in the region of δ = 7.42–7.62 ppm integrating for 10 protons confirm the other aromatic protons. The ^{13}C-NMR spectrum fully supported the proposed structure due to the appearance of signal at δ = 170.4 ppm due to C═N carbon in imidazoline ring as well as the appearance of signal around δ = 13.8 ppm assignable to methyl group of the pyrazole ring. Carbon of C-2 position displayed a chemical shift at δ = 90.1 ppm. Two carbons of aziridine ring showed two chemical shifts at δ = 41.9 and 57.5 ppm, which confirms the presence of carbons at 5- and 6-positions, respectively. The pyrazole C═N and ═C—Cl carbons resonates at δ = 148.8 and 114.4 ppm, respectively. The aromatic carbons in the structure of the desired compound were observable at δ 147.4–123.6 ppm.

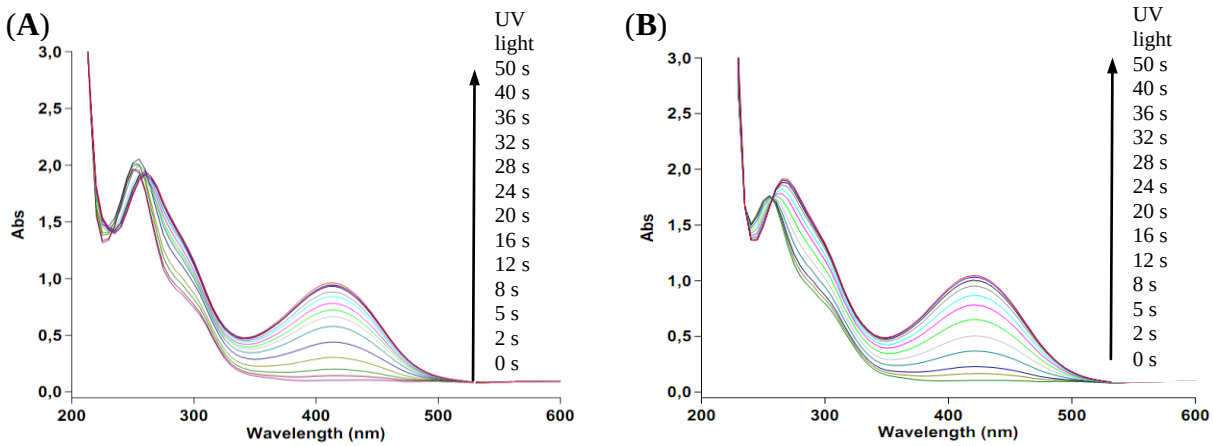
Proposed photochromic color change of pyrazolyl-1,3-diazabicyclo[3.1.0]hex-3-ene **7a** based on reversible aziridine ring-opening and ring-closing photoisomers is illustrated in scheme 2. The ring-closed photoisomer of bicyclic aziridine **7a** exhibits slight conjugation and consequently lacks of absorption in the visible region of the spectrum. However, it can absorb a photon in the ultraviolet region of the spectrum and its aziridine moiety can undergo an electrocyclic ring-opening reaction to yield the open photoisomer forms **7b**. The installation of an azomethine ylide moiety in the ring-open isomer leads to a longer π-system, which has an electronic transition corresponding to photons in the visible region of the spectrum; this photoisomer, upon absorption of visible light, undergoes a cyclization reaction to generate the ring-closed isomer.

Scheme 2. Proposed photochromic color change from **7a** to **7b**.



The photochromic behavior of the 2-(5-chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene induced by photoirradiation at ambient temperature was evaluated both in EtOH and in dichloromethane (DCM) solutions (3.0×10^{-4} mol L^{-1}). Exposure of the solutions of **7a** to UV light (centered on 365 nm) induces a color change in the solution from colorless (**7a**) to yellow (**7b**). This change color occurs in EtOH and DCM solutions, whereas change color in solid state occurs from pale beige crystals (**7a**) to deep orange crystals (**7b**). Upon irradiation with UV light, compound **7a** underwent a photochromic reaction (Scheme 2); this goes along with noticeable changes in the absorption spectra as shown in Figure 1.

Figure 1. Overlay UV/Vis spectral changes of **7a** under 365 nm irradiation at ambient temperature (**A**) in EtOH (3.0×10^{-4} mol L^{-1}) and (**B**) in DCM (3.0×10^{-4} mol L^{-1}).



The changes in the absorption spectra of 2-(5-chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene in EtOH induced by irradiation with UV light is shown in Figure 1A. Before irradiation with UV light, there is no band in the visible region. After UV irradiation of the solution, absorption bands appeared in the visible region. Before irradiation, closed isomer of **7a** showed a sharp absorption peak at 255 nm in EtOH. Upon irradiation with 365 nm light, a new visible absorption band focused at 415 nm was appeared. The appearance of this new band is ascribable to the formation of the open-ring photoisomer forms **7b**. This could be seen with the naked eye, as the colorless solution of **7a** turned yellow. As expected, with increased irradiation time, intensity of the absorption band in the visible region is gradually increased, which states that the ring-opening reaction occurs. These spectral changes showed that **7a** display photochromic behavior, similar to known *triaryl*-1,3-diazabicyclo[3.1.0]hex-3-enes [11–32]. In DCM solution, **7a** also exhibited similar photochromic color change to that in EtOH. The changes in the absorption spectra of 2-(5-chloro-3-methyl-1-phenyl-1*H*-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene is shown in Figure 1B. Upon irradiation with 365 nm UV light, the colorless solution of **7a** turned yellow, of which the absorption maximum was observed at 420 nm in consequence of the formation of the open-ring photoisomer **7b**. Also, an isosbestic point around 270 nm in Figure 1B, showed the presence of two species **7a** and **7b**. Color change in solid and solution state was observed by eye-naked, when compounds are exposed to light (UV light from mercury, xenon lamp, fluorescent lamp or sunlight) at ambient temperature. Moreover, **7b** was converted to **7a** when the **7b** is kept in the dark for 6-8 h or after putting it in the oven for 8 min at 80 °C.

Experimental

Preparation of 3-Methyl-1-phenyl-1H-pyrazol-5(4H)-one (**6**)

To a magnetically stirred solution of the ethyl acetoacetate (1.91 mL, 15 mmol) and dry ethanol (4 mL), phenyl hydrazine (1.48 mL, 15 mmol) was added dropwise at room temperature. The reaction mixture was then heated in an oil bath under reflux condition for 5.5 h. After completion of reaction the reaction mixture was cooled in ice bath to precipitate. The precipitates obtained were filtered, dried and recrystallized from ethanol to give the product **6**. Yield: 80%; m.p. 129–131 °C (Lit. [55] m.p. 128–130 °C).

Preparation of 5-Chloro-3-methyl-1-phenyl-1H-pyrazole-4-carbaldehyde (**3**)

To an ice-cold dimethylformamide (15 mmol, 1.15 mL) was added dropwise with stirring phosphorus oxychloride (35 mmol, 3.2 mL) over a period of 15 min, stirring was continued for further 20 min keeping the reaction mixture at 0 °C. To this mixture was added 3-methyl-1-phenyl-1*H*-pyrazol-5(4*H*)-one (0.88 g, 5 mmol), and the reaction mixture was then heated under reflux for 1.5 h. After completion of the reaction, as monitored with TLC, the reaction mixture was cooled to room temperature, the reaction mixture was poured into mixture of crushed ice and water (60 mL) whereupon the solid product separated out that was filtered, washed with excess of cold water, dried and recrystallized from ethanol to afford the pale yellow solid compound **3**. Yield: 80%; m.p. 141–142 °C (Lit. [55] m.p. 140–141 °C).

Synthesis of 2-(5-chloro-3-methyl-1-phenyl-1H-pyrazol-4-yl)-6-(4-nitrophenyl)-4-phenyl-1,3-diazabicyclo[3.1.0]hex-3-ene (**7a**)

Similar to the recently published synthesis [31,32], to a magnetically stirred solution of *trans*-2-benzoyl-3-(4-nitrophenyl)aziridine **1** (0.268 g, 1 mmol) and 5-chloro-3-methyl-1-phenyl-1*H*-pyrazole-4-carbaldehyde **3** (0.221 g, 1 mmol) in 7 mL of absolute ethanol was added NH_4OAc (0.78 g, 10 mmol) at room temperature. The mixture was stirred for 48 h. The reaction mixture was filtered, washed with absolute ethanol, dried under reduced pressure, and the resulting solid was recovered, purified by silica gel column chromatography using ethyl acetate/hexane (1:5, v/v) as the eluent, and recrystallized from absolute ethanol (10 mL) to give the target compound **7a** as pale beige colorless solid that changed to the deep orange (**7b**).

Yield: 80%; m.p. 175–176 °C.

IR (KBr) ν_{max} cm^{-1}: 3057, 2924, 2862, 1599, 1508, 1345, 1108, 1046, 977, 859, 771, 742, 691.

^{1}H-NMR (400 MHz, $CDCl_3$) (δ/ppm): 8.20 (d, *J* = 8.8 Hz, 2H, Ar-H), 8.02 (dd, *J* = 1.2, 6.8 Hz, 2H, Ar-H), 7.61 (t, *J* = 7.2 Hz, 1H, Ar-H), 7.62–7.46 (m, 9H, Ar-H), 6.66 (s, 1H, H-2), 3.78 (t, *J* = 1.6 Hz, 1H, H-5), 2.74 (s, 1H, H-6), 2.43 (s, 3H, CH_3).

^{13}C-NMR (100 MHz, $CDCl_3$) δ: 170.4 (C═N, imidazole), 148.8 (C═N, pyrazole), 147.4, 145.3, 138.1, 131.9, 131.4, 129.0, 128.4, 128.3, 127.4, 126.1, 125.1, 123.6, 114.4 (═C–Cl, pyrazole), 90.1 (C-2), 57.5 (C-5), 41.9 (C-6), 13.8 (CH_3).

Anal. Calcd. for $C_{26}H_{20}ClN_5O_2$: C, 66.45; H, 4.29; Cl, 7.54; N, 14.90; O, 6.81. Found: C, 66.50; H, 4.32; N, 14.94; O, 6.74.

UV-Vis (EtOH, λ_{max}/nm): 255 before irradiation, and 260, 415 after irradiation; UV-Vis (DCM, λ_{max}/nm): 255 before irradiation, and 265, 420 after irradiation.

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Conflict of Interest

The authors declare no conflict of interest.

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