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FULL PAPER

The synthesis, identification, and evaluation of some new antioxidant activities β-lactam from N-carbazole derivatives

Mohammed Hasan Mohammed AL-Dahlaki | Suaad M.H. Al-Majidi

Department of Chemistry, Collage of Science, University of Baghdad, Baghdad, Iraq

This research involved the synthesis of new four-member cyclic derivatives by reacting carbazole with NaH in dry DMF at 0 °C to give a sodium salt carbazole suspended in water and react with chloroacetyl chloride to form chloro-N-carbazole acetamide chemically combining compound (1) with hydrazine hydrate yields and its respective hydrazino derivatives (2). Condensation reaction of compound 2 with various aromatic aldehydes to give Schiff base derivatives (3-8) 2-Azetidinones (9-14) and 2-diazetdinone derivatives (14-26) were synthesized by cyclization of Schiff base derivatives (3-8) with chloroacetyl chloride, phenyl isocyanate, and phenyl isothiocyanate, respectively. The physical properties and melting points of the prepared compounds were determined. Spectral methods [IR, 1H-NMR, and 13C-NMR] were used to identify new compounds. Additionally, the activity and antioxidant capacity of the newly synthesized compounds were determined using the DPPH scavenging activity method and compared to a standard, ascorbic acid.

***Corresponding Author:**
Mohammed Hasan Mohammed AL-Dahlaki
Email: setmony@gmail.com
Tel.: +07817539469

KEYWORDS

Carbazole; β-lactam; antioxaidant activity; DPPH (2,2-diphenyl-1-picrylhydrazyl).

Introduction

Carbazole alkaloids have a fragrant tricyclic bone structure composed of a ring central pyrrole intertwined between two benzene rings. Due to the intriguing structural properties and promising therapeutic properties of these natural product, great strides have been made in the carbazole alkaloids field [1,2]. Heterocycles are a subclass of pharmacologically active compounds. Carbazoles, especially naturally occurring carbazole, have significant anti-cancer properties. For example, in 1965, Chakraborty isolated the first natural product of carbazole, murrayafoline A, from the Murraya koenigii tree; Murrayafoline A is an antibiotic [3] and an antitumor product [4]. Carbazole products are used in a wide range of high-tech applications, including organic light emitting diodes (OLEDs), organic photovoltaics (OPVs), dye solar cells (DSSCs), and sensors [5,6]. Carbazoles have been extensively studied for its biological properties, including antimicrobial [7], antiprotozoal [8], and pesticide activity, as well as anti-inflammatory [9,13], antiviral [10], antifungal [11], antibacterial [12], anti-inflammation [13], antioxidative [1], antiplatelet aggregative [1], and neuroprotective activity [14]. Three carbazole alkaloids, O-methylmukonal, 3-formyl-2,7-dimethoxycarbazole, and clauszoline-J, demonstrated promising anti-HIV-1 activity, with EC50 values of 2.7, 7.4, and 8.2 μg/mL, respectively, and PTI values of 56.7, 8.0, and 1.6, respectively [15].

Materials and procedures

All starting chemical compounds were obtained from Fluka or Aldrich. Using Gallenkamp and a Thomas capillary freezing point apparatus, melting points (MP) were determined in open glass capillaries and they were uncorrected. SHIMAZU INFRARED - 8400 Fourier transform infrared spectrophotometer used the KBr disc's INFRARED spectra. Purified and commercially available primary components and reagents were employed in their entirety. To record ^{1}H-NMR and ^{13}C-NMR spectra, a 500 MHz spectrometer was used. Agilent technologies model ultrashield nuclear resonance (NMR) spectra were acquired in dimethyl sulfoxide (DMSO-d6), and chemical shifts are given in (ppm) downfield using tetramethylsilane (TMS) as a reference. UV-vis spectra were acquired with a shimadzu spectrophotometer and an Apel PD-303 spectrophotometer, both made in Japan.

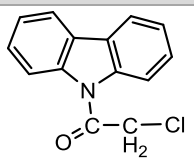
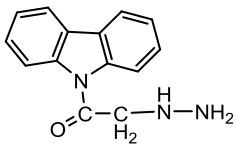
α-Chloro-N-carbazoleacetamide preparation (1) [16]

The carbazole compound solution (1.5 gram, 0.009 mole) in dry dimethylformamide (6 mL) was cooled to 0 °C and NaH (0.21 gm., 0.009 mol) was added to the solution in small amount on a periodic basis. Chloroacetyl chloride (0.66 mL, 0.009 mol) was added via syringe to the slurring and the mixture reaction was gradually brought to a temperature comparable to that of the surrounding air. After 14 hours, the reaction was quenched with water from the ethanol solvent via filtration and recrystallization. The table below summarizes the physical properties and IR absorption bands of the material (1).

α-Hydrazino -N- carbazoleacetamide preparation (2) [17]

In absolute ethanol, 1.5 gm of compound (1) (0.006 mol.) and 0.75 mL of hydrazine hydrate (0.012 mole.) were dissolved with constant stirring. After cooling the mixture, a white precipitate formed after it was refluxed in a water bath for 5 hours. Precipitate was present in the filtrate. The following table summarizes the product's physical and infrared spectral properties (1).

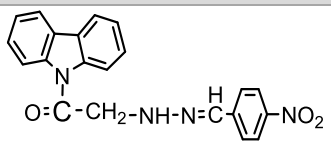
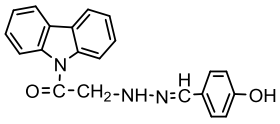
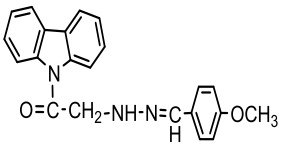
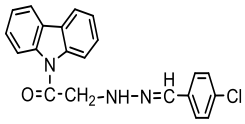
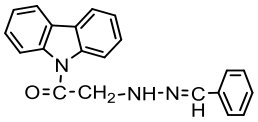
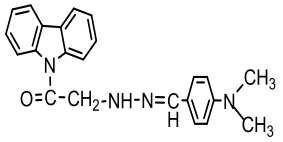
TABLE 1 Physical properties and infrared spectral data cm^{-1} compounds (1-2) of prepared

NO	Properties of physical				Absorption INFRARED spectra data (cm^{-1})				
Comp. No	Comp. structure	m.p. °C	Yield %	color	υ-NH	υ -CH Arom.	υ -CH Alpha.	υ -C=O	Other groups
1		138-140	80	yellow		3051	2923 2854	1699	υ C-Cl 750
2		230-232	85	Off white	3440	3051	2923 2852	1680	υ NH_2 Asym.3440 0 overlap Sym. 3315

Preparation of α-hydrazino-N-carbazoleacetamide Schiff base derivatives (3-8) [18]

Two to three drops of glacial acetic acid were added to the hot stirred solution of the hydrazide (2) (0.5 gm, 0.002 mol) in ethanol (5 mL). The para-substituted aromatic aldehyde (0.002 moles) added at (70-80) ºC for (4-6) hours were used to heat the reaction mixture. Filtration was used to remove any remaining liquid from the separated solid. The physical properties and FTIR spectral properties are listed in Table 2.

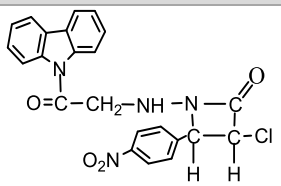
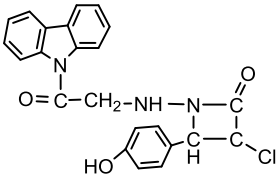
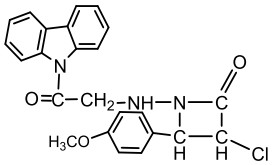
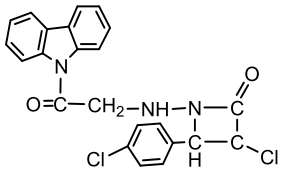
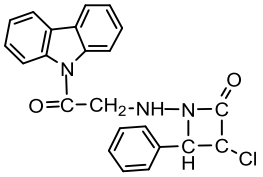
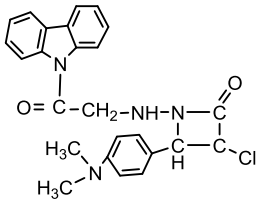
TABLE 2 physical properties & FT-IR data of spectral cm^{-1} of prepared compounds (3-8) Schiff base

NO	Physical properties				FTIR absorption spectra data (cm^{-1})				
Comp. No	Comp. structure	m.p. ℃	Yield %	color	ν N-H	ν C-H Arom.	ν C-H Alpha.	ν C=O	Other bands
3		173-175	90	Brown	3380	3051	2921 2850	1695	ν C=N 1660 ν NO_2 Asym.1537 Sym.1394 δ 817
4		210-212	80	pale yellow	3380	3051	2921 2850	1690	ν OH 3460 ν C=N 1650 ν C-O 1238 δ 840
5		189-190	85	Off yellow	3360	3033	2921 2840	1683	ν C=N 1650 ν C-O 1238 δ 846
6		190-192	80	Gray	3420	3053	2923 2848	1685	ν Cl 1091 ν C=N 1657 δ 850
7		188-190	75	Gray	3390	3031	2923 2870	1681	ν C=N 1660
8		128-130	75	Brown	3465	3051	2906 2819	1676	ν C=N 1660 δ 817

N- [3-chloro-4-(4-substituted phenyl)-2-oxoazetidine-1-yl) amino] aceto- 9H-carbazol-9-yl) (9-14) [19]

At 0-5 °C, a solution of Schiff bases (3-8) (0.001 mole.) in dry DMF (5 mL) was added to solutions of chloroacetyl chloride (0.086 mL, 0.001 mole.) and trimethylamine (0.15 mL, 0.001 mole) in dry DMF (3 mL). After refluxing the mixture at 110 °C for (14-16) hours, it was cooled to room temperature. The product compound (9-14) was rinsed with cold water & recrystallized using an appropriate solvent. The physical properties, infrared spectral and yield of compounds are listed in Table 3.

TABLE 3 properties of physical and FT-IR data of spectral cm^{-1} of prepared β-lactam compounds (9-14)

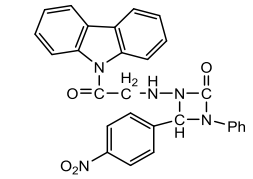
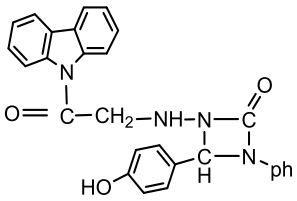
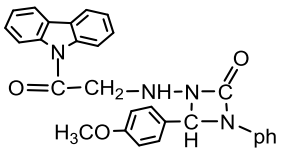
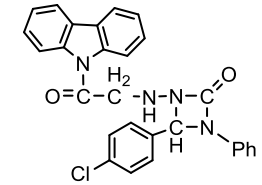
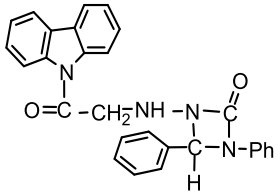
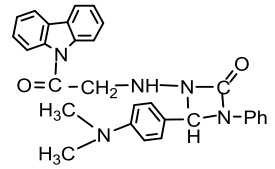
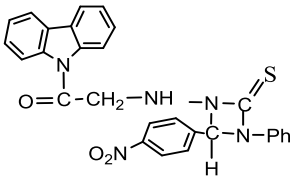
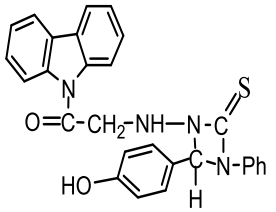
NO	Physical properties				Infrared absorption spectra data (cm^{-1})				
Comp. No	Comp. structure	m.p. ℃	Yield %	color	ν N-H	ν C-H Arom.	ν C-H Alpha.	ν C=O	Other bands
9		194 - 196	75	Brown	3350	3051	2921 2852	1701 1683	ν NO_2 Asym.1521 Sym.1396 ν C-Cl 927 δ 848
10		228 - 230	85	Gray	3365	3051	2921 2854	1699 1680	ν OH 3440 ν C-Cl 927 ν p-sub. 844
11		200 - 202	80	Gray	3480	3051	2923 2852	1690 1670	ν C-O 1238 ν C-Cl 927 ν p-sub. 844
12		195 - 197	75	Off white	3420	3051	2929 2850	1685 1650	ν C-Cl 929 ν p-sub. 852
13		170 - 172	75	Brown	3340	3051	2925 2854	1697 1652	ν C-Cl 927
14		192 - 194	80	Yellow	3440	3051	2921 2854	1679 1664	v C-Cl 929 δ. 819

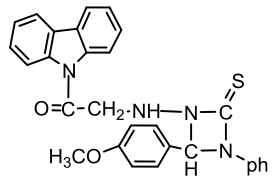
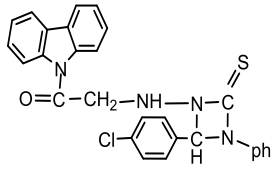
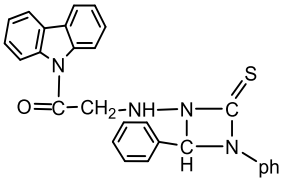
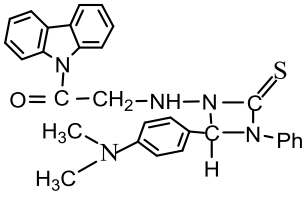
Synthesis of N- [2-oxo-3-phenyl-4-(4-substituted phenyl-1,3-diazetidine-1-yl amino) acetamide] carbazol-9-yl. (15-20)

N- [(2-oxo-3-phenyl-4-(4-substituted phenyl)-1,3- diazetidine-1-yl) amino) aceto] carbazol-9-yl)- 2-thione. (20-26) [19]

Mixture of Schiff base (3-8) (0.02mol) with dry DMF (12 mL) (phenyl isocyanate, phenylisothiocyanate) (0.02 mol) was added in few amounts with continuous stirring also, the mixture was gradually heated, then refluxed for (6-7) hours. Then, it was filtered and dried. Physical properties of compounds (15-26) and INFRARED spectral are shown in Table 4.

TABLE 4 physical properties and FT-IR spectral data cm^{-1} of prepared 1,3-diazetidine compounds (15-26)

NO	Physical properties				INFRARED absorption spectra data (cm^{-1})				
Comp. No	**Comp. structure**	**m.p. ℃**	**Yield %**	**color**	**ν N-H**	**ν C-H Arom.**	**ν C-H Alpha.**	**ν C=O**	**Other bands**
15		167-168	70	pale yellow	3299	3012	2923 2850	1692 1672	ν NO_2 Asym. 1560 Sym. 1396 δ 848
16		221-223	80	Gray	3332	3051	2918 2848	1681 1667	ν OH 3460 ν C-O 1284 ν p-sub. 856
17		190-192	72	Off white	3298	3051	2925 2854	1699 1679	ν C-O 1238 ν p-sub. 842
18		184-186	75	Off white	3326	3053	2842 2815	1686 1660	ν C-Cl 1091 ν p-sub. 850
19		197-198	80	Off white	3299	3053	2925 2850	1699 1673	
20		173-174	75	Yellow	3294	3053	2923 2819	1699 1660	ν p-sub. 817
21		220-222	80	Brown	3360	3049	2923 2852	1679	ν NO2 Asym. 1521 Sym. 1396 ν C=S 1452 ν p-sub. 850
22		187-188	85	Brown	3205	3049	2921 2852	1699	ν OH 3400 ν C=S 1452 ν C-O 1236 ν p-sub. 840

23		208-210	85	Off white	3330	3051	2954 2898	1681	ν C=S 1452 ν C-O 1288 ν p-sub. 858
24		150-152	90	pale yellow	3346	3051	2925 2850	1681	ν C=S 1450 ν C-Cl 1091 ν p-sub. 848
25		202-204	85	pale yellow	3461	3047	2931 2850	1681	ν C=S 1452
26		194-196	75	Brown	3207	3051	2923 2854	1679	ν C=S 1452 δ 817

Antioxidant activity (DPPH radical scavenging assay)

The antioxidant activity of compounds (1-26) was assessed using the stable DPPH free radical according to a known procedure [20]. Three different concentrations 100, 200 and 400 µg/mL of the synthesized compounds (1-26) were mixed with EtOH solution (up to 2mL) including 0.0002 µg/mL of DPPH. The absorbance of the reaction mixture was measured at 517 nm after incubation for 30 min at room temperature, using spectrophotometer. Ascorbic acid was used as a control at the same concentrations of the tested compounds. Percentage inhibitions of compounds (1-26) and that of ascorbic acid were calculated using the following formula:

DPPH inhibition effect7 (%) =((Ac-As)/Ac) *100

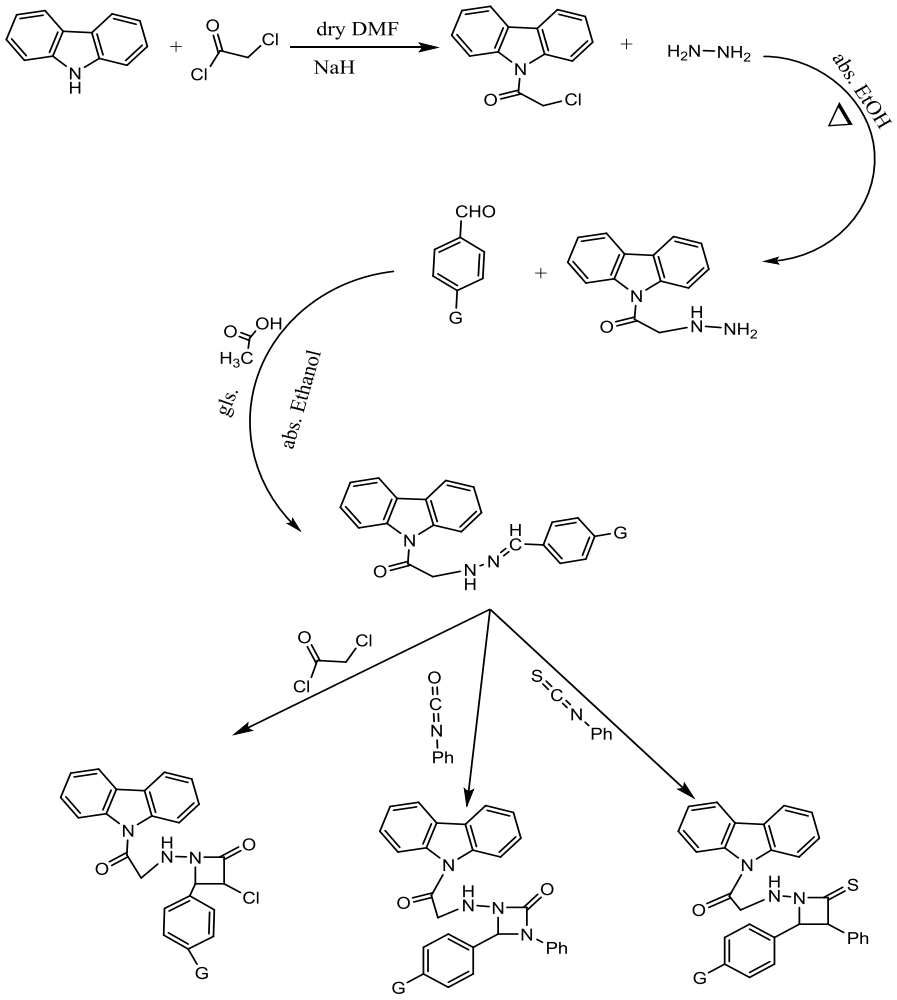
Were

Ac=Absorbance reading of the control

As=Absorbance reading of the sample

Results and discussion

In this research, new α-Chloro-N-carbazole acetamide (1), α-hydrazino-N- carbazole acetamide (2), it's Schiff bases derivatives (3-8), and β-Lactams (9-14), 1,3-diazetidine (15-26) were synthesized, as shown in Scheme 1.



SCHEME 1

Carbazole reaction with sodium hydrate and chloroacetylchloride to give compound (1) was confirmed by physical properties which are listed in Table 1. Infrared spectral data showed the absorption at 3051 and 2923, 2854 cm^{-1} for ν (C-H Aromatic and υ C-H alpha.) respectively 1699 cm^{-1} for υ (C=O) amide [21] 750 cm^{-1} for (C-Cl). The compound (1) reacted with hydrazine hydrate to give α-hydrazino-N-carbazole acetamide (2). FITR spectrum data showed absorption at 3440, 3051, (2923, 2852), 3440 overlap, 3315 cm^{-1} could be attributed to N-H, υ C-H Aromatic and υ C-H Alpha. υ NH_2 Asym. and Sym. Respectively and 1680 cm^{-1} for υ (C=O). While the ^{1}H-NMR spectra data of compound (2) ppm in DMSO-d_6 solvent [22] shown in Table (5) (3.25) (s,2H, -$COCH_2$-); 4.25 (s,2H, NH_2); 7.1-7.5 (m,8H, Ar-H); 8.13 (s,1H, -NH-). ^{13}C-NMR spectra for compound (2) shown in Table 6. The Schiff bases (3-8) were synthesized by condensation reaction of α-hydrazino-N-carbazole acetamide (2) with different substituted aromatic aldehydes with a little drop of glacial acetic acid in absolute ethanol to form Schiff's bases (3-8) (Scheme 1). The sterchaning absorption bands showed at (3465- 3380) cm^{-1} for υ(N-H) and confirmed the formation of compound (3-8) from the appearance of the bands at (1660-1650) cm^{-1} to υ (N=C) of Schiff's bases (3-8), respectively [23]. With the disappearance of υ (NH_2), all details of infrared spectral data to compounds (3-8) were in Table 2. ^{1}H-NMR spectrum of compound 7 was shown in Table 5, a singlet signal at δ= (3.38) ppm for (O=C-CH_2) proton,

a singlet signal at δ = (6.80) ppm due to (-NH-N -) proton, multiplate signal at δ = (7.16-8.18) ppm is due to aromatic rings (Ar-H) protons, a singlet signal at δ = (8.60) ppm due to(-N=CH-). ^{1}H-NMR spectrum of compound (8) shown in Table 5, 3.23 (s,6H, $N(CH_3)_2$), 3.37), 3.37 (s,2H, O=C-CH_2), 6.81 (s,1H, -NH-N), -NH-N), 7.15-8.18 (m,12H, Ar -H), 8.52 (s,1H, N=CH). ^{13}C-NMR spectra for compound (7,8) shown in Table 6.

TABLE 5 ^{1}H -NMR spectral data ($^{\delta}$ ppm) for compounds

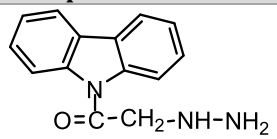
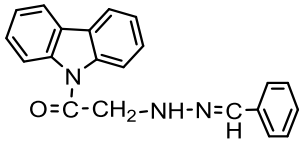
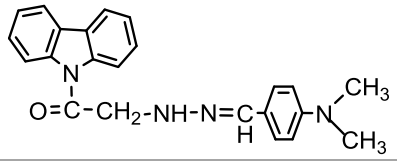
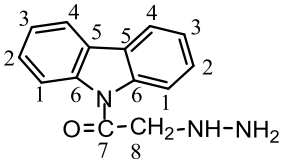
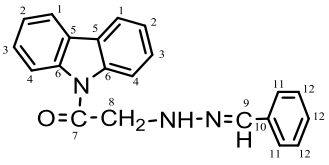
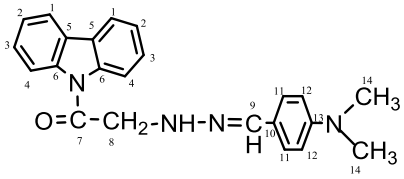
No	Compound structure	^{1}H -NMR spectral data ($^{\delta}$ ppm)
2		3.25 (s, 2H, -$COCH_2$ -), 4.25 (s, 2H, NH_2),7.1-7.5 (m, 8H, Ar-H), 8.13 (s, 1H, -NH-).
7		3.38(S, 2H, O=C-CH_2), 6.80(S, H, -NH-N), 7.16-8.13(m,12H, Ar-H), 8.60(S,1H, -N=CH)
8		3.23(S,6H, N(CH3), 3.372 (S, 2H, O=C-CH_2), 6.81(S, H, -NH-N), 7.15 8.18(m,12H, Ar-H), 8.52(S,1H, N=CH)

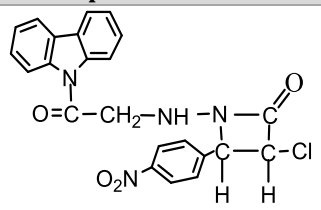
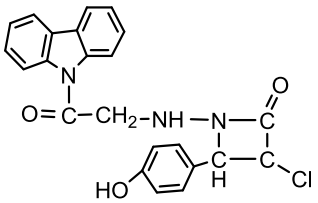
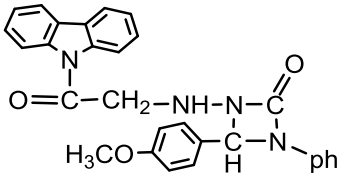
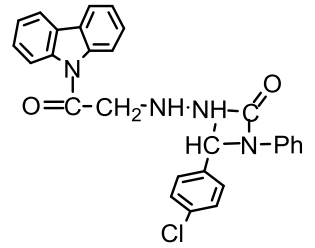
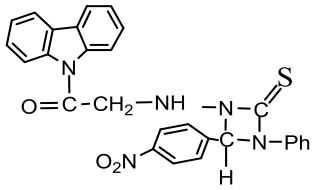
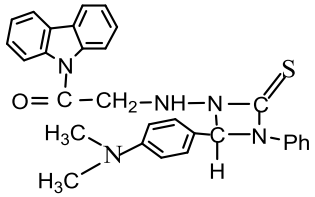
TABLE 6 ^{13}C -NMR spectral information ($^{\delta}$ ppm)) for compounds

No	Compound structure	^{13}C -NMR data of spectral ($^{\delta}$ ppm)
2		79.56(C8), 109.71-122.87(C2, C3, C4), 122.36-139.71(C12, C5), 140.20(C6), 170.16(C7)
7		50.10(C8), 110.01(C2), 111.39(C3), 118.94-122.95(C4, C6, C5, C1), 125.97(C11), 131(C12), 136(C9), 140.17(C10), 163.60(C7)
8		40.49(C14), 50.10(C8), 108-111.47(C2, C3, C12), 118(C1), 120.61(C5), 122.84(C4), 125.96(C6), 128(C11), 131.30(C9), 135.90(C10), 140.16(C13), 163.75(C7)

Schiff bases (3-8) were reacted with chloroacetyl chloride followed by the addition of triethylamine to produce the compounds of N- [3-chloro-4-(4-substituted phenyl)-2-oxoazetidene-1-yl) amino] aceto-9H-carbazol-9-yl) (9-14). The structure of azetidine-2-one has been confirmed by infrared spectroscopy. Infrared spectrum for compound (9-14) showed the appearance of the absorption band (3480, 3440, 3420, 3365, 3350, 3340) cm^{-1} for υ(N-H), (1701-1679) cm^{-1} and at (1683-1650) cm^{-1} for the υ(C=O) amide. Every detail of a compound's infrared spectral data (9-14) was indicated in Table 3. Table 7 shows the 1H-NMR spectrum of compound 9 at a signal of singlet δ = (3.23) ppm for (H_2 C-C=O) protons, at a signal of singlet δ = (4.40) ppm to (-CH-Cl azetidine ring) protons, at a signal of singlet δ = (4.80) ppm for (-CH azetidine ring), at a signal of singlet δ = (6.80) ppm to (-NH-N) protons, multiplate signals at δ = (7.15-8.19) ppm are Ar-H due to aromatic rings protons,

^{1}H-NMR spectrum of compound (10) shown in Table 7, at a signal of singlet δ = (3.39) ppm due to (H_2C-C=O) protons, at a signal of singlet δ = (4.60) ppm for (-CH-Cl azetidine ring), at a signal of singlet δ=(5.00) ppm for (-CH azetidine ring), at a signal of singlet δ = (6.89) ppm to (-N-NH-) protons, at δ = (S, 7.16-8.18) ppm Ar-H to protons in aromatic rings, at signal of singlet δ=(8.90) ppm to (-OH) protons. Data for the compounds (9,10) 13C-NMR spectroscopy are shown in Table 8.

TABLE 7 ^{1}H -NMR spectral data ($^\delta$ ppm) for compounds

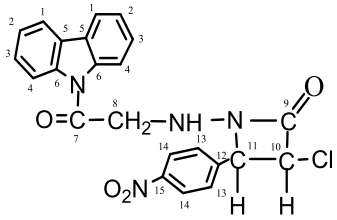
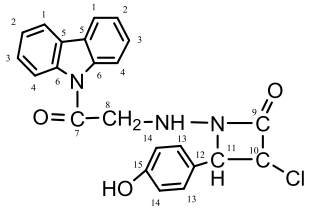
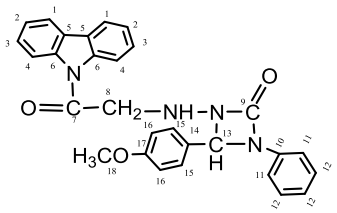
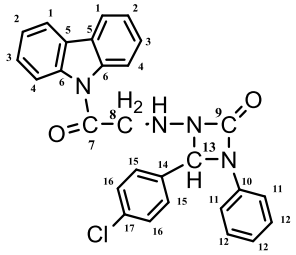
No	Compound structure	^{1}H -NMR spectral data ($^\delta$ ppm)
9		3.23(S,2H, O=C-CH_2), 4.40(S, H, -CH-Cl azetidine ring), 4.80(S, H, - CH azetidine ring), 6.80(S, H, -NH-N), 7.15-8.19(m,12H, Ar-H)
10		3.39(S,2H, -O=C-CH_2), 4.60(S, H, - CH-Cl azetidine ring), 5.00(S, H, -CH azetidine ring), 6.89(S, H, -NH-N), 7.16-8.18(m,12H, Ar-H), 8.90(S, H, -OH)
17		3.22(S,3H, CH3), 3.36 (S,2H, O=C-CH_2), 4.45 (S, H, - CH diazetidine ring), 6.99(S, H, -NH-N), 7.15-8.67(m,17H, Ar-H)
19		3.40(S,2H, O=C-CH_2), 5.65(S, H, -CH diazetidine ring), 6.99(S, H, -NH-N), 7.15-8.68(m,17H, Ar-H)
21		3.38(S,2H, O=C-CH_2), 5.63(S, H, CH diazetidine ring), 6.90(S, H, -NH-N), 7.16-8.44(m,17H, Ar-H)
26		3.05 (S,6H, N(CH_3)$_2$, 3.36(S, 2H, O=C-CH_2), 5.50(S, H, CH diazetidine ring), 6.81(S, H, -NH-N), 7.12-8.13(m,17H, Ar-H)

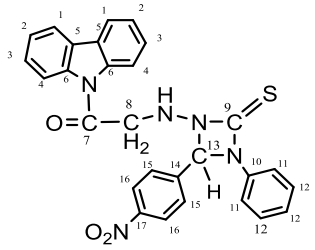
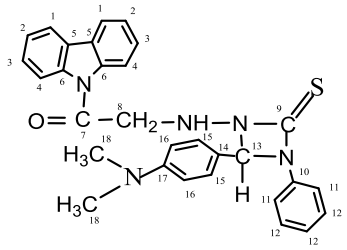
Schiff bases (3–8) react with phenyl isocyanate and phenyl isothiocyanate in dry DMF under reflux to form 1,3-diazetidine (15–26). The structure of 1,3-diazetidine derivatives has been definite by infrared spectroscopy. Infrared spectrum of the synthesized compounds (15-20) for phenyl isocyanate showed υ (N-H) at (3332-3298) cm^{-1}, (1699-1672) cm^{-1} and at (1673-1660) cm^{-1} for the υ(C=O) amide.

^{1}H-NMR spectrum of compound (17) has been shown in Table 7 at a signal of singlet δ = (3.22) ppm to (-CH3)protons, at signals of singlet δ = (3.36) ppm to(H_2C-C=O)protons,

at a signal's of singlet δ = (4.45) ppm, for (-CH diazetidine ring), at a signal of singlet δ = (6.99) ppm is due to (-NH-N-) protons, a signals at δ = (7.15-8.67) ppm (Ar-H) due to aromatic rings protons. ^{1}H-NMR spectrum of compound (18) has been shown in Table (7) at a signal of singlet δ = (3.40) ppm for (H_2C-C=O) protons, at signal of singlet δ= (5.65) ppm for (-CH diazetidine ring), at a signal of singlet δ = (6.99) ppm is due to (-NH-N) protons, a signal at δ = (7.15-8.68) ppm (Ar-H) due to aromatic rings protons. ^{13}CNMR spectral data of compound (17,18) is shown in Table 8. Infrared spectrum for compounds (20-26) for phenyl isothiocyanate showed υ (N-H) at (3461-3205) cm^{-1} and bands of υ (C=O) at (1699-1679) cm^{-1}, in addition to the disappearance bands of υ (N=C) with appearance of υ(C=S) at (1452-1450) cm^{-1}. Infrared spectral data for compounds (15-26) is listed in a Table 4 that includes all information. ^{1}H-NMR spectrum of compound (21) shown in Table 7 showed at a signal of singlet δ = (3.38) ppm to (O=C-CH2) protons, a signal of singlet δ = (5.63) ppm for (-CH diazetidine ring), at a signal of singlet δ = (6.90) ppm is to (-NH-N) protons, a signal at δ = (7.16-8.44) ppm (Ar-H) for aromatic rings protons. ^{1}H-NMR spectrum of compound (26) shown in Table 7; at a signal of singlet δ = (3.05) ppm to $N(CH_3)_2$ protons, at a signal of singlet δ = (3.36) ppm to(H_2C-C=O) protons at a signal of singlet δ = (5.50) ppm for (H-C-diazetidine ring), at a signal of singlet δ = (6.81) ppm is to (-N-NH-) protons, a signals at δ = (7.12-8.13) ppm (Ar-H) to aromatic rings protons. ^{13}C-NMR spectral data of compounds (21,26) was shown in Table 8.

TABLE 8 ^{13}C -NMR spectral data ($^{\delta}$ ppm) for compounds

No	Compound structure	^{13}C -NMR spectral data ($^{\delta}$ ppm)
9		53(C_8), 64(C_{10}), 68.30(C_{11}), 109.99(C_2), 111.38 (C_3), 118.93(C_4), 120.61(C_1), 122.84 (C_5), 125.96(C_6), 128(C_{13}), 134(C_{14}), 136.40 (C_{12}), 140.16(C_{15}), 164.80(C_7), 168.80(C_9)
10		51(C_8), 60.60(C_{10}), 65(C_{11}), 108.50-111.39 (C_{10}, C_2, C_3), 118.94(C_6), 120.62-122.86(C_4, C_5), 125.87(C_{13}), 131(C_{14}), 136(C_{12}), 140.17 (C_{15}), 160(C_7), 168(C_9)
17		70 (C13), 86(C18), 106-110(C8, C2, C3,), 115(C4), 118.18-120.14(C1, C5), 122.37(C6), 125.49(C11), 128.81(C12), 130.50(C16), 134.20(C15), 135(C10), 139.69(C17), 160(C7), 168(C9)
19		50.01(C8), 65(C13), 111.38(C3, C1), 118.65(C2), 119.93(C4), 120.60(C5), 122.27 (C6), 123.84(C11), 129.22(C15), 130.26(C10), 125.95(C12), 131.62 (C16), 139.17 (C14), 140.20(C17), 165(C7), 170(C9)

21		53(C8),66 (C13), 106(C2), 111.39(C3), 115.10(C1), 118.94-122.85(C4, C5, C6), 125.96(C11), 128(C12), 132.20(C15), 135.90(C16), 140.17(C14), 143(C10), 150.85(C17), 164.90(C7), 177(C9)
26		40.48(C18), 50.03(C8), 65.50(C13), 104(C2), 108(C3), 111.38(C1), 118.93(C4), 120.62(C5), 122.83(C6), 125.96-128.50(C11, C12), 134.50(C10), 136(C16), 140.15(C15), 154.06(C17), 165(C7), 175.50(C9)

Antioxidant activity

Antioxidants are critical compounds that inhibit or neutralize free radicals, thereby protecting cells from oxidative damage [24]. As with any other radical chain reaction, autoxidation consists of three steps: initiation, propagation, and termination [25]. As a result, the development of effective antioxidant agents requires sufficient attention during the drug design and discovery process [26]. The antioxidant activity of the compounds was determined in vitro using DPPH scavenging activity.

DPPH scavenging activity

All the compounds (1-26) and starting carbazole showed comparable or slight less activity to the standard (ascorbic acid). It was predestined by DPPH (2,2-diphenyl-1-picrylhydrazyl) assay method at various concentrations (100 ,200 and 400 µg/mL). The compound is known as an antioxidant or a non-antioxidant by changing the color of the compound (DPPH) from violet to colorless, or there is a change in the color of the compound (DPPH), and this change depends on the color of the compound used. The compound is considered an antioxidant if there is a change in color (DPPH). Compounds (3,4,5,7,9,10,11,13,15,18 ,21,22,24, 25,26) exhibited the best results among all compounds. Some compounds (3,9,15,21) bearing a nitro group (electron withdrawing group) at para position showed high antioxidant activity when compared to some compounds that have methoxyl group (electron donating group). Compounds (7,13,25) substituted with halogen groups –Cl (electron withdrawing group) exhibit good antioxidant activity. Compounds that showed less antioxidant activity are (1,2,6,8,12,14,20) and carbazole. These compounds possessed good reducing power ability at medium concentration (200 µg/mL) among other compounds and exhibited close or higher antioxidant activity than the standard solution (ascorbic acid). Figure 1 represented the DPPH scavenging activity of the newly synthesized compound.

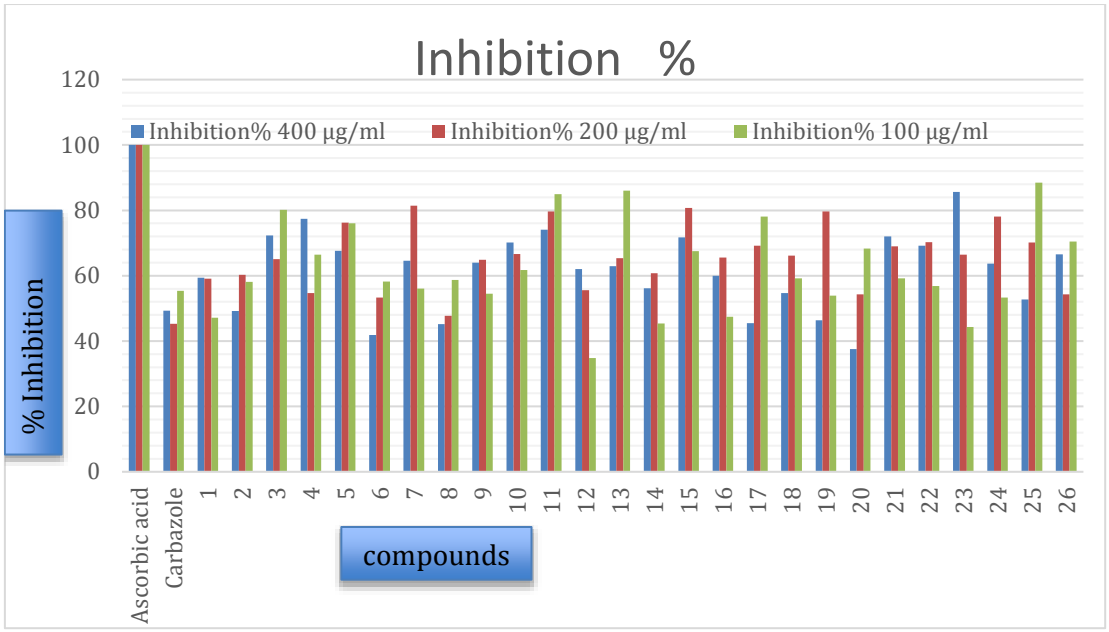


FIGURE 1 DPPH scavenging activity of the newly synthesized compound

Conclusion

New β-lactam derivatives were synthesized and identified by [FT-IR, ^{1}H-NMR & ^{13}C-NMR], physical and chemical properties, all this new synthesis of carbazole derivatives were studied in-vitro antioxidant activity; the results display that test had a good biological activity.

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