Electronic supplementary information-ESI

Synthesis of (3-nitro-2-oxo-benzaldehyde thiosemicarbazonato) - zinc(II) complexes : the position of nitro group in phenyl ring alters antimicrobial activity against *K. pneumoniae* 1, *S. typhimurium* 2, MRSA and *C. albicans*†

Tarlok S. Lobana,*[a] Shikha Indoria,[aΨ] Henna Sood,[c] Daljit S. Arora,[c] Manpreet Kaur[d] and Jerry P. Jasinski[d]

[a]*Department of Chemistry, Guru Nanak Dev University, Amritsar – 143 005, India*

[b]*Department of Microbiology, Guru Nanak Dev University, Amritsar-143 005, India*

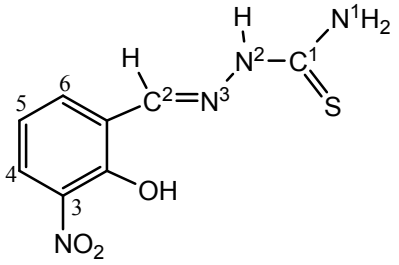
[c]*Department of Chemistry, Keene State College, Keene NH 03435-2001, USA*

**E-mail: tarlokslobana@yahoo.co.in; Fax: +91-183-2258820.*

[Ψ]Present Address: Department of Chemistry, Kanya Maha Vidyalaya , Jalandhar-144004, India;

1S. Thiosemicarbazone ligands

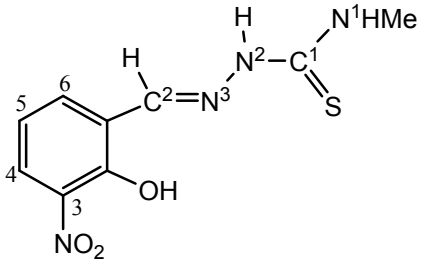
1S.1. 3-nitro-salicylaldehyde thiosemicarbazone (3-NO_2-stscH_2-N^1H_2)



To a solution of NH_2 thiosemicarbazide (1.0 g, 0.011 mol) in hot methanol (50 mL) and glacial acetic acid (5 mL), was added 5-NO_2-salicyladehyde (1.83 g, 0.011 mol). The contents were refluxed for 6 h. The clear solution obtained was poured in a beaker and allowed to evaporate at room temperature. Slow evaporation of the solution gave orange colored compound. Color: Orange. Yield: 0.86 g, 86 %, m.p. 200-201 °C. IR (KBr, cm^{-1}): ν(N^1–H) 3452 s; ν(N^2–H) + ν(O−H) 3328 s; ν(C–H) 3144 w, 3099 w, 3006 w, 2950 m; ν(C=N) + ν(C=C)+ δ(N−H) 1593 s, ν(N=O) 1532 s; δ(C−H) 1438 s, 1428 w; δ(N=O) 1369 s, 1272 s, 1148m, 1096 w, 1054 w; 944 w, ν(C–S) 854 s, 825 s, 695 w, 644 w, 538 w, 420 s. ^{1}H NMR (δ, ppm; DMSO): δ = 10.99 (1H, s, OH), 8.50 (1H, s, N^2H), 8.22 (1H, s, C^2H), 8.11 (2H, d, C^4H + C^6H),

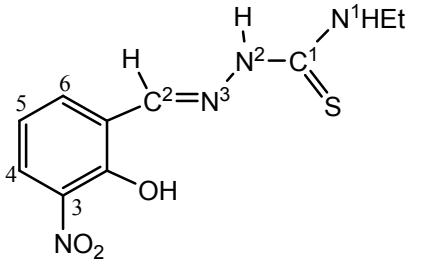
7.52 (2H, s, N^1H_2), 7.05 (1H, d, C^5H). Electronic absorption spectrum (10^{-4} M in DMSO, λ_{max} /nm, ε /L·mol^{-1}·cm^{-1}): 316 (2.368 x10^4). Thio-ligands **10**, **11** and **12** were also prepared by a similar method.

1S.2. 3-nitro-salicylaldehyde-N^1-methyl thiosemicarbazone (3-NO_2-stscH$_2$-N^1HMe)



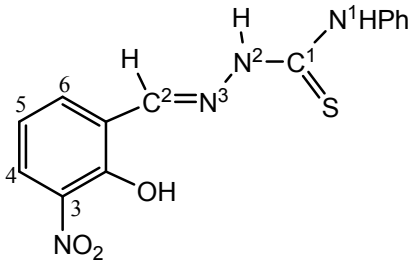
Color: Orange. Yield: 0.85 g, 85 %, m.p. 230- 232°C. IR (KBr, cm^{-1}): ν(N^1–H) 3351 s; ν(N^2–H)+ ν(O–H), 3137 s, ν(C–H) 2996 m, 2930 w, ; ν(C=N) + ν(C=C)+ δ(N−H) 1613 s, ν(N=O) 1548 s; δ(C−H) 1443 m; δ(N=O) 1385 w, 1333 w, 1299s, 1256 m, 1235 m, 1162 w, 1100 s, 1044 s; 939 s, ν(C–S) 857 s; 827 w, 698 w, 633 m, 504 m. ^{1}H NMR (δ, ppm; DMSO): δ = 11.45 (1H, s, OH), 8.47 (1H, d, N^2H), 8.25 (1H, d, C^2H), 8.09 (2H, d, C^4H + C^6H), 7.62 (1H, s, N^1H), 7.04 (1H, m, C^5H), 3.19 (3H, t, $CH_3(N^1)$). Electronic absorption spectrum (10^{-4} M in DMSO, λ_{max} /nm, ε /L·mol^{-1}·cm^{-1}): 315(1.877x 10^4).

1S.3. 3-nitro-salicylaldehyde-N^1-ethylthiosemicarbazone (3-NO_2-stscH$_2$-N^1HEt)



Color: Orange. Yield: 0.86 g, 86 %, m.p. 185-186 °C. IR (KBr, cm^{-1}): ν(N^1–H) 3360 s, ν(O−H) 3321 s, ν(N^2–H) 3176 br, ν(C–H) 2972 w; 2940 w, 2873; ν(C=N) + ν(C=C) + δ(N−H) 1613 s, 1594 s, ν(N=O) 1550s; δ(C−H) 1498 s; 1442 m, δ(N=O) 1353 s, 1320 s, 1289 s, 1250 s, 1250s, 1212 s, 1136 m, 1111 s, 1053 w, 920 m; ν(C–S) 850 s; 793 s, 743 s, 698 s, 672 s, 608 w, 583 w, 506 w, 456 w. ^{1}H NMR (δ, ppm; DMSO): δ = 11.02 (1H, s, OH), 8.88 (1H, s, N^2H), 8.31(1H, s, C^2H), 8.02 (2H, m, C^4H + C^6H), 7.45 (1H, s, N^1H), 6.91 (1H, d, C^5H), 3.59 (2H, m, $N^1(CH_2)$, 1.28 (3H, m, CH^3). Electronic absorption spectrum (10^{-4} M in DMSO, λ_{max} /nm, ε /L·mol^{-1}·cm^{-1}): 320(1.723x10^4).

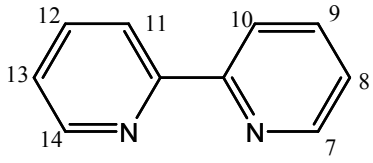
1S.4. *3-nitro-salicylaldehyde-N^1-phenyl thiosemicarbazone (3-NO_2-stscH$_2$-N^1HPh)*



Color: Yellow. Yield: 0.82 g, 82 %, m.p. 201-202 °C. IR (KBr, cm^{-1}): ν(N^1–H) 3369 s; ν(O−H) 3263 w, ν(N^2–H) 3179 br, 2989 m; ν(C=N) + ν(C=C)+ δ(N-H) 1643s, 1619 s, ν(N=O) 1531 s, 1511 s; δ(C−H) 1442 w; 1399 w, δ(N=O) 1369 w; 1282 s, 1161 s, 1000 s, ν(C–S) 842 s; 647 w, 6301 s, 565 w. ^{1}H NMR (δ, ppm; $CDCl_3$): δ = 11.53 (1H, s, OH), 10.21 (1H, s, N^2H), 9.26 (1H, s, C^2H), 8.46(1H, s, N^1H), 8.11 (2H, d, C^4H + C^6H), 7.52 (2H, s, o-H_{Ph}), 7.38(2H, m, m-$H_{Ph)}$, 7.15 (1H, m, p-H_{Ph}), 7.07 (1H, d, C^5H). Electronic absorption spectrum (10^{-4} M in DMSO, λ_{max} /nm, ε /L·mol^{-1}·cm^{-1}): 317 (1.348x10^4).

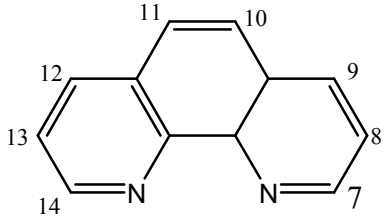
2S. Bipy and Phen Co-ligands – NMR data

2S.1 : 2, 2′-bipyridine (bipy)



^{1}H NMR of 2, 2′-bipyridine (δ, ppm; $CDCl_3$): δ = 8.70 (2H, d, C^7H_{bipy} + $C^{14}H_{bipy}$); 8.42 (2H, d, $C^{10}H_{bipy}$ + $C^{11}H_{bipy}$), 7.87 (2H, m, C^9H_{bipy} + $C^{12}H_{bipy}$), 7.32 (2H, m, C^8H_{bipy} + $C^{13}H_{bipy}$).

2S.2: 1, 10 –phenanthroline (phen)



^{1}H NMR of 1, 10 –phenanthroline (δ, ppm; $CDCl_3$): δ = 9.20 (2H, d, C^7H_{phen} + $C^{14}H_{phen}$); 8.25 (2H, d, C^9H_{phen} + $C^{12}H_{phen}$), 7.80 (2H, s, $C^{10}H_{phen}$ + $C^{11}H_{phen}$), 7.64 (2H, dd, C^8H_{phen} + $C^{13}H_{phen}$).

3S. ESI-mass data with isotopic patterns

3S.1 [Zn(3-NO_2-stsc-N^1H_2)(bipy)] **1**

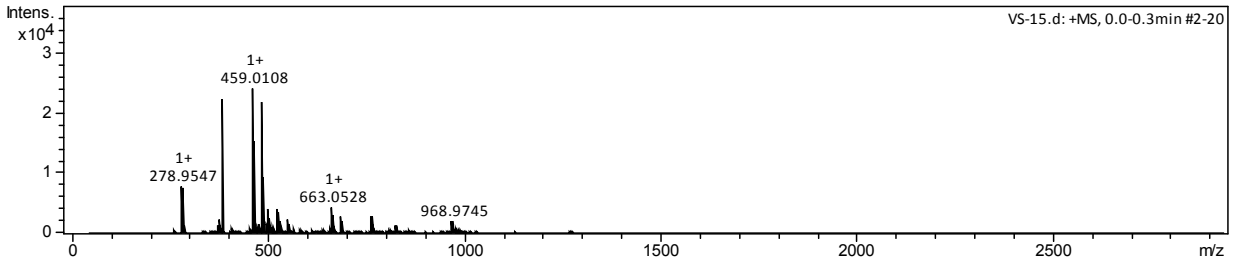


Fig. 3S.1.1: ESI mass spectra of [Zn(3-NO_2-stsc-N^1H_2)(bipy)] (**1**)

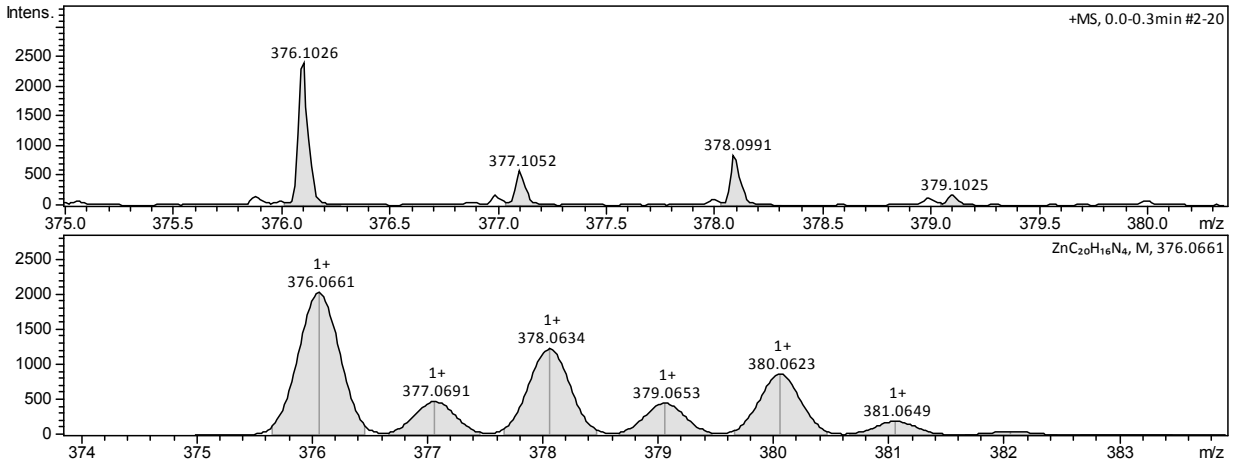


Fig. 3S.1.2: ESI-mass peak due to [Zn(bipy)$_2$+ H]$^+$(m/z = calcd, 376.1, obsd. 376.06)

species with isotopic pattern (complex **1**).

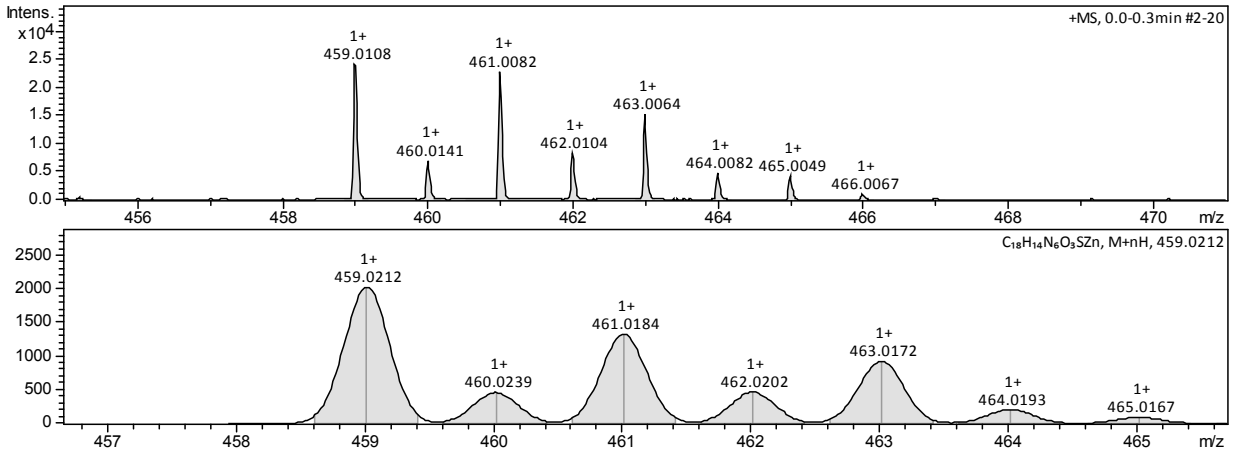


Fig. 3S.1.3: ESI-mass peak due to molecular ion [Zn(3-NO_2-stsc-N^1H_2)(bipy)+ H]$^+$ (m/z = calcd, 459.02, obsd. 459.01) with isotopic pattern (complex **1**).

3S.2.[Zn(3-NO_2-stsc-N^1HMe)(bipy] (**2**)

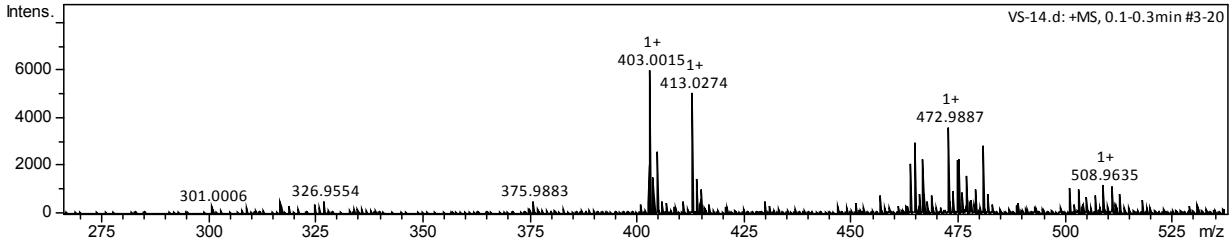


Fig. 3S.2.1. ESI mass spectra of [Zn(3-NO_2-stsc-N^1HMe)(bipy)] (**2**)

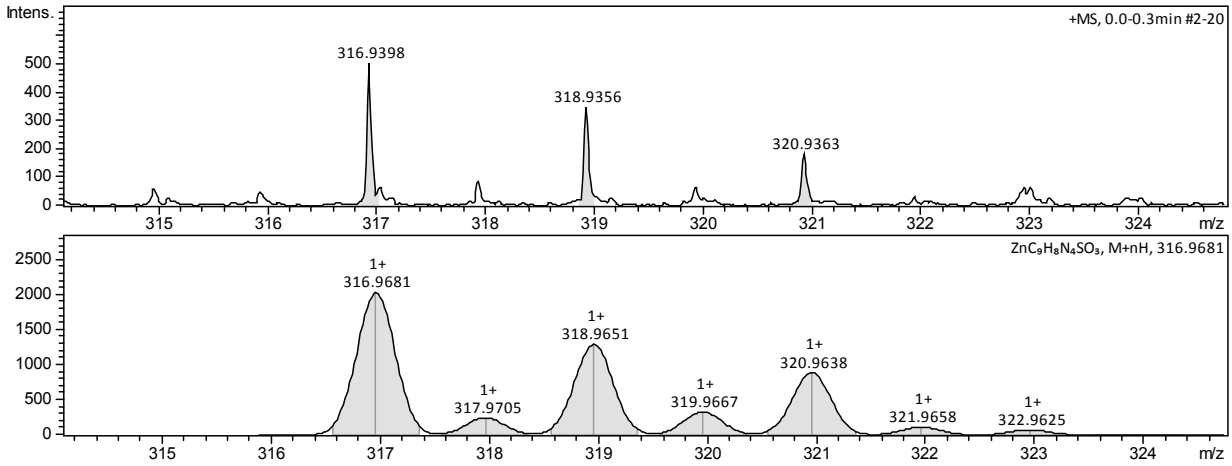


Fig. 3S.2.2. ESI-mass peak due to molecular ion [Zn(3-NO_2-stsc-N^1HMe)+ H]$^+$ (m/z = calcd, 316.96, obsd. 316.93) with isotopic pattern (complex **2**).

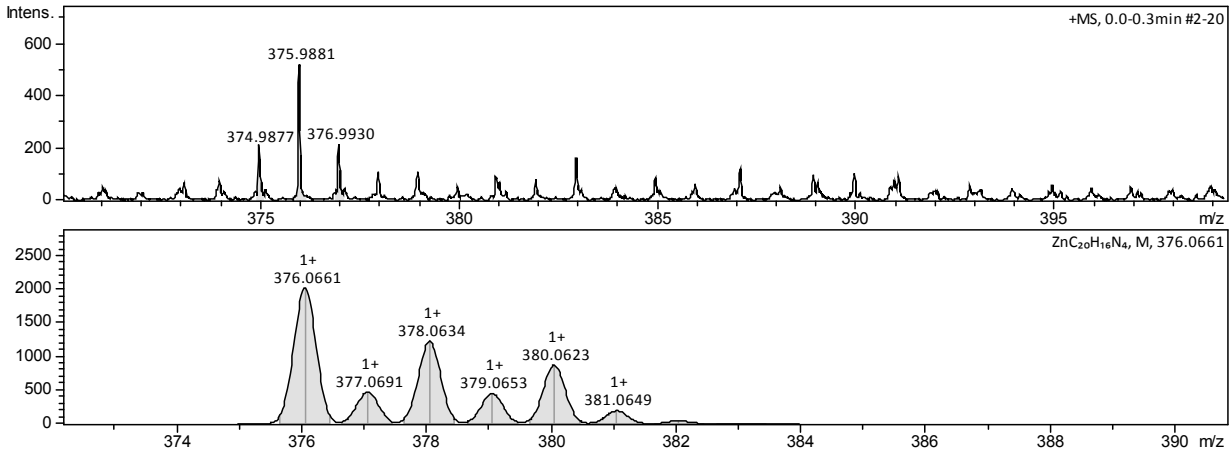


Fig. 3S.2.3. ESI-mass peak due to [Cu(bipy)$_2$+ H]$^+$(m/z = calcd, 376.06 obsd. 375.98) species with isotopic pattern (complex **2**).

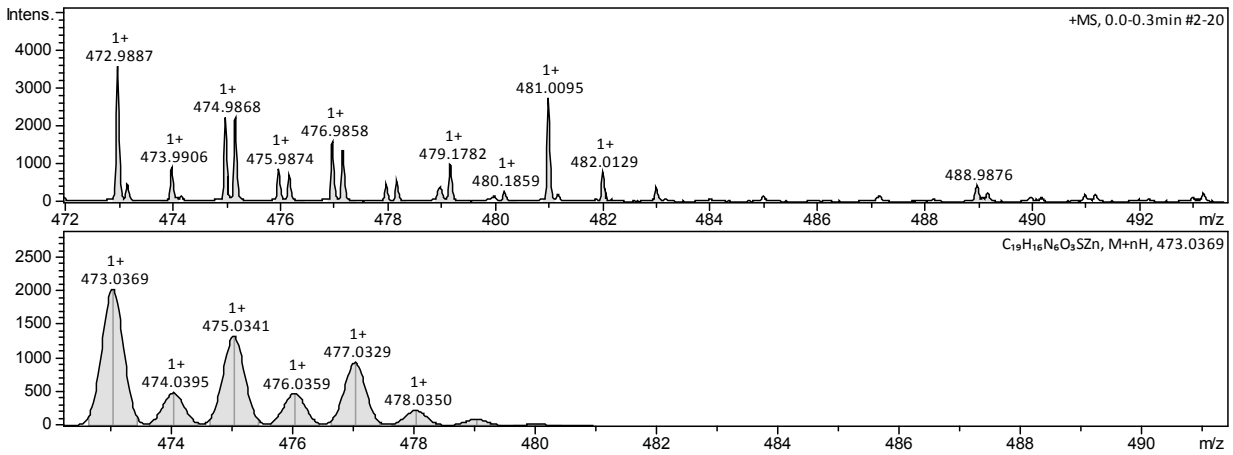


Fig. 3S.2.4. ESI-mass peak due to molecular ion [Zn(3-NO_2-stsc-N^1HMe)(bipy)+ H]$^+$ (m/z = calcd, 473.03, obsd. 472.98) with isotopic pattern (complex **2**).

3S.3. [Zn(3-NO_2-stsc-N^1HEt)(bipy] **(3)**

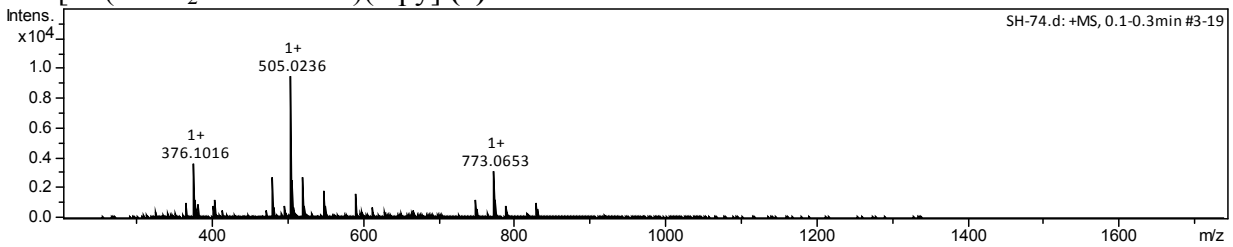


Fig. 3S.3.1 ESI mass spectra of [Zn(3-NO_2-stsc-N^1HEt)(bipy)] (**3**)

.

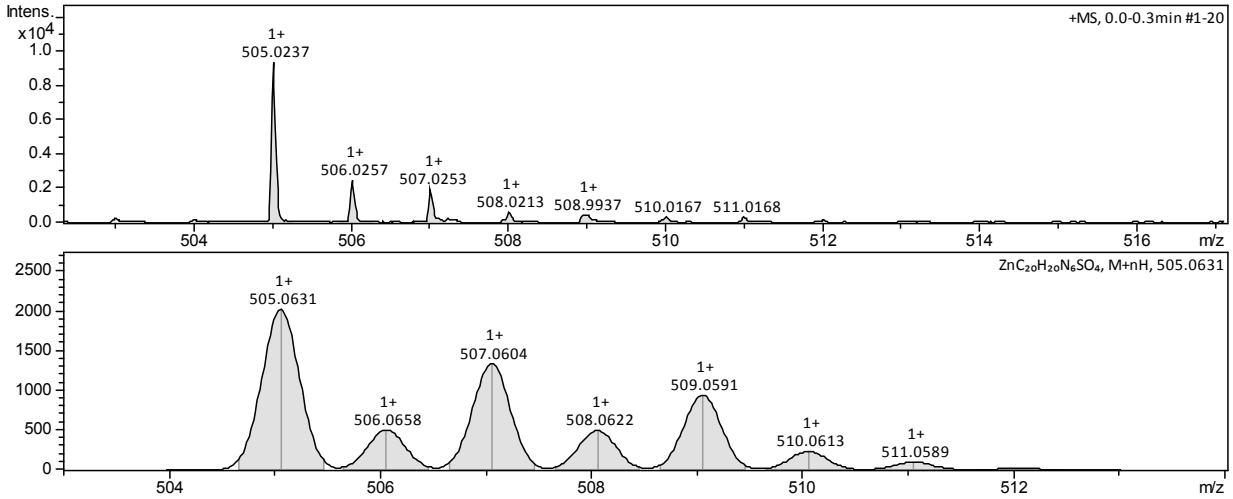
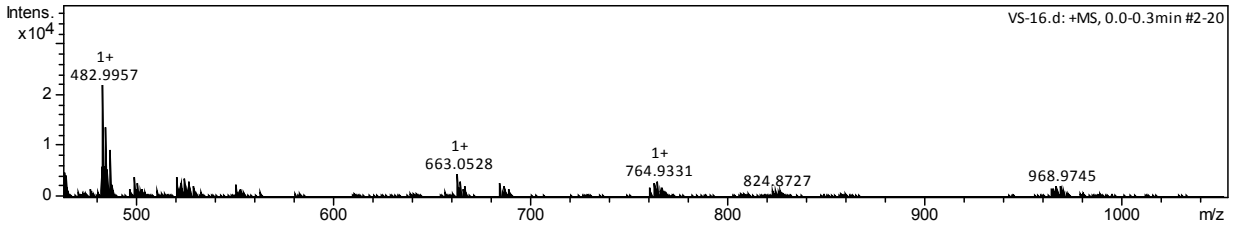
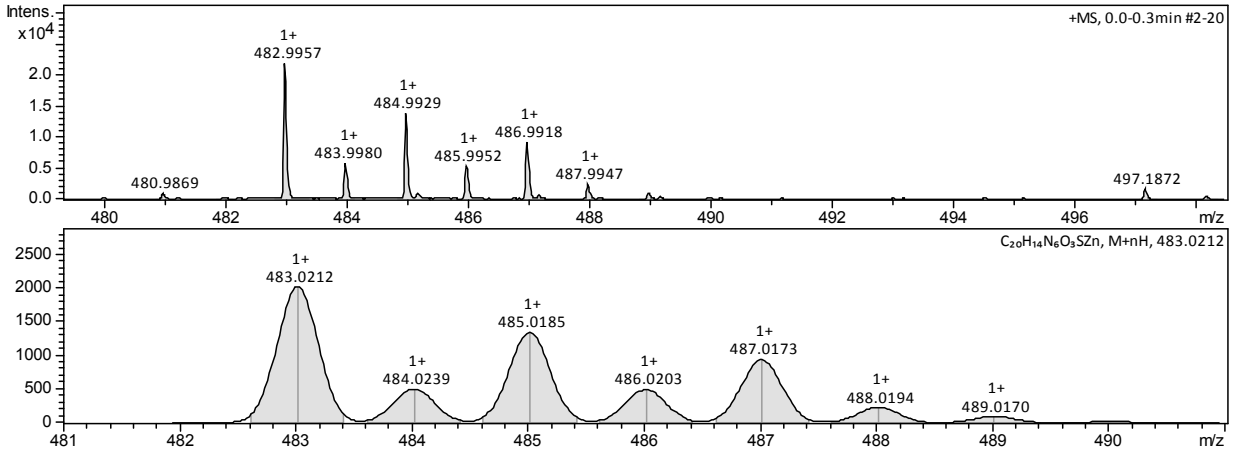


Fig. 3S.3.2. ESI-mass peak due to molecular ion [Zn(3-NO_2-stsc-N^1HEt)(bipy)+ H]$^+$·H_2O (m/z = calcd, 505.06, obsd. 505.02) with isotopic pattern (complex 3).

3S.4. Zn(3-NO_2-stsc-N^1H_2)(phen) (**5**)



3S.4.1. ESI mass spectra of [Zn(3-NO_2-stsc-N^1H_2)(phen)] (**5**)



3S.4.2. ESI-mass peak due to molecular ion [Cu(3-NO_2-stsc-N^1H_2)(phen)+ H]$^+$

(m/z = calcd, 483.02, obsd. 482.99) with isotopic pattern (complex **5**).

3S.5. [Zn(3-NO_2-stsc-N^1HPh)(phen)] (**8**)

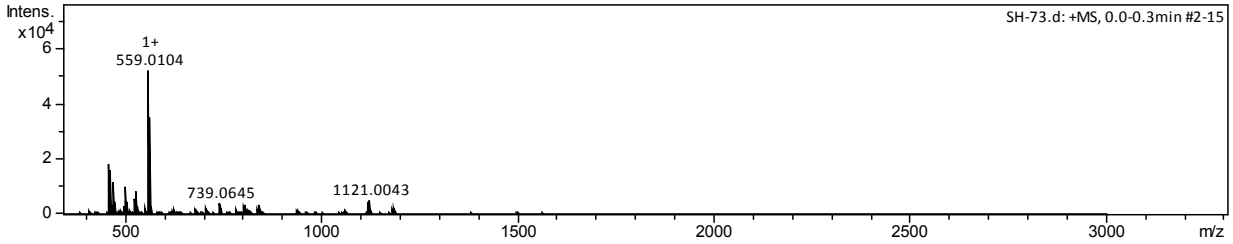
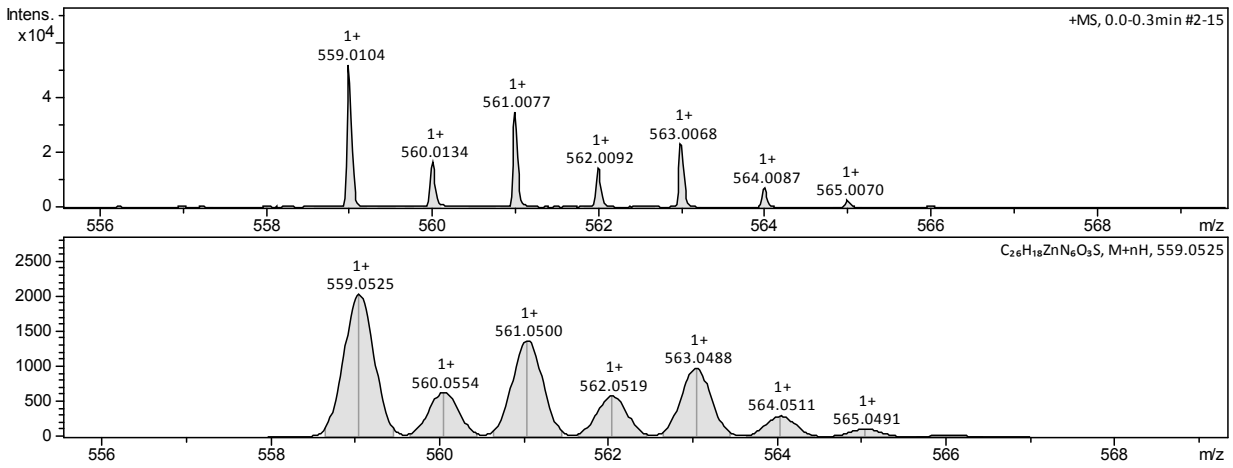


Fig. 3S.5.1. ESI mass spectra of [Zn(3-NO_2-stsc-N^1HPh)(phen)] (**8**)



3S.5.2. ESI-mass peak due to molecular ion $[Zn(3\text{-}NO_2\text{-}stsc\text{-}N^1HPh)(phen)+ H]^+\cdot H_2O$ (m/z = calcd, 559.05, obsd. 559.01) with isotopic pattern (complex **8**).

4S. Zone of inhibtion values

Table 1S. Zone of inhibition (ZOI, in mm) for zinc complexes **1-8** and free ligands. [a,b]

Complex No.	*MRSA* *ZOI*	*S. aureus* *ZOI*	*K. pneumoniae 1* *ZOI*	*S. typhimurium2* *ZOI*	*C. albicans* *ZOI*
1 (H, bipy)	15	15	16	NA	16
2 (Me, bipy)	21	24	21	21	25
3 (Et, bipy)	24	21	19	15	25
4 (Ph, bipy)	21	21	20	20	21
5 (H, phen)	18	21	18	13	27
6 (Me, phen)	19	14	15	NA	15
7 (Et, phen)	23	22	23	14	25
8 (Ph, phen)	21	17	19	12	15
$3\text{-}NO_2\text{-}stscH_2\text{-}N^1H_2$	18	-	14	NA	14
$3\text{-}NO_2\text{-}stscH_2\text{-}N^1HMe$	20	15	18	NA	20
$3\text{-}NO_2\text{-}stscH_2\text{-}N^1HEt$	20	16	16	10	17

3-NO_2-stscH_2-N[1]HPh	18	15	15	11	15
Gentamicin[c]	33	26	35	35.5	-
Amphotericin[d]	-	-	-	-	34

[a]All measurements are in mm diameter of the inhibition zone. [b]Studies were made in 30% DMSO. [c]Gentamicin was used as positive control against bacteria {*MRSA, S. aureus, S. typhimurium* 2*, K.pneumoniae* 1) and [d]Amphotericin acts as a positive control against yeast (*C. albicans*).