

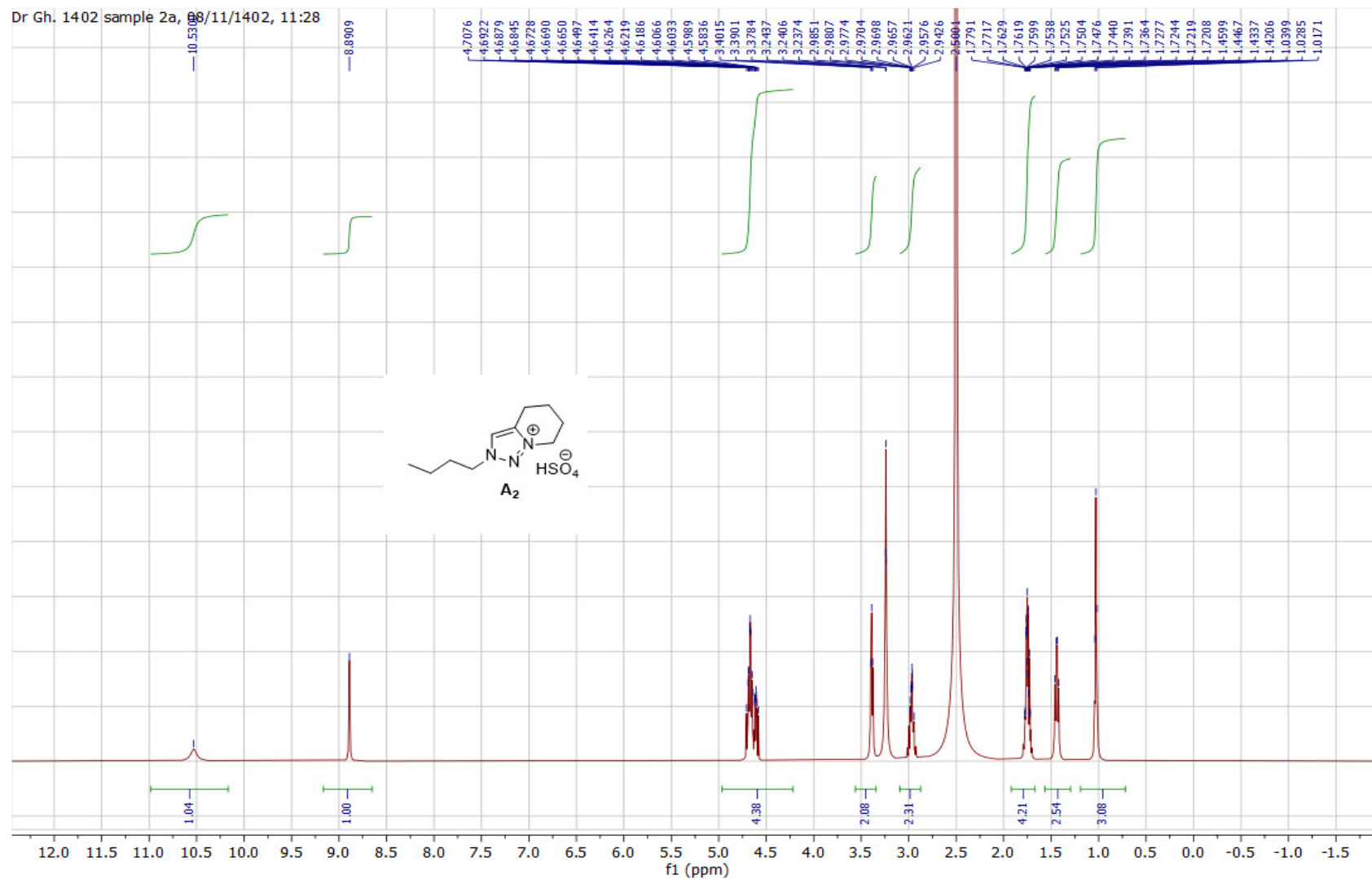
**Bicyclic 1,2,3-Triazolium Ionic Liquids as a novel ionic liquid based catalytic systems for the preparation of spirobenzo[f]pyrano[3,2-c]chromene derivatives under ultrasonic irradiation conditions**

Abbas Fazlinia,<sup>1</sup> Fatemeh Hosna Tavakoli,<sup>2</sup> Majid Ghashang\*<sup>2</sup>

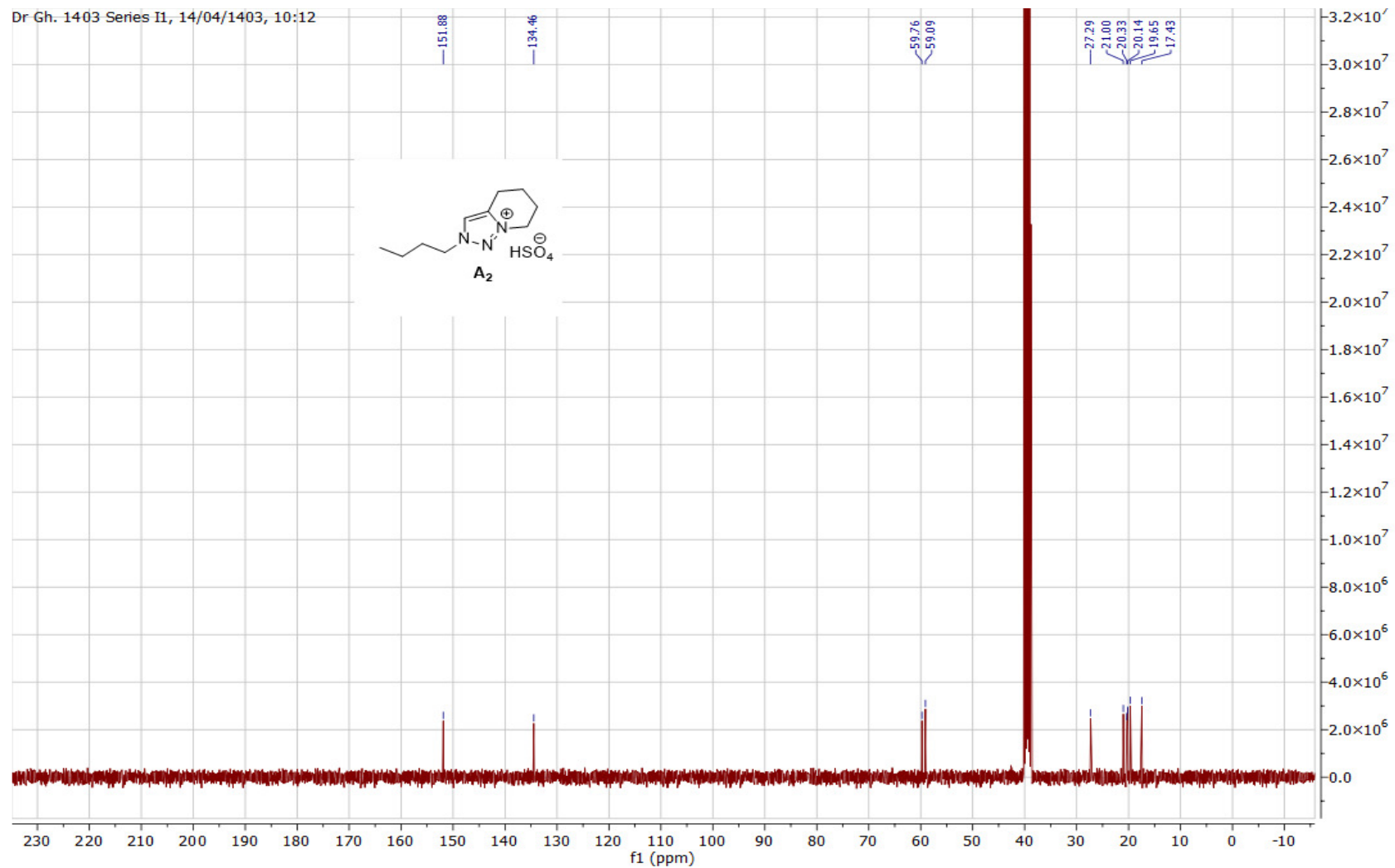
<sup>1</sup>Department of Chemistry, Zarghan Branch, Islamic Azad University, Zarghan, Iran. E-mail: [Fazliniaabbas@gmail.com](mailto:Fazliniaabbas@gmail.com)

<sup>2</sup>Department of Chemistry, Najafabad Branch, Islamic Azad University, P.O. Box: 517; Najafabad, Iran, Tel: +98-3142291004; Fax: +98-3142291016; (Corresponding Author E-mail: [ghashangmajid@gmail.com](mailto:ghashangmajid@gmail.com); [ghashangmajid@pmt.iaun.ac.ir](mailto:ghashangmajid@pmt.iaun.ac.ir) (Majid Ghashang))

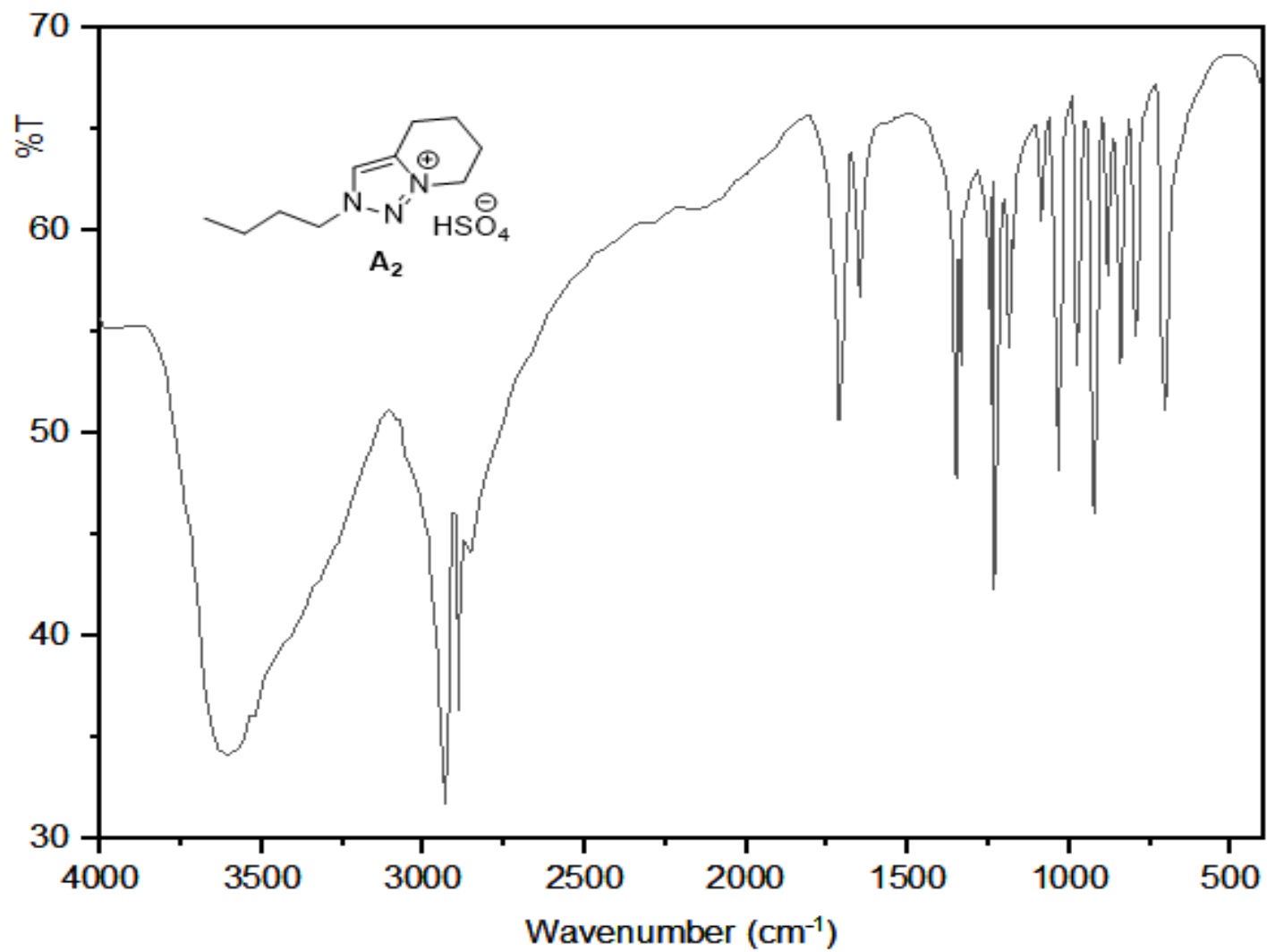
<https://doi.org/10.57647/j.ijc.2025.1501.06>



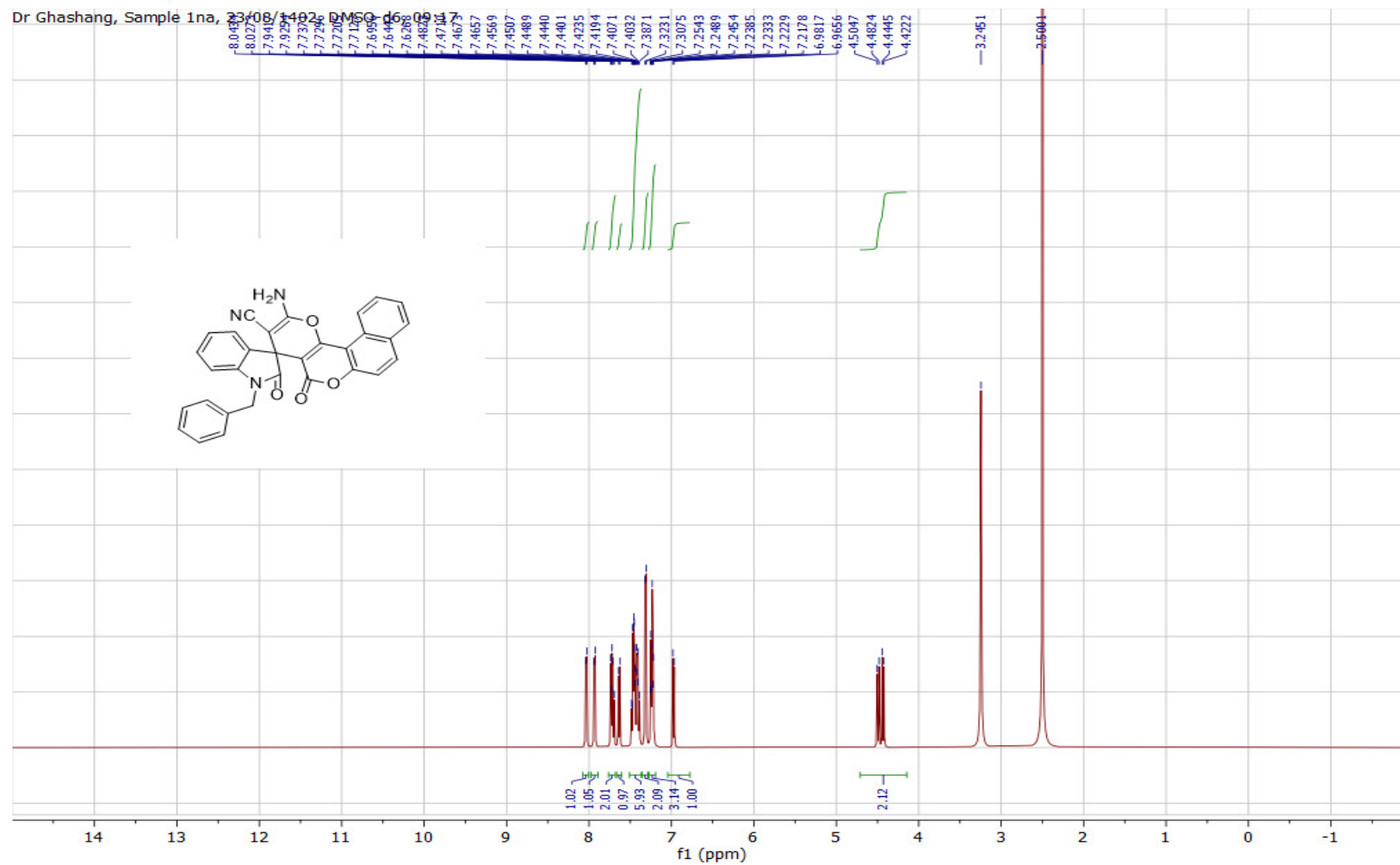
**Figure S<sub>1</sub>:** <sup>1</sup>H-NMR spectrum of 2-Butyl-4,5,6,7-tetrahydro-2H-[1,2,3]triazolo[1,5-a]pyridin-8-ium hydrogen sulfate (Scheme 2, A<sub>2</sub>)



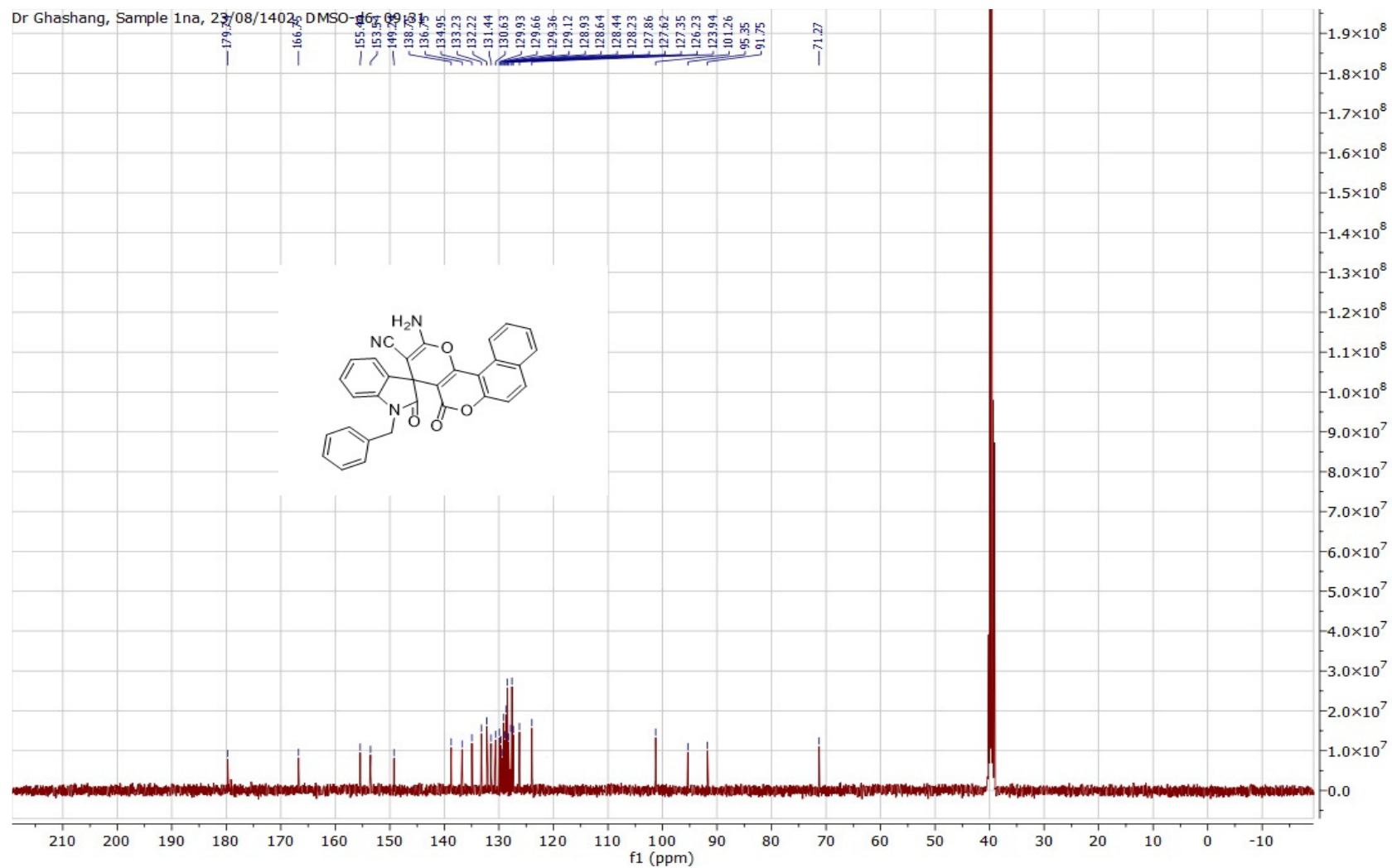
**Figure S<sub>2</sub>:** <sup>13</sup>C-NMR spectrum of 2-Butyl-4,5,6,7-tetrahydro-2H-[1,2,3]triazolo[1,5-a]pyridin-8-ium hydrogen sulfate (Scheme 2, A<sub>2</sub>)



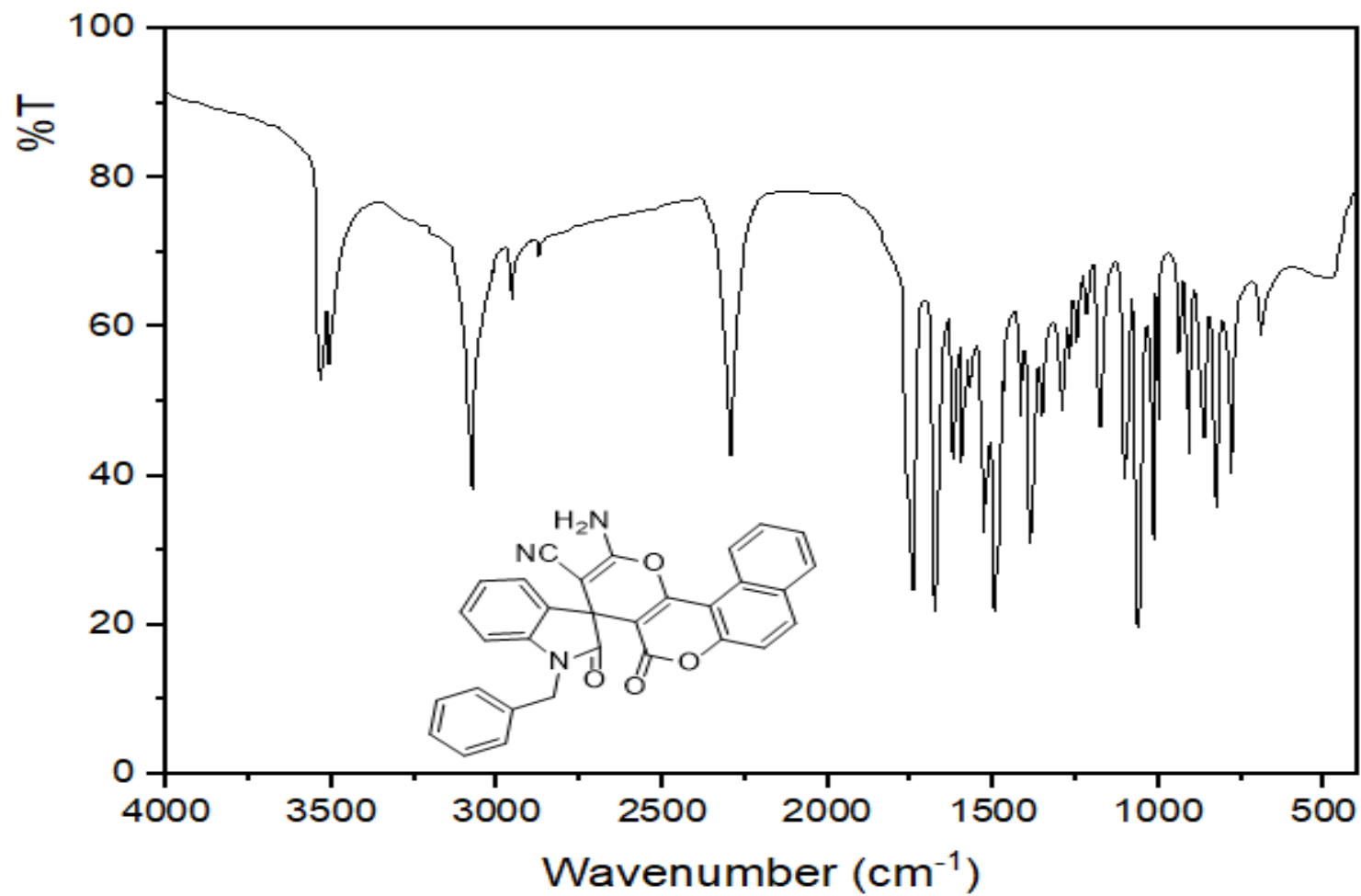
**Figure S<sub>3</sub>:** FT-IR analysis of 2-Butyl-4,5,6,7-tetrahydro-2H-[1,2,3]triazolo[1,5-a]pyridin-8-ium hydrogen sulfate (Scheme 2, A<sub>2</sub>)



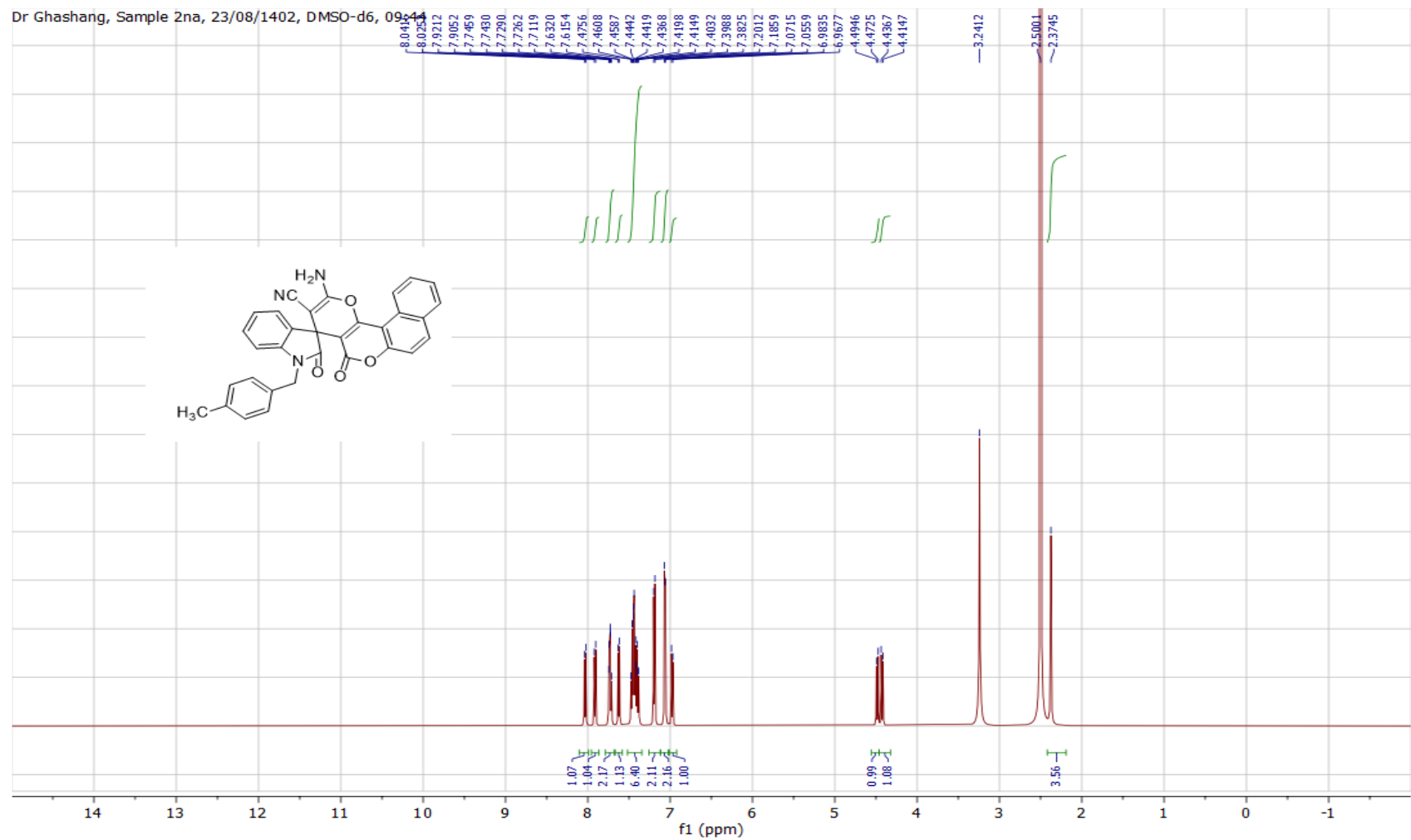
**Figure S4:**  $^1\text{H-NMR}$  spectrum of 2-Amino-1'-benzyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 1a)



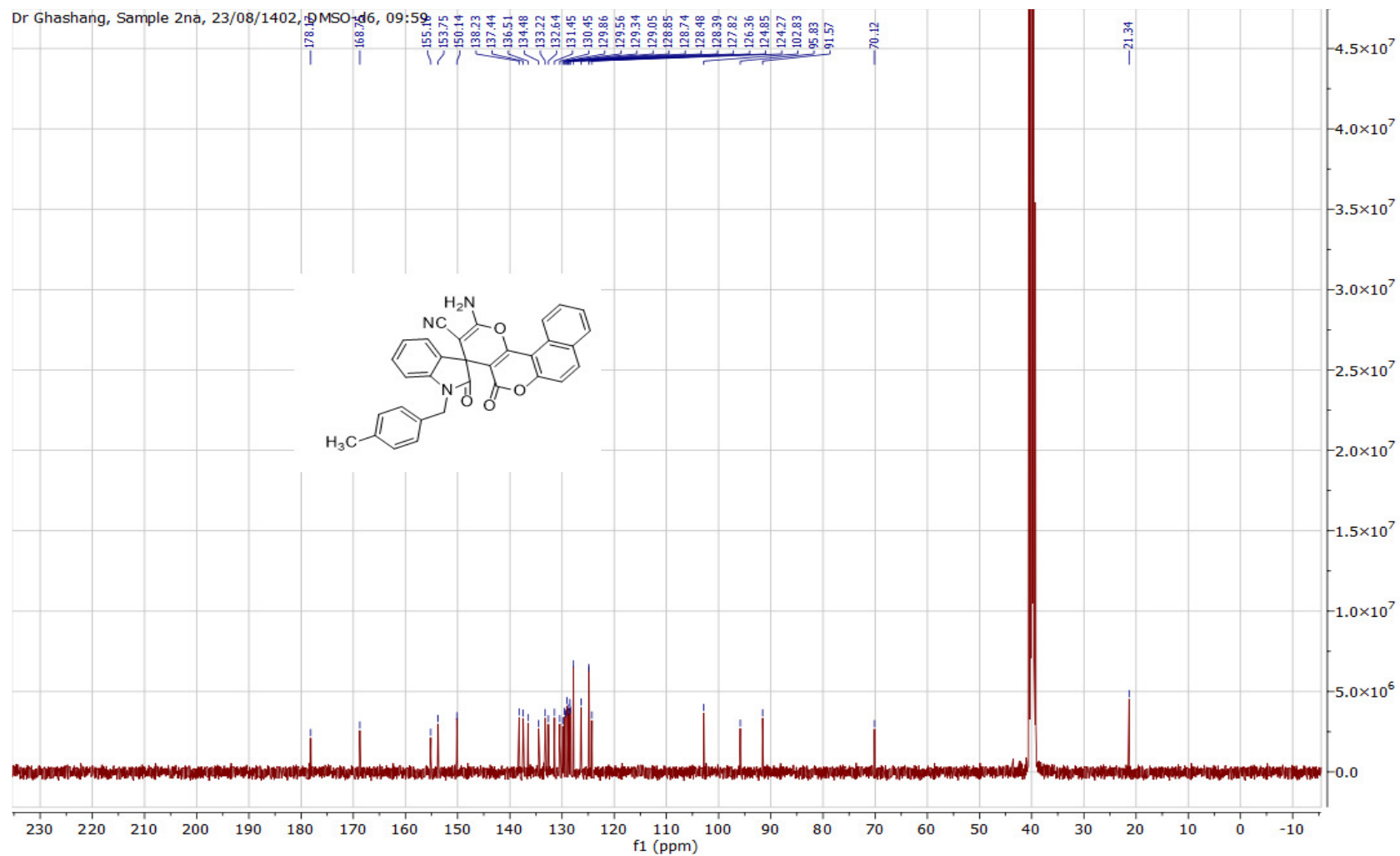
**Figure S<sub>5</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-1'-benzyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 1a)



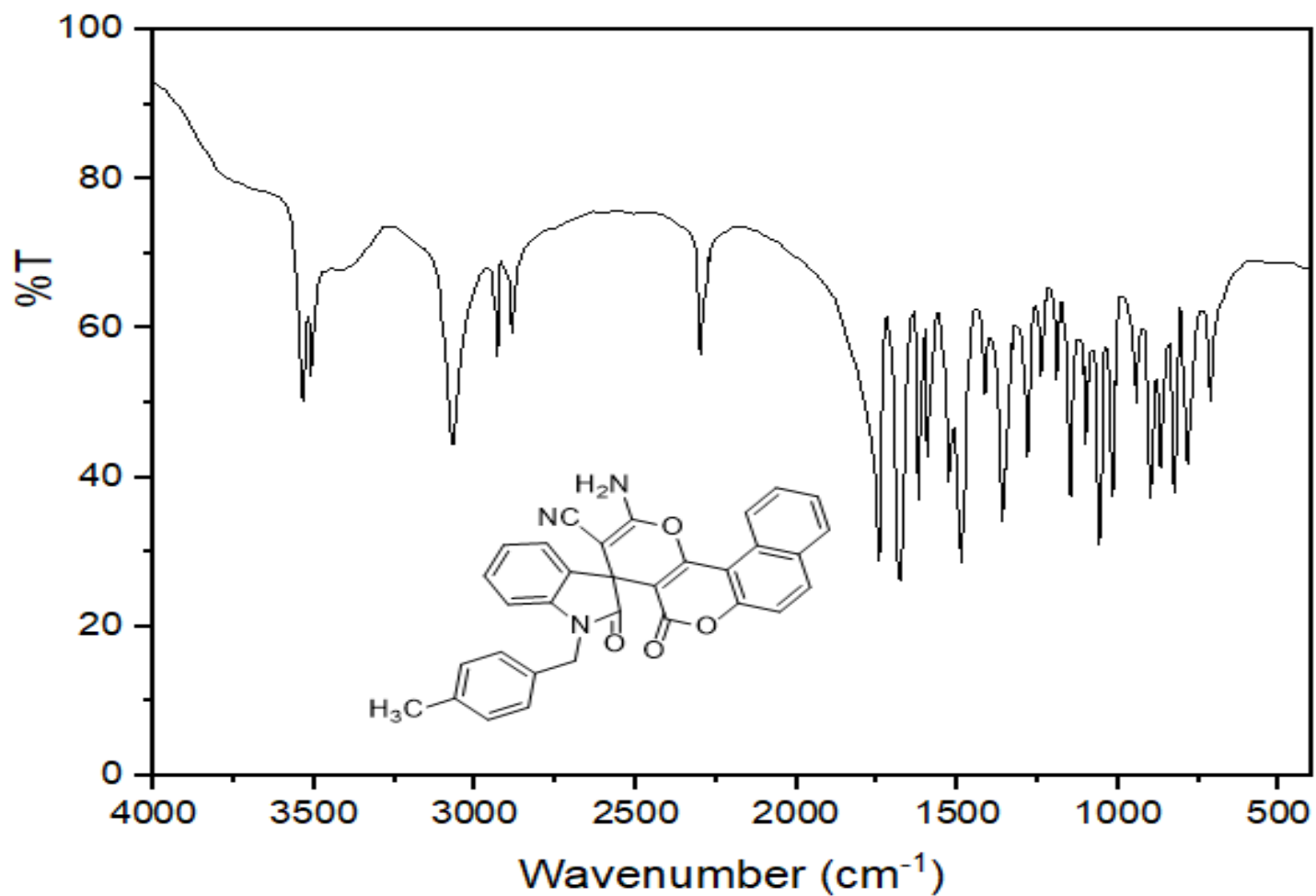
**Figure S<sub>6</sub>:** FT-IR analysis of 2-Amino-1'-benzyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 1a)



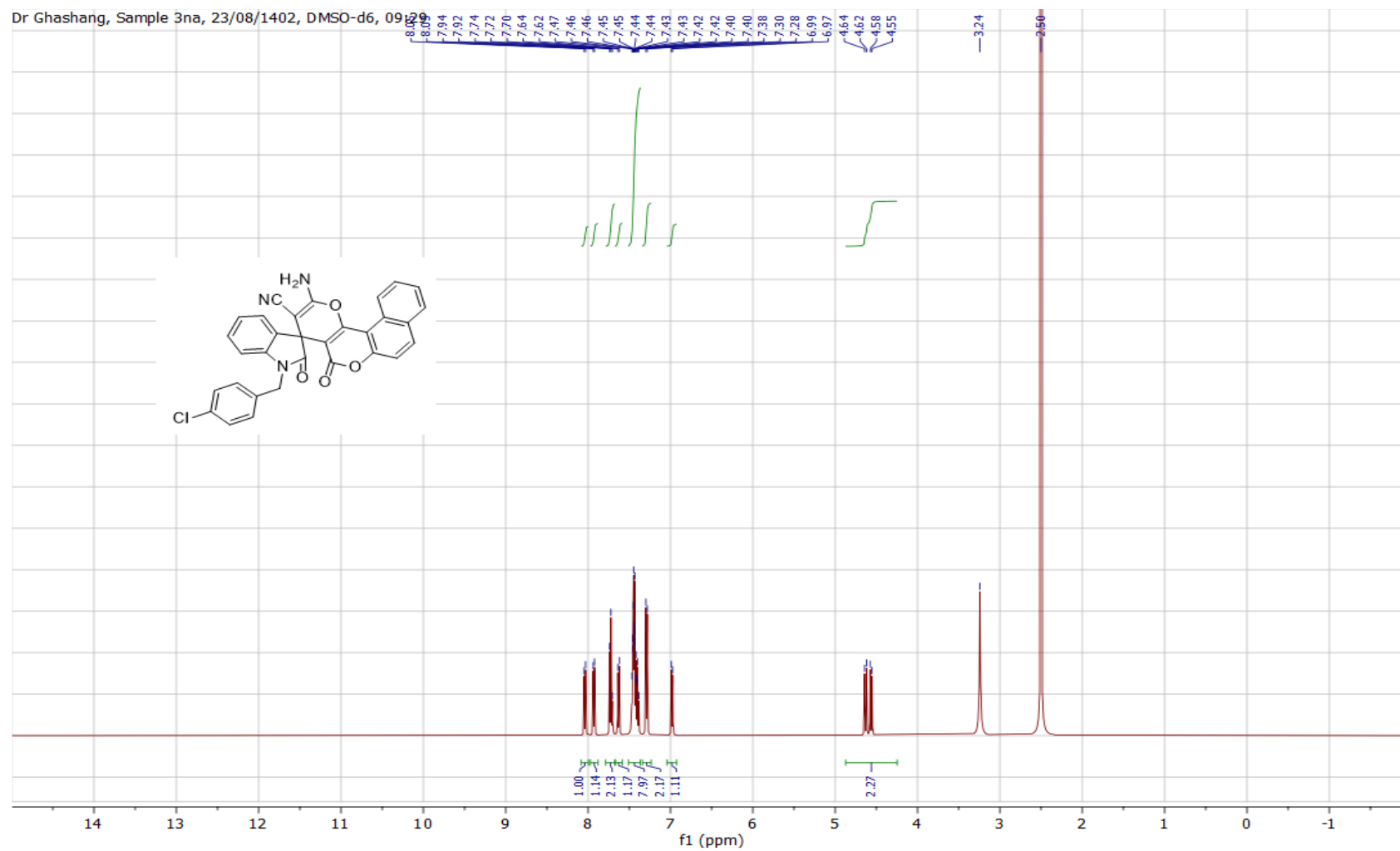
**Figure S7:** <sup>1</sup>H-NMR spectrum of 2-Amino-1'-(4-methylbenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 2a)



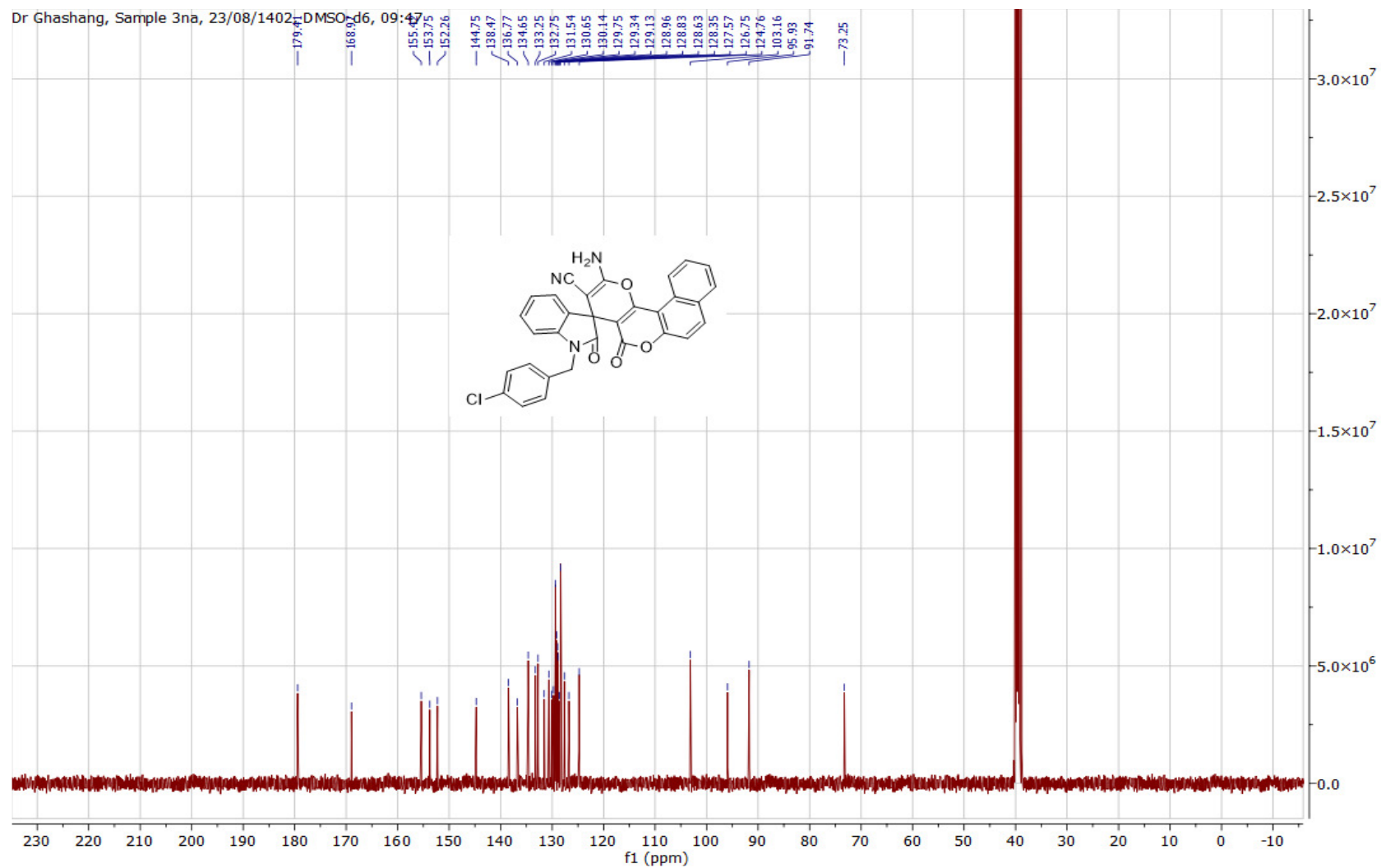
**Figure S<sub>8</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-1-(4-methylbenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 2a)



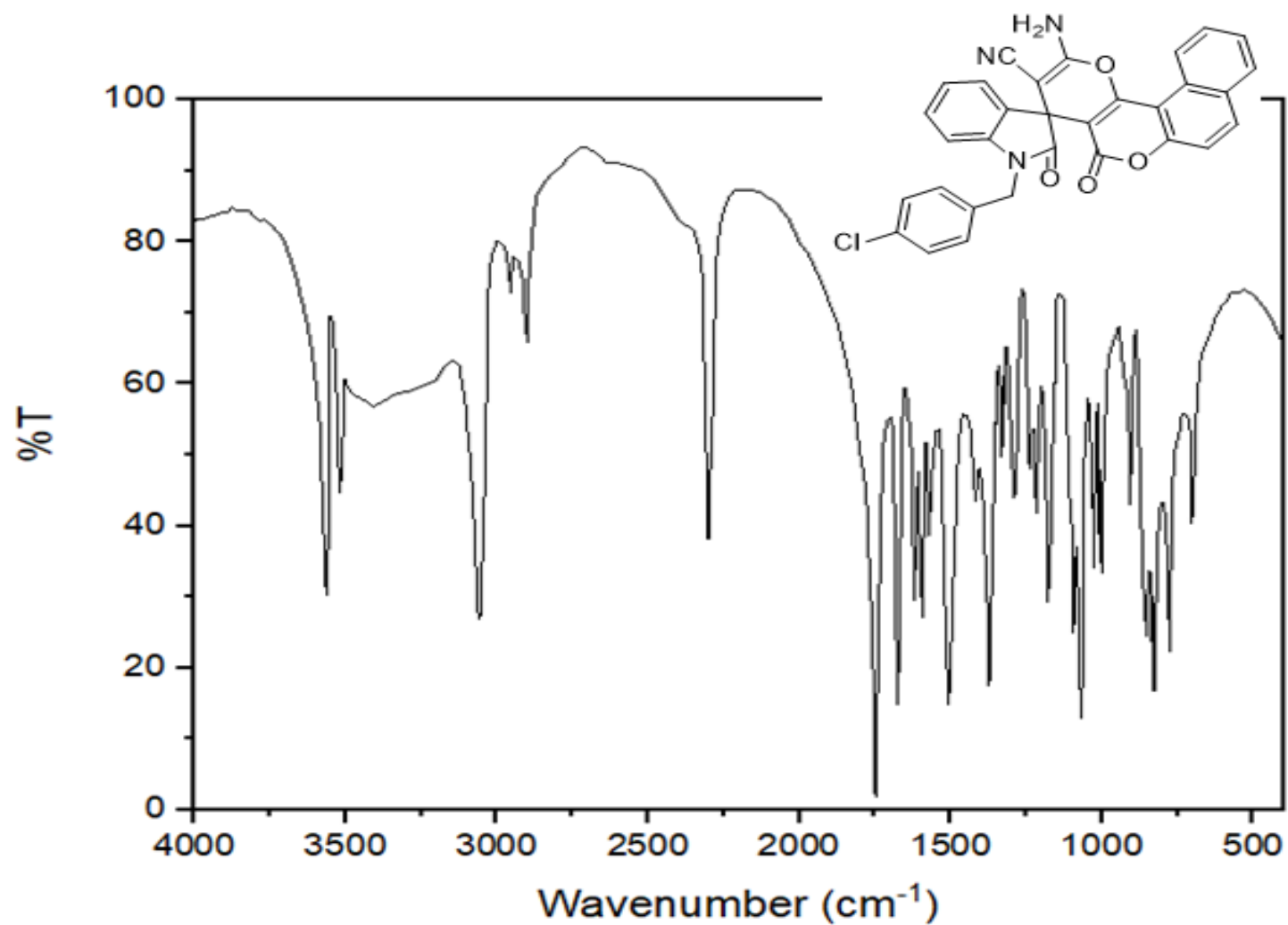
**Figure S9:** FT-IR analysis of 2-Amino-1'-(4-methylbenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 2a)



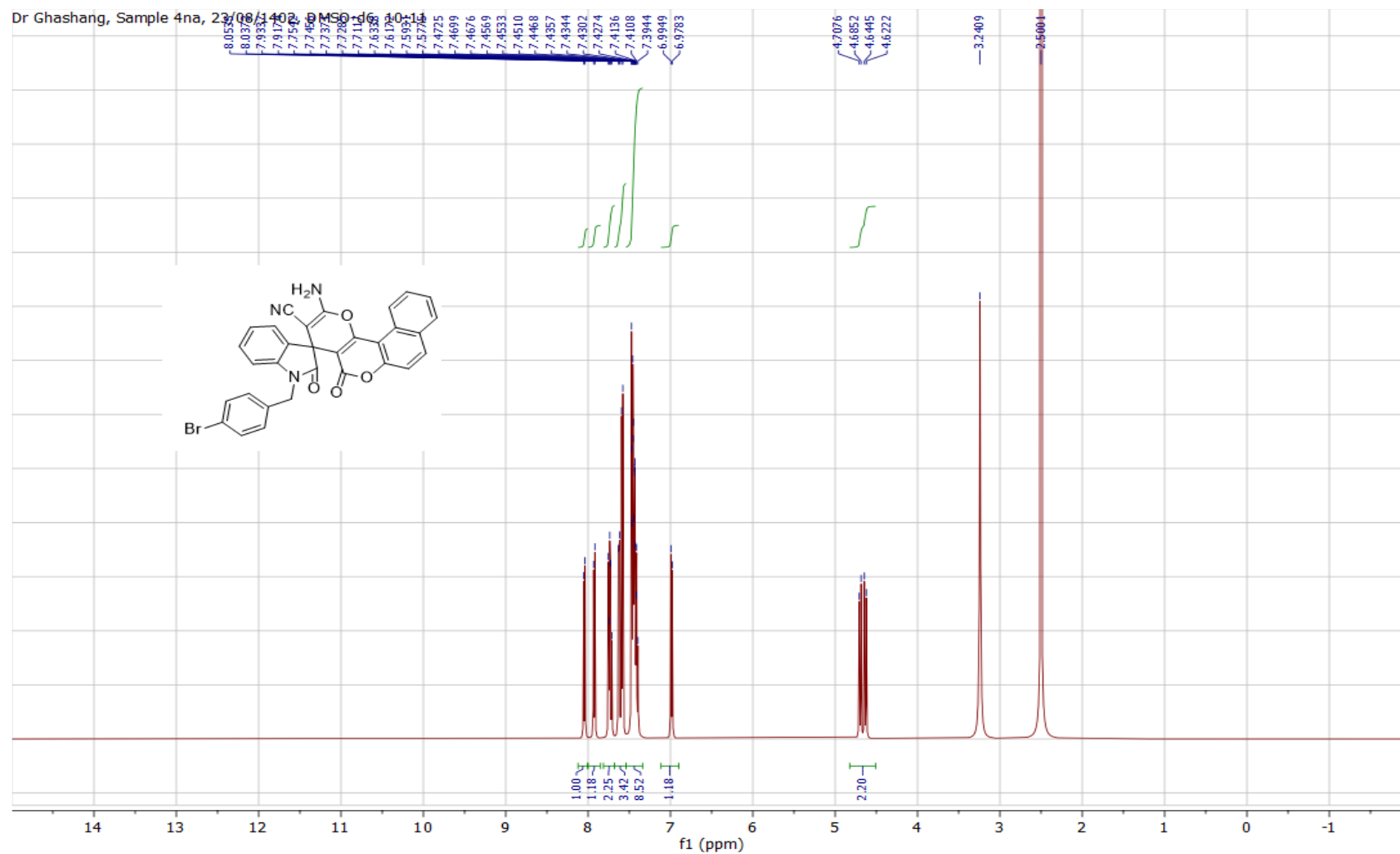
**Figure S<sub>10</sub>:** <sup>1</sup>H-NMR spectrum of 2-Amino-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 3a)



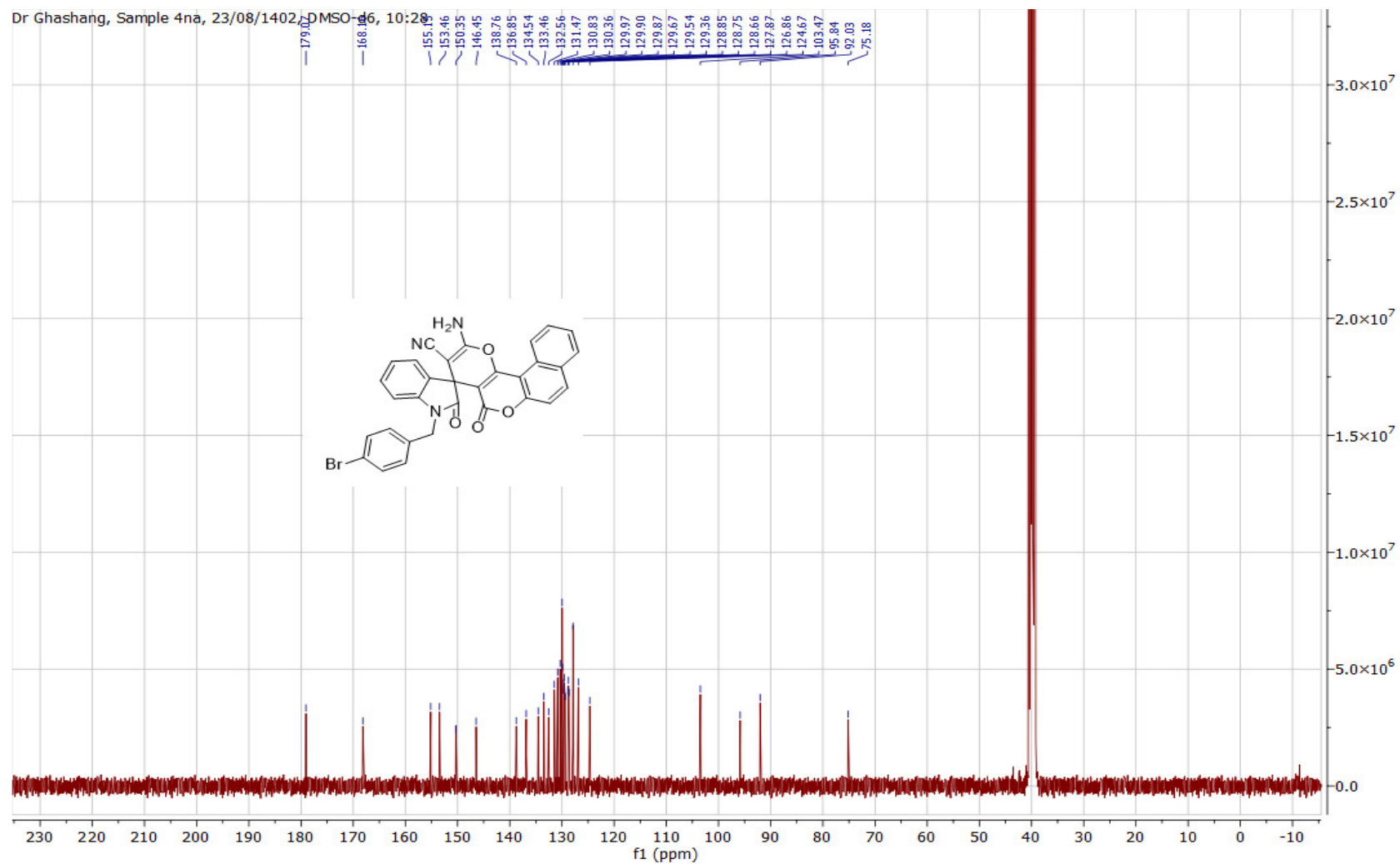
**Figure S<sub>11</sub>:**  $^{13}\text{C}$ -NMR spectrum of 2-Amino-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 3a)



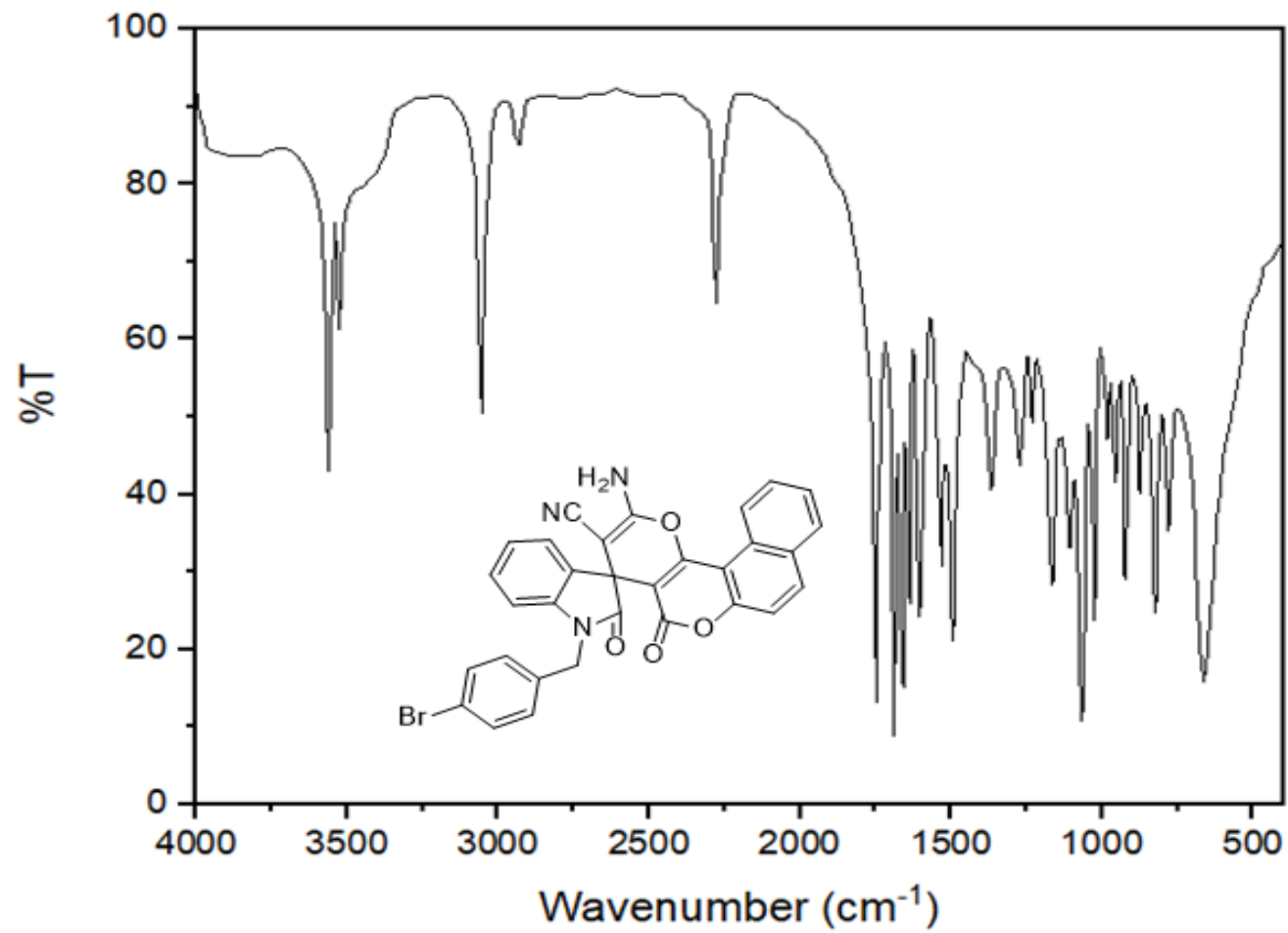
**Figure S<sub>12</sub>:** FT-IR analysis of 2-Amino-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 3a)



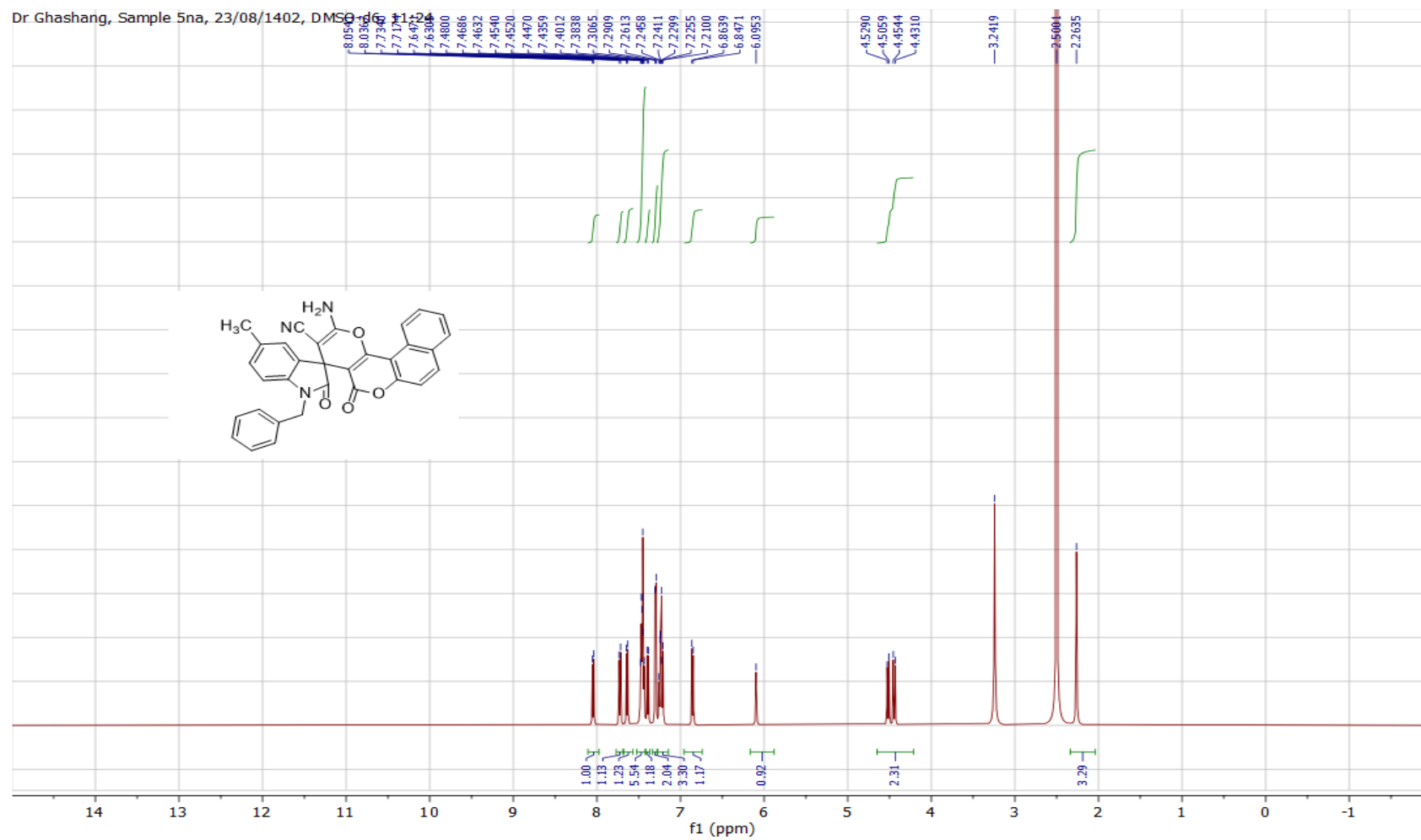
**Figure S<sub>13</sub>:** <sup>1</sup>H-NMR spectrum of 2-Amino-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 4a)



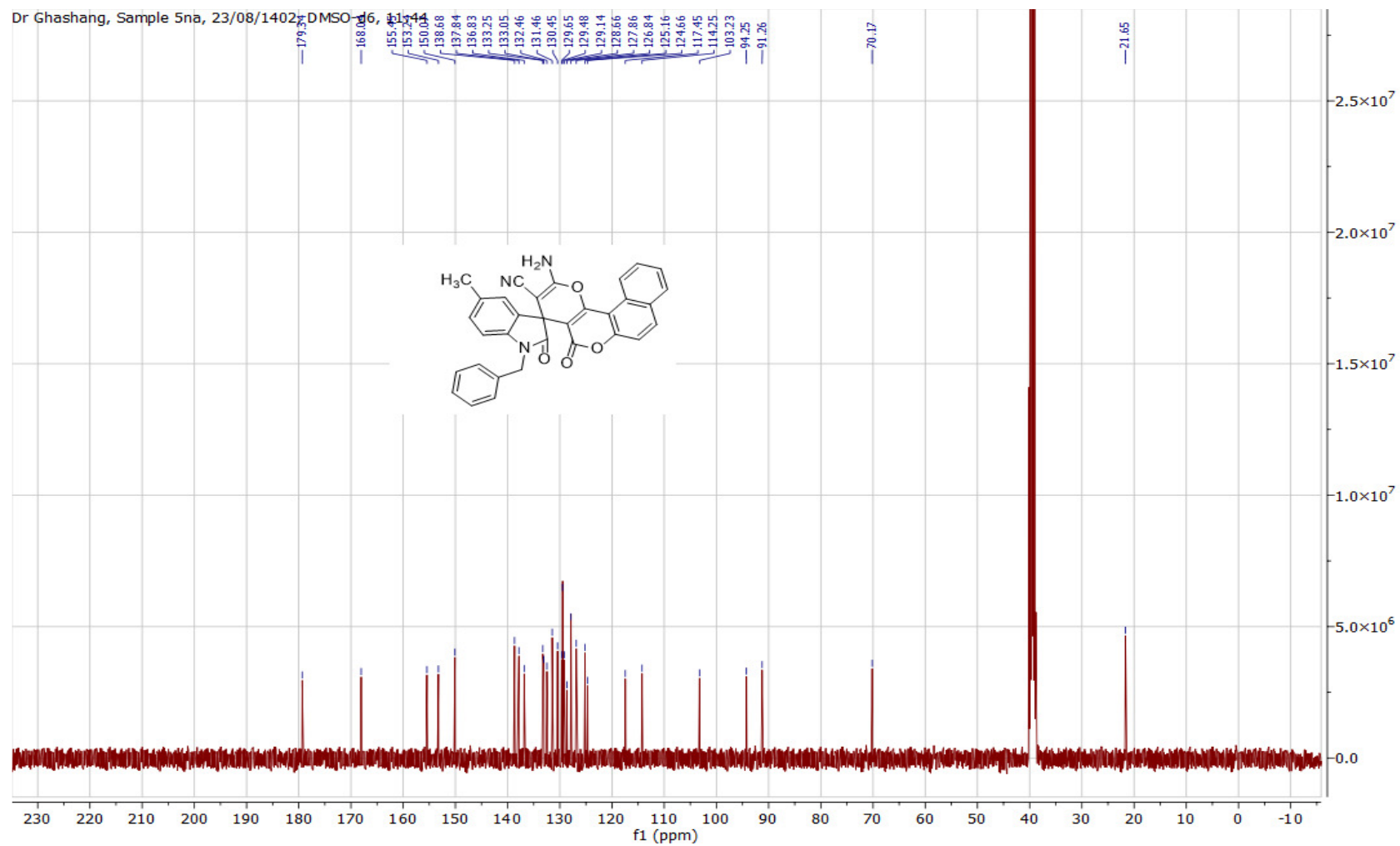
**Figure S14:**  $^{13}\text{C}$ -NMR spectrum of 2-Amino-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 4a)



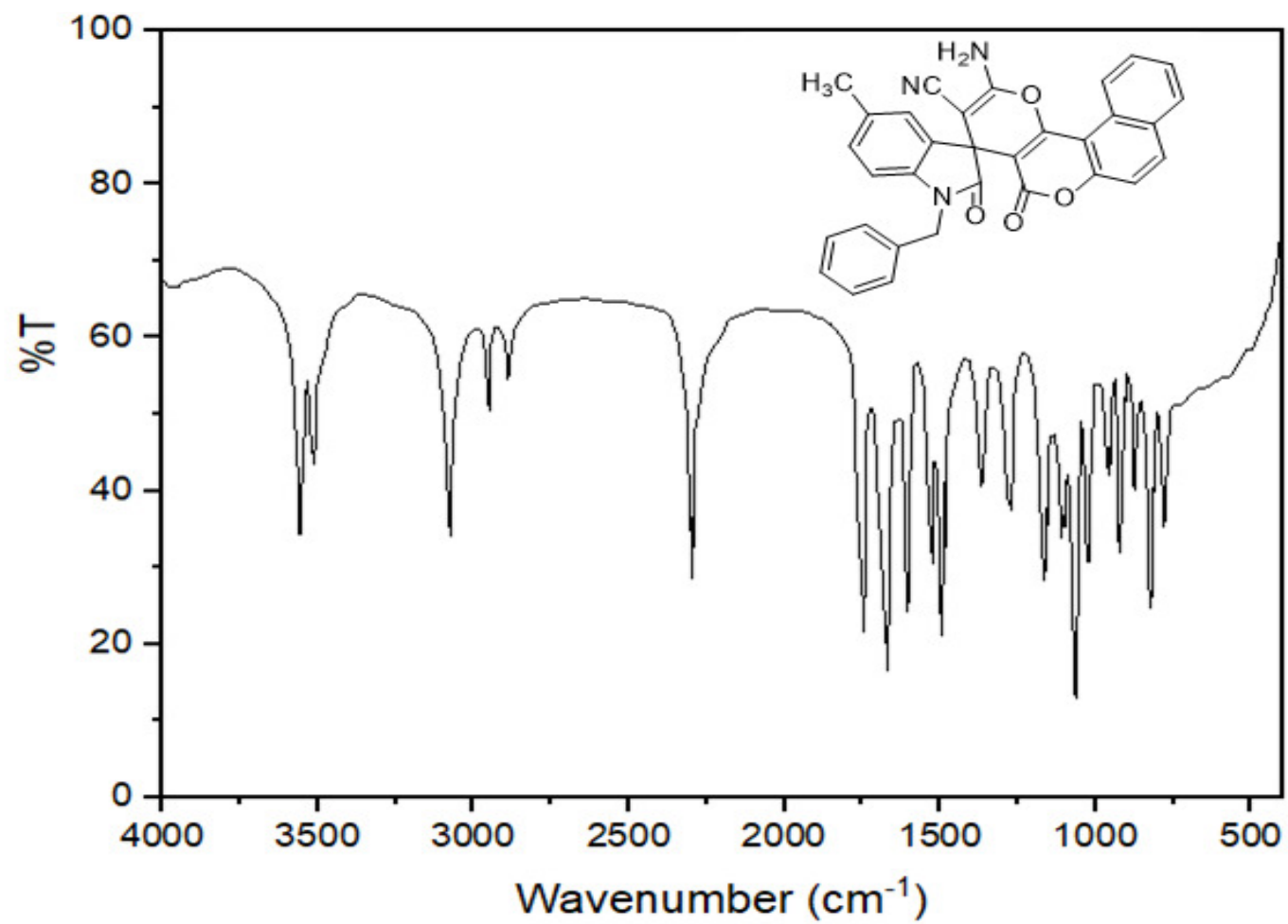
**Figure S15:** FT-IR analysis of 2-Amino-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 4a)



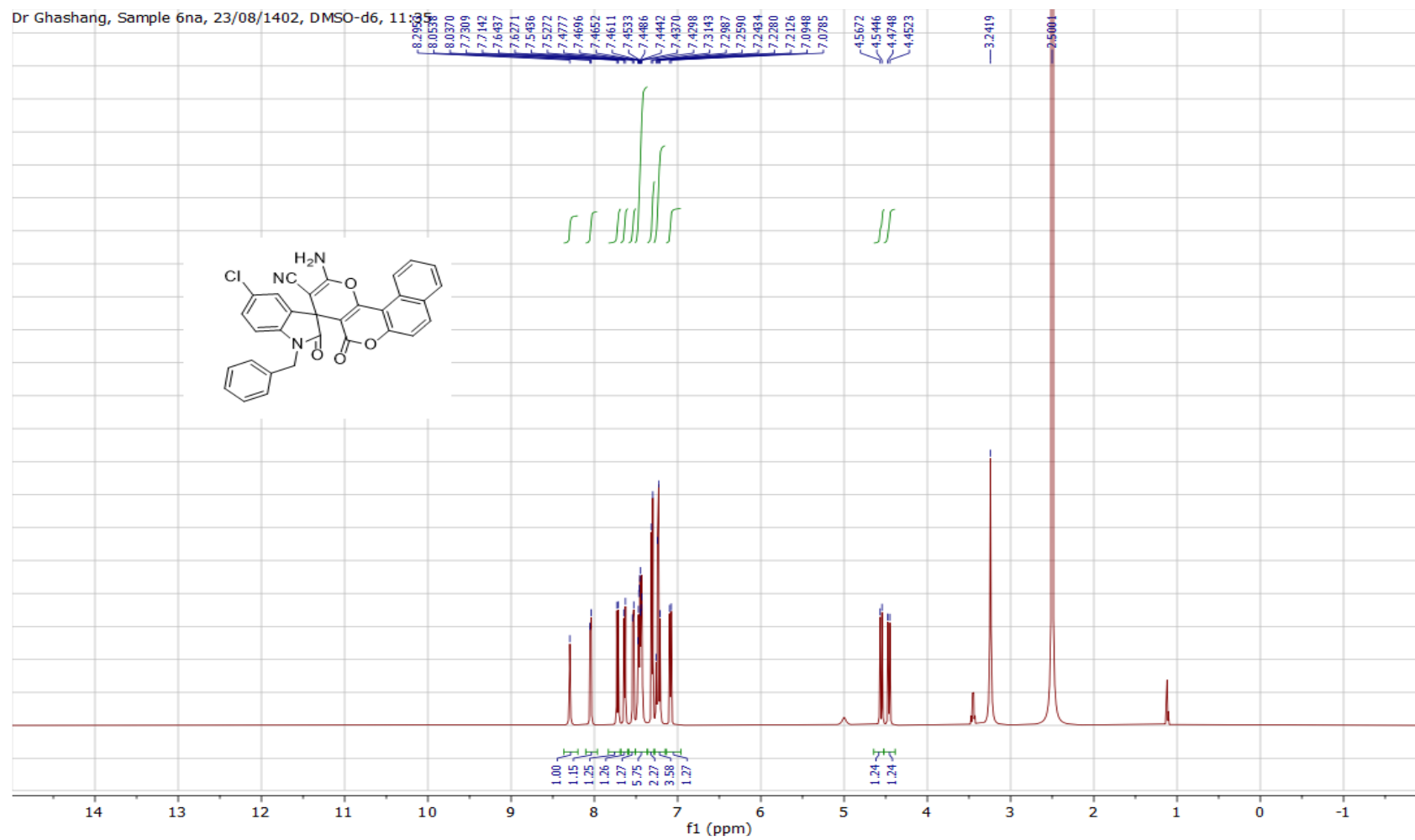
**Figure S<sub>16</sub>:** <sup>1</sup>H-NMR spectrum of 2-Amino-1'-benzyl-5'-methyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 5a)



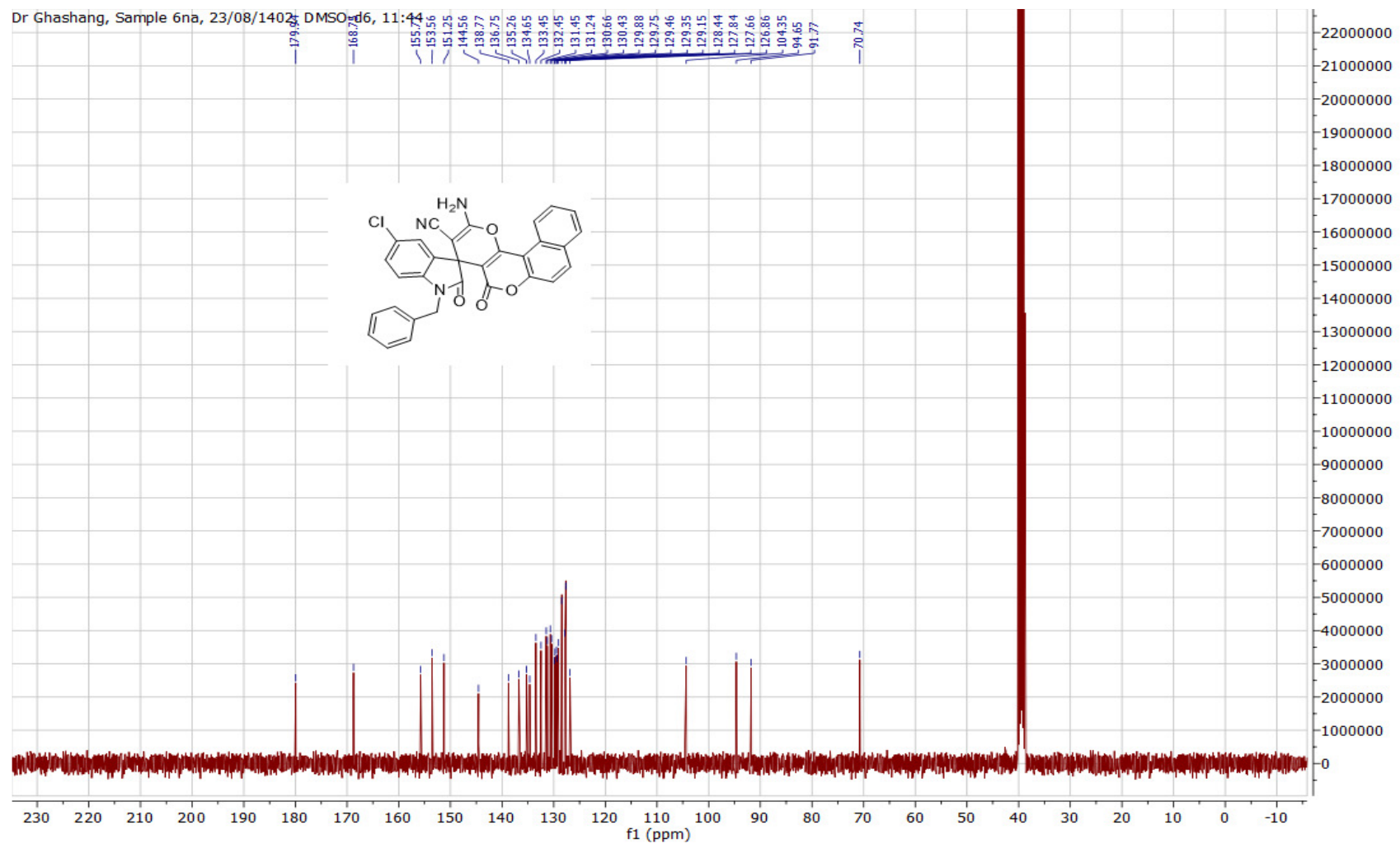
**Figure S17:**  $^{13}\text{C}$ -NMR spectrum of 2-Amino-1'-benzyl-5'-methyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 5a)



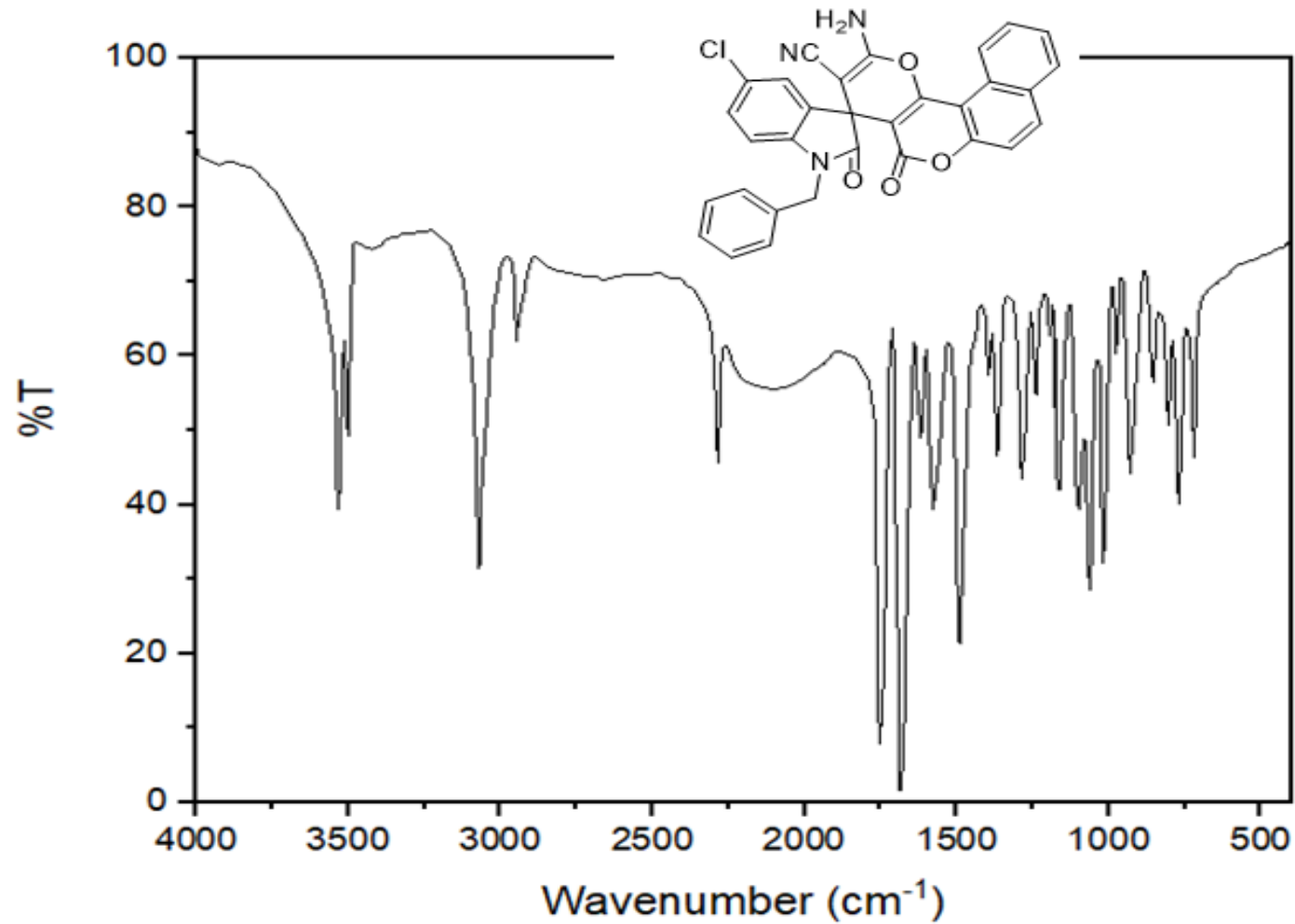
**Figure S18:** FT-IR analysis of 2-Amino-1'-benzyl-5'-methyl-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 5a)



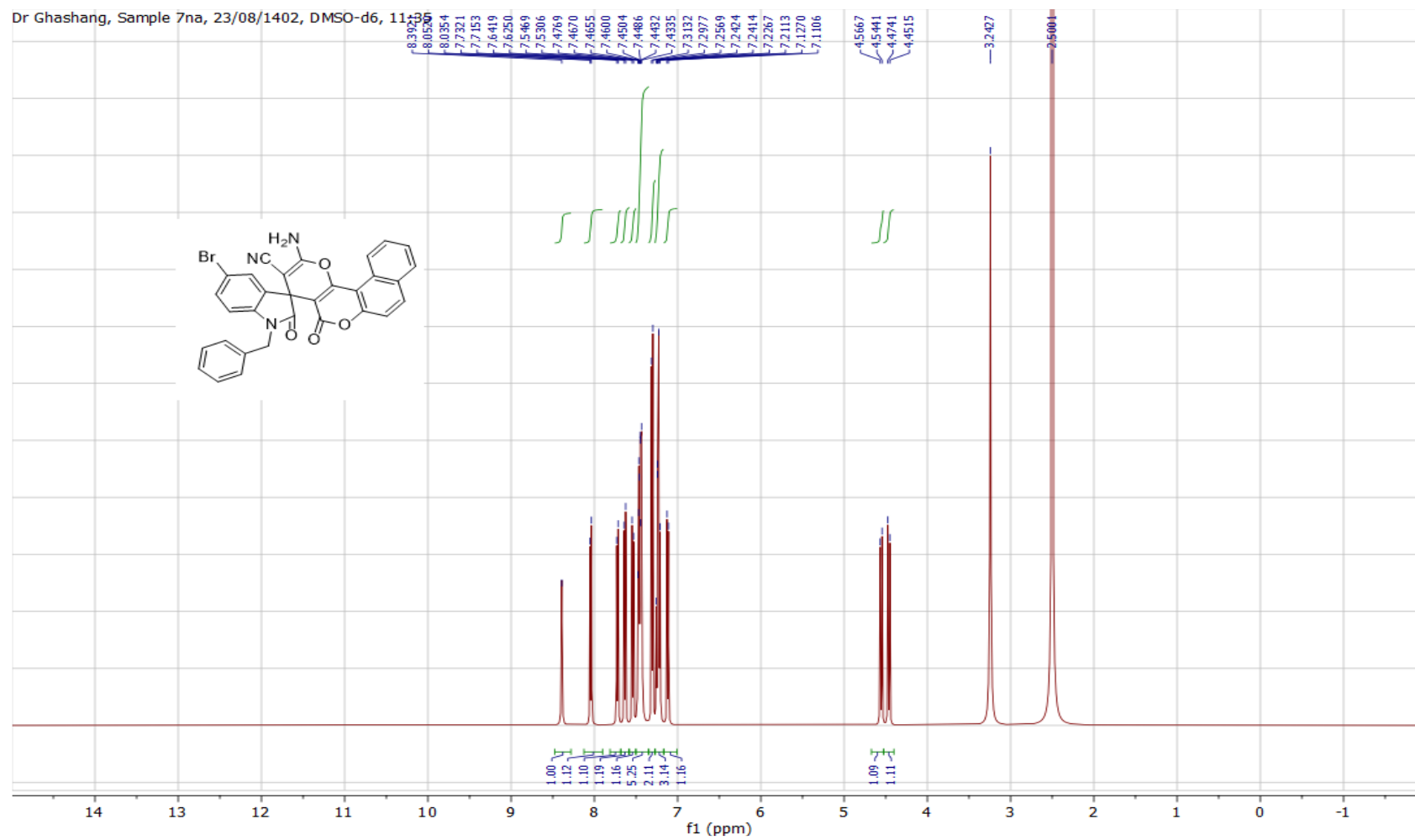
**Figure S19:**  $^1\text{H-NMR}$  spectrum of 2-Amino-1'-benzyl-5'-chloro-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 6a)



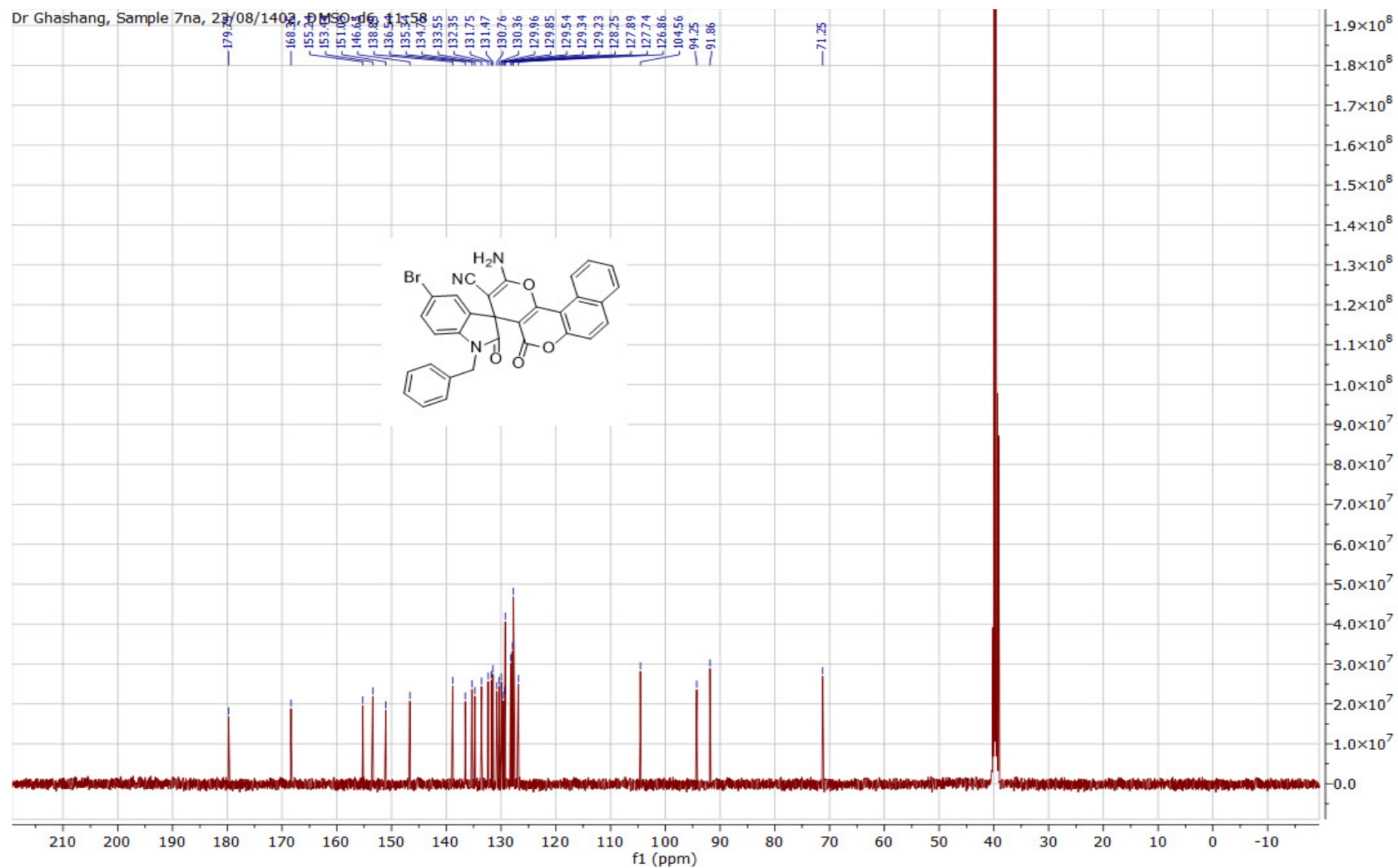
**Figure S<sub>20</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-1'-benzyl-5'-chloro-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 6a)



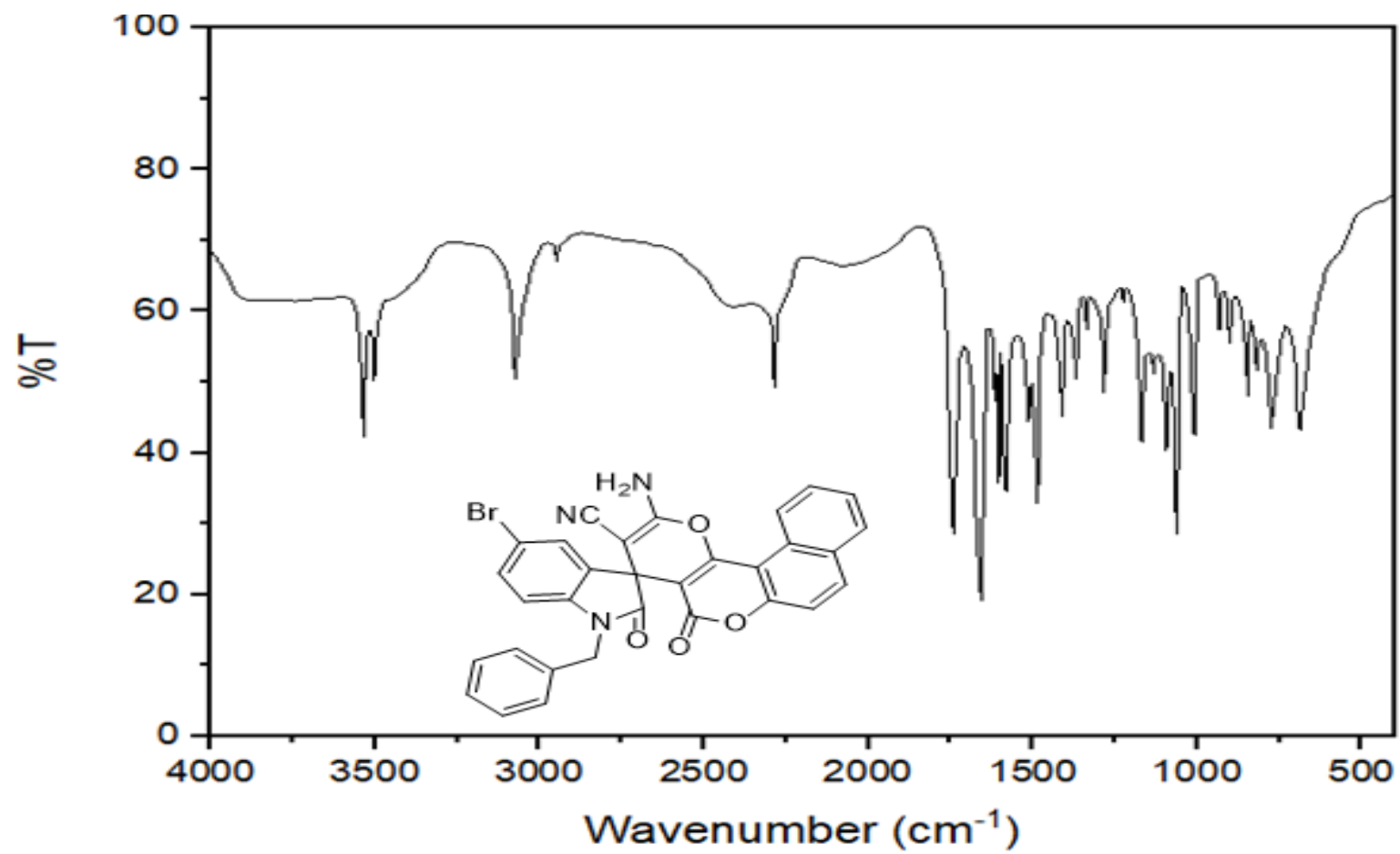
**Figure S21:** FT-IR analysis of 2-Amino-1'-benzyl-5'-chloro-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 6a)



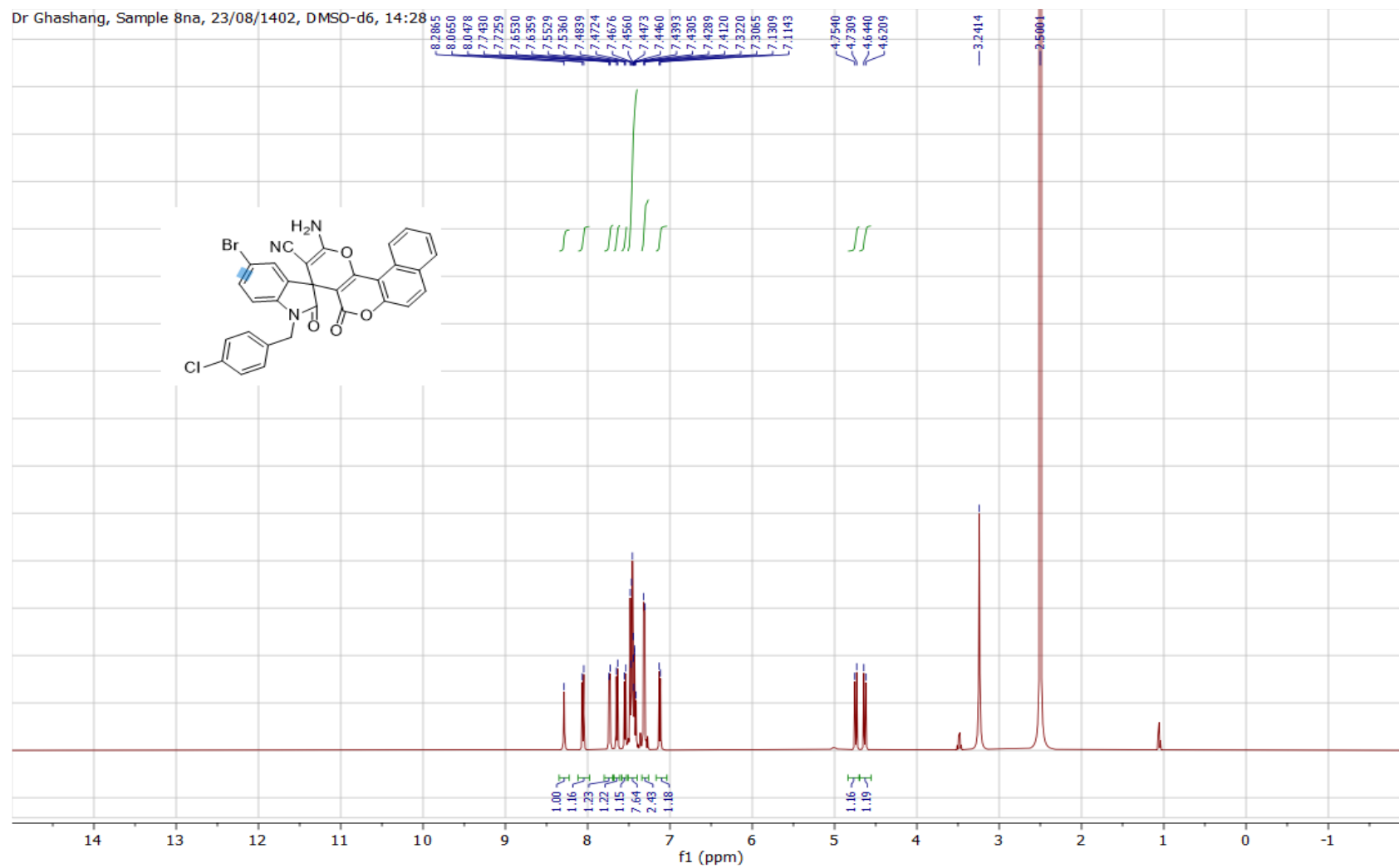
**Figure S22:**  $^1\text{H-NMR}$  spectrum of 2-Amino-1'-benzyl-5'-bromo-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 7a)



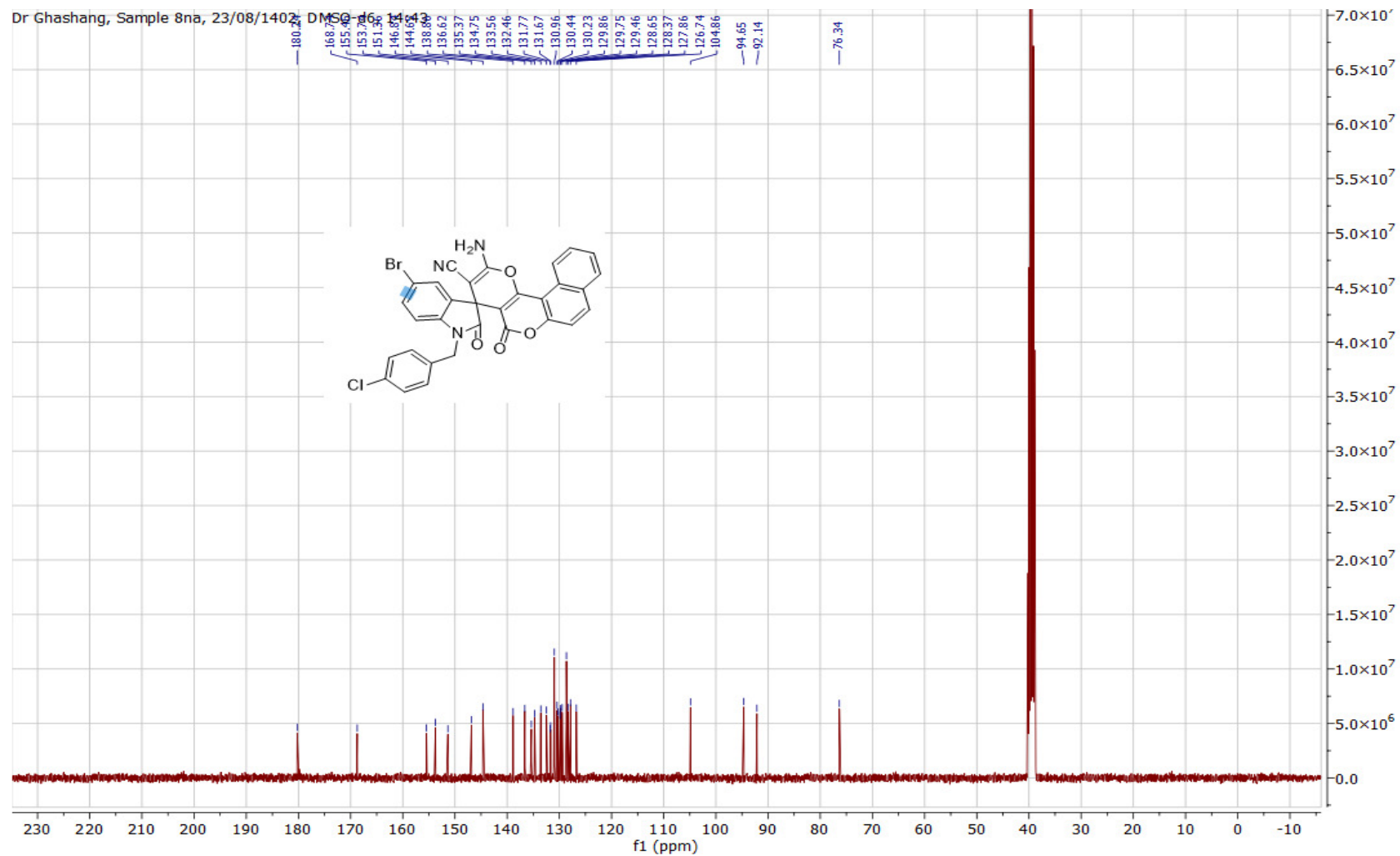
**Figure S<sub>23</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-1'-benzyl-5'-bromo-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 7a)



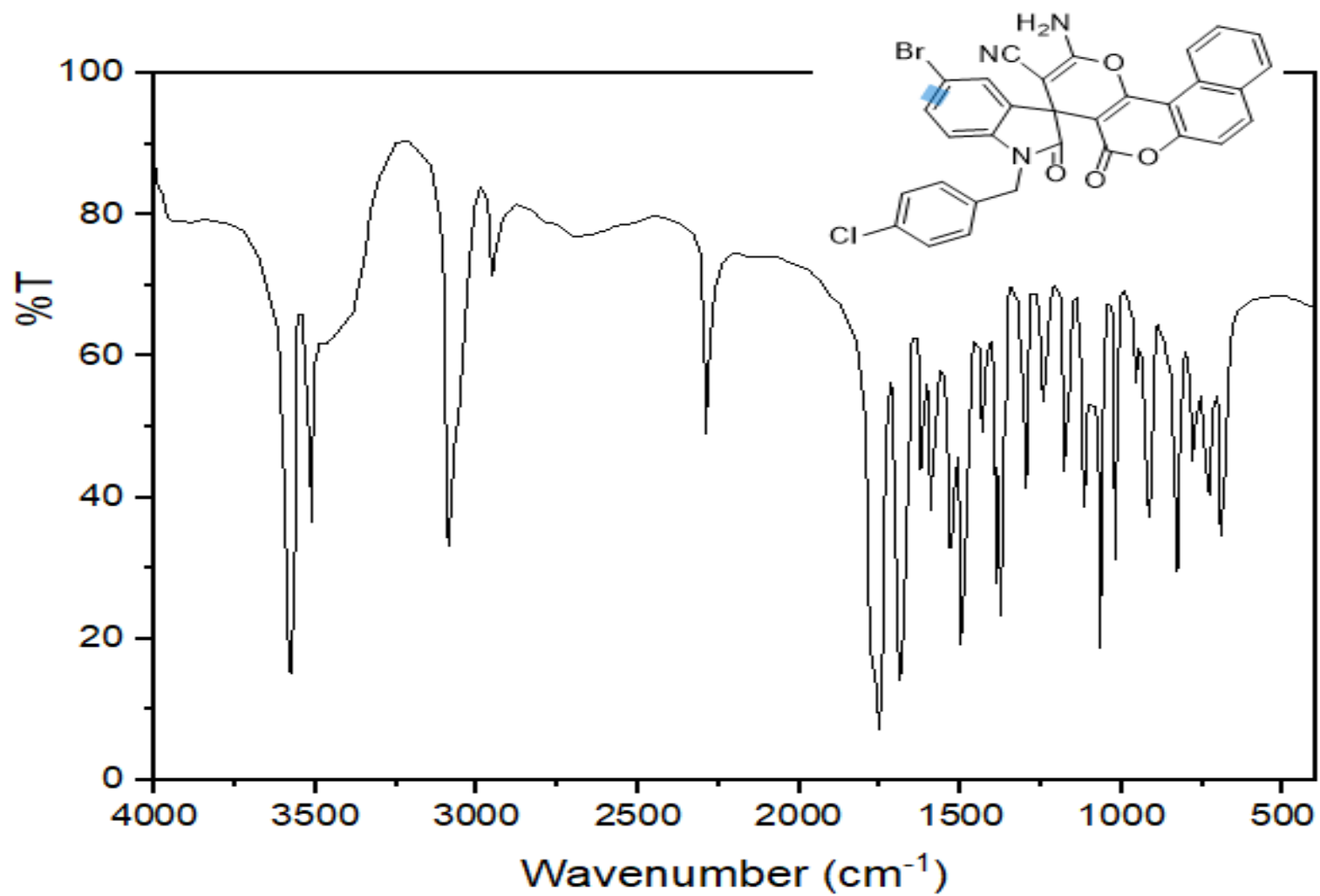
**Figure S<sub>24</sub>:** FT-IR analysis of 2-Amino-1'-benzyl-5'-bromo-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 7a)



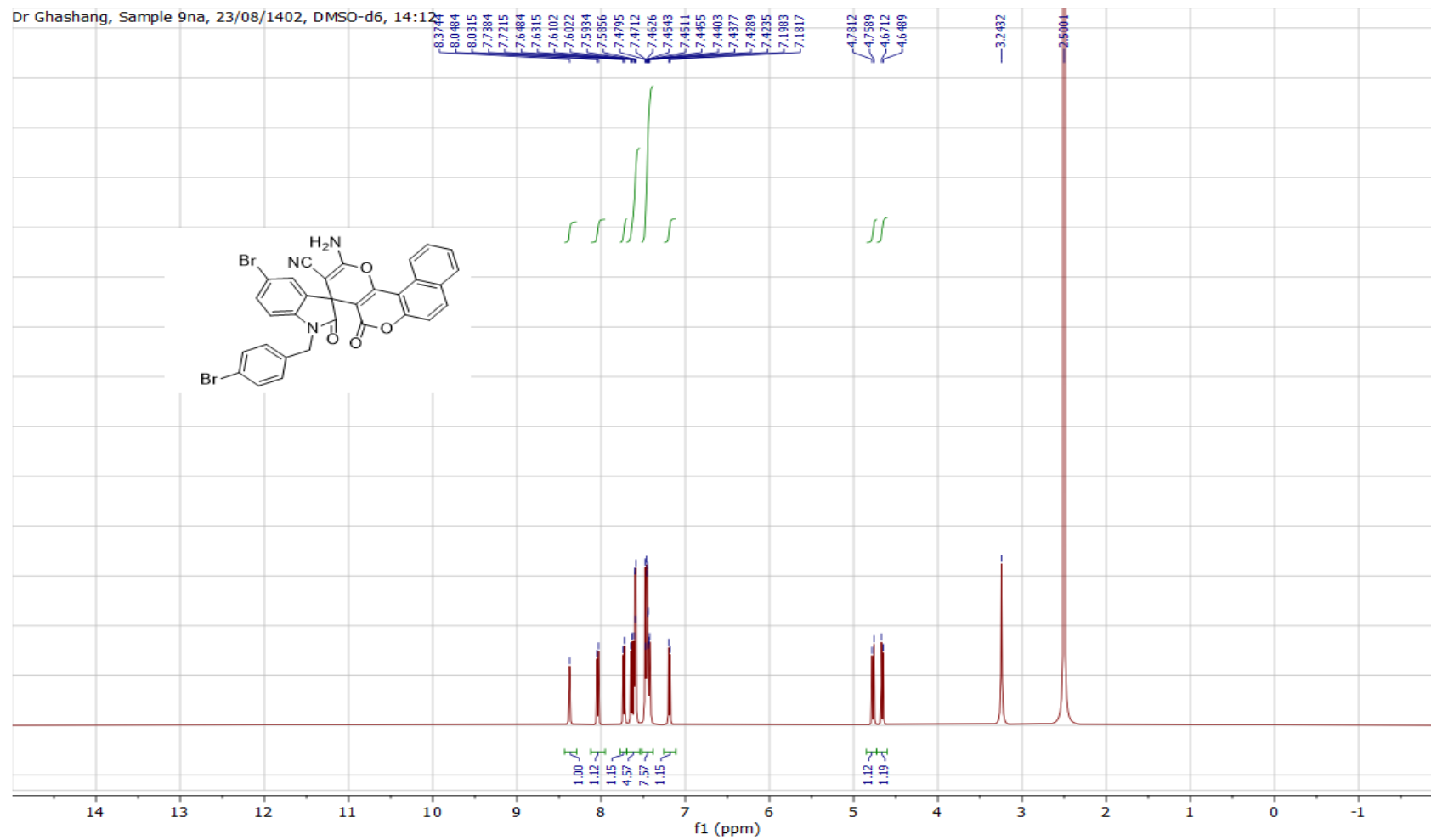
**Figure S<sub>25</sub>:** <sup>1</sup>H-NMR spectrum of 2-Amino-5'-bromo-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 8a)



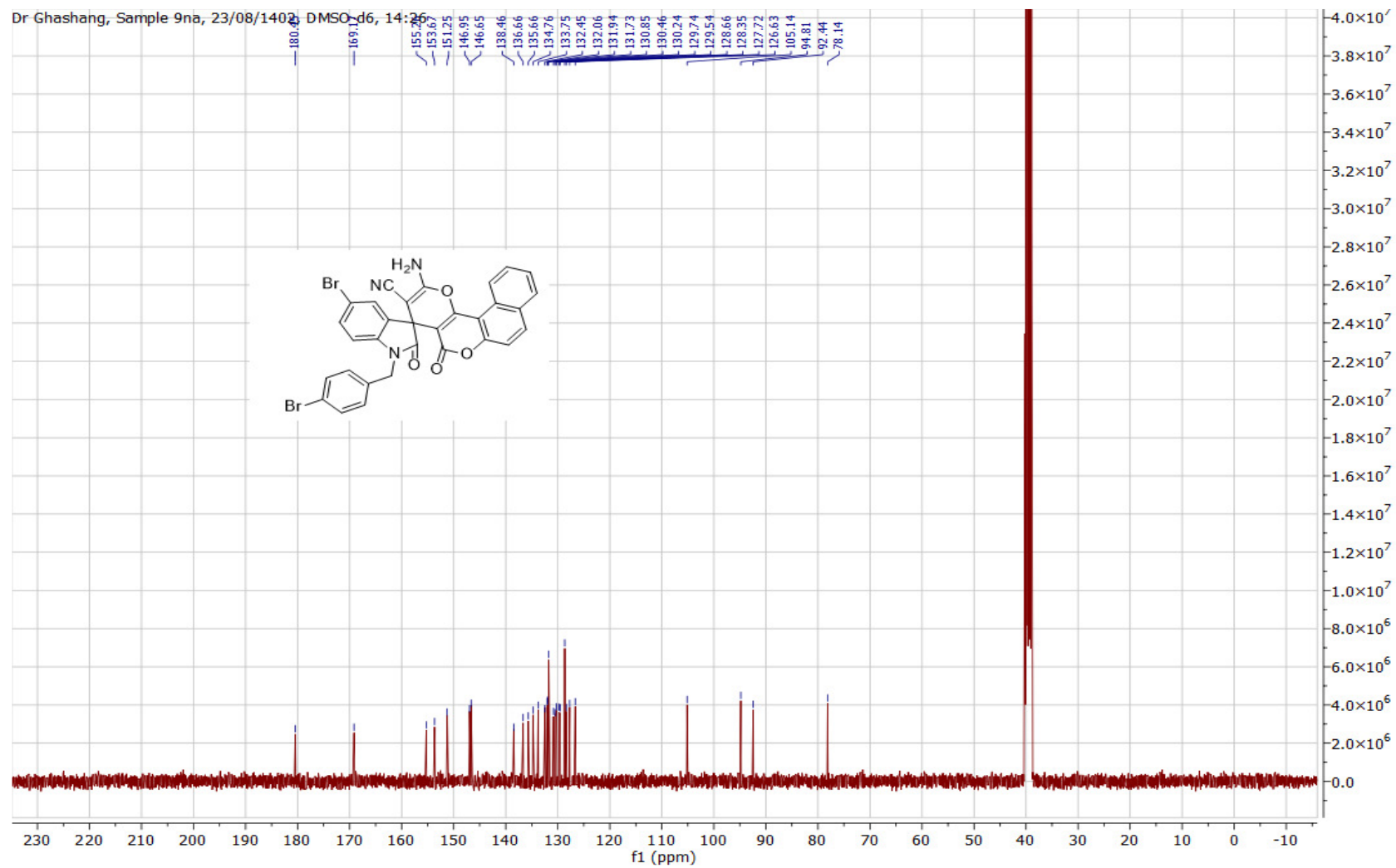
**Figure S<sub>26</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-5'-bromo-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 8a)



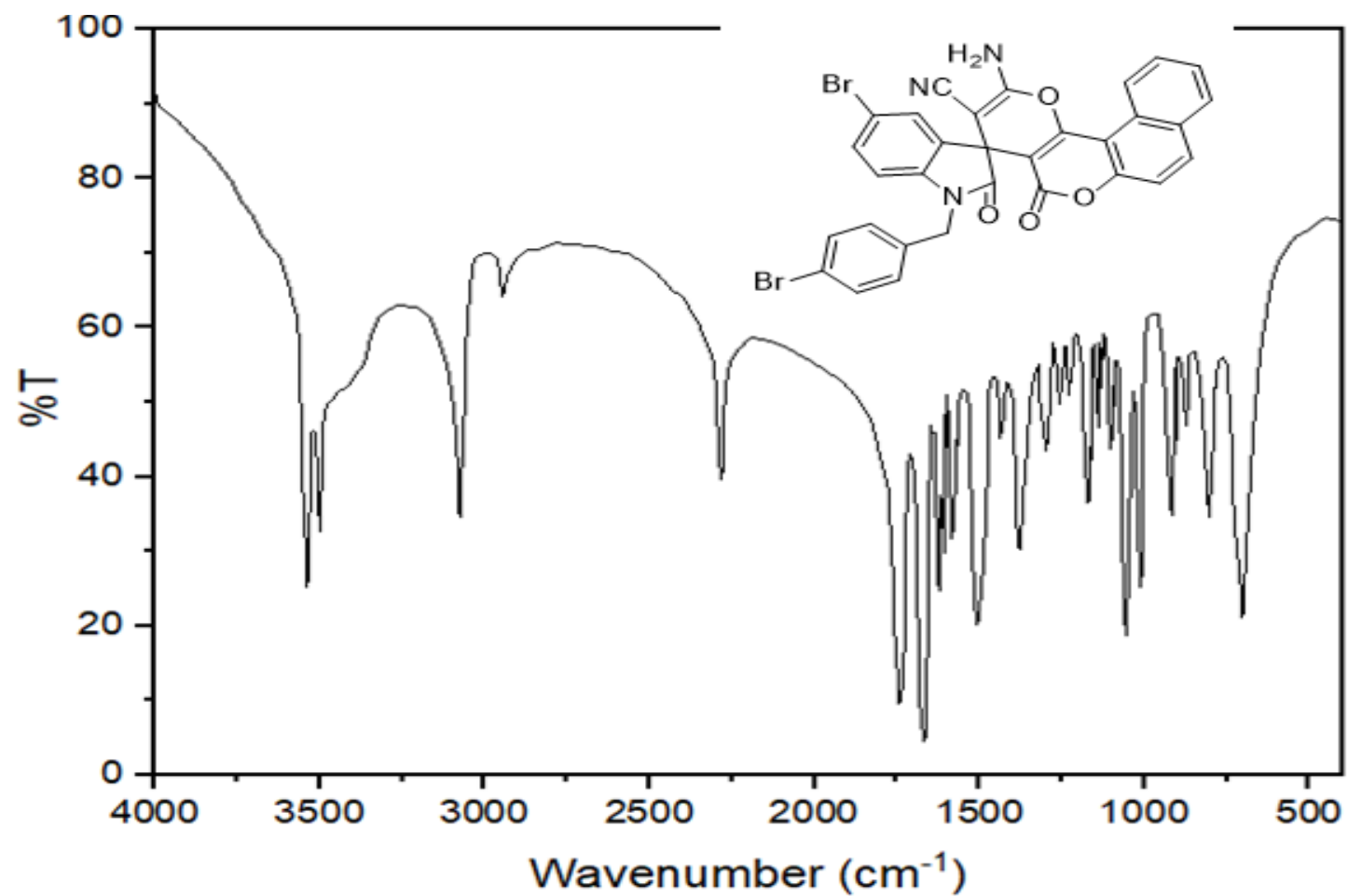
**Figure S<sub>27</sub>:** FT-IR analysis of 2-Amino-5'-bromo-1'-(4-chlorobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 8a)



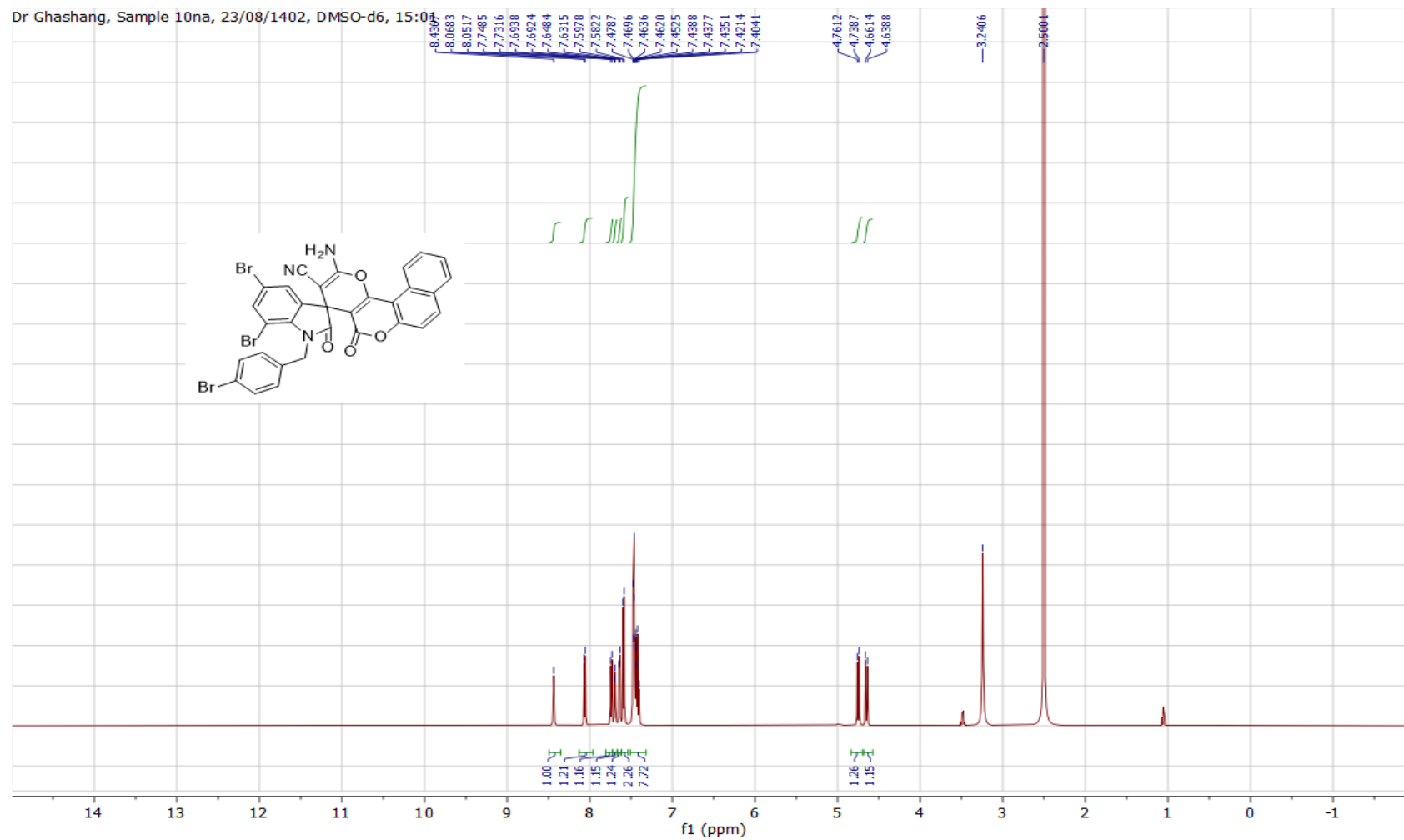
**Figure S28:**  $^1\text{H-NMR}$  spectrum of 2-Amino-5'-bromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 9a)



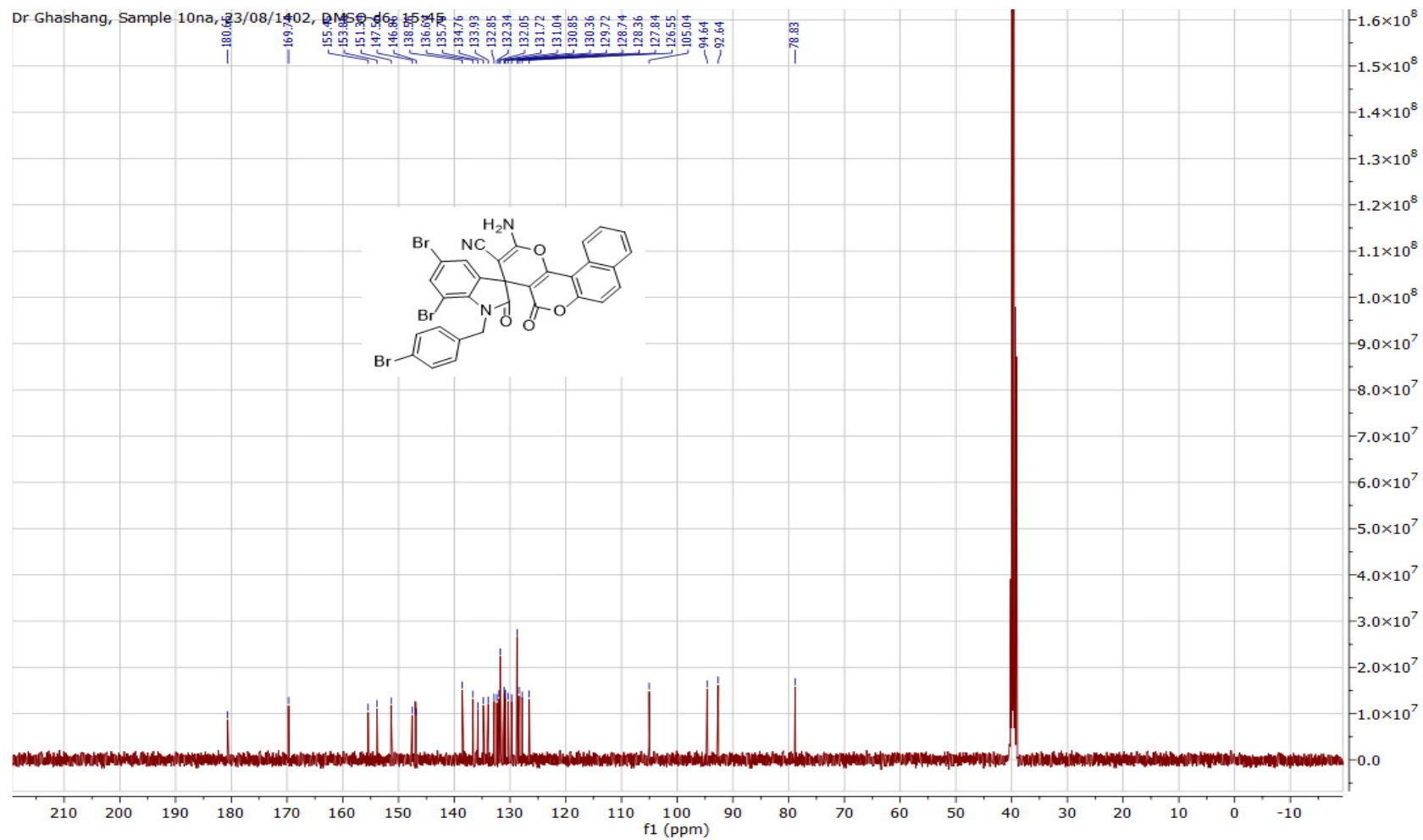
**Figure S<sub>29</sub>:** <sup>13</sup>C-NMR spectrum of 2-Amino-5'-bromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 9a)



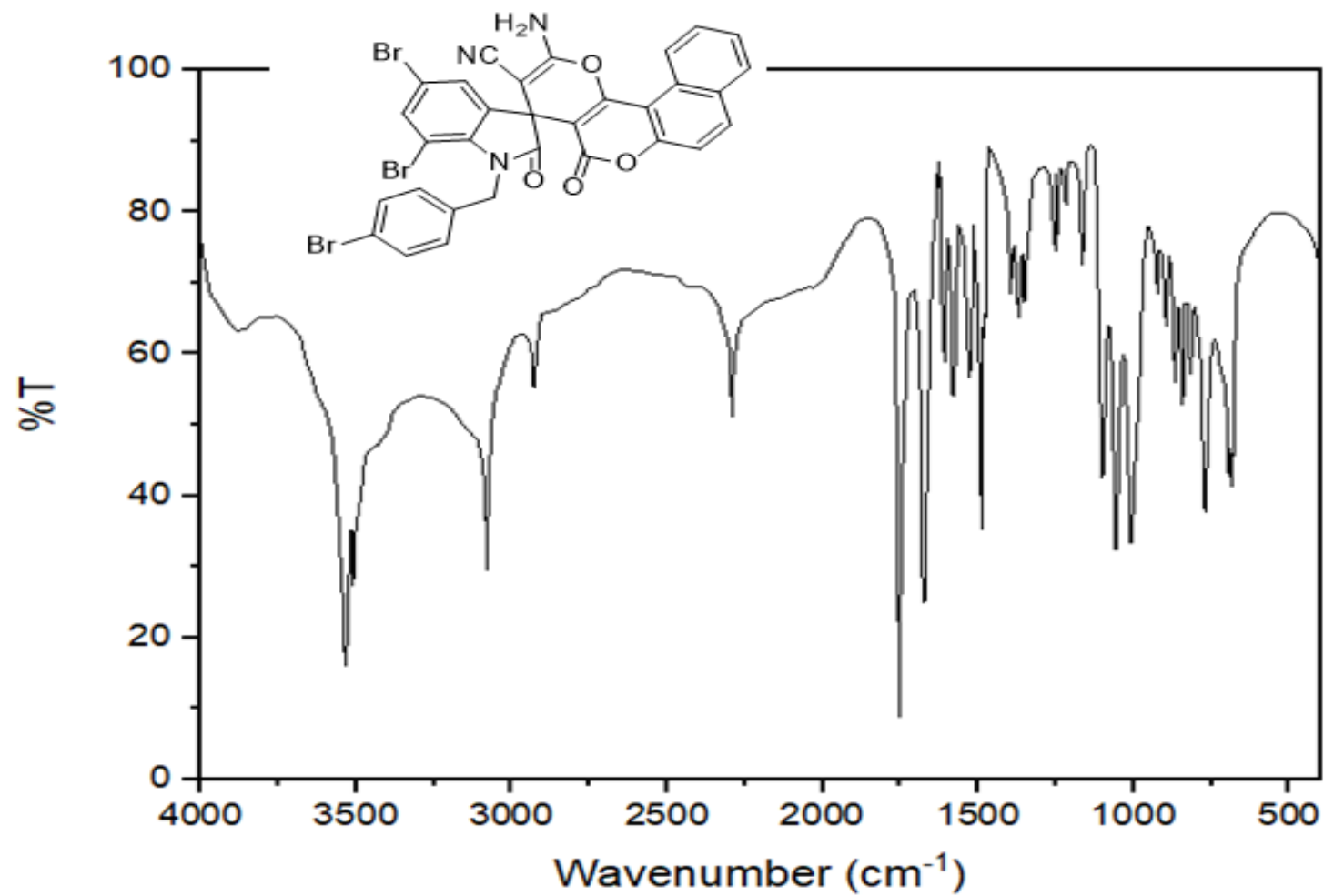
**Figure S30:** FT-IR analysis of *2-Amino-5'-bromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile* (Table 2, Product 9a)



**Figure S31:**  $^1\text{H-NMR}$  spectrum of 2-Amino-5',7'-dibromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 10a)



**Figure S32:** <sup>13</sup>C-NMR spectrum of 2-Amino-5',7'-dibromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 10a)



**Figure S33:** FT-IR analysis of 2-Amino-5',7'-dibromo-1'-(4-bromobenzyl)-2',5-dioxo-5H-spiro[benzo[f]pyrano[3,2-c]chromene-4,3'-indoline]-3-carbonitrile (Table 2, Product 10a)