STRUCTURAL INVESTIGATIONS OF SUBSTITUTED INDOLIZINE DERIVATIVES BY NMR STUDIES*

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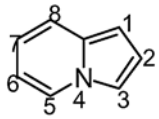
Owing to the increasing importance of indolizine heterocycles in the field of biology and pharmacology we have synthesized and investigated the obtained heterocycles by NMR techniques. In order to investigate the substituent effects on the spectroscopic properties, a series of indolizine derivatives were studied by ^{1}H-NMR, ^{13}C-NMR and 2D NMR (GCOSY, GHMBC and GHMQC spectra).

Key words: indolizine, NMR spectroscopy, spectra-structure correlation.

1. INTRODUCTION

Organic compounds containing two condensed rings (5- and 6-membered) and a bridging nitrogen atom are known as indolizines.



the indolizine system

This system is izoelectronic with indole and represents a group of heterocyclic compounds structurally related to purines (from ADN, ARN). Therefore, indolizines can be considered as a 10-π electron system.

Many substituted indolizines are subject of extensive researches due to biological, medicinal, photographic and other useful applications. Thus, the chemistry, synthesis and properties of this fused system and its analogues have been frequently reviewed [1–4].

Owing to the increasing importance of indolizine heterocycles in the field of biology and pharmacology (fluorescence properties, potential antioxidants)

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[5–8], the development of new and efficient methods for the synthesis of these compounds are of considerable interest.

1,3-Dipolar cycloaddition is on of the most important methods for constructing five-membered heterocycles [9–11]. We [12, 13] and other [14, 15] have previously described the synthesis of indolizines from 4,4′-bipyridinium salts using a [3+2] cycloaddition reaction.

The present papers describe the structural and mechanistically investigations made by NMR-spectroscopy on the two new series of pyridinium-substituted indolizines synthesized from asymmetric diquaternary salts of 4,4′-bipyridine.

2. RESULTS AND DISCUSSION

New water-soluble pyridinium-substituted indolizines (**5–12**), bearing different substituents, were synthesized by cycloadditon reactions from asymmetric 4,4′-bipyridinium-diquaternary salts (**1–4**) and activated acethylenic dipollarophyles (ethyl-propiolate and 4-nitro-phenyl-propiolate) (Fig. 1).

The structures of the new compounds were assessed by spectral analysis (NMR, MS) and elemental analysis. In particular, the proton chemical shifts were assigned on the basis of ^{1}H-NMR, (^{1}H-^{1}H) COSY (Correlated SpectroscopY) and NOESY (Nuclear Overhauser Effect SpectroscopY) experiments. The ^{13}C-NMR spectra were recorded using an INADEQUAT C13 mult impulse sequence; which can provide both the chemical shifts and nature of carbon nuclei (primary, secondary, tertiary or quaternary). A complete spectral attribution of ^{13}C NMR signals was obtained with 2D (^{1}H-^{13}C) HMQC (Heteronuclear Multiple Quantum Coherence) and long-range (^{1}H-^{13}C) HMBC (Heteronuclear Multiple Bond Correlation) experiments.

In the ^{1}H NMR spectra of a sharp singlet at 4.37–4.40 ppm confirms the presence of the N^{+}-CH_3 group. The down field shift of the N^{+}-CH_3 is due to the

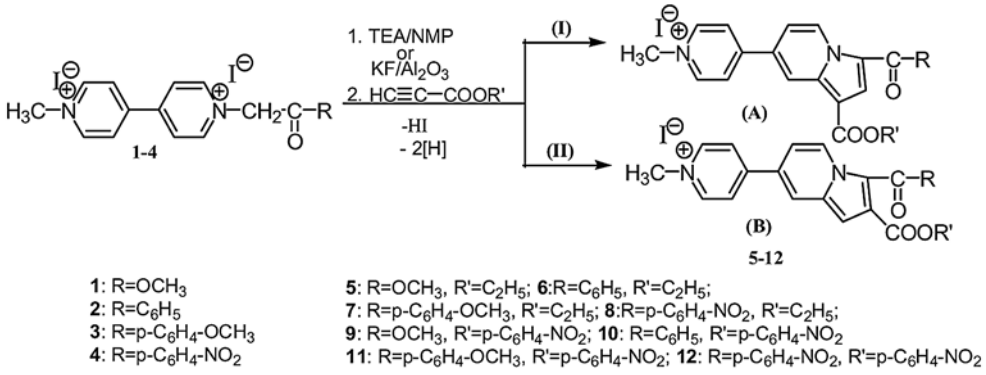

Fig. 1 – Synthesis of substituted N-methyl-4(indolizin-7-yl)-pyiridinum iodides.

inductive effect of the quaternary nitrogen at CH_3. For the **5–8** compounds, the ester methylenic protons appear as a quartet at δ 4.35–4.36 ppm (J = 6.9–7.20 Hz), due to the coupling with the CH_3 protons, which give a triplet in the up field region at 1.35–1.37 ppm (J = 6.9–7.20 Hz).

For **9–12** compounds, the protons of the p-nitro-phenoxy ring appears in aromatic region as two coupled dublets at 7.61–7.67 ppm and 8.37–8.38 ppm, the latest deshielded by the presence of the NO_2 group in the ring. The methoxy group of the **5**, **7**, **9** and **11** give a sharp singlet at 3.89–3.95 ppm, even if it is an esteric group or a substitutent of the phenyl ring.

In the aromatic region of the ^{1}H NMR spectra we can also find the signals of the heterocyclic rings protons (Fig. 2) as we presented in the Table 1.

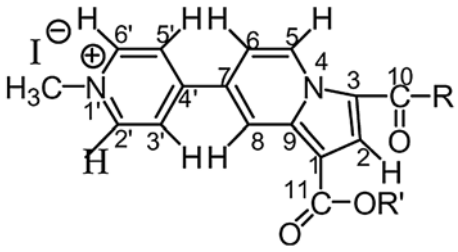

Fig. 2 – Pyridinium-substituted indolizine rings.

Table 1

Heterocycle ^{1}H NMR spectral data of indolizines (**5**–**12**)

Compd	^{1}H NMR spectral data (DMSO-d_6), δ ppm, J [Hz]					
	H-2	H-5	H-6	H-8	H-2′ H-6′	H-3′ H-5′
5	7.85 (s)	9.49 (dd, J = 7.48, 0.79)	7.82 (dd, J = 7.50, 2.14)	8.77 (d, J = 1.23)	9.11 (d, J = 6.93)	8.59 (d, J = 6.95)
6	7.73–7.67 (m)	9.99 (dd, J = 7.47, 0.81)	7.91 (dd, J = 7.51, 2.19)	8.88 (dd, J = 2.15, 0.84)	9.11 (d, J = 6.94)	8.65 (d, J = 6.96)
7	7.73 (s)	9.83 (d, J = 7.45)	7.88–7.84 (m)	8.87 (d, J = 1.25)	9.10 (d, J = 6.85)	8.64 (d, J = 6.87)
8	7.74 (s)	9.95 (dd, J = 7.45, 0.74)	7.96 (dd, J = 7.50, 2.14)	8.90 (dd, J = 2.10, 0.79)	9.12 (d, J = 6.96)	8.66 (d, J = 6.98)
9	8.20 (s)	9.65 (d, J = 7.59)	7.92 (dd, J = 7.56, 1.49)	8.85 (d, J = 1.45)	9.08 (d, J = 6.56)	8.64 (d, J = 6.59)
10	8.01–7.98 (m)	9.99 (d, J = 7.65)	8.01–7.98 (m)	8.91 (d, J = 1.34)	9.10 (d, J = 6.79)	8.68 (d, J = 6.81)
11	8.01–7.91 (m)	9.90 (d, J = 7.54)	8.01–7.91 (m)	8,90 (s)	9.10 (d, J = 6.42)	8.67 (d, J = 6.46)
12	8.12–8.02 (m)	10.01 (d, J = 7.46)	8.12–8.02 (m)	8.92 (d, J = 1.23)	9.12 (d, J = 6.65)	8.69 (d, J = 6.68)

The pyridinium ring protons appear like two coupled doublets at 9.10–9.12 ppm (J = 6.42–6.94 Hz) and 8.59–8.69 ppm (J = 6.46–6.98 Hz). The complete attribution of these signals wad made by NOESY experiments, when we can observe the NOE effects of the H-2′, H-6′ protons with the N^+-CH_3 protons and of the H-5′ protons with the H-6 proton.

The H-5 proton appeared in the down field region at 9.49–10.01 ppm as a doublet (J ~ 7.5 Hz) or sometimes (**5, 6** and **8**) as a doublet of doublet (J ~ 7.5 Hz and 0.8 Hz) due to a stronger coupling with the H-6 and possible to a weaker coupling with H-8. This data are confirmed by the COSY and NOESY experiments. The presence of the adjacent ring nitrogen deshields the H-5 proton. A sharp doublet (J = 1.23–1.45 Hz) and sometimes a very sharp doublet of doublet (J = 2.10–2.15 and 0.79–0.84 Hz) were observed for H-8 proton at 8.77–8.92 ppm. The H-6 proton appears as a doublet of doublet at δ 7.82–7.98 ppm (J ~ 7.5 and 1.49–2.19 Hz) because of the coupling with H-5 and H-8 protons. A singlet at δ 7.73–8.20 ppm appears for H-2 proton. Sometimes, these signals enter in the composition, or appear under the multiplets offered by the aromatic protons of the R radical's benzoyl rings.

In the case of the compounds with an aromatic R radical, the chemical shifts of the protons from the phenyl ring appears in the aromatic region, and are influenced by the substituent present in the ring. So, we can observe a downfield shift in the case of electron acceptor group (NO_2) and an up field shift for the electron donor substituent (OCH_3).

Using the direct connectivity of the carbons with the corresponding protons the HMQC experiments determine the ^{13}C-chemical shifts of protonated carbons. The quaternary carbons were established by using long-range correlated (HMBC) experiments involving the $^3J_{H\text{-}C}$ coupling constants. Thus, the complete spectral attribution of indolizine and pyridinium rings ^{13}C signals is presented in the Table 2.

In this way, C-9 (long range connectivity with H-8, H-2 and H-5), C-7 (long range connectivity to H-3′, H-5′ and H-5) and C-4′ (long range connectivity to H-8, H-6 and H-2′, H-6′) could be unequivocally assigned as illustrated in the Fig. 3 for the compound **11**.

Also, due to the long-range connectivity with the H-2′ and H-6′ the CH_3 signal observed at ~ 47 ppm was assigned to the N^+CH_3 group. Following a similar spectral analysis the ^{13}C chemical shifts of phenyls rings were assigned to all compounds **5**–**12**.

In the ^{13}C NMR spectra of **6**–**8, 10**–**12** compounds, the carbonyl group C-10 appear at 183–185 ppm. The ester carbonyl group attached to the C-1 was observed at δ 155–162 ppm, whereas, the ester carbonyl group attached to the C-3 position for **5** and **9** appear at ~160.20 ppm (Table 2).

Table 2

Heterocycle ^{13}C NMR chemical shifts of indolizines (**5**–**12**)

		Compound							
		5	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Atom	δ C-1	107.32	107.84	107.58	108.30	105.17	105.62	105.36	106.09
	δ C-2	123.68	127.86	127.03	128.46	124.64	128.92	127.79	129.32
	δ C-3	115.44	122.97	123.12	122.64	116.24	123.51	123.72	133.64
	δ C-5	127.99	129.17	129.01	129.34	128.61	129.60	129.52	129.76
	δ C-6	112.88	113.63	113.22	114.07	113.60	114.15	113.79	114.57
	δ C-7	130.37	132.20	131.69	132.80	131.57	133.07	132.66	138.90
	δ C-8	118.49	118.47	118.41	118.48	118.41	118.23	118.22	118.24
	δ C-9	136.87	137.83	137.49	138.24	138.84	138.40	138.29	144.89
	δ C-4′	151.26	151.27	151.25	151.16	151.21	151.06	151.12	149.16
	δ C-2′ δ C-6′	145.81	145.91	145.87	145.96	145.86	145.91	145.88	145.94
	δ C-3′ δ C-5′	124.18	124.46	124.33	124.56	124.49	124.62	124.56	124.71
	δ C-10	160.20	184.91	183.59	183.15	160.22	184.96	183.66	183.31
	δ C-11	162.52	162.64	162.69	162.52	155.04	160.32	160.39	160.22

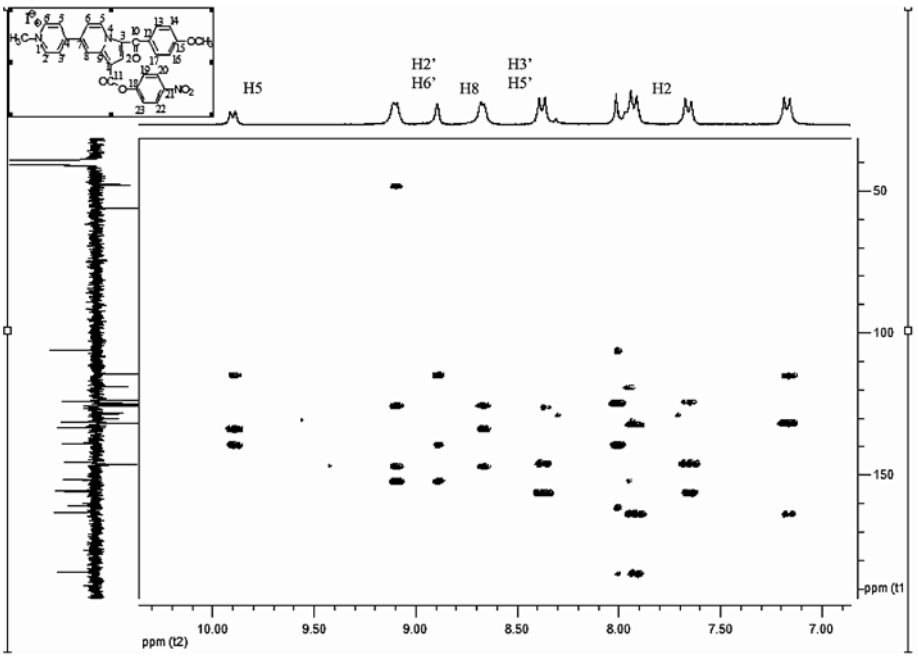

Fig. 3 – Long-range CH correlations in the HMBC spectrum of **11**.

The heteronuclear 2D NMR experiments (HMBC) were also used to confirm the regioselectivity of the reaction. Two $^3J_{H\text{-}C}$ between proton H-2 and both the carbonyl (C-10) and carboxylate carbon (C-11) atoms are identified, as we can saw from the HMBC spectra presented in Fig. 3. These results proved that the ylide carbon atom reacts with the unsubstituted carbon atom of the propiolates as described previously for the synthesis of bis-indolizines [16].

3. CONCLUSIONS

In this paper we have proved the structure of two new series of pyridinium-substituted indolizines by NMR studies.

The NMR experiments also confirm that, the cycloaddition of the ylides with the unsymmetrical propiolates is fully regioselective and gave only one dehydrogenated product **(A)**; the other possible regioisomer was ruled out by NMR analysis.

4. EXPERIMENTAL

For all measurements, the spectra were performed at 25°C, in 5 mm NMR tubes, the samples being dissolved in DMSO-d_6. ^{1}H, ^{13}C, COSY, HMQC and HMBC spectra were recorded on a Bruker DRX300 spectrometer equipped with a 5 mm indirect detection probe, operating at 300 MHz for proton and 75 MHz for carbon. The Bruker NMR standard software was used. ^{1}H NMR spectra were obtained with a 30° pulse, 16 scans, 2.5 s time delay, using a spectral width of 4.2 kHz and 32 K data points. ^{13}C NMR spectra were obtained with a 30° pulse, 128 scans, 2.5 s time delay, using a spectral width of 22.7 kHz and 32 K data points, under full proton broadband decoupling. Gradient-assisted COSY spectra were obtained with spectral width of 4.2 kHz in both dimensions, 2K data points in F2, 128 experiments in F1 with one transient for each one; relaxation delay 1.2 s. Gradient-assisted HMQC and HMBC spectra were obtained with a spectral width of 16.6 kHz in F1 and 4.2 kHz in F2, 2K data points in F2, 256 experiments in F1 zero filled to 512, with 4 transients for each one; GARP decoupling, relaxation delay 1.5 s; filter function square sine bell in both dimensions. For HMBC spectra a low-pass *J* filter was used to suppress one-bond correlations. The delay for evolution of long-range C, H couplings was 60 ms.

N-methyl-4(1-ethoxycarbonyl-3-methoxycarbonyl-indolizin-7-yl)-pyridinium iodide (5). Yellow crystals, mp. 233–235°C.

^{1}H NMR (300 MHz, *DMSO-d_6*) δ ppm= 9.49 (dd, *J* = 7.48, 0.79 Hz, 1H: H-5), 9.11 (d, *J* = 6.93 Hz, 2H: H-2′, H-6′), 8.77 (d, *J* = 1.23 Hz, 1H: H-8), 8.59 (d, *J* = 6.95 Hz, 2H: H-3′, H-5′), 7.85 (s, 1H: H-2), 7.82 (dd, *J* = 7.50, 2.14 Hz,

1H: H-6), 4.40 (s, 3H: N^+ C$\underline{H}_3$), 4.35 (q, *J* = 6.90 Hz, 2H: C$\underline{H}_2$), 3.90 (s, 3H: OC$\underline{H}_3$), 1.37 (t, *J* = 6.90 Hz, 3H: C$\underline{H}_3$).

^{13}C NMR (75 MHz, *DMSO-d*$_6$) δ ppm = 162.52 (<u>C</u>OO, C-11); 160.20 (<u>C</u>OO, C-10); 151.26 (C-4′); 145.81 (C-2′, C-6′); 136.87 (C-9); 130.37 (C-7); 127.99 (C-5); 124.18 (C-3′, C-5′); 123.68 (C-2); 118.49 (C-8); 115.44 (C-3); 112.88 (C-6); 107.32 (C-1); 59.92 (C-13); 51.75 (O<u>C</u>H$_3$); 47.22 (N$^+$<u>C</u>H$_3$); 14.15 (C-14).

N-methyl-4(1-ethoxycarbonyl-3-benzoyl-indolizin-7-yl)-pyridinium iodide (6). Yellow crystals, m.p. 215–219°C.

^{1}H NMR (300 MHz, *DMSO-d*$_6$) δ ppm = 9.92 (dd, *J* = 7.47, 0.81 Hz, 1H: H-5), 9.11 (d, *J* = 6.94 Hz, 2H: H-2′, H-6′), 8.88 (dd, *J* = 2.15, 0.84 Hz, 1H: H-8), 8.65 (d, *J* = 6.96 Hz, 2H: H-3′, H-5′), 7.91 (dd, *J* = 7.51, 2.17 Hz, 1H: H-6), 7.85-7.82 (m, 2H: H-13, H-17), 7.73-7.67 (m, 2H: H-2, H-15), 7.64-7.59 (m, 2H: H-14, H-16), 4.39(s, 3H: N$^+$C$\underline{H}_3$), 4.36 (q, *J* = 7.20Hz, 2H: C$\underline{H}_2$,), 1.35 (t, *J* = 7.20 Hz, 3H: C$\underline{H}_3$).

^{13}C NMR (75 MHz, *DMSO-d*$_6$) δ ppm = 184.91 (<u>C</u>=O, C-10); 162.64 (<u>C</u>OO, C-11); 151.27 (C-4′); 145.91 (C-2′, C-6′); 138.66 (C-12); 137.83 (C-9); 132.20 (C-7); 132.05 (C-15); 129.17 (C-5); 128.69 (C-13, C-17); 128.55 (C-14, C-16); 127.86 (C-2); 124.46 (C-3′, C-5′); 122.97 (C-3); 118.47 (C-8); 113.63 (C-6); 107.84 (C-1); 60.07 (C-18); 47.27 (N$^+$<u>C</u>H$_3$); 14.19 (C-19).

N-methyl-4(1-ethoxycarbonyl-3-(*para*-methoxy)benzoyl-indolizin-7-yl)-pyridinium iodide (7). Yellow crystals, m.p. 238–240°C.

^{1}H NMR (300 MHz, *DMSO-d*$_6$) δ ppm = 9.83 (d, *J* = 7.45 Hz, 1H: H-5), 9.10 (d, *J* = 6.85 Hz, 2H: H-2′, H-6′), 8.87 (d, *J* = 1.25 Hz, 1H: H-8), 8.64 (d, *J* = 6.87 Hz, 2H: H-3′, H-6′), 7.88-7.84 (m, 3H: H-6, H-13, H-17), 7.73 (s, 1H: H-2), 7.16 (d, *J* = 8.79 Hz, 2H: H-14, H-16), 4.40(s, 3H:N$^+$C$\underline{H}_3$), 4.36 (q, *J* = 7.20Hz, 2H: C$\underline{H}_2$), 3.89 (s, 3H: OC$\underline{H}_3$), 1.36 (t, *J* = 7.20 Hz, 3H: C$\underline{H}_3$).

^{13}C NMR (75 MHz, *DMSO-d*$_6$) δ ppm = 183.59 (<u>C</u>=O, C-10); 162.69 (<u>C</u>OO, C-11); 162.49 (C-15); 151.25 (C-4′); 145.87 (C-2′, C-6′); 137.49 (C-9); 131.69 (C-7); 131.09 (C-13, C-17); 130.86 (C-12); 129.01 (C-5); 127.03 (C-2); 124.33 (C-3′, C-5′); 123.12 (C-3); 118.41 (C-8); 113.89 (C-14, C-16); 113.22 (C-6); 107.58 (C-1); 60.01 (C-18); 55.45 (O<u>C</u>H$_3$); 47.24 (N$^+$<u>C</u>H$_3$); 14.69 (C-19).

N-methyl-4(1-ethoxycarbonyl-3-(*para*-nitro)benzoyl-indolizin-7-yl)-pyridinium iodide (8). Yellow crystals, m.p. 237–238°C.

^{1}H NMR (300 MHz, *DMSO-d*$_6$) δ ppm= 9.95 (dd, *J* = 7.45, 0.74 Hz, 1H: H-5), 9.12 (d, *J* = 6.96 Hz, 2H: H-2′, H-6′), 8.90 (dd, *J* = 2.10, 0.79 Hz, 1H: H-8), 8.66 (d, *J* = 6.98 Hz, 2H: H-3′, H-5′), 8.43 (d, *J* = 8.81 Hz, 2H: H-14, H-16), 8.06 (d, *J* = 8.84 Hz, 2H: H-13, H-17), 7.96 (dd, *J* = 7.50, 2.14 Hz, 1H:

H-6), 7.74 (s, 1H: H-2), 4.40 (s, 3H: $N^+C\underline{H}_3$), 4.36 (q, *J* = 7.20Hz, 2H:, $C\underline{H}_2$), 1.35 (t, *J* = 7.17 Hz, 3H: $C\underline{H}_3$).

^{13}Cmult NMR (75 MHz, *DMSO-d_6)* δ ppm = 183.15 (<u>C</u>=O, C-10); 162.52 (<u>C</u>OO, C-11); 151.16 (C-4′); 149.16 (C-15); 145.96 (C-2′, C-6′); 144.06 (C-12); 138.24 (C-9); 132.80 (C-7); 129.96 (C-13, C-17); 129.34 (C-5); 128.46 (C-2); 124.56 (C-3′, C-5′); 123.72 (C-14, C-16); 122.64 (C-3); 118.48 (C-8); 114.07 (C-6); 108.30 (C-1); 60.13 (C-18); 47.31 ($N^+\underline{C}H_3$); 14.19 (C-19).

N-methyl-4(1-(4-nitrophenoxycarbonyl)-3-methoxycarbonil-indolizin-7-yl)-pyridinium iodide (9). Yellow crystals, m.p. 190–192°C.

^{1}H NMR (300 MHz, *DMSO-d_6)* δ ppm = 9.65 (d, *J* = 7.59 Hz, 1H: H-5), 9.08 (d, *J* = 6.56 Hz, 2H: H-2′, H-6′), 8.85 (d, *J* = 1.45 Hz, 1H: H-8), 8.64 (d, *J* = 6.594 Hz, 2H: H-3′, H-5′), 8.38 (d, *J* = 9.05 Hz, 2H: H-15, H-17), 8.20 (s, 1H: H-2), 7.92 (dd, *J* = 7.56, 1.49 Hz, 1H: H-6), 7.67 (d, *J* = 9.05 Hz, 2H: H-14, H-18), 4.37 (s, 3H: $N^+C\underline{H}_3$), 3.95 (s, 3H: $OC\underline{H}_3$).

^{13}Cmult NMR (75 MHz, *DMSO-d_6)* δ ppm = 160.22 (COO, C-10); 155.19 (C-13); 155.04 (<u>C</u>OO, C-11); 151.21 (C-4′); 145.86 (C-2′, C-6′); 144.85 (C-16); 137.84 (C-9); 131.57 (C-7); 128.61 (C-5); 125.12(C-15, C-17); 124.67 (C-2); 124.49 (C-3′, C-5′); 123.17 (C-14, C-18); 118.41 (C-8); 116.24 (C-3); 113.60 (C-6); 105.17 (C-1); 51.93 ($O\underline{C}H_3$); 47.27 ($N^+\underline{C}H_3$).

N-methyl-4(1-(4-nitrophenoxycarbonyl)-3-benzoyl-indolizin-7-yl]-pyridinium iodide (10). Yellow crystals, m.p. 195–196°C.

^{1}H NMR (300 MHz, *DMSO-d_6*??) δ ppm = 9.99 (d, *J* = 7.65 Hz, 1H: H-5), 9.10 (d, *J* = 6.79 Hz, 2H:H-2′, H-6′), 8.91 (d, *J* = 1.34 Hz, 1H: H-8), 8.68 (d, *J* = 6.81 Hz, 2H: H-3′, H-5′), 8.37 (d, *J* = 9.13 Hz, 2H: H-20, H-22), 8.01–7.98 (m, 2H: H-6, H-2), 7.92-7.88 (m, 2H: H-13, H-17), 7.74-7.61 (m, 5H: H-14, H-15, H-16, H-19, H-23), 4.39 (s, 3H: $N^+C\underline{H}_3$).

^{13}Cmult NMR (75 MHz, *DMSO-d_6)* δ ppm = 184.96 (<u>C</u>=O, C-10); 160.32 (<u>C</u>OO, C-11); 155.10 (C-18); 151.06 (C-4′); 145.91 (C-2′, C-6′); 144.88 (C-21); 138.54 (C-12); 138.40 (C-9); 133.07 (C-7); 132.20 (C-15); 129.60 (C-5); 128.92 (C-2); 128.79 (C-13, C-17); 128.59 (C-14, C-16); 125.07 (C-20, C-22); 124.62 (C-3′, C-5′); 123.51 (C-3); 123.23 (C-19, C-23); 118.23 (C-8); 114.15 (C-6); 105.62 (C-1); 47.31 ($N^+\underline{C}H_3$).

N-methyl-4(1-(4-nitrophenoxycarbonyl)-3-(*para*-methoxy-benzoyl)-indolizin-7-yl]-pyridinium iodide (11). Yellow crystals, m.p. 198–199°C.

^{1}H NMR (300 MHz, *DMSO-d_6)* δ ppm= 9.90 (d, *J* = 7.54 Hz, 1H: H-5), 9.10 (d, *J* = 6.42 Hz, 2H: H-2′, H-6′), 8.90 (s, 1H: H-8), 8.67 (d, *J* = 6.46 Hz, 2H: H-3′, H-5′), 8.38 (d, *J* = 9.04 Hz, 2H: H-20, H-22), 8.01-7.91 (m, 4H: H-2, H-6; H-13, H-17), 7.66 (d, *J* = 9.01 Hz, 2H: H-19, H-23), 7.17 (d, *J* = 8.76 Hz, 2H: H-14, H-16), 4.38 (s, 3H: $N^+C\underline{H}_3$), 3.89 (s, 3H: $OC\underline{H}_3$).

^{13}Cmult NMR (75 MHz, *DMSO-d_6*) δ ppm = 183.66 (C=O, C-10); 162.65 (C-15); 160.39 (COO, C-11); 155.16 (C-18); 151.12 (C-4′); 145.88 (C-2′, C-6′); 144.86 (C-21); 138.29 (C-9); 132.66 (C-7); 131.24 (C-13, C-17); 130.65 (C-12); 129.52 (C-5); 127.79 (C-2); 125.09 (C-20, C-22); 124.56 (C-3′, C-5′); 123.72 (C-3); 123.22 (C-19, C-23); 118.22 (C-8); 113.97 (C-14, C-16); 113.79 (C-6); 105.36 (C-1); 55.46 ($O\underline{C}H_3$); 47.29 ($N^+\underline{C}H_3$).

N-methyl-4(1-(4-nitrophenoxycarbonyl)-3-(*para*-nitro-benzoyl)-indolizin-7-yl)-pyridinium iodide (12). Yellow crystals, m.p. 195–197°C.

^{1}H NMR (300 MHz, *DMSO-d_6*) δ ppm = 10.01 (d, *J* = 7.46 Hz, 1H:H-5), 9.12 (d, *J* = 6.65 Hz, 2H: H-2′, H-6′), 8.92 (d, *J* = 1.23 Hz, 1H: H-8), 8.69 (d, *J* = 6.68 Hz, 2H: H-3′, H-5′), 8.44 (d, *J* = 8.81 Hz, 2H: H-14, H-16), 8.37 (d, *J* = 9.15 Hz, 2H: H-20, H-22), 8.12-8.02 (m, 4H: H-2, H-6, H-13, H-17), 7.64 (d, *J* = 9.16 Hz, 2H: H-19, H-23), 4.40 (s, 3H: $N^+C\underline{H}_3$).

^{13}Cmult NMR (75 MHz, *DMSO-d_6*) δ ppm = 183.31 (C=O, C-10); 160.22 (COO, C-11); 155.04 (C-18); 160.97 (C-15); 149.16 (C-4′, C-21); 145.94 (C-2′, C-6′); 144.89 (C-9); 143.81 (C-12); 138.9 (C-7); 133.64 (C-3); 130.04 (C-13, C-17); 129.76 (C-5); 129.32 (C-2); 125.10 (C-20, C-22); 124.71 (C-3′, C-5′); 123.72 (C-19, C-23); 123.17 (C-14, C-16); 118.24 (C-8); 114.57 (C-6); 106.09 (C-1); 47.35 ($N^+\underline{C}H_3$).

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