

Supporting information

For

Synthesis of benzo[*a*]carbazole derivatives *via* the intramolecular cyclization using Brønsted acidic carbonaceous material as the catalyst

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Section S1. Amorphous carbon-immobilized sulfonic acid characterization (AC- SO₃H)

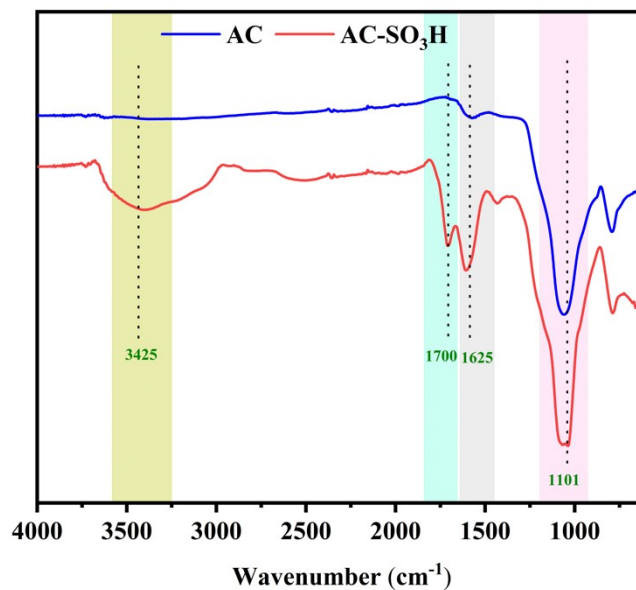


Fig. S1. FT-IR spectrum of AC and AC-SO₃H.

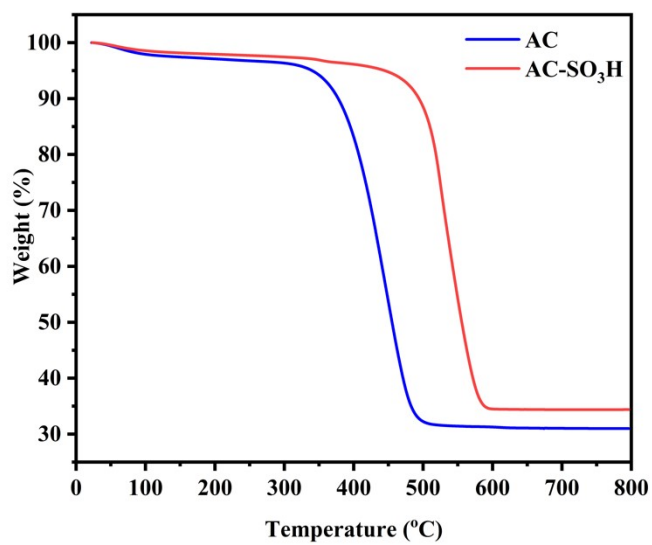


Fig. S2. TGA curves of AC and AC-SO₃H.

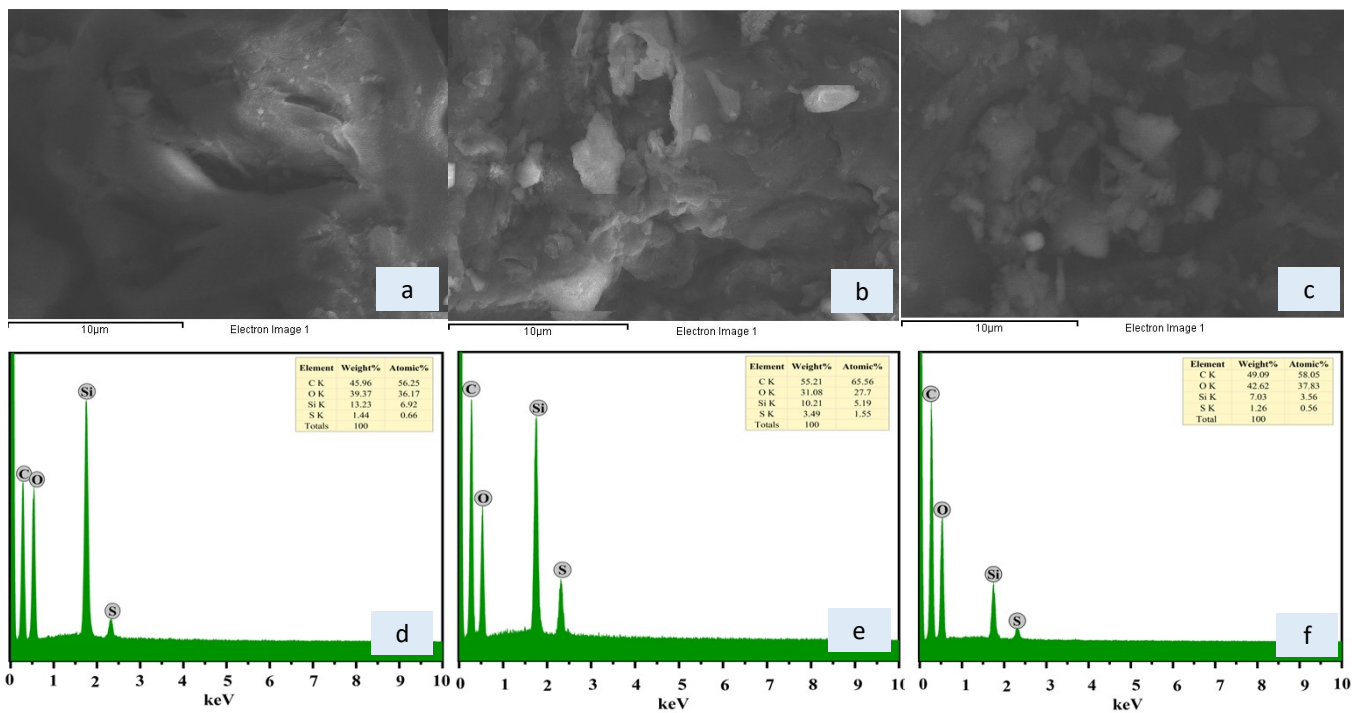


Fig. S3. SEM image of AC (a), AC-SO₃H (b), AC-SO₃H after three times (c); EDX analysis of AC (d), AC-SO₃H (e), AC-SO₃H after three times (f).

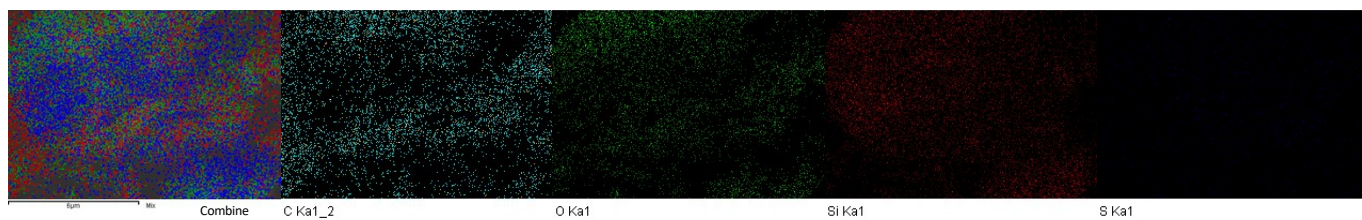


Fig. S4. Elemental mapping analysis of AC-SO₃H.

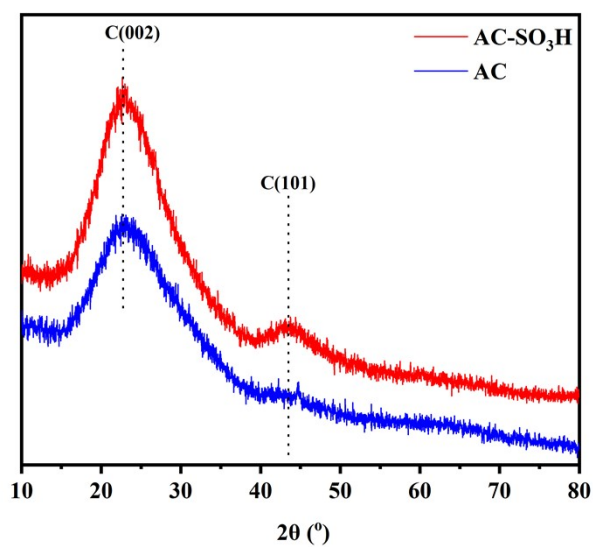


Fig. S5. P-XRD analysis of AC and AC-SO₃H.

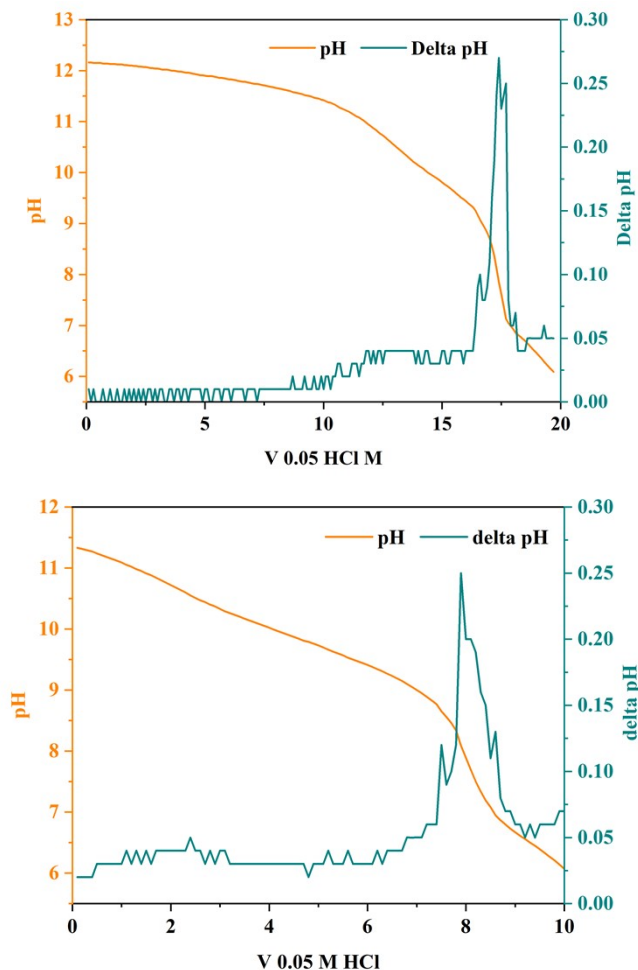


Fig. 6. Direct pH-metric titration curves with HCl solutions for AC (above) and AC-SO₃H (below); 0.05 N NaOH calibrated with oxalic acid was 0.0497 N; 0.05 N HCl calibrated with borates was 0.0492 N.

Table S1. Acidity of the AC, and AC-SO₃H by Boehm titration.

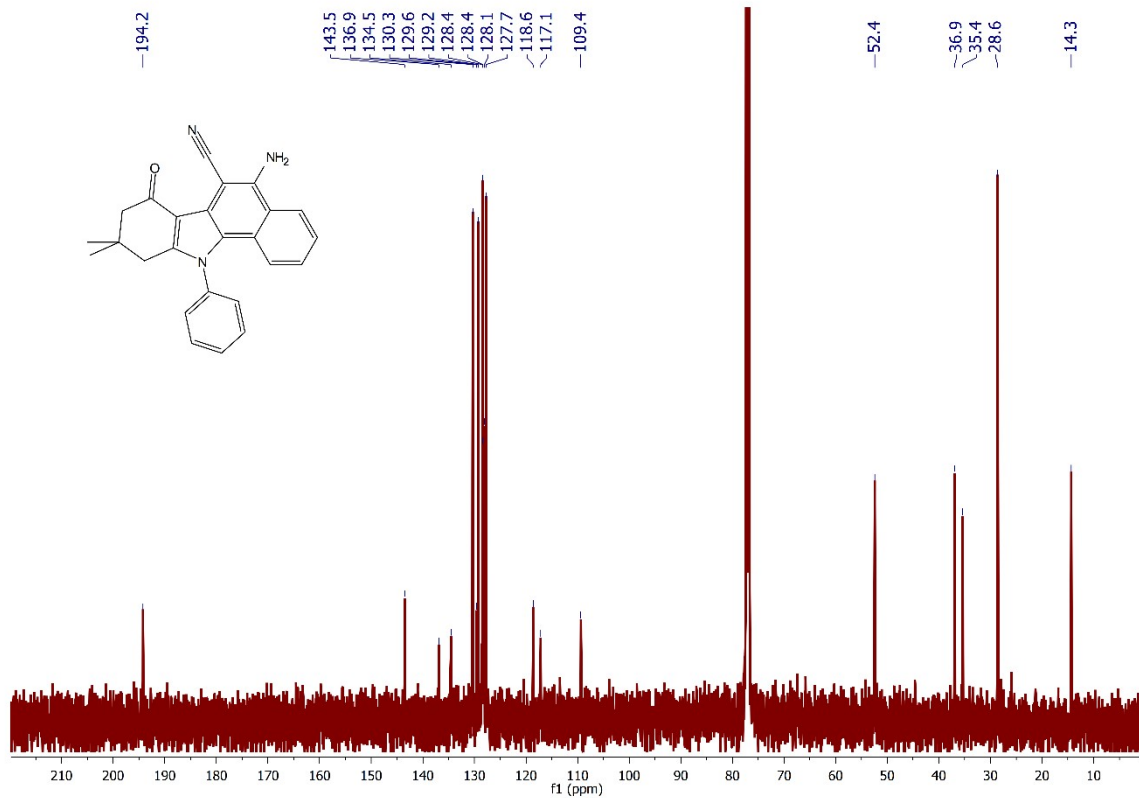
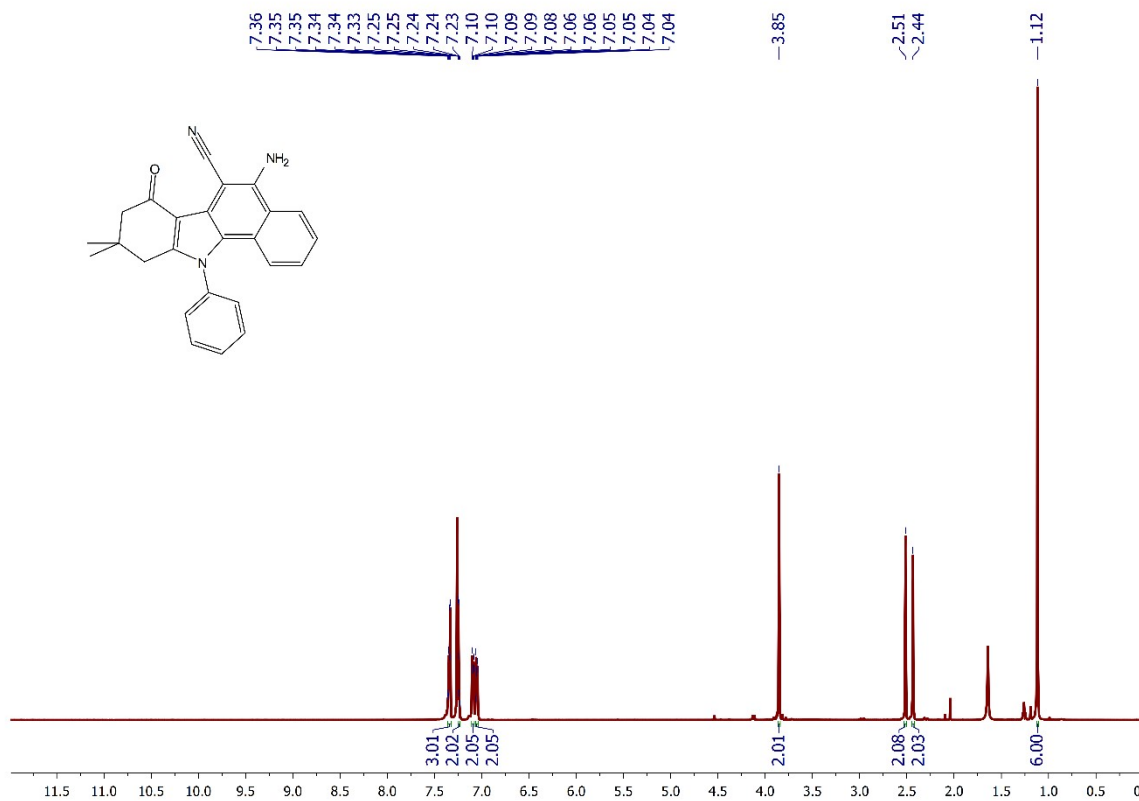
| Materials | Acidity (mmol/g) | |
|----------------------|--------------------------------|--------------------|
| | SO ₃ H ^a | Total ^b |
| AC | - | 0.828 |
| AC-SO ₃ H | 2.185 | 4.606 |

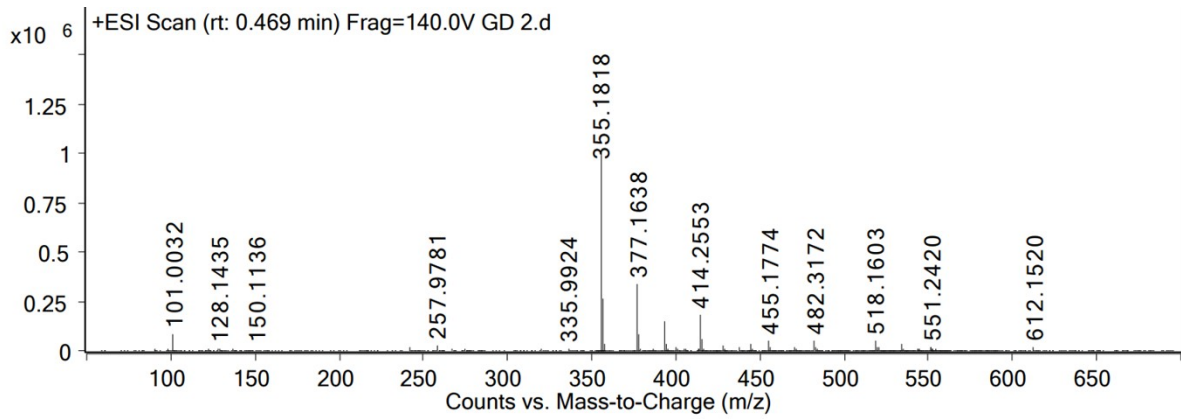
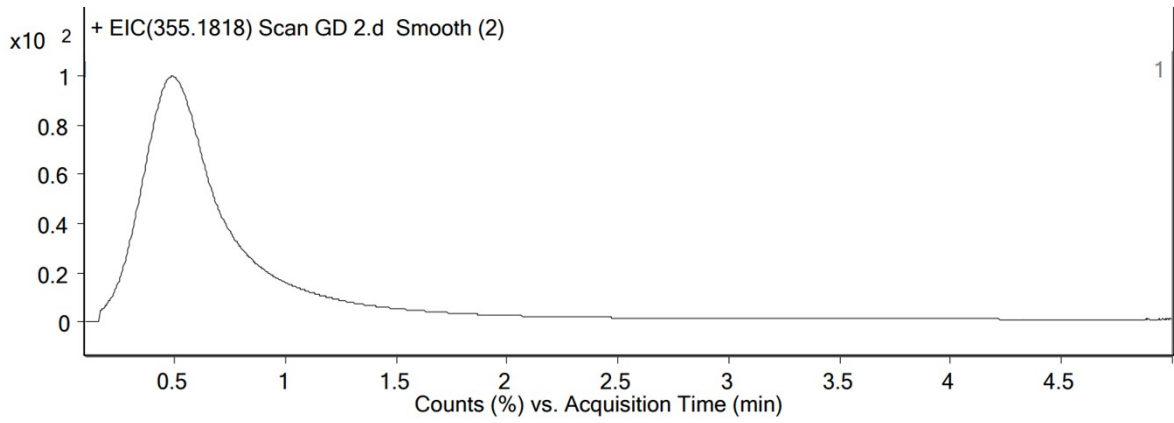
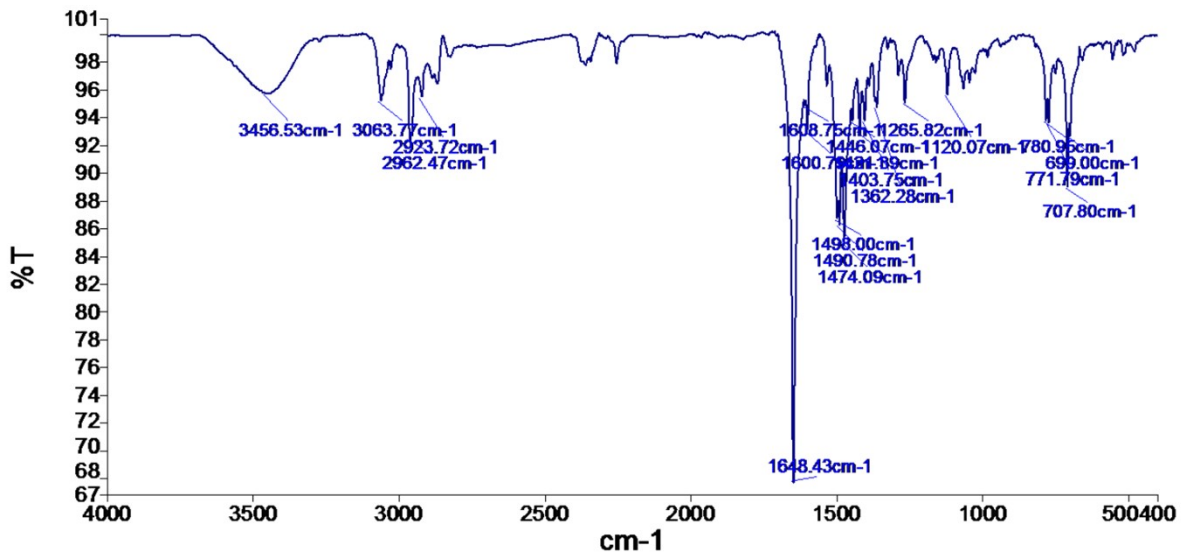
^aCalculated based on ICP-MS.

^bSO₃H, carboxylic acid, phenolic groups.

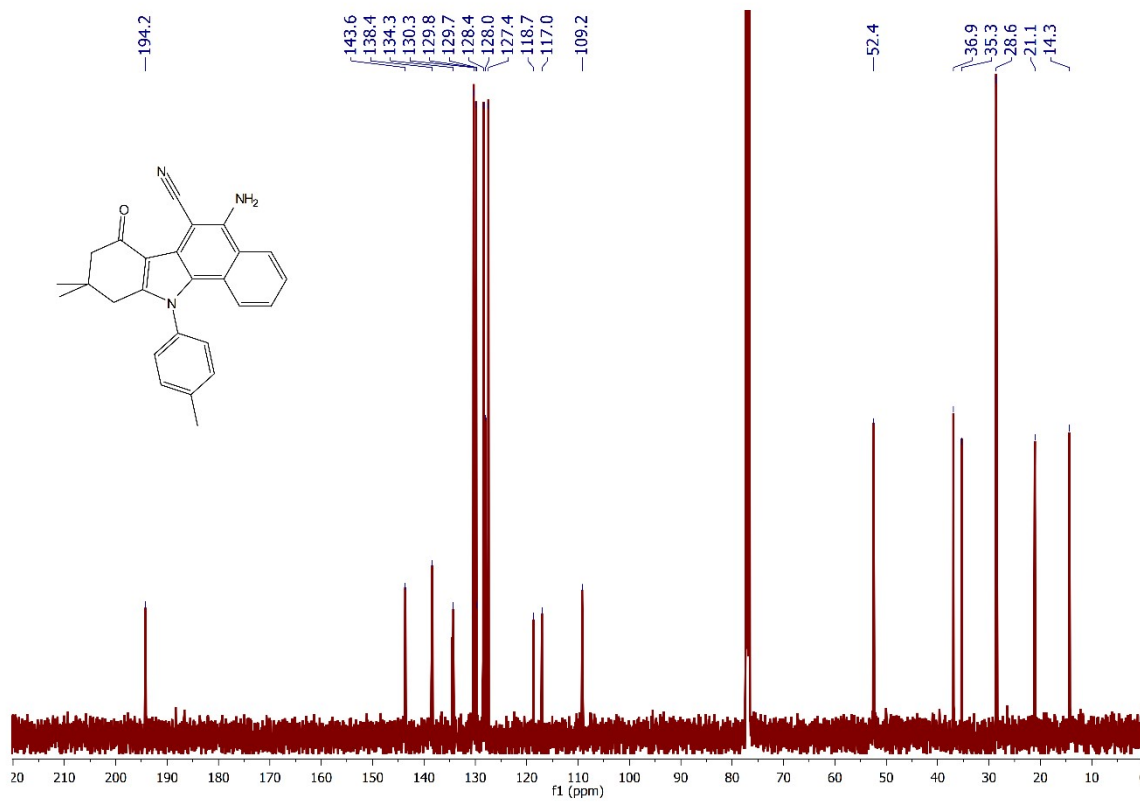
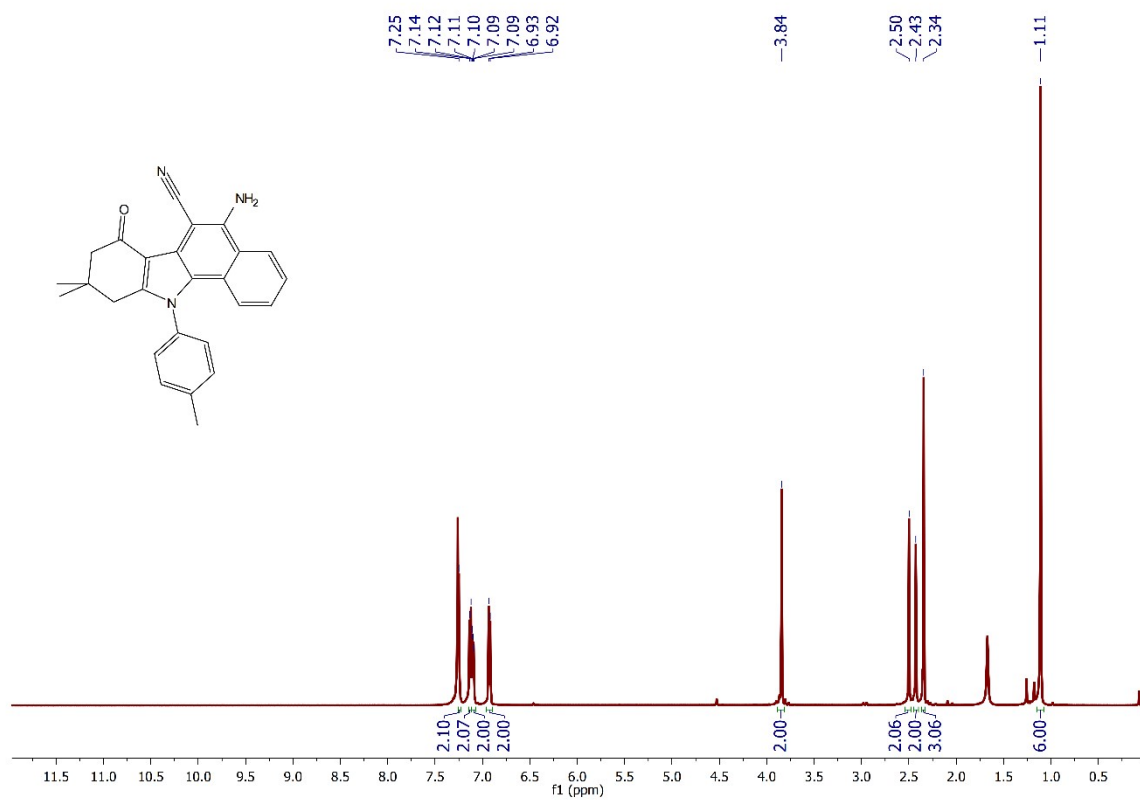
Section S2. NMR spectra, and HRMS(ESI)

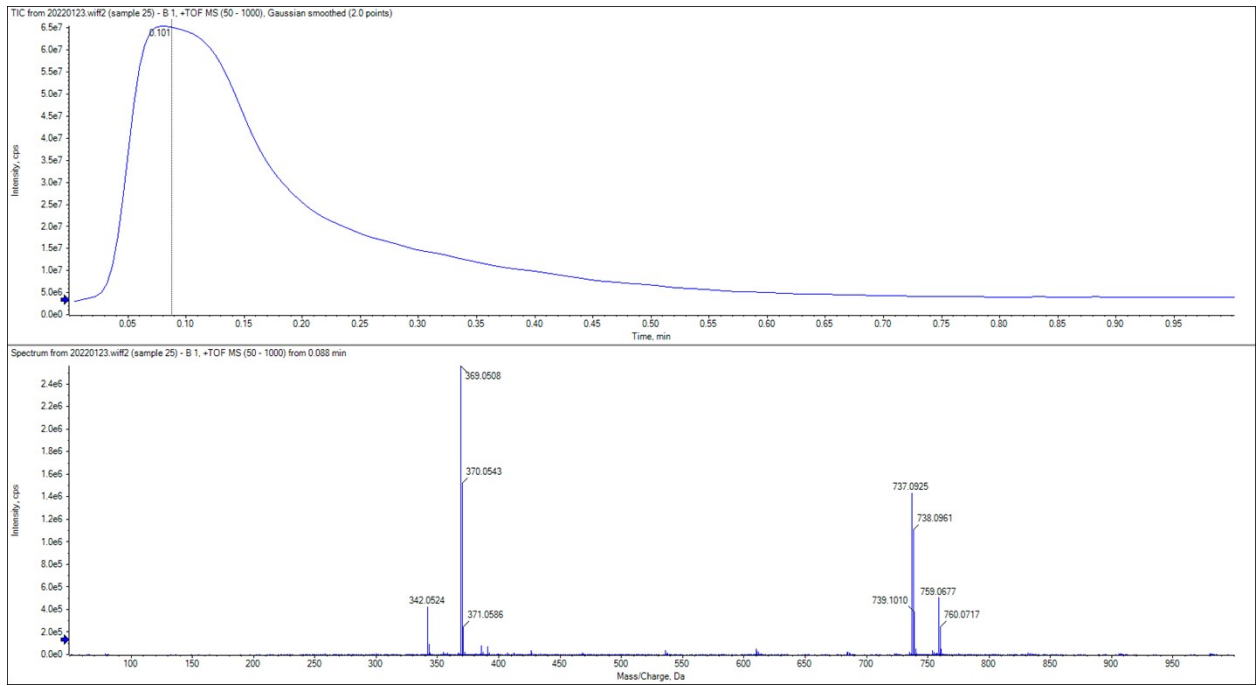
^1H , ^{13}C NMR spectra, FTIR, and HRMS(ESI) of 5-amino-9,9-dimethyl-7-oxo-11-phenyl-8,9,10,11-tetrahydro-7*H*-benzo[*a*]carbazole-6-carbonitrile (1a)



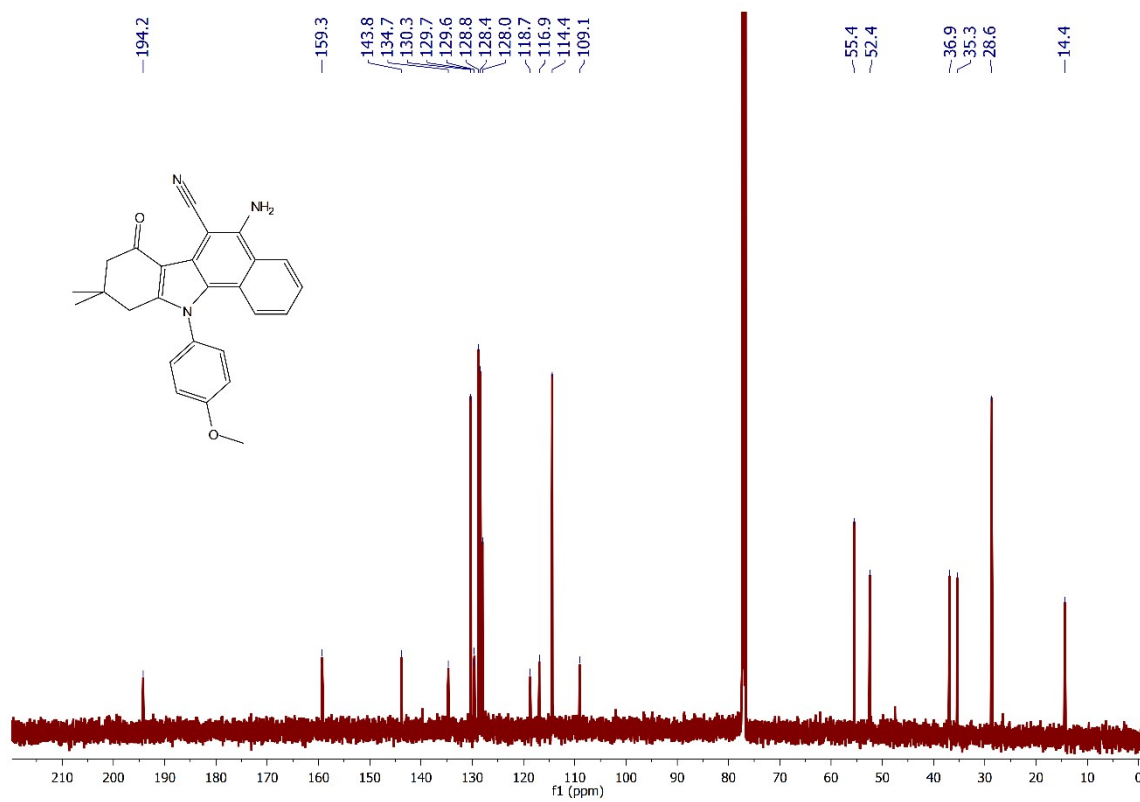
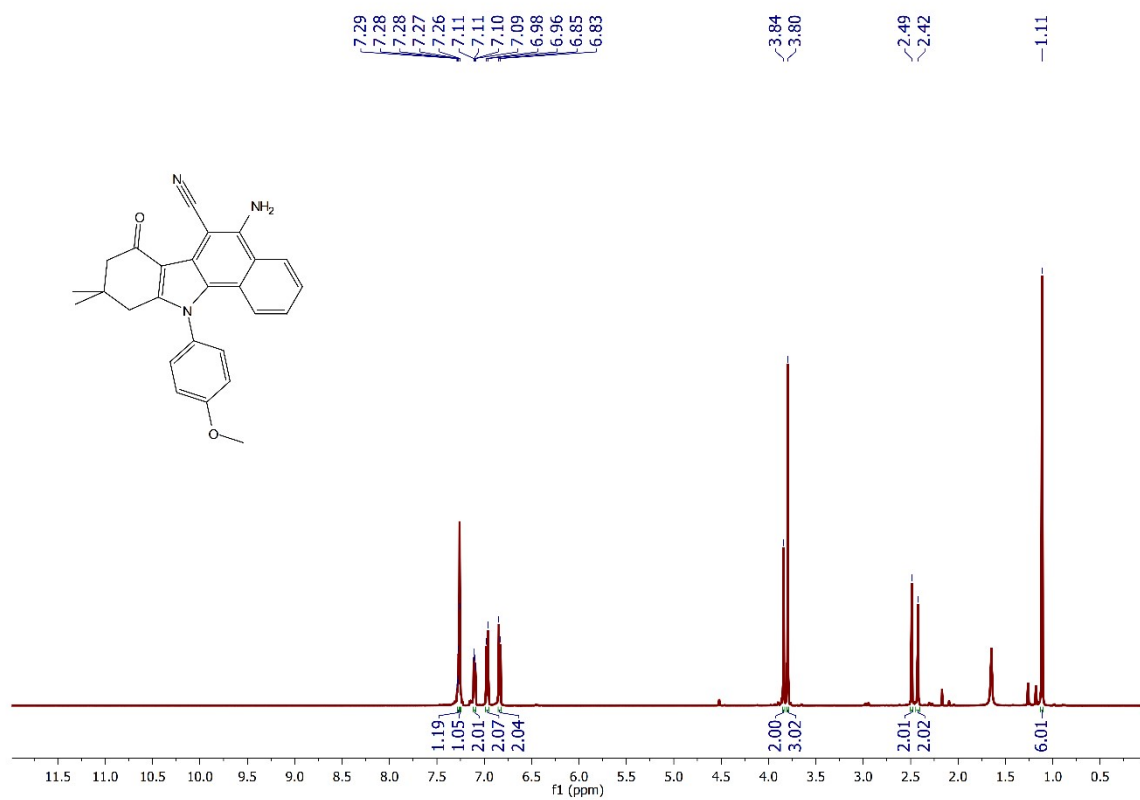


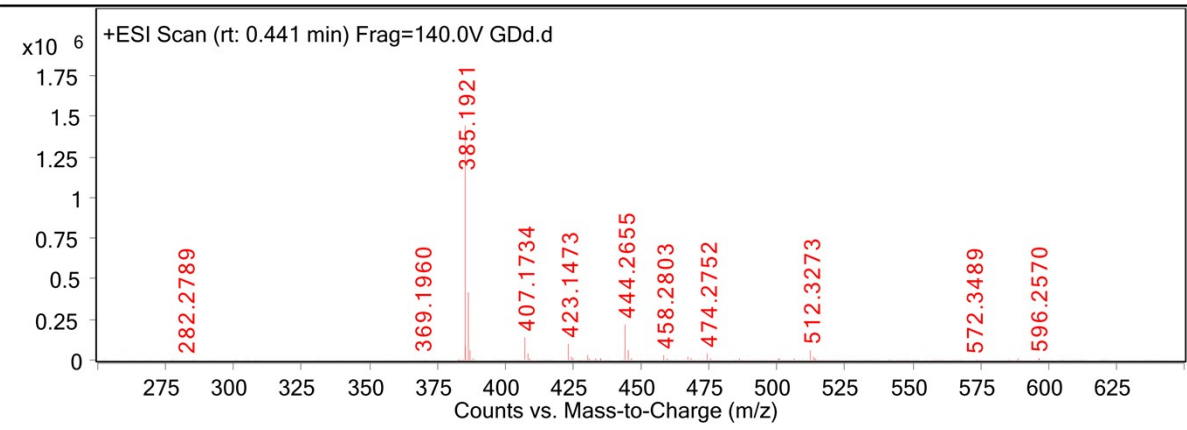
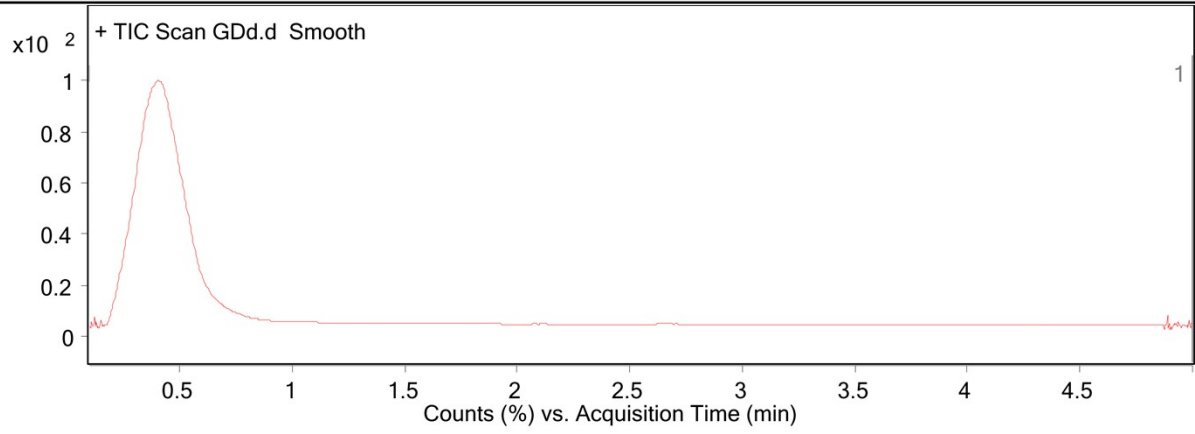
¹H, ¹³C NMR spectra and HRMS of 5-Amino-9,9-dimethyl-7-oxo-11-(*p*-tolyl)-8,9,10,11-tetrahydro-7*H*-benzo[*a*]carbazole-6-carbonitrile (2a)



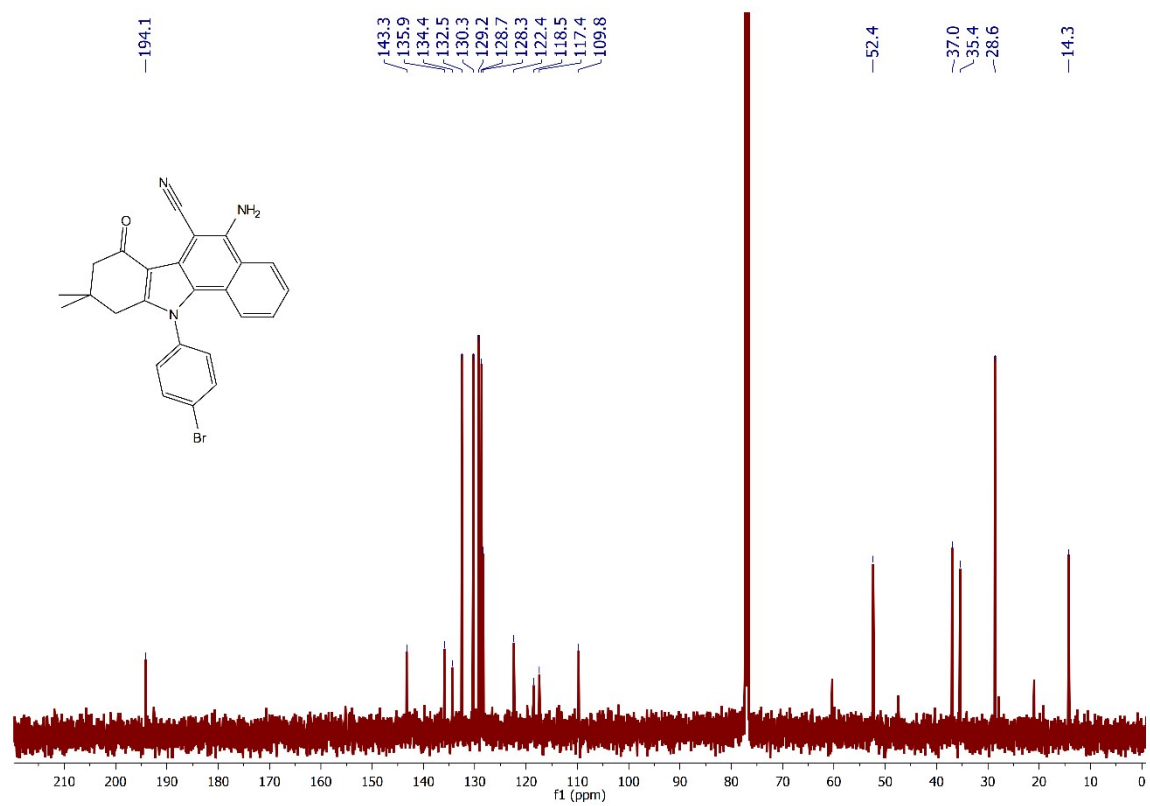
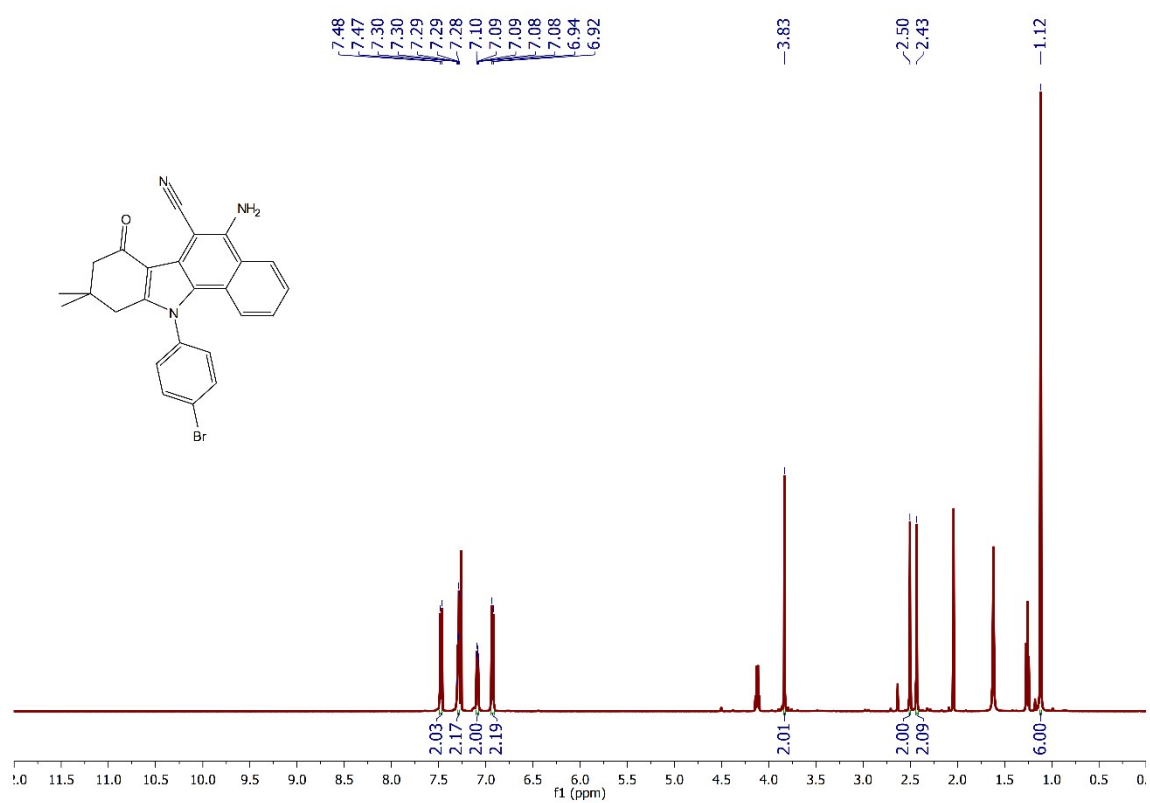


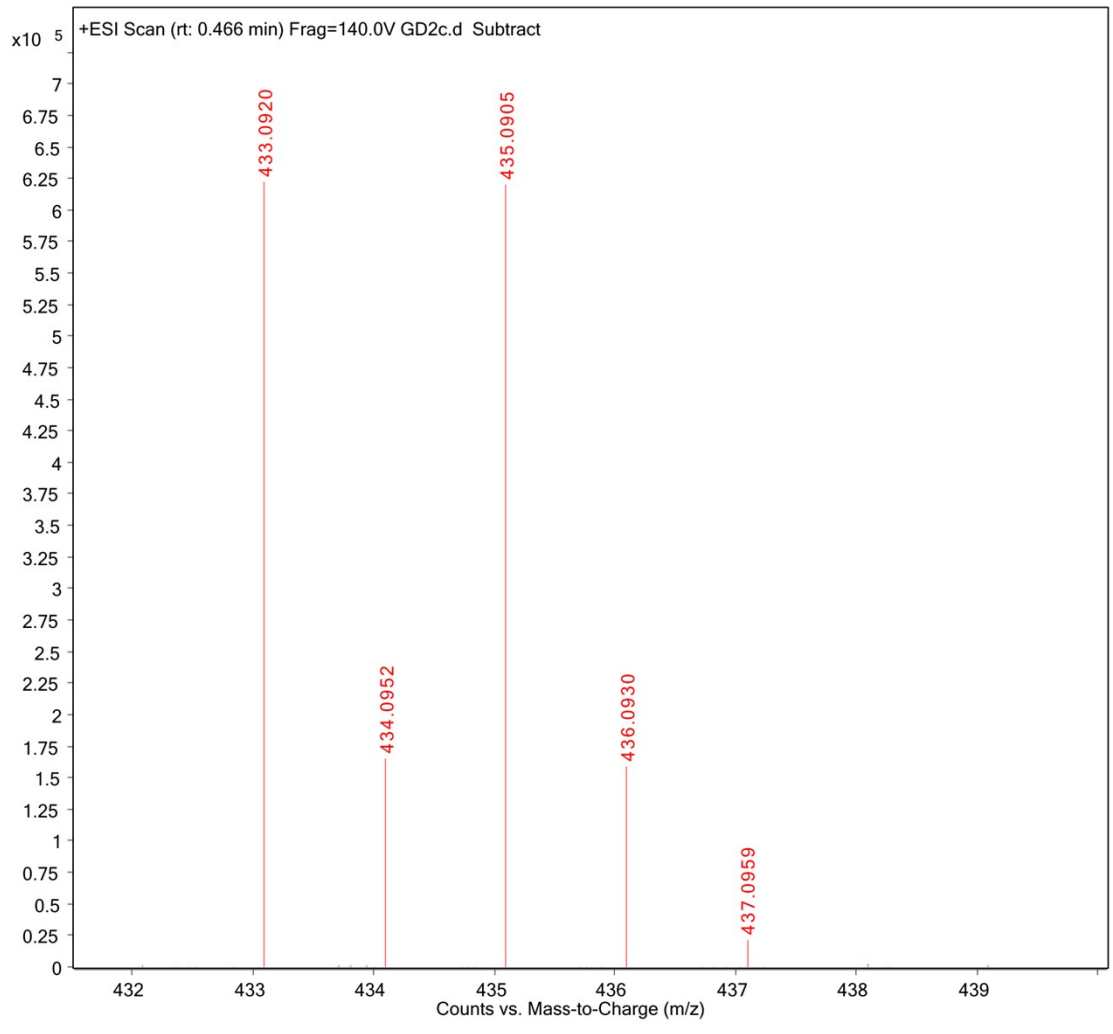
^1H , ^{13}C NMR spectra and HRMS of 5-amino-11-(4-methoxyphenyl)-9,9-dimethyl-7-oxo-8,9,10,11-tetrahydro-7H-benzo[*a*]carbazole-6-carbonitrile (3a)



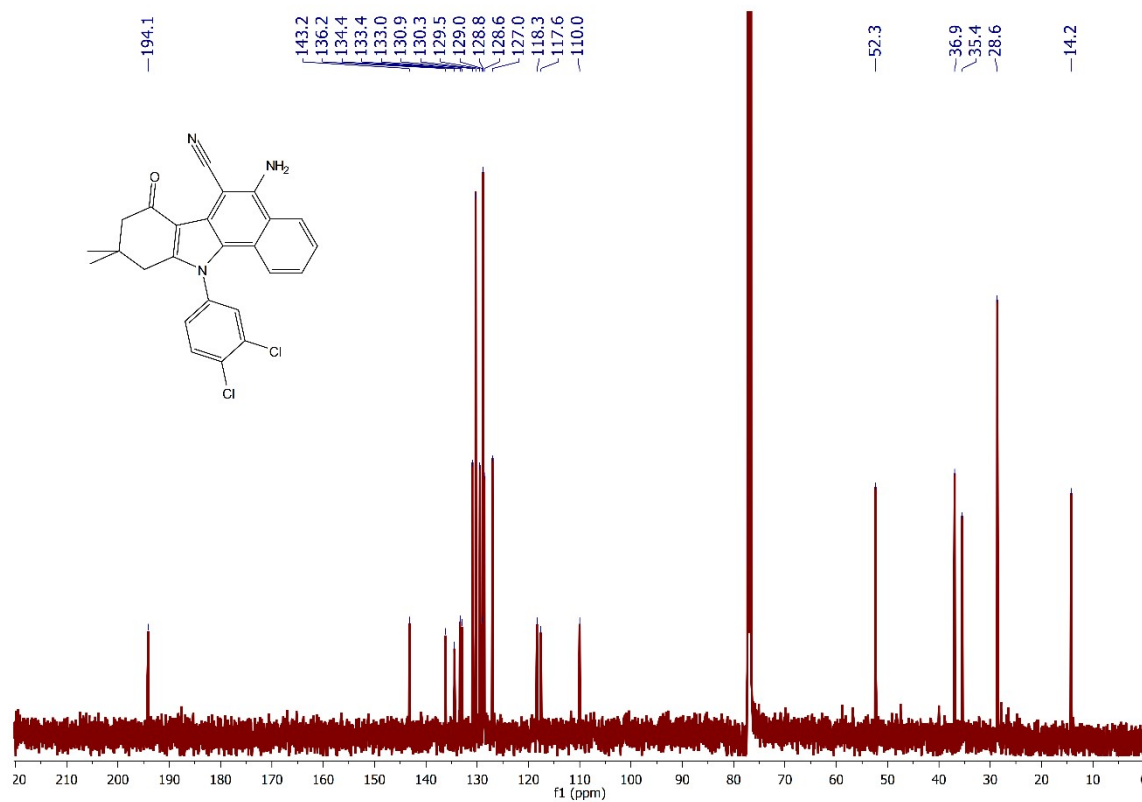
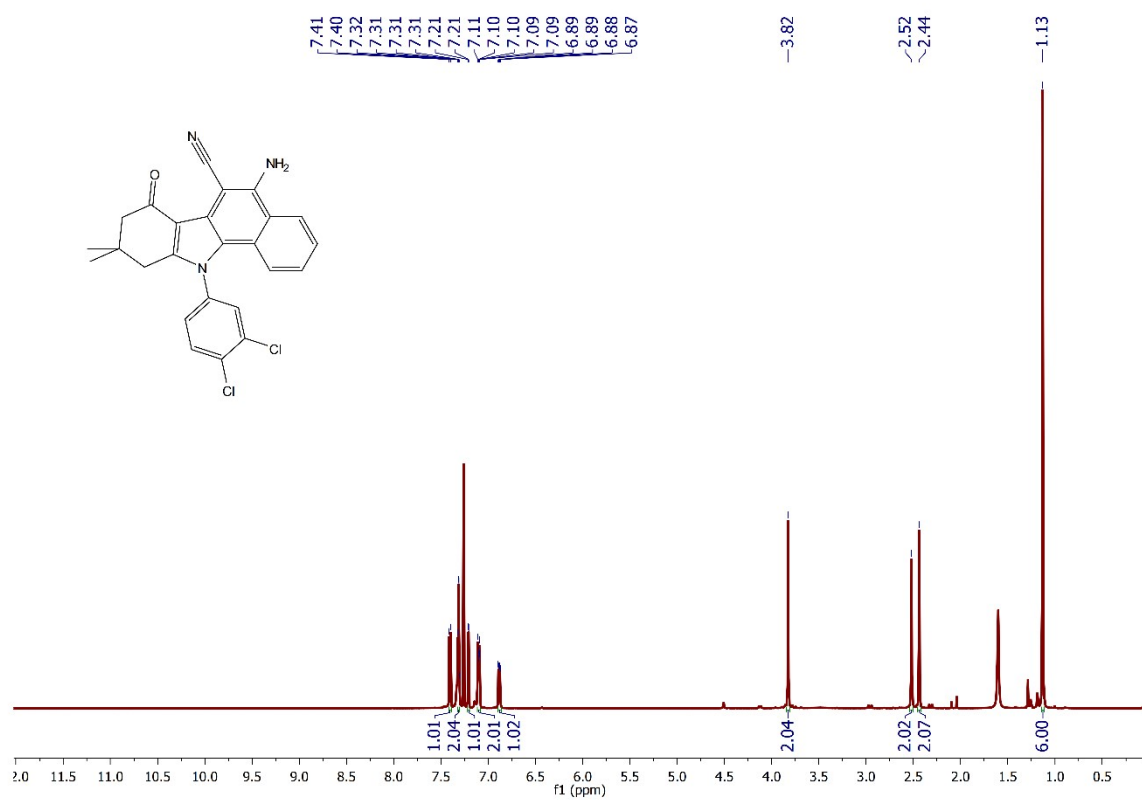


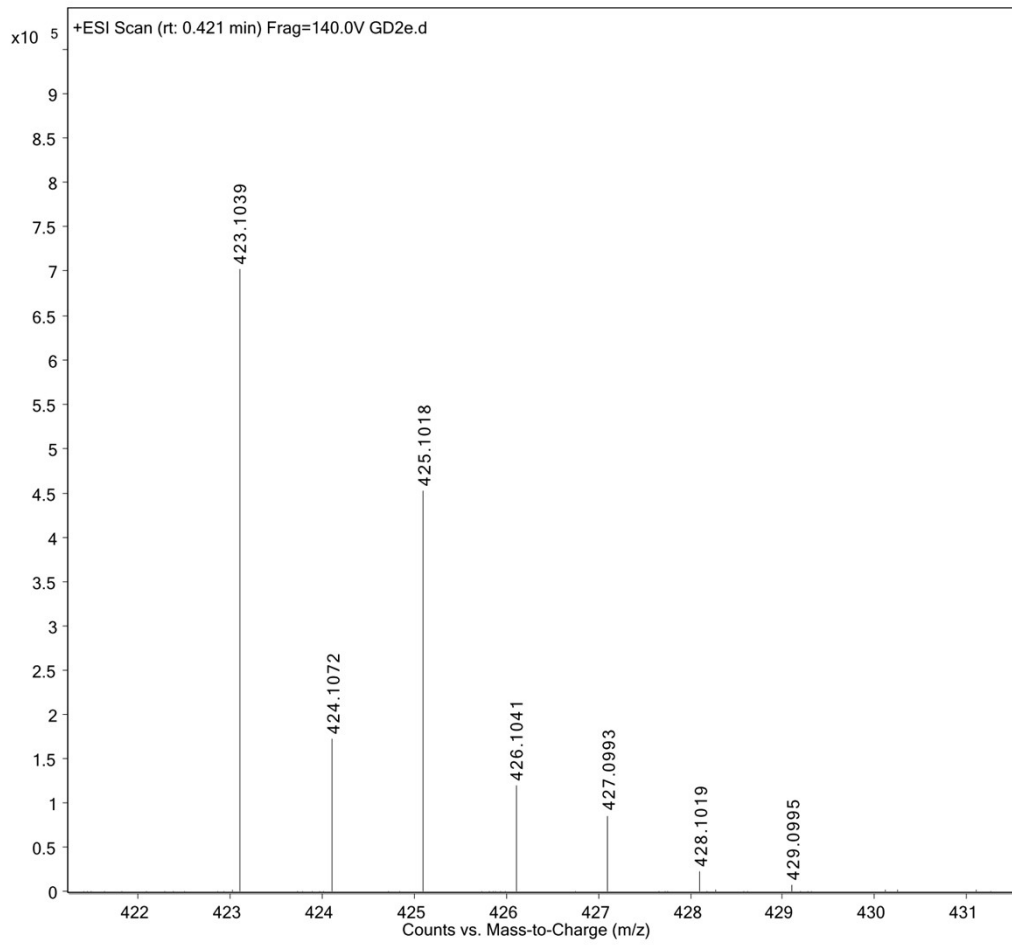
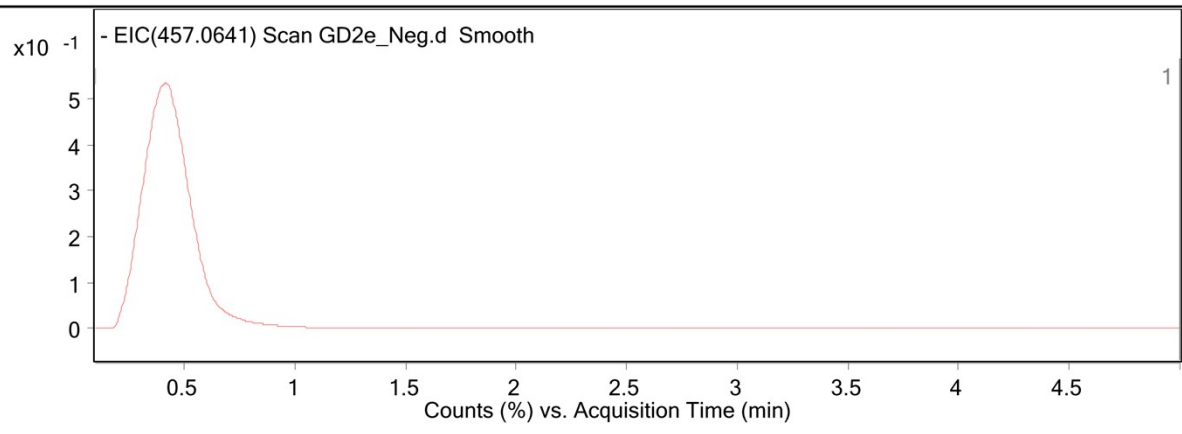
^1H , ^{13}C NMR spectra and HRMS of 5-amino-11-(4-bromophenyl)-9,9-dimethyl-7-oxo-8,9,10,11-tetrahydro-7H-benzo[*a*]carbazole-6-carbonitrile (4a)



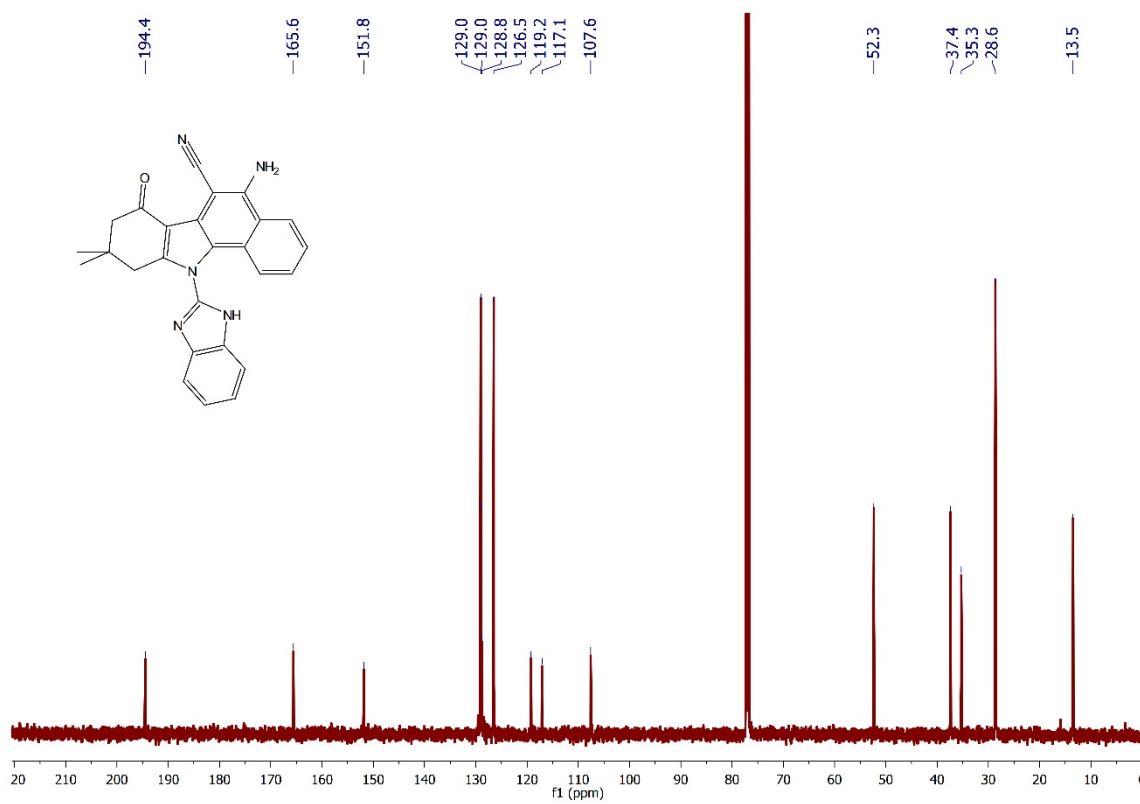
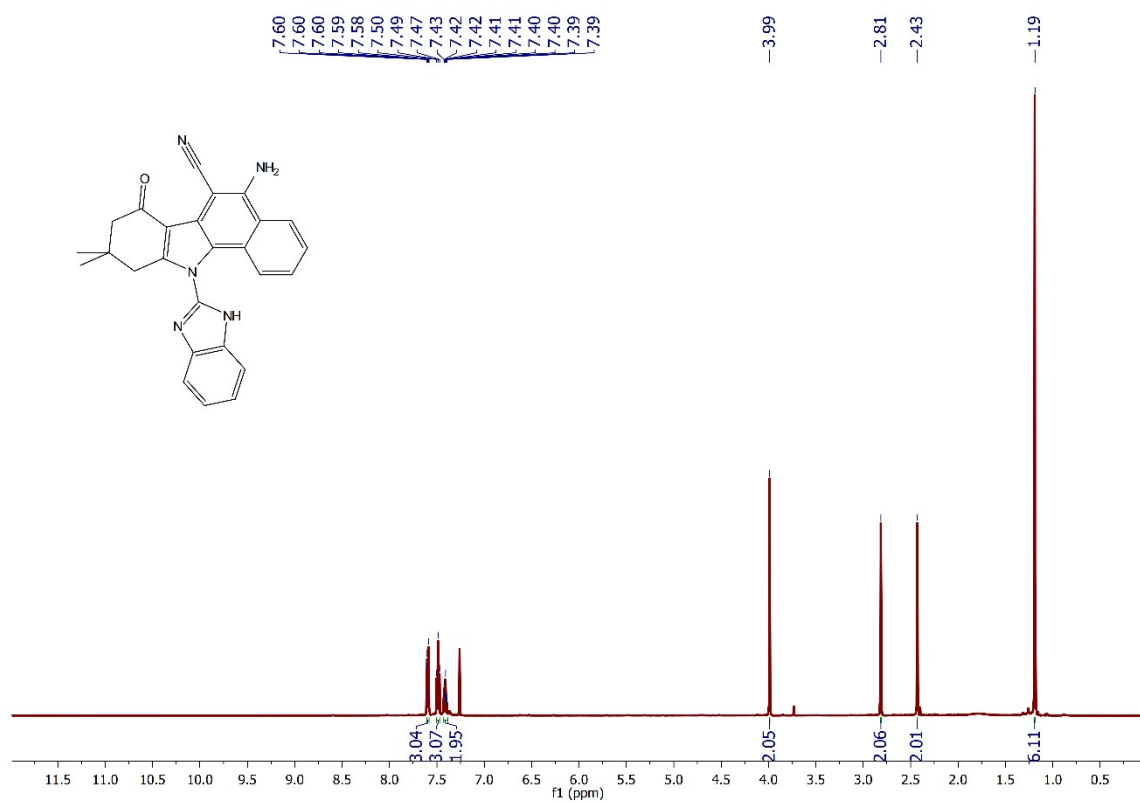


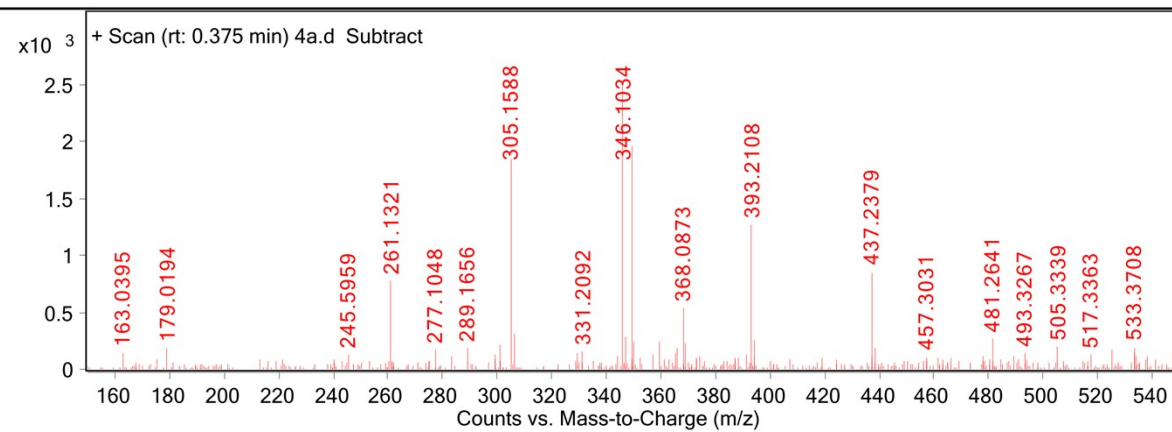
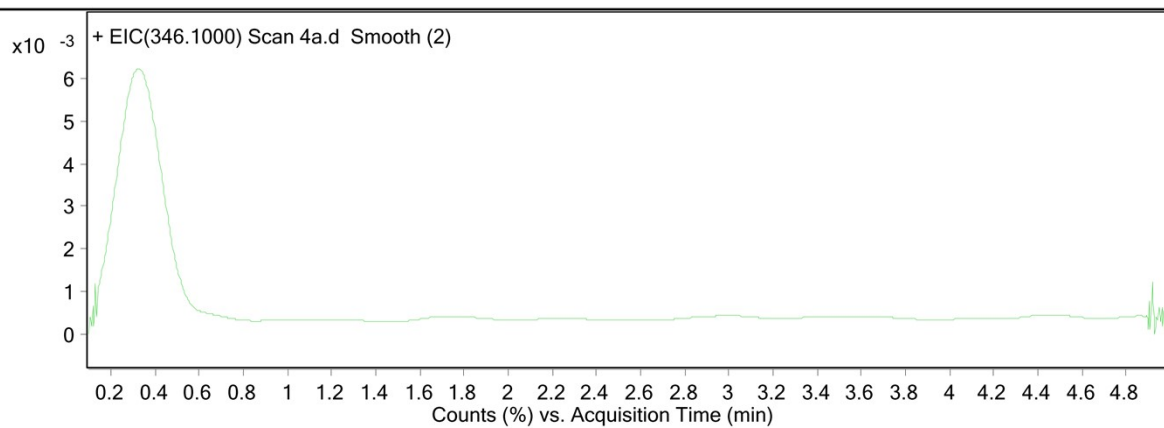
¹H, ¹³C NMR spectra and HRMS of 5-amino-11-(3,4-dichlorophenyl)-9,9-dimethyl-7-oxo-8,9,10,11-tetrahydro-7H-benzo[*a*]carbazole-6-carbonitrile (5a)



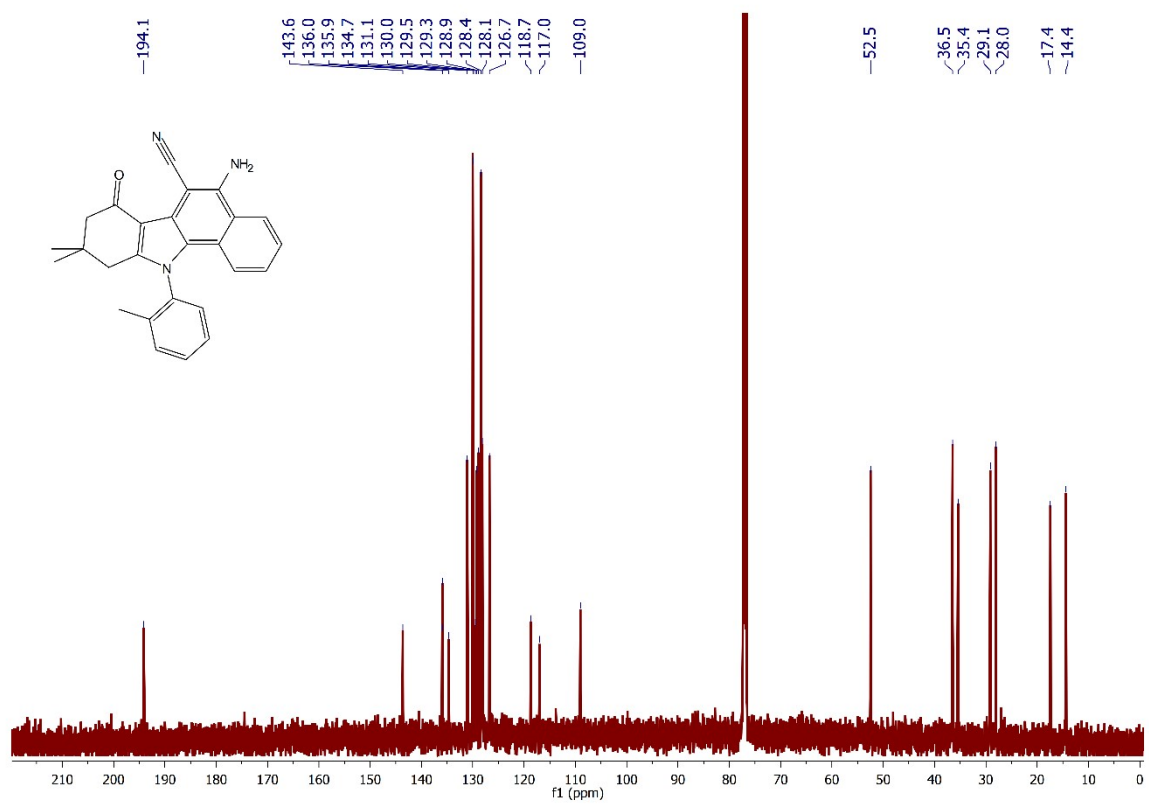
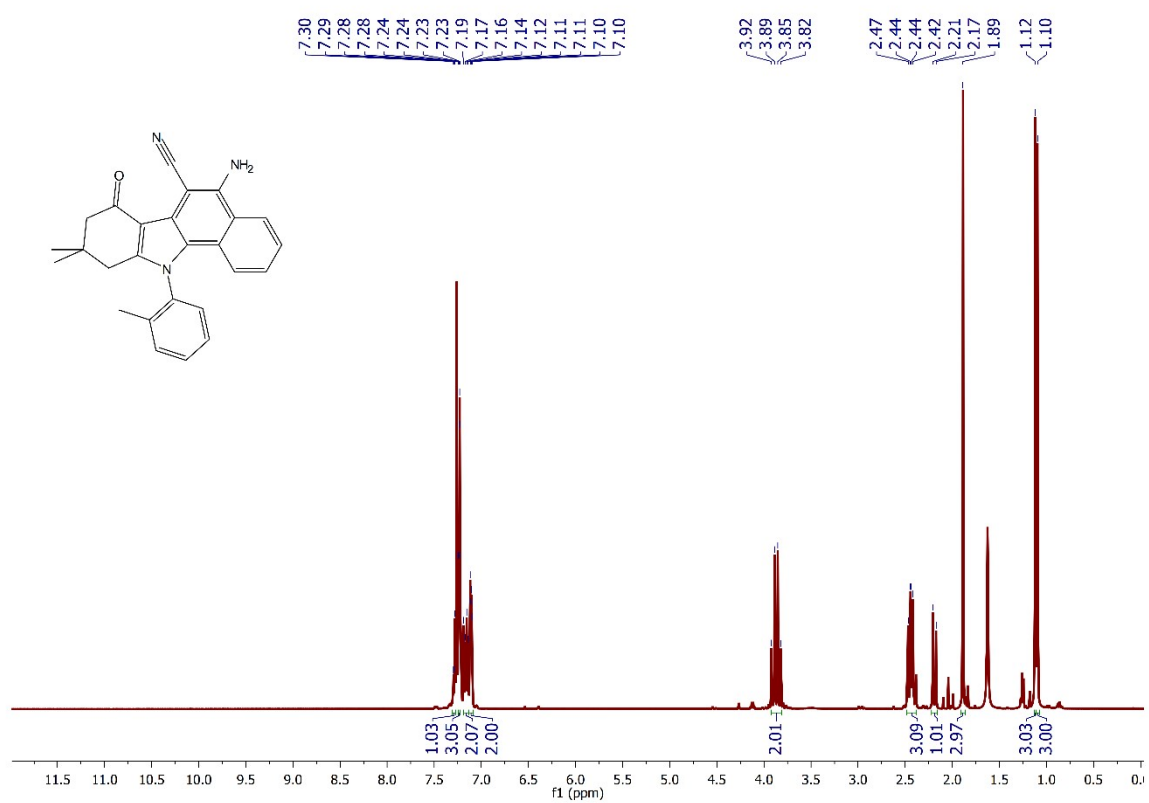


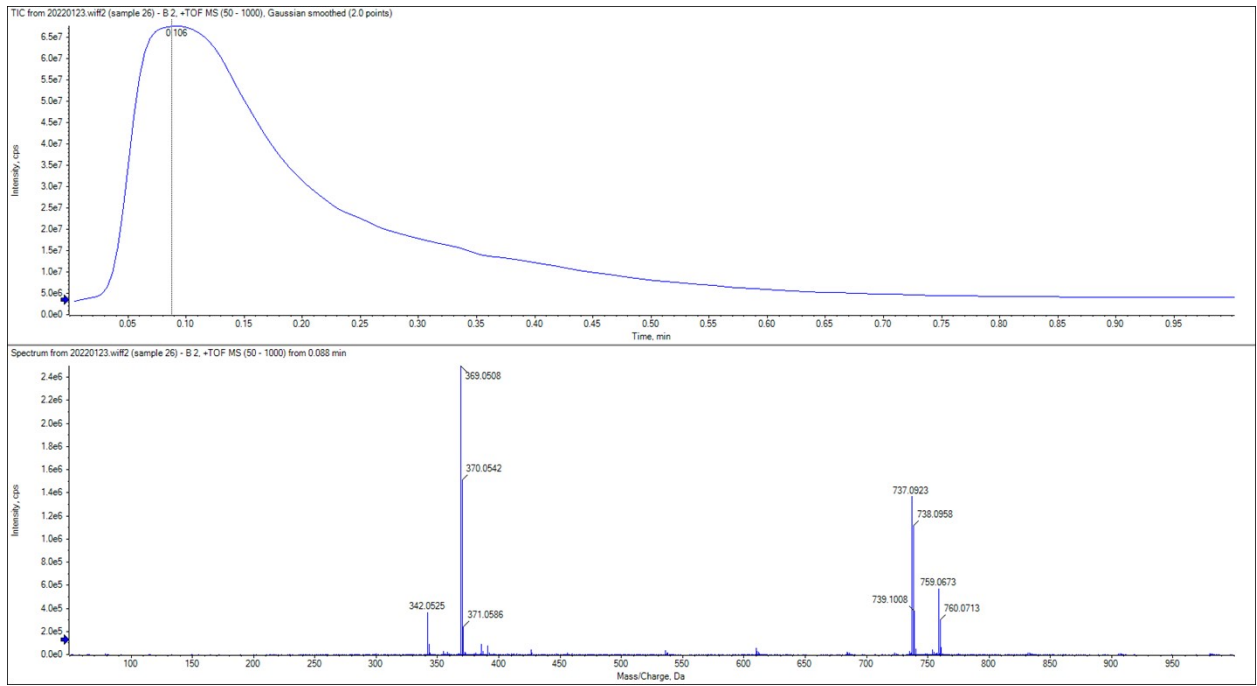
^1H , ^{13}C NMR spectra and HRMS of 5-amino-11-(1*H*-benzo[d]imidazol-2-yl)-9,9-dimethyl-7-oxo-8,9,10,11-tetrahydro-7*H*-benzo[*a*]carbazole-6-carbonitrile (6a)



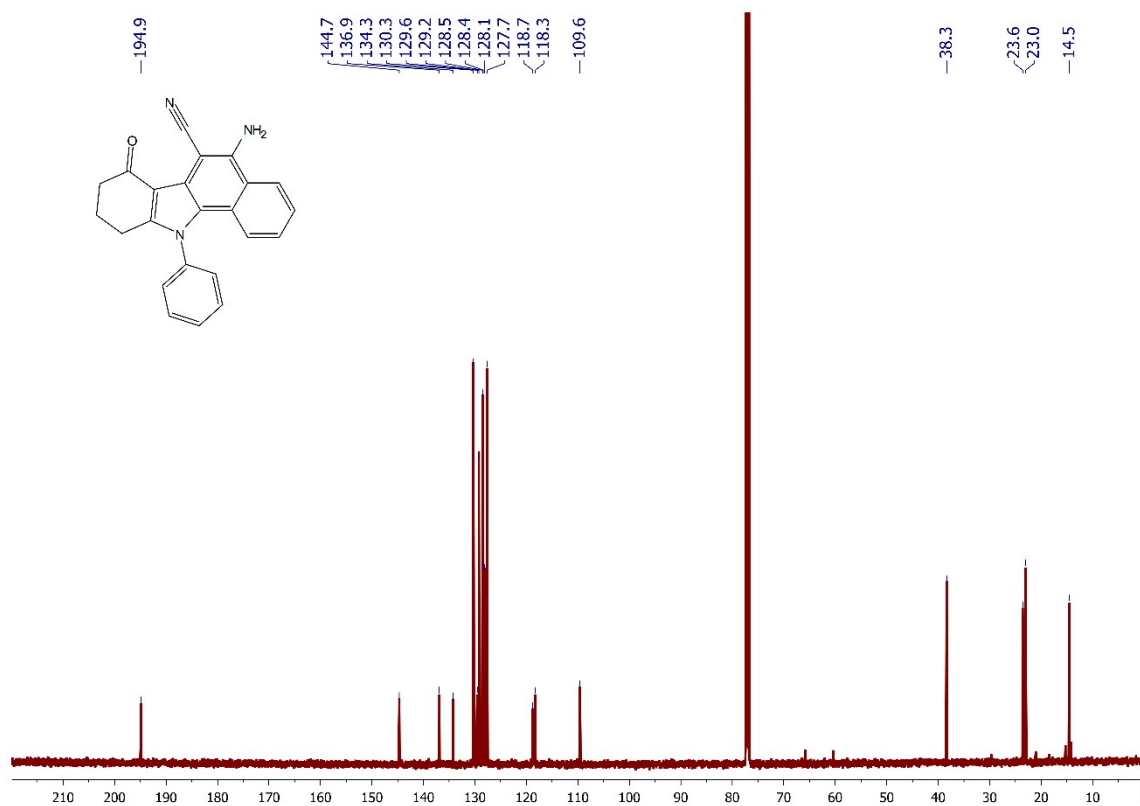
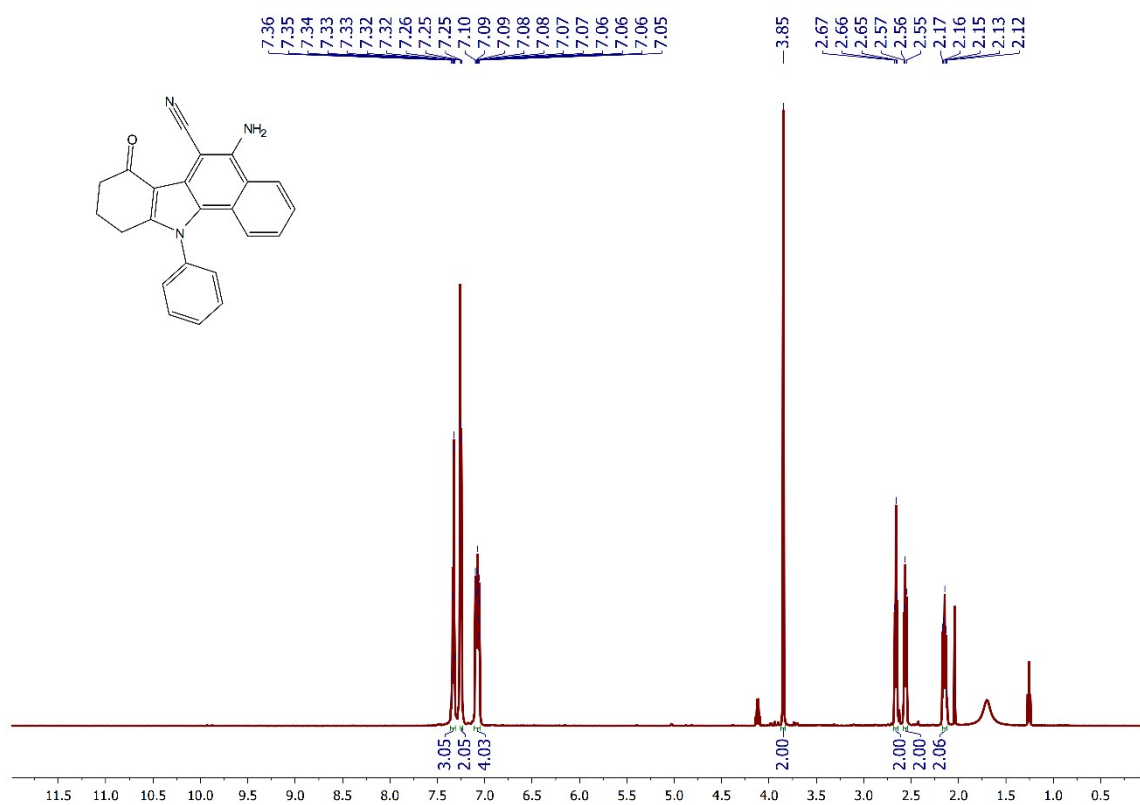


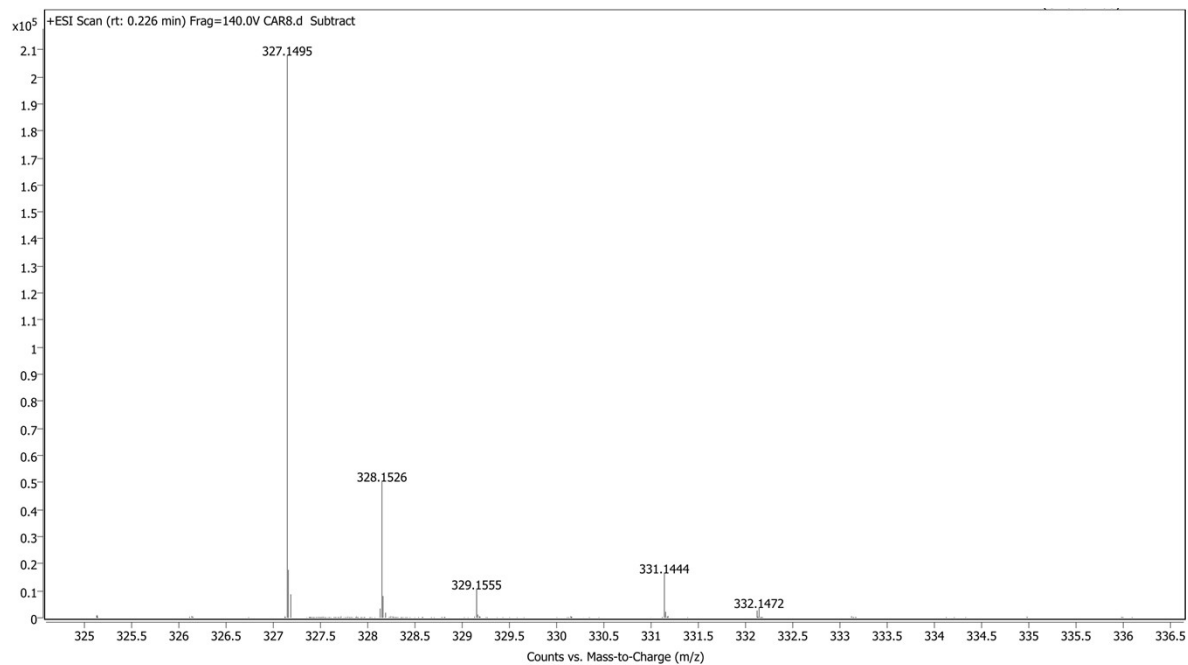
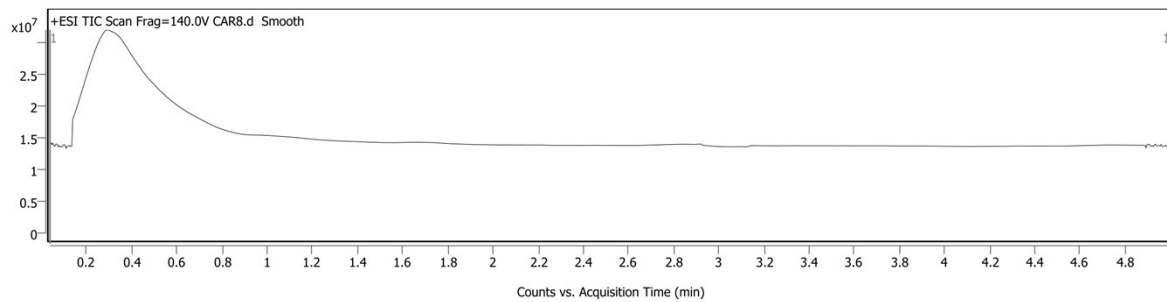
^1H , ^{13}C NMR spectra and HRMS of 5-amino-9,9-dimethyl-7-oxo-11-(*o*-tolyl)-8,9,10,11-tetrahydro-7*H*-benzo[*a*]carbazole-6-carbonitrile (7a)



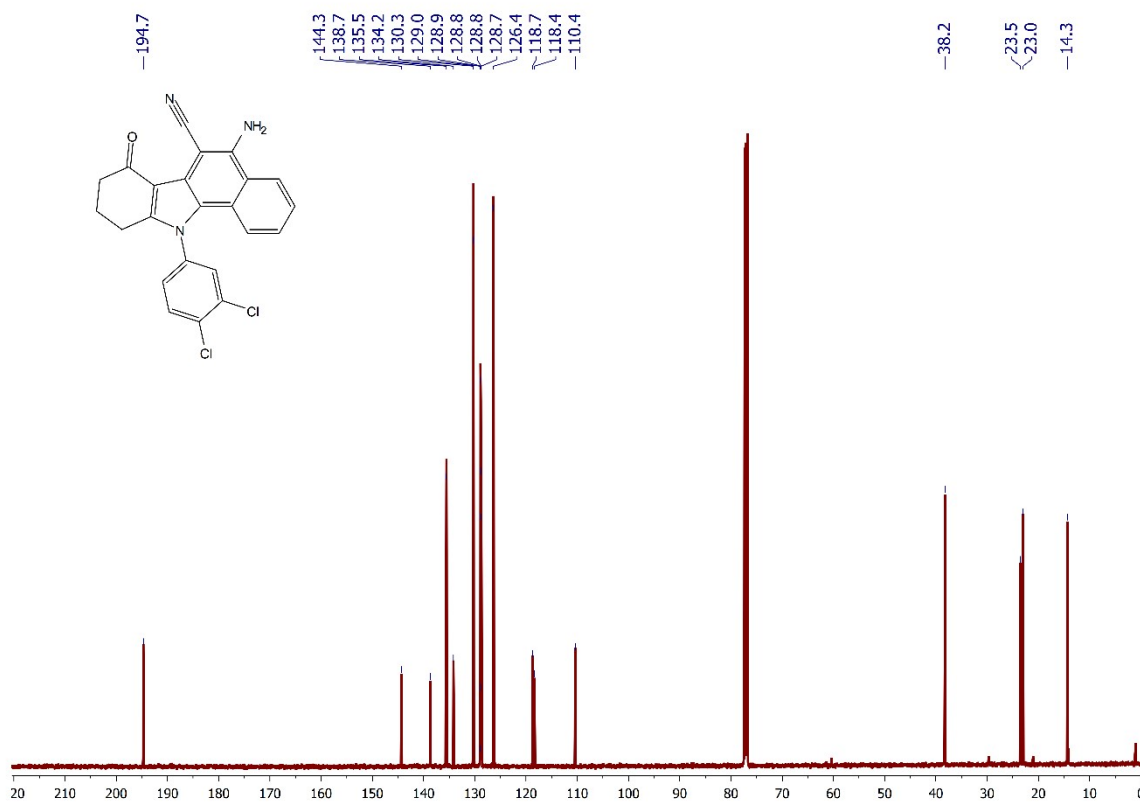
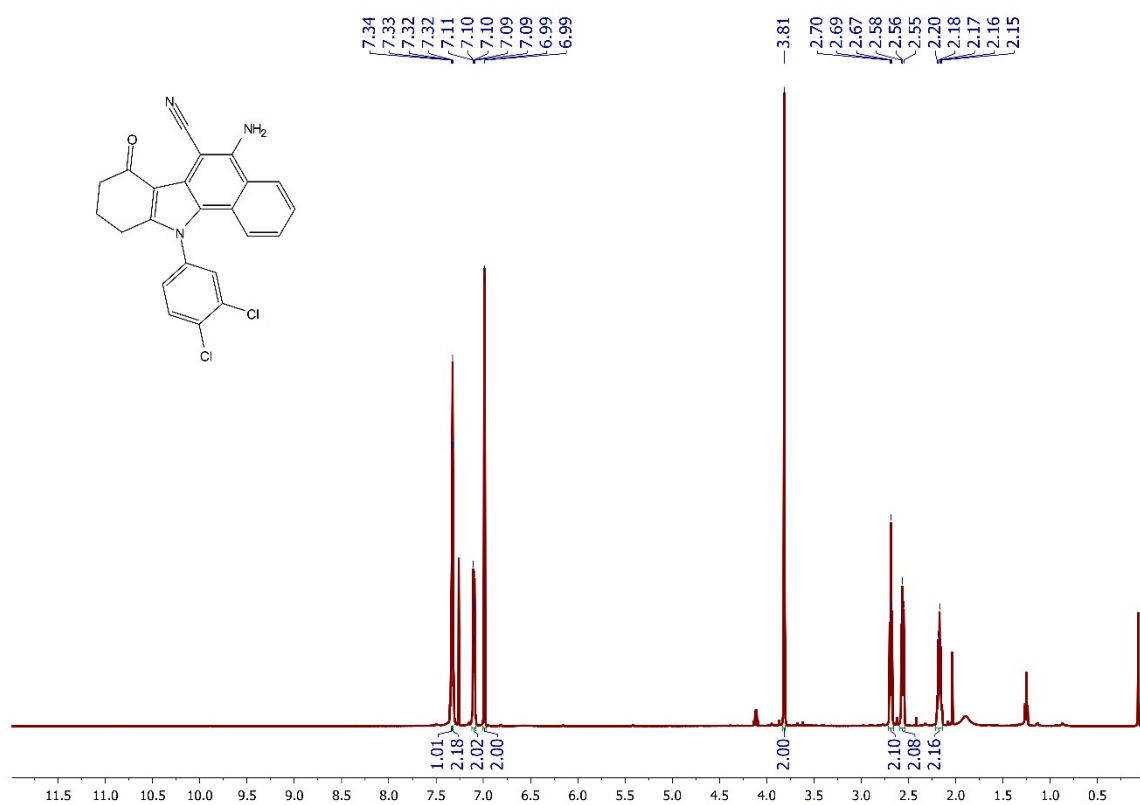


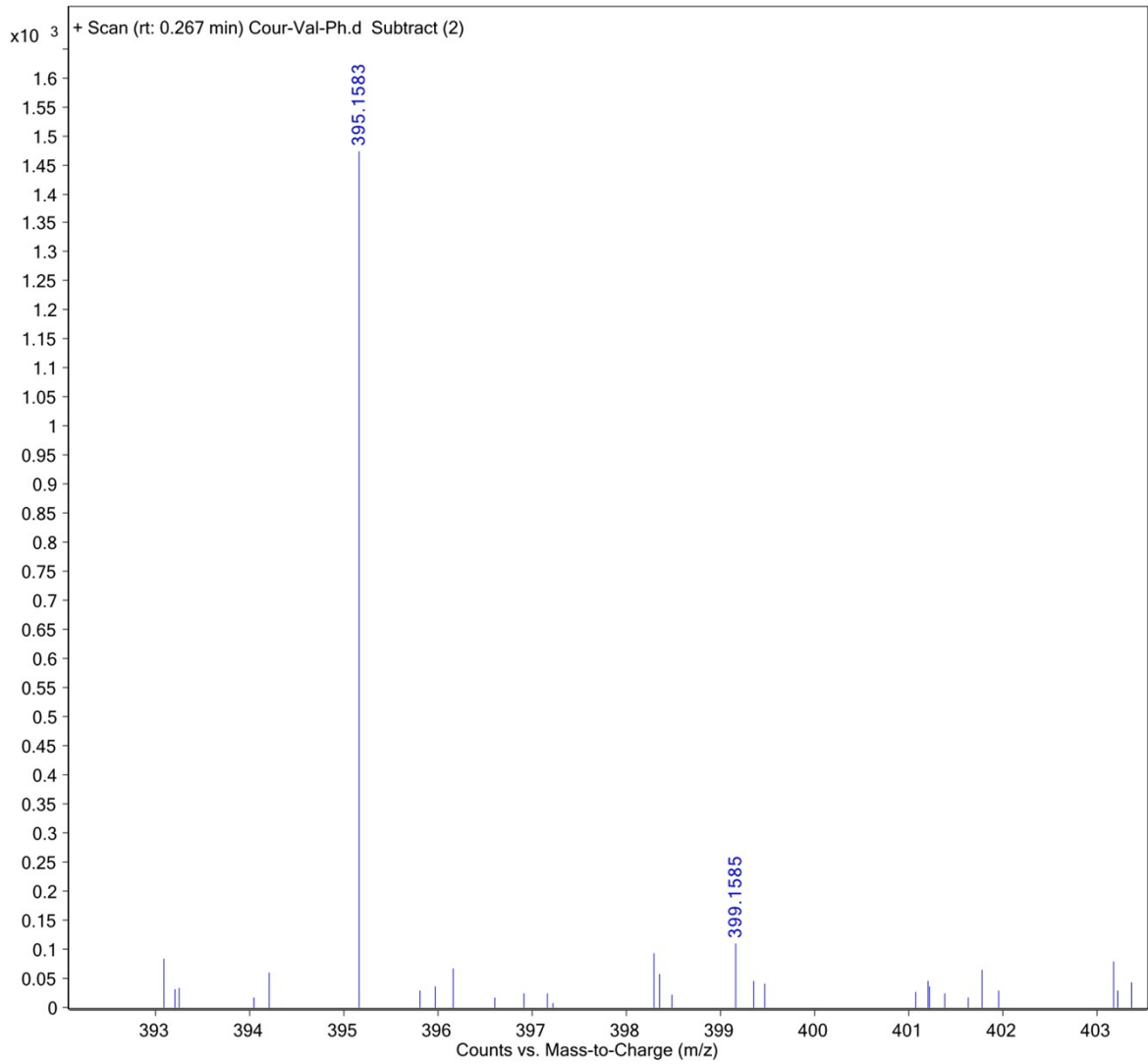
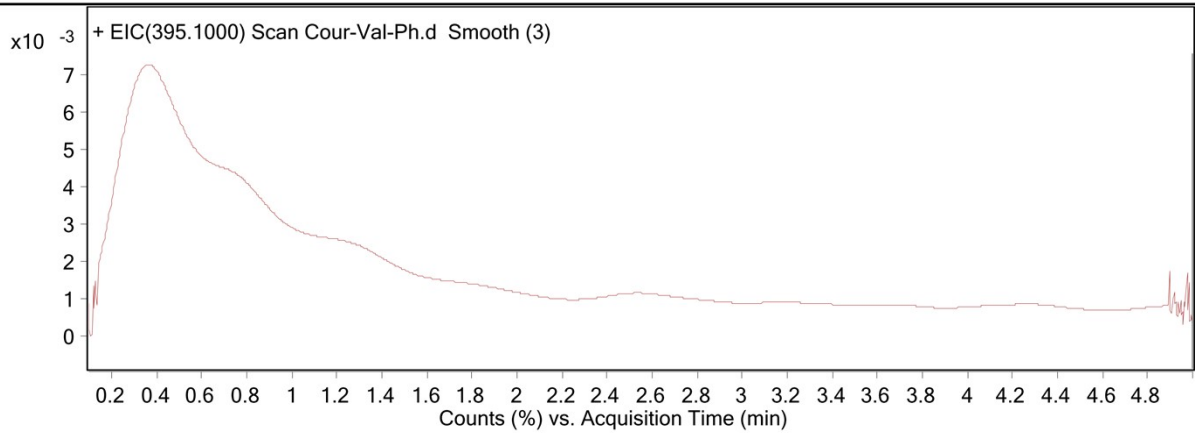
^1H , ^{13}C NMR spectra and HRMS of 5-amino-7-oxo-11-phenyl-8,9,10,11-tetrahydro-7H-benzo[*a*]carbazole-6-carbonitrile (1b)





¹H, ¹³C NMR spectra and HRMS of 5-amino-7-oxo-11-(3,4-dichlorophenyl)-8,9,10,11-tetrahydro-7H-benzo[a]carbazole-6-carbonitrile (5b)





^1H , ^{13}C NMR spectra and HRMS of 5-amino-7-oxo-11-(*o*-tolyl)-8,9,10,11-tetrahydro-7*H*-benzo[*a*]carbazole-6-carbonitrile (7b)

