

Synthesis and application of bimetallic-organic framework with sulfonic acid tages in preparation of biological active nicotinonitriles via a cooperative vinylogous anomeric-based oxidation

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Antibacterial activity assay

The antibacterial activity of the synthesized compounds was evaluated using the standard Chinese method as defined by K. Xie et al. The compounds were tested on *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 5923), and an isolate methicillin-resistant *Staphylococcus aureus* (MRSA) which represent both Gram-positive and -negative bacteria. A concentration equivalent to 0.5 McFarland (1.5×10^8 CFU/ml) was prepared in sterile normal saline. thereupon, 5 μ g of the synthesized compounds were added to 1 ml of each bacterial solution. A tube containing no substance was also cultured as the negative control. The microtubes were placed in a shaker incubator at 37°C (100 RPM) for 24 hours. Afterwards, each solution was diluted 1:10 with sterile normal saline. Then, 100 μ l of the 10⁻⁴ dilution of the bacterial suspensions, which contained approximately 30-300 CFU, were cultured on two Mueller-Hinton agar plates with and without the synthesized compounds. The plates were then incubated at 37°C for 24 hours. A colony count was conducted, and the average number of colonies was considered as the corresponding colony count. Finally, the inhibition rate for each compound was calculated using the following formula:

$$Y = \frac{Wt - Qt}{Wt} \times 100\%$$

Where:

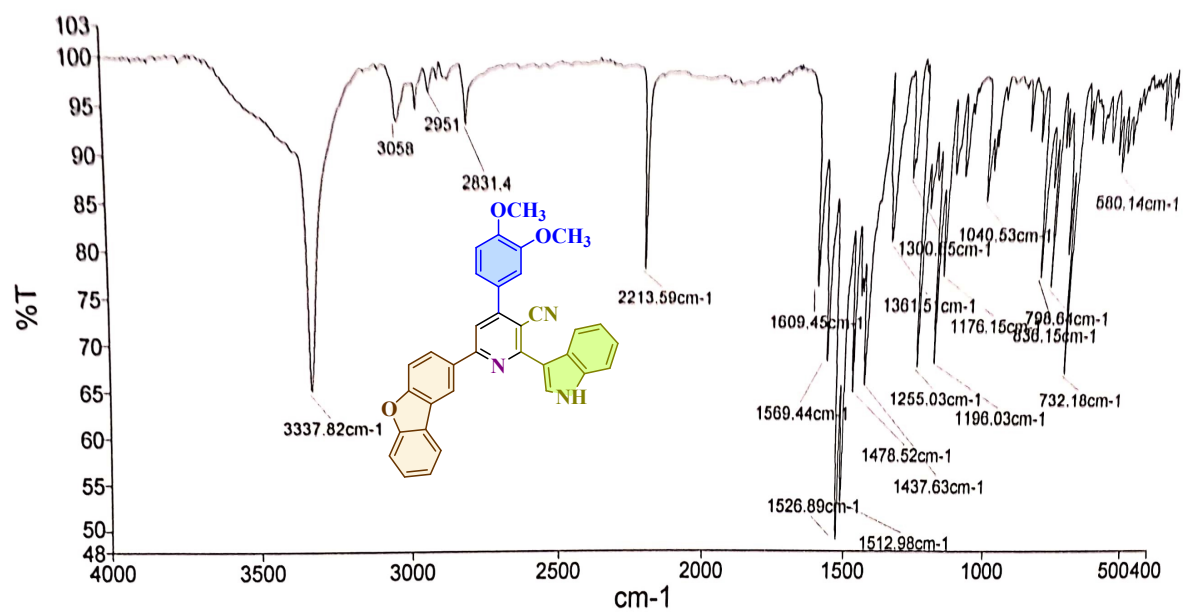
Y = Inhibition rate of the sample

Wt = Average colony number calculated from the control bacterial suspension contained no compound (after 24h culture)

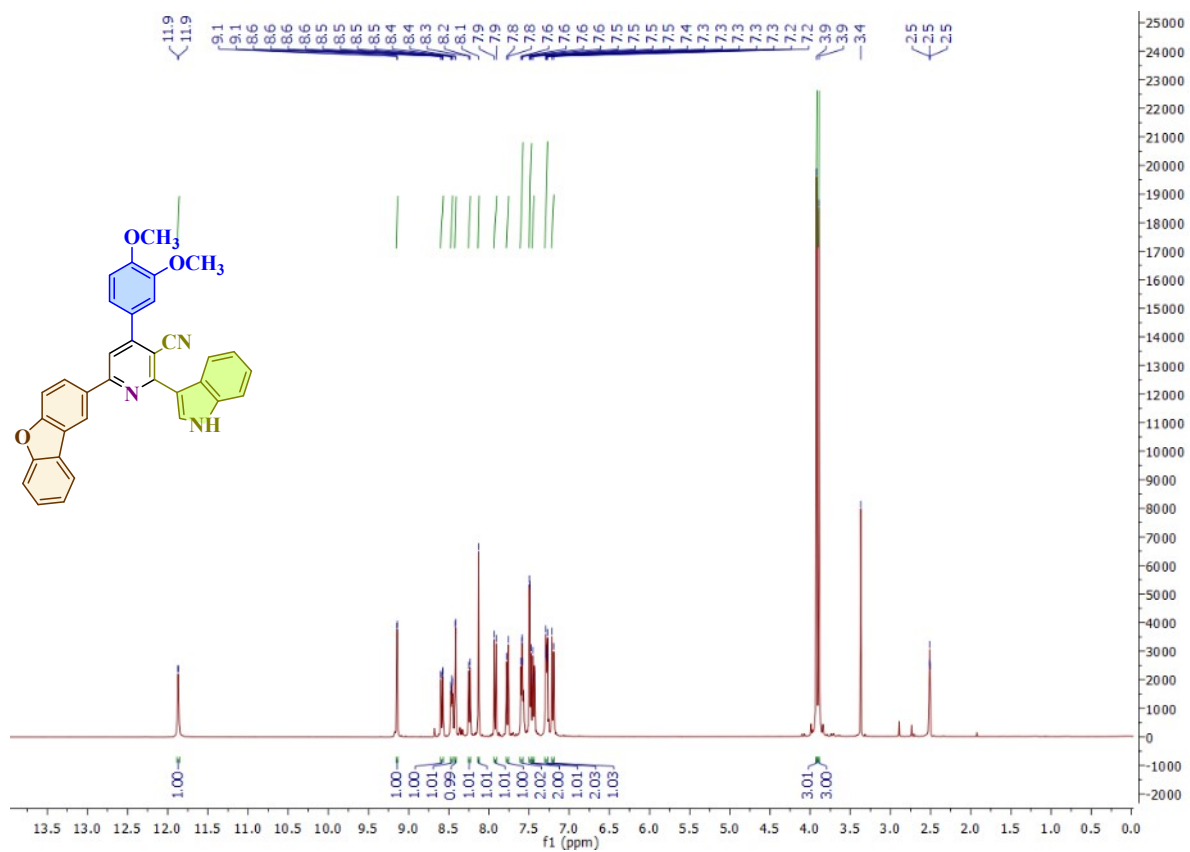
Qt = Average colony number calculated from the bacterial suspension containing the examined compound (after 24h culture)

[1] Xie, K.; Xu, S.; Xu, K.; Zhang, W.; Yu, S.; Wang, P.; Han, Z.; He, N. and Chen, P. Preparation and antibacterial properties of copper phthalate/polyethylene terephthalate composition fiber. *Alex. Eng. J.*, **2023**, 75, 271-278.

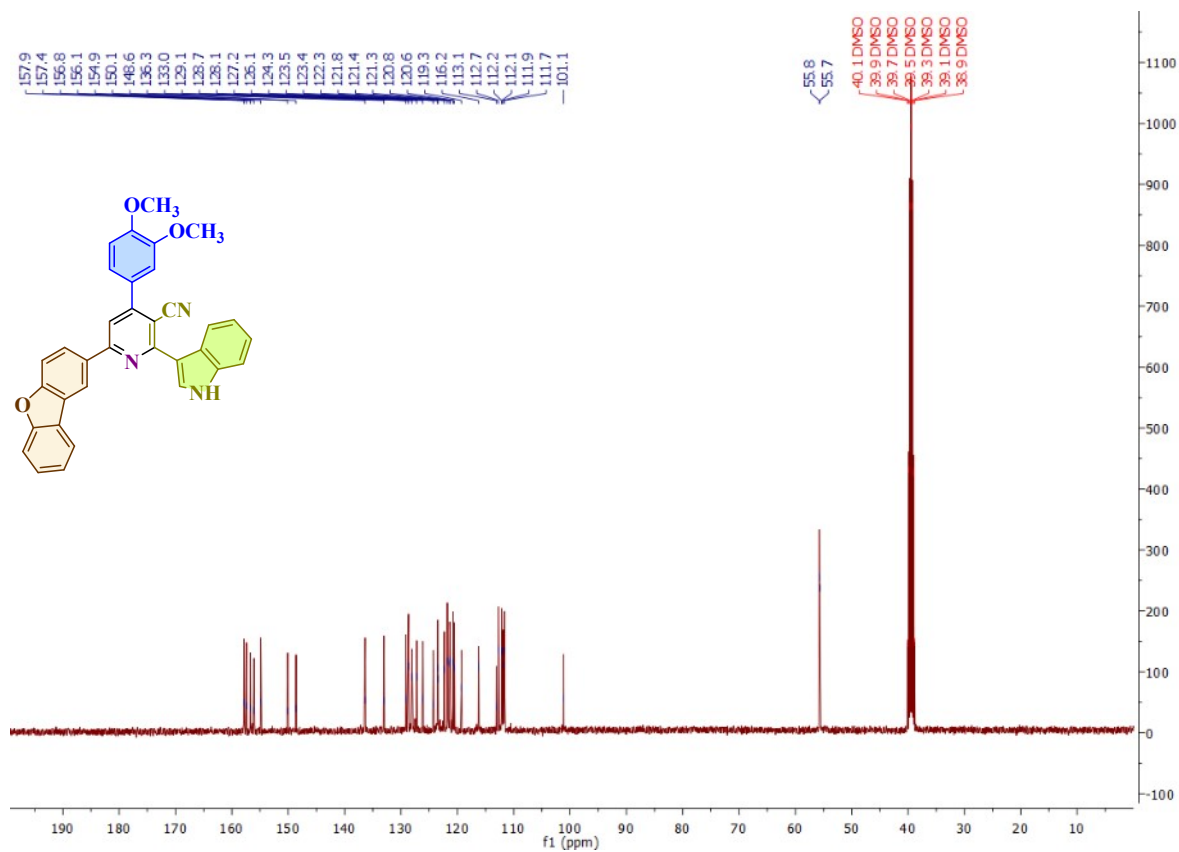
[2] Tavakoli, E.; Sepehrmansourie, H.; Zolfigol, M. A.; Khazaei, A.; Mohammadzadeh, A.; Ghytasranjbar, E.; As' Habi, M. A. Synthesis and application of task-specific bimetal-organic frameworks in the synthesis of biological active spiro-oxindoles. *Inorg. Chem.* **2024**, 63, 5805-5820.



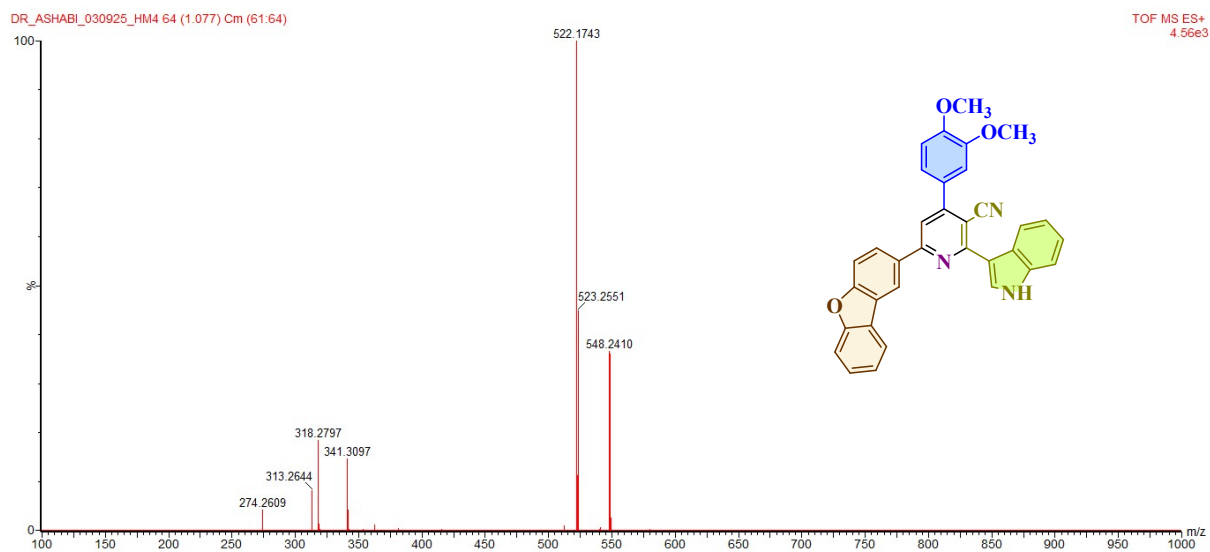
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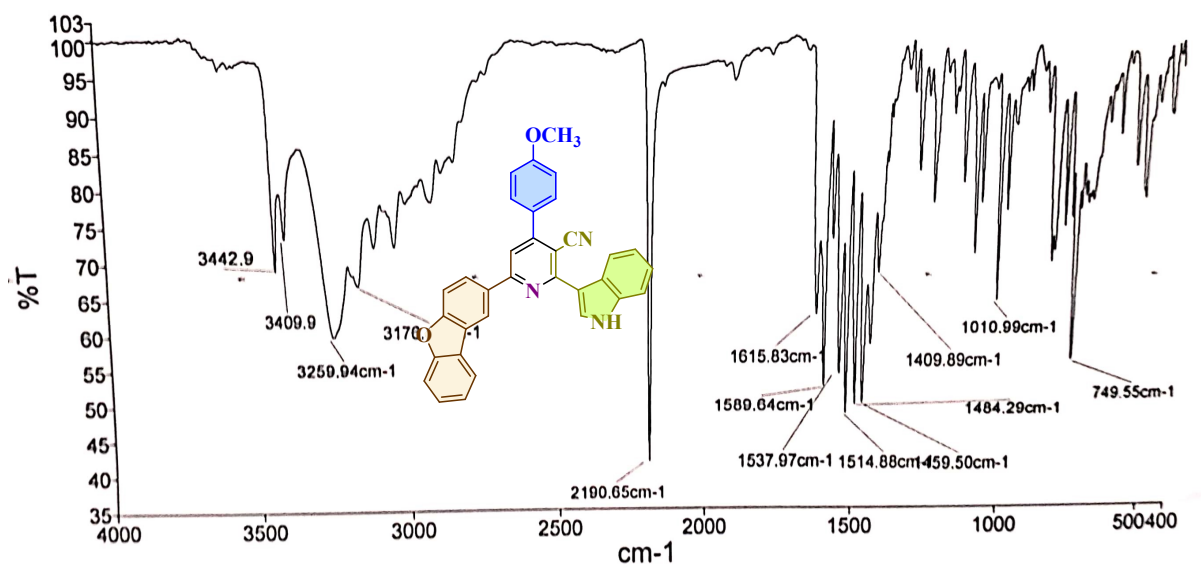
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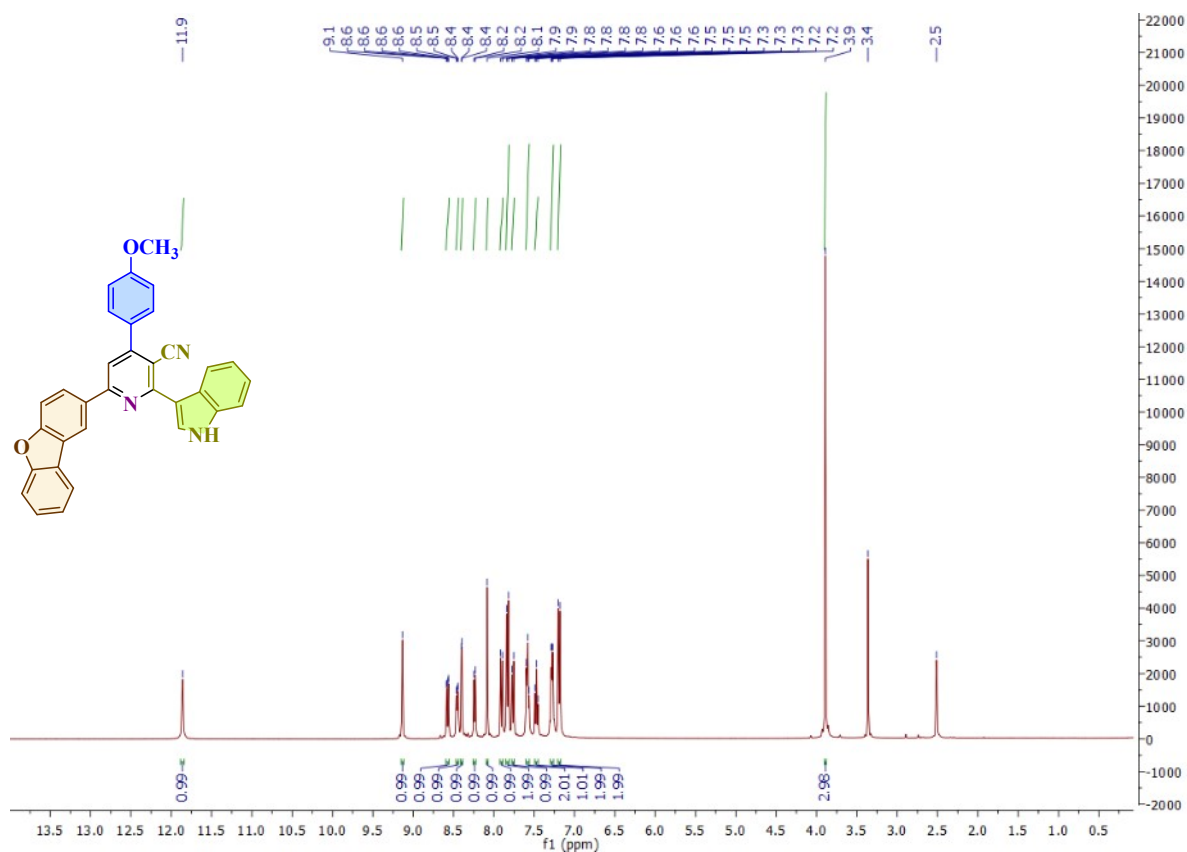
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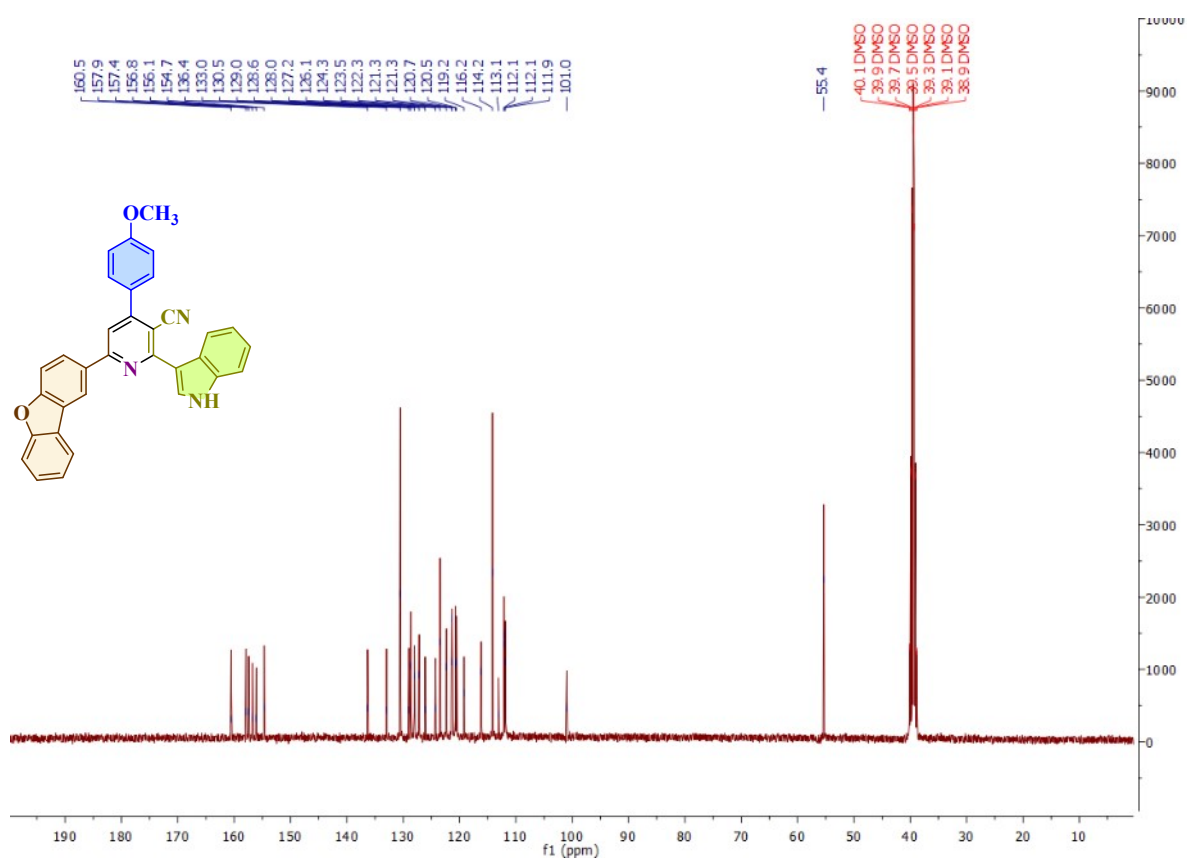
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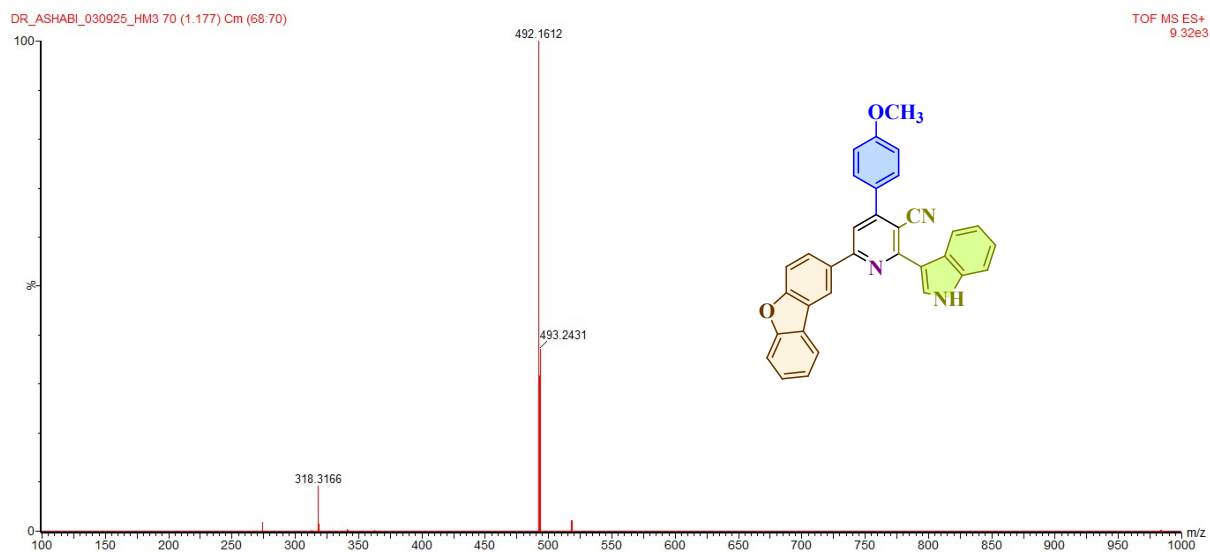
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(4-methoxyphenyl)nicotinonitrile (A2).



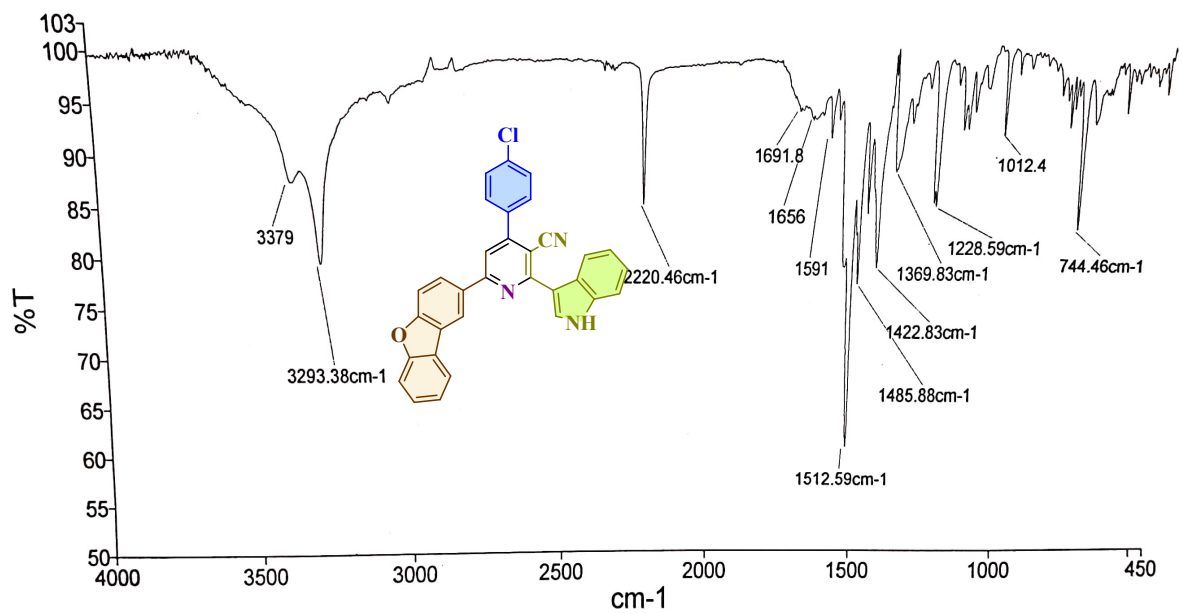
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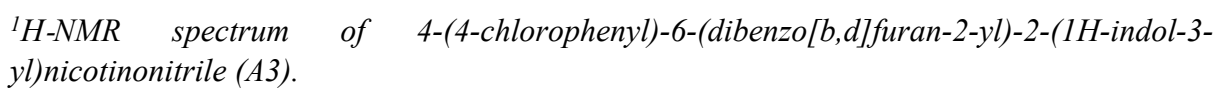
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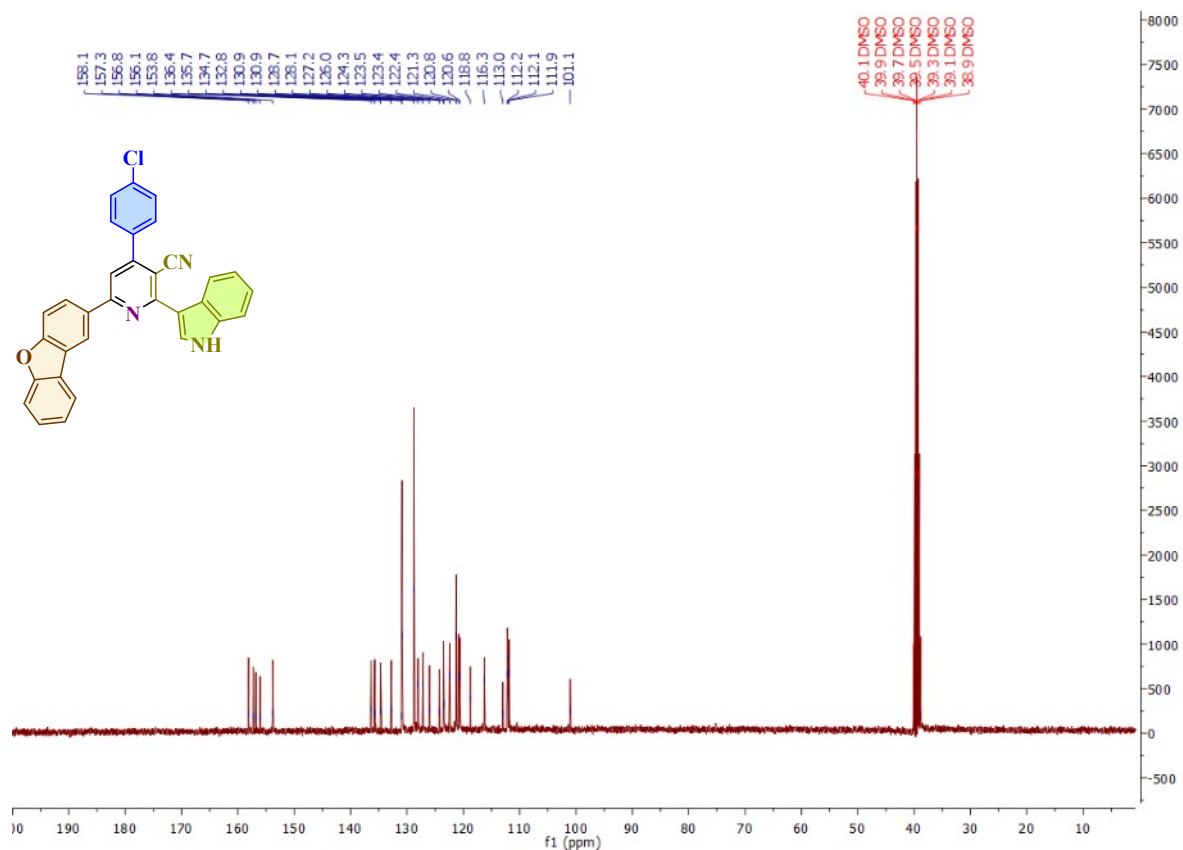


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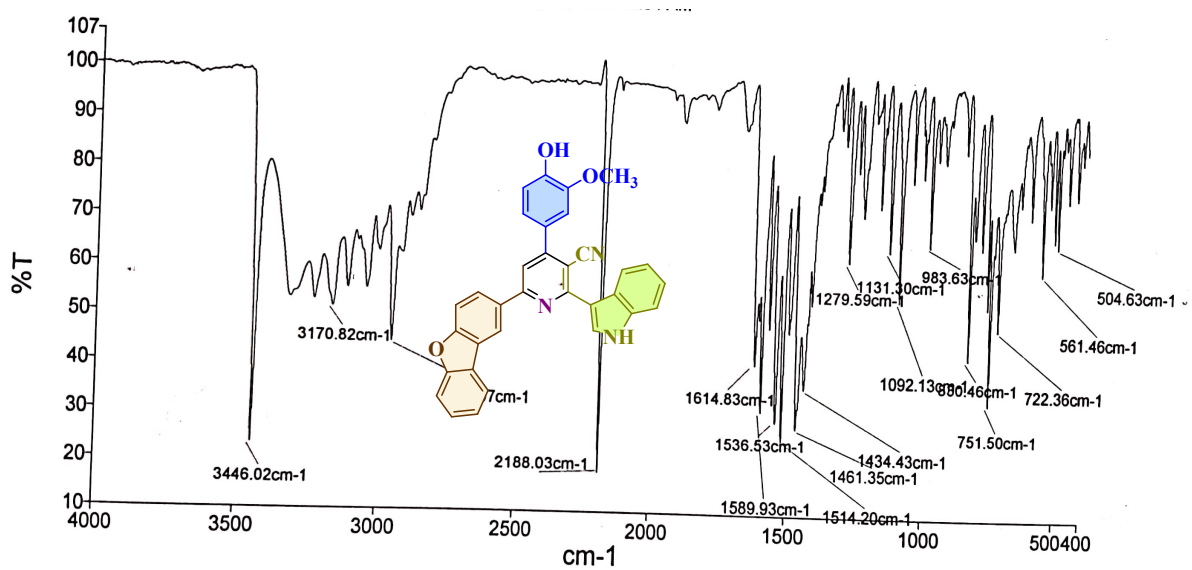


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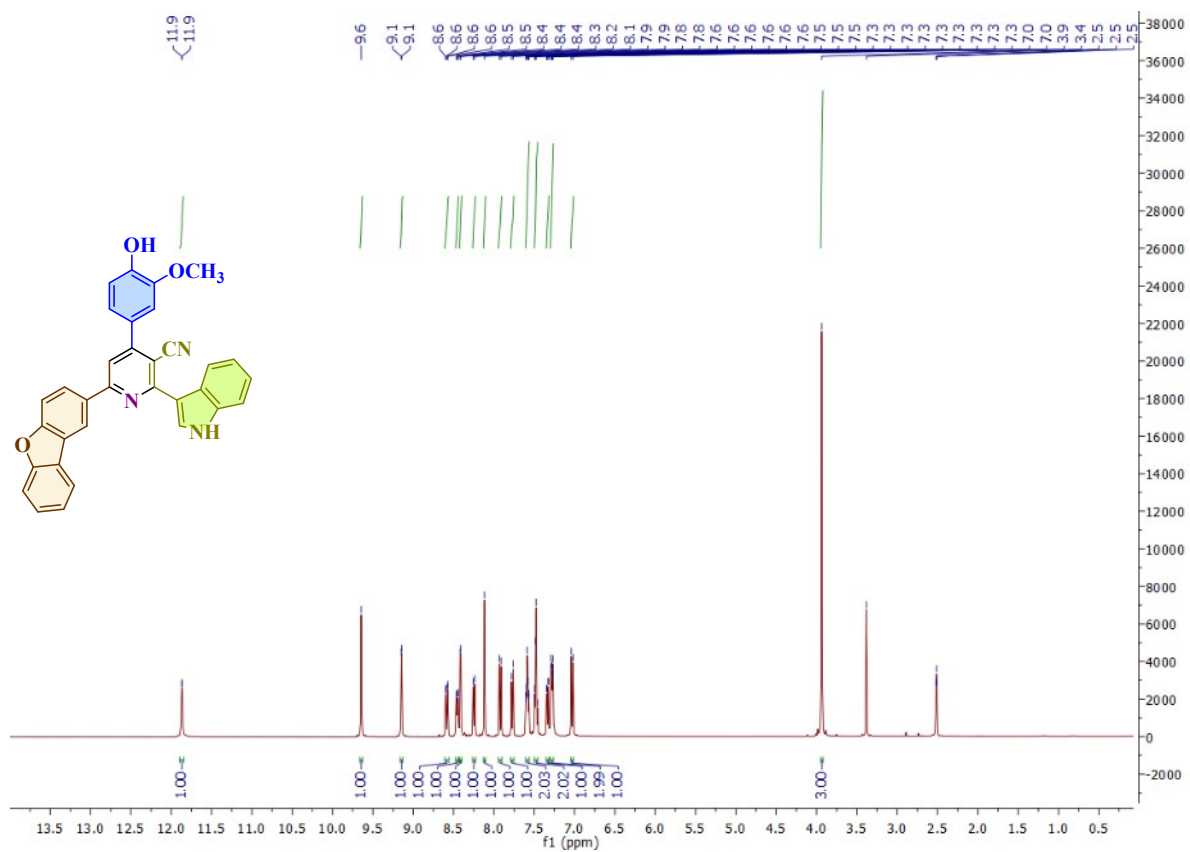




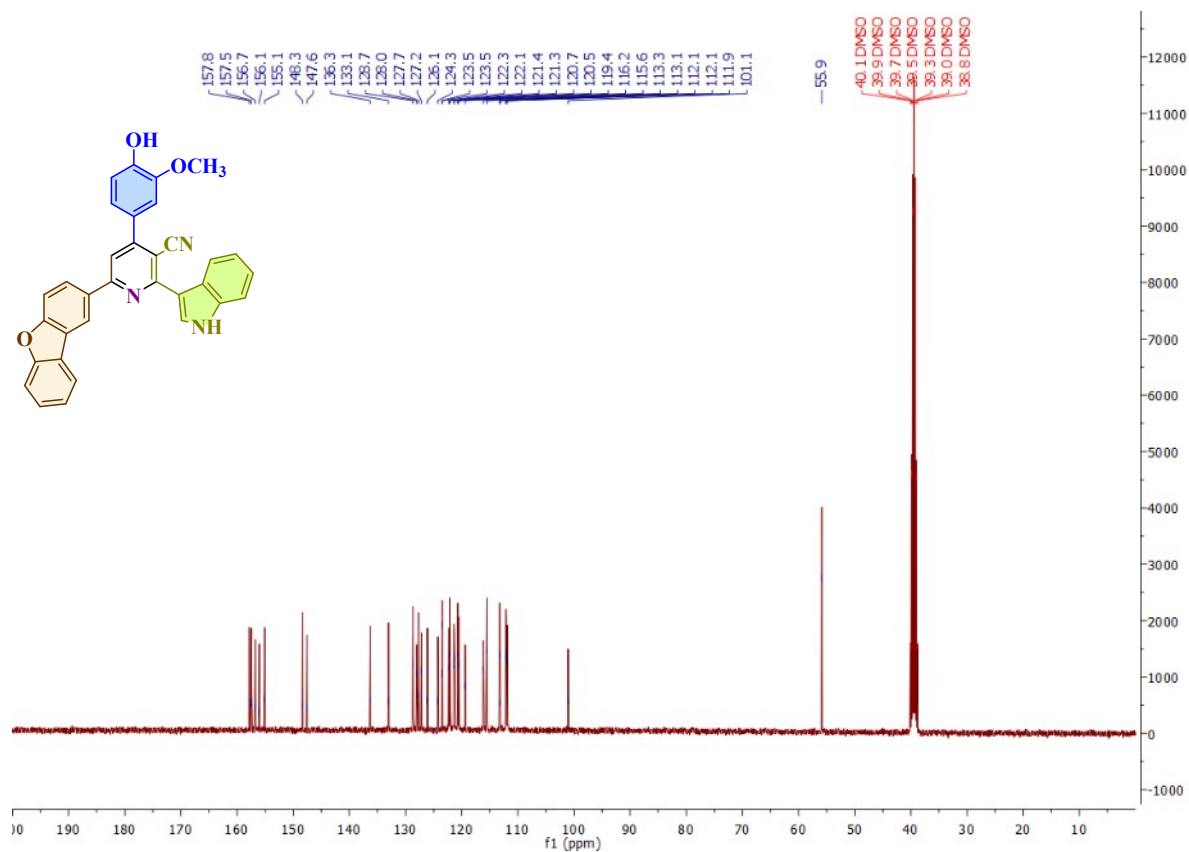
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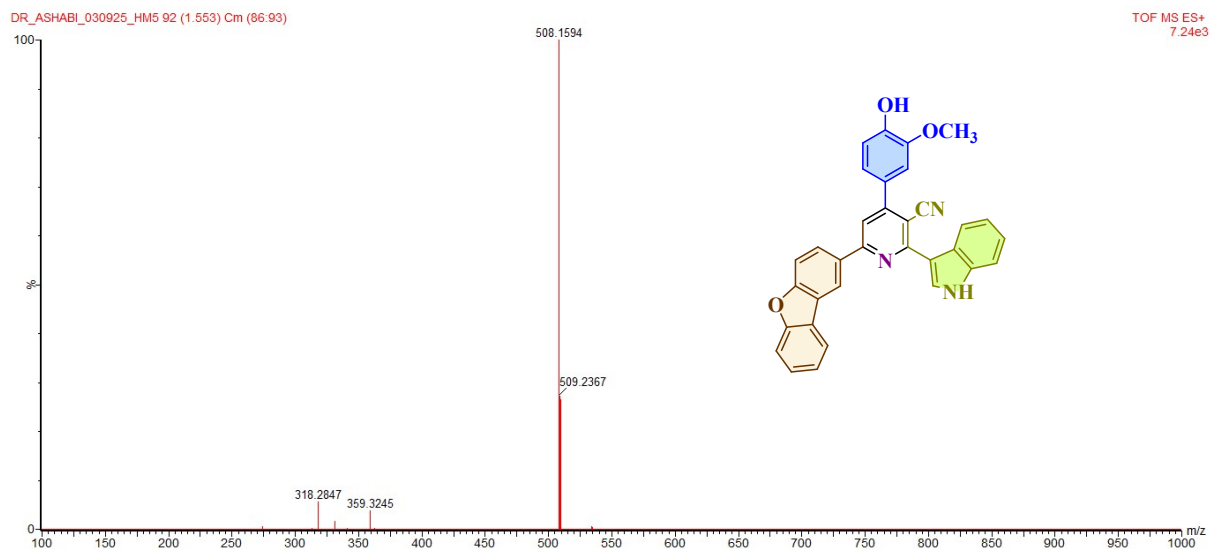
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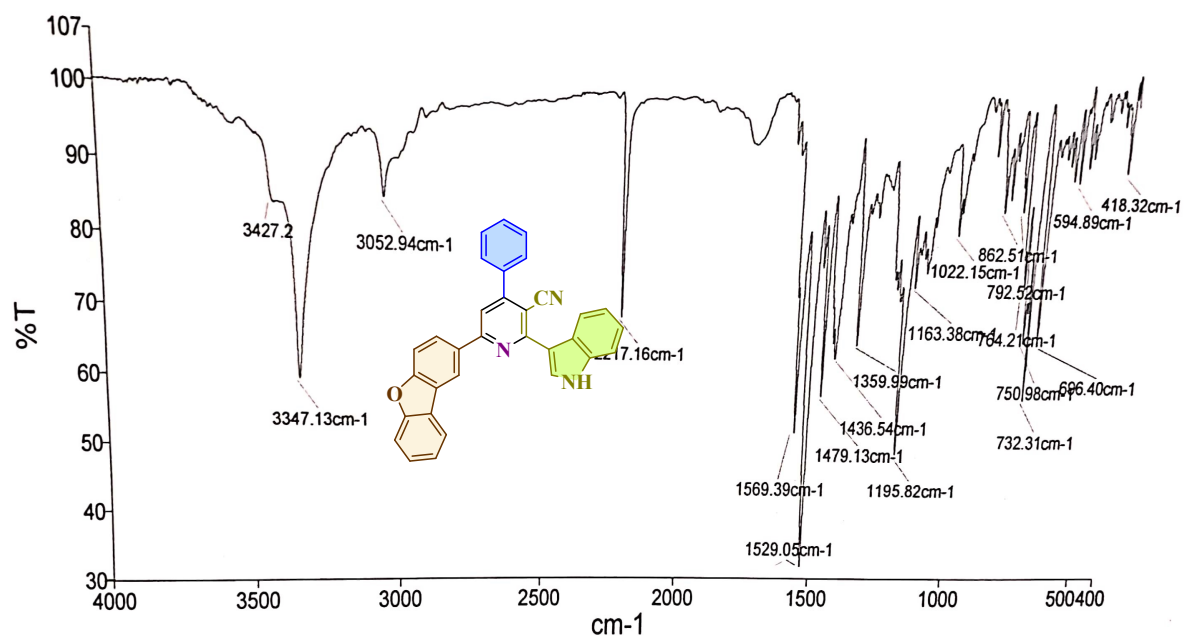
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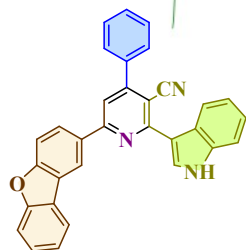
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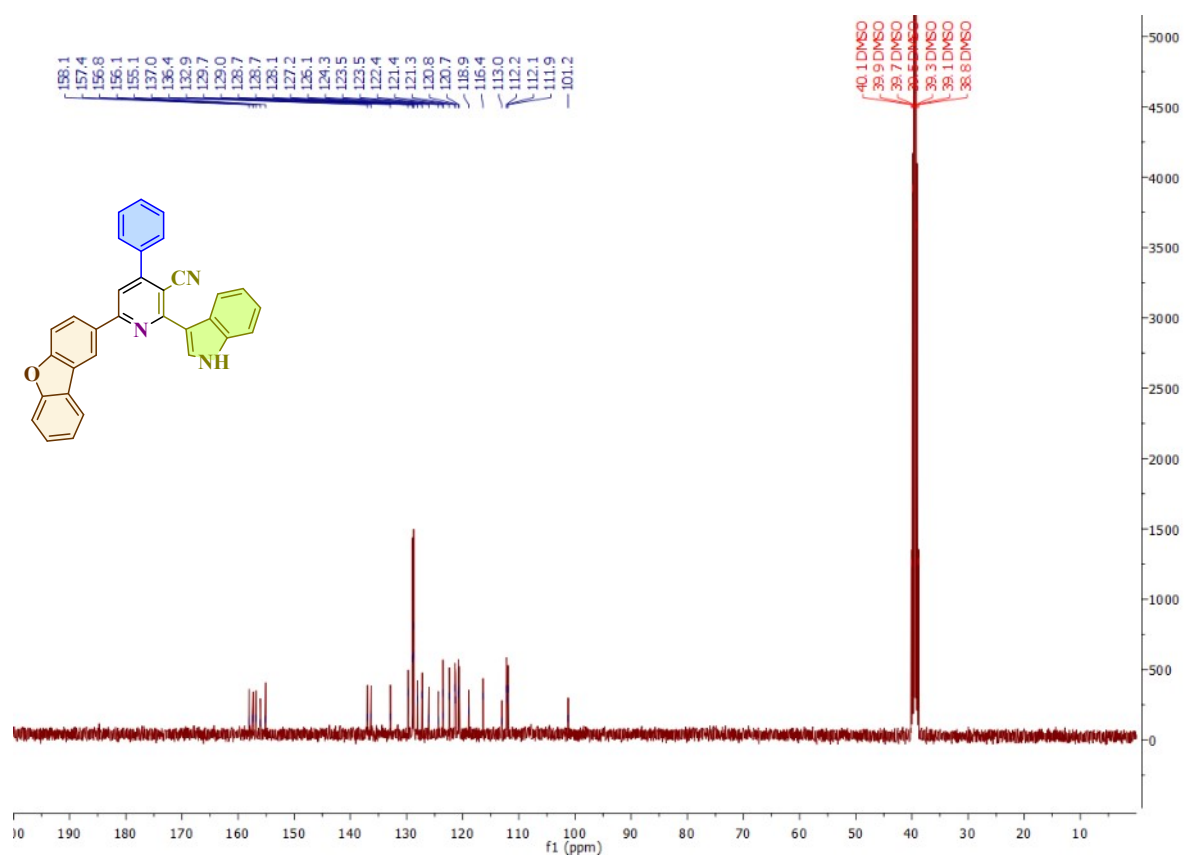
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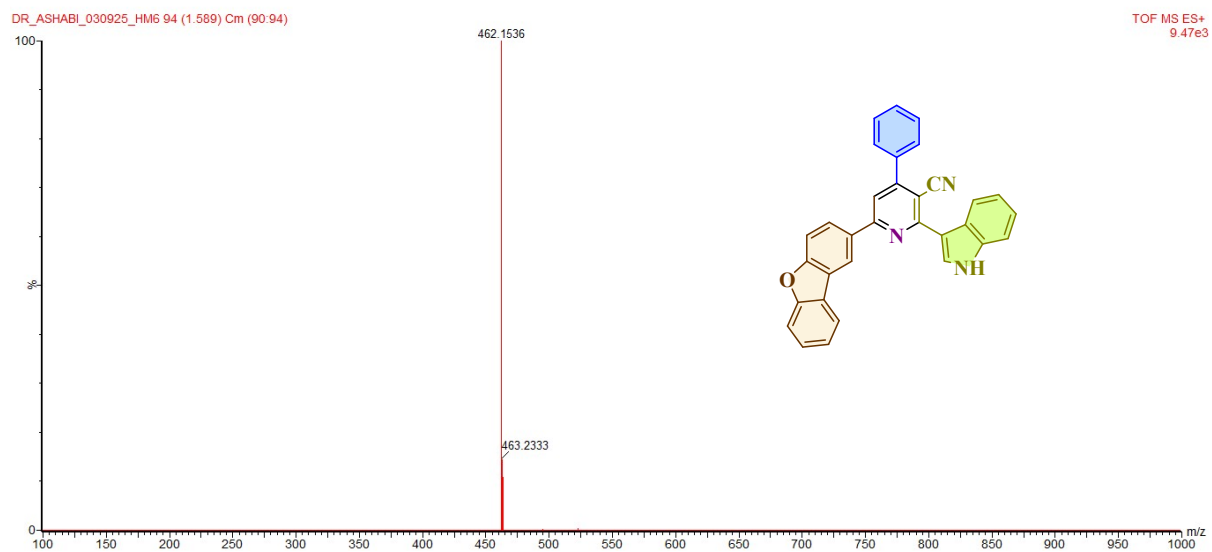
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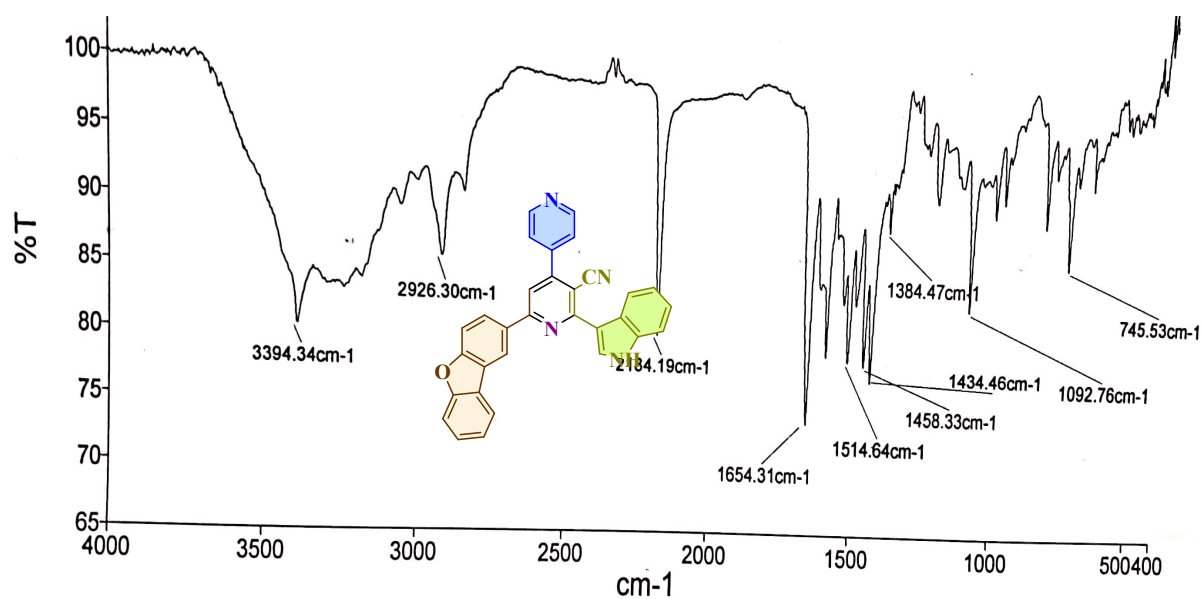
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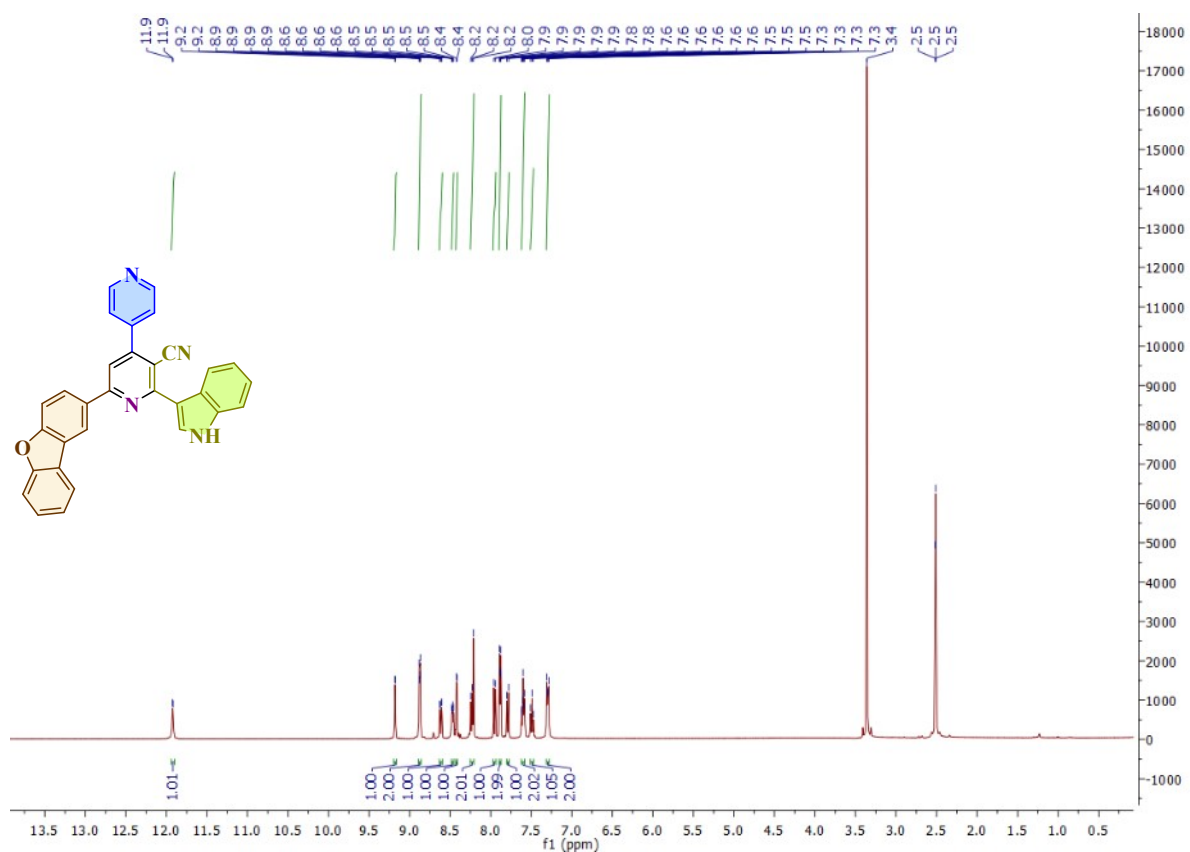
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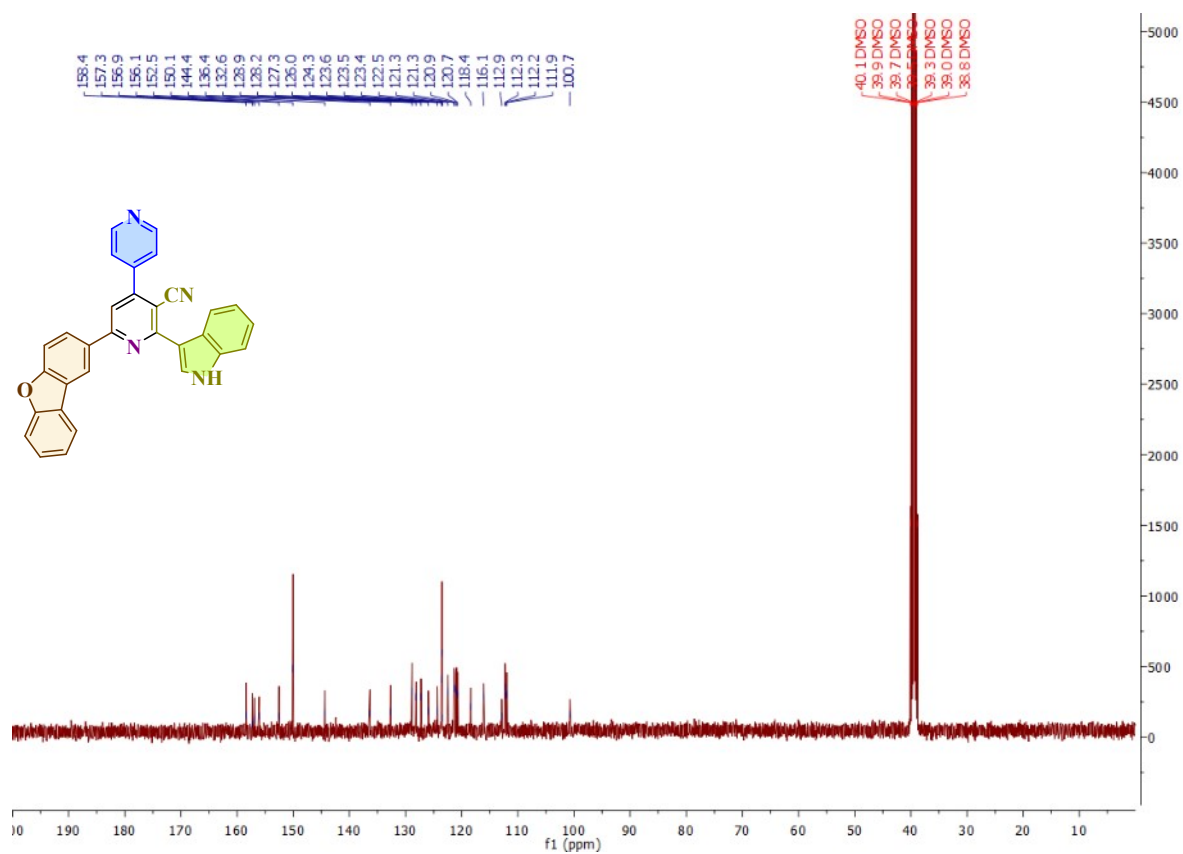
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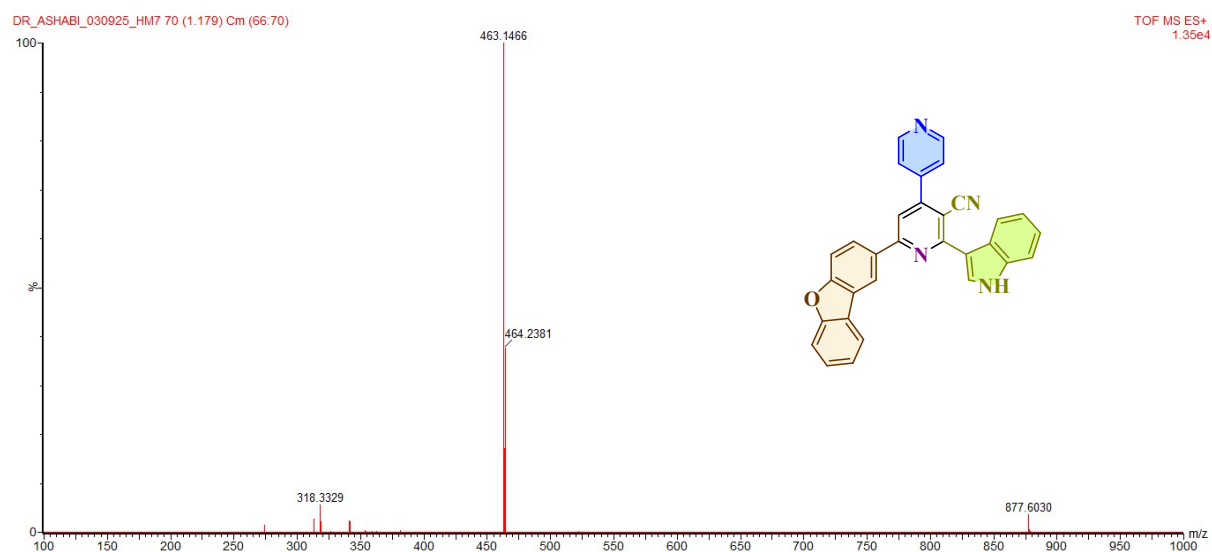
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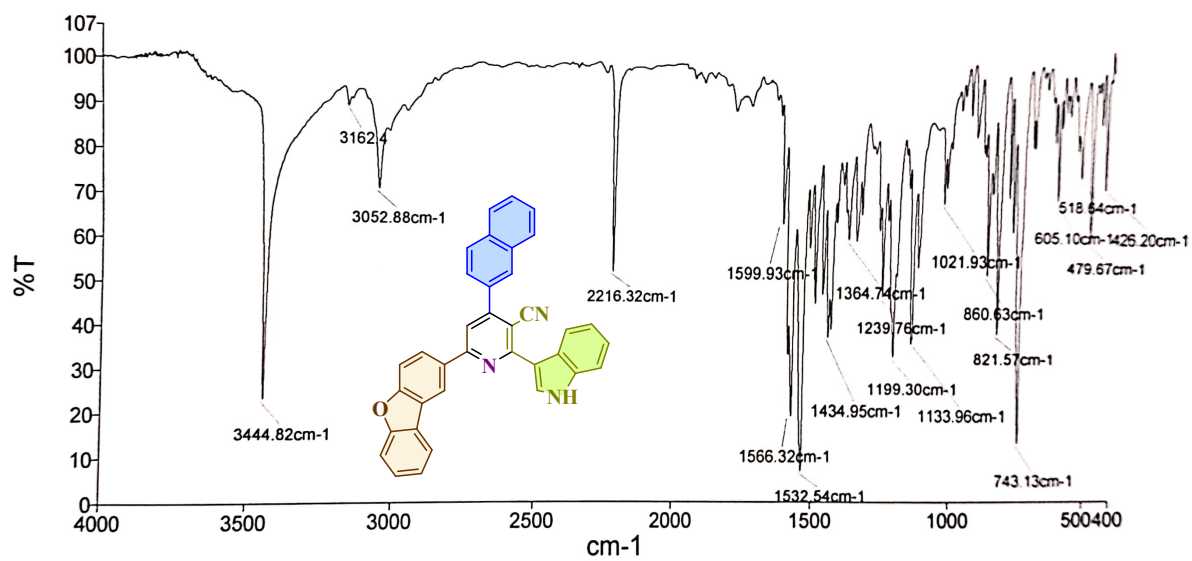
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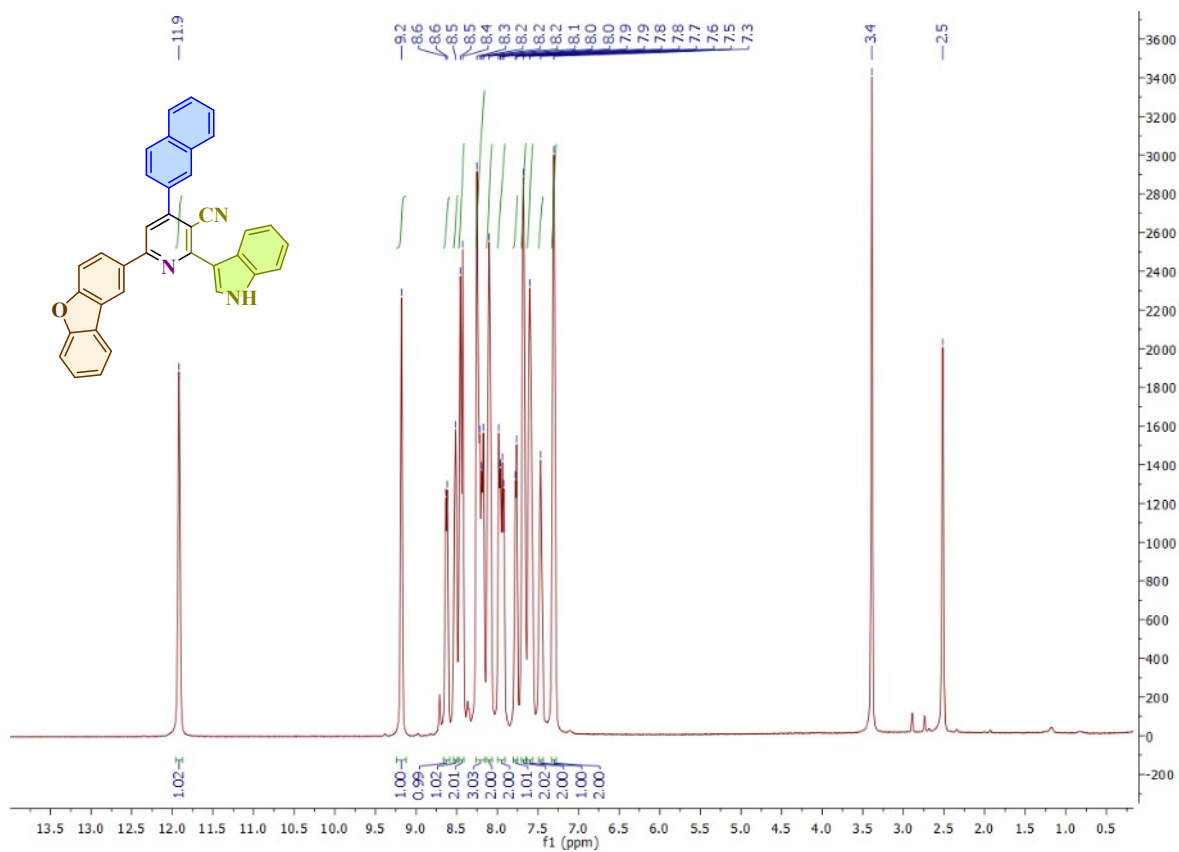
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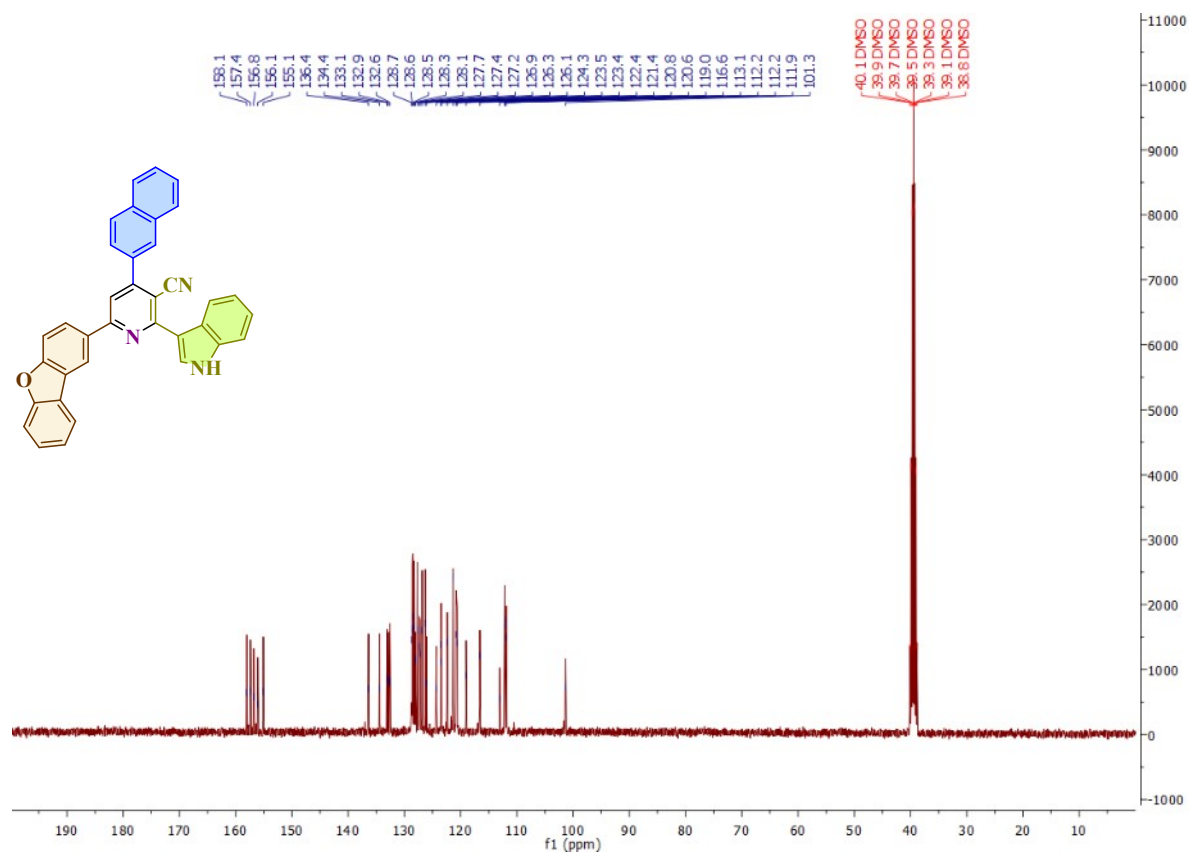
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-[4,4'-bipyridine]-3-carbonitrile (A6).



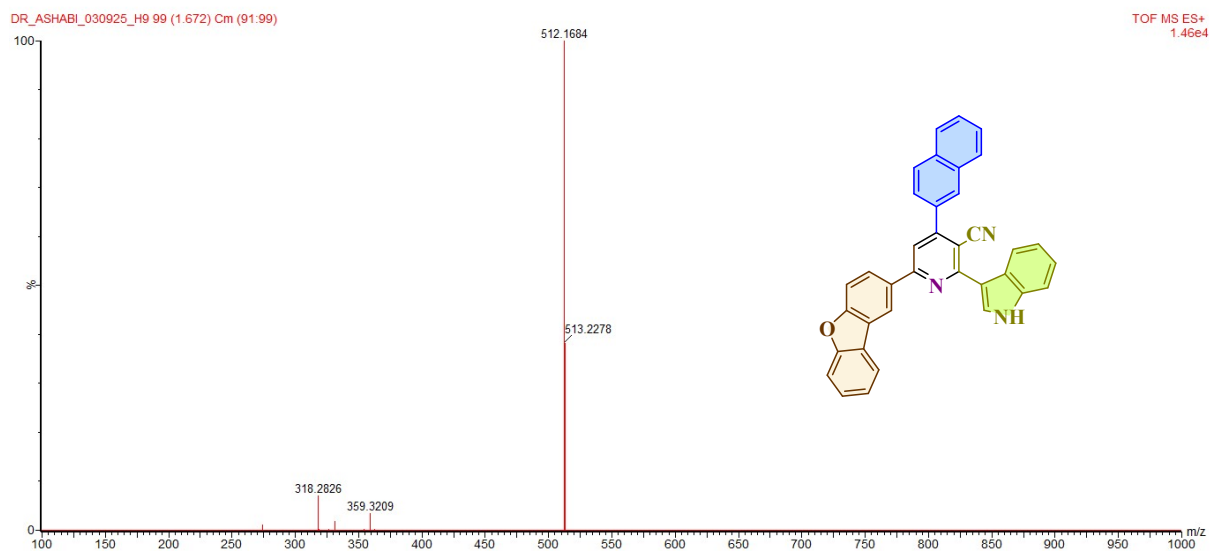
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(naphthalen-2-yl)nicotinonitrile (A7).



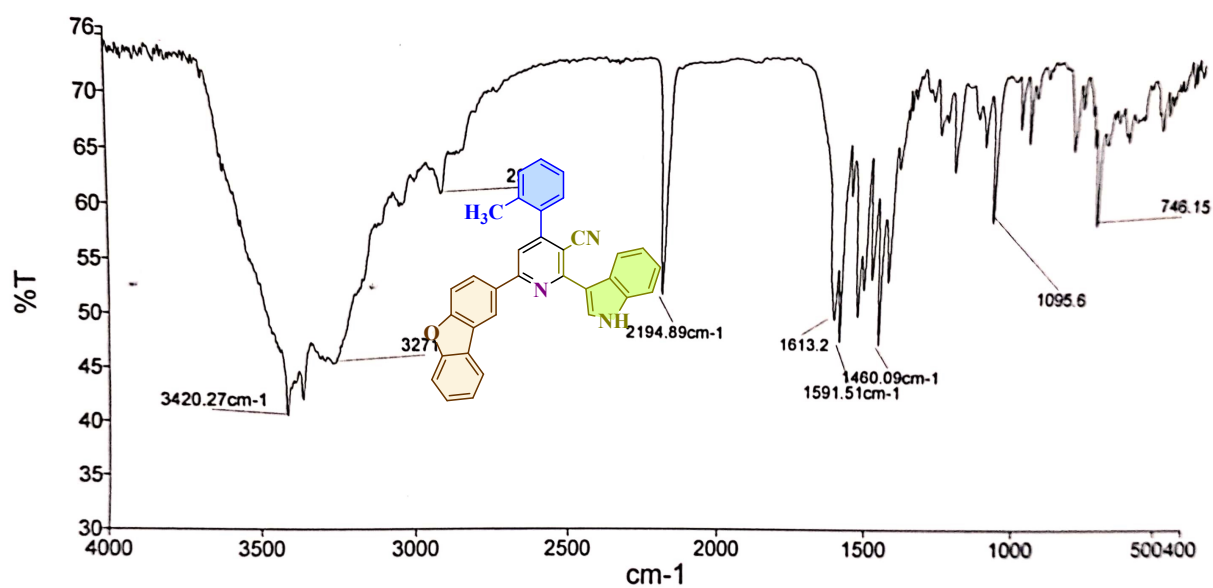
^1H -NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(naphthalen-2-yl)nicotinonitrile (A7).



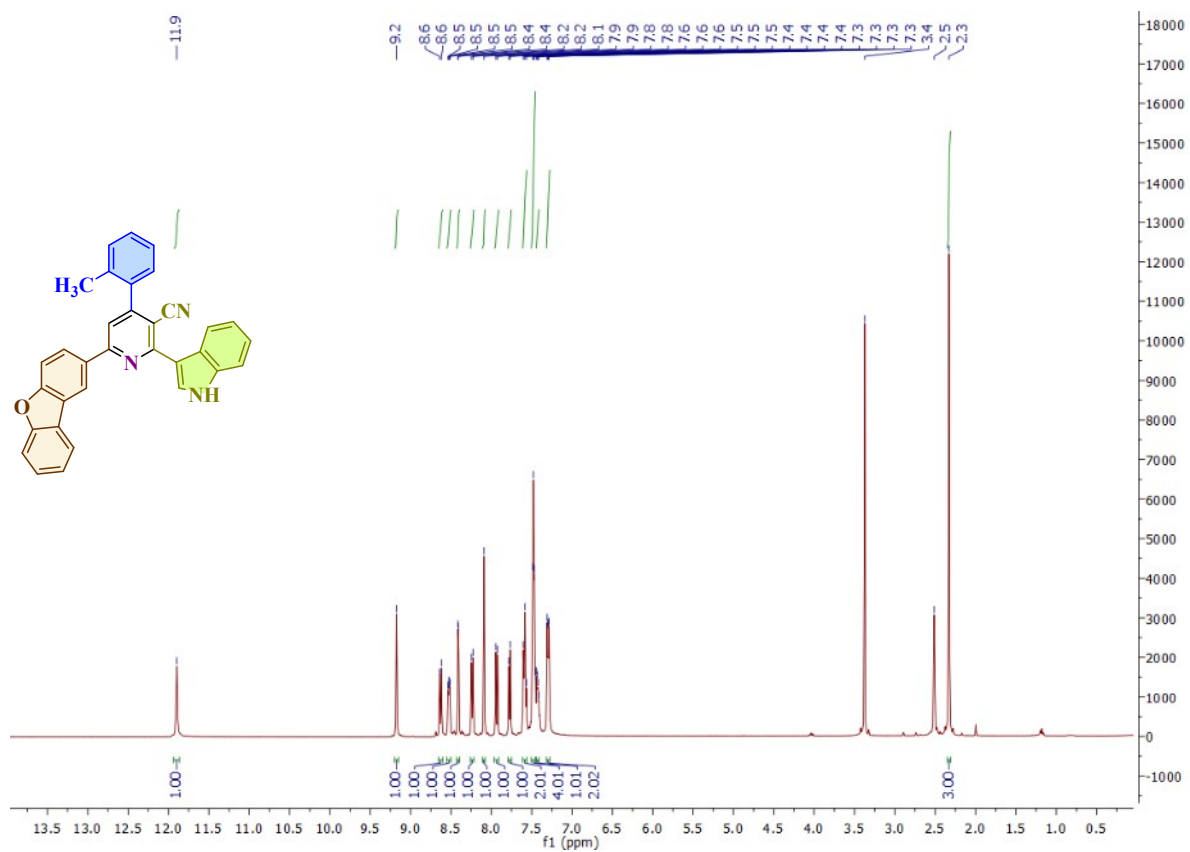
¹³C-NMR spectrum of 6-(dibenzo[*b,d*]furan-2-yl)-2-(1*H*-indol-3-yl)-4-(naphthalen-2-yl)nicotinonitrile (A7).



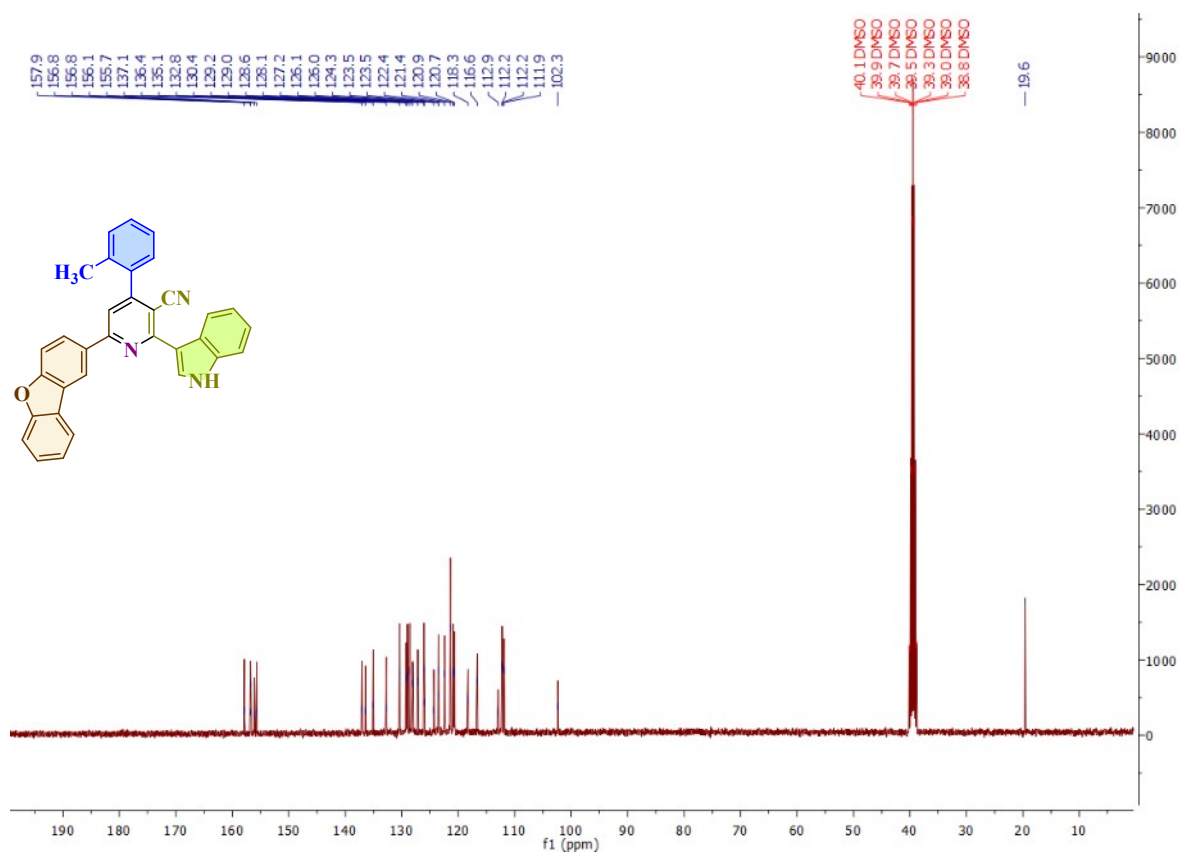
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(naphthalen-2-yl)nicotinonitrile (A7).



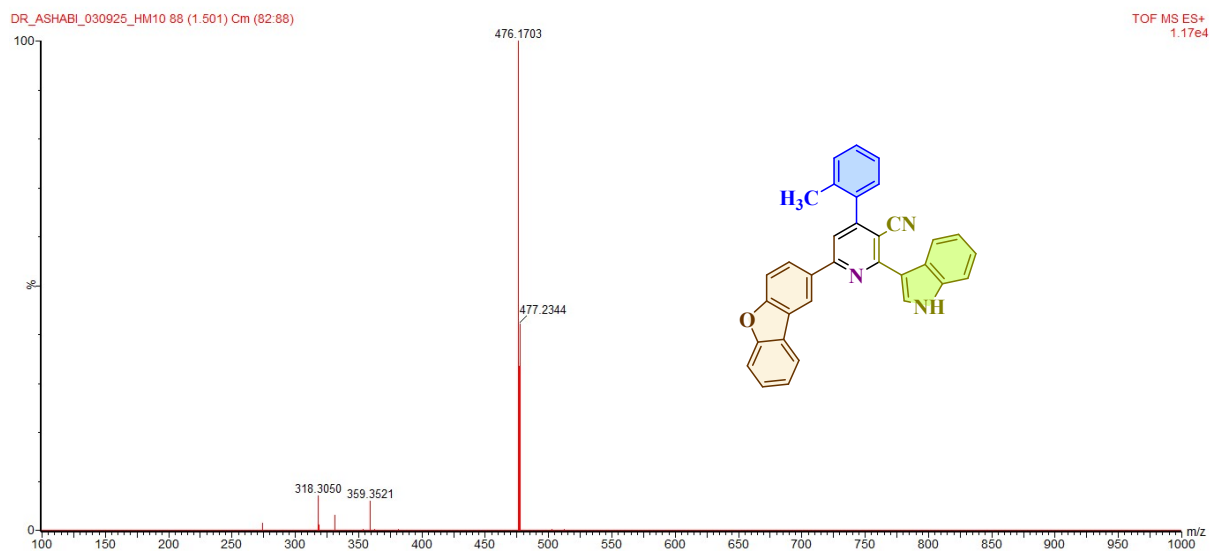
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(o-tolyl)nicotinonitrile (A8).



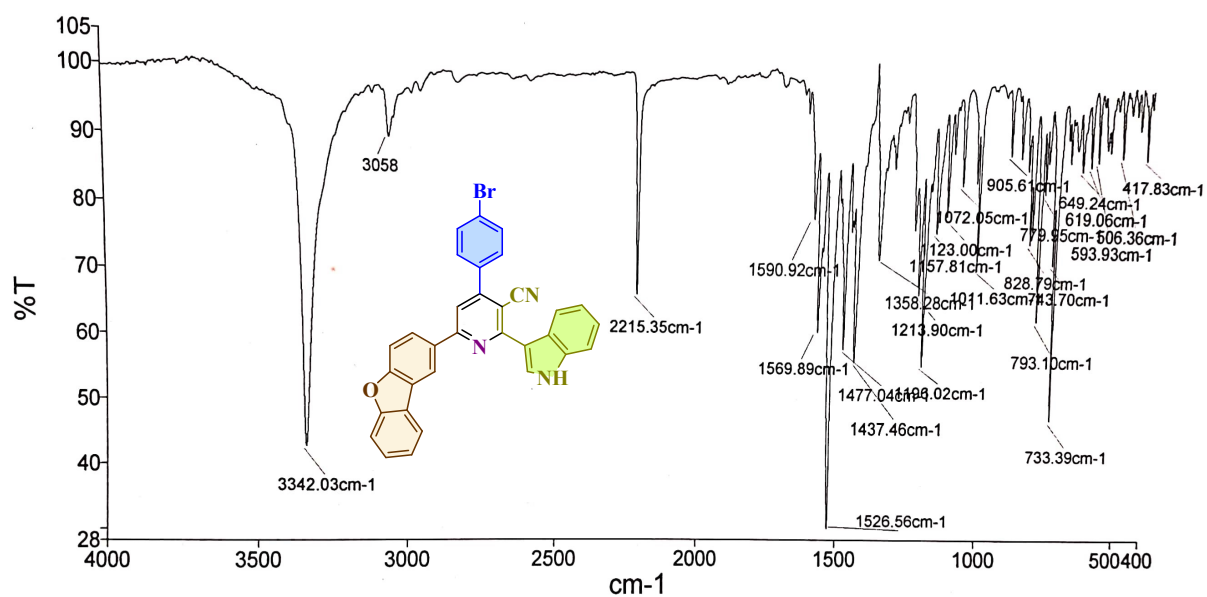
¹H-NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(o-tolyl)nicotinonitrile (A8).



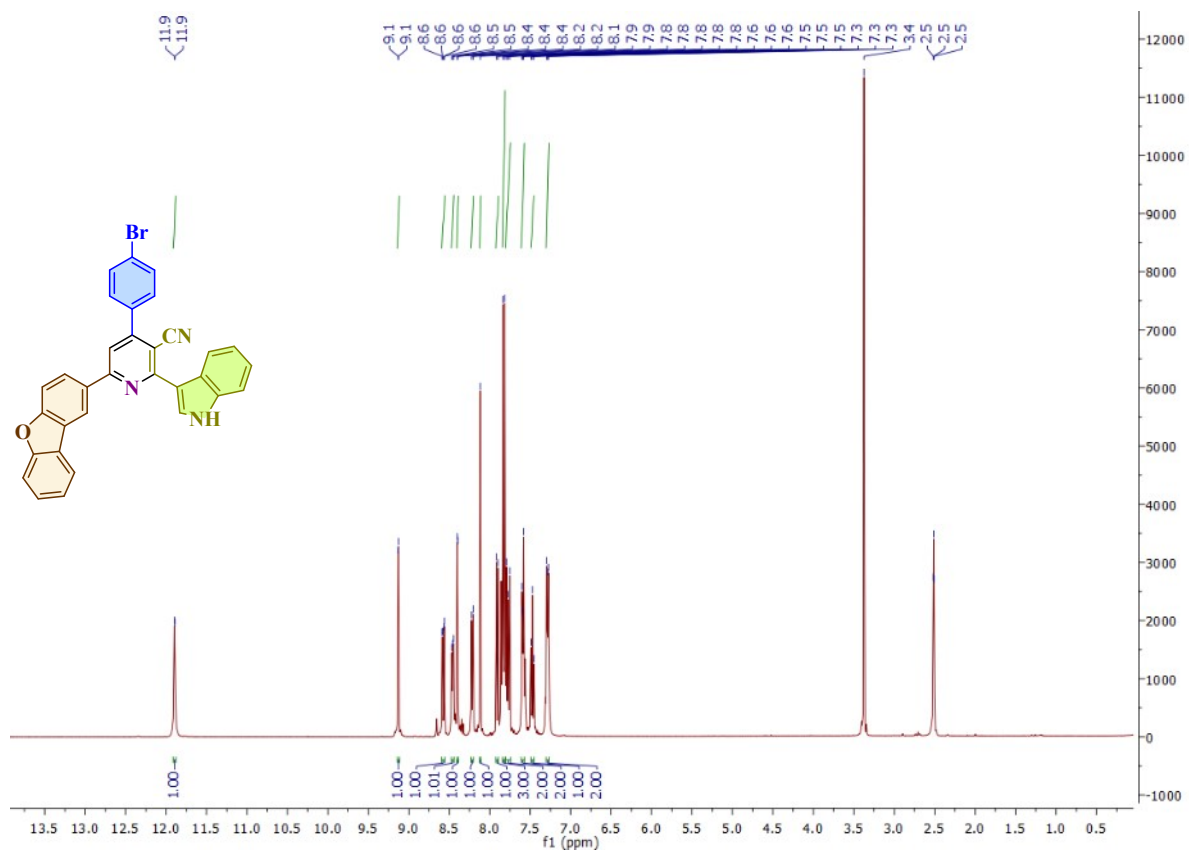
¹³C-NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(o-tolyl)nicotinonitrile (A8).



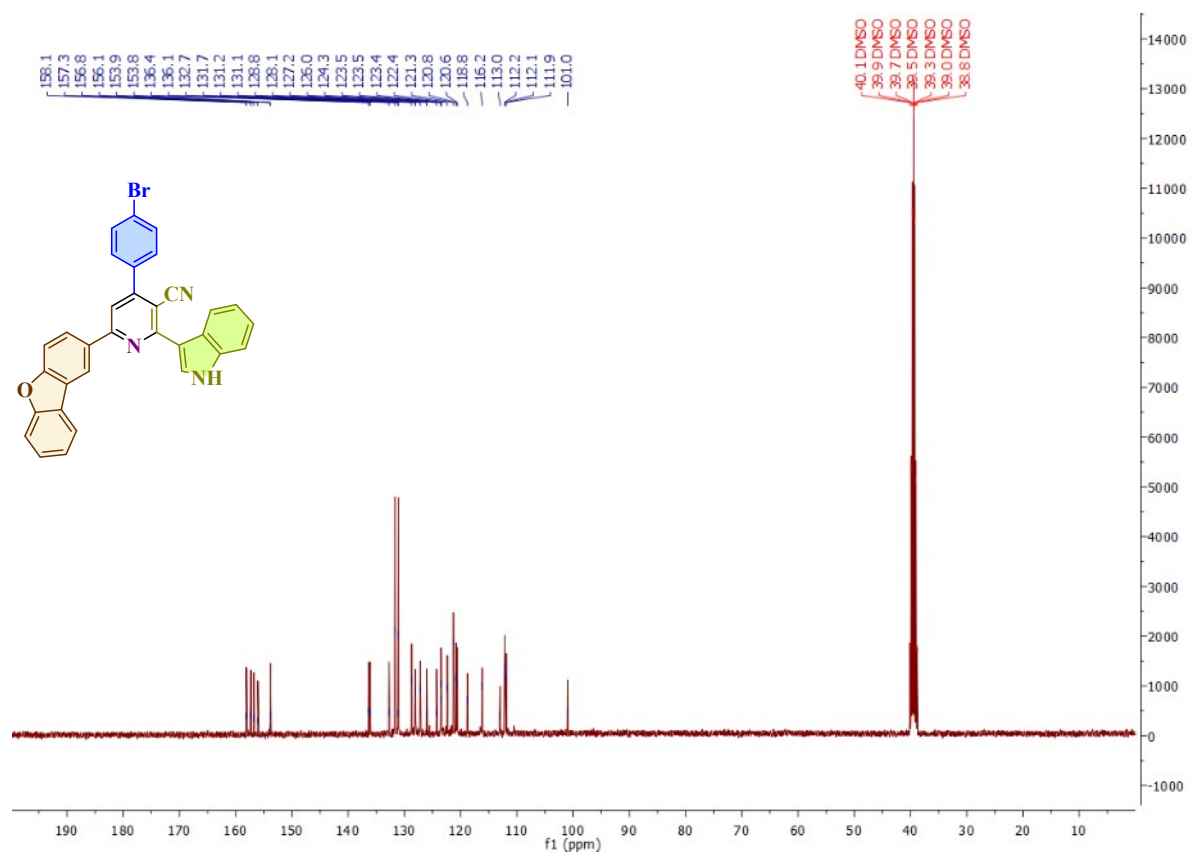
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(o-tolyl)nicotinonitrile (A8).



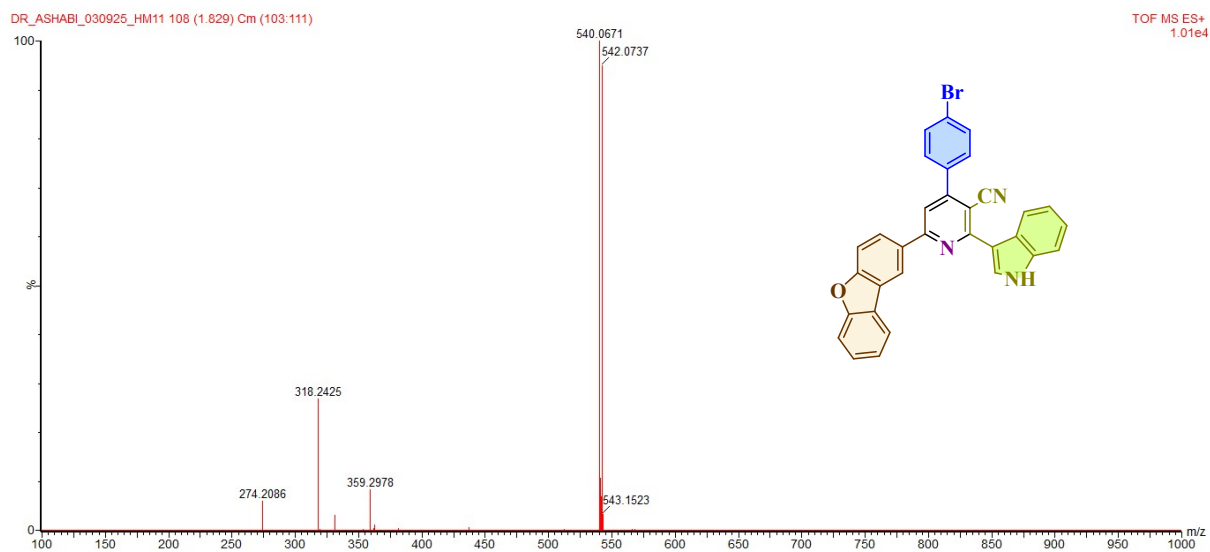
FT-IR spectrum of 4-(4-bromophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A9).



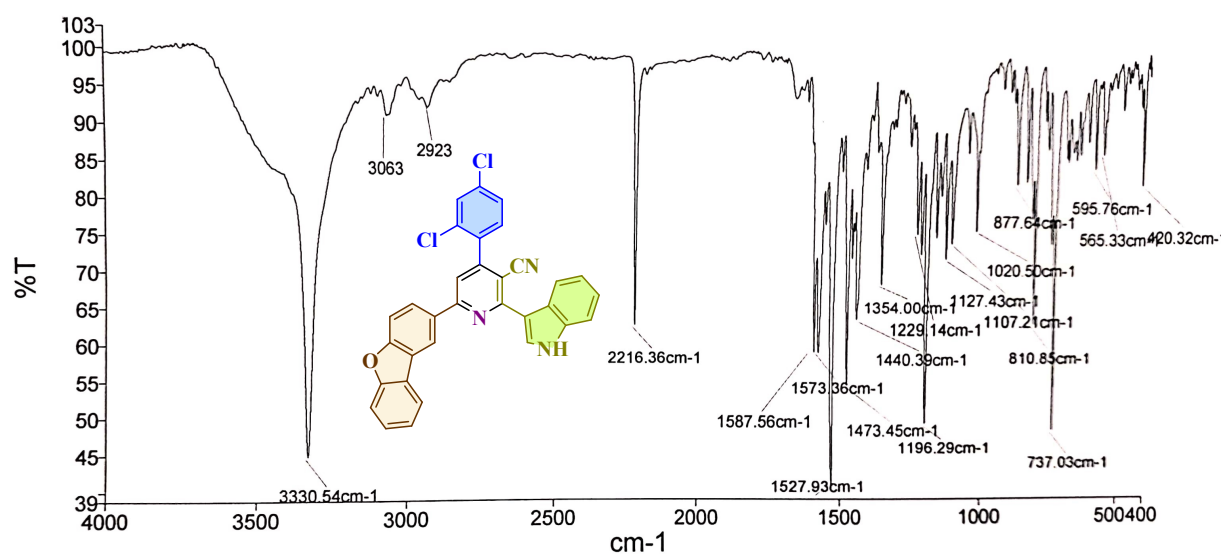
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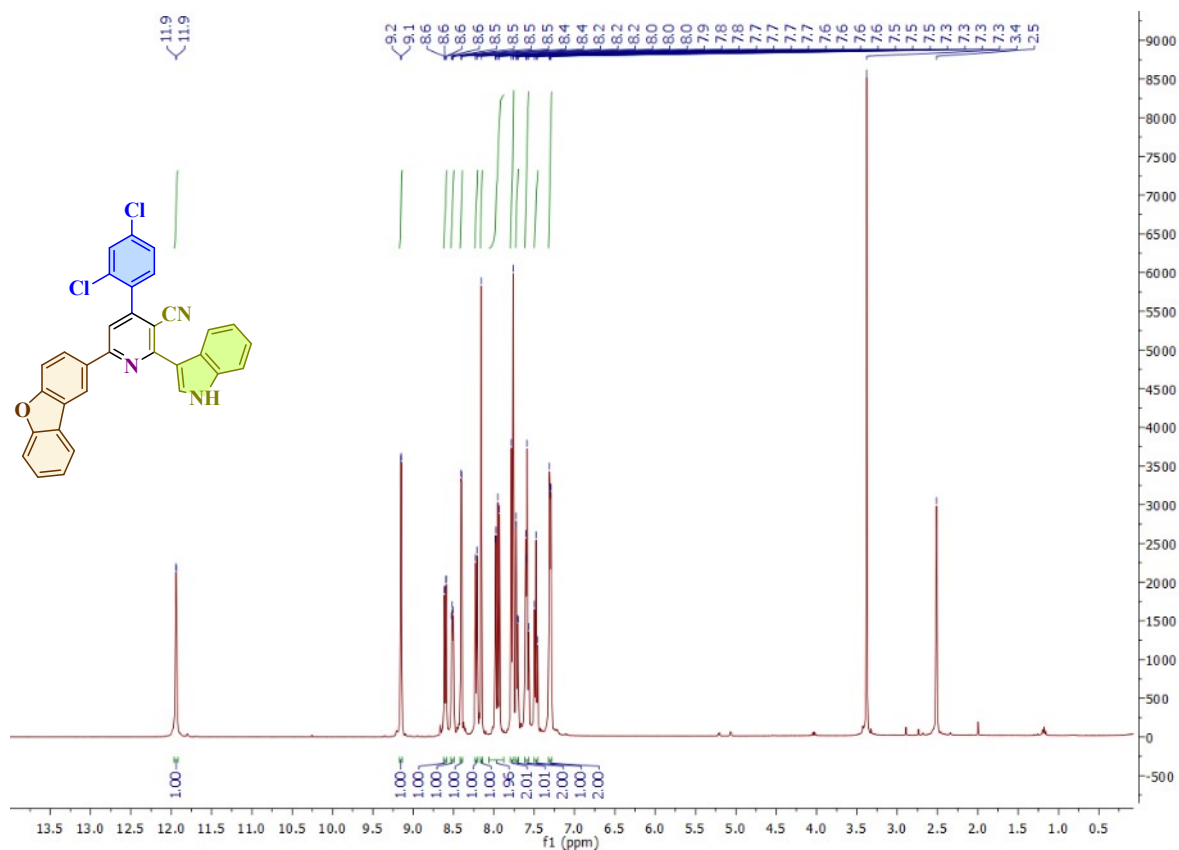
¹³C-NMR spectrum of 4-(4-bromophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A9).



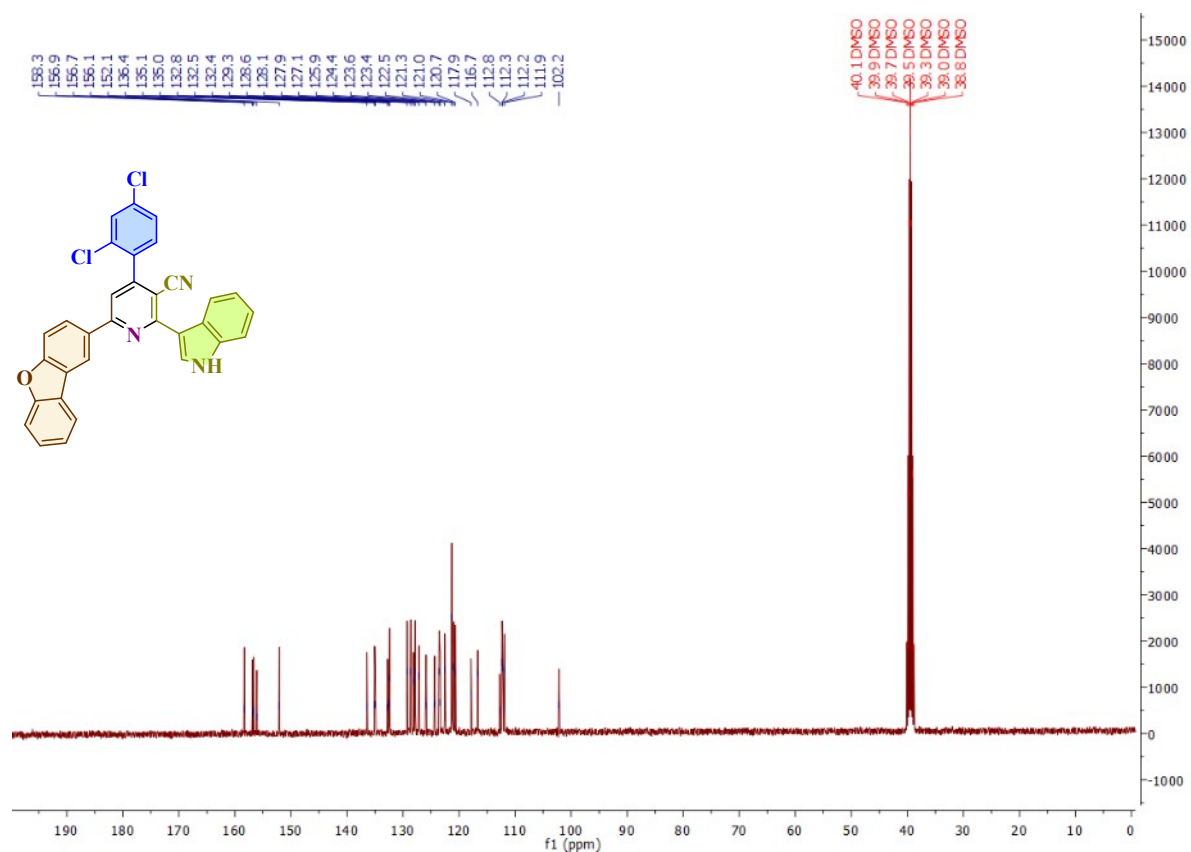
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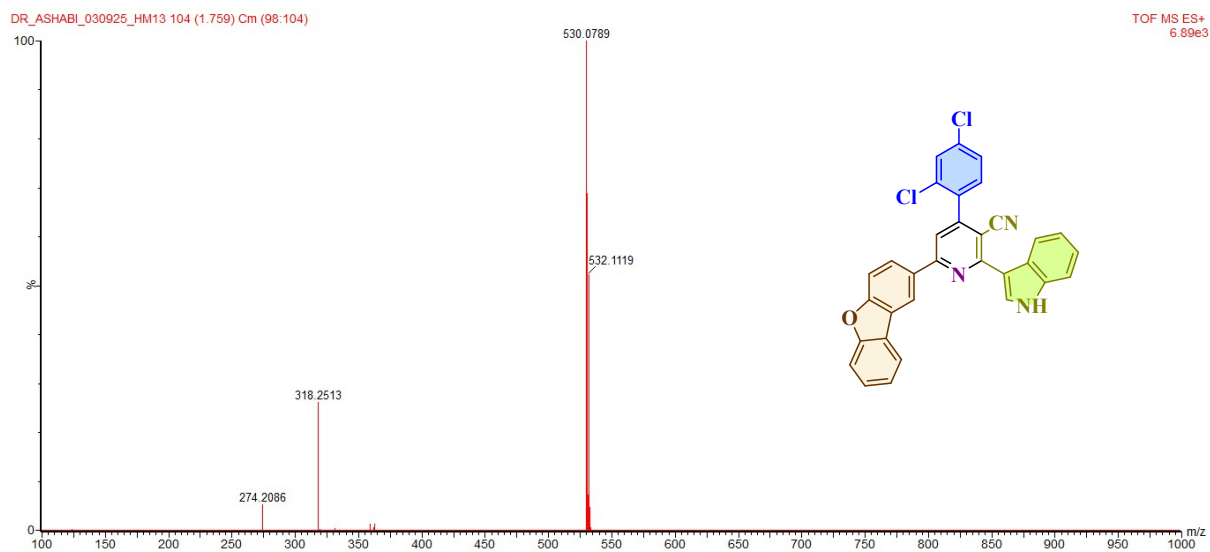
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(2,4-dichlorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A10).



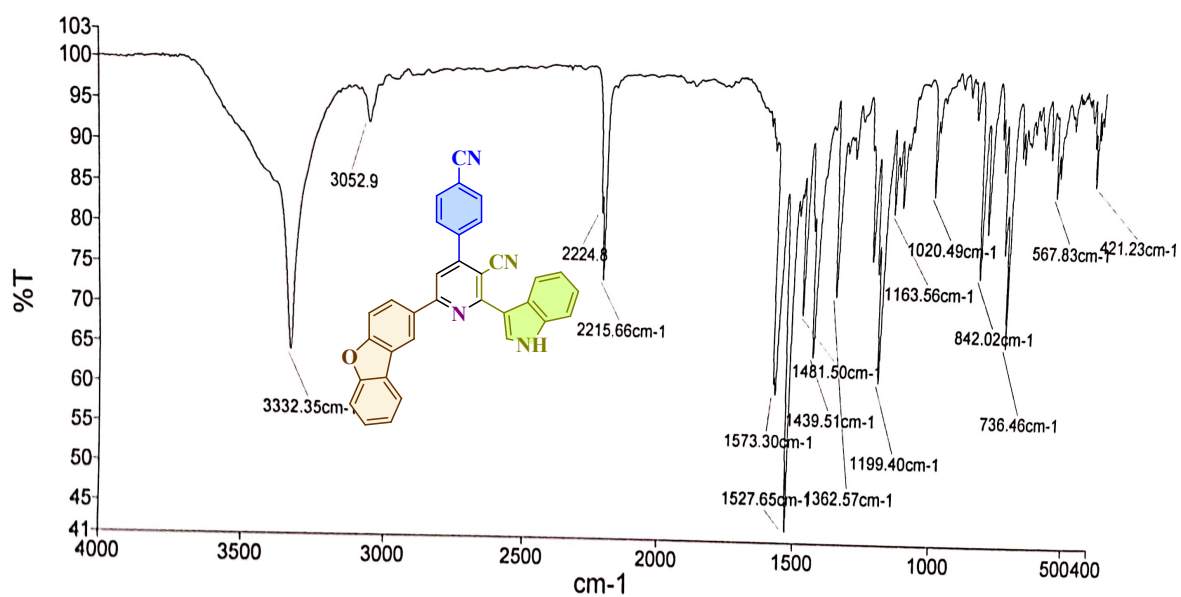
^1H -NMR spectrum of 6-(dibenzo[*b,d*]furan-2-yl)-4-(2,4-dichlorophenyl)-2-(1*H*-indol-3-yl)nicotinonitrile (A10).



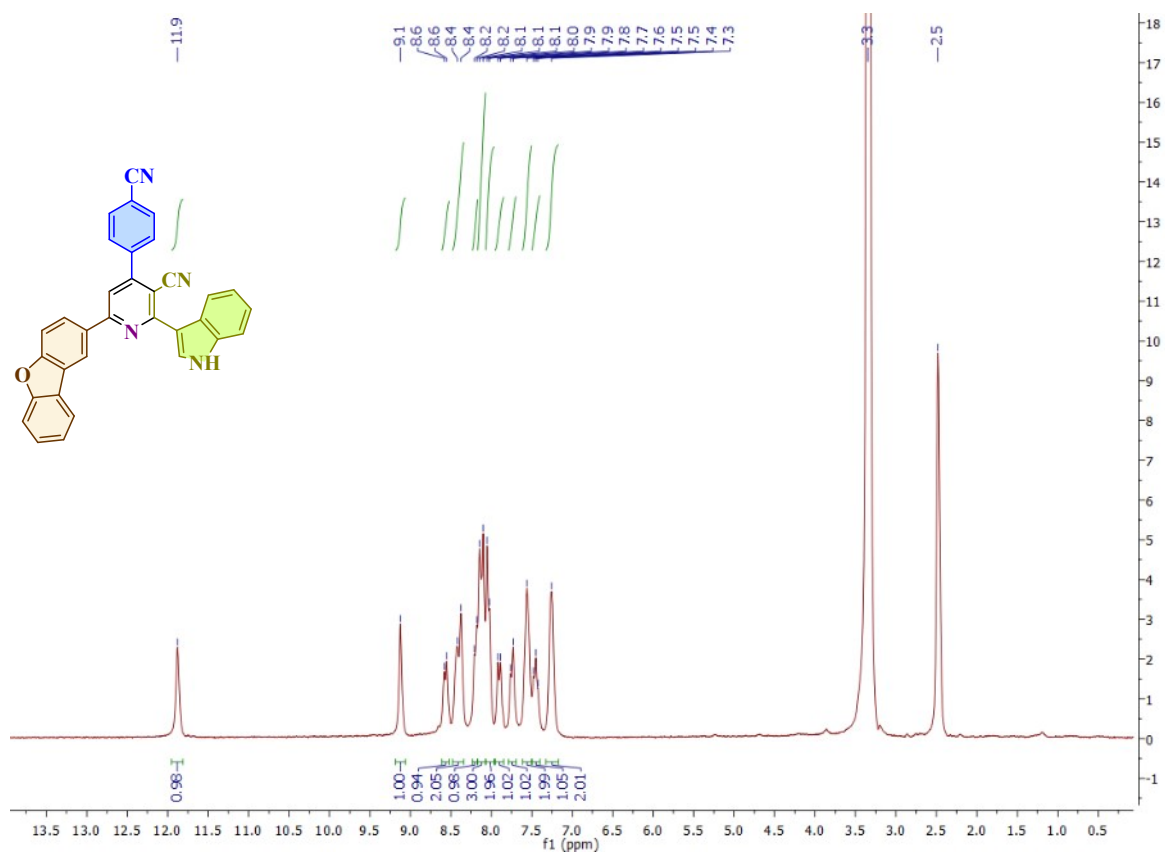
^{13}C -NMR spectrum of 6-(dibenzo[*b,d*]furan-2-yl)-4-(2,4-dichlorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A10).



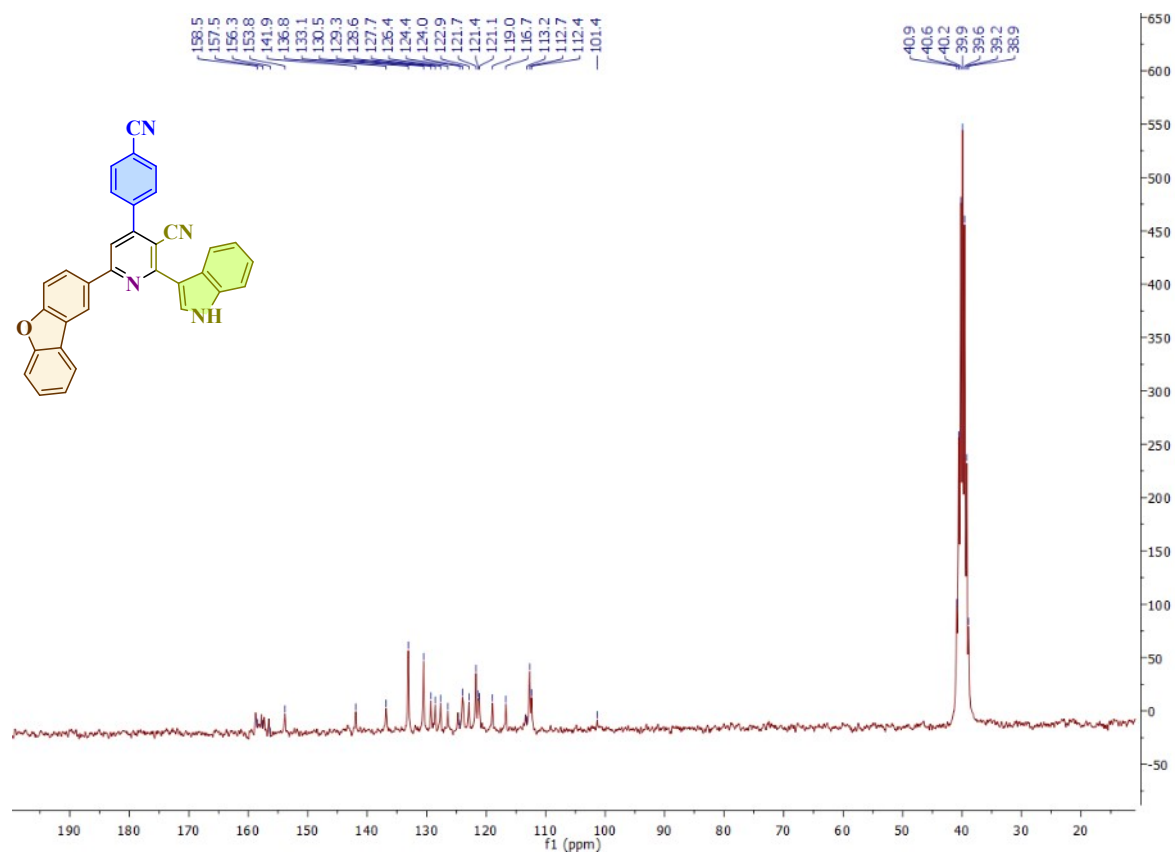
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(2,4-dichlorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A10).



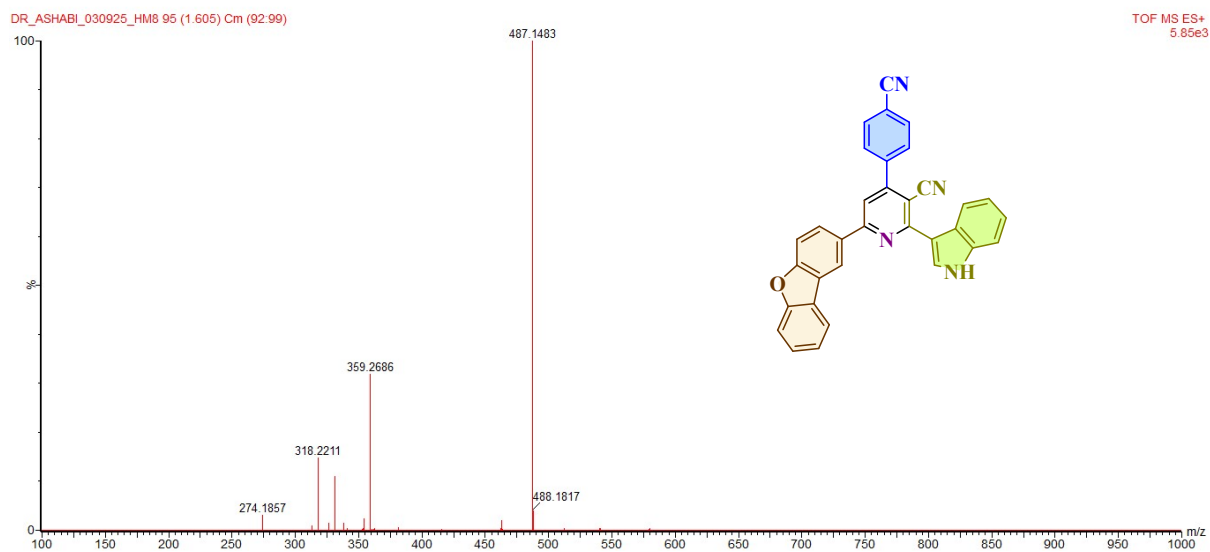
FT-IR spectrum of 4-(4-cyanophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A11).



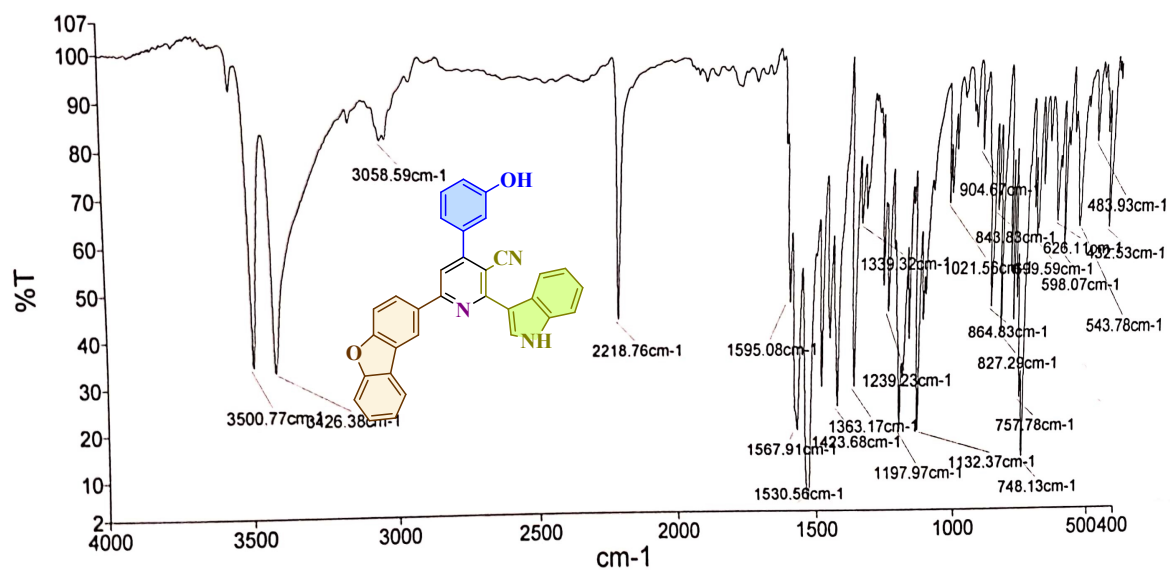
¹H-NMR spectrum of 4-(4-cyanophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A11).



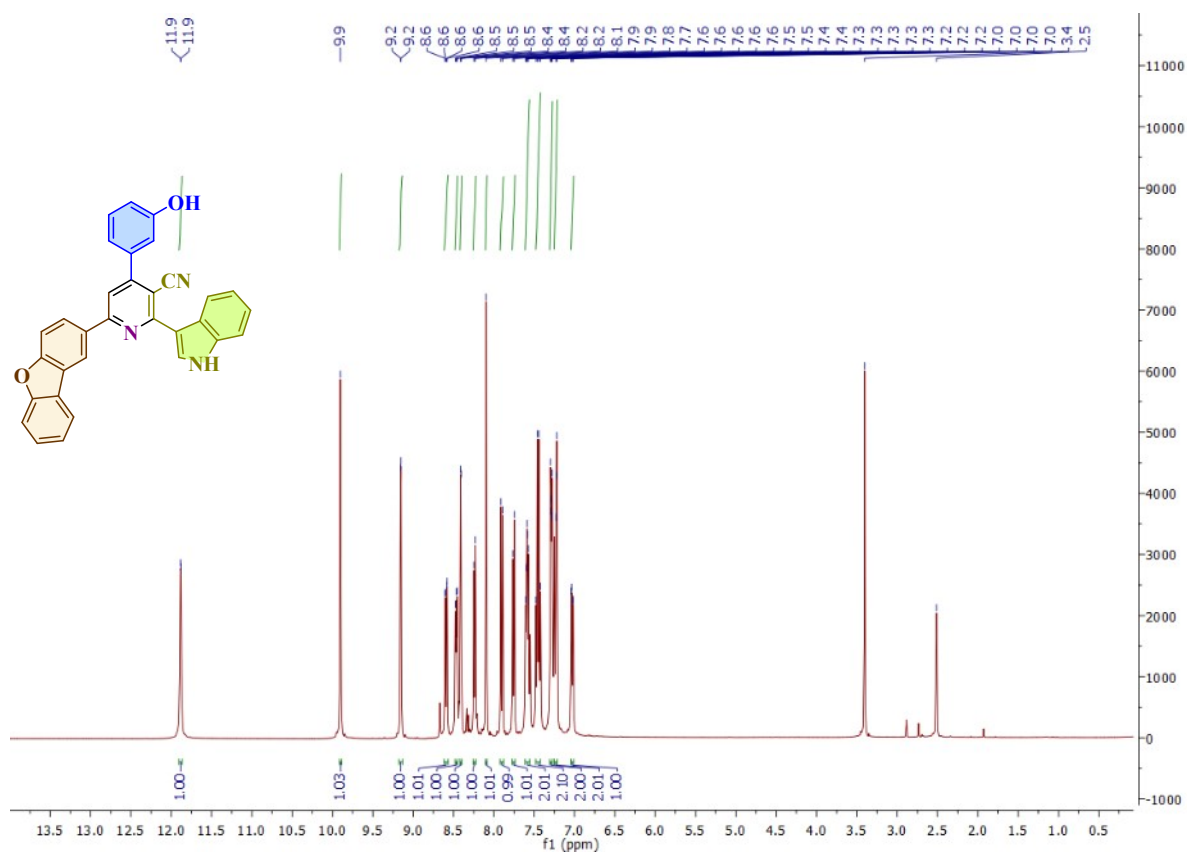
¹³C-NMR spectrum of 4-(4-cyanophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A11).



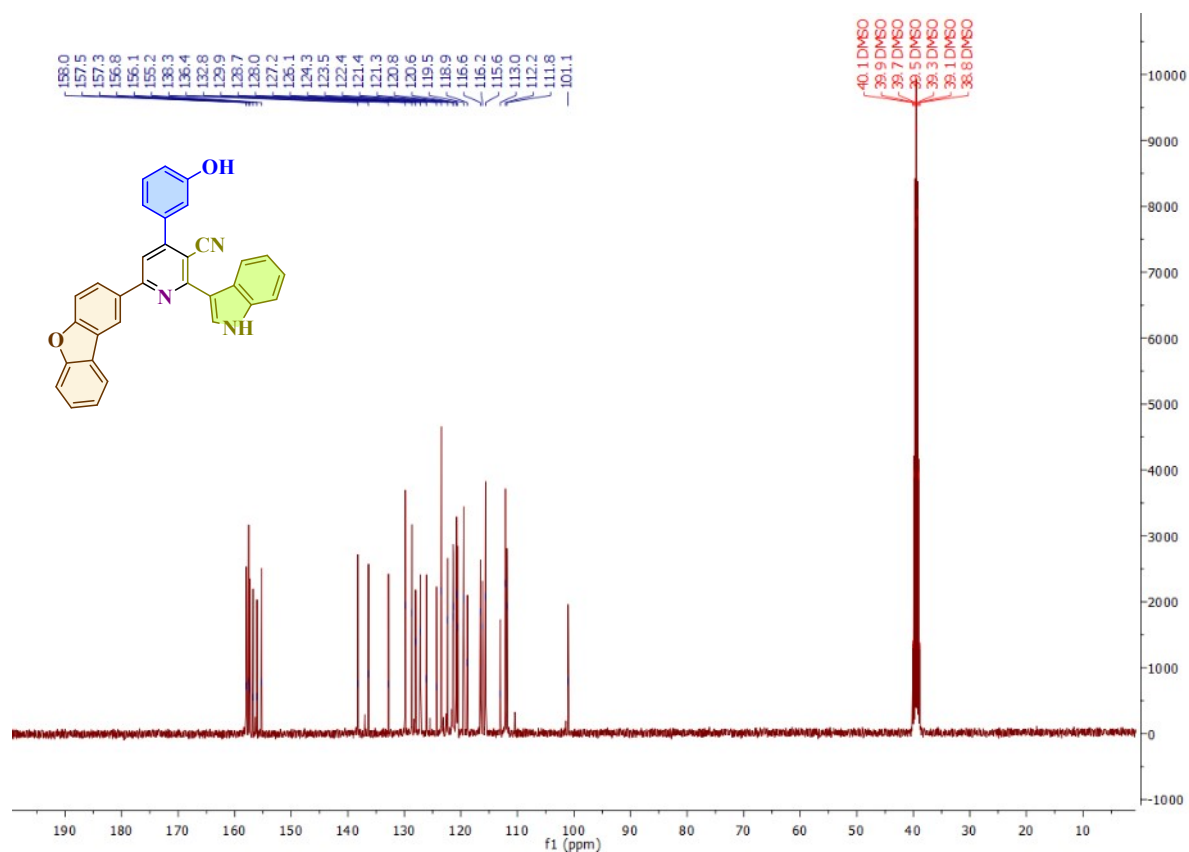
HR-Mass spectrum of 4-(4-cyanophenyl)-6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)nicotinonitrile (A11).



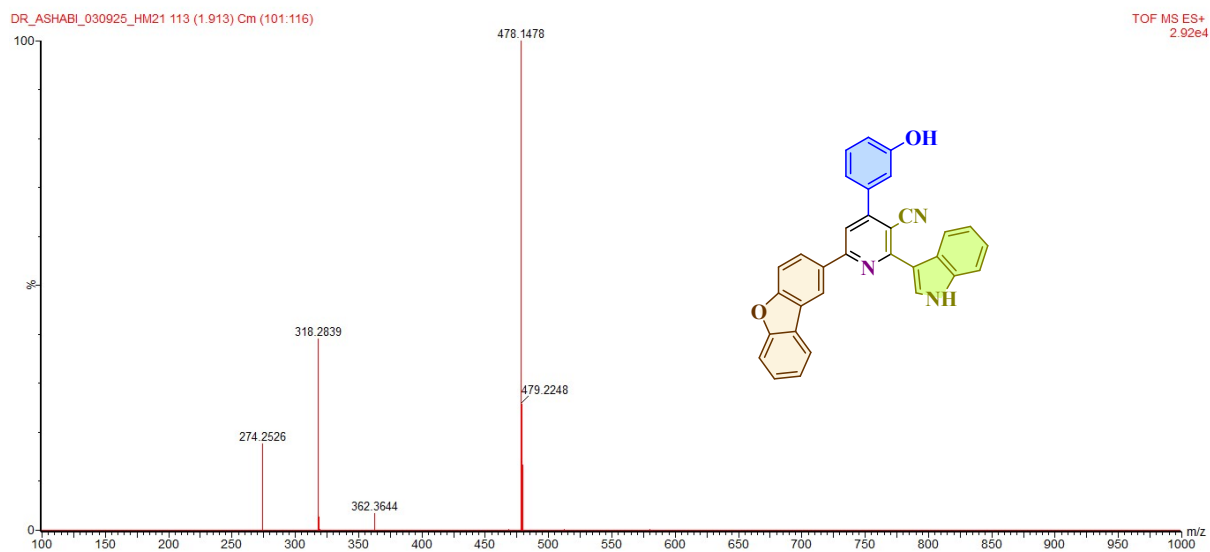
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(3-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A12).



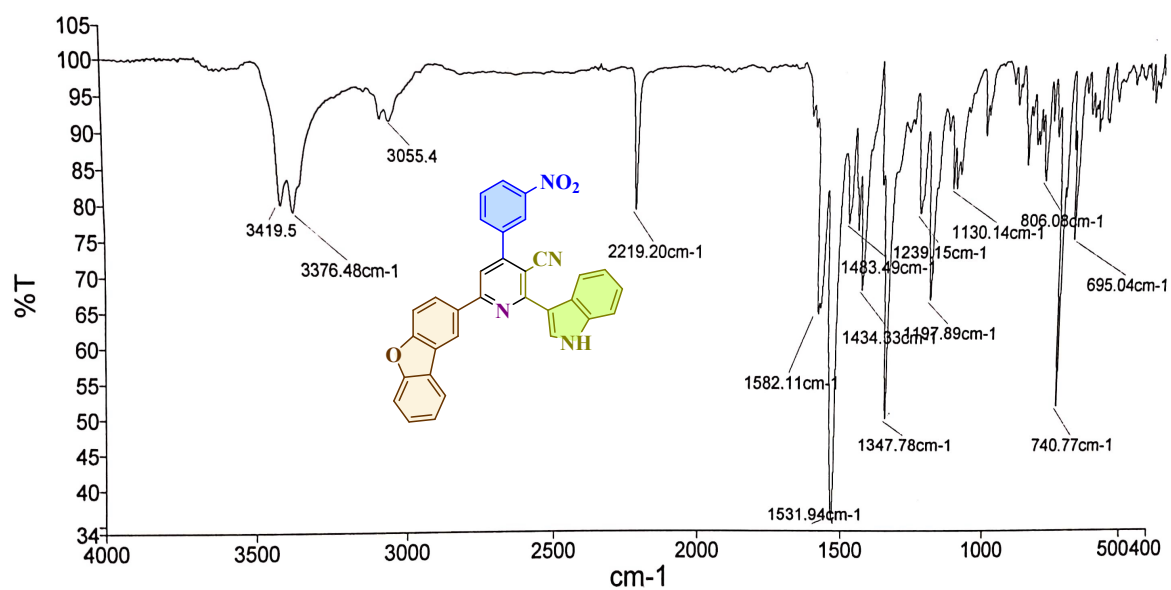
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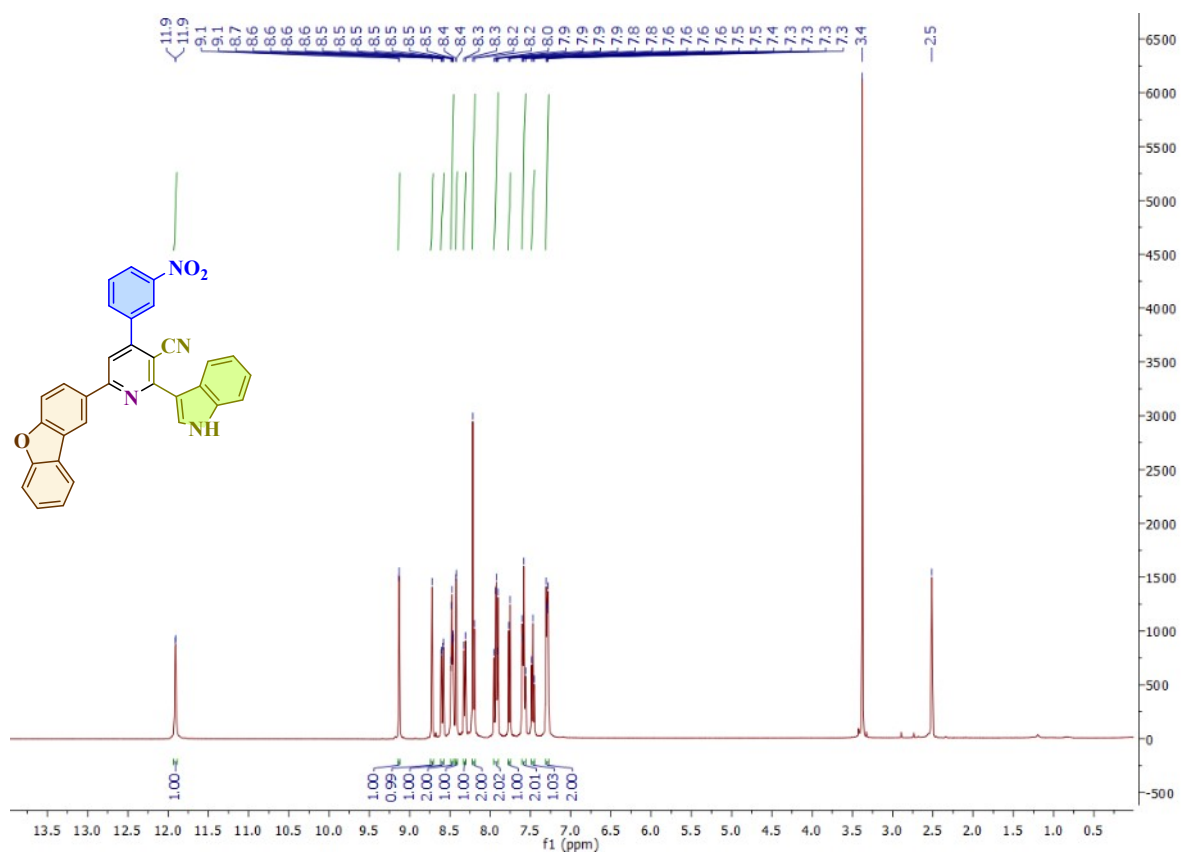
^{13}C -NMR spectrum of 6-(dibenzo[*b,d*]furan-2-yl)-4-(3-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A12).



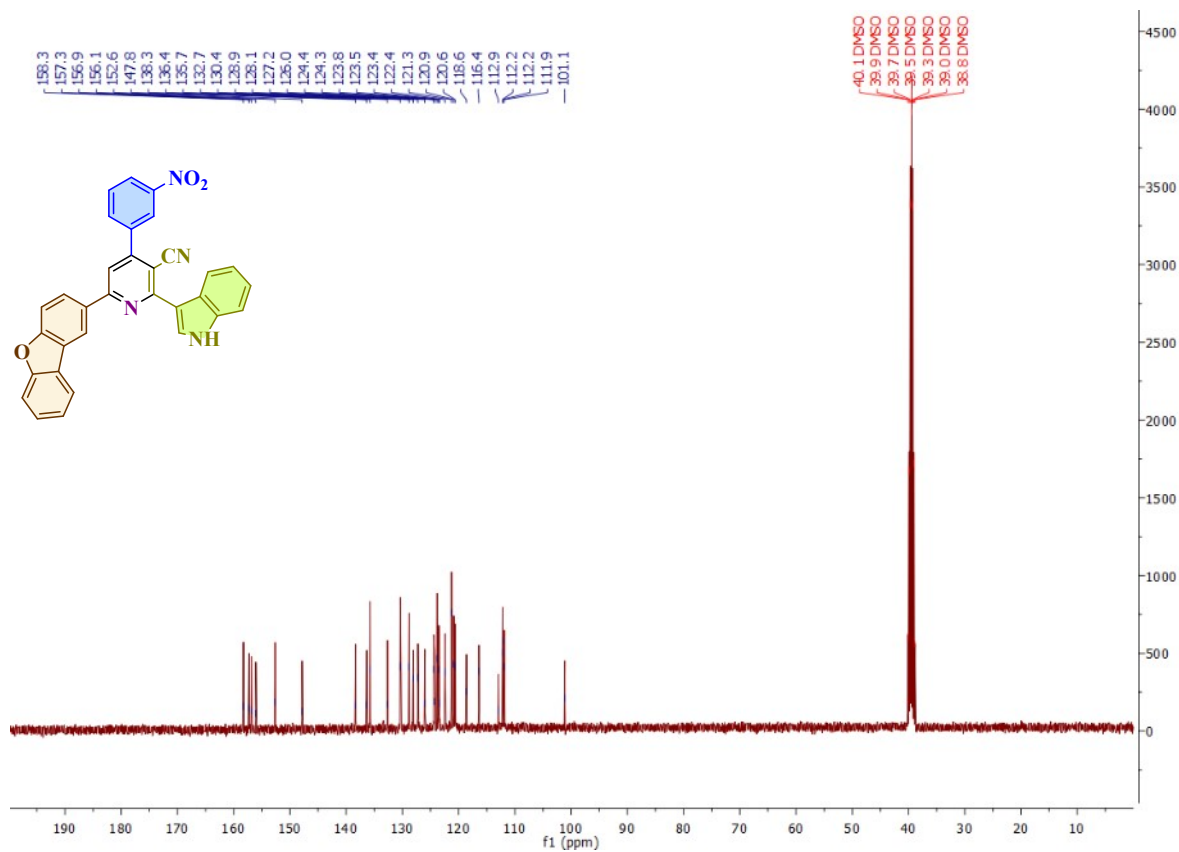
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(3-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A12).



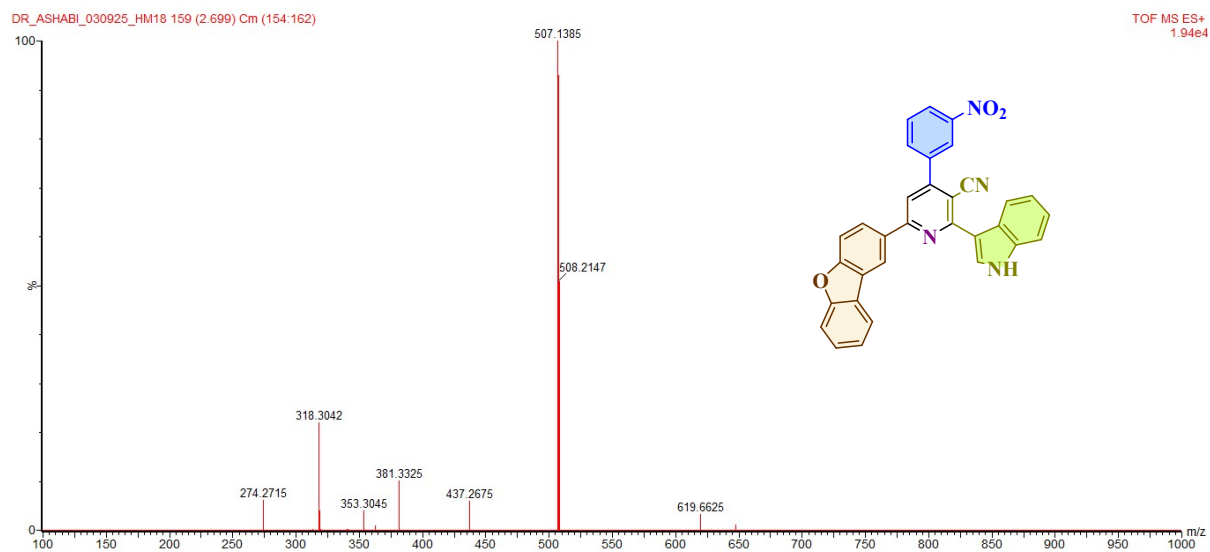
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(3-nitrophenyl)nicotinonitrile (A13).



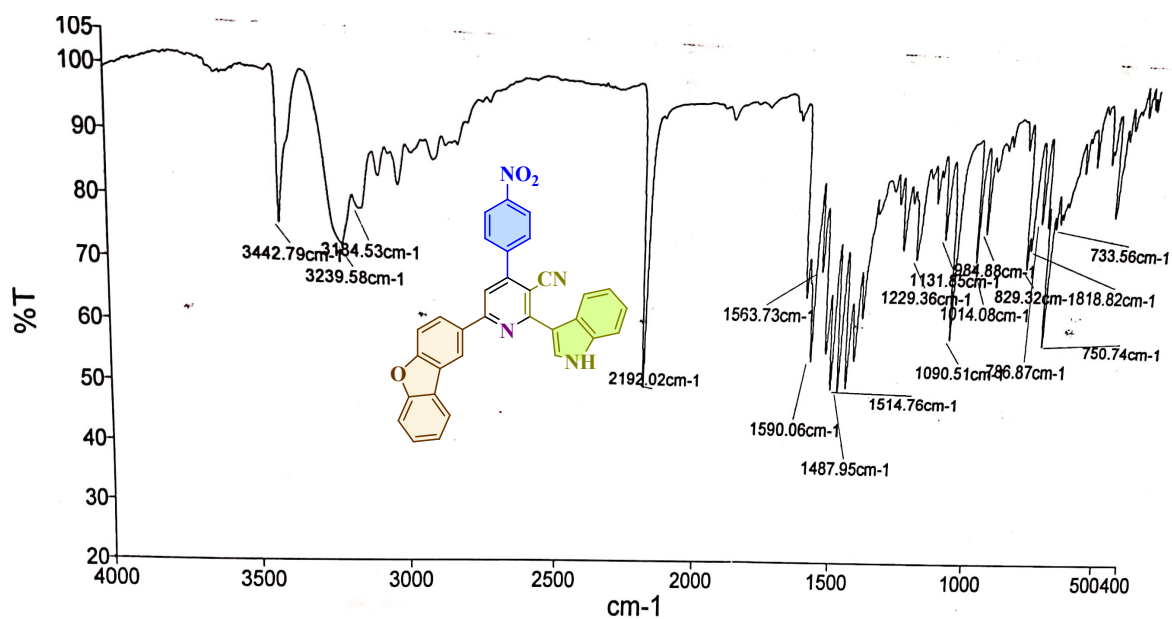
$^1\text{H-NMR}$ spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(3-nitrophenyl)nicotinonitrile (A13).



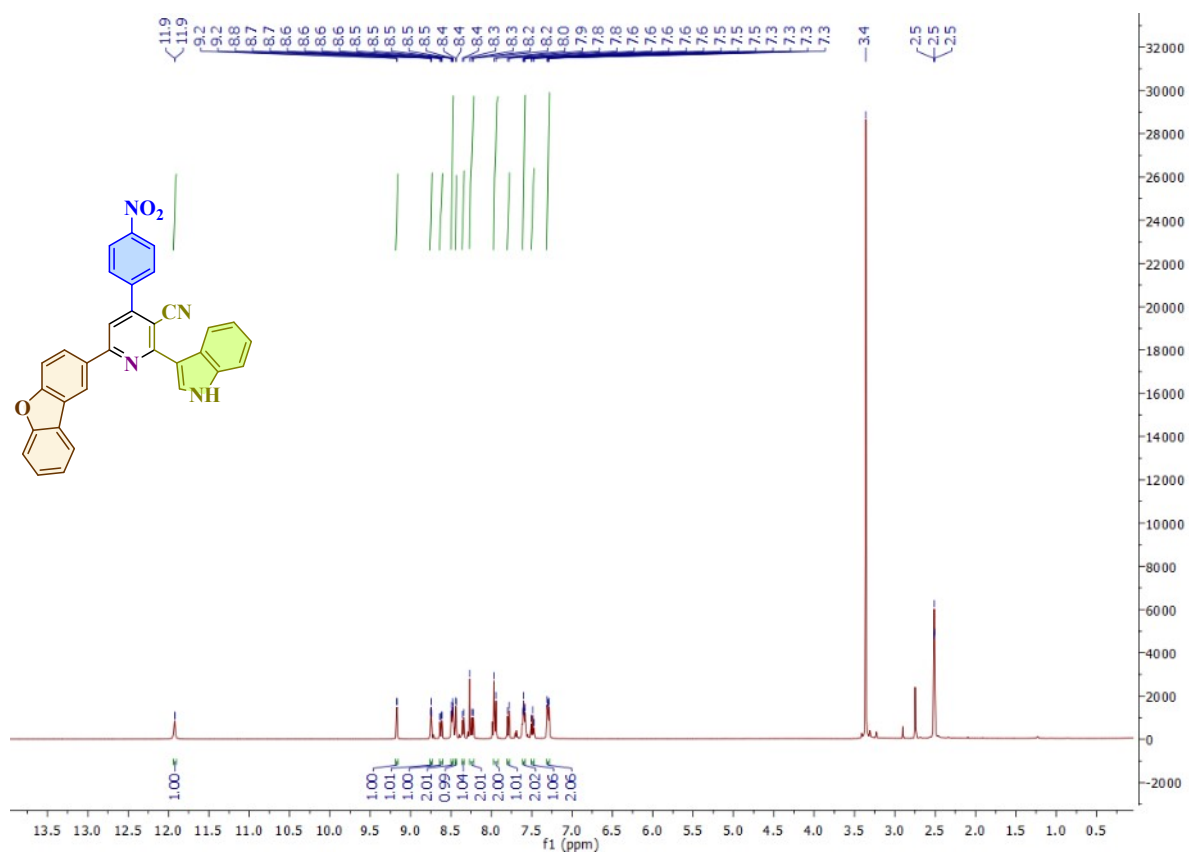
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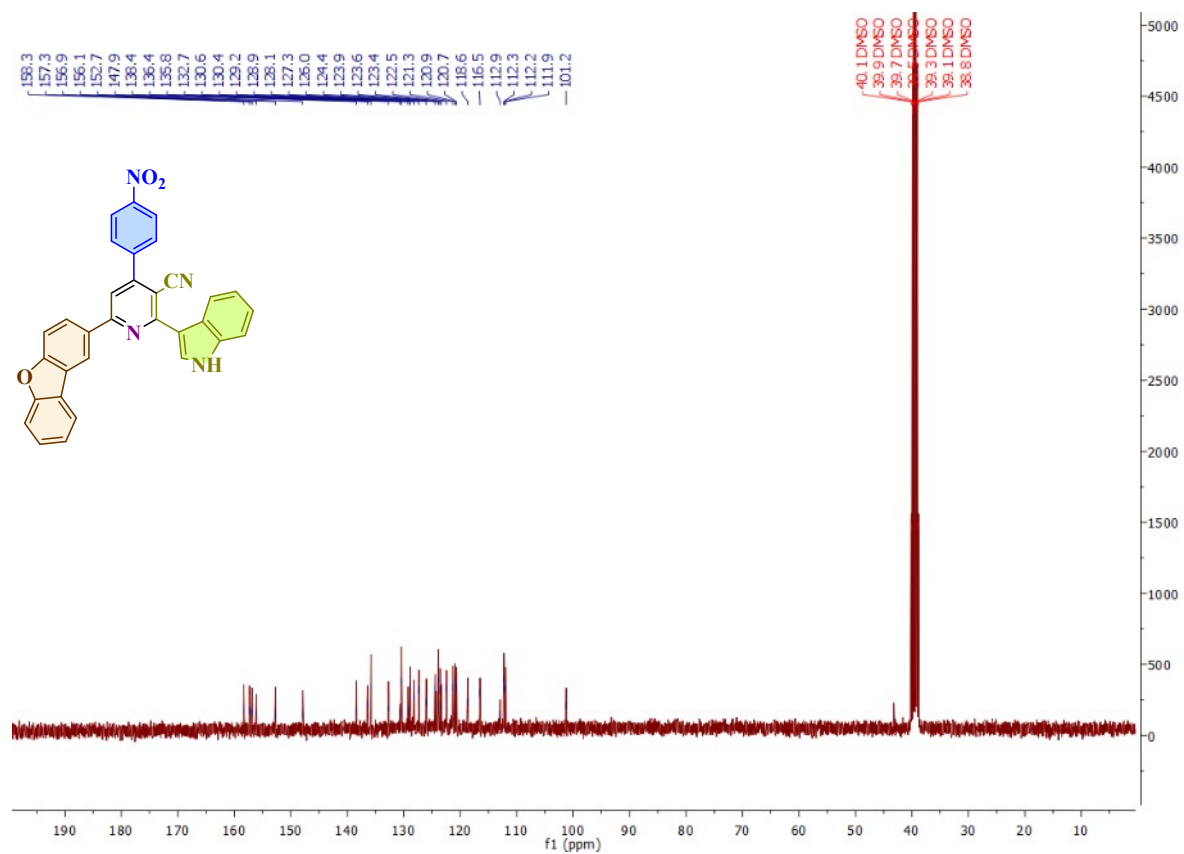
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(3-nitrophenyl)nicotinonitrile (A13).



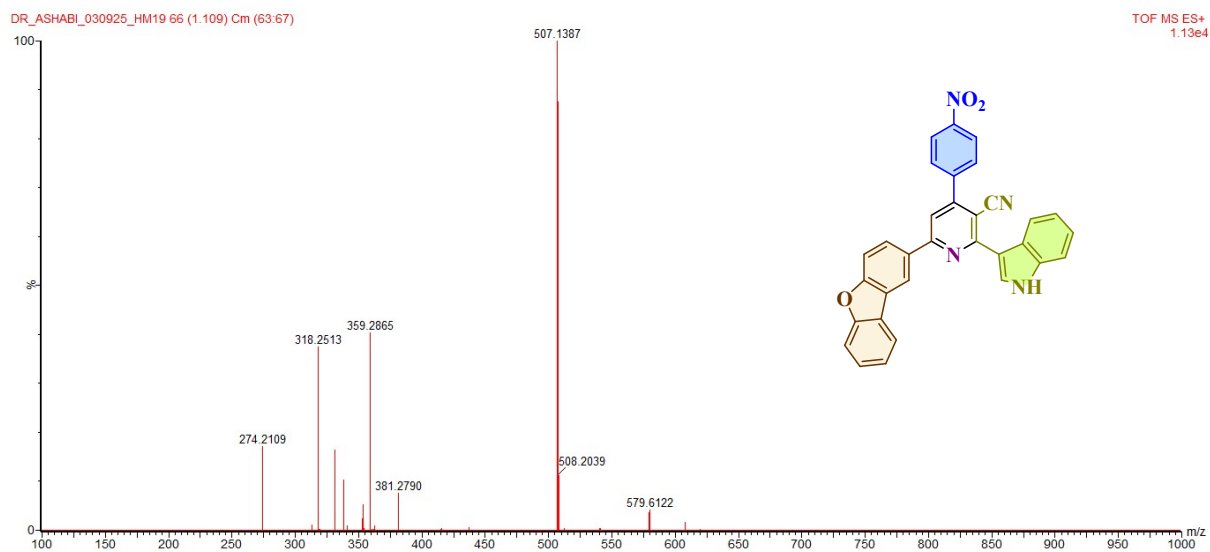
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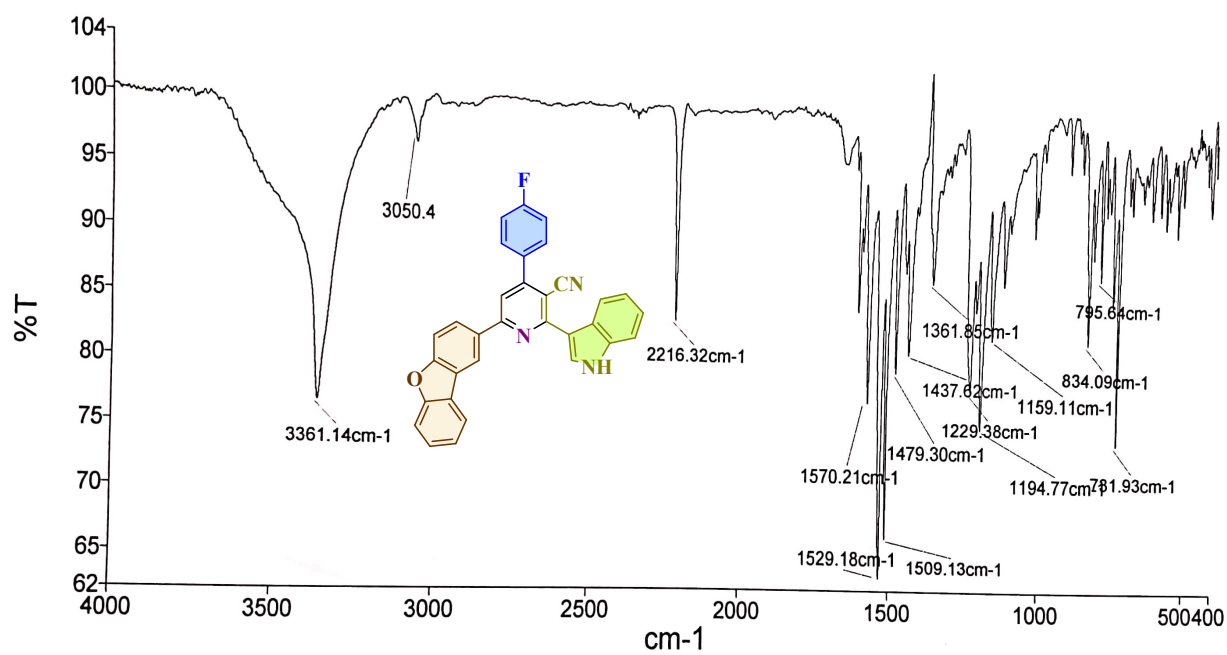
¹H-NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(4-nitrophenyl)nicotinonitrile (A14).



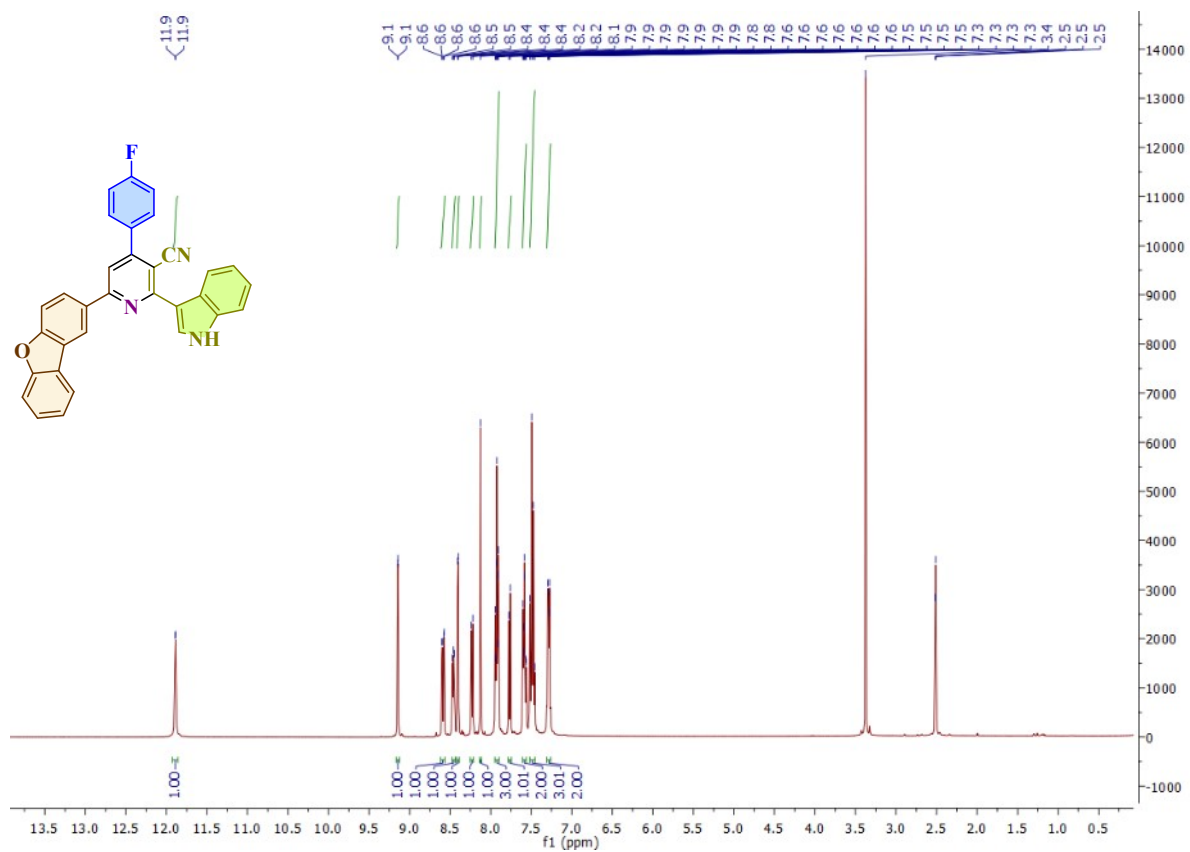
^{13}C -NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(4-nitrophenyl)nicotinonitrile (A14).



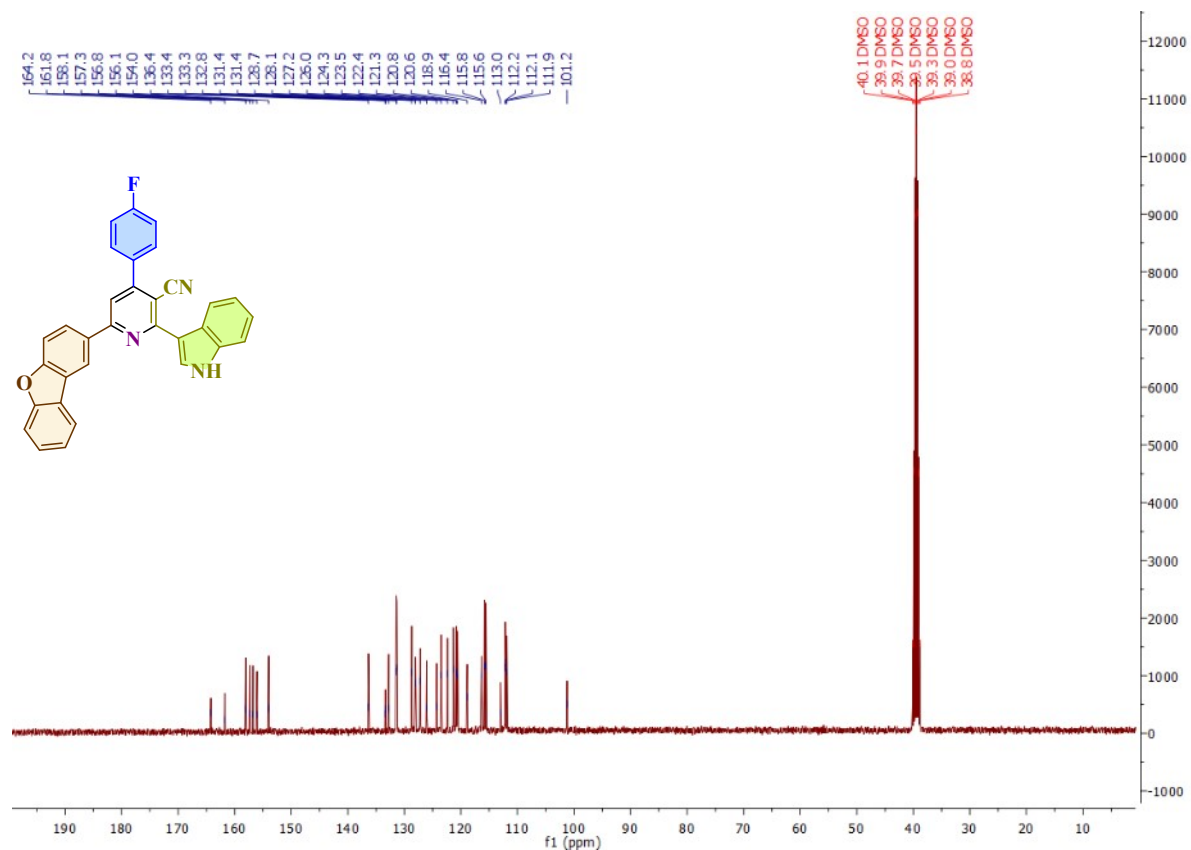
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(4-nitrophenyl)nicotinonitrile (A14).



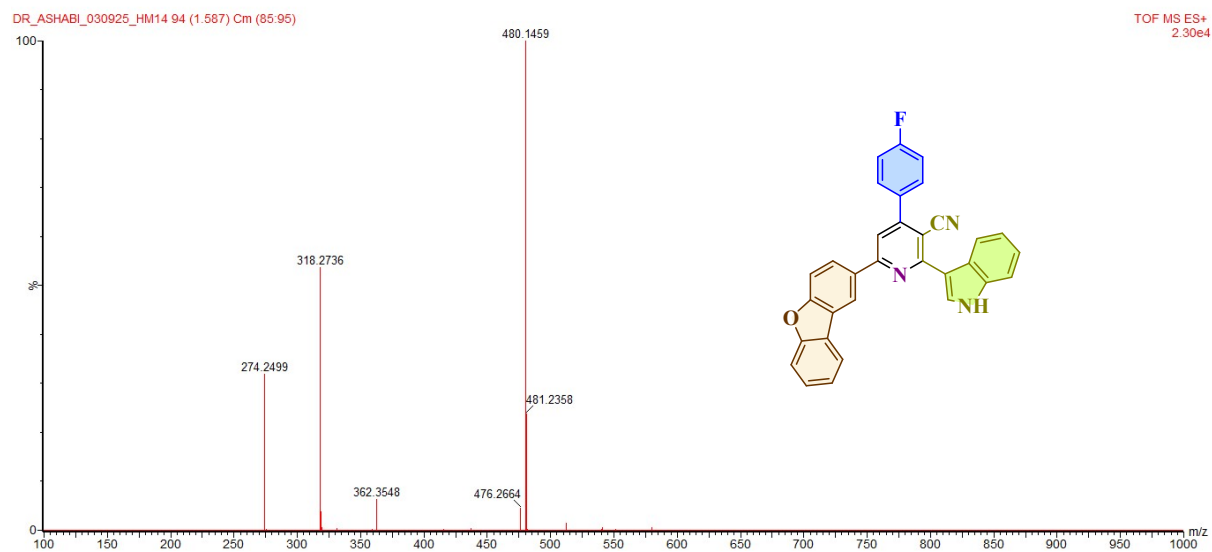
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-fluorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A15).



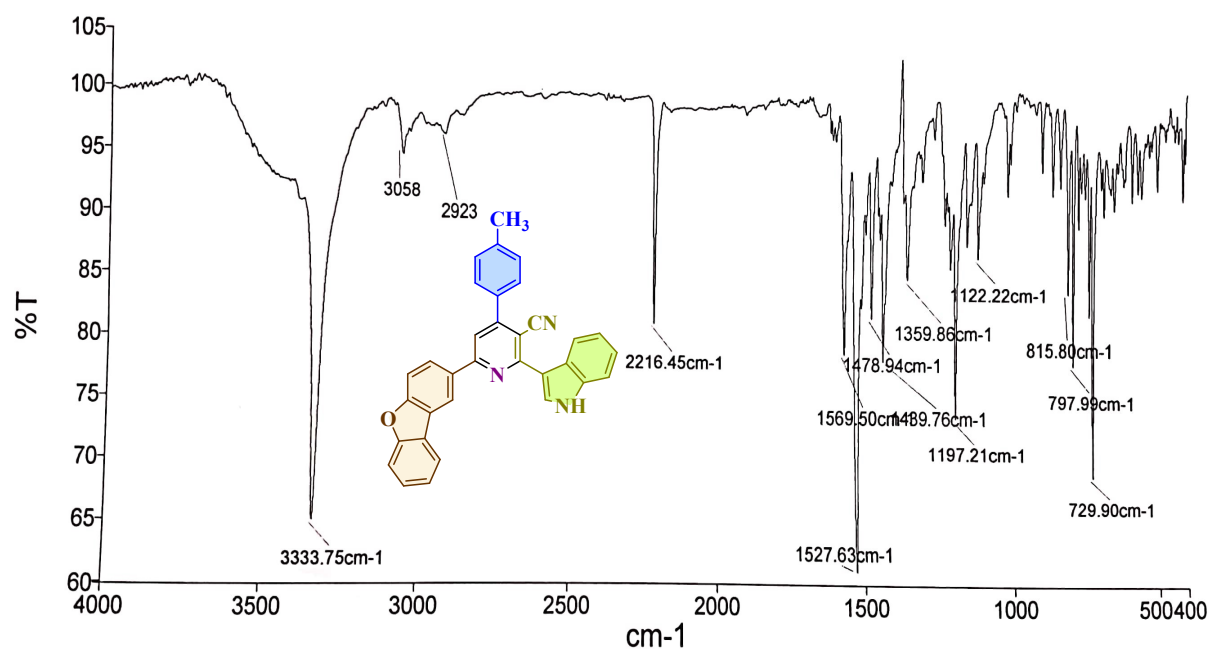
^1H -NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-fluorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A15).



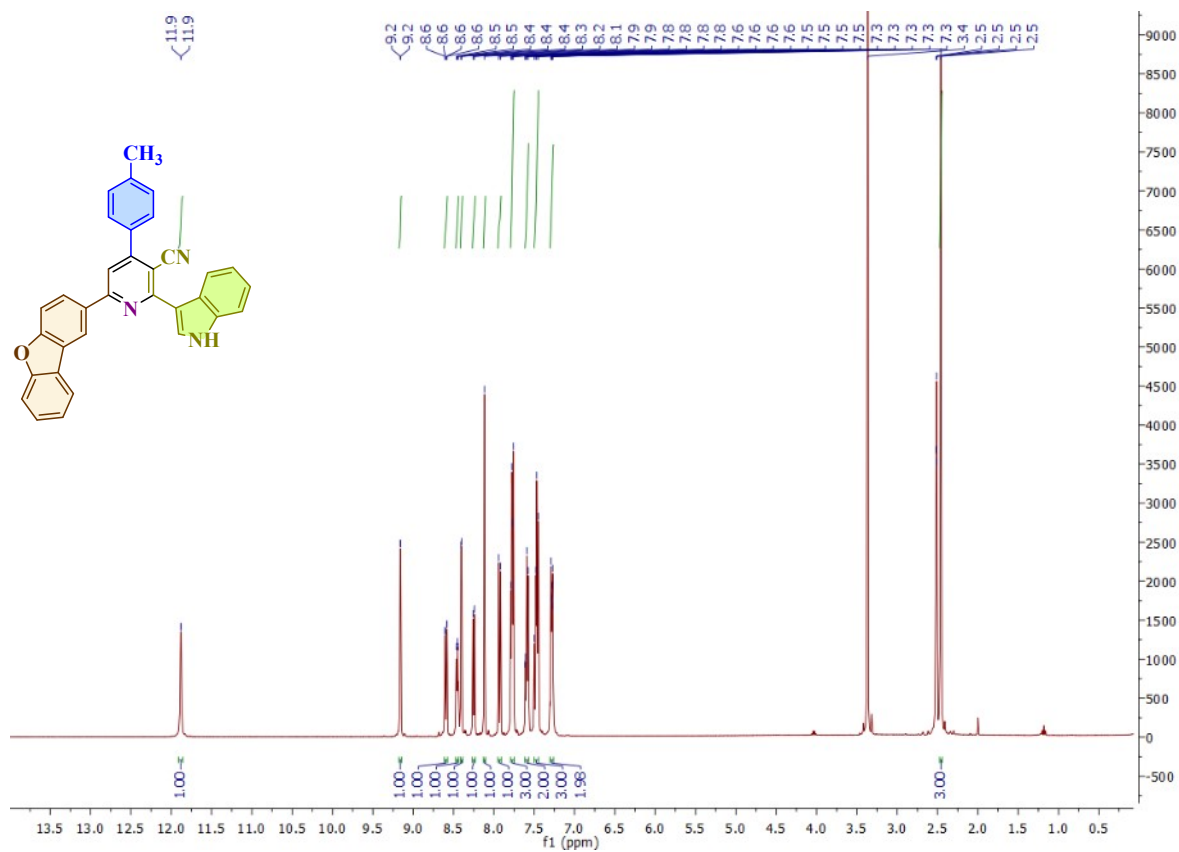
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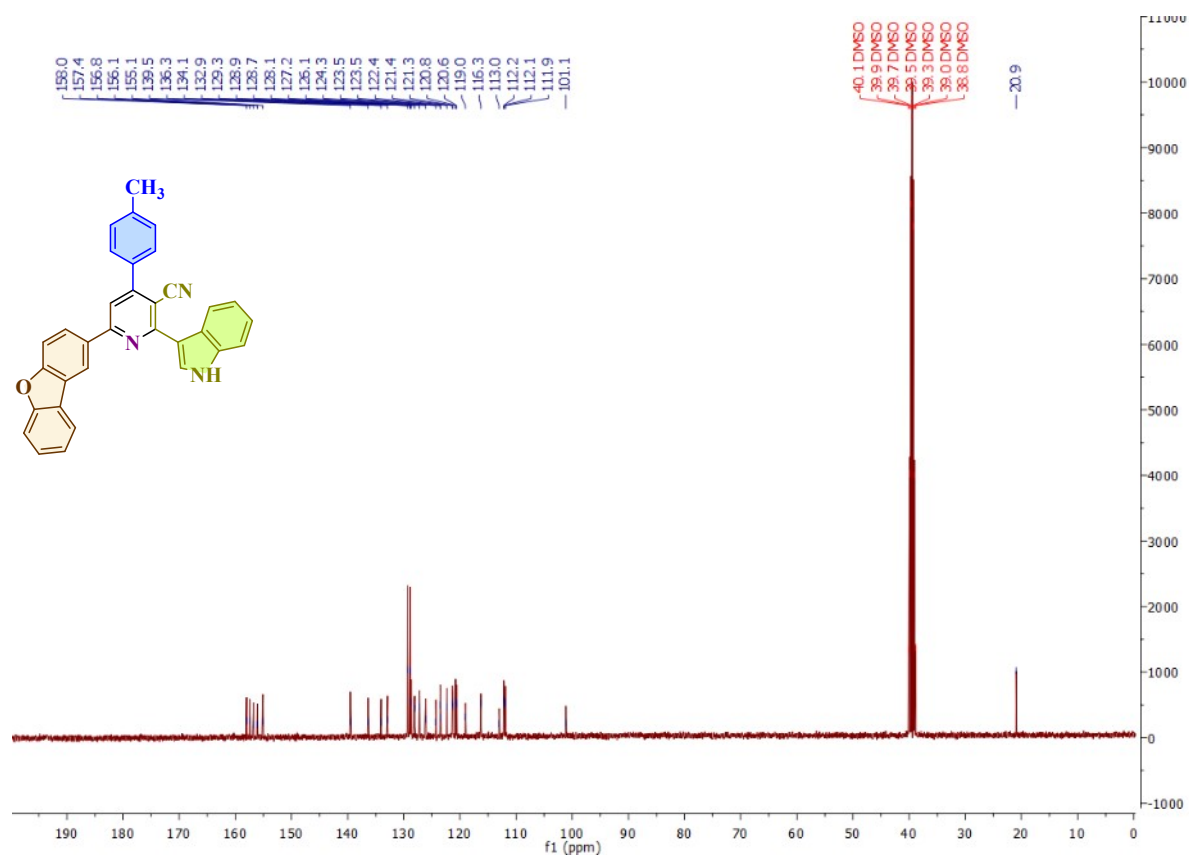
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-fluorophenyl)-2-(1H-indol-3-yl)nicotinonitrile (A15).



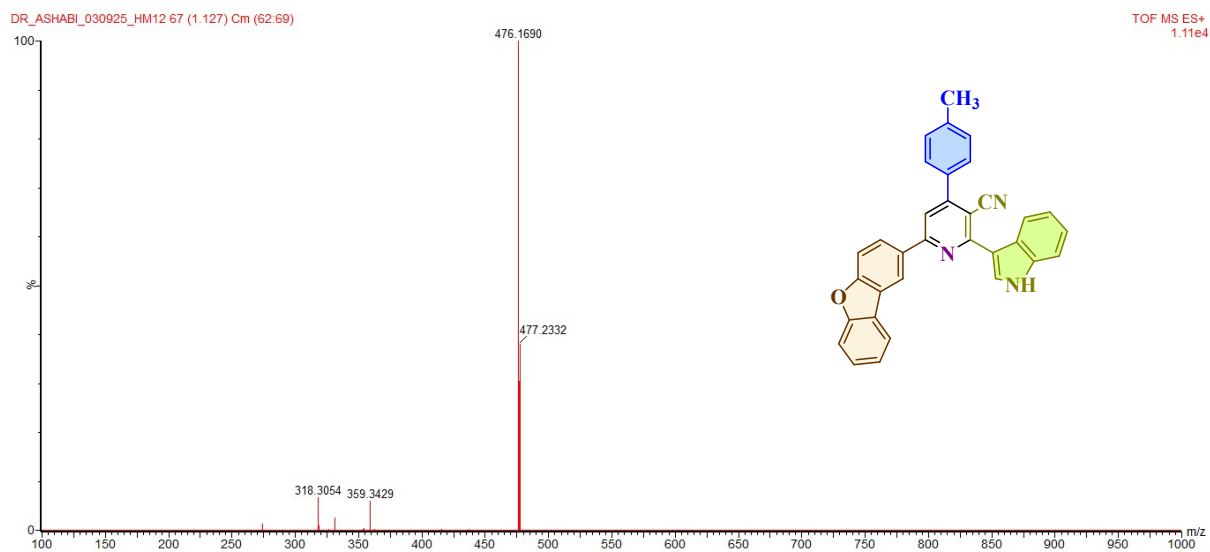
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(p-tolyl)nicotinonitrile (A16).



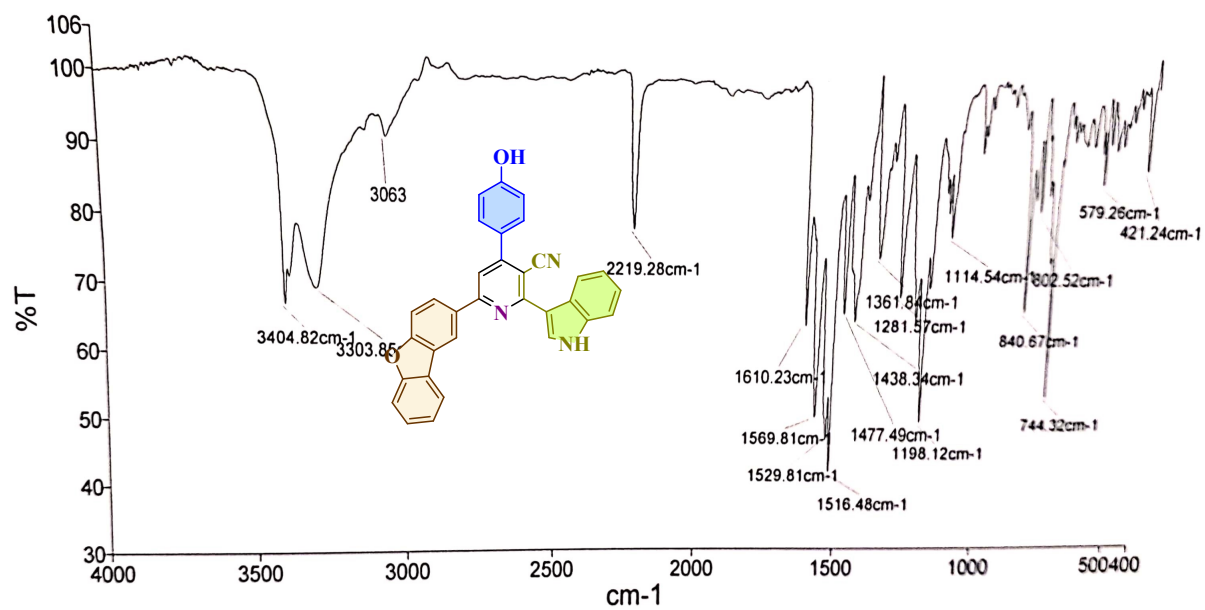
$^1\text{H-NMR}$ spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(p-tolyl)nicotinonitrile (A16).



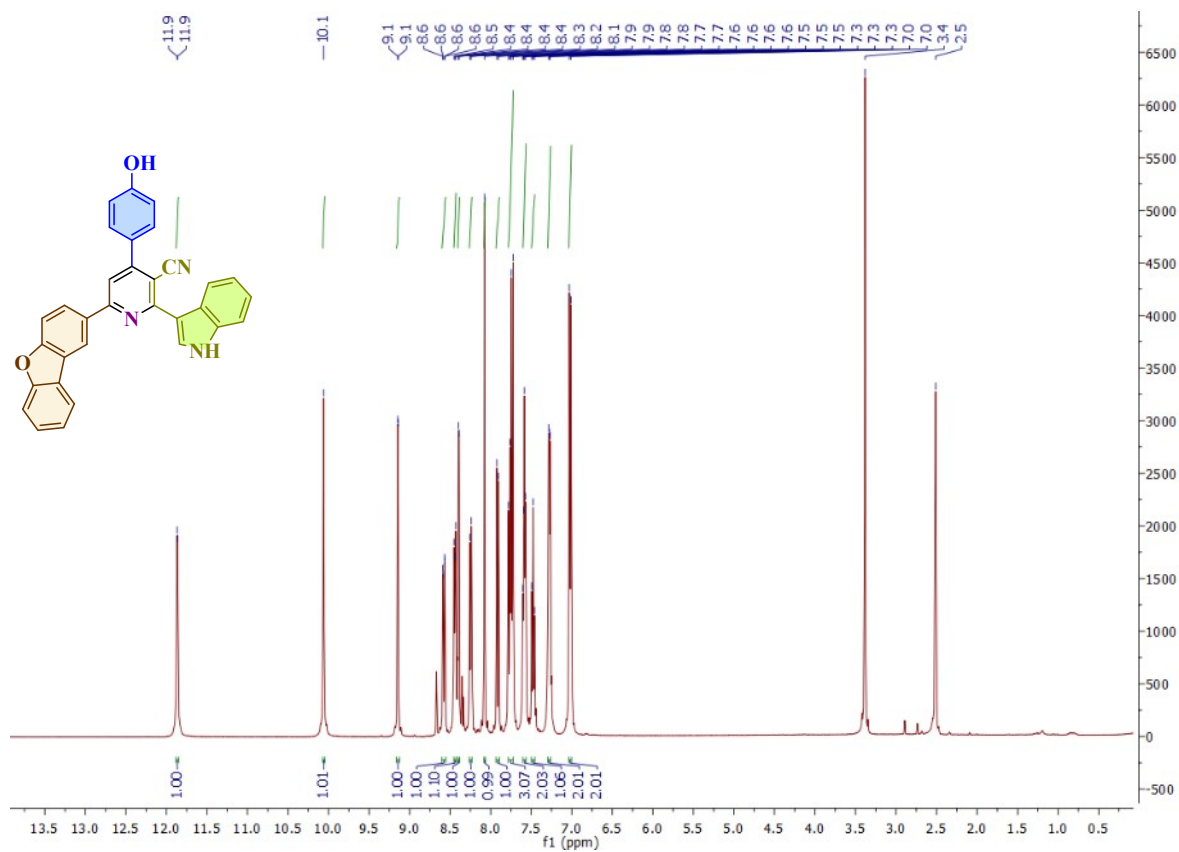
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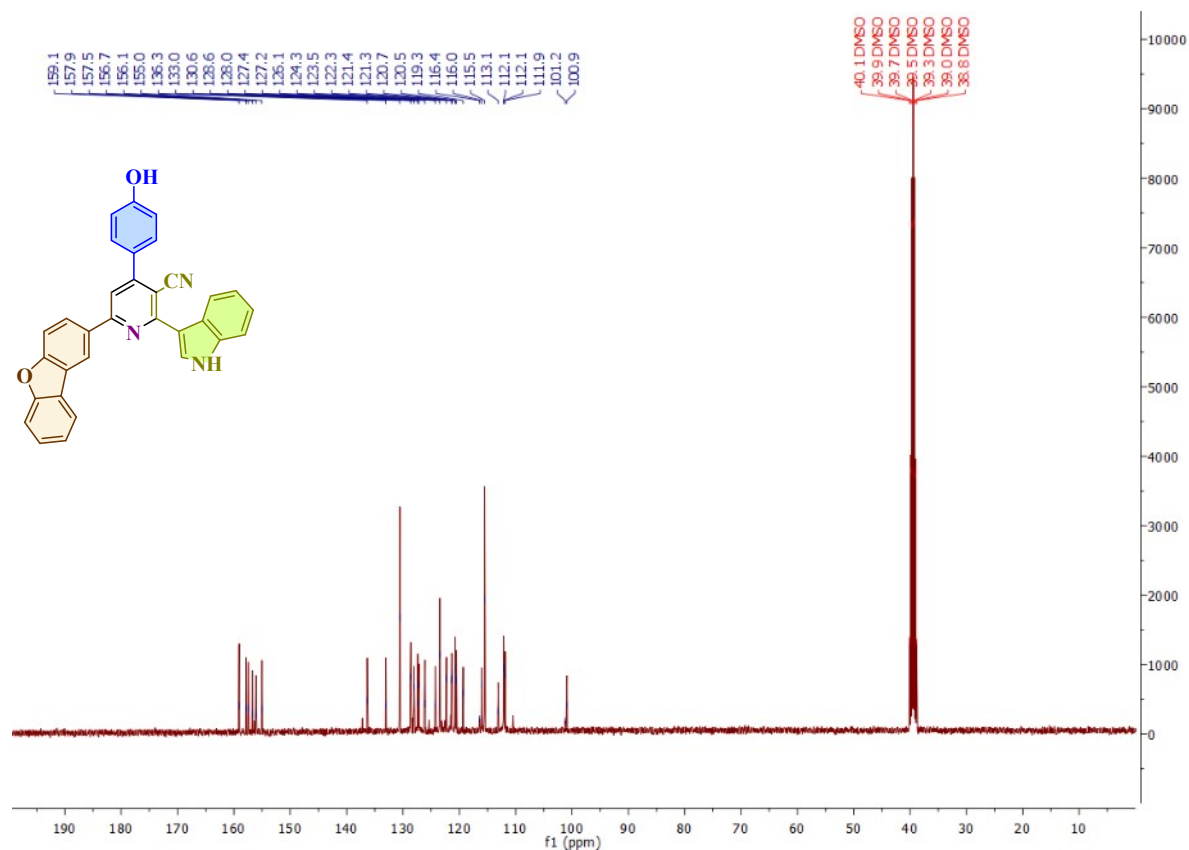
HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-2-(1H-indol-3-yl)-4-(p-tolyl)nicotinonitrile (A16).



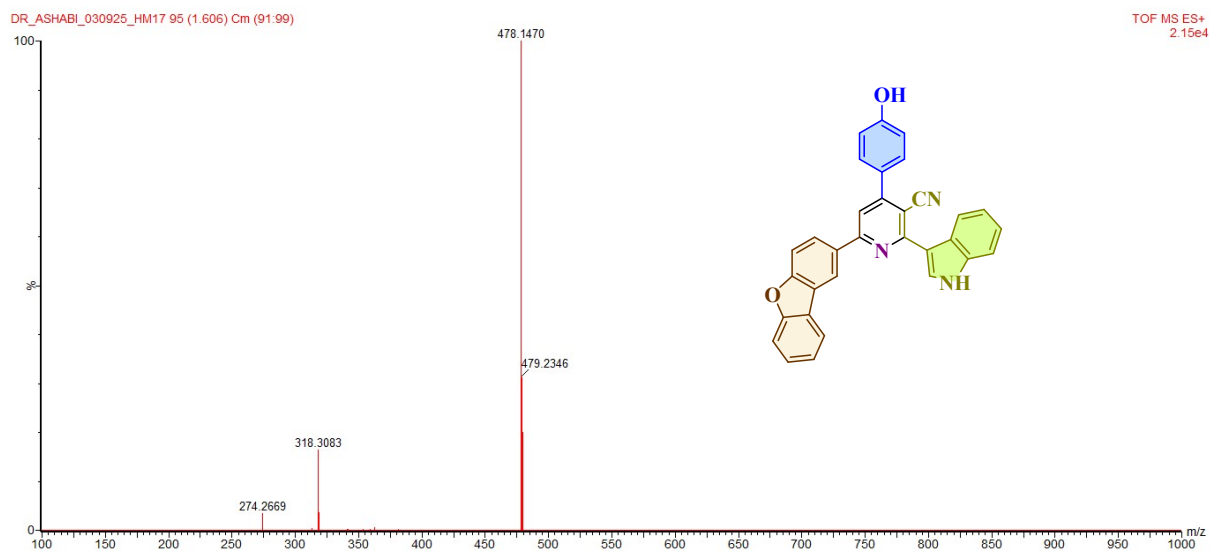
FT-IR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A17).



^1H -NMR spectrum of 6-(dibenzo[*b,d*]furan-2-yl)-4-(4-hydroxyphenyl)-2-(1*H*-indol-3-yl)nicotinonitrile (A17).



¹³C-NMR spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A17).



HR-Mass spectrum of 6-(dibenzo[b,d]furan-2-yl)-4-(4-hydroxyphenyl)-2-(1H-indol-3-yl)nicotinonitrile (A17).