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# A FACILE MICROWAVE ASSISTED SYNTHESIS AND SPECTRAL CHARACTERIZATION OF SUBSTITUTED BENZYLIDINE CARBAZOLES, PYRAZOLO[3,4-*a*]CARBAZOLES AND ISOOXAZOLO[3,4-*a*]CARBAZOLES

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**ABSTRACT:** Aldol condensation between 1-oxo-1,2,3,4-tetrahydrocarbazole **1** and benzaldehyde yielded 2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole **2.** Which on treatment with hydrazine hydrate in ethanol afforded substituted 4,5-dihydro-3-phenyl-2*H*-pyrazolo[3,4-*a*]carbazoles **3**. The compound **2** on treatment with hydroxylamine hydrochloride in ethanol yielded 3-phenyl isooxazolo[3,4-*a*]carbazoles **4**. Microwave irradiation of **2** with hydrazine hydrate and hydroxylamine hydrochloride in ethanol separately yielded the same products **3** and **4** respectively.
**Key words**: Microwave Assisted, Benzylidine Carbazoles

## INTRODUCTION

Development of new methods for the synthesis of heterocyclo-fused carbazoles is currently attracting the organic chemists due to the discovery of many carbazole alkaloids with varied biological activities[1]. Ever since the first isolation of a carbazole alkaloid, organic chemists have been interested in the synthesis of carbazole and its derivatives due to their promising biological activities. Recently *Knolker* and *Reddy* extensively reviewed the synthesis of biologically active carbazole alkaloids[2]. Ellipticine and other pyridocarbazoles are usually classified as Indole alkaloids[3] and are important owing to their antitumor activity which is in turn due to inhibition of DNA replication and RNA transcription both *invivo* and *invitro*[4]. Many elegant approaches have been developed for the synthesis of benzo and heterocyclo-fused carbazoles[5-8], indoles [9-23] and other related natural products involving annulation of indoles. Ellipticine, in particular has found clinical applications in advanced breast cancer, mieloblastic leukemia and solid tumors.[24] Indolo[2,3-*a*], pyrrolo[3,4-*c*]carbazole alkaloids form a class of compounds endowed with potent antitumor, antiviral and antimicrobial activities[25,26]. Indolocarbazoles represent an important class of antitumor agents. Antibiotics such as stauroporine and K-252*a* in which the sugar units are linked to both indole nitrogens used as potent protein kinase C (PKC) inhibitors[27].



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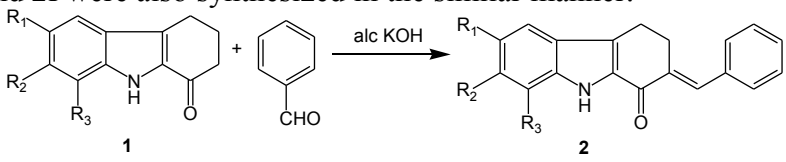
During the past four decades a wide variety of biologically active carbazole alkaloids have been isolated from the plant sources[28]. These results motivated us to synthesise various new carbazole derivatives like imino, pyrano, pyrazino, and pyrazolo carbazoles[29,31]. Aim of our work is to synthesise trinitrogen heterocyclic compounds to increase efficacy towards pharmacological activities. Hence in this paper we are reporting the synthesis new benzylidine, pyrazolo and isooxazolo carbazoles derivatives **2a-f**, **3a-f**, **4a-f** from 1-oxo-1,2,3,4-tetrahydrocarbazoles **1a-f** were carried out by conventional heating and microwave irradiation methods.

## RESULTS AND DISCUSSION

Mixed aldol condensation of 1-oxo-1,2,3,4-tetrahydrocarbazole (**1a**) with benzaldehyde in alcoholic potassium hydroxide under basic condition stirred for 6 h at room temperature gave a single product 2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole (**2a**). The structure of the compound **2a** was established on the basis of elemental analysis and spectral data. The FT-IR spectrum exhibited a sharp and strong absorption band at 1649 $cm^{-1}$, characteristic of $\alpha$-$\beta$-unsaturated carbonyl group and a band at 3262 $cm^{-1}$, ascribable to NH group. In the 1H-NMR spectrum of **2a** C3, C4 protons appear as triplet centered at δ 3.20 and 3.04 ppm, respectively with $J$ = 5.62, 6.11. A singlet peak appearing at δ 2.48 ppm is due to the benzylic proton and carbazole NH as a singlet at δ 11.85 ppm. The multiplet signal appearing in the range δ 7.11-7.62 ppm is attributed to the eight aromatic protons of carbazole nucleus. Totally, 18 distinct peaks appeared in the $^{13}$C-NMR (Fig. 3) spectrum. Two peaks appeared at δ 21.06 and 27.23 ppm for two aliphatic $CH_2$ carbon and a peak at δ 179.64 ppm for carbonyl carbon. The remaining signals appearing from δ 112.65 to δ 137.38 ppm have been assigned to the aromatic carbons. The appearance of signals for all the corresponding protons and the carbons confirmed the molecular structure of the synthesized benzylidine carbazole. Elemental analysis was compatible with the molecular formula $C_{19}H_{15}NO$. The compounds **2b, 2c, 2d, 2e** and **2f** were also synthesized in the similar manner.

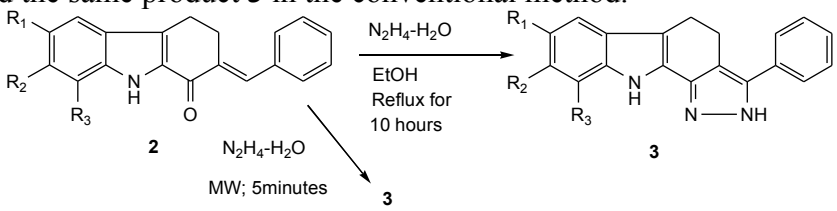



| $R_1$ | $R_2$ | $R_3$ | Abbreviation |
|---|---|---|---|
| H | H | H | **1,2a** |
| $CH_3$ | H | H | **1,2b** |
| H | $CH_3$ | H | **1,2c** |
| H | H | $CH_3$ | **1,2d** |
| Cl | H | H | **1,2e** |
| Br | H | H | **1,2f** |

**Scheme 1**. Preparation of benzyldine carbazoles

When the 2-benzyldine-1-oxo-1,2,3,4-tetrahydrocarbazole and hydrazine hydrate in ethanol were irradiated in microwave over for 5 min., yielded the compound **3a**. The formation of the compound **3a** is confirmed by the absence of carbonyl absorption and simultaneous appearance of a strong band at 1645 $cm^{-1}$ for C=N in the FT-IR spectrum.

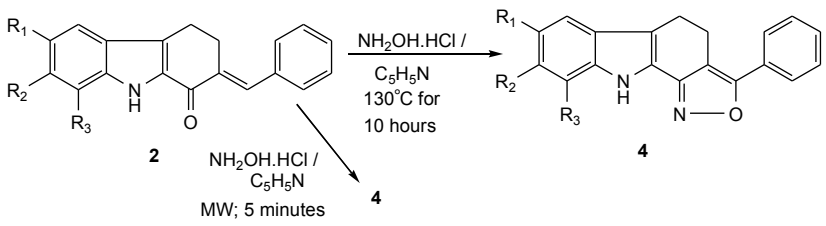
The asymmetric N-H stretching appears at 3259 $cm^{-1}$. The $^1$H-NMR spectrum of the compound **3a** in $CDCl_3$ solution showed two triplets centered at δ 3.04, 3.24 which are assigned to C4, C5 protons respectively. A singlet at δ 7.79 ppm is accountable for the pyrazolo NH proton. The ten aromatic protons resonate between δ 7.01 and 7.72 ppm and appear as a multiplet. The carbazole NH proton appeared as a broad singlet at δ 9.42 ppm. The mass spectrum of the compound has shown the molecular ion peak at m/z 271. Further the elemental analysis agreed well with the molecular formula $C_{19}H_{15}N_3$. On the basis of the data given above the product was established as 4,5-dihydro-3-phenyl-2*H*-pyrazolino[3,4-*a*]carbazole **3a**. In a similar manner, the reactions were carried out for **2b-2f** which yielded the corresponding pyrazolo[3,4-*a*]carbazole derivatives **3b-3f** respectively (**Scheme 3**). The compound **2** was mixed with hydrazine hydrate in ethanol and was refluxed for 10 hours which afforded the same product **3** in the conventional method.




| $R_1$ | $R_2$ | $R_3$ | Abbreviation |
|---|---|---|---|
| H | H | H | **2,3a** |
| $CH_3$ | H | H | **2,3b** |
| H | $CH_3$ | H | **2,3c** |
| H | H | $CH_3$ | **2,3d** |
| Cl | H | H | **2,3e** |
| Br | H | H | **2,3f** |

**Scheme 3**. Preparation of 3-Phenyl-2,4,5,10-tetrahydro-1,2,10-triaza-cyclopenta[*a*]carbazole

In another experiment the compound **2a** on microwave irradiation with hydroxylamine hydrochloride in dry pyridine yielded a single product which was purified by column chromatography. The FT-IR spectrum of **2a** exhibited two absorption bands at 1615 and 3230 $cm^{-1}$ owing to the C=N stretching and NH asymmetric stretching vibrations respectively. The $^1$H-NMR spectrum in $CDCl_3$ solution, showed two multiplet peaks centered at δ 2.90, 3.20 ppm for C4, C5 protons respectively. The ten aromatic protons collectively stand responsible for the multiplet signal appearing in the range δ 7.00-8.02 ppm. A broad singlet appearing at 10.30 ppm is due to the NH proton. The elemental analysis agreed well with the proposed molecular formula $C_{19}H_{14}N_2O$. Based on the spectral data, the product was established as 4,5-dihydro-3-phenyl-2*H*-isooxazolo[3,4-*a*]carbazole **4a**. In this similar manner, the reaction was carried out for **2b-2f** which yielded the corresponding isooxazolo[3,4-*a*]carbazole derivative compounds **4b-4f** respectively (**Scheme 4**). In conventional method, the compound **2** was mixed with hydroxylamine hydrochloride in pyridine and refluxed for 10 h. at 130°C which also afforded the same product **4**. On comparing the conventional and microwave techniques, the microwave assisted synthesis is more advantageous than the former because it is an eco-friendly green synthesis and the time consumption is also less. The analytical, FT-IR and $^1$H-NMR data of the compounds **2a-f**, **3a-f**, **4a-f** are listed in the Tables. **1, 2** and **3** respectively.

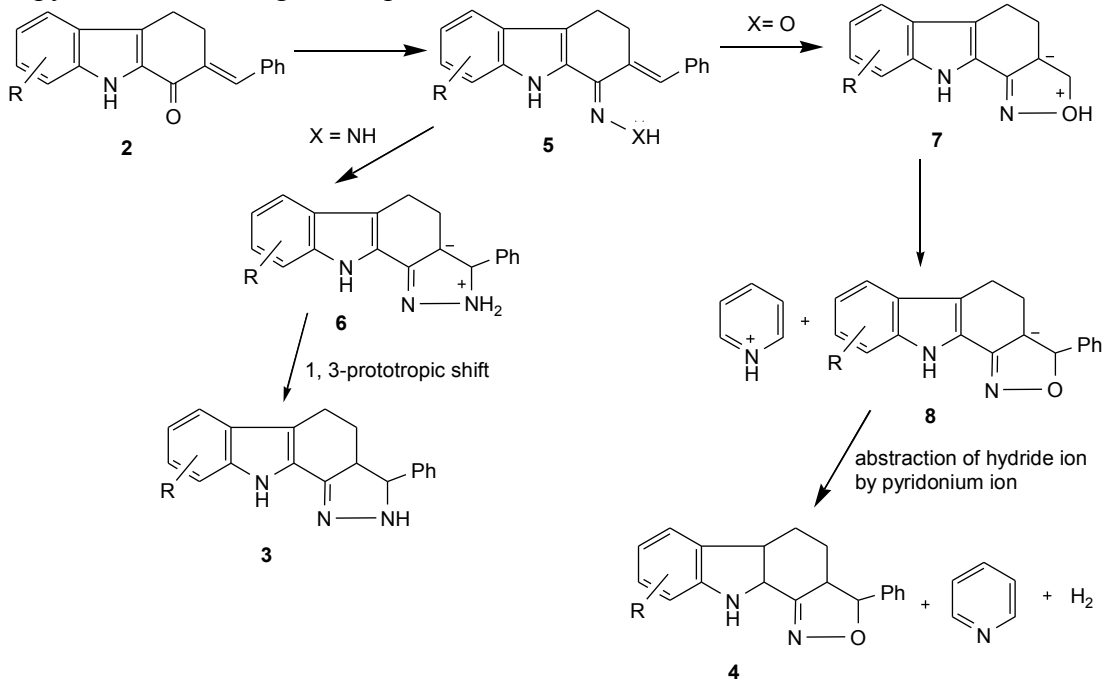



| $R_1$ | $R_2$ | $R_3$ | Abbreviation |
|---|---|---|---|
| H | H | H | **2,4a** |
| $CH_3$ | H | H | **2,4b** |
| H | $CH_3$ | H | **2,4c** |
| H | H | $CH_3$ | **2,4d** |
| Cl | H | H | **2,4e** |
| Br | H | H | **2,4f** |

**Scheme 4**. Preparation of isooxazolo[3,4-*a*]carbazoles

The proposed mechanism for the formation of the products (**3,4**) from the compound **2** is given in **Scheme 5**. The compound **2** also reacted separately with hydrazine hydrate in pyridine and with hydroxylamine hydrochloride in ethanol and the starting materials were recovered in both the cases. The lone pair of electrons on nitrogen of the hydrozones intermediate **5** (X=NH) (obtained from the reaction of **2** with hydrazine hydrate in ethanol) attacks benzylic carbon to pave the way for the formation of carbanion intermediate **6**, which undergoes 1,3-prototropic shift to yield the expected product **3**.

In the formation of product **4**, a lone pair of electrons on oxygen of the ketoxime **5** (X=O) (obtained from the reaction **2** with hydroxylamine hydrochloride in pyridine) attacks the benzylic carbon to afford the carbanion intermediate **7** which subsequently loses hydride ion to pyridonium ion to give the product **4**.




**Scheme 5**. Reaction mechanism of pyrazolo and isooxazolo[3,4-*a*]carbazoles

## Experimental

### General procedures

Melting points (Mp) were determined using a Mettler FP-5, in capillaries and are uncorrected. FT-IR (KBr, $cm^{-1}$) spectra were recorded on a Shimadzu spectrophotometer in the region of 400-4000 $cm^{-1}$. $^{1}H$ and $^{13}C$ NMR spectra were recorded on a Varian AMX-400 (400 MHz) spectrometer using TMS as an internal reference (Chemical shifts in δ ppm). Elemental analysis was performed on a Perkin Elmer 240 CHN-analyzer. Mass spectra were recorded employing a Joel Sx 102/Da-600 spectrometer in CDRI, Lucknow. Purity of the compounds were checked by TLC and chromatographed by column chromatographic technique.

### Preparation of 2-Benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole 2

A mixture of respective 1-oxo-1,2,3,4-tetrahydrocarbazole (**1)** (4 mmol) and 1-benzaldehyde (4 mmol) was mixed with 4% alcoholic potassium hydroxide (15 mL) and was stirred for 6 h. at room temperature. The precipitated crystalline product was filtered off and washed with rectified spirit. A further crop of the condensation product was obtained on neutralization with acetic acid and was diluted with water. The products were recrystalised from methanol (**Scheme 1**). The mass fragmentation pattern of the compound is given in **Scheme 2**.

*2-Benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2a***

Yield: 0.5 g, colour: Yellow, m.p 215-217°C, Infrared (KBr, $cm^{-1}$), 3262(N-H), 2922(C-H), 2399, 1649, 837, 704. $^{1}H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.20, 3.04 (2t, 2H, C(3), C(4), $J$ = 5.62, 6.11 Hz); 7.11-7.62 (m, 9H); 11.85 (br s, N-H). Anal. calcd. for $C_{19}H_{15}NO$ (273.33): C 83.48, H 5.53, N 5.12; found: C 83.47, H 5.51, N 5.10.

*6-Methyl-2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2b***

Yield: 0.4 g, colour: Yellow, m.p 220-223°C, Infrared (KBr, $cm^{-1}$), 3278(N-H), 2920(C-H), 1397, 1641, 804, 787. $^{1}H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.15, 2.98 (2t, 2H, C(3), C(4), $J$ = 4.91, 5.66 Hz); 2.45 (s, 3H, 6-$CH_3$); 7.11-7.67 (m, 8H); 11.72 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}NO$ (287.34): C 83.59, H 5.91, N 4.87; found: C 83.56, H 5.93, N 4.82.

*7-Methyl-2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2c***

Yield: 0.6 g, colour: Yellow, m.p 290-293°C, Infrared (KBr, $cm^{-1}$): 3401(N-H), 2925(C-H), 1398, 1659, 837, 704. $^{1}H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.18, 3.06 (2t, 2H, C(3), C(4), $J$ = 5.63, 6.10 Hz); 2.43(s, 3H, 7-$CH_3$); 7.11-7.60 (m, 8H); 11.85 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}NO$ (287.34): C 83.59, H 5.91, N 4.87; found: C 83.60, H 5.89, N 4.85.

*8-Methyl-2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2d***

Yield: 0.6 g, colour: Yellow, m.p 218-221°C, Infrared (KBr, $cm^{-1}$), 3260(N-H), 2920(C-H), 1397, 1651, 837, 704. $^{1}H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.22, 2.95 (2t, 2H, C(3), C(4), $J$ = 4.93, 5.68 Hz); 2.45(s, 3H, 8-$CH_3$); 7.12-7.66 (m, 8H); 11.92 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}NO$ (287.34): C 83.59, H 5.91, N 4.87; found: C 83.62, H 5.90, N 4.82.

*6-Chloro-2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2e***
Yield: 0.6 g, colour: Yellow, m.p 210-212 °C, Infrared (KBr, $cm^{-1}$), 3267(N-H), 2921(C-H), 1398, 1643, 803, 765. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.17, 3.01 (2t, 2H, C(3), C(4), *J* = 5.53, 6.53 Hz); 7.11-7.67 (m, 8H); 12.02 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{14}NOCl$ (307.66): C 74.16, H 4.55, N 4.55; found: C 74.15, H 4.52, N 4.58.
*6-Bromo-2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole* ***2f***
Yield: 0.6 g, colour: Yellow, m.p 225-227 °C, Infrared (KBr, $cm^{-1}$), 3257(N-H), 2980(C-H), 1399, 1623, 887, 837. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.05, 3.25 (2t, 2H, C(4), C(5), *J* = 6.26, 4.82 Hz); 7.00-7.70 (m, 8H); 7.80(s, 2NH); 9.45 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{14}NOBr$ (352.21): C 64.78, H 4.00, N 3.97; found: C 64.75, H 4.02, N 3.95.

**Preparation 4,5-Dihydro-3-phenyl-2*H*-pyrazolo[3,4-*a*]carbazole 3**

2-Benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole (**2**) (1 mmol) was dissolved in absolute ethanol (20 mL) and to this, hydrazine hydrate (0.5 mL, 10 mmol) was added and the mixture was kept in microwave oven for 5 min. The crude reaction mixture was poured into the ice cold water and extracted with chloroform, washed with water and the combined organic layer was dried over anhydrous sodium sulphate. Evaporation of the solvent followed by crystallization with pet. ether yielded the corresponding 4,5-dihydro-3-phenyl-2*H*-pyrazolo[3,4-*a*]carbazoles **3**. In the conventional method, the reactants were taken in the same molar ratio as in microwave assisted synthesis and the mixture was refluxed for 10 h. The same workup procedure as in microwave assisted synthesis was adopted to get the compound **3**.

*4,5-Dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3a***
Yield: 0.5 g, colour: Brown, m.p 130-133°C, Infrared (KBr, $cm^{-1}$), 3259(N-H), 2929 (C-H), 1345, 1645, 807, 802. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.04, 3.24 (2t, 2H, C(4), C(5), *J* = 6.25, 4.81 Hz); 7.01-7.72 (m, 9H); 7.79(s, 2NH); 9.42 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{15}N_3$ (271.23): C 84.13, H 5.53, N 15.48; found: C 84.15, H 5.51, N 15.50.
*6-Methyl-4,5-dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3b***
Yield: 0.6 g, colour: Brown, m.p 105-107°C, Infrared (KBr, $cm^{-1}$), 3240(N-H), 2931(C-H), 1341, 1642, 809, 792. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.03, 3.27 (2t, 2H, C(4), C(5), *J* = 6.21, 5.58 Hz); 2.39(s, 3H, 6-$CH_3$); 7.20-7.69 (m, 8H); 7.78(s, 2NH); 9.12 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}N_3$ (299.20): C 80.28, H 5.68, N 14.03; found: C 80.30, H 5.70, N 14.02.
*7-Methyl-4,5-dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3c***
Yield: 0.8 g, colour: Brown, m.p 170-172°C, Infrared (KBr, $cm^{-1}$), 3276(N-H), 2930(C-H), 1348, 1640, 809, 703. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.05, 3.26 (2t, 2H, C(4), C(5), *J* = 6.29, 5.98 Hz); 2.45(s, 3H, 7-$CH_3$); 7.22-7.70 (m, 8H); 7.80(s, 2NH); 9.07 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}N_3$ (299.20): C 80.28, H 5.68, N 14.03; found: C 80.32, H 5.71, N 14.01.
*8-Methyl-4,5-dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3d***
Yield: 0.7 g, colour: Brown, m.p 90-93 °C, Infrared (KBr, $cm^{-1}$), 3245(N-H), 2921(C-H), 1310, 1640, 859, 800. $^1$H nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.05, 3.25 (2t, 2H, C(4), C(5), *J* = 6.20, 4.79 Hz); 2.45(s, 3H, 8-$CH_3$); 6.80-7.60 (m, 8H); 7.81(s, 2NH); 9.40 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{17}N_3$ (299.20): C 80.28, H 5.68, N 14.03; found: C 80.30, H 5.70, N 14.00.

*6-Chloro-4,5-dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3e***

Yield: 0.7 g, colour: Yellow, m.p 180-183 °C, Infrared (KBr, $cm^{-1}$), 3265(N-H), 2924(C-H), 1374, 1643, 865, 809 $cm^{-1}$. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.05, 3.25 (2t, 2H, C(4), C(5), $J$ = 6.49, 4.75 Hz); 7.00-7.70 (m, 8H); 7.80(s, 2NH); 9.30 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{14}N_3Cl$ (319.66): C 71.38, H 4.37, N 13.13; found: C 71.40, H 4.39, N 13.15.

*6-Bromo-4,5-dihydro-3-phenyl-2H-pyrazolo[3,4-a]carbazole* ***3f***

Yield: 0.8 g, colour: Yellow, m.p 175-178 °C, Infrared (KBr, $cm^{-1}$), 3261(N-H), 2923(C-H), 1380, 1644, 867, 805. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 3.05, 3.25 (2t, 2H, C(4), C(5), $J$ = 6.26, 4.82 Hz); 7.00-7.70 (m, 8H); 7.80(s, 2NH); 9.45 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{14}N_3Br$ (364.23): C 62.64, H 3.84, N 11.53; found: C 71.40, H 3.85, N 11.54.

**Preparation of 3-Phenyl isooxazolo[3,4-*a*]carbazole 4**

2-benzylidine-1-oxo-1,2,3,4-tetrahydrocarbazole (**2**) (1 mmol) was mixed with hydroxylamine hydrochloride (1 g, 14 mmol) in pyridine (5 mL) and the reaction mixture was kept in microwave oven for 5 min. The reaction mixture was then poured into crushed ice. The resulting semi-solid separated out was extracted with chloroform and subsequently washed with dilute hydrochloric acid and water and dried over anhyd. sodium sulphate. Removal of solvent yielded the crude product which was then purified by column chromatography using pet. ether, EtOAc as solvent system over silica gel. The product was recrystallised from the same solvent system. In the conventional method, the reactants were taken in the same molar ratio as in microwave assisted synthesis and the mixture was refluxed for 10 h. The same workup procedure as in microwave assisted synthesis was adopted to get the compound **4**.

*3-Phenyl isooxazolo[3,4-a]carbazole* ***4a***

Yield: 0.8 g, colour: Brown, m.p 210-212 °C, Infrared (KBr, $cm^{-1}$), 3230(N-H), 2291(C-H), 1398, 1615, 823, 745. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.90 (m, 2H, C(4); 3.20 (m, 2H, C(5); 7.00-8.02 (m, 9H); 10.30 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{14}N_2O$ (286.19): C 79.73, H 4.89, N 9.78; found: C 79.75, H 4.90, N 9.79.

*6-Methyl-3-phenyl isooxazolo[3,4-a]carbazole* ***4b***

Yield: 0.6 g, colour: Brown, m.p 123-125 °C, Infrared (KBr, $cm^{-1}$), 3252(N-H), 2925(C-H), 1329, 1650, 805, 790. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.41 (s, 3H, 6-$CH_3$); 3.02 (m, 2H, C(4); 3.19 (m, 2H, C(5); 6.98-8.00 (m, 8H); 10.01 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{16}N_2O$ (300.34): C 79.97, H 5.32, N 9.32; found: C 79.95, H 5.33, N 9.35.

*7-Methyl-3-phenyl isooxazolo[3,4-a]carbazole* ***4c***

Yield: 0.7 g, colour: Brown, m.p 110-113 °C, Infrared (KBr, $cm^{-1}$), 3264(N-H), 2918(C-H), 1397, 1626, 908, 823. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.40 (s, 3H, 7-$CH_3$); 3.00 (m, 2H, C(4); 3.20(m, 2H, C(5); 6.90-8.10 (m, 8H); 10.20 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{16}N_2O$ (300.34): C 79.97, H 5.32, N 9.32; found: C 79.96, H 5.31, N 9.30.

*8-Methyl-3-phenyl isooxazolo[3,4-a]carbazole* ***4d***

Yield: 0.7 g, colour: Brown, m.p 110-113 °C, Infrared (KBr, $cm^{-1}$), 3244(N-H), 2922(C-H), 1376, 1621, 798, 787. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.20 (s, 3H, 8-$CH_3$); 3.00 (m, 2H, C(4); 3.20(m, 2H, C(5); 6.70-8.10 (m, 8H); 10.10 (br s, N-H) ppm. Anal. calcd. for $C_{20}H_{16}N_2O$ (300.34): C 79.97, H 5.32, N 9.32; found: C 79.95, H 5.30, N 9.31.

*6-Chloro-3-phenyl isooxazolo[3,4-a]carbazole* ***4e***

Yield: 0.8 g, colour: Brown, m.p 130-133 °C, Infrared (KBr, $cm^{-1}$), 3246(N-H), 2924(C-H), 1320, 1626, 862, 796. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.90 (m, 2H, C(4); 3.20 (m, 2H, C(5); 7.00-8.10 (m, 8H); 10.30 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{13}N_2OCl$ (320.66): C 71.16, H 4.05, N 8.73; found: C 71.15, H 4.03, N 8.72.

*6-Bromo-3-phenyl isooxazolo[3,4-a]carbazole* ***4f***

Yield: 0.8 g, colour: Brown, m.p 172-175 °C, Infrared (KBr, $cm^{-1}$), 3245 (N-H), 2922(C-H), 1320, 1625, 862, 796. $^1H$ nmr (400 MHz, $CDCl_3$-TMS), δ (ppm) 2.92 (m, 2H, C(4); 3.20(m, 2H, C(5); 7.01-8.08 (m, 8H); 10.02 (br s, N-H) ppm. Anal. calcd. for $C_{19}H_{13}N_2OBr$ (365.09): C 62.50, H 3.56, N 7.66; found: C 62.51, H 3.57, N 7.65.

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