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Ultrasound- and Microwave-Assisted Synthesis of (*E*)-1-Aryl-3-[2-(piperidin-1-yl)quinolin-3-yl]prop-2-en-1-ones and (*E*)-1-Aryl-3-[2-(pyrrolidin-1-yl)quinolin-3-yl]prop-2-en-1-ones, and Their Antimicrobial Activity[1]

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Abstract—Series of new (*E*)-1-aryl-3-[2-(piperidin-1-yl)quinolin-3-yl]prop-2-en-1-ones and (*E*)-1-aryl-3-[2-(pyrrolidin-1-yl)quinolin-3-yl]prop-2-en-1-ones have been efficiently prepared via the Claisen-Schmidt condensation of 2-(piperidin-1-yl)quinoline-3-carbaldehyde and 2-(pyrrolidin-1-yl)quinoline-3-carbaldehyde, respectively, with aryl methyl ketones under conditions of ultrasound and microwave irradiation. Structures of the products have been confirmed by IR, ^{1}H NMR, ^{13}C NMR, and mass spectroscopy, as well as by elemental analysis. Evaluation of the *in vitro* antibacterial activity against bacterial (Gram-positive *Staphylococcus aureus* and Gram-negative *Escherichia coli*) and fungal (*Aspergillus niger* and *Candida metapsilosis*) strains has revealed good antimicrobial activity of some of the tested compounds.

Keywords: ultrasound-assisted synthesis, microwave-assisted synthesis, antimicrobial activity

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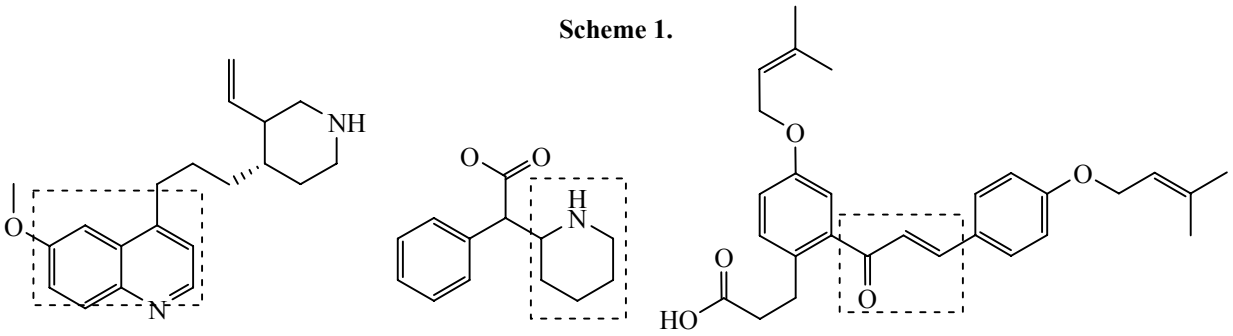
Quinoline and its derivatives represent a vast class of heterocycles that are found in many natural products and drugs [see example (a) in Scheme 1] and are of significant importance in medicinal applications. Several quinoline derivatives have been reported to exhibit various biological activities: antibacterial [1], antimalarial [2], antiallergenic [3], antiinflammatory [4], and antitumor [5]. Among the quinolines, 2-chloro-3-formylquinolines are of special importance for organic synthesis as key intermediates for further β-annelation of various ring systems and interconversion of many functional groups [6]. Piperidine derivatives are known as active pharmacological agents as well: antimicrobial [7], anticonvulsant [8], antiinflammatory [9], antidepressant (Paroxetine), and attention-deficit hyperactivity disorder (ADHD) [Methylphenidate, example (b) in Scheme 1] drugs. Pharmacological activity of pyrrolidines is versatile as well: they reveal antimicrobial [10], antitumor [10], anti-HIV [11], and anticonvulsant [12] activity. Chalcones form another important class of structures showing antimicrobial [13], anti-inflammatory [14], and anticancer [15] activity. For instance, Sofalcone [example (c) in Scheme 1] is a gastroprotective chalcone-based drug promoting healing of gastric ulcer and inhibiting some types of enzymes. Chalcones constitute an important class of natural products belonging to the flavonoid family [16] which are key precursors in synthesis of many biologically important heterocycles such as benzothiazepines [17], pyrazolines [18], 1,4-diketones [19], and flavones [20]. Preparation of chalcones has been therefore of emerging interest among organic as well as medicinal chemists (Scheme 1).

Microwave-assisted organic reaction enhancement (MORE) is nowadays a well established technique for synthesis of various heterocycles. Virtually any thermally driven reaction can be accelerated by microwave irradiation. The spectacular results (shorter reaction time, experimental simplicity, and selectivity) have clearly indicated the advantages of this technique over conventional heating. Similarly, the advantages of ultrasound-assisted synthesis include higher yields, shorter reaction times, and milder reaction conditions as compared with conventional methods. Our research group has made considerable efforts to design and put into practice innovative synthetic protocols adopting a more eco-sustainable approach [21]. As a part of our

[1] The text was submitted by the authors in English.

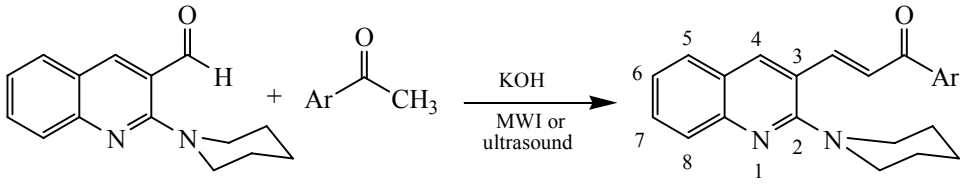
Scheme 1.



Viqualine Methylphenidate Sofalcone

(a) Quinoline-based drug (b) Piperidine-based drug (c) Chalcone-based drug

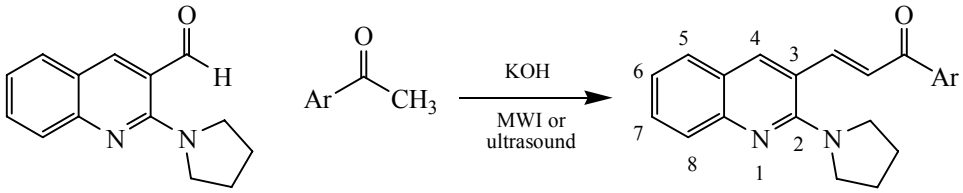
Scheme 2.



I **IIa–IIi** **IIIa–IIIi**

Ar = **a**: phenyl, **b**: 4-methylphenyl, **c**: 4-methoxyphenyl, **d**: 4-chlorophenyl, **e**: 4-bromophenyl, **f**: 4-nitrophenyl, **g**: 2-naphthyl, **h**: 1-naphthyl, **i**: thienyl.

Scheme 3.



IV **IIa–IIg** **Va–Vg**

Ar = **a**: phenyl, **b**: 4-methylphenyl, **c**: 4-methoxyphenyl, **d**: 4-chlorophenyl, **e**: 4-bromophenyl, **f**: 4-nitrophenyl, **g**: 1-naphthyl.

research program, herein we report on preparation of new (*E*)-1-aryl-3-[2-(piperidin-1-yl)quinolin-3-yl]prop-2-en-1-ones and (*E*)-1-aryl-3-[2-(pyrrolidin-1-yl)quinolin-3-yl]prop-2-en-1-ones via conventional and non-conventional (ultrasound- and microwave-assisted) methods. Structures of the prepared products are shown in the Schemes 2, 3; syntheses conditions are tabulated along with the observed melting points; results from other characterization methods are to be found in the Experimental.

All the compounds were screened for their antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* using ampicillin as a reference drug. The prepared compounds **IIIa**, **IIIe**, **Va**, **Vf**, and **Vg** showed good antibacterial activity against all the tested organisms. Screening of antifungal activity of the prepared products (against *Aspergillus niger* and *Candida metapsilosis* using grieseofulvin as standard drug) revealed that the products **IIIa**, **IIId**, **Vf**, and **Vg** showed good antifungal activity against all the tested organisms.

EXPERIMENTAL

Melting points were determined in open capillary tubes and are uncorrected. Purity of the compounds was checked by TLC using precoated silica gel plates

Preparation conditions of (*E*)-1-aryl-3-[2-(piperidin-1-yl)quinolin-3-yl]prop-2-en-1-ones (**IIIa–IIIi**) and (*E*)-1-aryl-3-[2-(pyrrolidin-1-yl)quinolin-3-yl]prop-2-en-1-ones (**Va–Vg**) and the products melting points

Product no.	mp, °C	Reaction time			Yield, %		
		conventional, h	USI[a], min	MWI[b], min	conventional, h	USI[a]	MWI[b]
IIIa	142	5.0	45	3.0	70	82	88
IIIb	102	5.5	40	3.5	71	84	90
IIIc	128	5.0	40	3.5	72	84	92
IIId	136	6.0	45	4.0	66	80	86
IIIe	120	6.0	45	3.5	68	79	87
IIIf	192	6.0	50	4.0	70	83	86
IIIg	186	6.0	40	4.0	72	80	90
IIIh	132	6.0	40	4.0	70	78	88
IIIi	172	5.0	40	3.0	74	80	90
Va	133	6.0	40	4.0	72	83	90
Vb	119	5.5	35	3.5	69	81	89
Vc	126	5.0	35	3.5	72	82	90
Vd	151	6.0	40	4.0	66	80	88
Ve	163	5.5	40	4.0	66	80	88
Vf	115	5.0	40	3.5	72	82	90
Vg	107	6.0	40	4.0	74	80	86

[a] Ultrasound irradiation. [b] Microwave irradiation.

60_{254} (Merck). Microwave reactions were carried out in the milestone multi SYNTH microwave system. Sonication was performed in Shanghai BUG40-06 ultrasonic cleaner (with a frequency of 25 kHz, 40 kHz, 59 kHz and a nominal power of 250 W). IR (KBr) spectra were recorded on a Shimadzu FT-IR-8400s spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded using the Bruker Avance II 400 MHz instrument with tetramethylsilane as an internal reference. Mass spectra were recorded using the CMS-QP 1000 EX mass spectrometer. Elemental analysis was determined with the Thermo Finnigan CHNS analyzer.

Antifungal activity evaluation. Antifungal activity of the products was tested against *Aspergillus niger* and *Candida metapsilosis* with grieseofulvin as a reference drug. The activity was determined using cup plate agar diffusion method by measuring the zone of inhibition in mm. The compounds were screened at concentration of 100 μg/mL in DMSO.

Preparation of (*E*)-1-aryl-3-[2-(piperidin-1-yl) quinolin-3-yl]prop-2-en-1-ones (IIIa–IIIi) and (*E*)-1-aryl-3-[2-(pyrrolidin-1-yl)quinolin-3-yl]prop-2-en-1-ones (Va–Vg) *(general procedures)***.** *Conventional method.* A mixture of 2-piperidin- (**I**) or 2-pyrrolidin-1-yl-quinoline-3-carbaldehyde **(IV)** (1 mmol), aryl methyl ketone **(IIa–IIi)** (1 mmol), and potassium hydroxide (3 mmol) was dissolved in ethanol (10 mL) and stirred at room temperature. The reaction progress was monitored by TLC; after completion of the reaction, the reaction mixture was poured into ice water and neutralized with diluted HCl solution. The separated solid was filtered off, washed with water, dried, and purified by column chromatography using (silica gel, eluent: hexane:ethyl acetate, 10 : 1, v/v) to yield the pure compounds **IIIa–IIIi** and **Va–Vg**.

Ultrasound-assisted method. A mixture of 2-piperidin- (**I**) or 2-pyrrolidin-1-yl-quinoline-3-carbaldehyde **(IV)** (1 mmol), aryl methyl ketone **(IIa–IIi)**

(1 mmol), and potassium hydroxide (3 mmol) was dissolved in ethanol (20 mL). The solution was then subject to ultrasound irradiation during 40–50 min. at 60°C. The reaction progress was monitored by TLC; after completion of the reaction, the reaction mixture was poured into ice water and neutralized with diluted HCl solution. The separated solid was filtered off, washed with water, dried, and purified by column chromatography using (silica gel, eluent – hexane : ethyl acetate, 10 : 1, v/v) to yield the pure compounds **IIIa–IIIi** and **Va–Vg**.

Microwave-assisted method. A mixture of 2-piperidin- (**I**) or 2-pyrrolidin-1-yl-quinoline-3-carbaldehyde **(IV)** (1 mmol), aryl methyl ketone **(IIa–IIi)** (1 mmol), and potassium hydroxide (3 mmol) was dissolved in ethanol (5 mL) and subject to periodic microwave irradiation at 160 W (3–4 min at 30 s intervals). The reaction progress was monitored by TLC; after completion of the reaction, the reaction mixture was poured into ice water and neutralized with diluted HCl solution. The separated solid was filtered off, washed with water, dried, and purified by column chromatography using (silica gel, eluent – hexane : ethyl acetate, 10 : 1, v/v) to yield the pure compounds **IIIa–IIIi** and **Va–Vg**.

IIIa. IR spectrum, ν, cm^{-1}: 1593 (C=C), 1654 (C=O), 3059 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.66–1.67 t (2H, –CH_2–), 1.75–1.79 m (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.34–3.37 t (4H, 2XN–CH_2–), 7.34–7.38 t (1H, C_6–H), 7.52–7.64 m (4H, C_7–H and ArH), 7.67–7.74 m (2H, C_8–H and $H_α$), 7.83–7.85 d (1H, C_5–H), 7.99–8.03 d (1H, $H_β$), 8.06–8.08 d (2H, ArH), 8.25 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.1, 51.8, 123.1, 123.6, 124.3, 124.6, 127.3, 127.6, 128.8, 129.4, 131.1, 132.6, 134.9, 142.2, 142.9, 148.1, 160.8, 189.2. Found, %: C 80.67; H 6.48; N 8.18. $C_{23}H_{22}N_2O$. Calculated, %: C 80.61; H 6.52; N 8.14. *M* 343 $[M + H]^+$.

IIIb. IR spectrum, ν, cm^{-1}: 1585 (C=C), 1654 (C=O), 2933 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.66–1.67 t (2H, –CH_2–), 1.75–1.80 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 2.46 s (3H, CH_3), 3.34–3.37 t (4H, 2XN–CH_2–), 7.32–7.37 m (3H, C_6–H and ArH), 7.59–7.73 m (3H, C_7–H, C_8–H, and $H_α$), 7.82–7.84 d (1H, C_5–H), 7.98–8.02 m (3H, ArH and $H_β$), 8.25 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 21.7, 24.6, 26.0, 51.8, 122.6, 123.3, 124.3, 124.7, 127.4, 127.8, 128.7, 129.4, 130.3, 135.5, 136.9, 142.2, 143.7, 147.8, 160.7, 189. Found, %: C 80.87; H 6.79; N 7.86. $C_{24}H_{24}N_2O$. Calculated, %: C 80.81; H 6.73; N 7.88. *M* 357 $[M + H]^+$.

IIIc. IR spectrum, ν, cm^{-1}: 1595 (C=C), 1660 (C=O), 2924 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.65–1.68 t (2H, –CH_2–), 1.76–1.80 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.34–3.37 t (4H, 2XN–CH_2–), 3.91 s (3H, OCH_3), 7.01–7.03 d (2H, ArH), 7.33–7.37 t (1H, C_6–H), 7.59–7.73 m (3H, C_7–H, C_8–H, and $H_α$), 7.82–7.85 d (1H, C_5–H), 7.98–8.02 d (1H, $H_β$), 8.09–8.11 d (2H, ArH), 8.24 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.1, 51.8, 55.5, 113.8, 122.4, 123.4, 124.2, 124.7, 127.4, 127.7, 130.3, 131.0, 136.8, 141.7, 147.8, 160.8, 188.6. Found, %: C 77.39; H 6.49; N 7.52. $C_{24}H_{24}N_2O_2$. Calculated, %: C 77.34; H 6.51; N 7.48. *M* 373 $[M + H]^+$.

IIId. IR spectrum, ν, cm^{-1}: 1593 (C=C), 1658 (C=O), 2927 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.66–1.68 t (2H, –CH_2–), 1.76–1.79 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.33–3.36 t (4H, 2XN–CH_2–), 7.34–7.38 t (1H, C_6–H), 7.50–7.52 d (2H, ArH), 7.61–7.63 m (3H, C_7–H, C_8–H, and $H_α$), 7.83–7.85 d (1H, C_5–H), 8.00–8.04 m (3H, ArH, and $H_β$), 8.24 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.1, 51.8, 121.9, 122.9, 124.3, 124.7, 127.4, 127.7, 129.0, 129.9, 130.5, 136.4, 137.1, 139.3, 143.1, 147.9, 160.7, 189.1. Found, %: C, 73.30; H 5.62; N 7.43. $C_{23}H_{21}ClN_2O$. Calculated, %: C, 73.26; H 5.65; N 7.40. *M* 377 $[M + H]^+$.

IIIe. IR spectrum, ν, cm^{-1}: 1591 (C=C), 1658 (C=O), 2926 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.65–1.69 t (2H, –CH_2–), 1.75–1.81 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.34–3.36 t (4H, 2XN–CH_2–), 7.33–7.38 t (1H, C_6–H), 7.61–7.74 m (5H, C_7–H, C_8–H, $H_α$, and ArH), 7.83–7.85 d (1H, C_5–H), 7.93–7.95 d (2H, ArH), 8.01–8.04 d (1H, $H_β$), 8.25 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.1, 51.8, 121.9, 122.9, 124.6, 127.5, 127.8, 129.9, 130.5, 131.5, 131.9, 136.8, 137.1, 143.2, 147.9, 160.7, 189.3. Found, %: C, 65.57; H 5.02; N 6.65. $C_{23}H_{21}BrN_2O$. Calculated, %: C, 65.52; H 5.06; N 6.69. *M* 421$[M + H]^+$.

IIIf. IR spectrum, ν, cm^{-1}: 1583 (C=C), 1664 (C=O), 2920 (C–H). ^{1}H NMR spectrum, δ, ppm: δ 1.67–1.68 t (2H, –CH_2–), 1.75–1.81 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.33–3.36 t (4H, 2XN–CH_2–), 7.27–7.37 d (2H, ArH), 7.63–7.84 m (4H, C_6–H, C_7–H, C_8–H, and $H_α$), 7.93–7.95 d (2H, ArH), 8.03–8.28 m (2H, C_5–H and $H_β$), 8.38 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.5, 26.0, 51.9, 121.7, 122.4, 123.9, 124.5, 124.6, 127.6, 127.9, 129.4, 130.8, 137.4, 142.9, 144.6, 148.1, 150.1, 160.7, 189.0. Found, %: C, 71.30; H 5.46; N 10.85. $C_{23}H_{21}N_3O_3$. Calculated, %: C 71.24; H 5.51; N 10.80. *M* 388 $[M + H]^+$.

IIIg. IR spectrum, ν, cm^{-1}: 1583 (C=C), 1654 (C=O), 2927 (C–H). ^1H NMR spectrum, δ, ppm: 1.65–1.68 t (2H, $–CH_2–$), 1.78–1.81 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.36–3.39 t (4H, 2XN–CH_2–), 7.35–7.39 t (1H, C_6–H), 7.59–7.65 m (3H, C_7–H, C_8–H, and $H_α$), 7.75–7.77 d (1H, C_5–H), 7.84–8.04 m (5H, ArH), 8.07–8.11 d (1H, $H_β$), 8.15–8.17 d (1H, ArH), 8.31 s (1H, C_4–H), 8.61 s (1H, ArH). ^{13}C NMR spectrum, $δ_C$, ppm: 24.5, 26.0, 51.8, 122.5, 123.2, 124.3, 124.5, 124.7, 126.8, 127.5, 127.8, 127.9, 128.4, 128.7, 129.6, 130.0, 130.4, 135.4, 135.6, 137.0, 142.5, 147.9, 160.8, 190.2. Found, %: C 82.62; H 6.16; N 7.14. $C_{27}H_{24}N_2O$. Calculated, %: C 82.56; H 6.22; N 7.17. *M* 393 $[M + H]^+$.

IIIh. IR spectrum, ν, cm^{-1}: 1582 (C=C), 1657 (C=O), 2932 (C–H). ^1H NMR spectrum, δ, ppm: 1.52–1.55 t (2H, $–CH_2–$), 1.61–1.64 p (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.23–3.26 t (4H, 2XN–CH_2–), 7.35–7.42 m (2H, C_6–H and ArH), 7.51–7.82 m (6H, C_5–H, C_7–H, C_8–H, $H_α$, and ArH), 7.87–8.07 m (5H, ArH, and $H_β$), 8.24 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.0, 51.7, 120.5, 122.2, 122.9, 124.6, 124.8, 126.8, 127.4, 127.87, 127.9, 128.0, 128.4, 129.2, 130.4, 131.6, 135.5, 143.1, 146.9, 160.7, 190.1. Found, %: C 82.59; H 6.19; N 7.26. $C_{27}H_{24}N_2O$. Calculated, %: C 82.56; H 6.22; N 7.17. *M* 393 $[M + H]^+$.

IIIi. IR spectrum, ν, cm^{-1}: 1591 (C=C), 1658 (C=O), 2926 (C–H). ^1H NMR spectrum, δ, ppm: 1.65–1.69 t (2H, $–CH_2–$), 1.75–1.81 q (4H, 2XN–CH_2–$C\underline{H}_2$–), 3.33–3.36 t (4H, 2XN–CH_2–), 7.22–7.24 t (1H, ArH),7.39–7.42 m (1H, C_6–H), 7.59–7.78 m (5H, C_7–H, C_8–H, $H_α$, and ArH), 7.86–7.88 d (1H, C_5–H), 8.05–8.08 d (1H, $H_β$), 8.15 s (1H, C_4–H). ^{13}C NMR spectrum, $δ_C$, ppm: 24.6, 26.1, 51.8, 121.9, 122.9, 124.6, 127.5, 127.8, 129.9, 130.5, 131.5, 131.9, 136.8, 137.1, 143.2, 147.9, 160.7, 189.3. Found, %: C 72.38; H 5.79; N 8.04; S, 9.20. $C_{21}H_{20}N_2OS$. Calculated, %: C 72.32; H 5.84; N 8.09; S, 9.15. *M* 349 $[M + H]^+$.

Va. IR spectrum, ν, cm^{-1}: 1571 (C=C), 1654 (C=O), 2960 (C–H). ^1H NMR spectrum, δ, ppm: 1.93–1.96 m (4H, 2X–CH_2–), 3.69–3.72 t (4H, 2XN–CH_2–), 7.21–7.25 t (1H, C_6–H), 7.46–7.66 m (5H, C_7–H, C_7–H, $H_α$, and ArH), 7.71–7.73 d (1H, C_5–H), 8.06–8.11 m (3H, ArH and C_4–H), 8.17–8.21 d (1H, $H_β$), ^{13}C NMR spectrum, $δ_C$, ppm: 25.8, 50.8, 121.0, 122.3, 122.6, 123.3, 126.5, 127.7, 128.2, 128.5, 130.5, 132.9, 137.1, 137.9, 144.3, 148.4, 156.7, 189.9. Found, %: C 80.46; H 6.14; N 8.53. $C_{22}H_{20}N_2O$. Calculated, %: C 80.46; H 6.14; N 8.53. *M* 329$[M + H]^+$.

Vb. IR spectrum, ν, cm^{-1}: 1583 (C=C), 1654 (C=O), 2964(C–H). ^1H NMR spectrum, δ, ppm: 1.93–1.96 m (4H, 2X–CH_2–), 2.45 s (3H, CH_3), 3.69–3.72 t (4H, 2XN–CH_2–), 7.21–7.24 m (1H, C_6–H), 7.32–7.34 d (2H, ArH), 7.45–7.49 d (1H, $H_α$), 7.53–7.57 m (1H, C_7–H), 7.63–7.66 d (1H, C_8–H), 7.71–7.73 d (1H, C_5–H), 7.98–8.00 d (2H, ArH), 8.10 s (1H, C_4–H), 8.15–8.19 d (1H, $H_β$), ^{13}C NMR spectrum, $δ_C$, ppm: 21.7, 25.8, 50.7, 121.1, 122.4, 122.6, 123.3, 126.5, 127.7, 128.7, 129.4, 130.5, 135.4, 137.0, 143.8, 148.3, 156.7, 189.3. Found, %: C 80.67; H 6.48; N 8.18. $C_{23}H_{22}N_2O$. Calculated, %: C 80.67; H 6.48; N 8.18. *M* 343 $[M + H]^+$.

Vc. IR spectrum, ν, cm^{-1}: 1585 (C=C), 1655 (C=O), 2962 (C–H). ^1H NMR spectrum, δ, ppm: 1.93–1.96 m (4H, 2X–CH_2–), 3.69–3.72 t (4H, 2XN–CH_2–), 3.91 s (3H, OCH_3), 7.00–7.02 t (1H, C_6–H), 7.21–7.24 d (2H, ArH), 7.46–7.50 d (1H, $H_α$), 7.53–7.57 m (1H, C_7–H), 7.64–7.66 d (1H, C_8–H), 7.71–7.73 d (1H, C_5–H), 8.08–8.10 m (3H, ArH and C_4–H), 8.15–8.19 d (1H, $H_β$). ^{13}C NMR spectrum, $δ_C$, ppm: 25.8, 50.7, 55.5, 113.9, 121.2, 122.2, 122.6, 123.3, 126.5, 127.7, 130.2, 130.9, 136.9, 143.4, 148.3, 156.7, 163.5, 188.0. Found, %: C 77.07; H 6.19; N 7.82. $C_{23}H_{22}N_2O_2$. Calculated, %: C 77.07; H 6.19; N 7.82. *M* 359 $[M + H]^+$.

Vd. IR spectrum, ν, cm^{-1}: 1579 (C=C), 1654 (C=O), 2964 (C–H). ^1H NMR spectrum, δ, ppm: 1.91–1.95 m (4H, 2X–CH_2–), 3.70–3.76 t (4H, 2XN–CH_2–), 7.21–7.23 t (1H, C_6–H), 7.41–7.73 m (5H, C_7–H, C_8–H, $H_α$, and ArH), 7.92–7.94 d (1H, C_5–H), 8.01–8.03 d (2H, ArH), 8.11 s (1H, C_4–H), 8.18–8.22 d (1H, $H_β$). ^{13}C NMR spectrum, $δ_C$, ppm: 25.2, 50.8, 120.8, 121.4, 122.7, 122.9, 123.3, 124.2, 127.4, 132.2, 132.7, 135.5, 141.2, 146.3, 154.2, 188.8. Found, %: C 72.82; H 5.28; N 7.72. $C_{22}H_{19}ClN_2O$. Calculated, %: C 72.82; H 5.28; N 7.72. *M* 363 $[M + H]^+$.

Ve. IR spectrum, ν, cm^{-1}: 1587 (C=C), 1656 (C=O), 2964 (C–H). ^1H NMR spectrum, δ, ppm: 1.93–1.96 m (4H, 2X–CH_2–), 3.68–3.71 t (4H, 2XN–CH_2–), 7.21–7.25 m (1H, C_6–H), 7.46–7.64 m (5H, m, 5H, C_7–H, C_8–H, $H_α$, and ArH), 7.73–7.75 d (1H, C_5–H), 8.08–8.14 m (3H, ArH and C_4–H), 8.20–8.24 d (1H, $H_β$). ^{13}C NMR spectrum, $δ_C$, ppm: 26.0, 51.0, 121.0, 122.3, 122.6, 123.3, 126.5, 127.7, 128.2, 128.5, 130.5, 132.9, 137.1, 137.9, 144.3, 148.4, 156.7, 189.9. Found, %: C 64.87; H 4.70; N 6.88. $C_{22}H_{19}BrN_2O$. Cal-culated, %: C 64.87, H 4.70; N 6.88. *M* 407 $[M + H]^+$.

Vf. IR spectrum, ν, cm^{-1}: 1589 (C=C), 1654 (C=O), 2968 (C–H). ^1H NMR spectrum, δ, ppm: 1.94–1.97 m (4H, 2X–CH_2–), 3.68–3.72 t (4H, 2XN–CH_2–), 7.22–

7.24 t (1H, C_6–H), 7.42–7.46 d (1H, H_α), 7.56–7.67 m (3H, C_7–H, C_8–H, and C_5–H), 8.14 s (1H, C_4–H), 8.18–8.21 d (2H, ArH), 8.24–8.28 d (1H, H_β), 8.38–8.40 d (2H, ArH). ^{13}C NMR spectrum, δ_C, ppm: 25.5, 50.4, 121.2, 122.8, 124.0, 124.9, 127.2, 127.9, 128.5, 129.0, 131.3, 132.6, 136.5, 141.8, 144.0, 148.5, 151.2, 159.6, 189.2. Found, %: C 70.76; H 5.13; N 11.25. $C_{22}H_{19}N_3O_3$. Calculated, %: C 70.76; H 5.13; N 11.25. *M* 374 $[M + H]^+$.

Vg. IR spectrum, ν, cm^{-1}: 1592 (C=C), 1666 (C=O), 2965 (C–H). ^{1}H NMR spectrum, δ, ppm: 1.97–2.00 m (4H, 2X–CH_2–), 3.63–3.66 t (4H, 2XN–CH_2–), 7.20–7.24 t (1H, C_6–H), 7.48–7.58 m (4H, C_7–H, C_8–H H_α, and ArH), 7.60–8.00 m (6H, C_5–H and ArH), 8.35–8.40 m (2H, C_4–H and H_β), 8.73–8.76 d (1H, ArH). ^{13}C NMR spectrum, δ_C, ppm: 25.8, 50.7, 121.8, 122.8, 123.8, 124.4, 125.9, 127.2, 127.7, 127.9, 128.3, 128.8, 129.5, 130.5, 132.1, 134.9, 135.2, 137.8, 140.2, 145.2, 164.8, 190.0. Found, %: C 82.42; H 5.92; N 7.48. $C_{26}H_{22}N_2O$. Calculated, %: C 82.51; 5.86; N 7.40. *M* 379 $[M + H]^+$.

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