

Construction of 5-(Alkylamino)-6-aryl/alkylpyrazine-2,3-dicarbonitriles via the One-Pot Reaction of Alkyl Isocyanides with Aryl/Alkyl Carbonyl Chlorides and Diaminomaleonitrile: Fluorescence and Antimicrobial Activity Evaluation

Amal Al-Azmi * and Elizabeth John

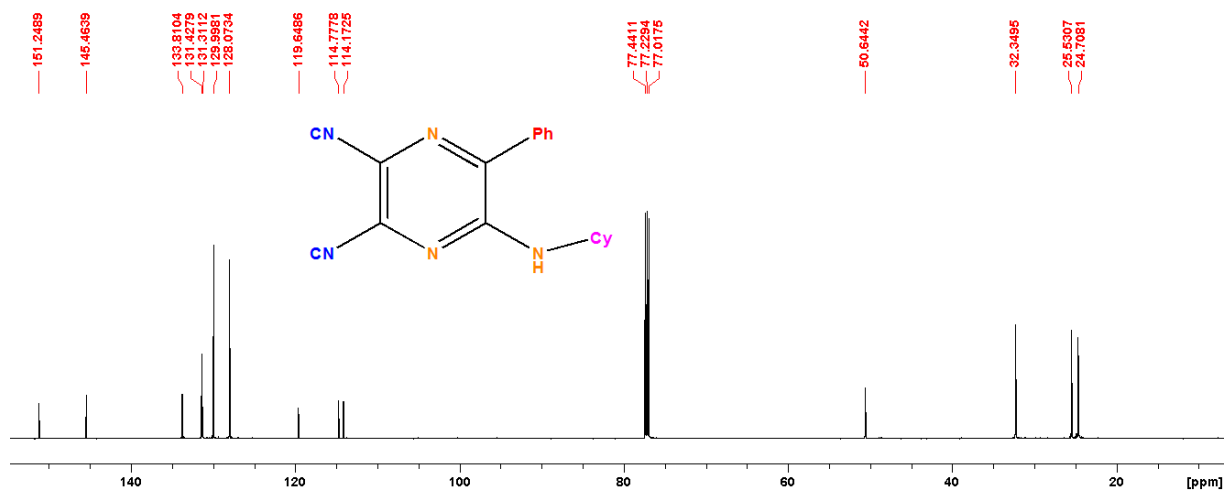
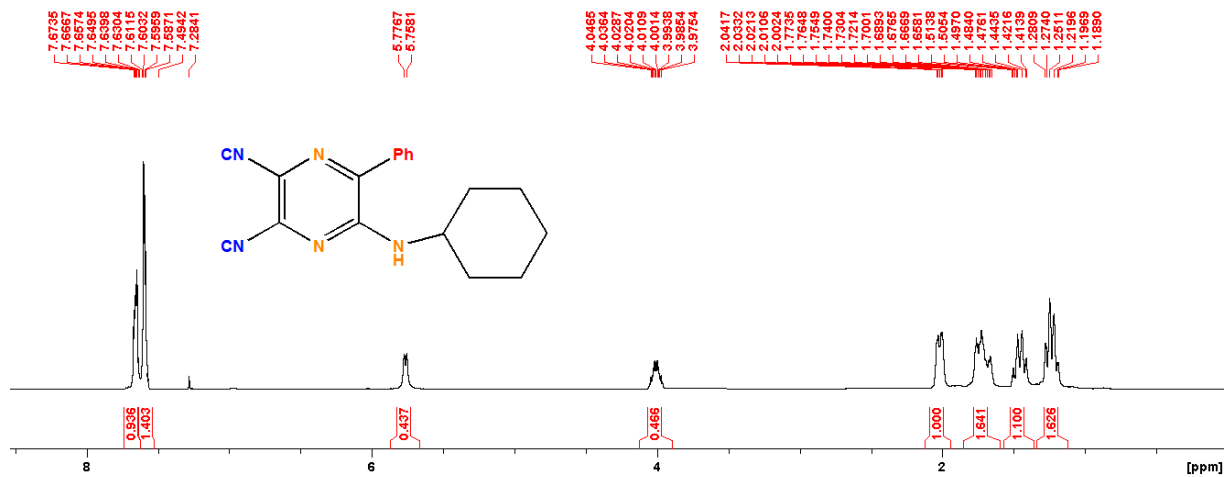
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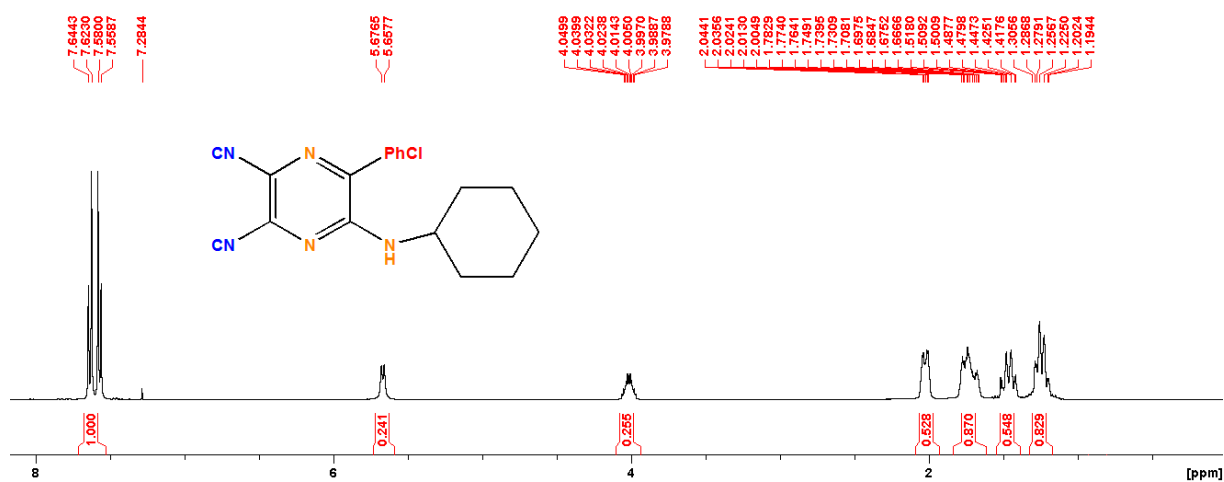
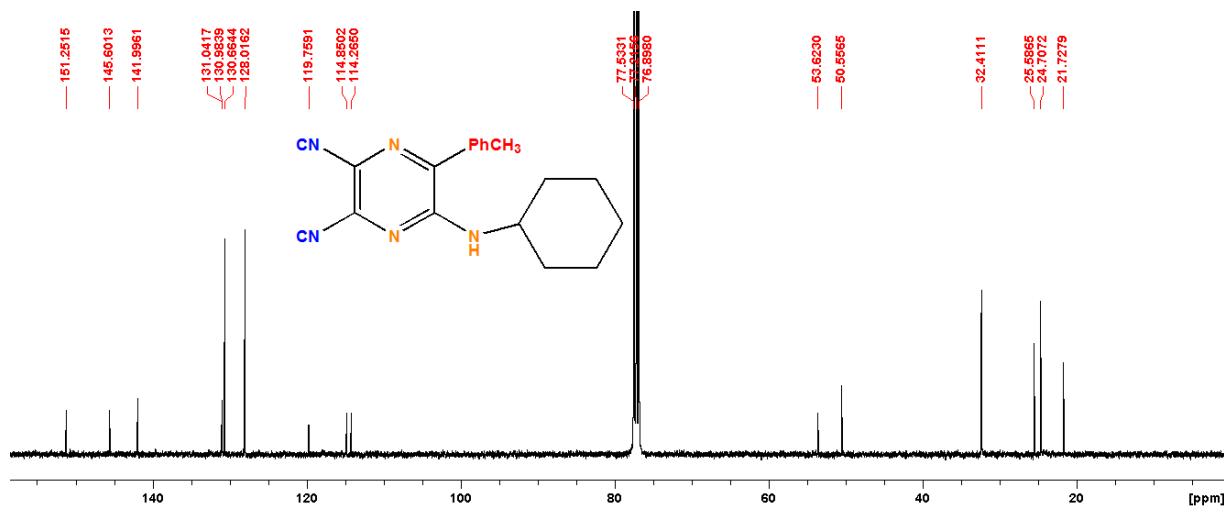
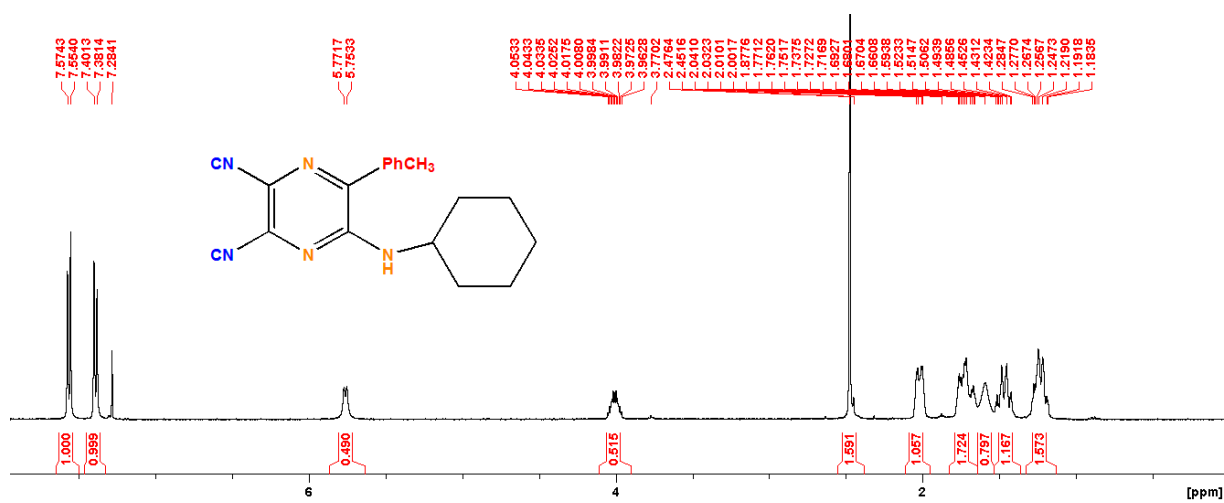
* Correspondence: amalrchem@gmail.com or amal.alazemi@ku.edu.kw

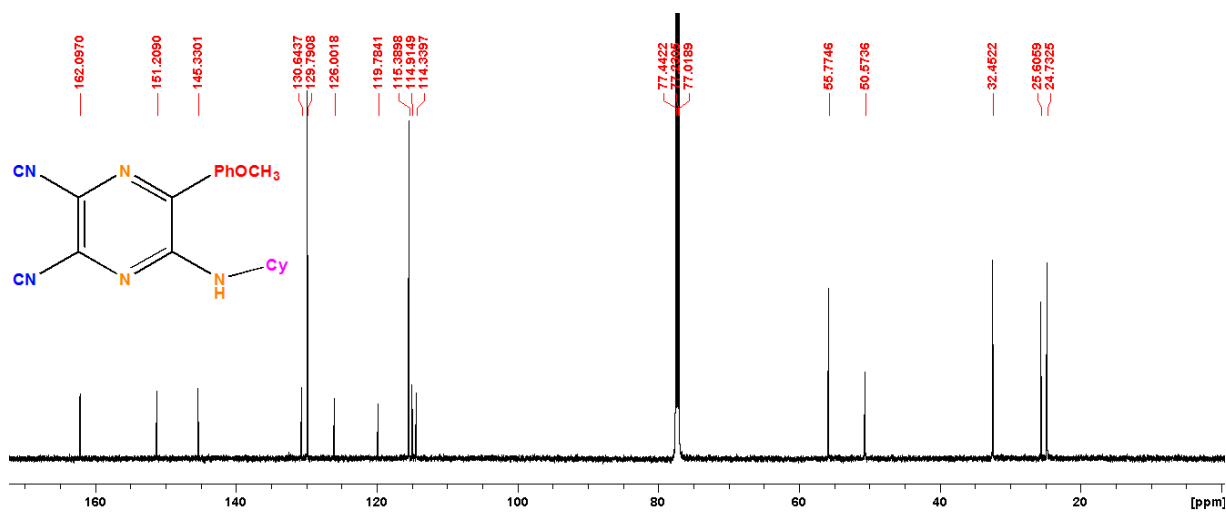
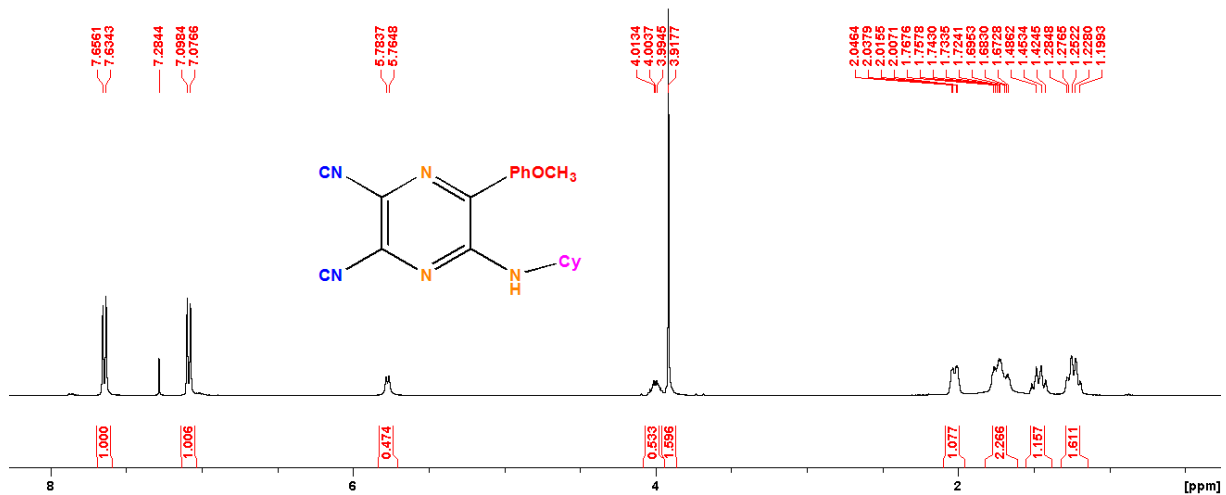
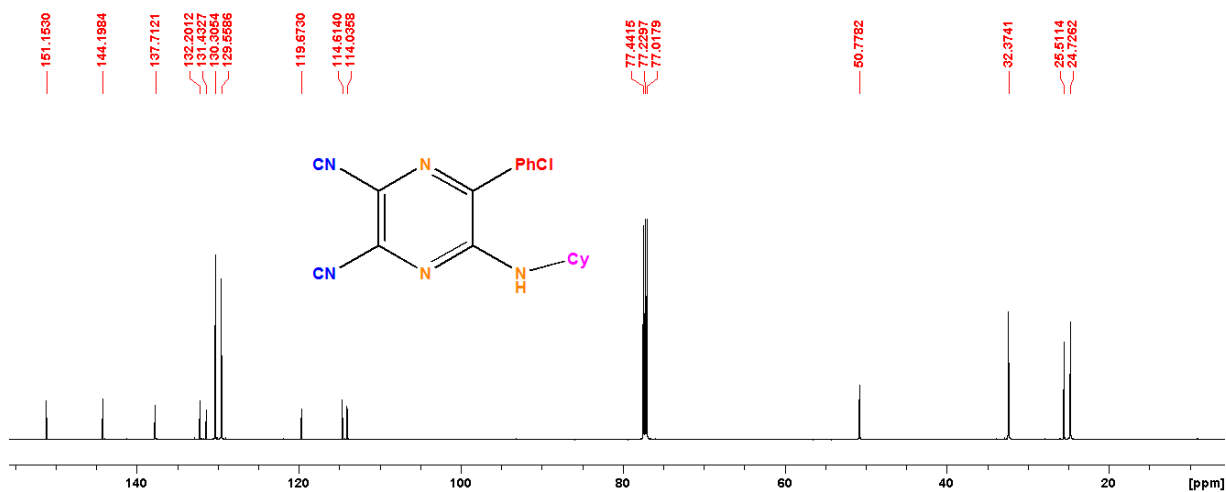
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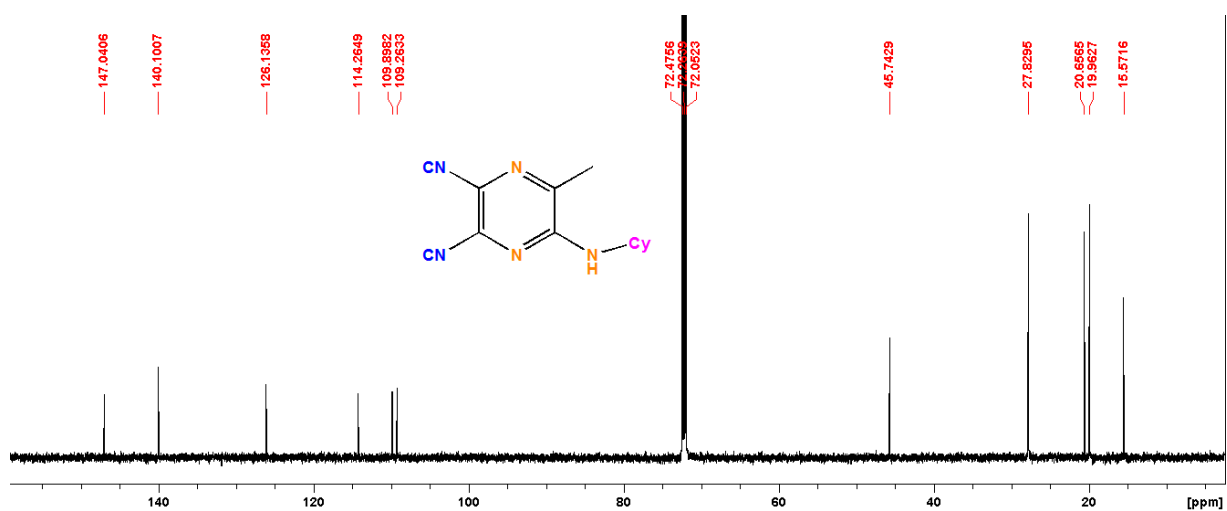
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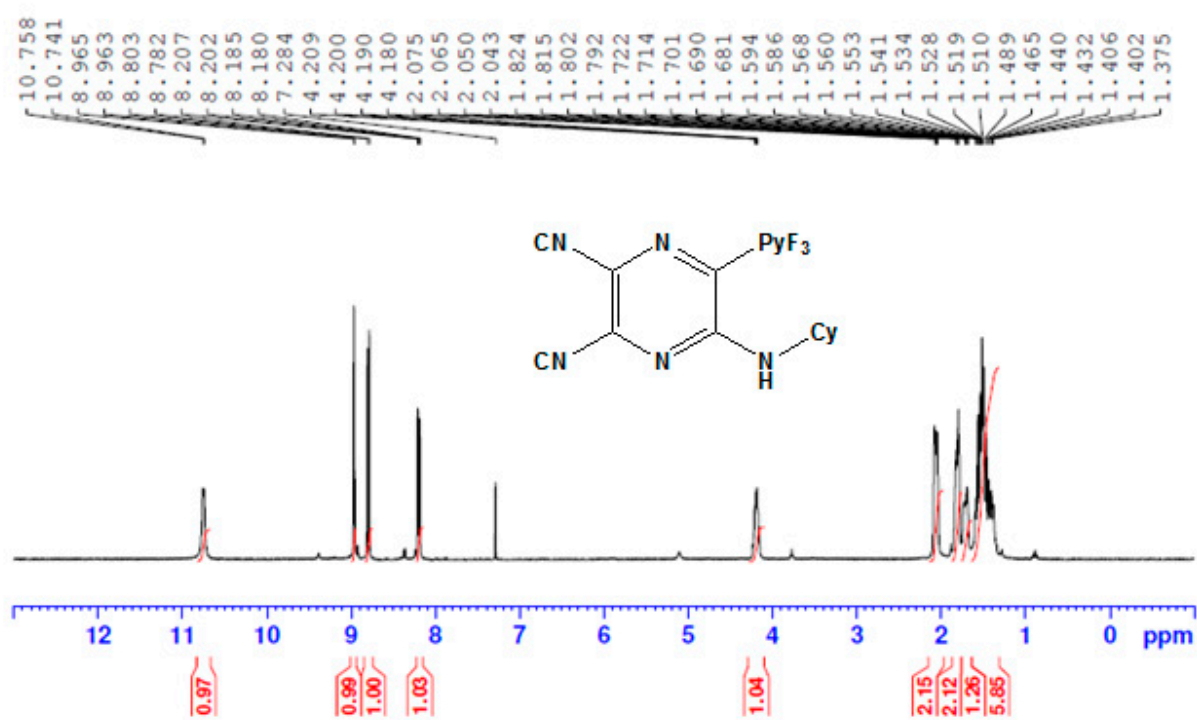
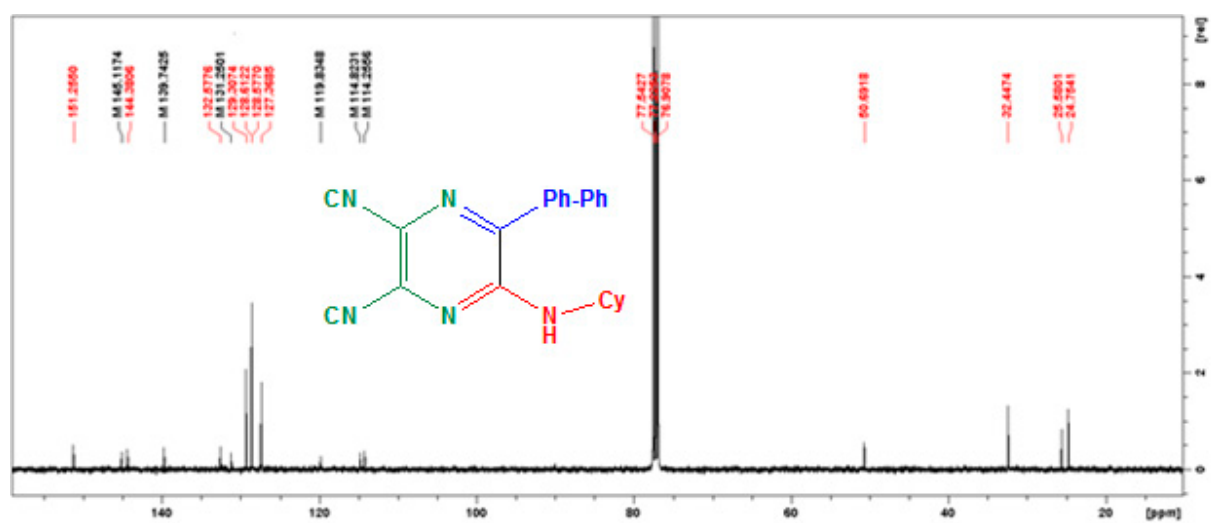
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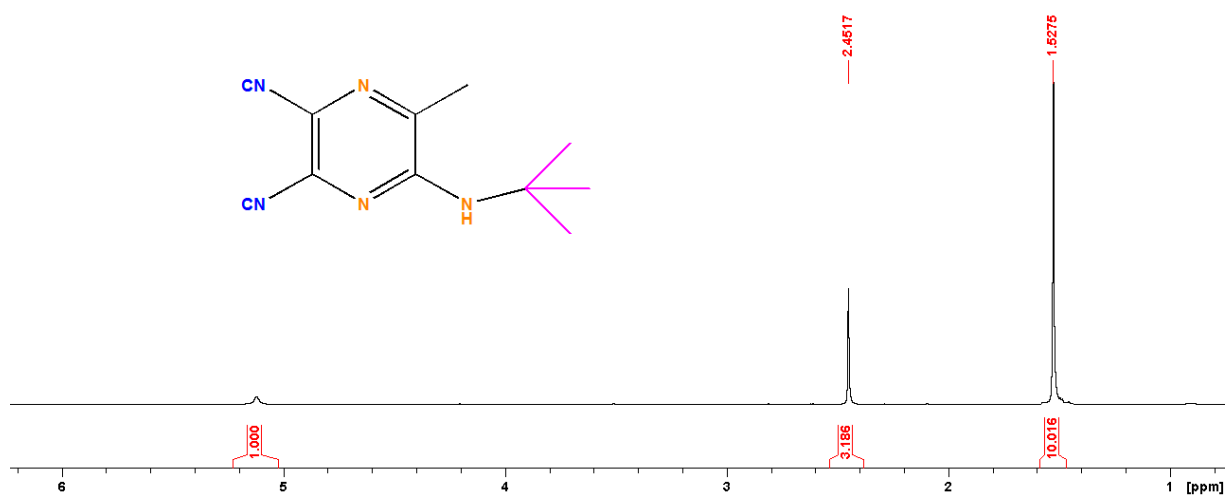
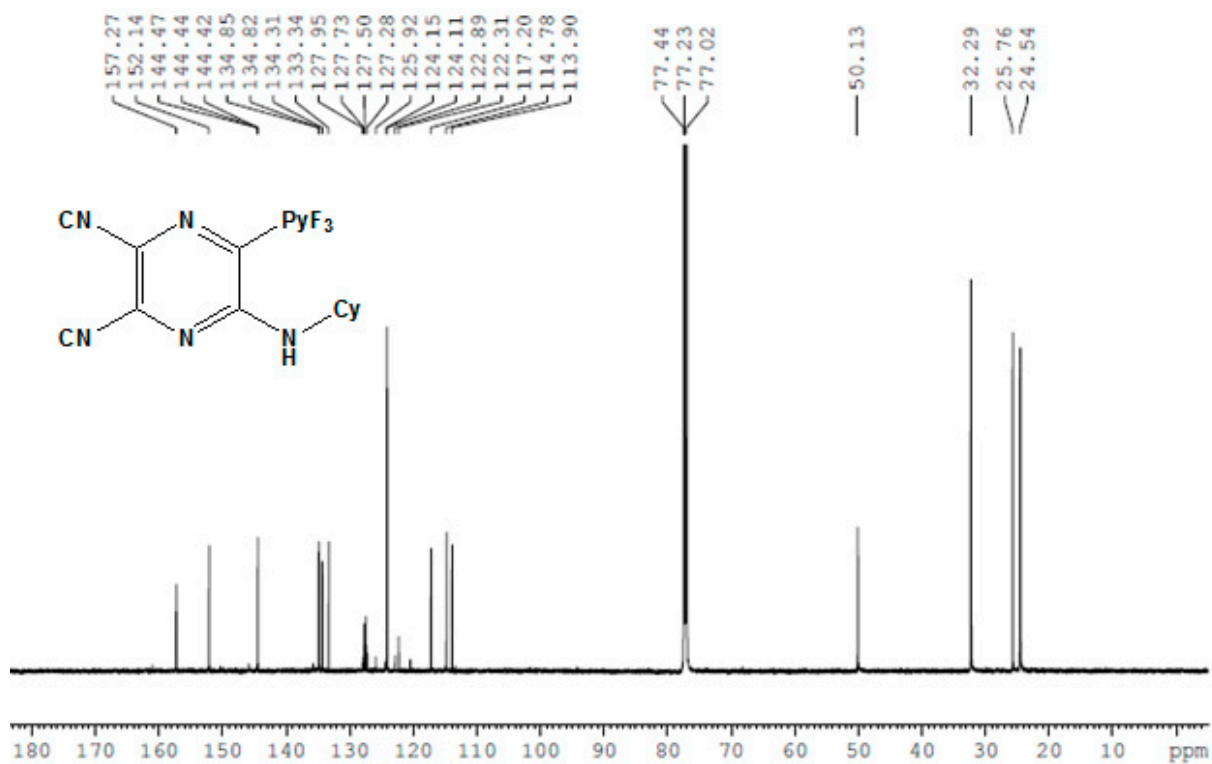


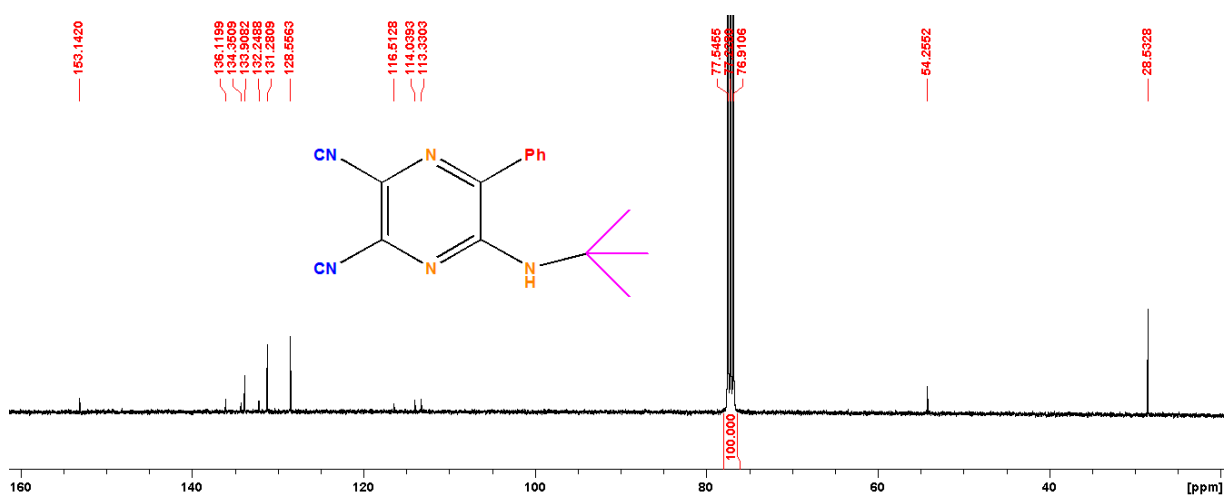
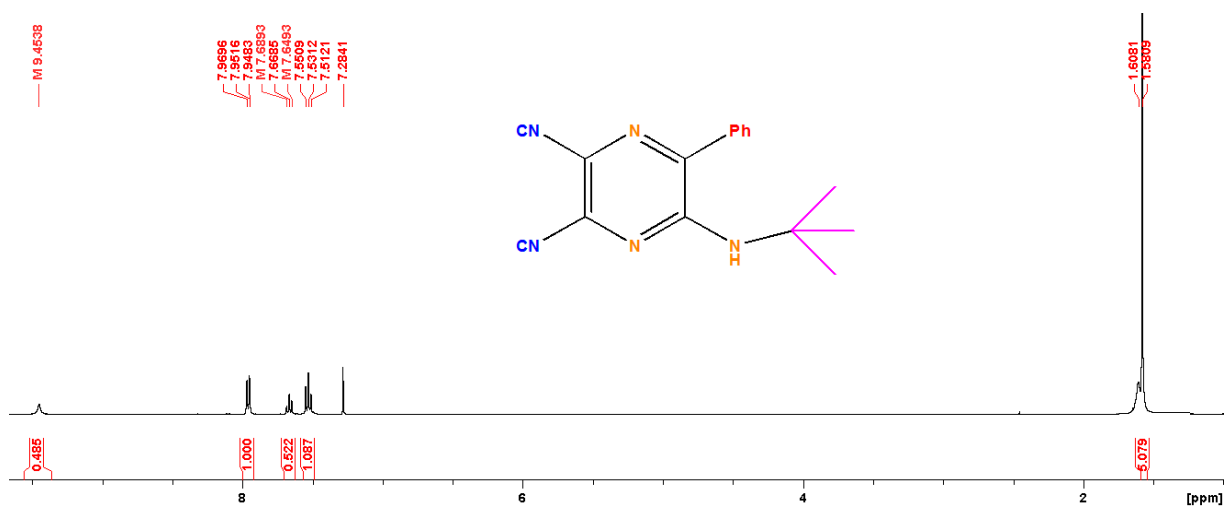
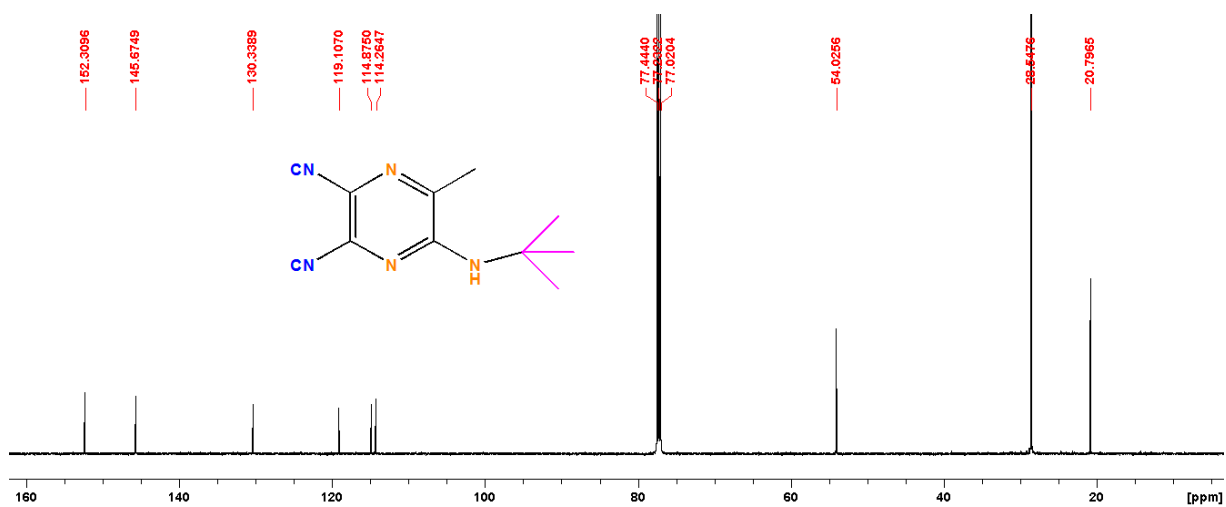


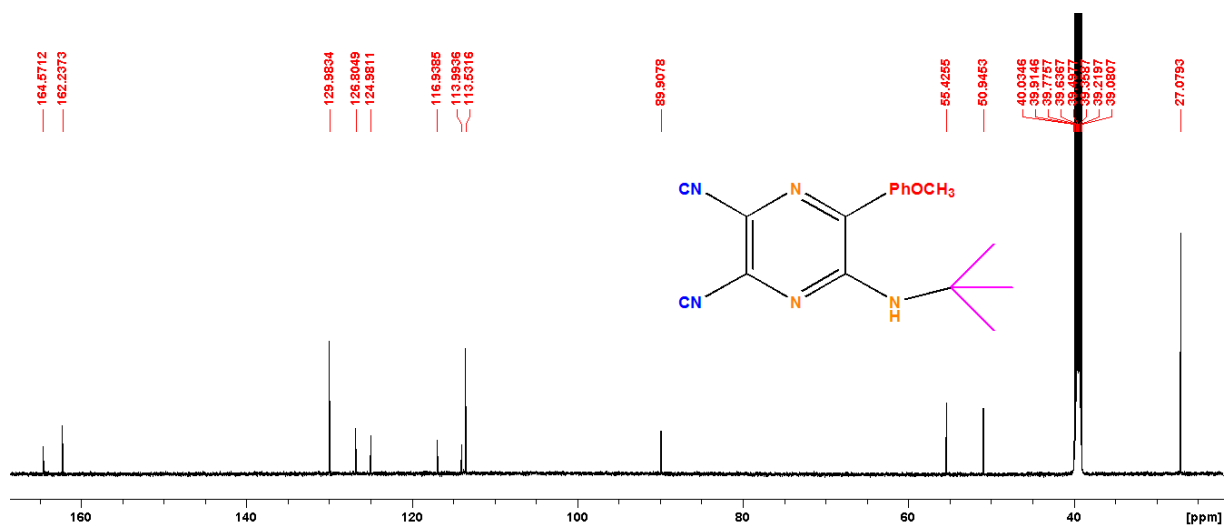
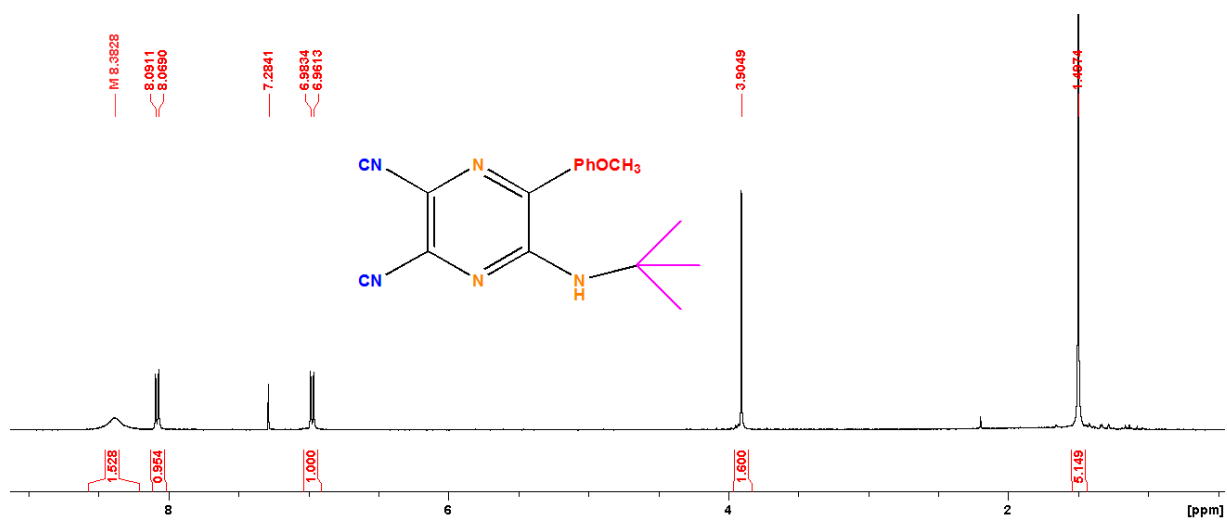


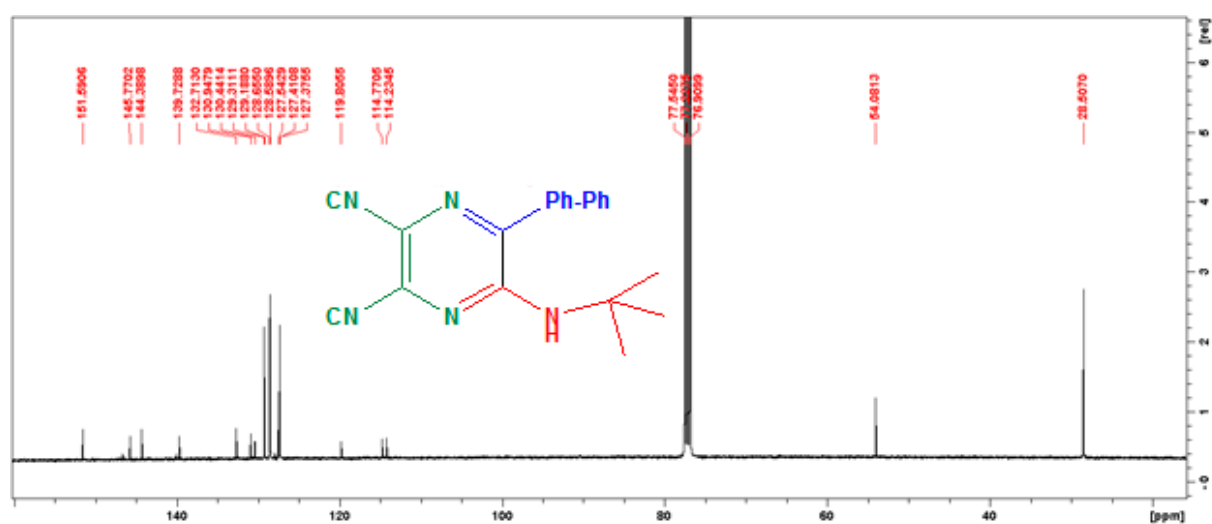
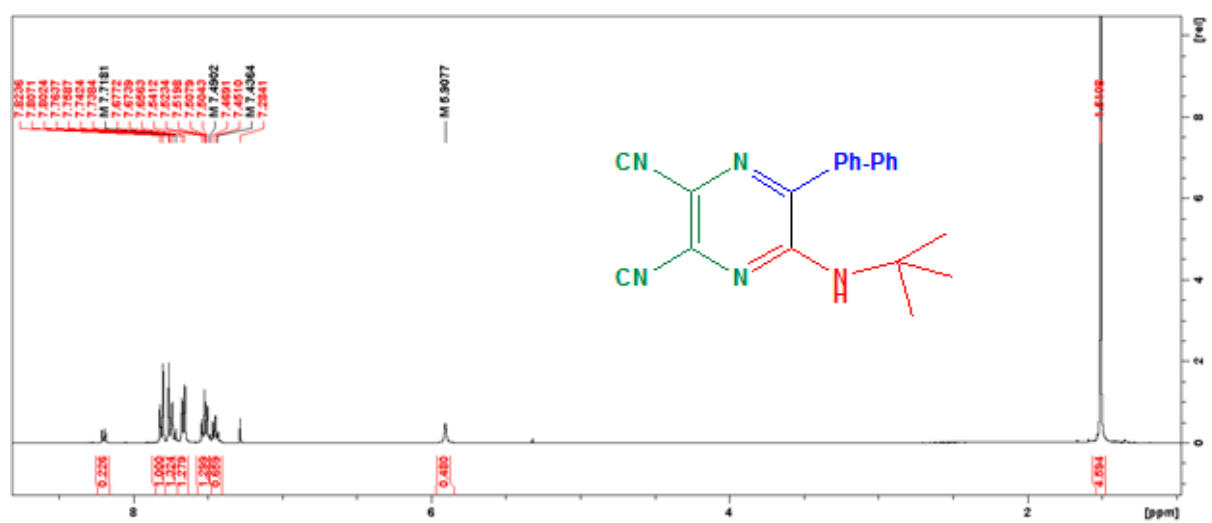


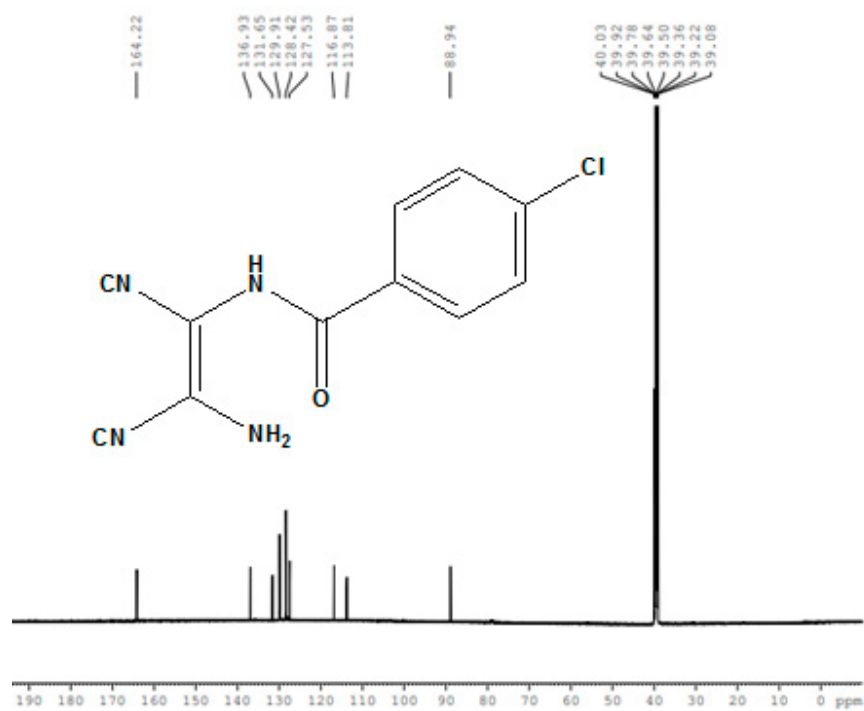
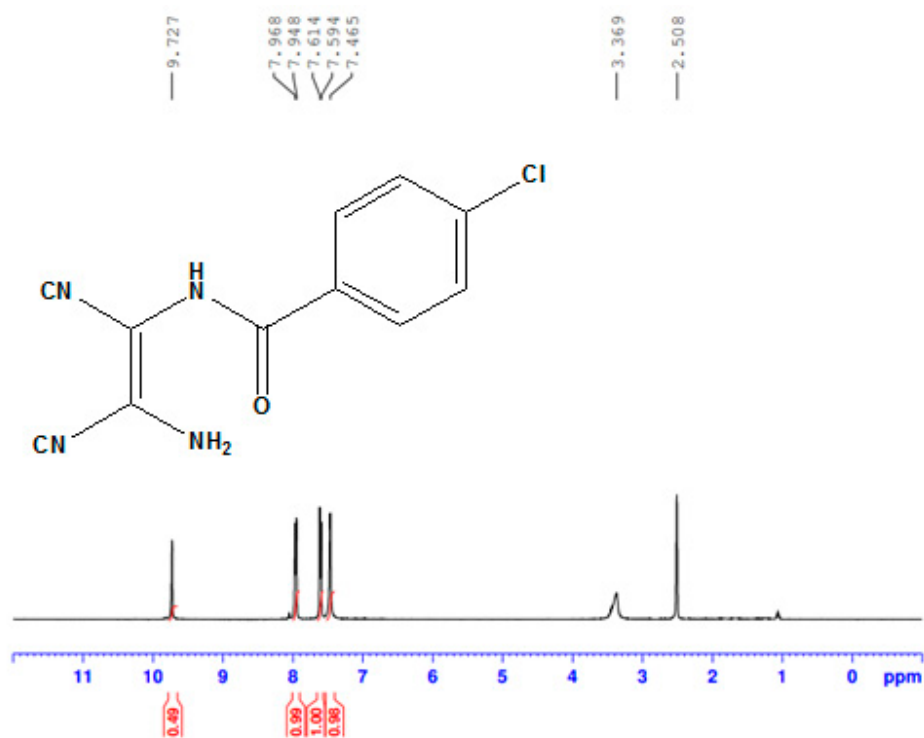


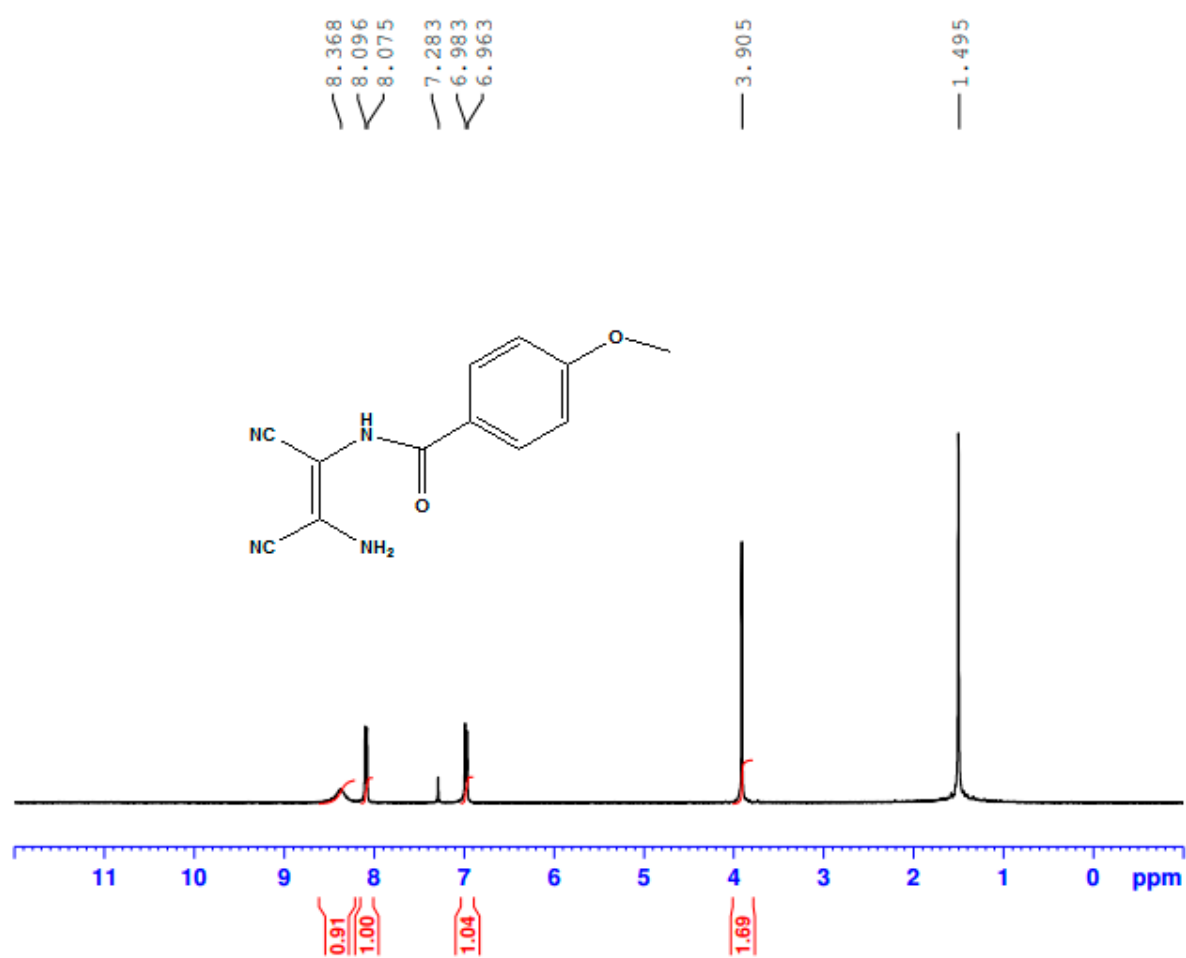


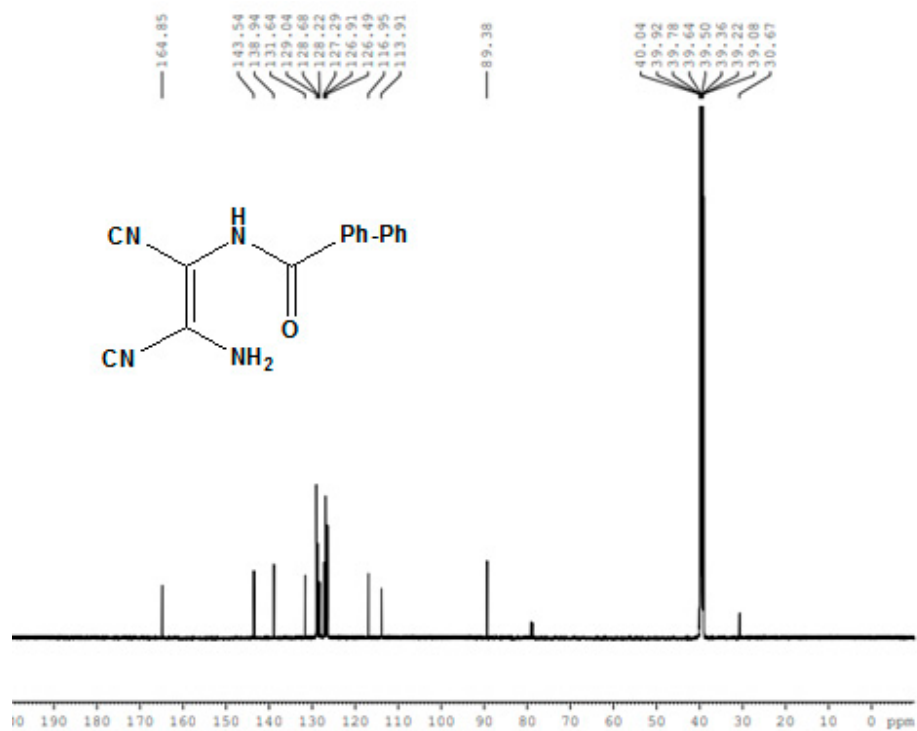
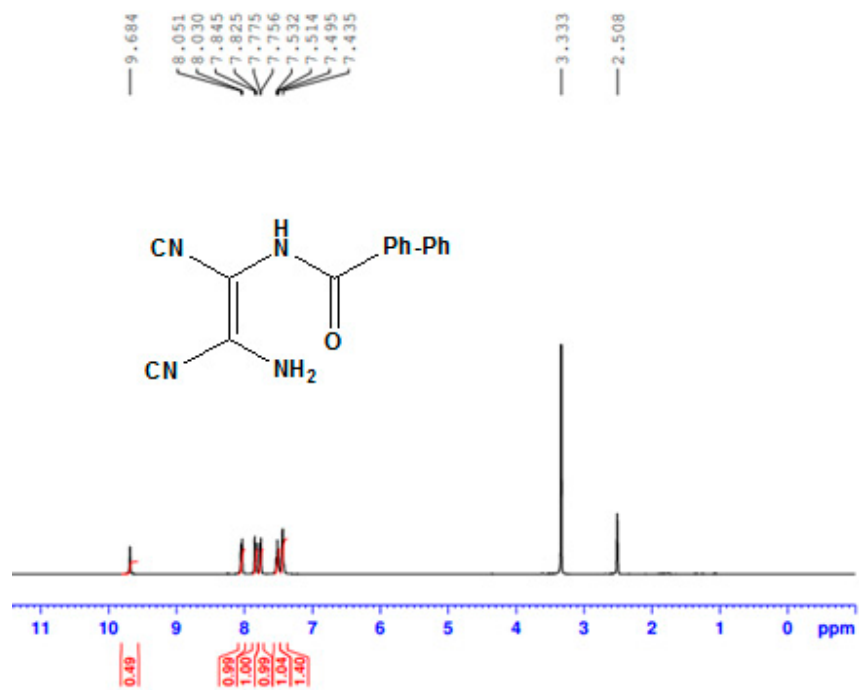






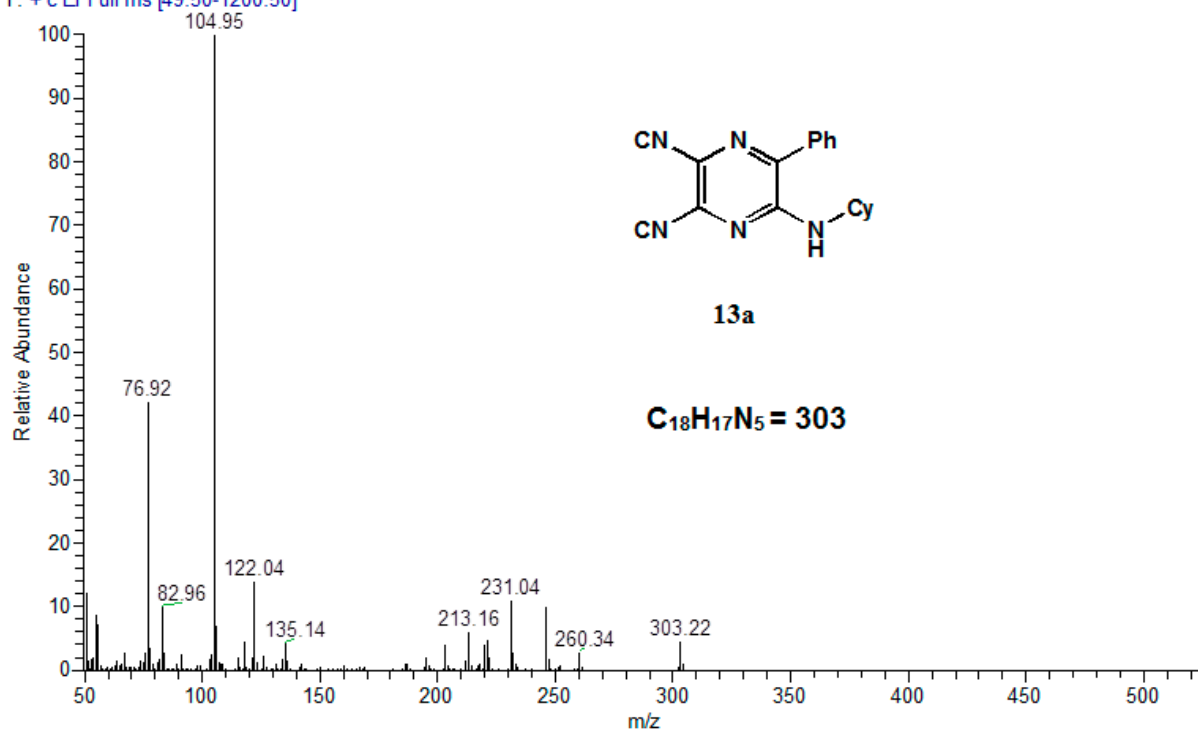




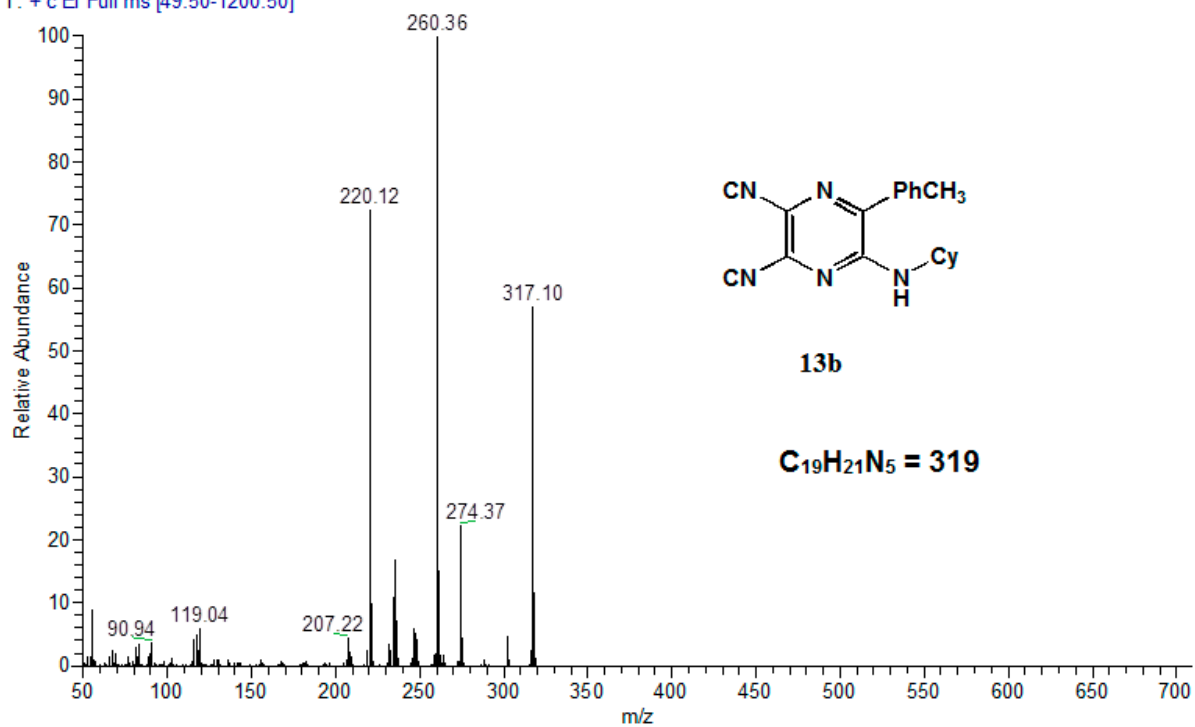


Mass spectra

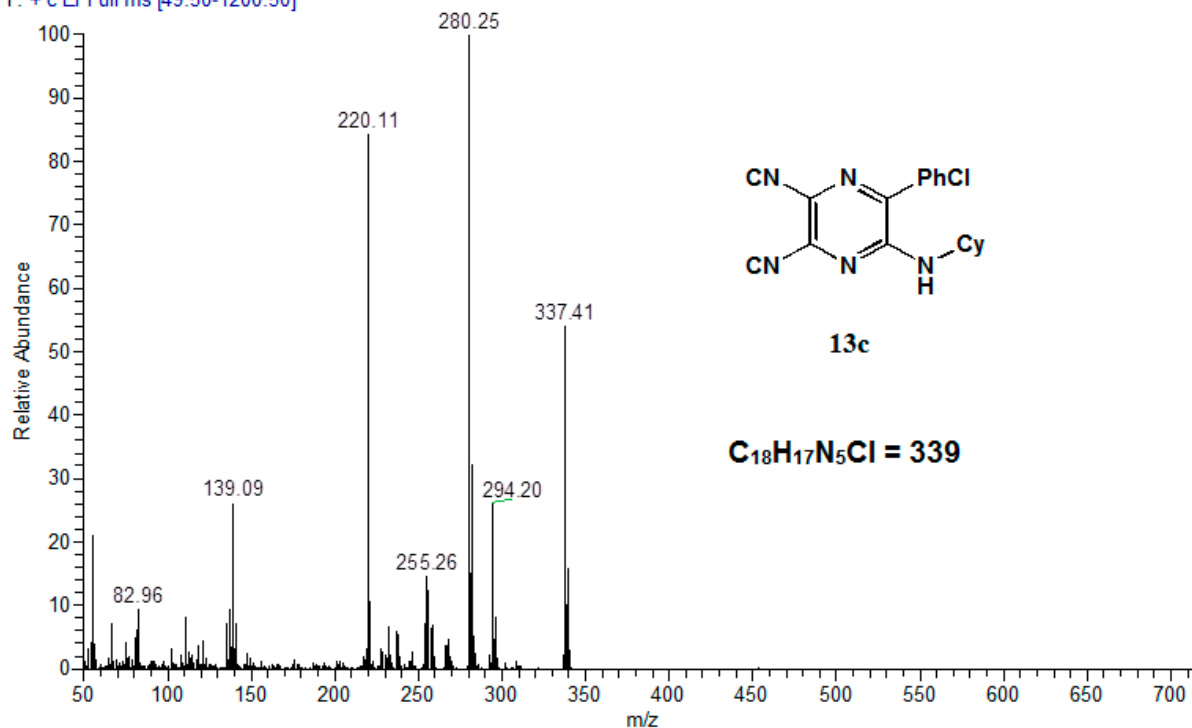
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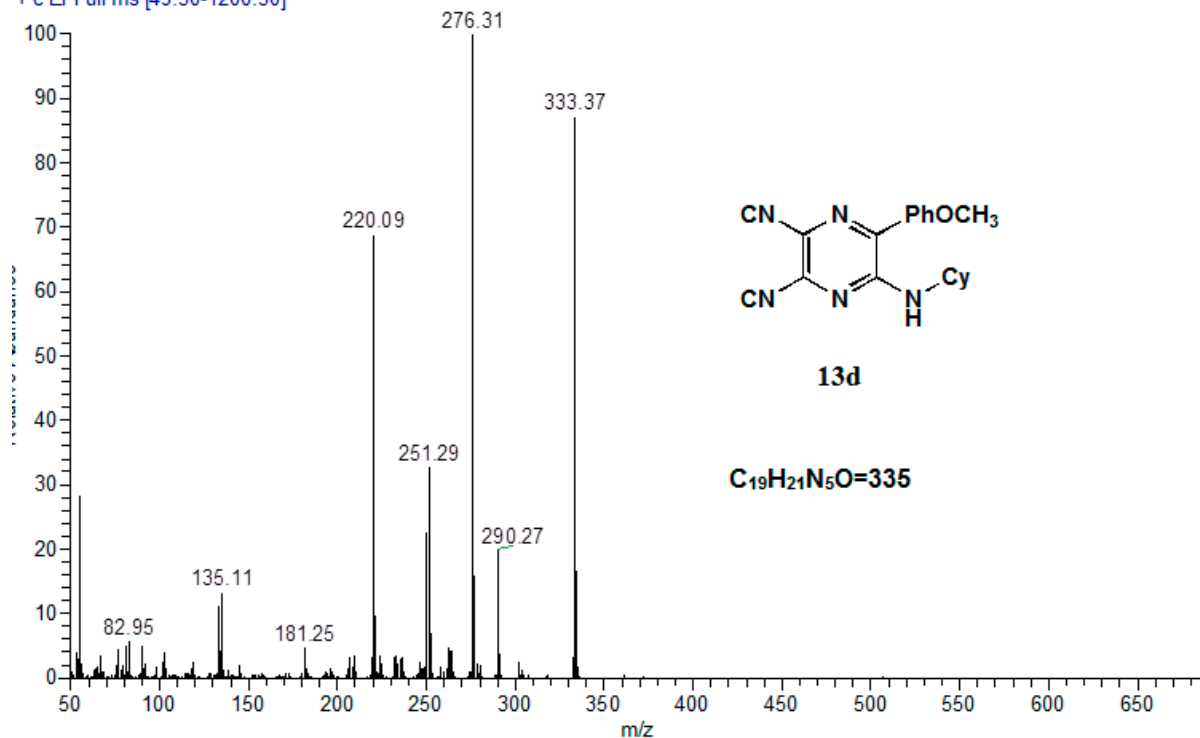
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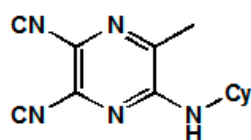
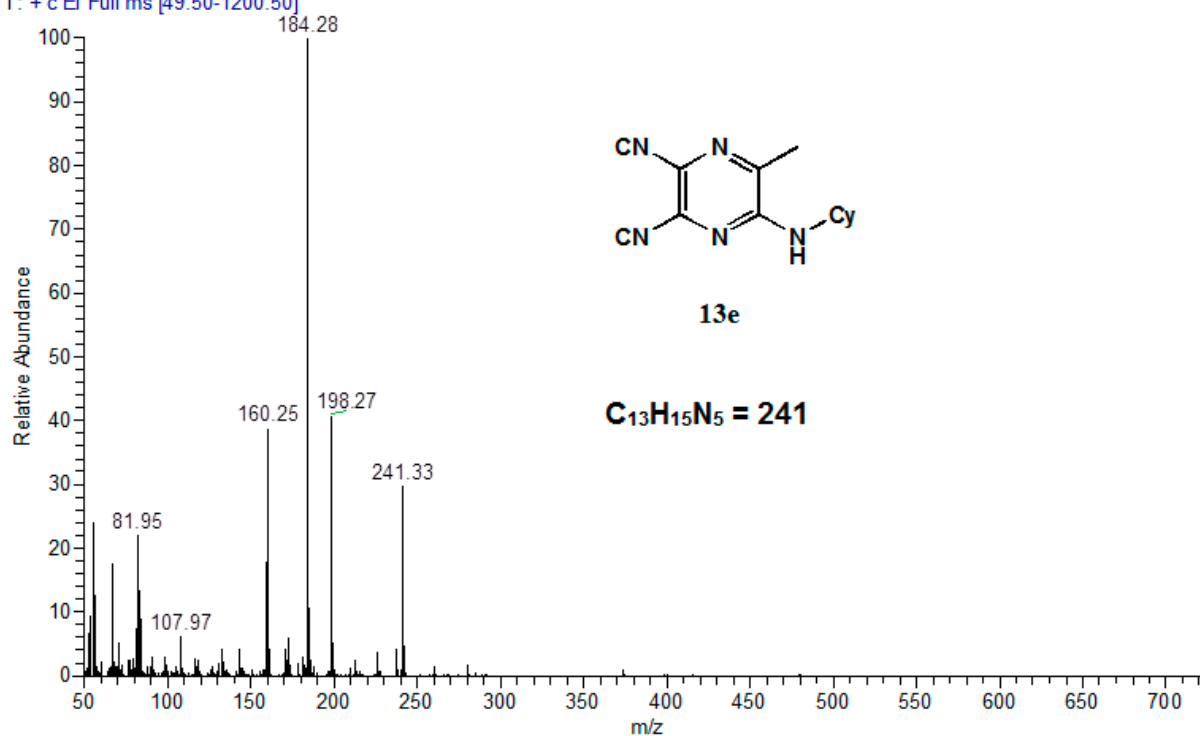
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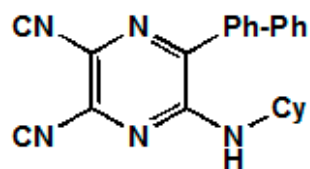
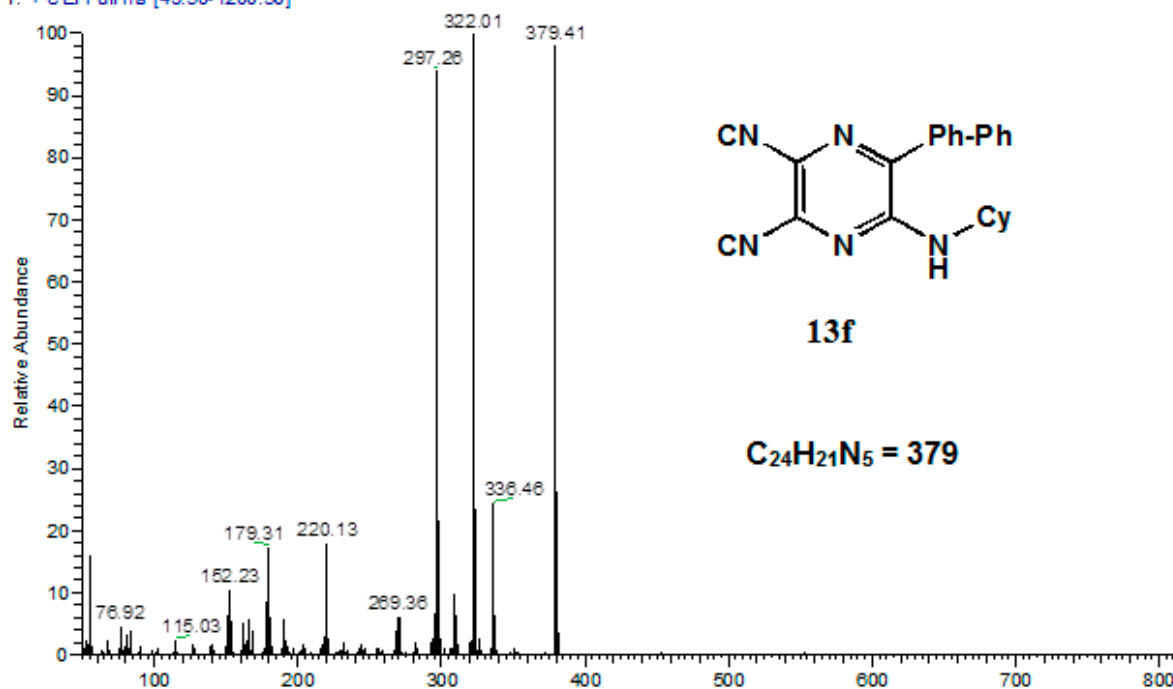
L 210616114706 #106 RT: 5.09 AV: 1 NL: 4.87E7
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13e

$C_{13}H_{15}N_5 = 241$

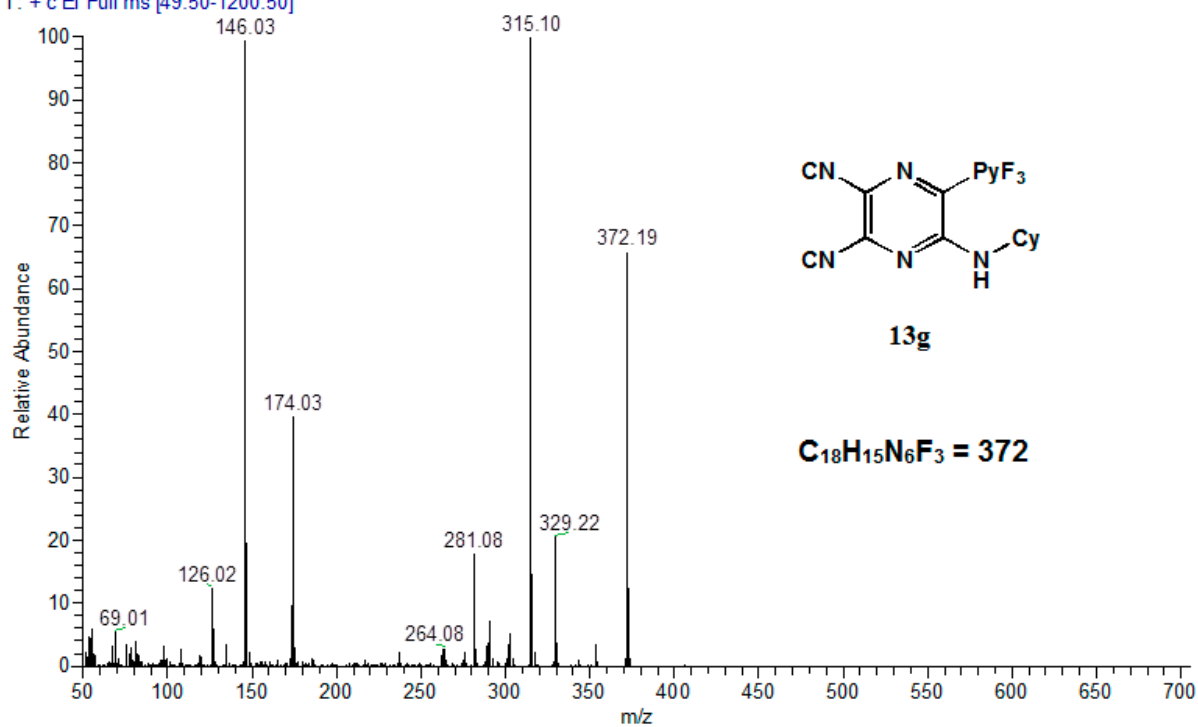
CYBnA #137 RT: 6.59 AV: 1 NL: 1.22E7
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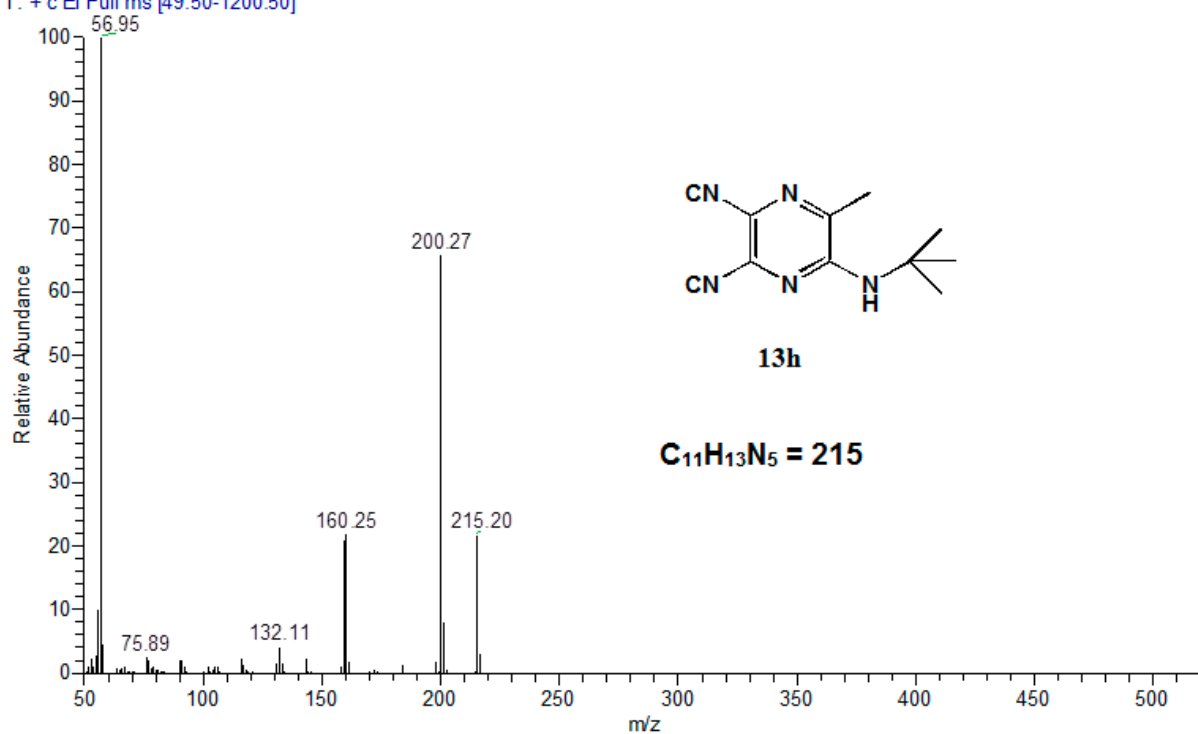
13f

$C_{24}H_{21}N_5 = 379$

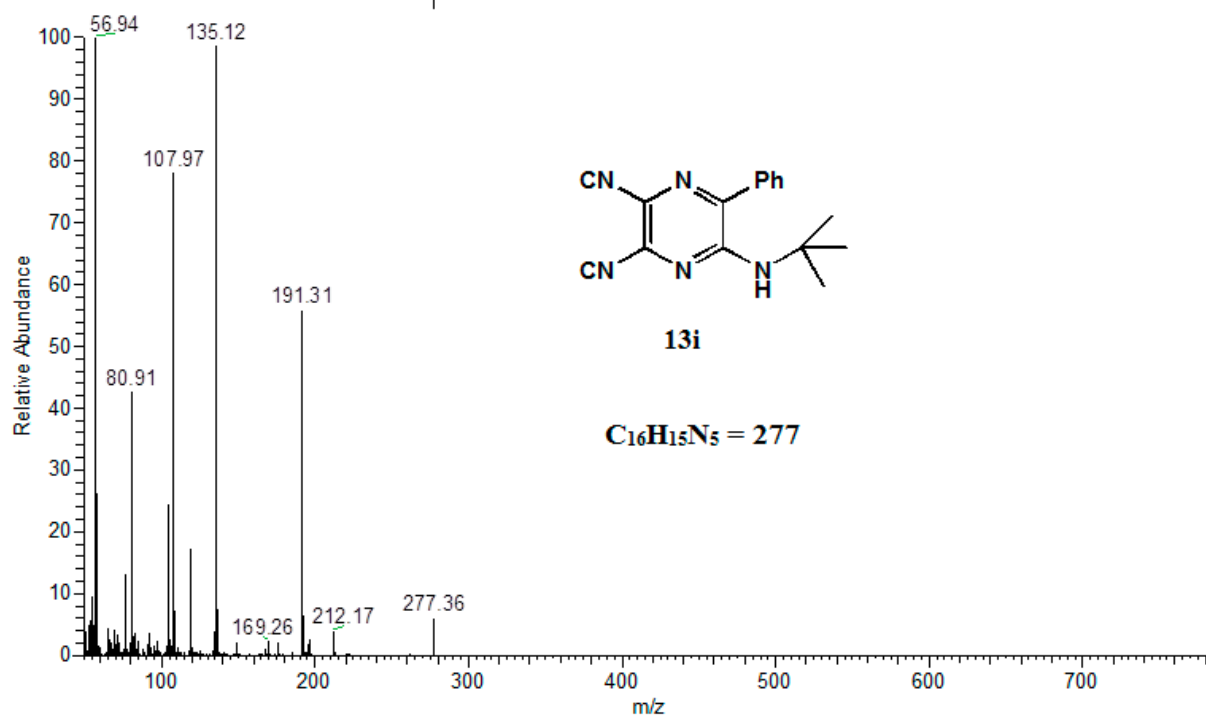
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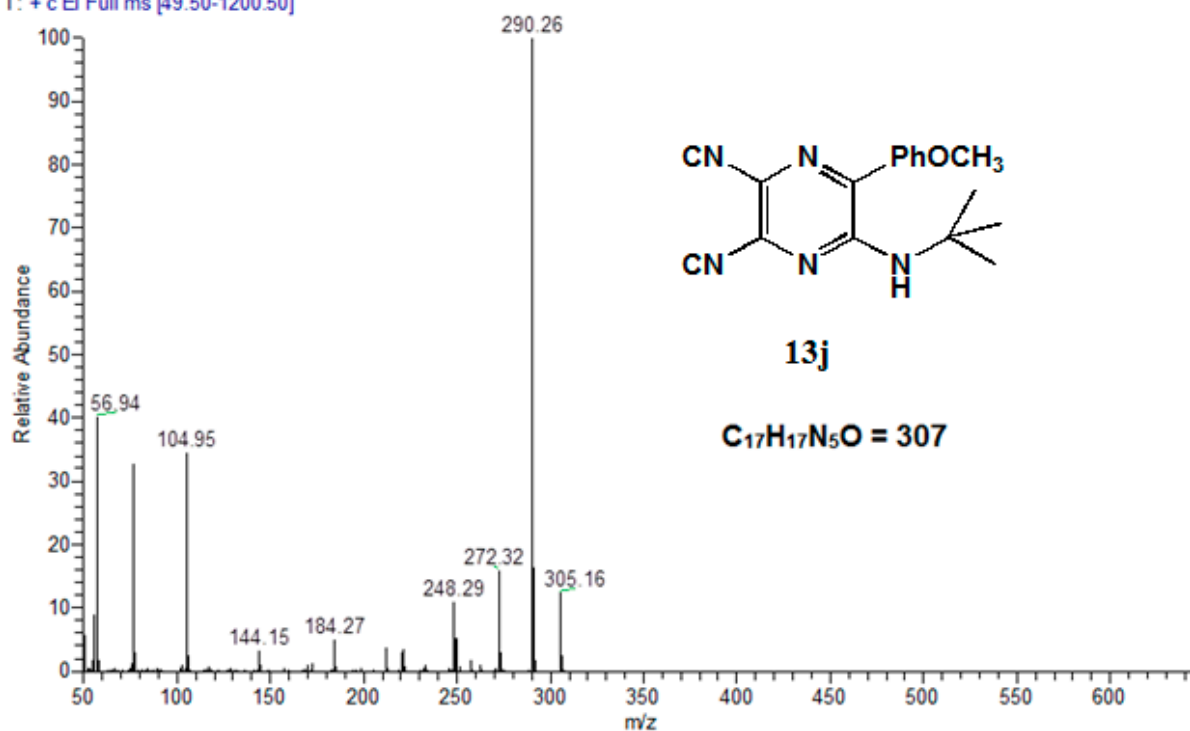
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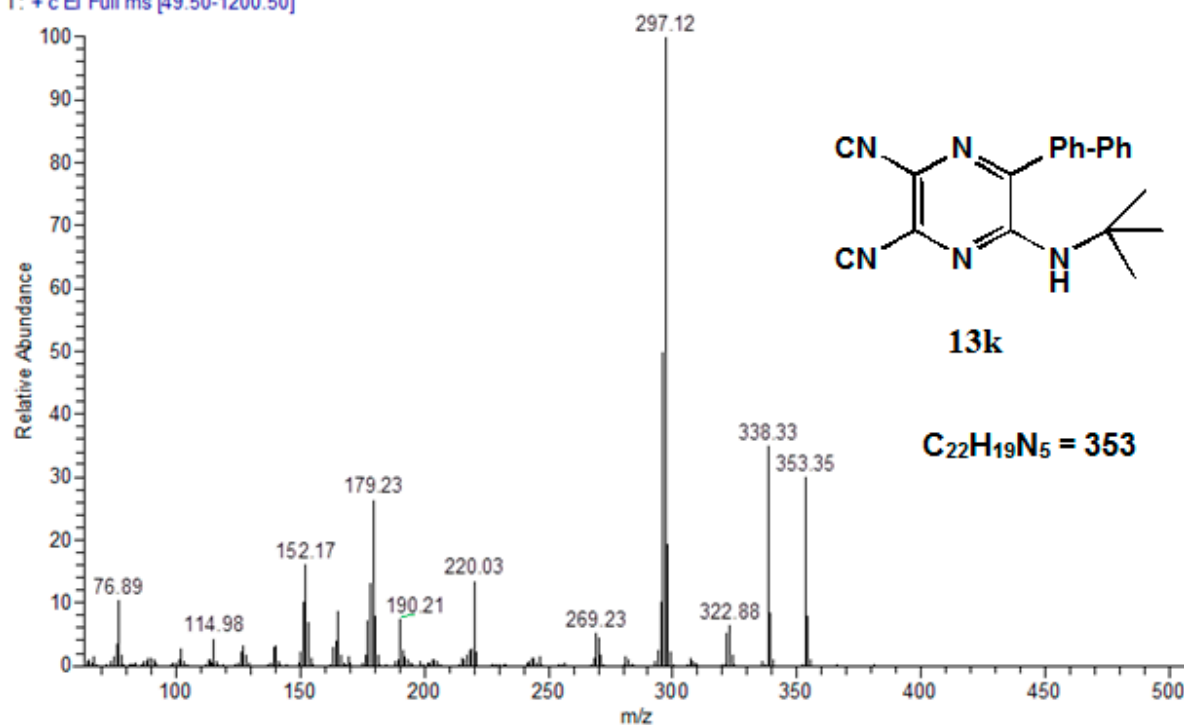
B-tb 210704130959 #66 RT: 3.16 AV: 1 NL: 8.27E6
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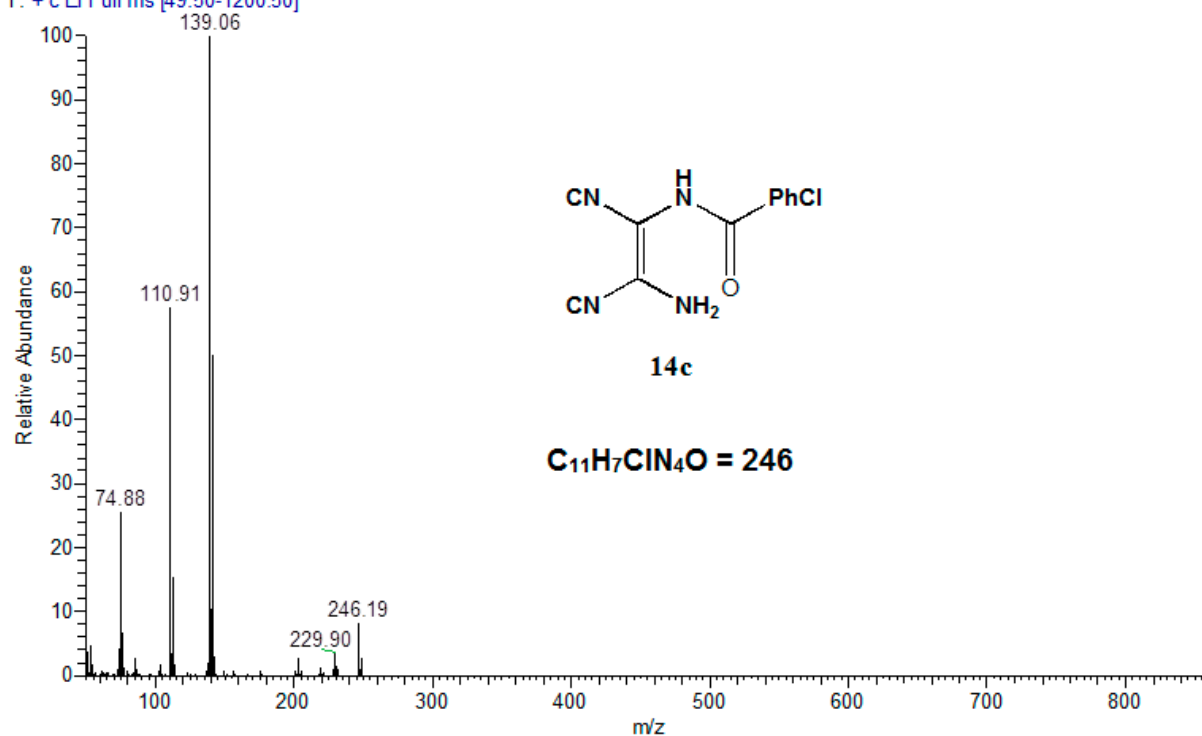
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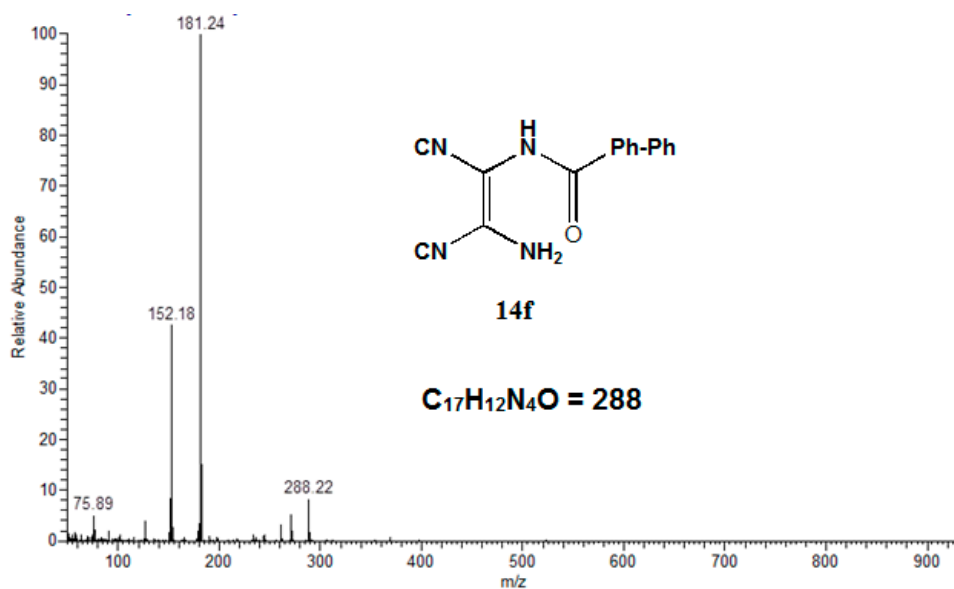
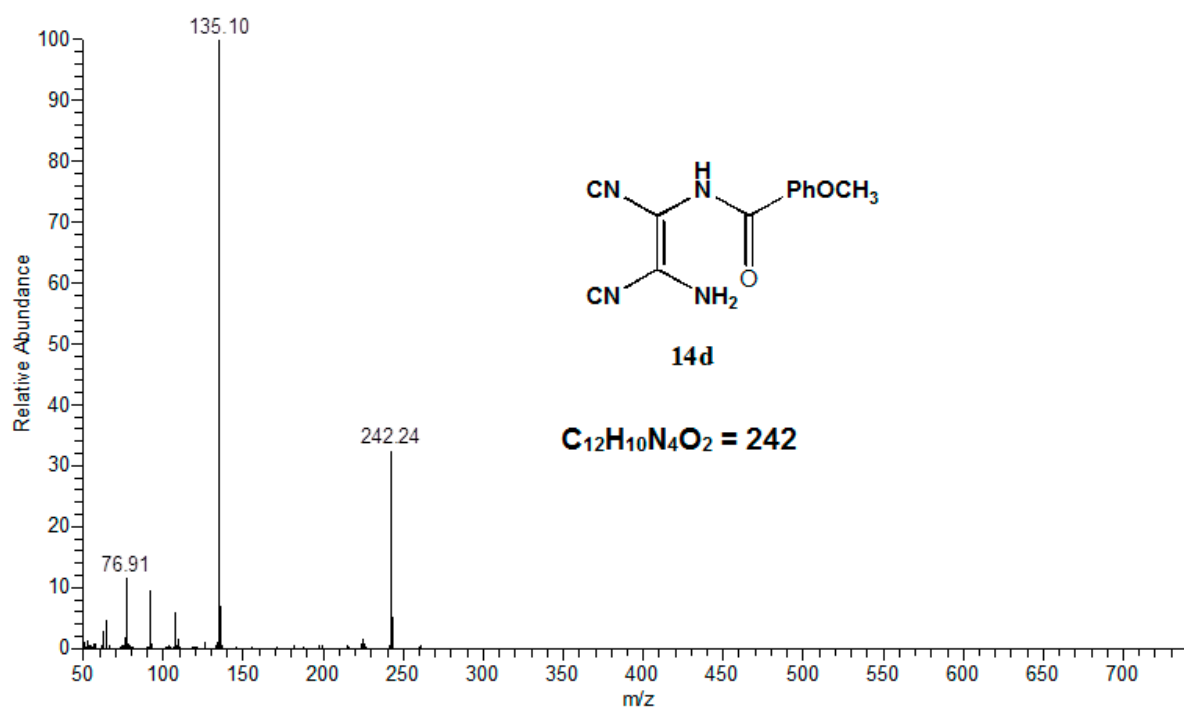
7t-b #118 RT: 5.68 AV: 1 NL: 6.69E7
T: + c EI Full ms [49.50-1200.50]



P-CLneo #180 RT: 8.70 AV: 1 NL: 9.47E7
T: + c EI Full ms [49.50-1200.50]

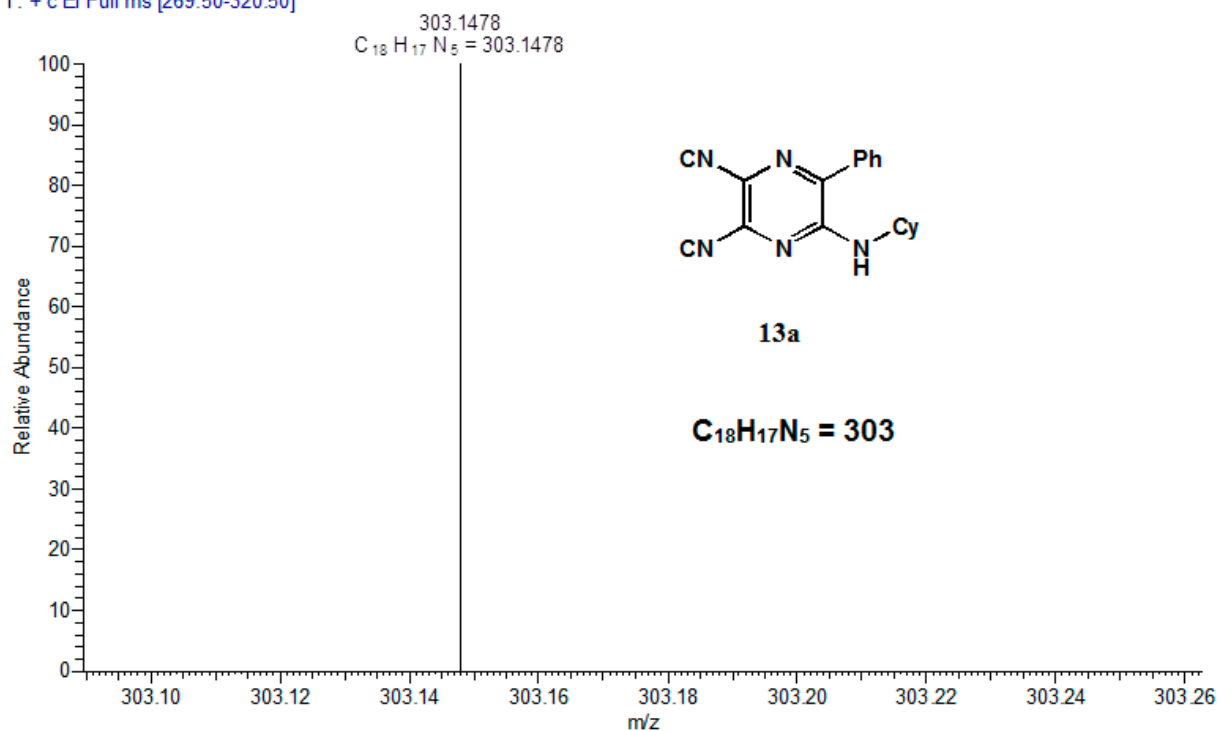


TbOMe-S45 #124 RT: 5.97 AV: 1 NL: 7.66E7
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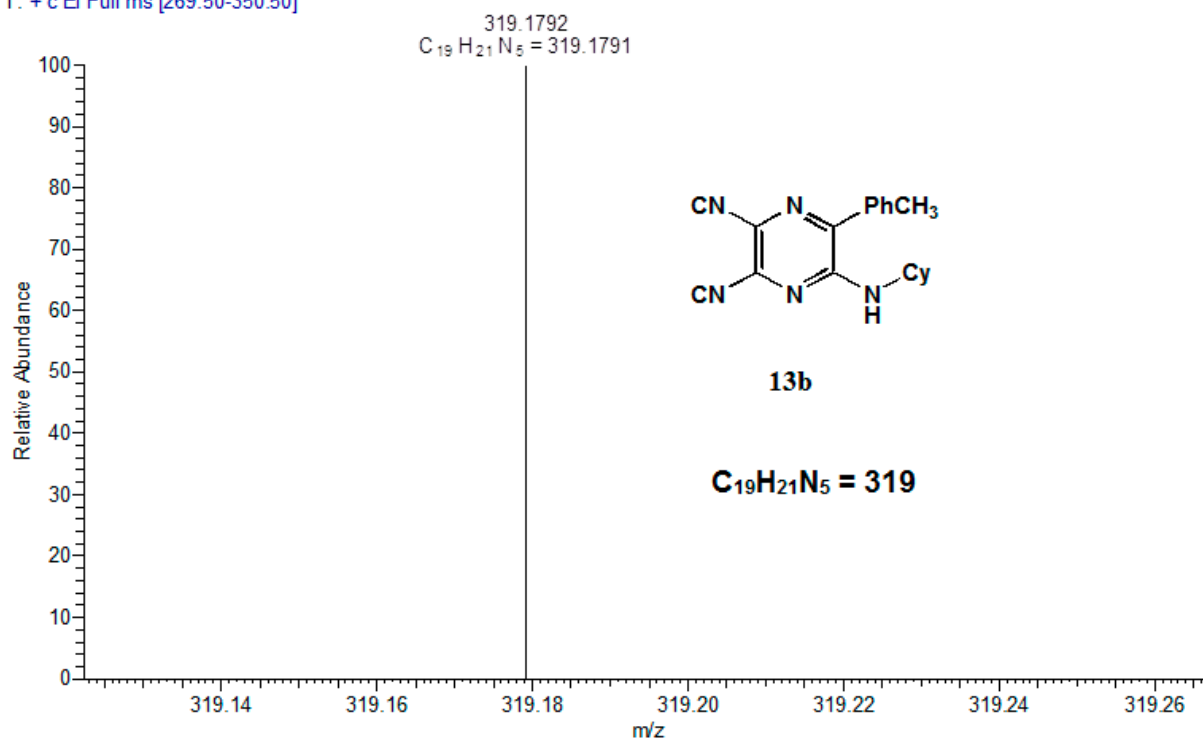


HRMS

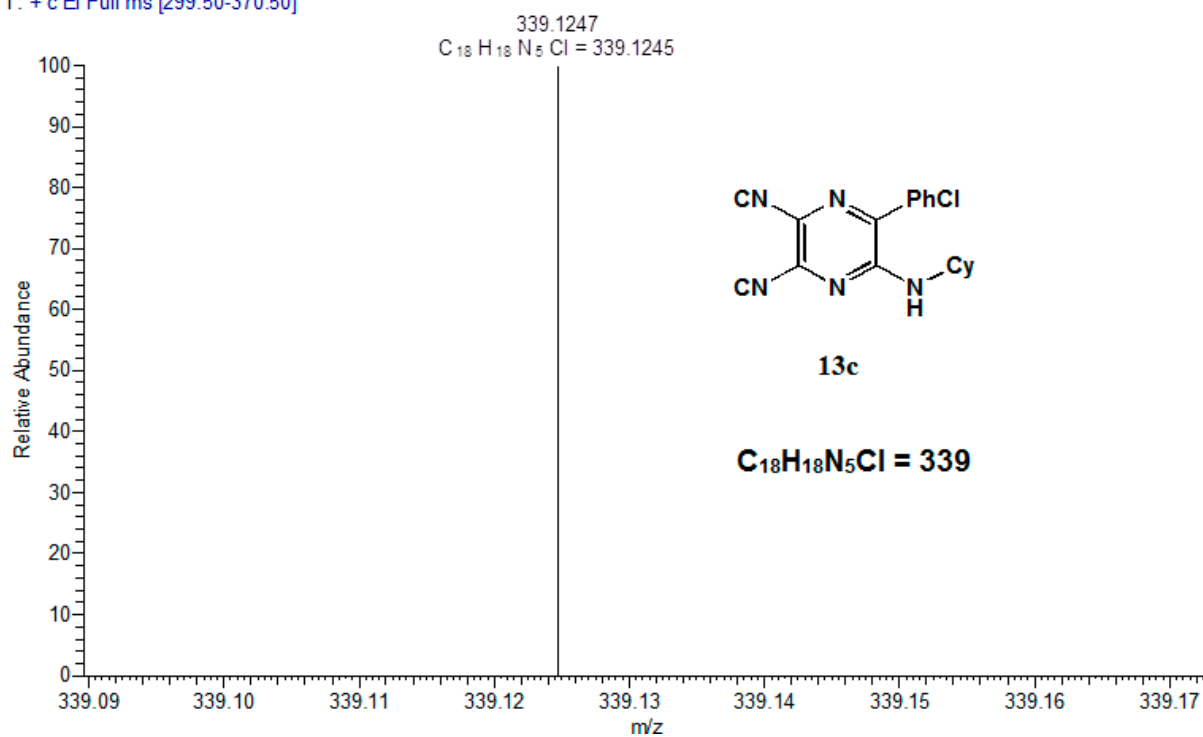
HRMS-PyCv-mass1 #173 RT: 6.24 AV: 1 NL: 8.34E5
T: + c EI Full ms [269.50-320.50]



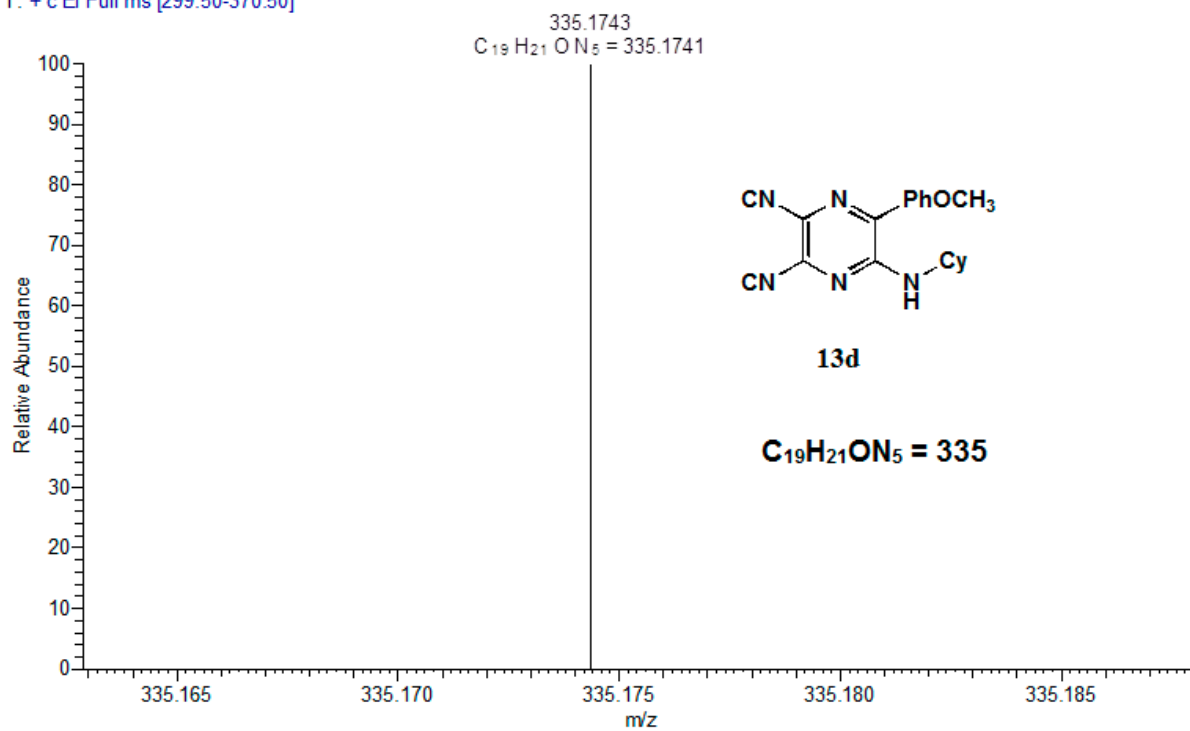
HRMS-MCY-cmass1#89 RT: 7.62 AV: 1 NL: 2.60E2
T: + c EI Full ms [269.50-350.50]



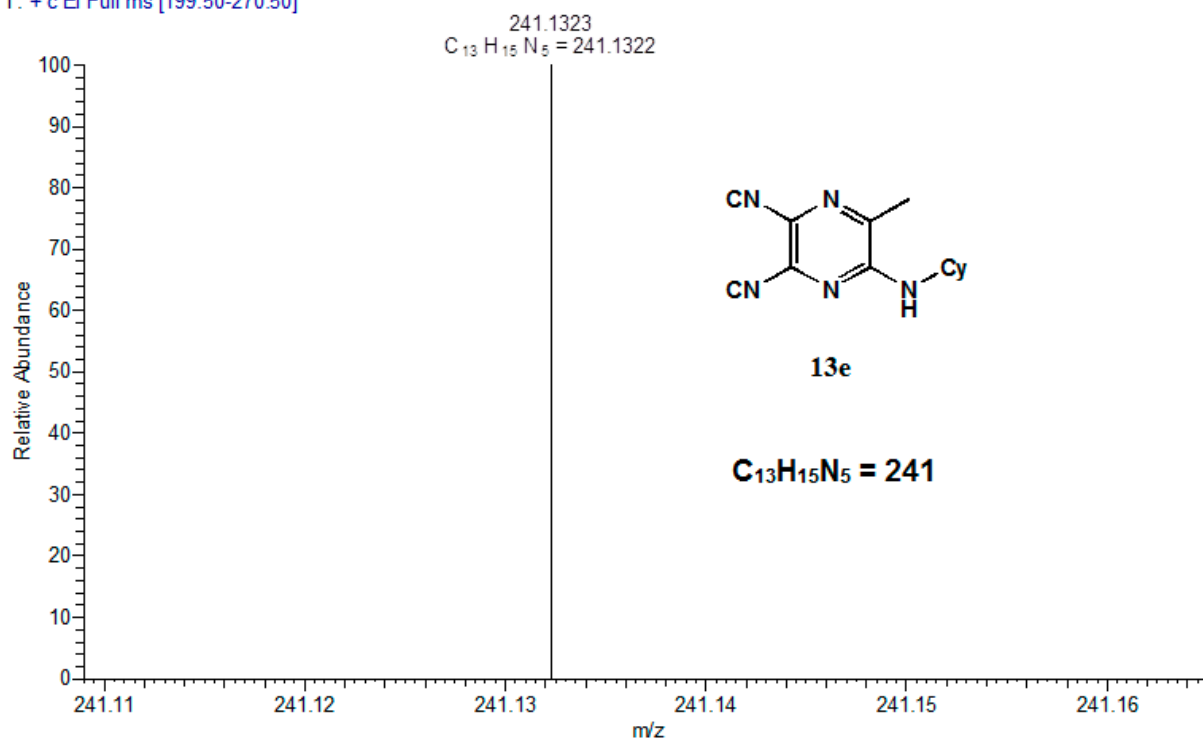
HRMS-PhCl-cmass1#84 RT: 6.41 AV: 1 NL: 7.22E3
T: + c EI Full ms [299.50-370.50]



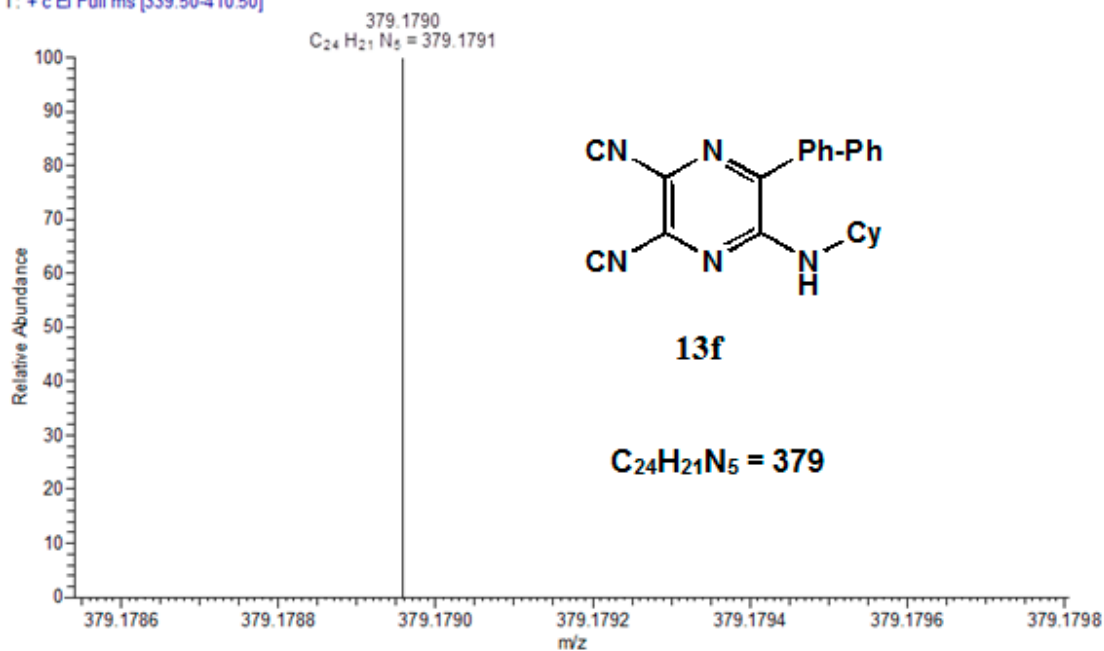
HRMS-CyOMe-cmass1 #12 RT: 3.90 AV: 1 NL: 3.43E3
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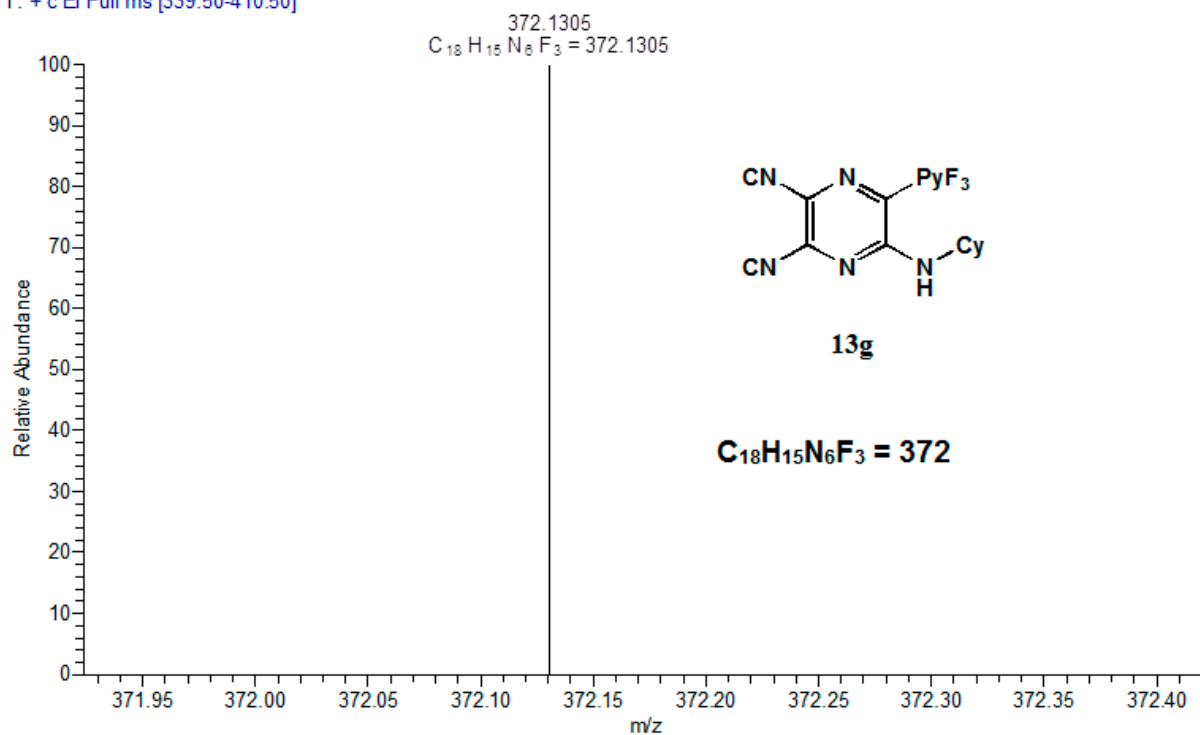
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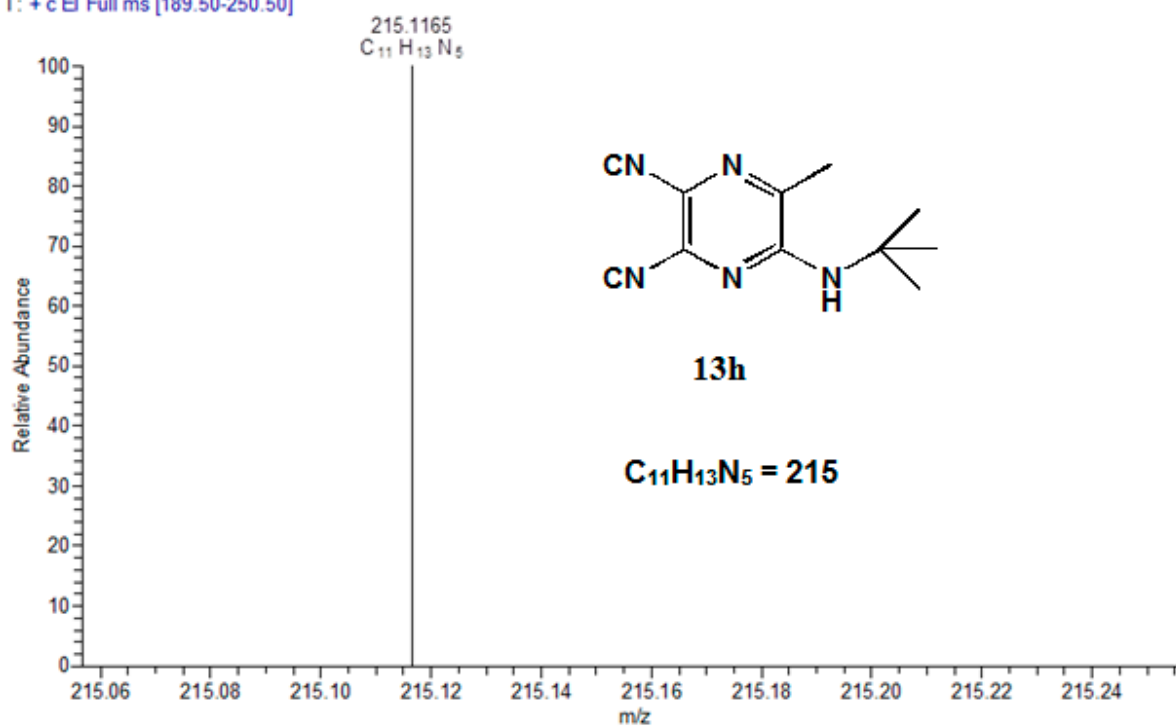
HRMS-3BPhy-mass1 #98 RT: 6.61 AV: 1 NL: 3.00E5
T: + c EI Full ms [339.50-410.50]



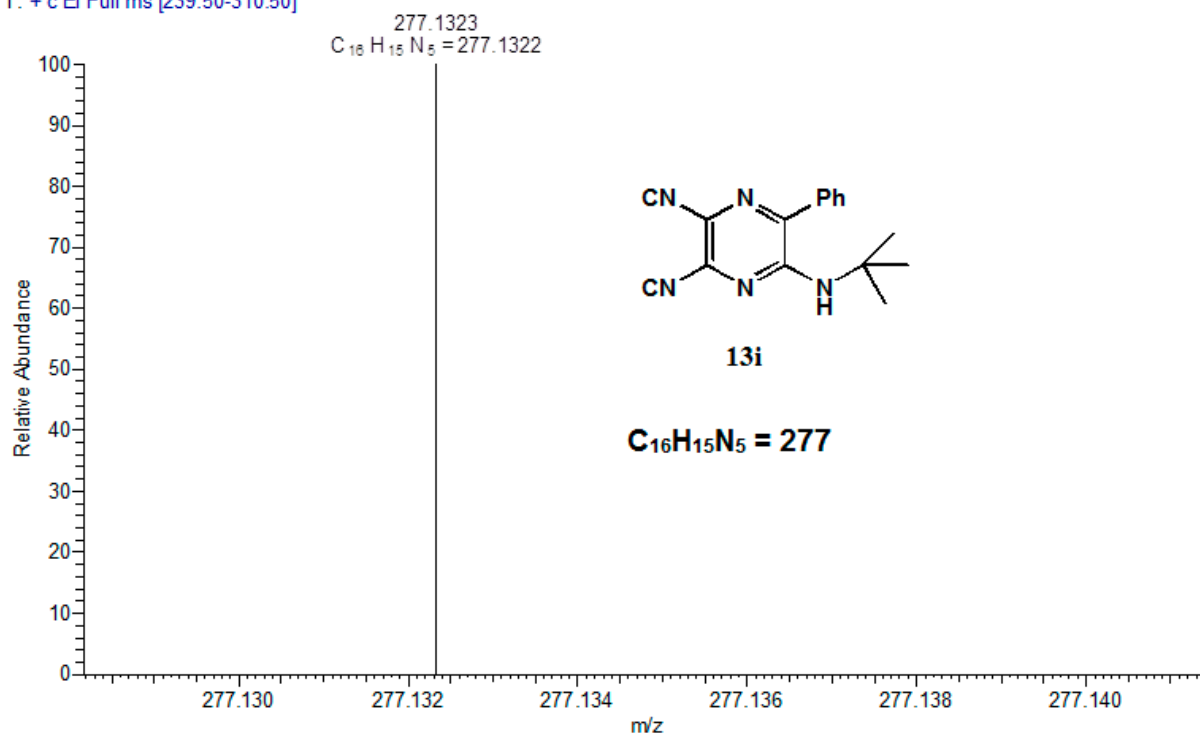
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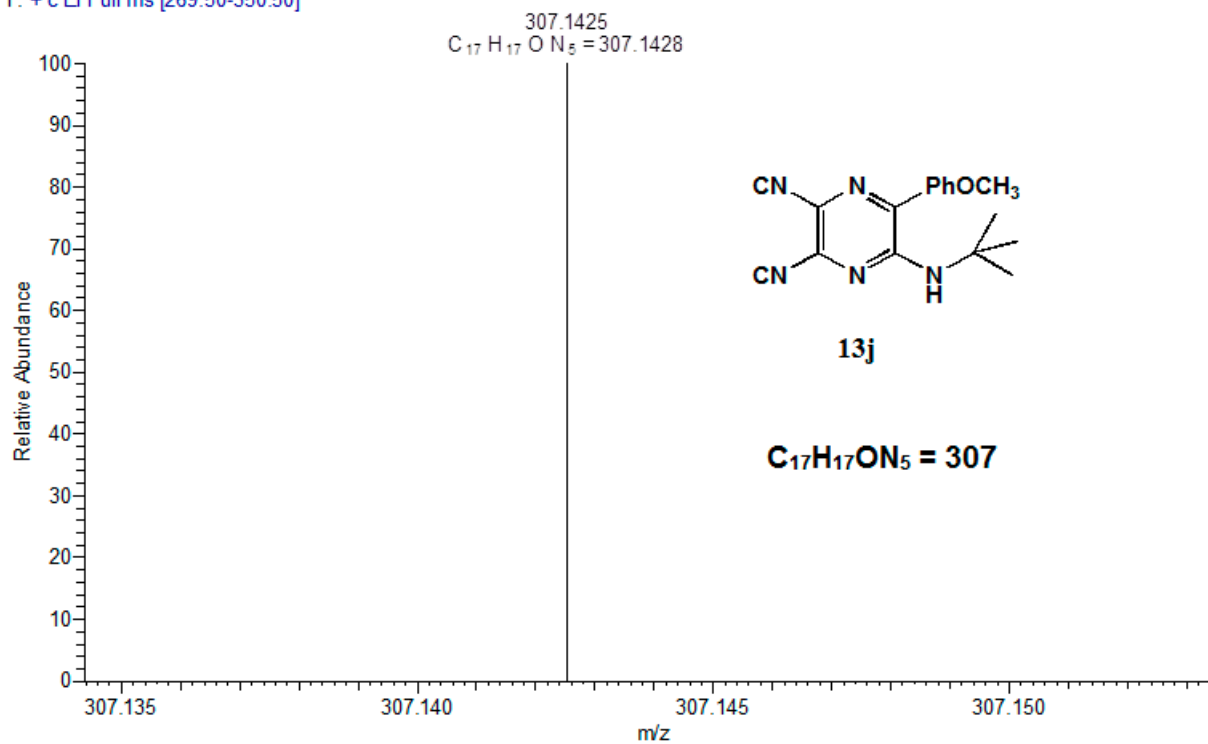
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T: + c EI Full ms [189.50-250.50]



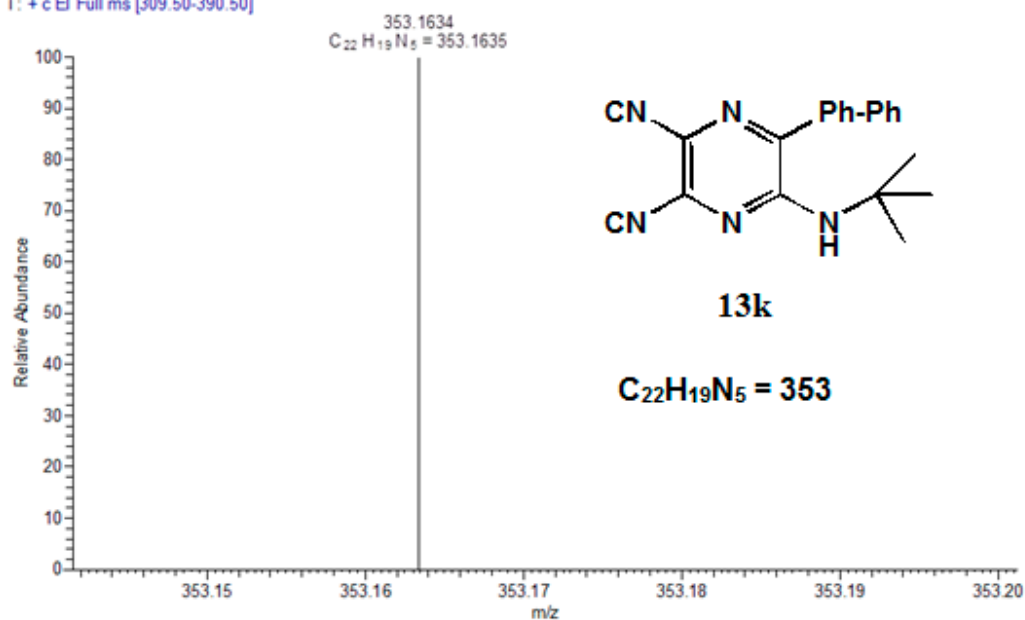
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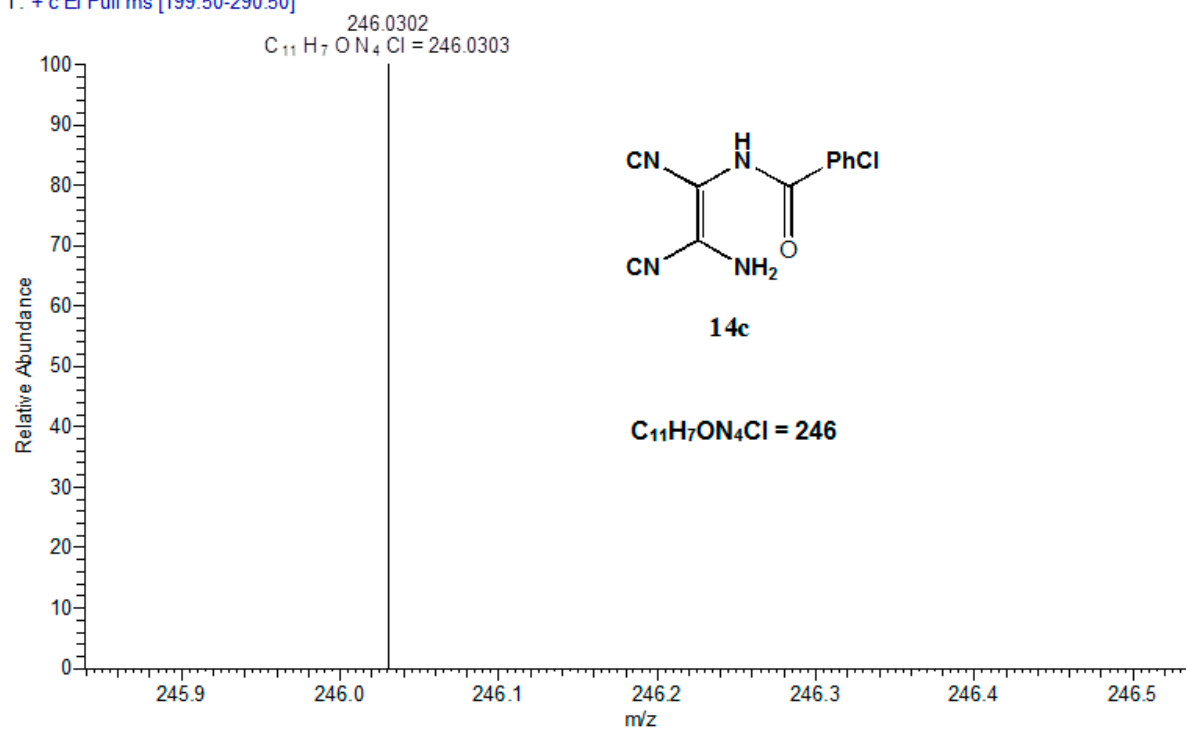
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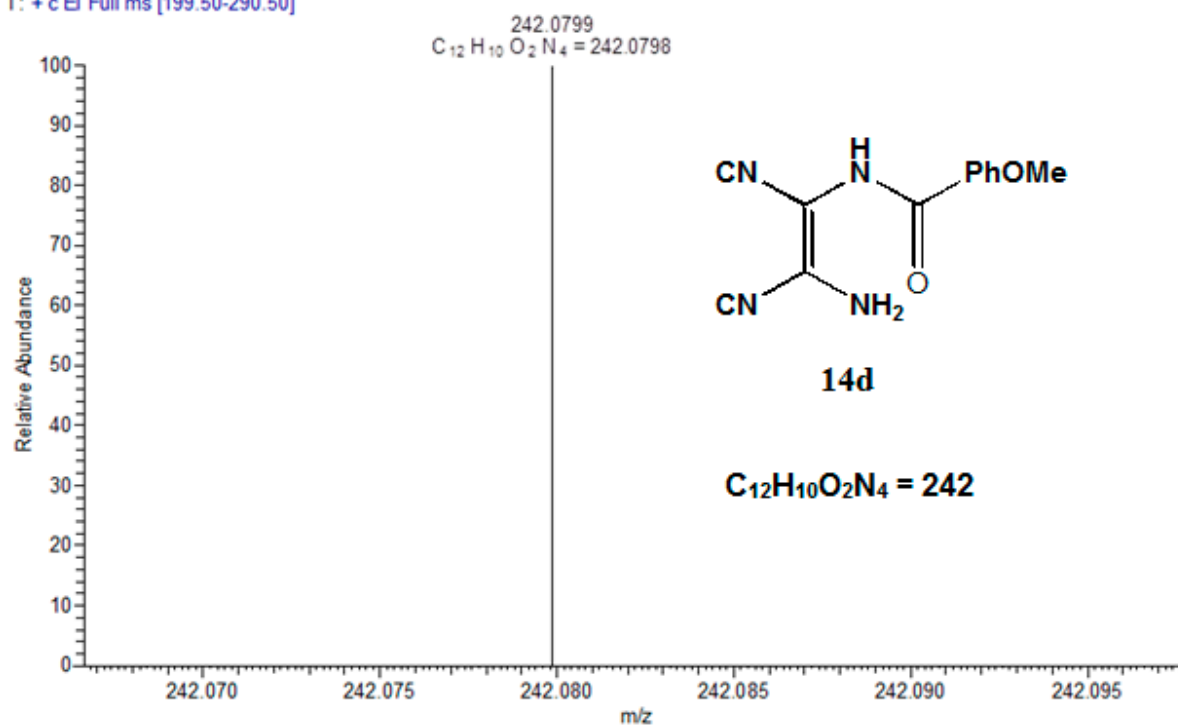
HRMS-7tb-cmass1#12 RT: 3.87 AV: 1 NL: 8.66E3
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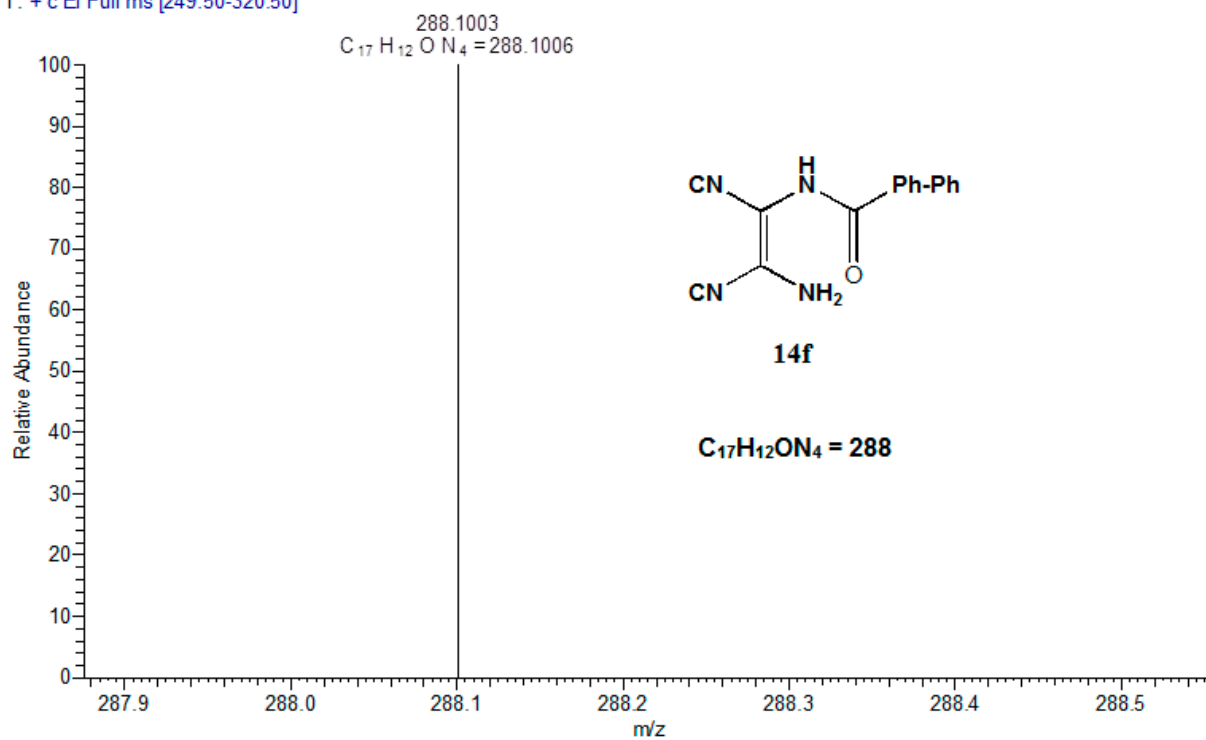
HRMS-PCInw #58 RT: 4.86 AV: 1 NL: 7.32E3
T: + c EI Full ms [199.50-290.50]



HRMS-TbOMe-S45-cmass1#36 RT: 3.92 AV: 1 NL: 1.39E3
T: + c EI Full ms [199.50-290.50]



HRMS-BPCy-S-mass1#78 RT: 8.11 AV: 1 NL: 2.53E4
T: + c EI Full ms [249.50-320.50]



Single crystal X- diffraction analysis of 13a, 13e, 13f & 13k

Experimental

The single crystal data collection was made either on Bruker X8 prospector diffractometer by Cu-K α radiation or on Rigaku Rapid II diffractometer by Mo-K α radiation at room temperature. In the former case the reflection frames were integrated with the Bruker SAINT Software package using a narrow-frame algorithm. Finally, the structure was solved using the Bruker SHELXTL Software Package and refined using SHELXL-2017/1. The data collected using the Rigaku diffractometer was processed by 'Crystalclear' software package. The structure was then solved by direct methods by 'CrystalStructure' crystallographic software package and the refinement was performed using SHELXL-2017/1. All non-hydrogen atoms were refined anisotropically.

The summary of the various crystallographic parameters of the 5 crystal samples discussed in the present study are provided in the **Table S1** & **Table S2**.

Table S1. Summary on the nature and various crystallographic parameters of 13a, 13e, 13f & 13k

Crystal sample	13a	13e
Chemical formula	<u>C₁₈H₁₇N₅</u>	<u>C₁₃H₁₅N₅</u>
M_r	<u>303.36</u>	<u>241.30</u>
Crystal system, space group	<u>Monoclinic, $P2_1/c$</u>	<u>Orthorhombic, $Pnma$</u>
Temperature (K)	<u>296</u>	<u>296</u>
a, b, c (Å)	<u>12.5902 (4), 7.3148 (3), 18.7251 (7)</u>	<u>22.2572 (18), 6.7423 (6), 8.8558 (7)</u>
α, β, γ (°)	90, <u>106.991 (2)</u> , 90	<u>90, 90, 90</u>
V (Å ³)	<u>1649.21 (11)</u>	<u>1328.94 (19)</u>
Z	<u>4</u>	<u>4</u>
Radiation type	<u>Cu $K\alpha$</u>	<u>Cu $K\alpha$</u>
μ (mm ⁻¹)	<u>0.61</u>	<u>0.62</u>
Crystal size (mm)	<u>0.34 × 0.27 × 0.12</u>	<u>0.20 × 0.20 × 0.10</u>
Diffractometer	<u>Bruker APEX-II CCD</u>	<u>Bruker APEX-II CCD</u>
Absorption correction	<u>Multi-scan</u> <u>SADABS2016/2 - Bruker</u> <u>AXS area detector</u> <u>scaling and absorption</u> <u>correction</u>	<u>Multi-scan</u> <u>SADABS2016/2 - Bruker</u> <u>AXS area detector</u> <u>scaling and absorption</u> <u>correction</u>

T_{\min}, T_{\max}	<u>0.83, 0.92</u>	<u>0.88, 0.94</u>
No. of measured, independent & observed [$I > 2\sigma(I)$] reflections	<u>18753, 2907, 2085</u>	<u>5714, 1269, 1033</u>
R_{int}	<u>0.061</u>	<u>0.046</u>
$(\sin \theta/\lambda)_{\max}$ (\AA^{-1})	0.596	0.595
$R[F^2 > 2\sigma(F^2)], wR(F^2), S$	<u>0.048, 0.144, 1.01</u>	<u>0.058, 0.181, 1.10</u>
No. of reflections	<u>2907</u>	<u>1269</u>
No. of parameters	<u>208</u>	<u>110</u>
H-atom treatment	<u>Constrained</u>	<u>Mixed</u>
$\Delta\rho_{\max}, \Delta\rho_{\min}$ (e \AA^{-3})	<u>0.11, -0.22</u>	<u>0.26, -0.20</u>

Table S2. Summary on the nature and various crystallographic parameters of **13f** & **13k**

Crystal sample	13f	13k
Chemical formula	$\text{C}_{24}\text{H}_{21}\text{N}_5$	$\text{C}_{22}\text{H}_{19}\text{N}_5$
M_r	379.46	353.42
Crystal system, space group	Monoclinic, $P2_1/n$	Monoclinic, $P2_1/c$
Temperature (K)	296	296
a, b, c (\AA)	11.8808 (4), 10.5852 (4), 17.3946 (7)	12.4754 (9), 10.2482 (7), 15.7377 (12)
α, β, γ ($^\circ$)	90, 106.785 (3), 90	90, 104.935 (4), 90
V (\AA^3)	2094.36 (14)	1944.1 (2)
Z	4	4
Radiation type	Cu $K\alpha$	Cu $K\alpha$
μ (mm^{-1})	0.58	0.59
Crystal size (mm)	$0.22 \times 0.14 \times 0.11$	$0.16 \times 0.15 \times 0.11$
Diffractometer	Bruker <i>APEX-II</i> CCD	Bruker <i>APEX-II</i> CCD
Absorption correction	Multi-scan <i>SADABS2016/2</i> - Bruker AXS area detector scaling and absorption correction	Multi-scan <i>SADABS2016/2</i> - Bruker AXS area detector scaling and absorption correction
T_{\min}, T_{\max}	0.88, 0.93	0.90, 0.94

No. of measured, independent & observed [$I > 2\sigma(I)$] reflections	10564, 3621, 2460	17845, 3335, 2140
R_{int}	0.045	0.062
$(\sin \theta/\lambda)_{\text{max}}$ (\AA^{-1})	0.596	0.596
$R[F^2 > 2\sigma(F^2)]$, $wR(F^2)$, S	0.055, 0.165, 1.04	0.060, 0.194, 1.08
No. of reflections	3621	3335
No. of parameters	262	244
H-atom treatment	Constrained	Constrained
$\Delta\rho_{\text{max}}$, $\Delta\rho_{\text{min}}$ (e \AA^{-3})	0.20, -0.18	0.16, -0.19

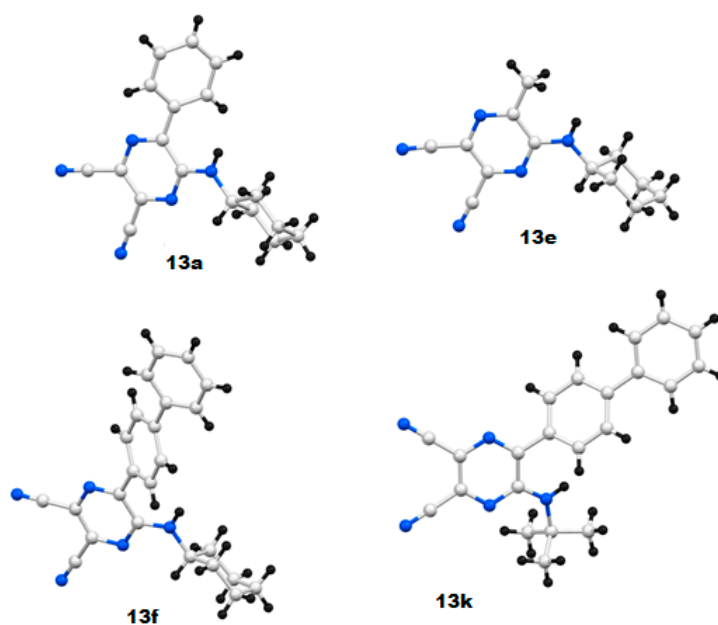


Figure S1. Crystal structure of **13a**, **13e**, **13f** and **13k**. Color code : gray-carbon; blue-nitrogen; yellow-fluorine and black-hydrogen.

Supporting information

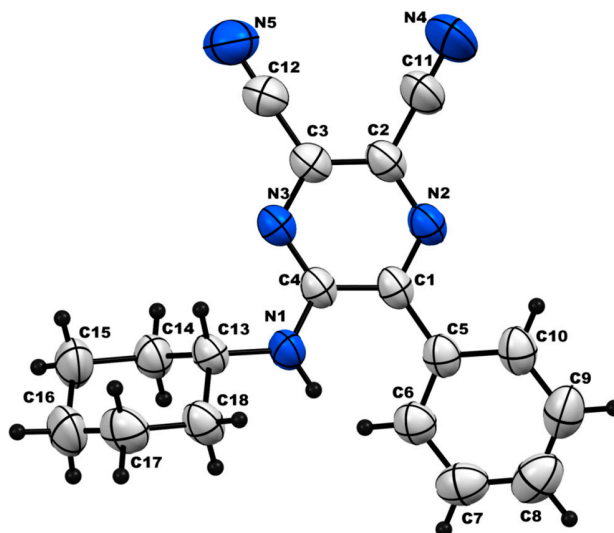


Figure S2. Crystal structure (Thermal ellipsoid representation) of **13a**.

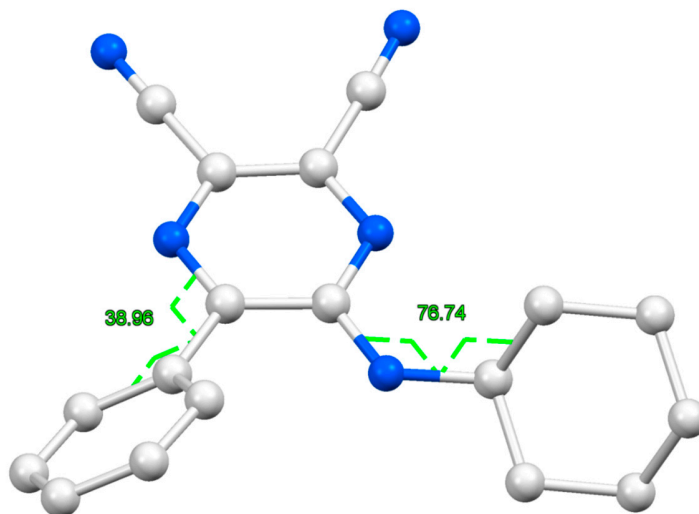


Figure S3. Orientation and the corresponding torsion angles of cyclohexyl and phenyl rings against the pyrazene ring in the crystal structure of the molecule **13a**.

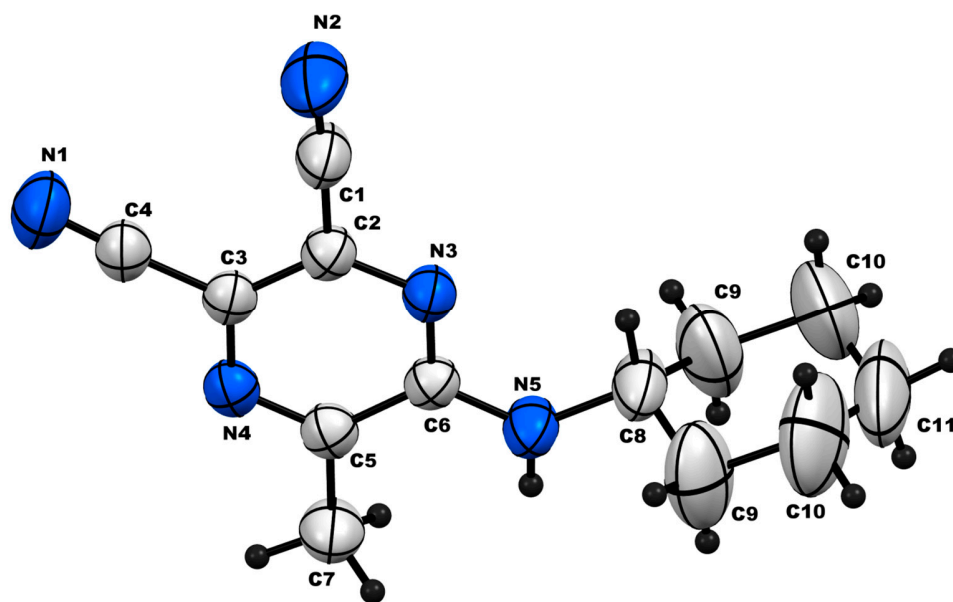


Figure S4. Crystal structure (Thermal ellipsoid representation) of **13e**.

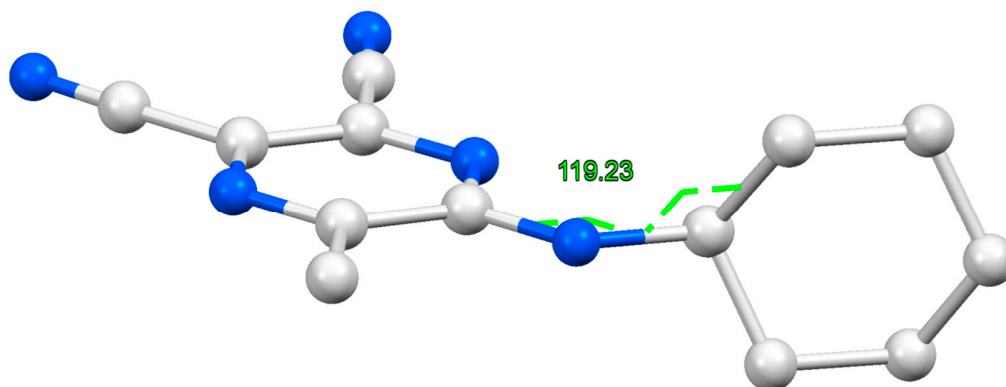


Figure S5. Orientation and the corresponding torsion angle of cyclohexyl ring against the pyrazene ring in the crystal structure of the molecule **13e**.

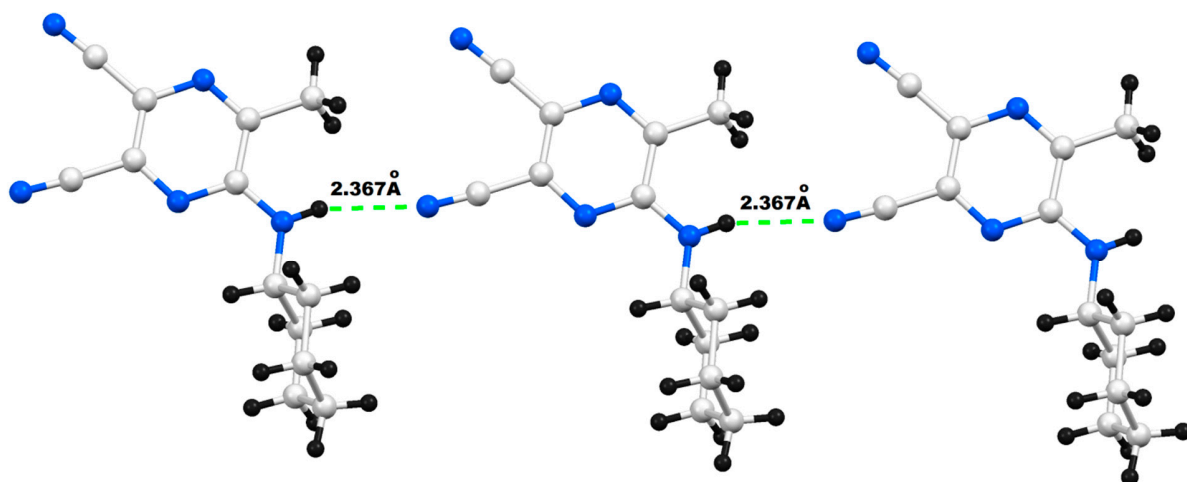


Figure S6. Intermolecular H-bonds experienced by **13e** molecules in its crystal network.

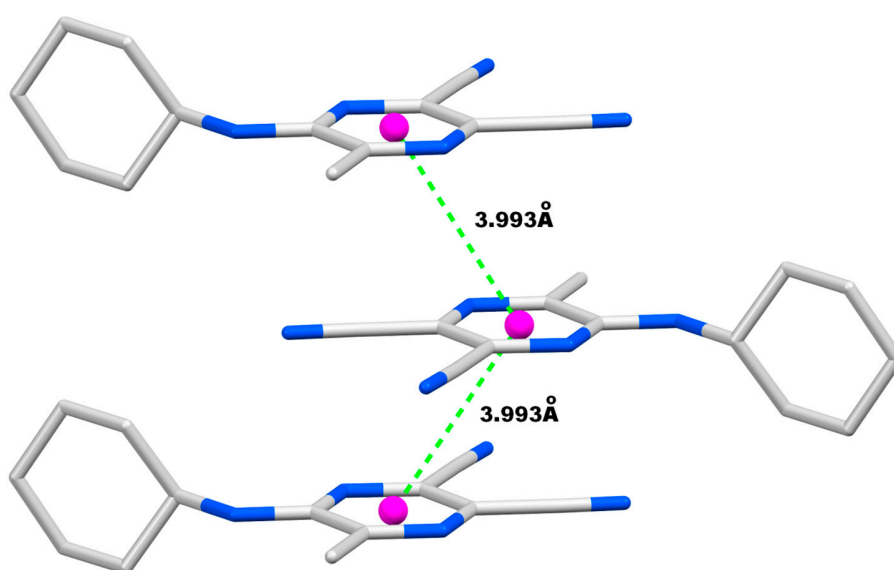


Figure S7. π - π interactions among **13e** molecules in their crystal network

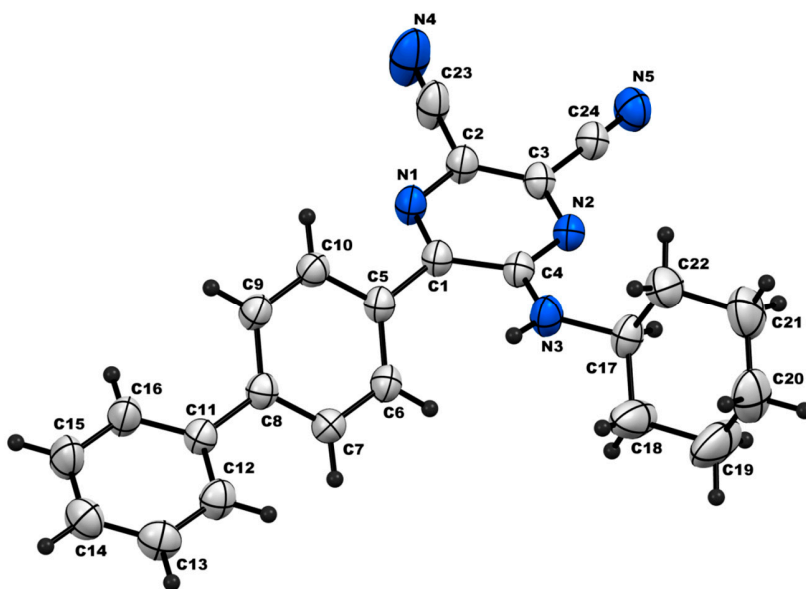


Figure S8. Crystal structure (Thermal ellipsoid representation) of **13f**.

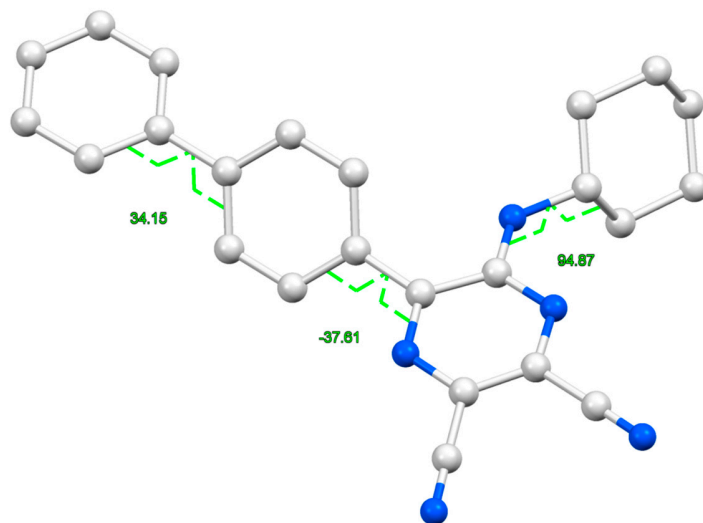


Figure S9. Orientation and the corresponding torsion angles of cyclohexyl and phenyl ring against the pyrazene ring along with the phenyl-phenyl orientation of the bi-phenyl moiety in the crystal structure of the molecule **13f**.

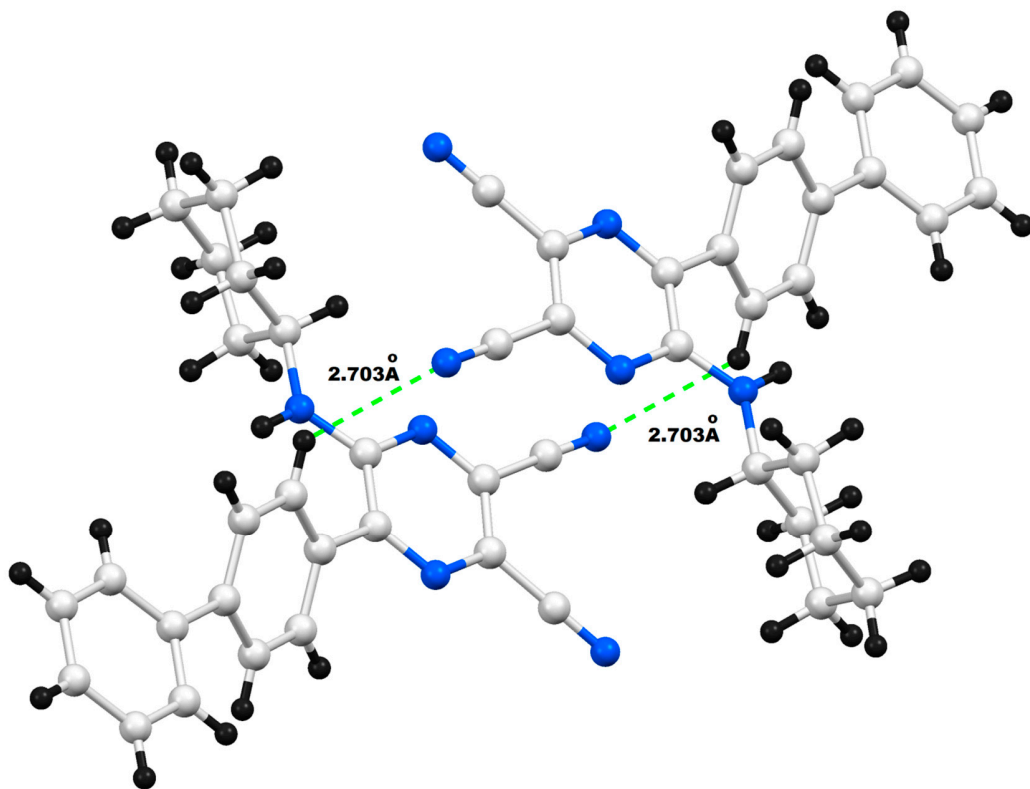


Figure S10. Intermolecular H-bonds experienced by **13f** molecules in its crystal network.

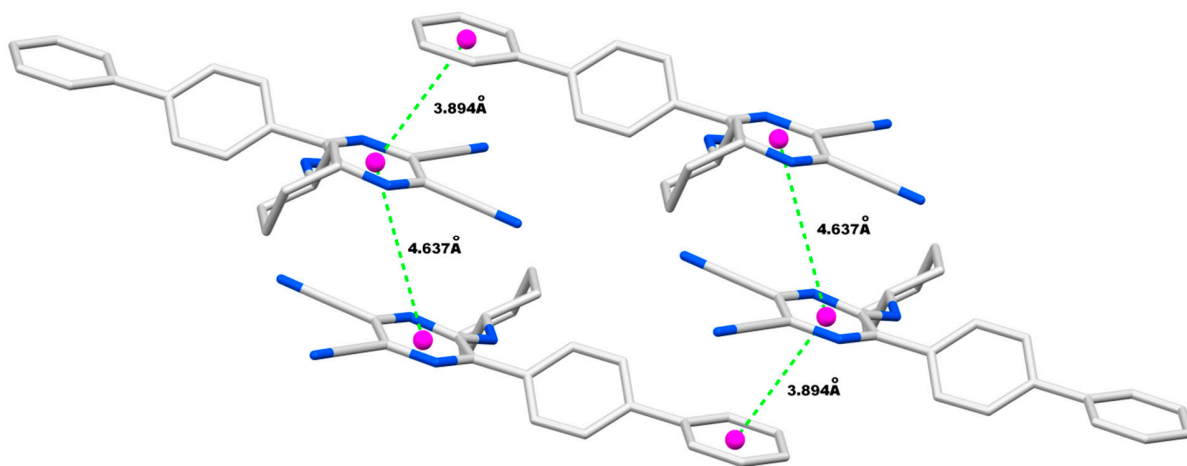


Figure S11. π - π interactions among **13f** molecules in their crystal network

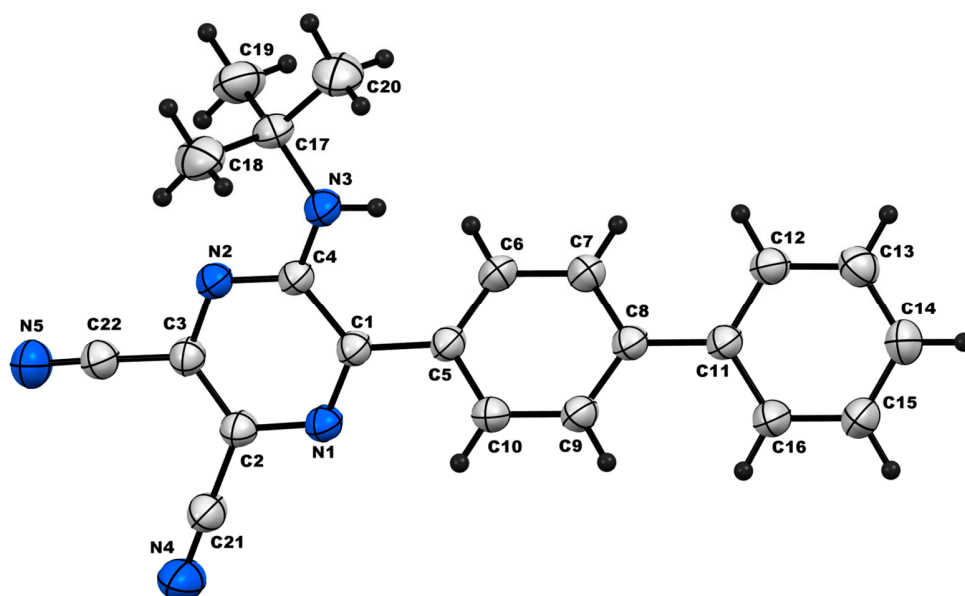


Figure S12. Crystal structure (Thermal ellipsoid representation) of **13k**.

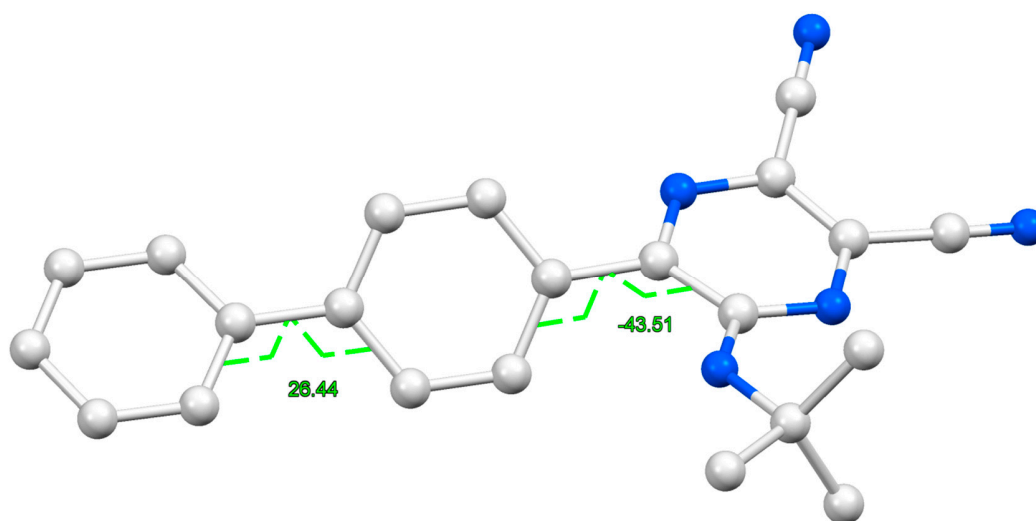


Figure S13. Orientation and the corresponding torsion angle of phenyl ring against the pyrazene ring along with the phenyl-phenyl orientation of the bi-phenyl moiety in the crystal structure of the molecule **13k**.

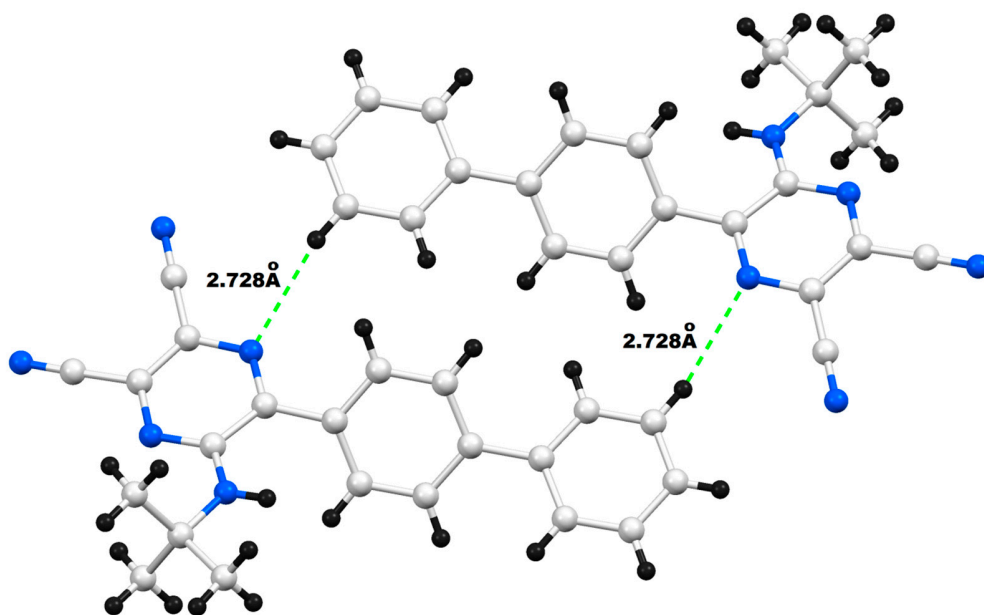


Figure S14. Intermolecular H-bonds experienced by **13k** molecules in its crystal network.

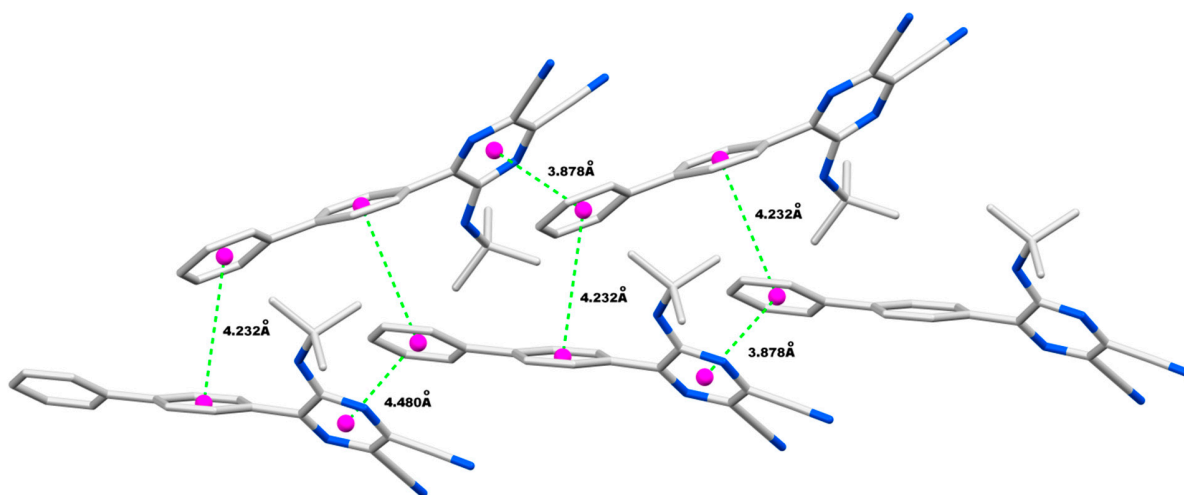


Figure S15. π - π interactions among **13k** molecules in their crystal network