

## Supplementary Information

### **Sonochemistry- and mechanochemistry-driven one-pot synthesis of polyfunctionalised 5-iodo-1*H*-1,2,3-triazoles through a copper(I)-catalysed click chemistry**

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## 1. General

All chemicals (analytical grade) were purchased from reputed companies and used without further purification.  $^1\text{H}$ ,  $^{13}\text{C}$ , and  $^{19}\text{F}$  NMR spectra were collected at 400, 100, and 376 MHz, respectively, on a Bruker DRX spectrometer using  $\text{CDCl}_3$  as solvent. Chemical shifts were reported in  $\delta$  (ppm), relative to the internal standard, TMS. The signals observed are described as s (singlet), d (doublet), t (triplet), and m (multiplet). Coupling constants are reported as  $J$  values in Hz. Mass spectrometry was obtained using a Microtek Q-TOF Micro YA 263 Waters high-resolution mass spectrometer. The melting points were recorded on a Chemiline CL-725 melting point apparatus and are uncorrected. Thin Layer Chromatography (TLC) was performed using silica gel 60 F<sub>254</sub>(Merck) plates. A PM 100, Retsch GmbH, Germany, ball-milling apparatus was used for all reactions. Safety statement of the procedure: We did not detect/encounter any unexpected, new, /or significant hazards or risks associated with the reported work.

## 2. General procedure

### 2.1 General procedure for the synthesis of functionalized 5-iodo-1*H*-1,2,3-triazoles **4** under the sonochemical method (Method A)

A mixture of aryl acetylenes (**1**; 0.2 mmol), benzyl bromides (**2**; 0.2 mmol), sodium azide (**3**; 0.2 mmol), CuI (1.1 equiv.), and 1,10-phenanthroline were added sequentially to an oven-dried glass vessel (20 mL), followed by the addition of 5 mL of acetonitrile ( $\text{CH}_3\text{CN}$ ). The mixture was then irradiated with ultrasound (130 W, 20 kHz at 40% amplitude) for 15 minutes (monitored by TLC). Upon completion of the reaction, the entire content was transferred into a 25 mL separating funnel, followed by the addition of 20 mL of a 3:1 (v/v) mixture of ethyl acetate and water. The resulting mixture was then shaken well; the organic layer was separated and dried over anhydrous sodium sulfate. The solvent was removed under reduced pressure to obtain the crude mass, which was then subjected to column chromatographic purification using EtOAc–hexane mixtures as eluents to isolate the desired products 5-iodo-triazoles **4** (**4a-4z** and **4a'-4d'**).

### 2.2 General procedure for the synthesis of functionalized 5-iodo-1*H*-1,2,3-triazoles **4** under the mechanochemical method (Method B)

A mixture of aryl acetylenes (**1**; 0.2 mmol), benzyl bromides (**2**; 0.2 mmol), sodium azide (**3**; 0.2 mmol) and CuI (1.1 equiv.) were ball-milled under neat-conditions using 7 stainless-steel balls (10 mm in diameter) within a 25 mL of stainless-steel jar at 550 rpm for 10 min in the presence of 1,10-Phenanthroline (10 mol %) as an additive. The ball-milling operation was performed in an inverted rotation direction, with 30-second breaks at 5-minute intervals. On completion of the reaction (confirmed by TLC upon ceasing the grinding operation), 20 mL of ethyl acetate and aqueous solution in a proportion of 3:1 (v/v) was added to the resulting mixture and shaken well in a separating funnel. The organic layer was separated and dried over anhydrous sodium sulphate. The solvent was then removed under reduced pressure to obtain a white crude mass, which was then subjected to column chromatographic purification using EtOAc–hexane mixtures as eluents, to obtain pure products of **4** (**4a-4z** and **4a'-4d'**).

3. Scanned copies of <sup>1</sup>H-NMR, <sup>13</sup>C-NMR, <sup>19</sup>F-NMR (for compound 4k) spectra for the synthesized compounds 4 (4a-4z, and 4a'-4d'), 12 (12a, 12m) and <sup>1</sup>H-NMR, <sup>13</sup>C-NMR, and HRMS spectra of (4w-d<sub>1</sub>+4w-d<sub>2</sub>) (Figure S1-S63)

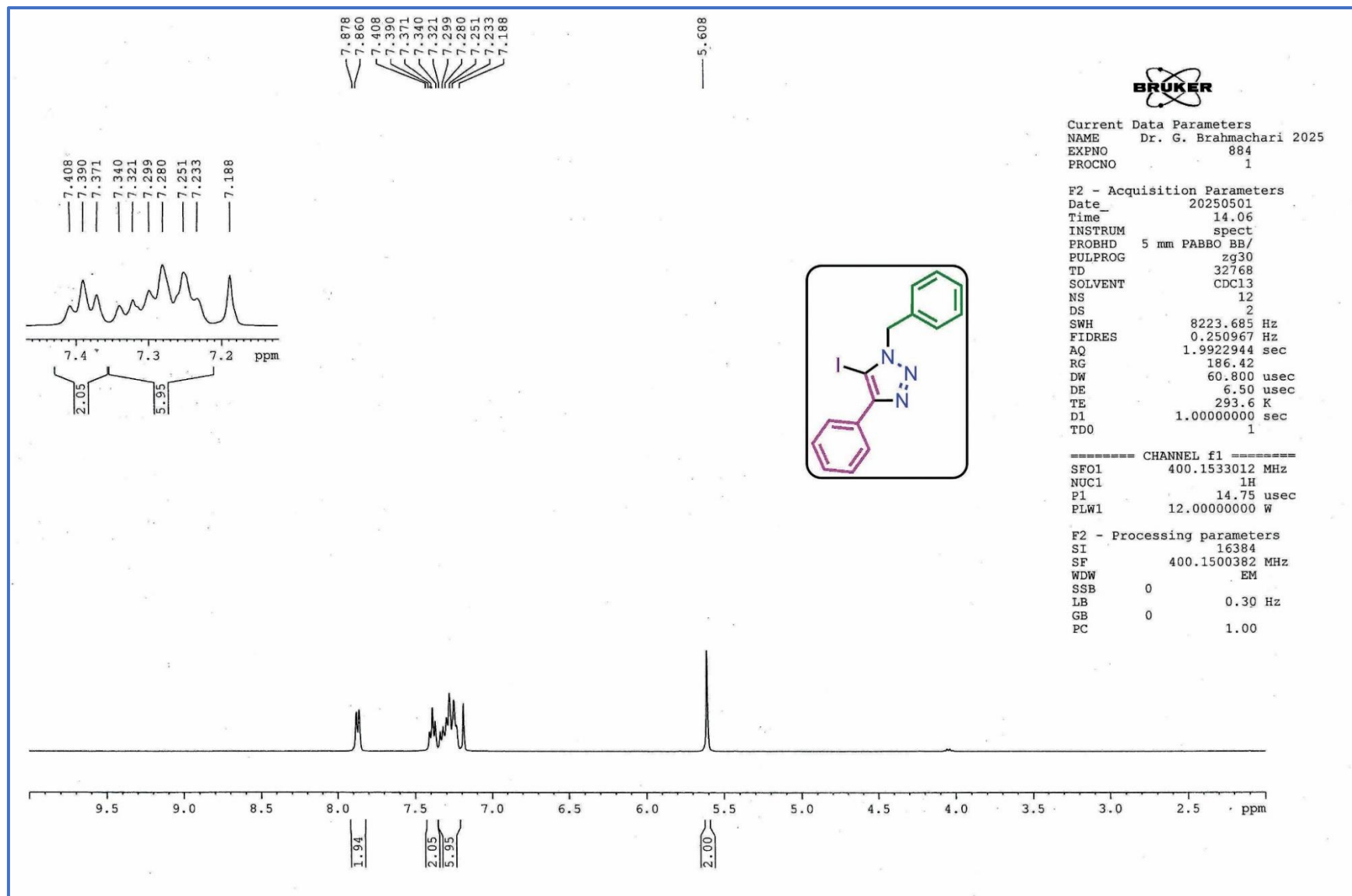


Figure S1. <sup>1</sup>H-NMR spectrum of 1-Benzyl-5-iodo-4-phenyl-1H-1,2,3-triazole (**4a**)

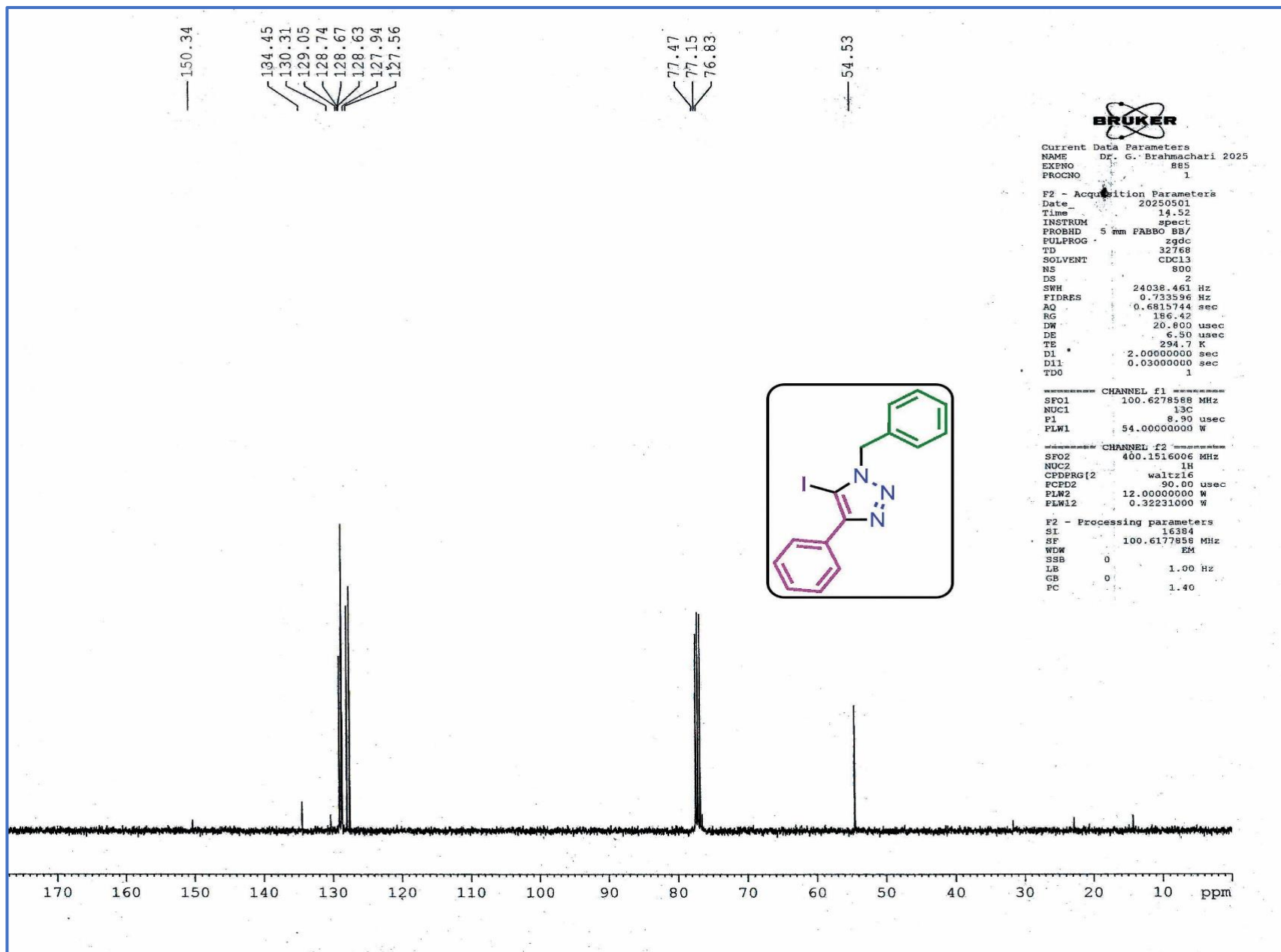


Figure S2.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-Benzyl-5-iodo-4-phenyl-1H-1,2,3-triazole (4a)

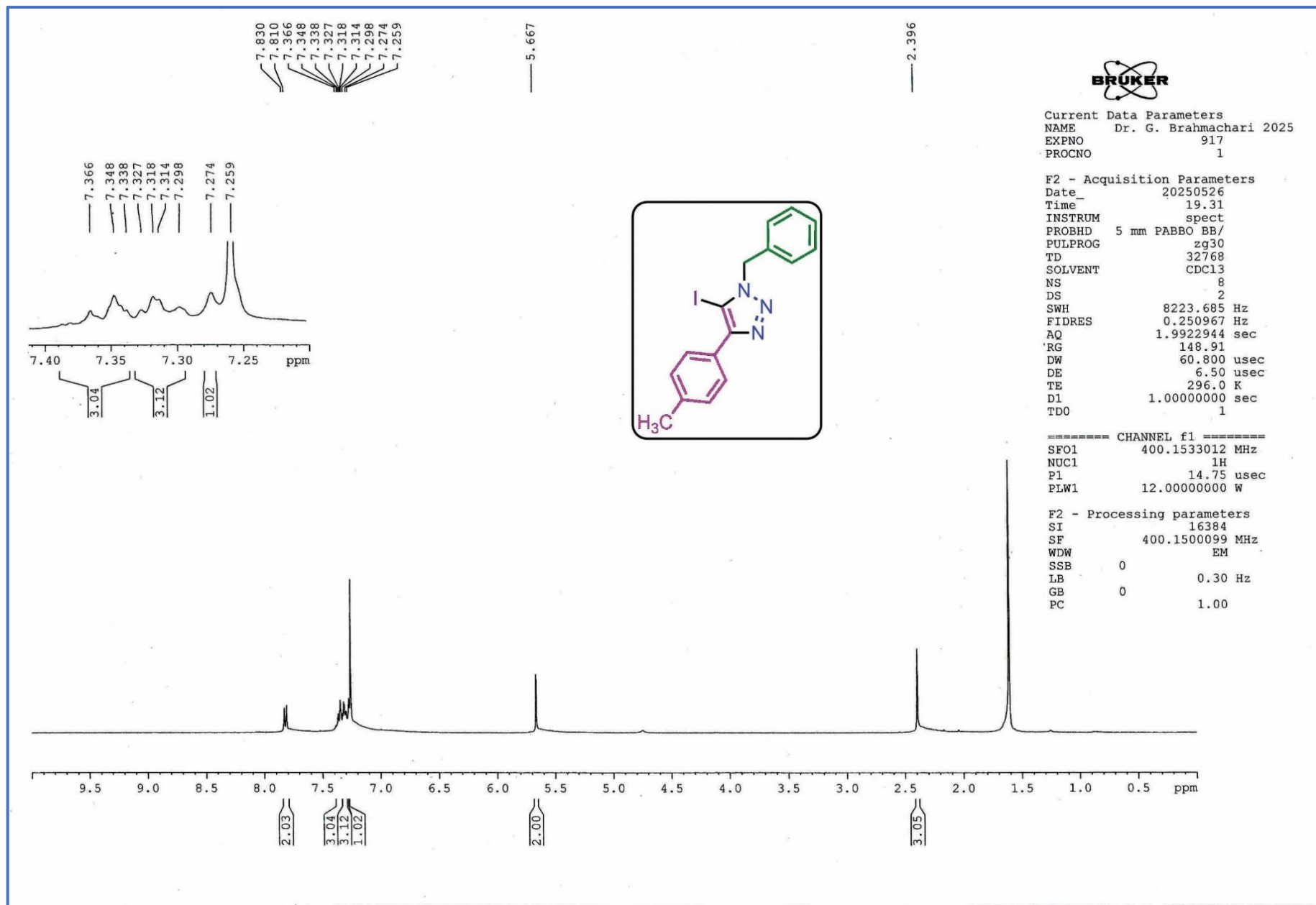


Figure S3. <sup>1</sup>H-NMR spectrum of 1-Benzyl-5-iodo-4-(*p*-tolyl)-1*H*-1,2,3-triazole (**4b**)

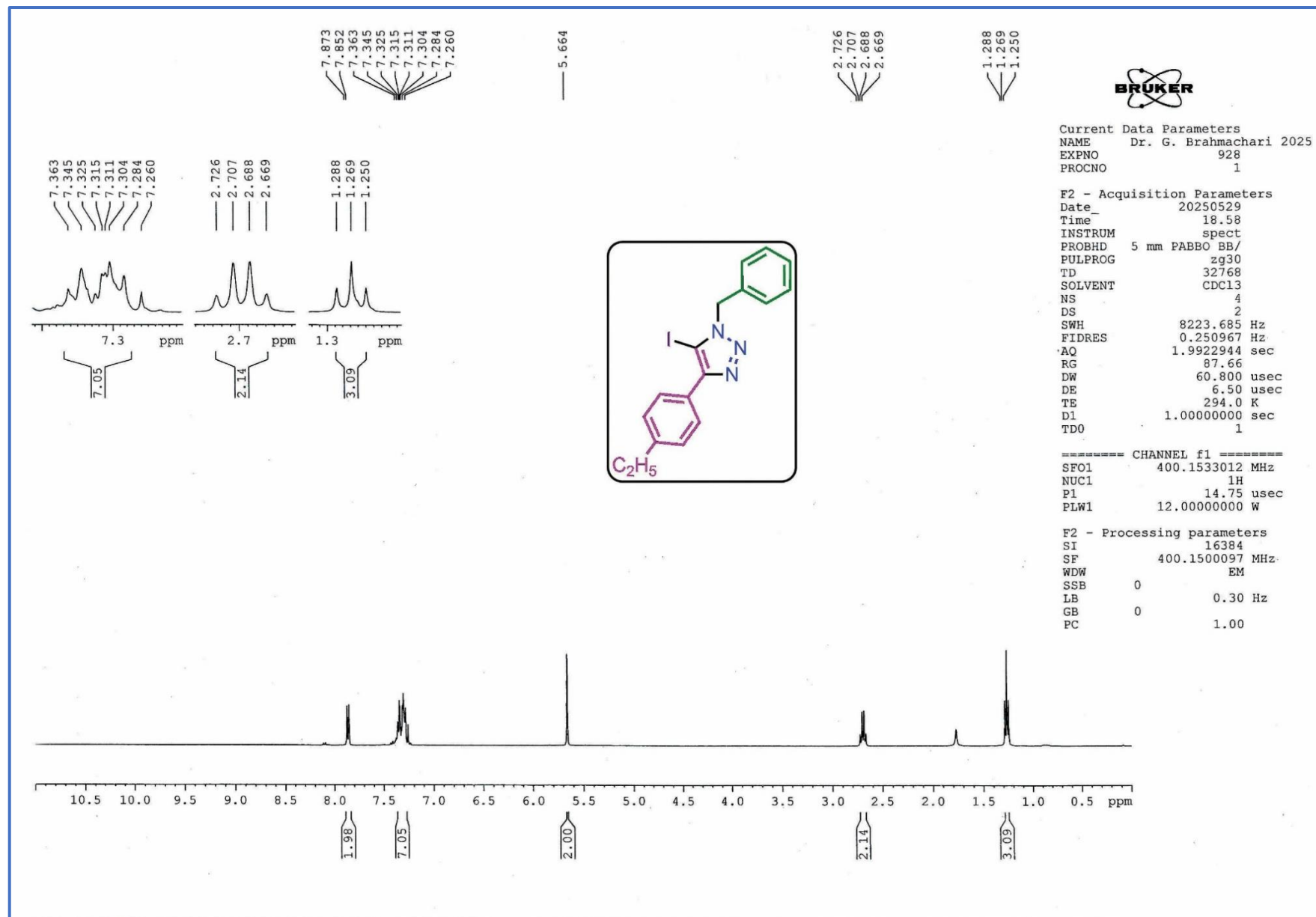


Figure S4. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-(4-ethylphenyl)-5-iodo-1H-1,2,3-triazole (**4c**)

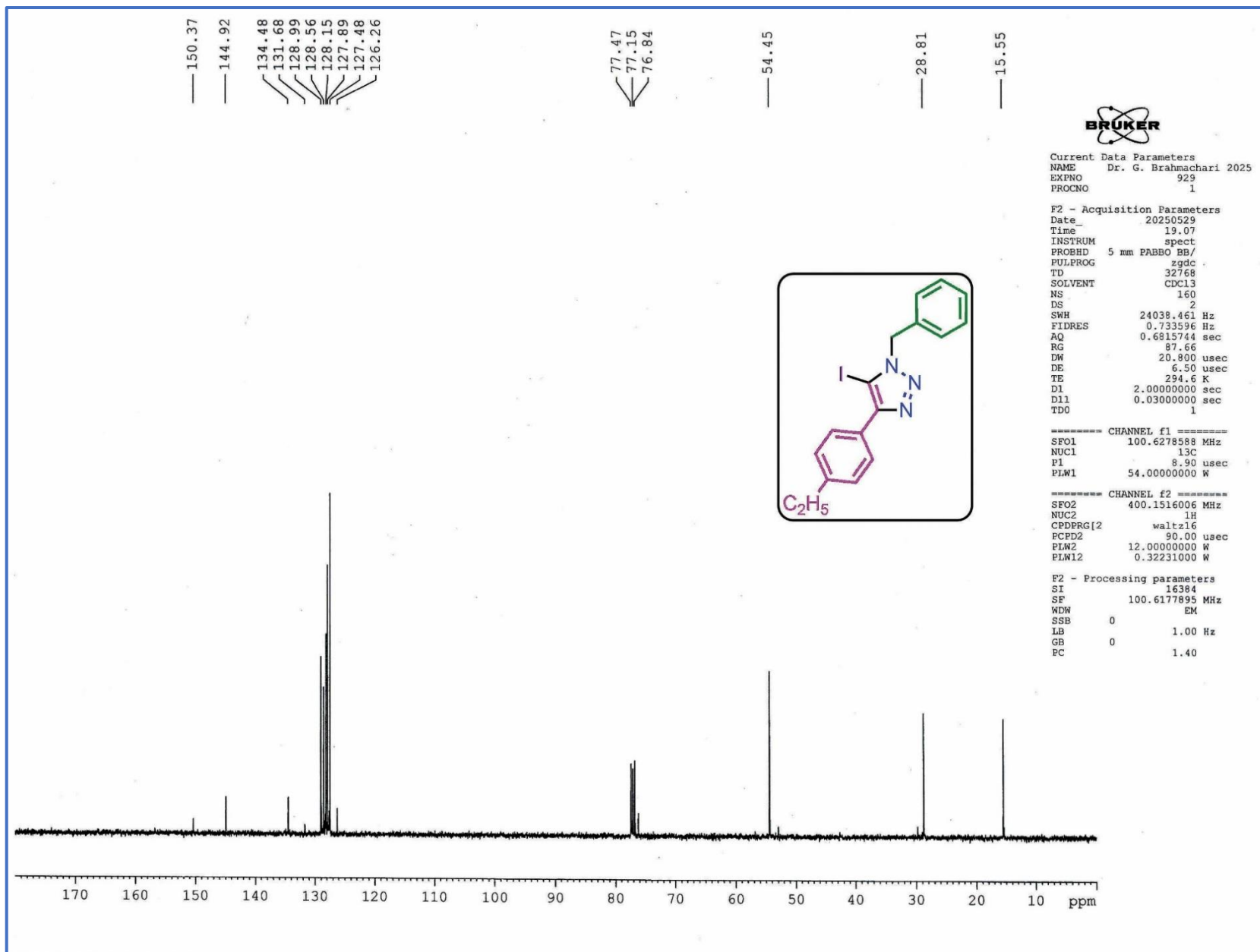


Figure S5.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-Benzyl-4-(4-ethylphenyl)-5-iodo-1H-1,2,3-triazole (**4c**)

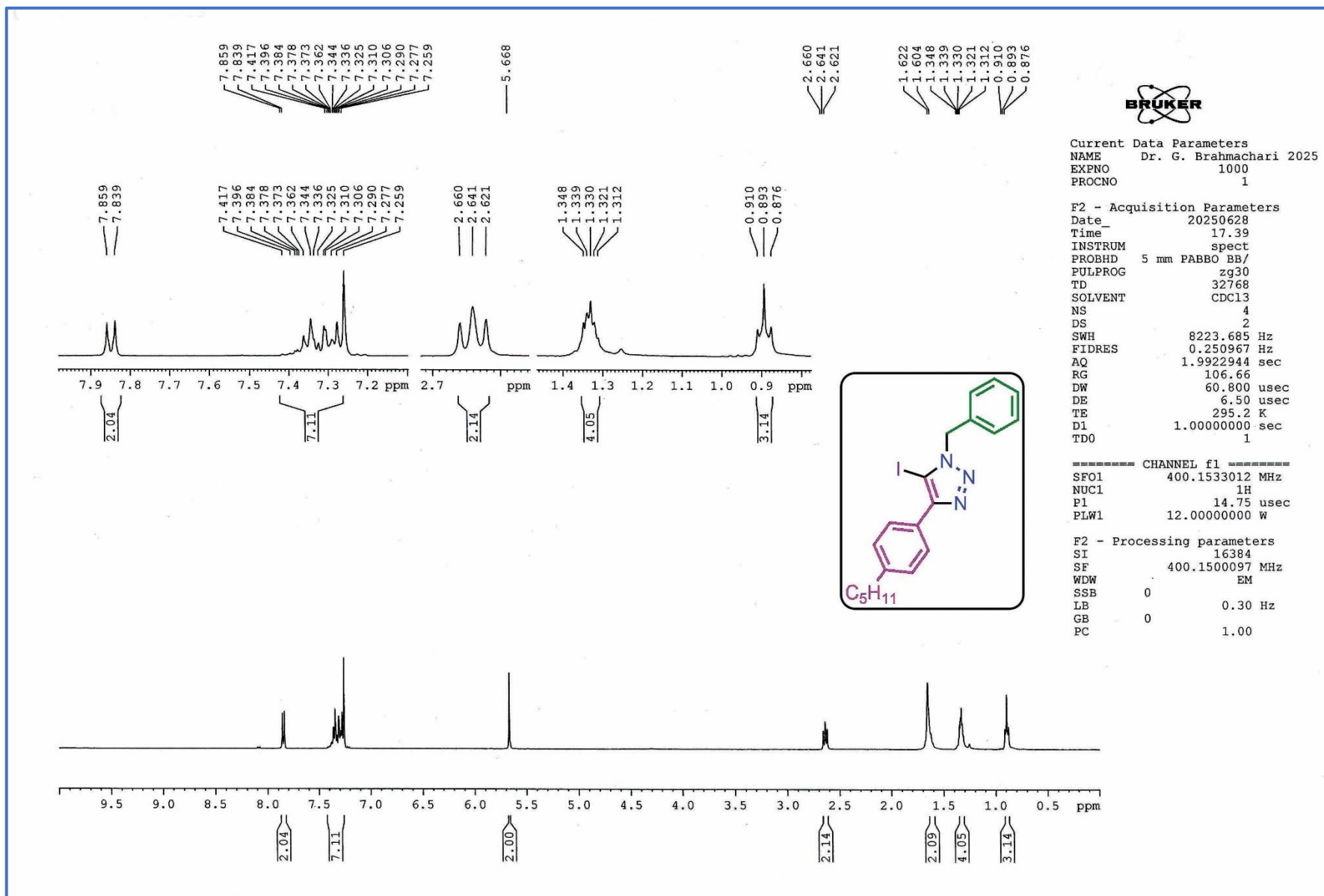


Figure S6. <sup>1</sup>H-NMR spectrum of 1-Benzyl-5-iodo-4-(4-pentylphenyl)-1H-1,2,3-triazole (**4d**)

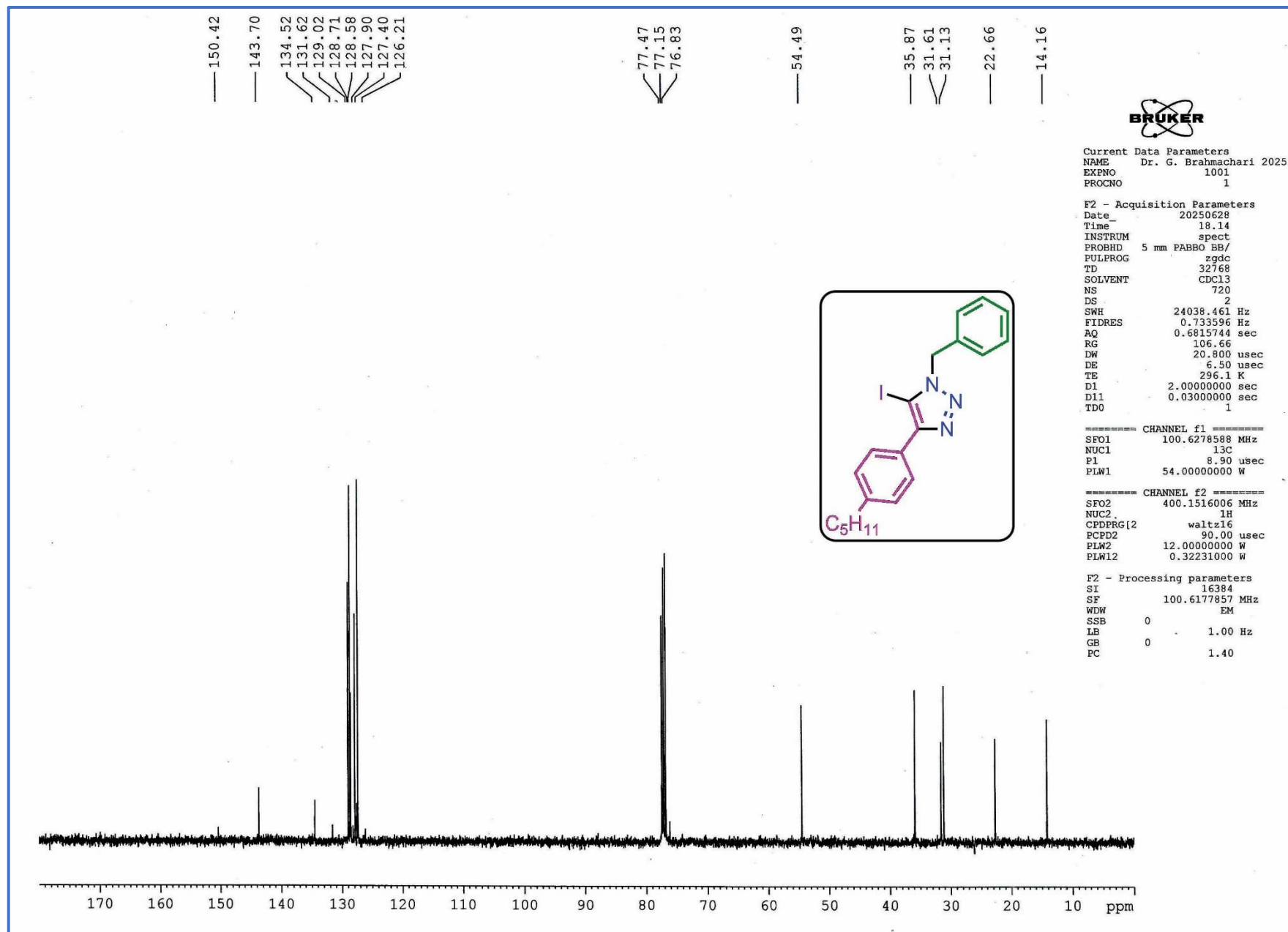


Figure S7.  $^{13}C\{^1H\}$  NMR spectrum of 1-Benzyl-5-iodo-4-(4-pentylphenyl)-1H-1,2,3-triazole (**4d**)

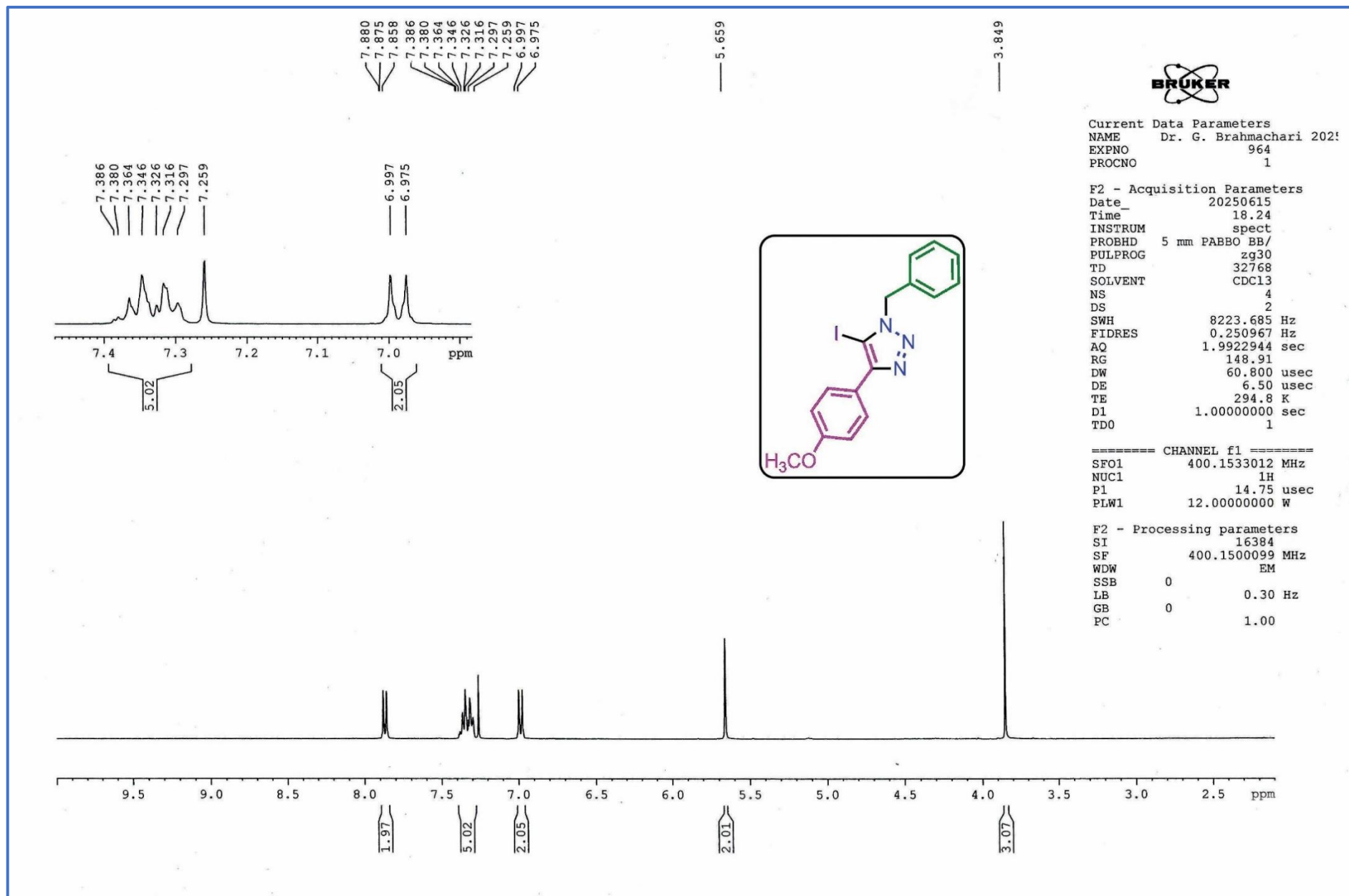


Figure S8. <sup>1</sup>H-NMR spectrum of 1-Benzyl-5-iodo-4-(4-methoxyphenyl)-1H-1,2,3-triazole (**4e**)

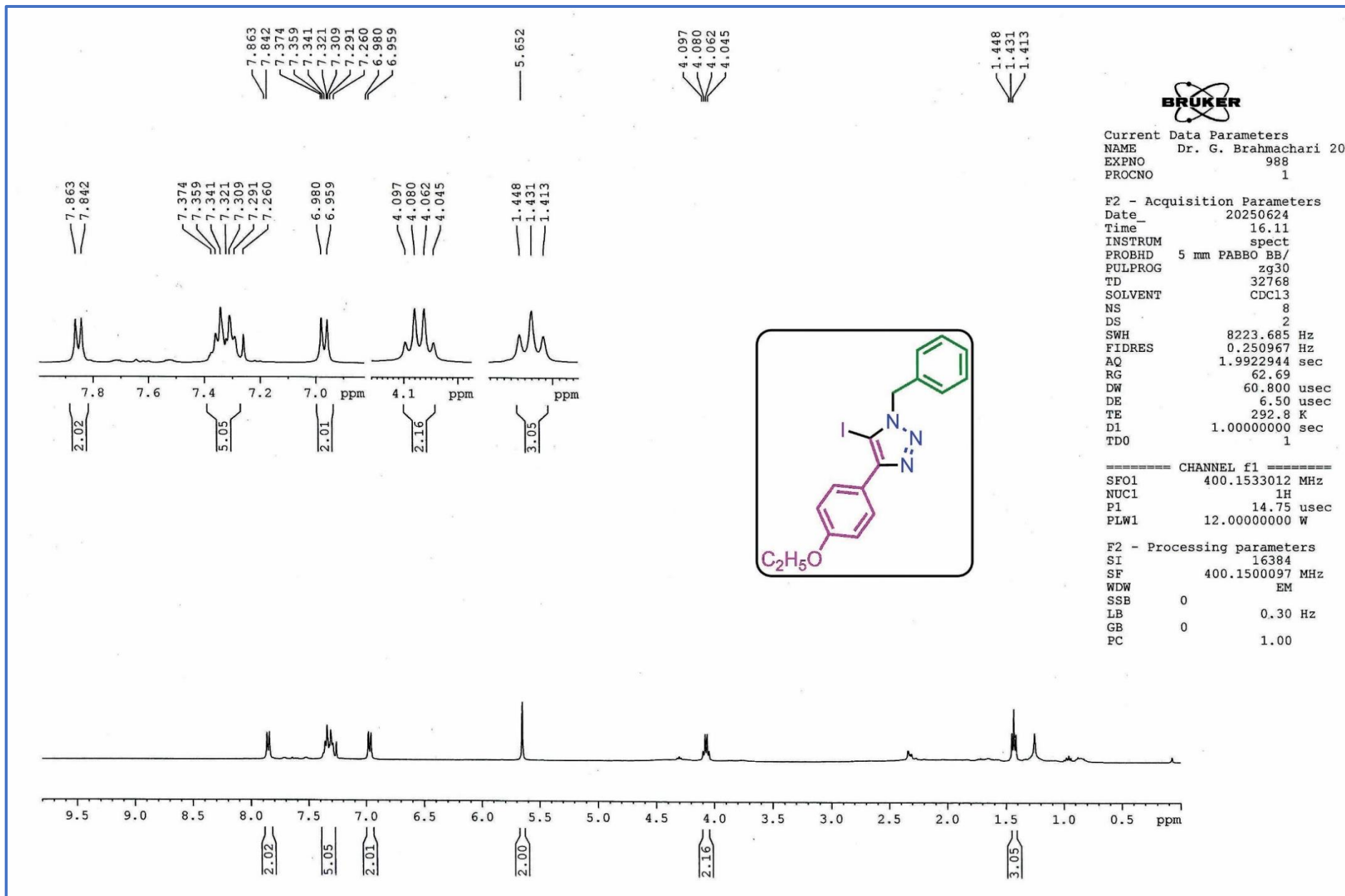


Figure S9. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-(4-ethoxyphenyl)-5-iodo-1H-1,2,3-triazole (**4f**)

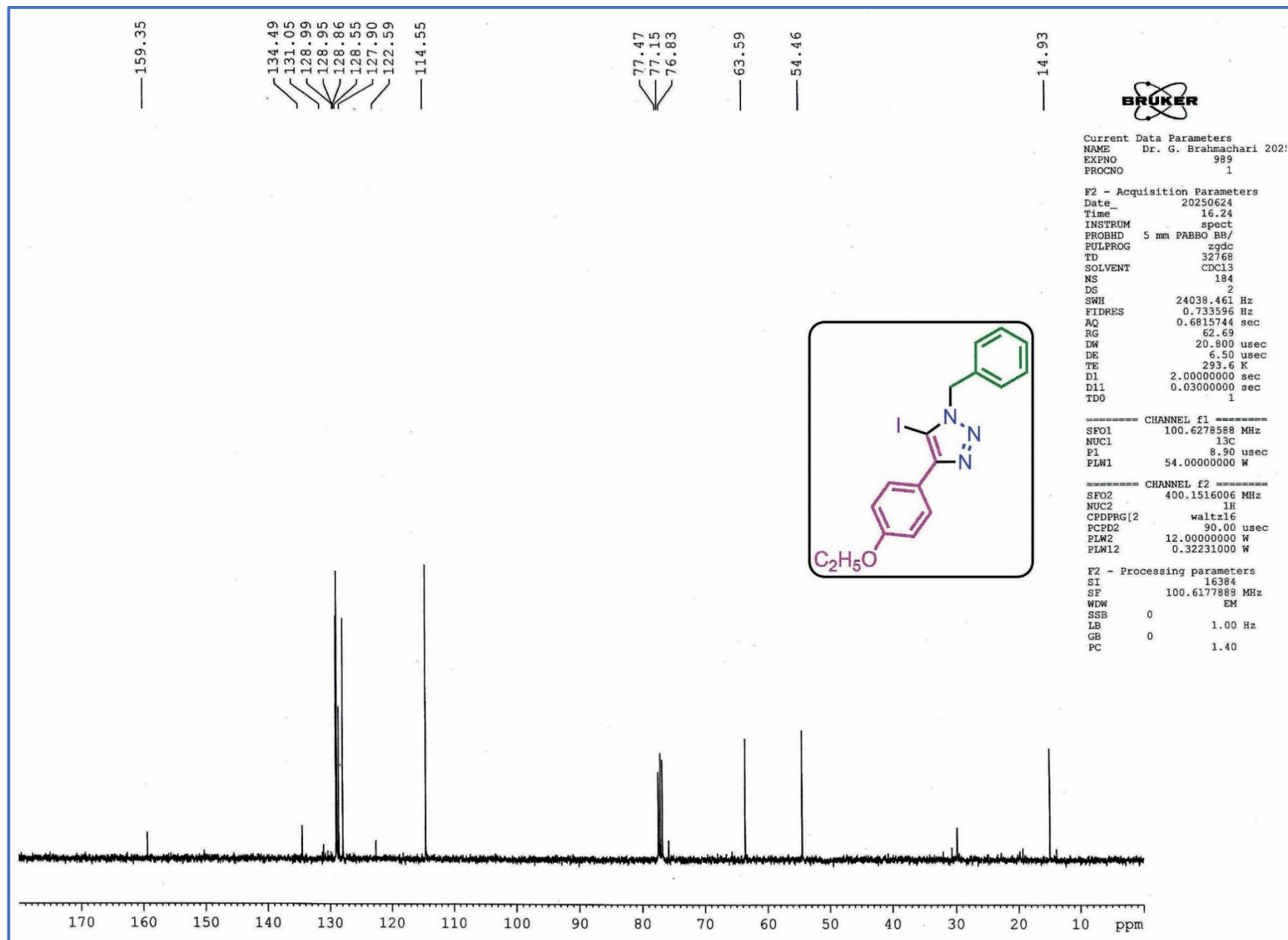


Figure S10.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-Benzyl-4-(4-ethoxyphenyl)-5-iodo-1H-1,2,3-triazole (**4f**)

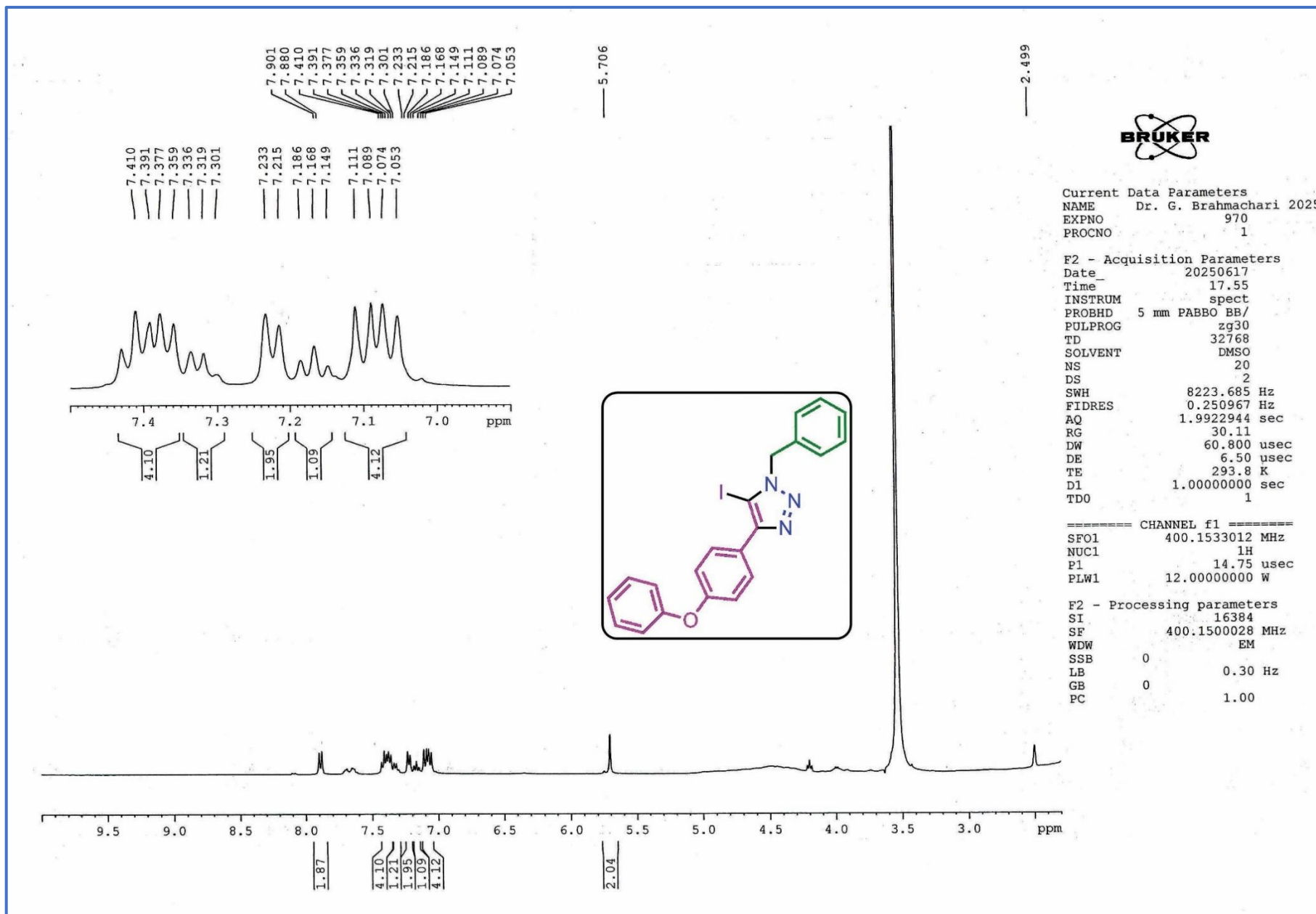


Figure S11. <sup>1</sup>H-NMR spectrum of 1-Benzyl-5-iodo-4-(4-phenoxyphenyl)-1H-1,2,3-triazole (**4g**)

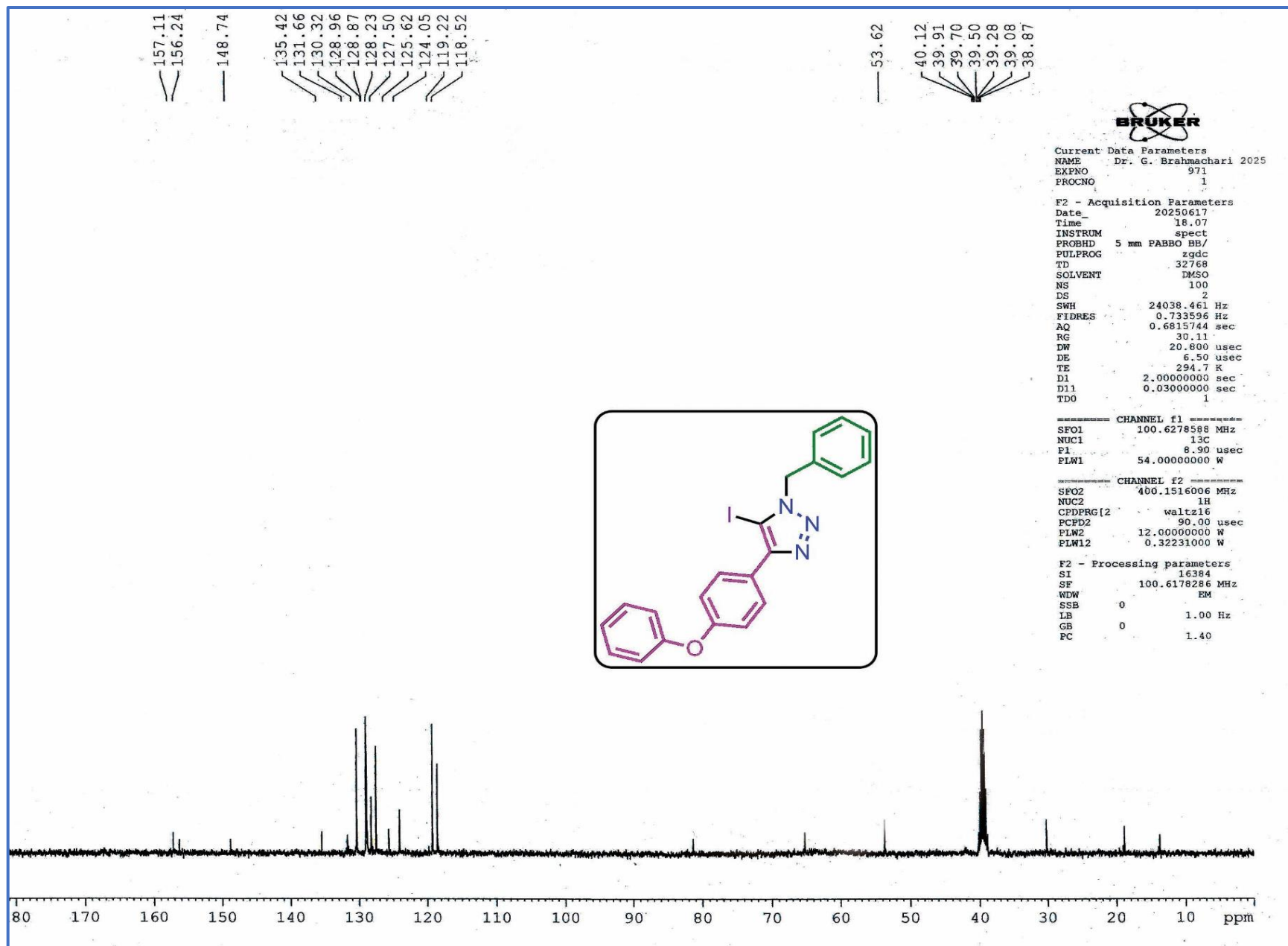


Figure S12.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-Benzyl-5-iodo-4-(4-phenoxyphenyl)-1H-1,2,3-triazole (**4g**)

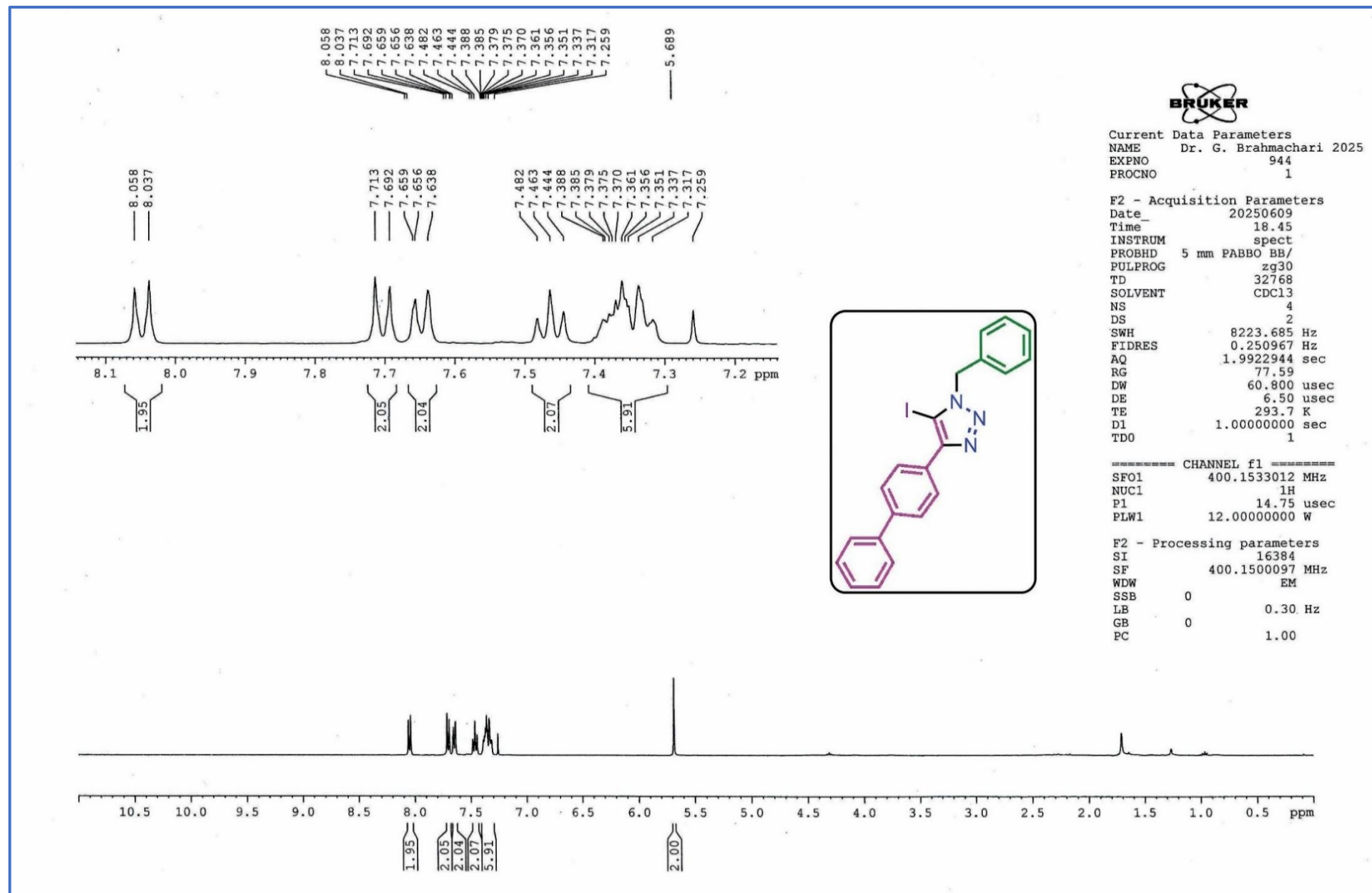


Figure S13. <sup>1</sup>H-NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-1-benzyl-5-iodo-1H-1,2,3-triazole (**4h**)

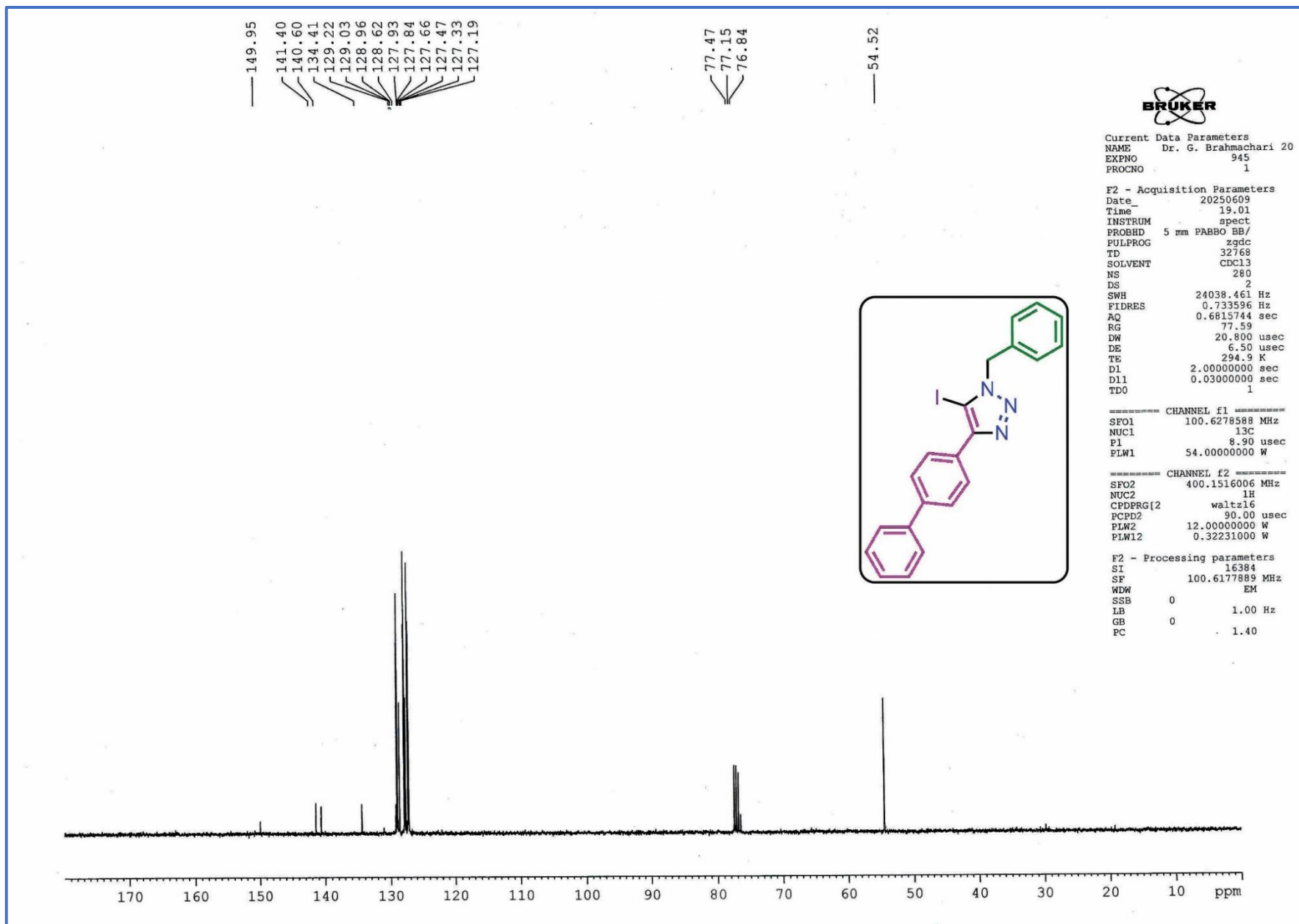


Figure S14.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-1-benzyl-5-iodo-1H-1,2,3-triazole (**4h**)

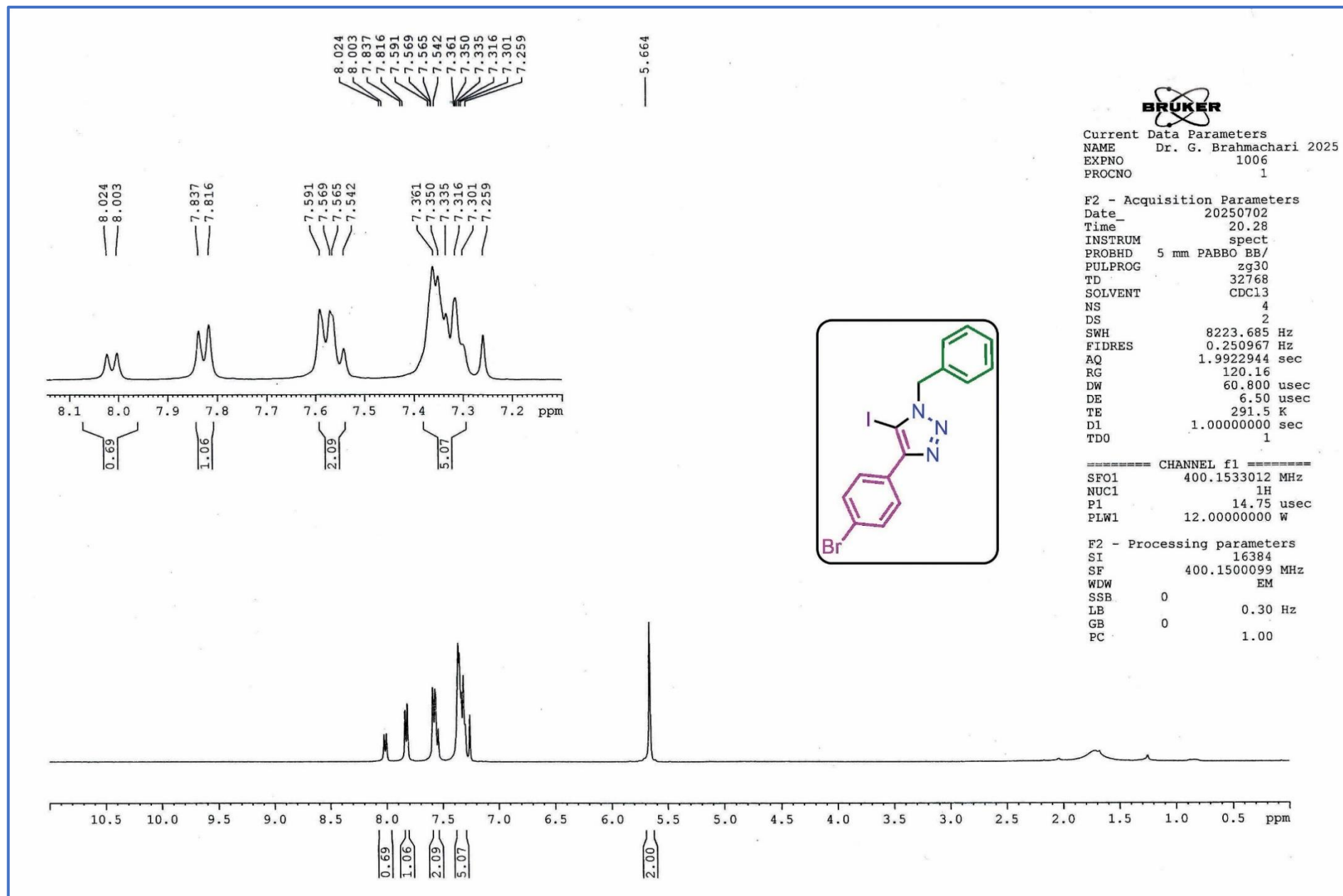


Figure S15. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-(4-bromophenyl)-5-iodo-1H-1,2,3-triazole (**4i**)

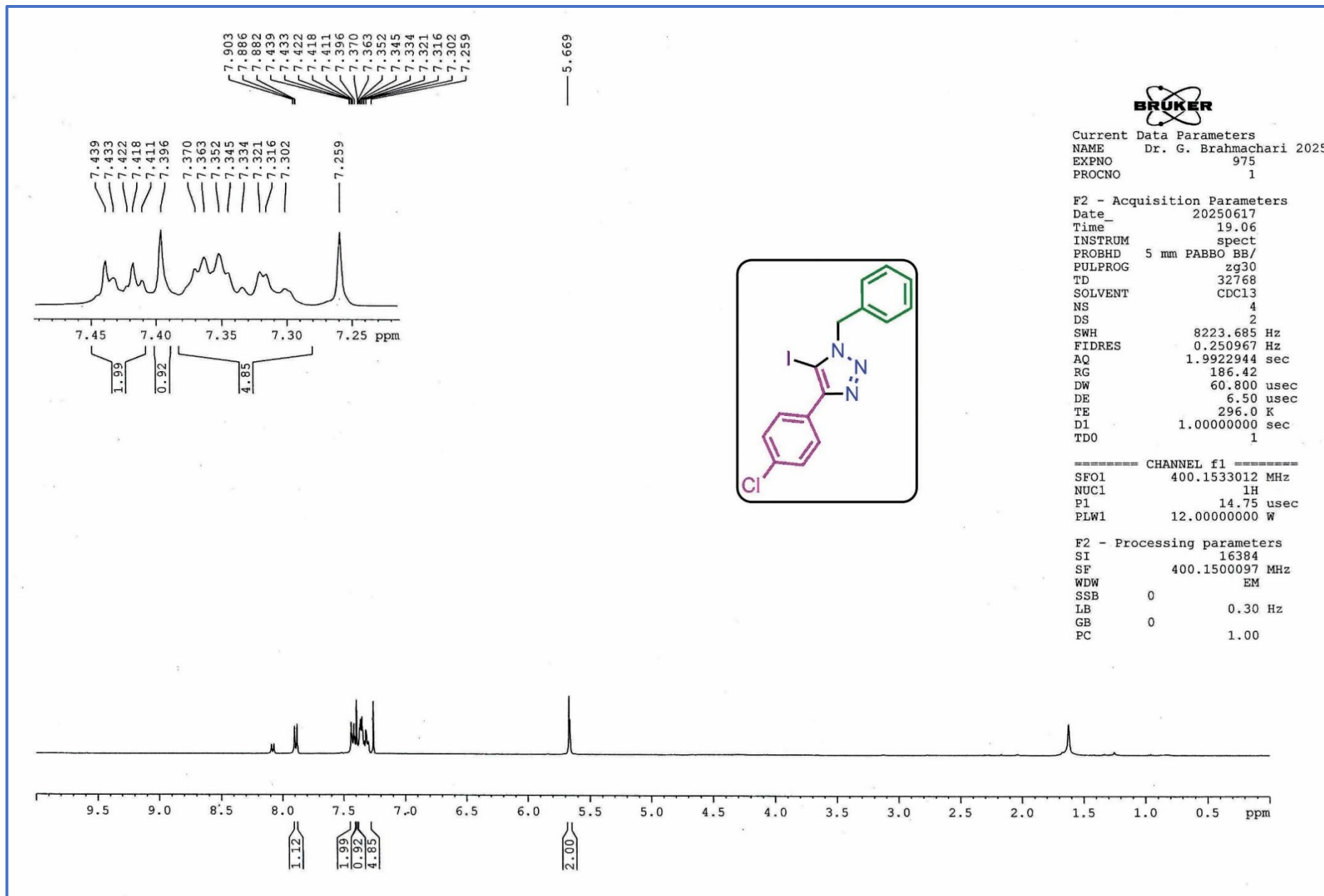


Figure S16. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-(4-chlorophenyl)-5-iodo-1H-1,2,3-triazole (**4j**)

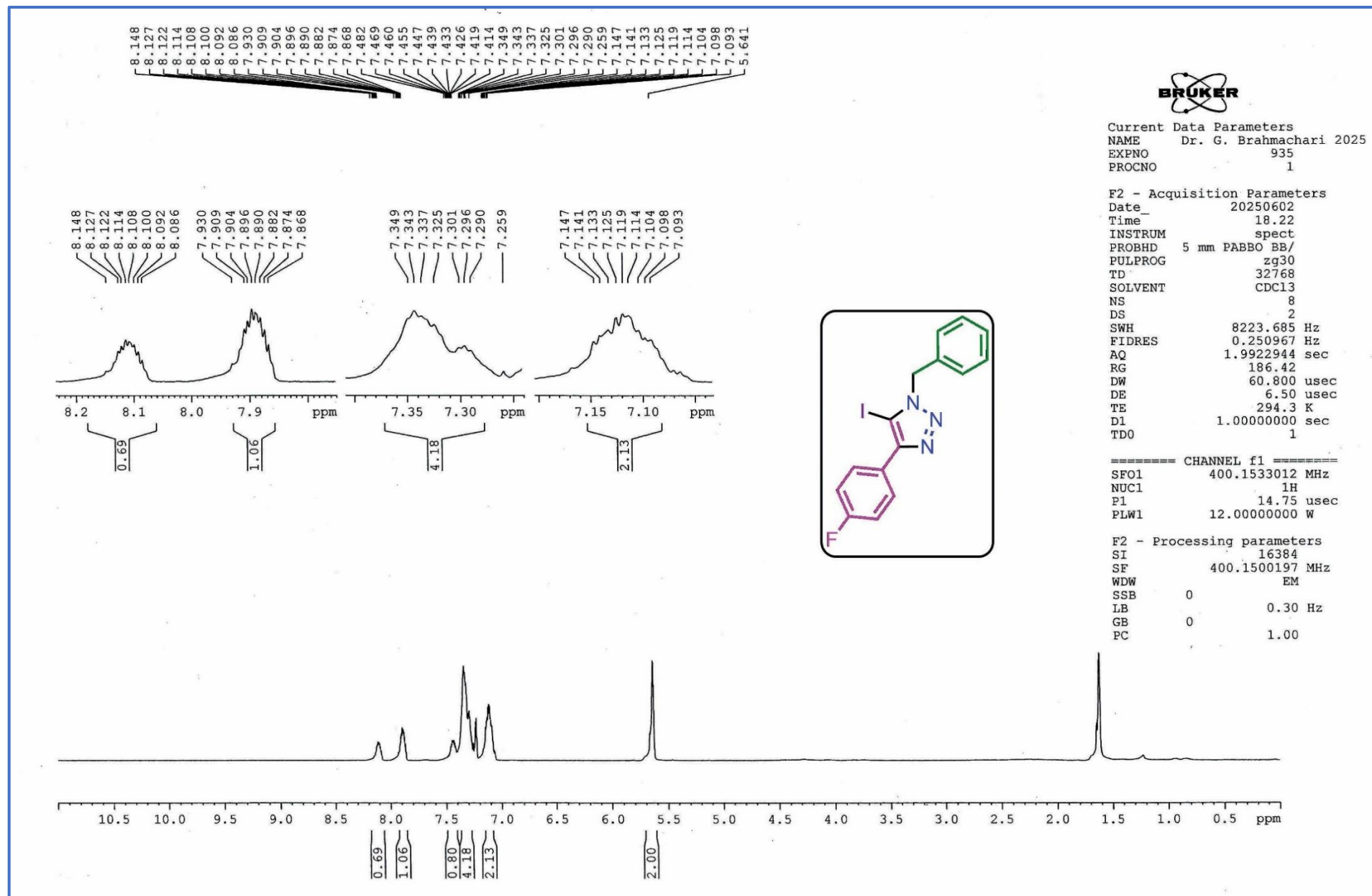


Figure S17. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-(4-fluorophenyl)-5-iodo-1H-1,2,3-triazole (**4k**)

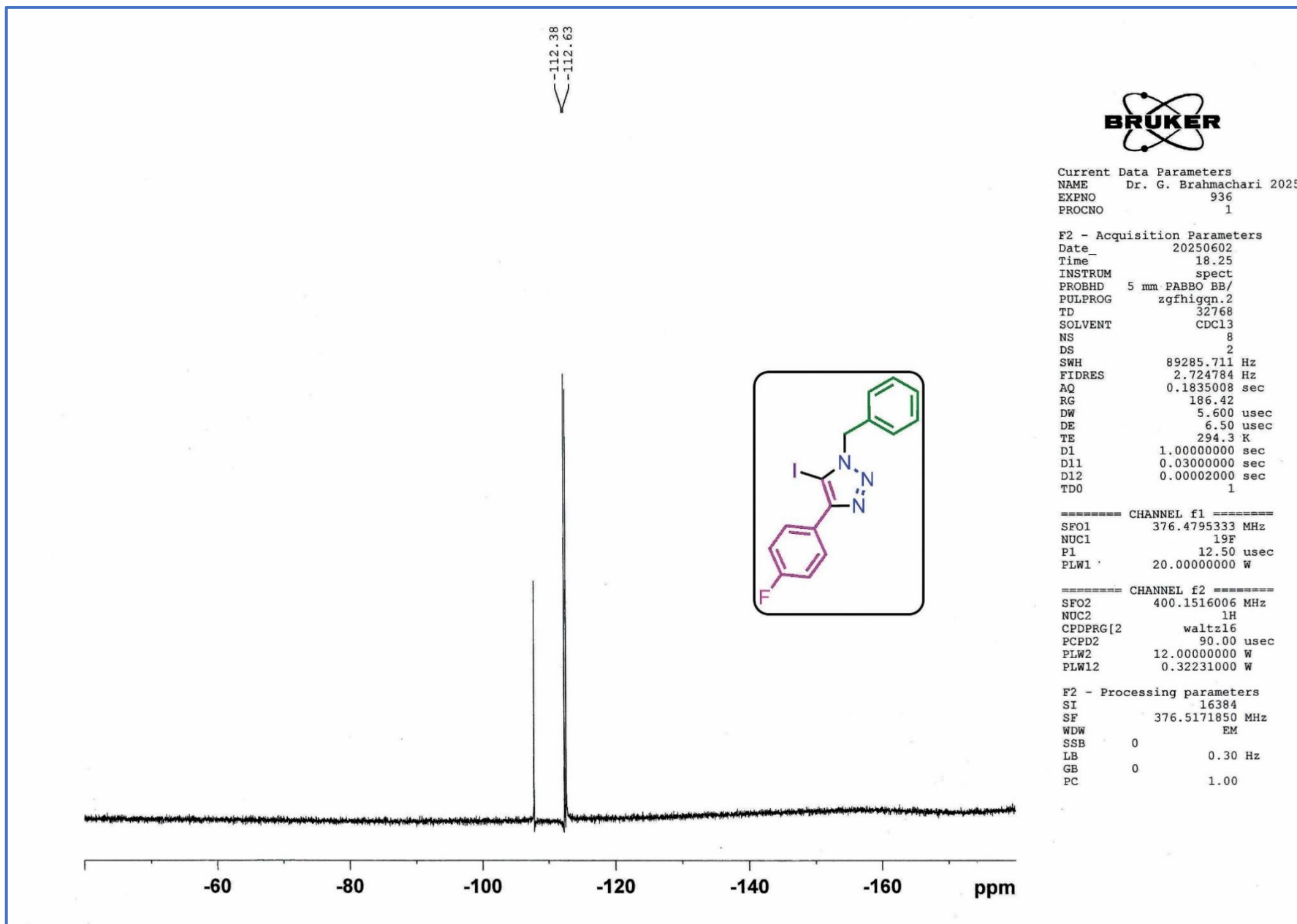


Figure S18.  $^{19}\text{F}$  NMR spectrum of 1-Benzyl-4-(4-fluorophenyl)-5-iodo-1*H*-1,2,3-triazole (**4k**)

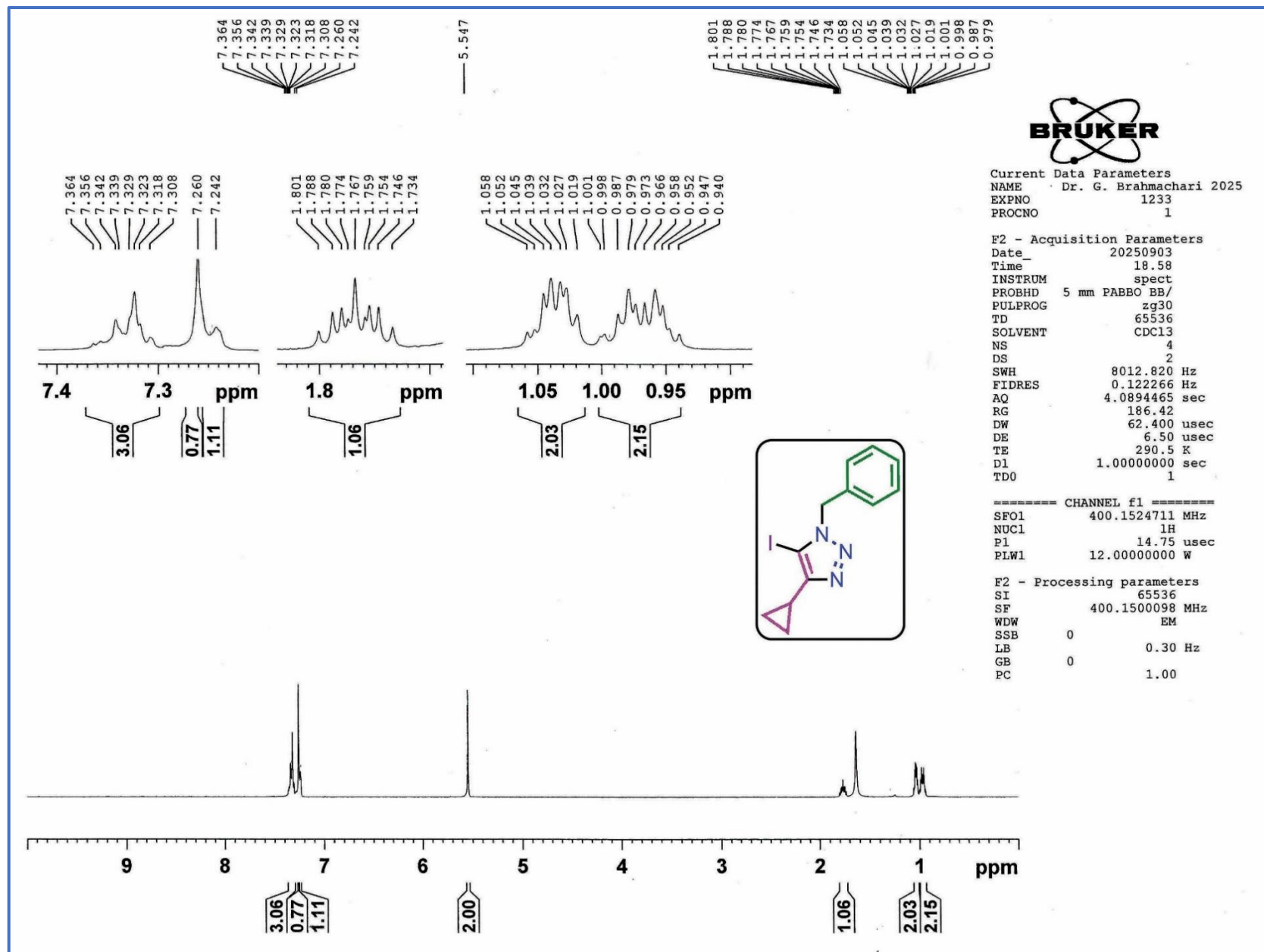


Figure S19. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4-cyclopropyl-5-iodo-1H-1,2,3-triazole (**41**)

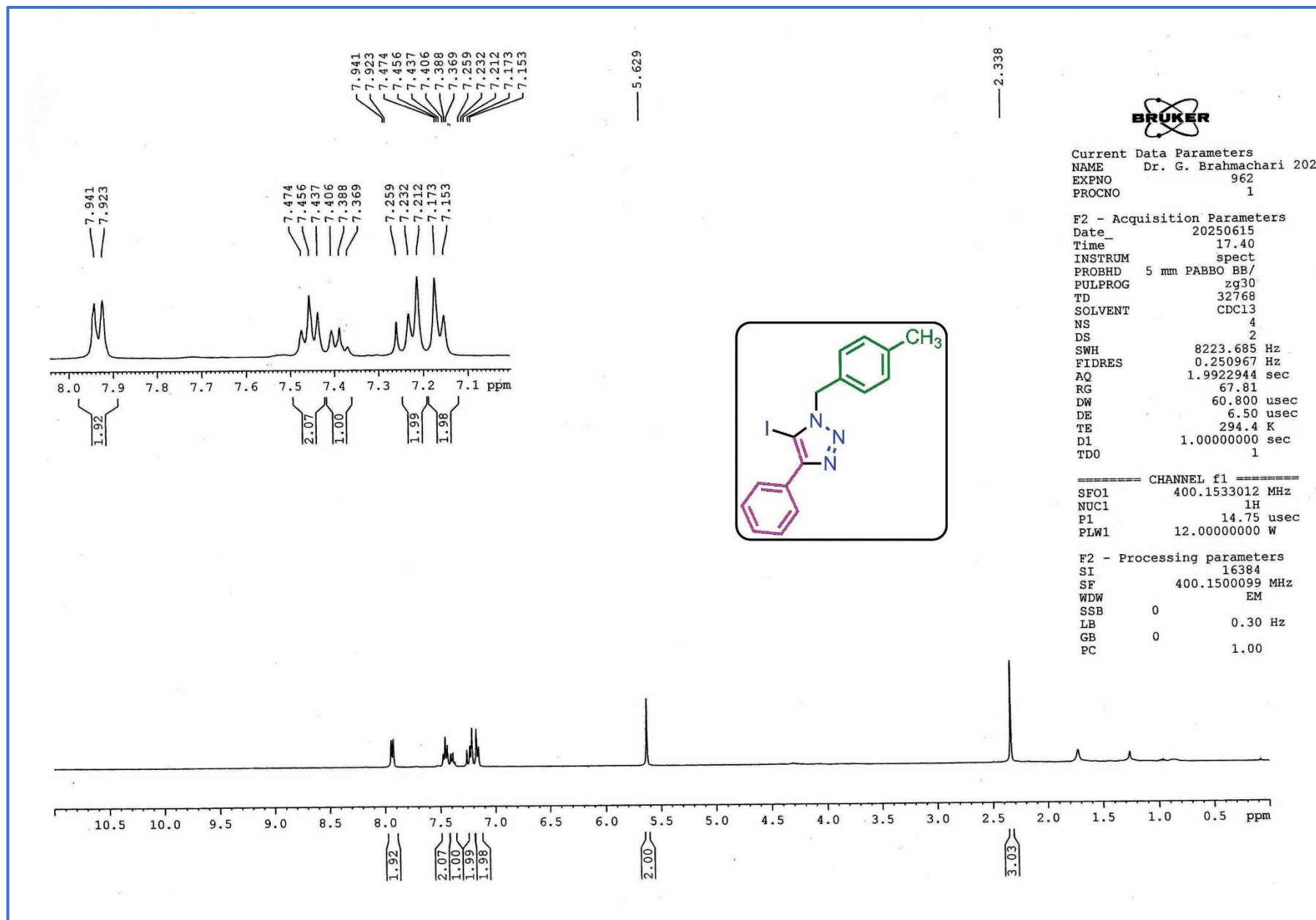


Figure S20. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-phenyl-1H-1,2,3-triazole (**4m**)

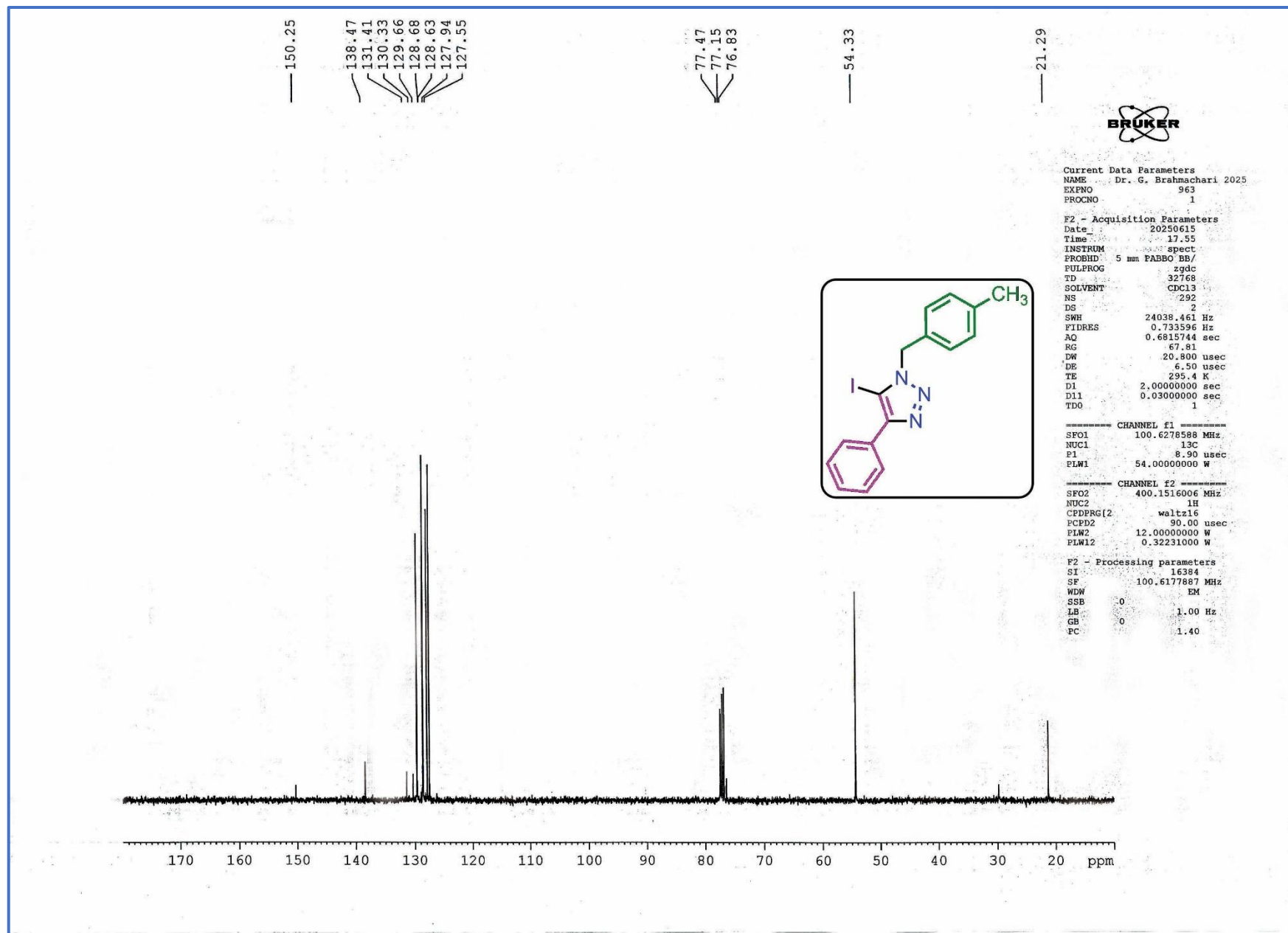


Figure S21.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-phenyl-1H-1,2,3-triazole (**4m**)

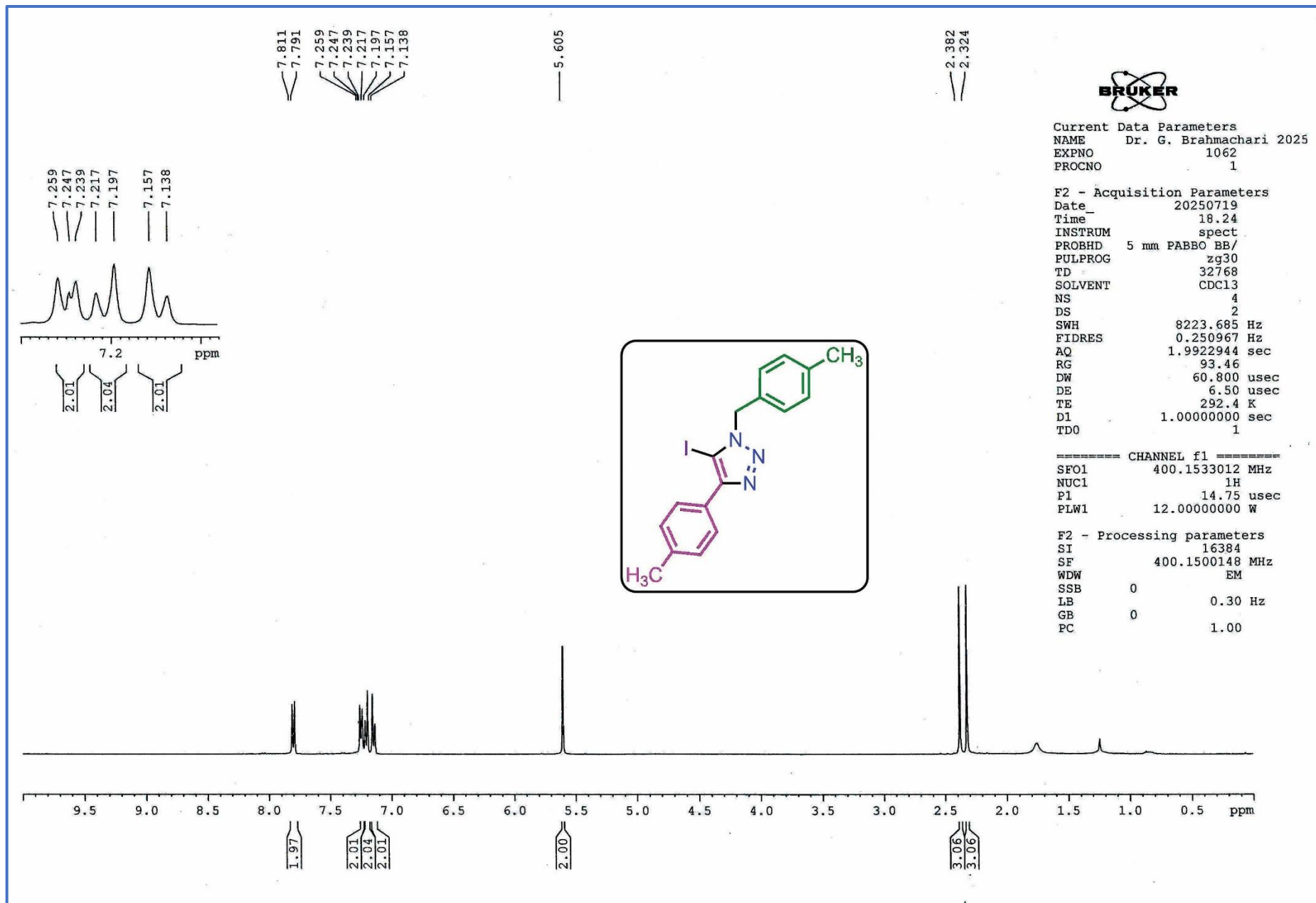


Figure S22. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(p-tolyl)-1H-1,2,3-triazole (**4n**)

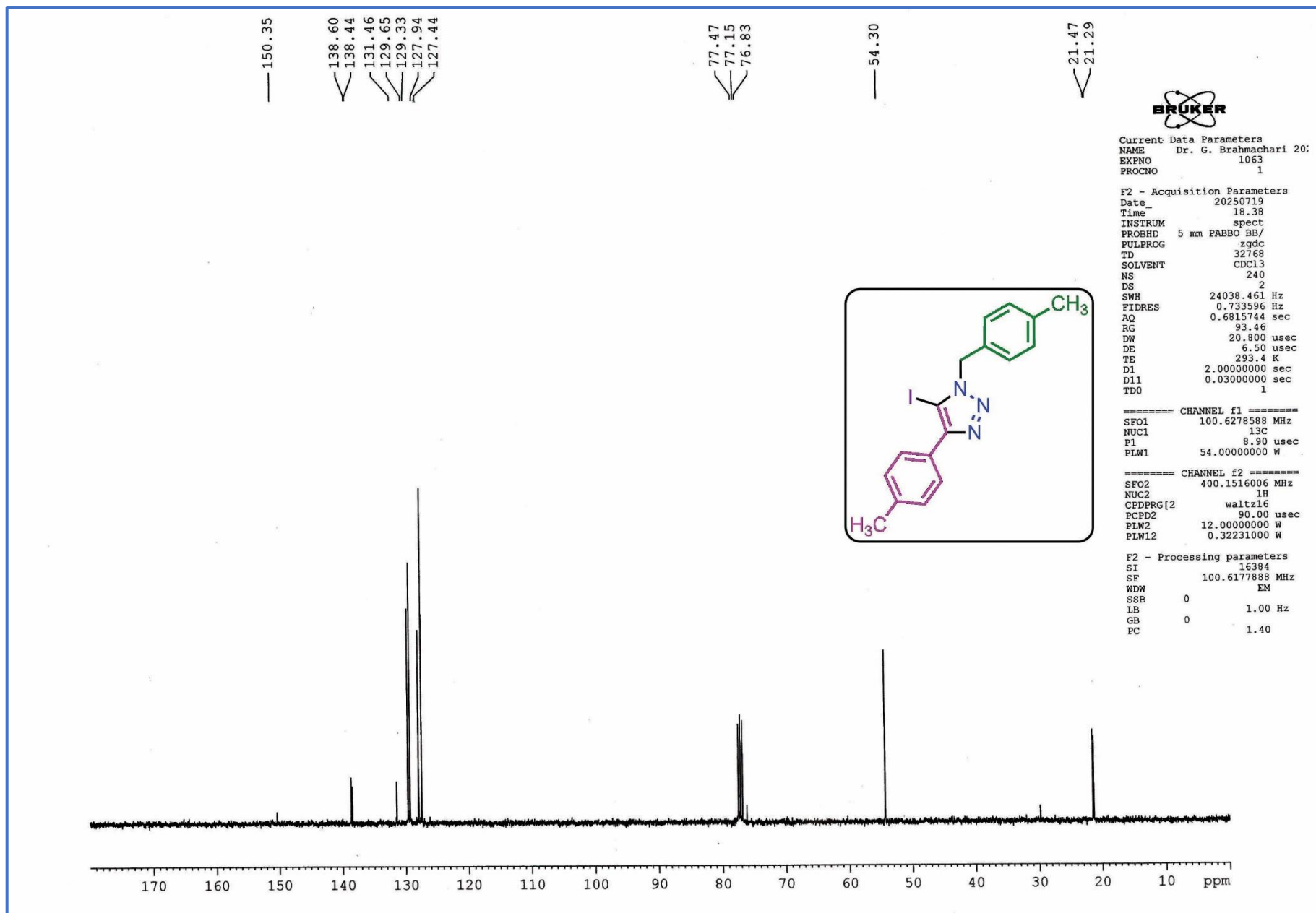


Figure S23.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(*p*-tolyl)-1*H*-1,2,3-triazole (**4n**)

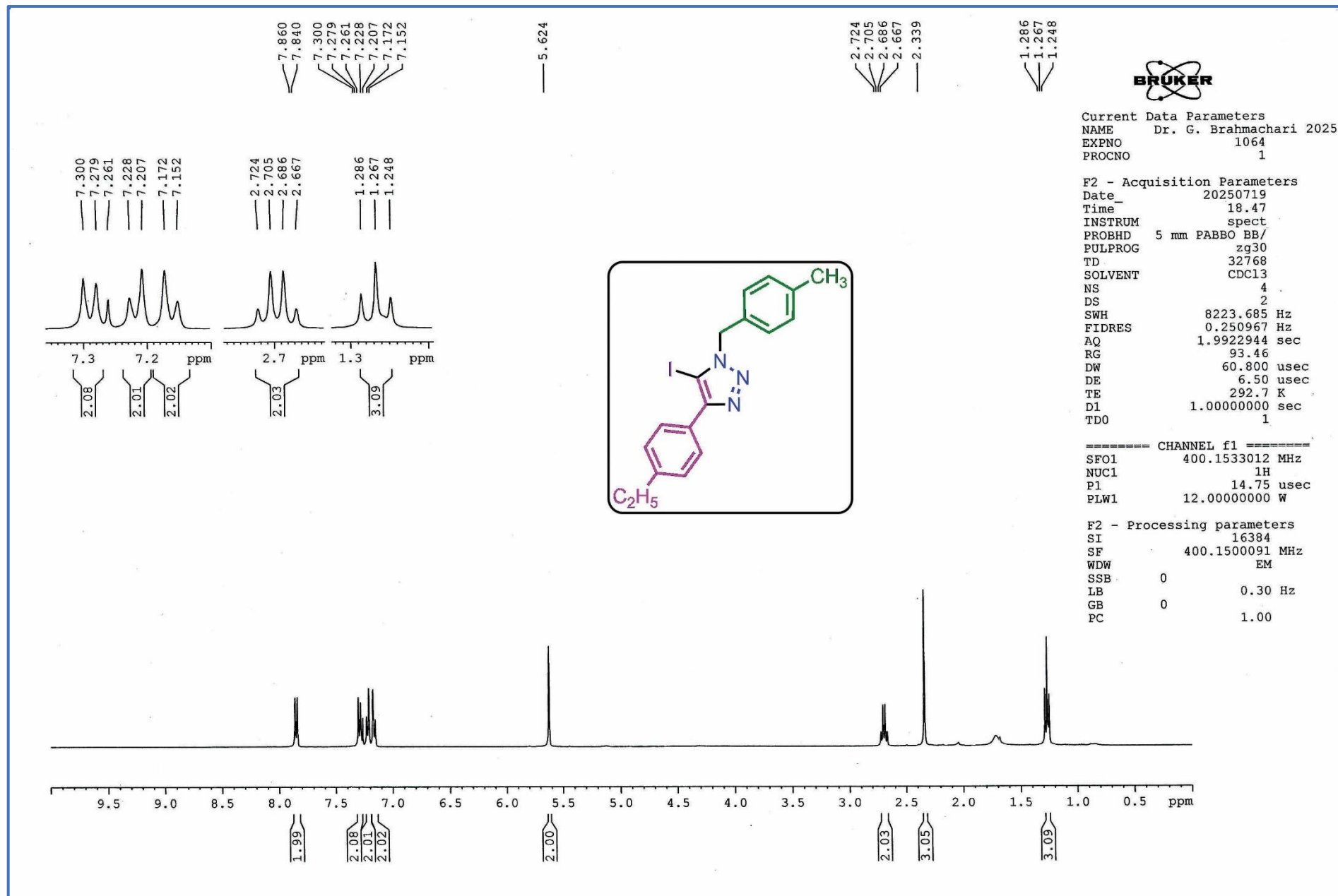


Figure S24. <sup>1</sup>H-NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (4o)

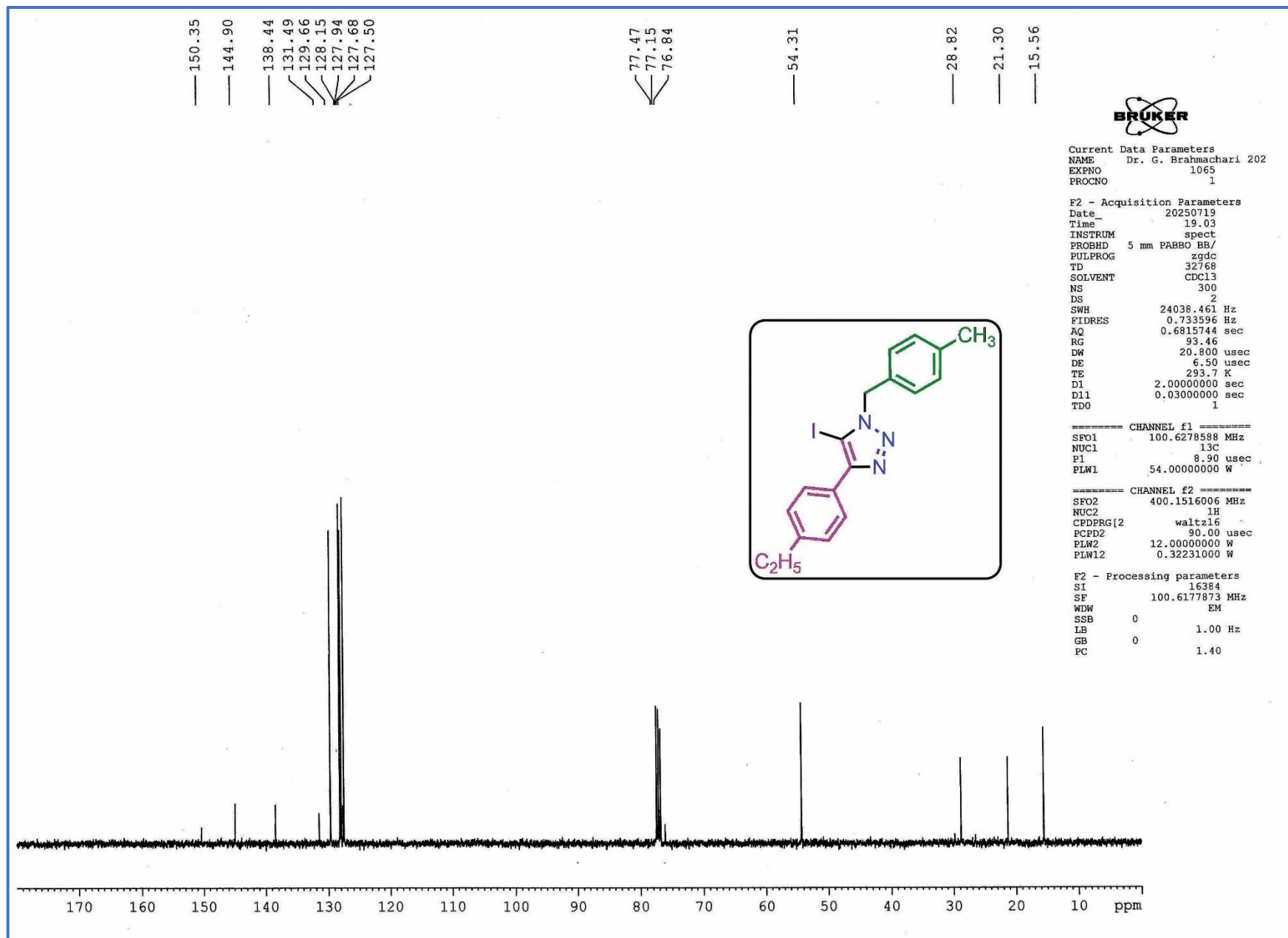


Figure S25.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (**40**)

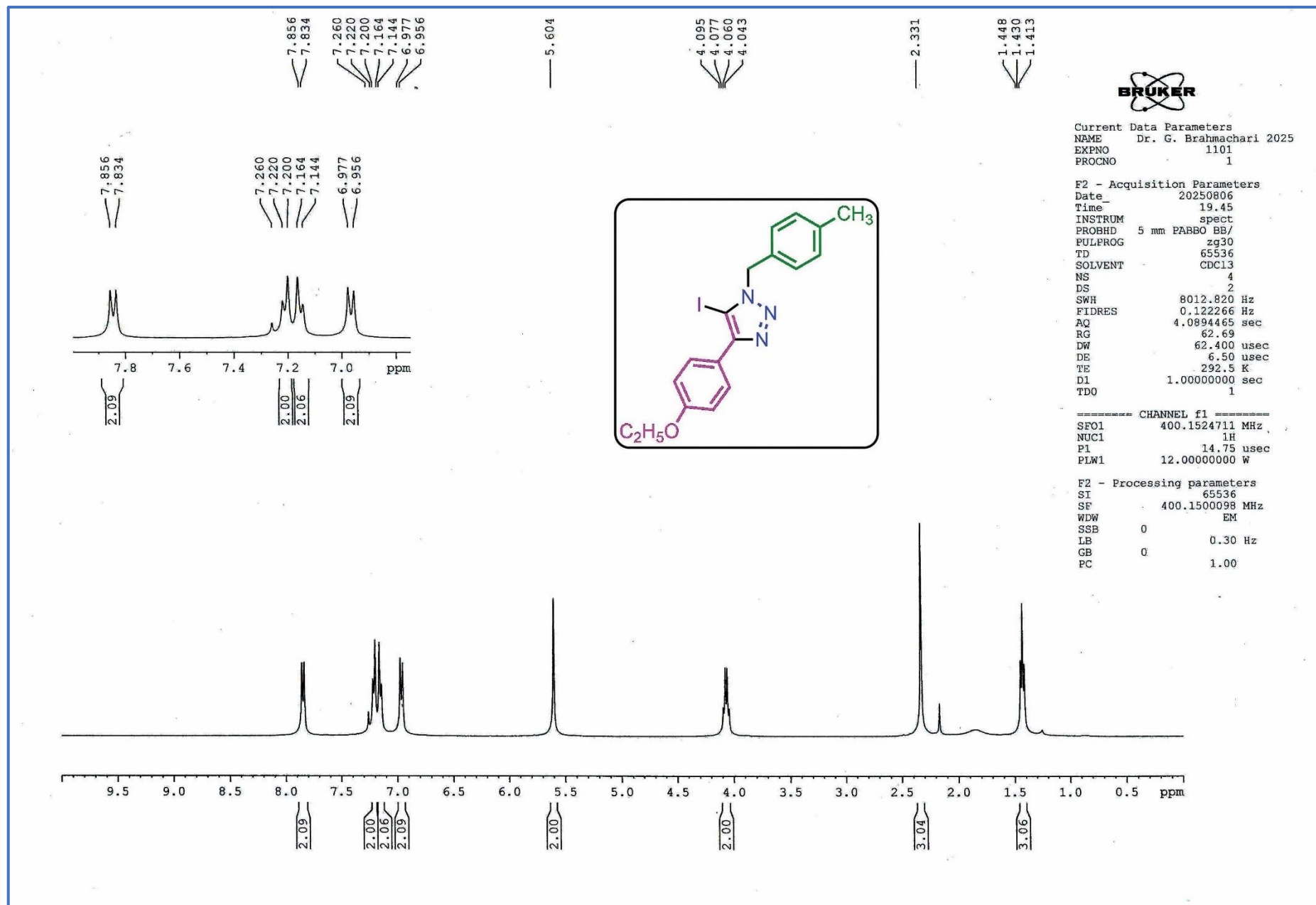


Figure S26. <sup>1</sup>H-NMR spectrum of 4-(4-Ethoxyphenyl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (**4p**)

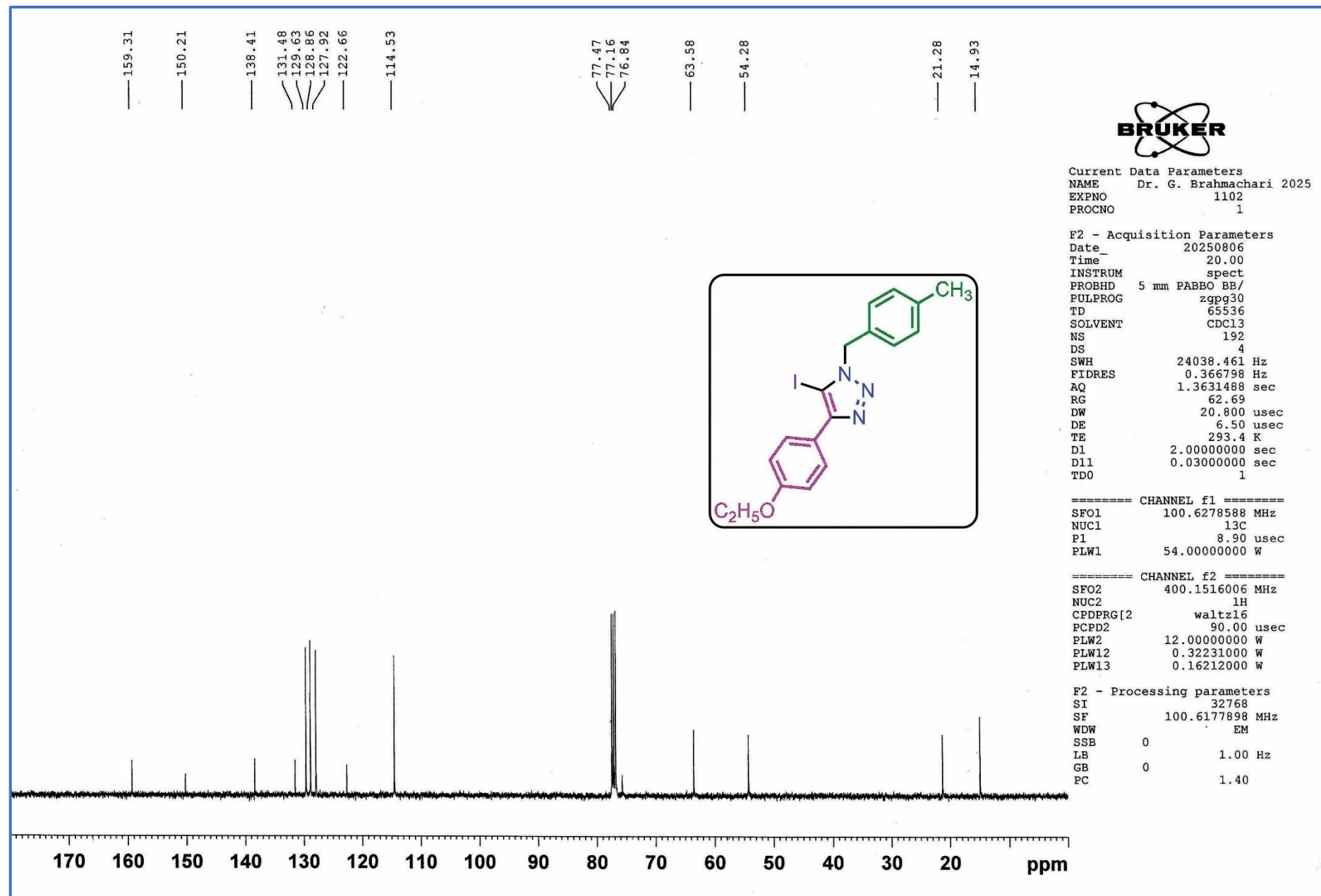


Figure S27.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-(4-Ethoxyphenyl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (**4p**)

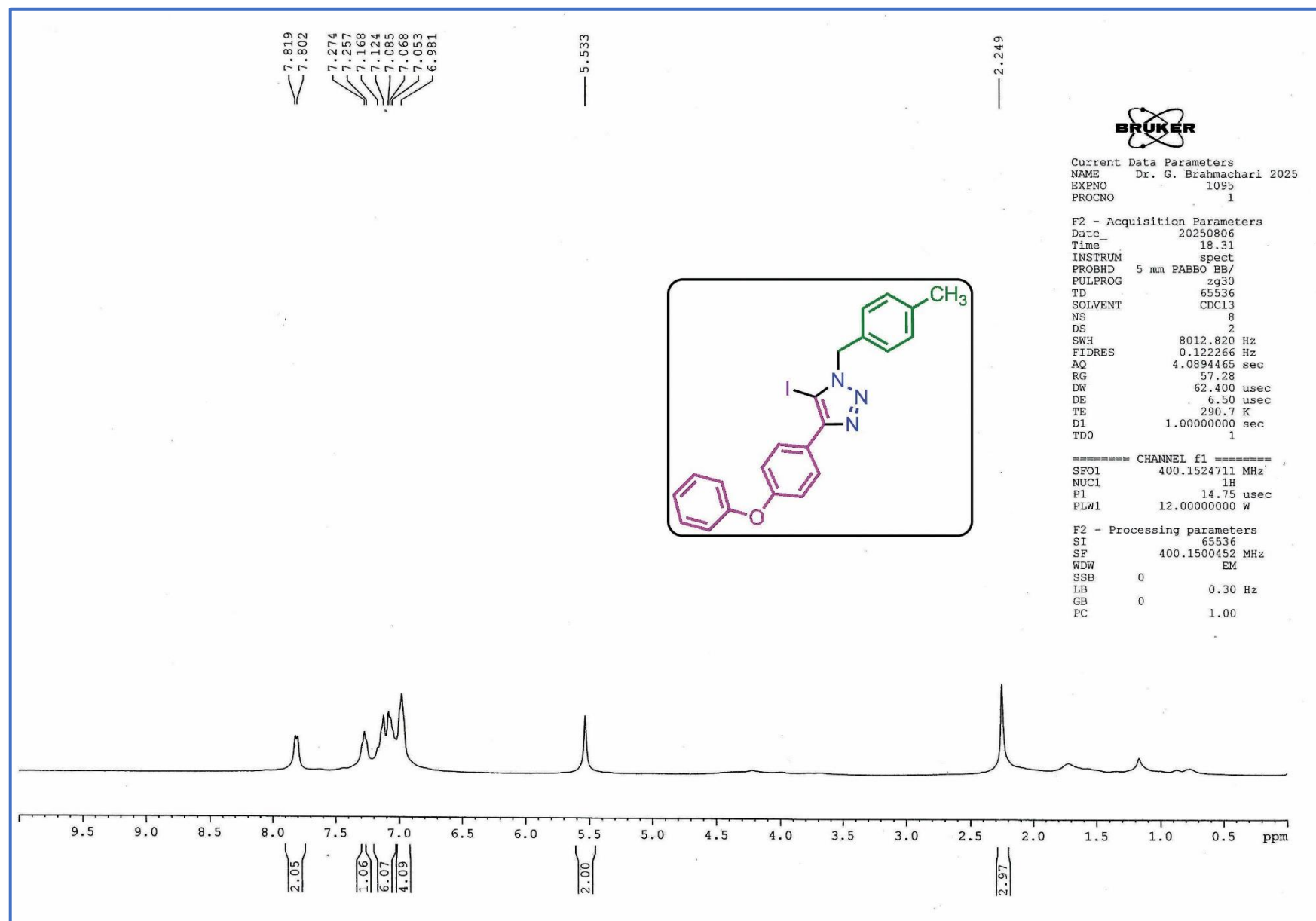


Figure S28. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(4-phenoxyphenyl)-1H-1,2,3-triazole (**4q**)

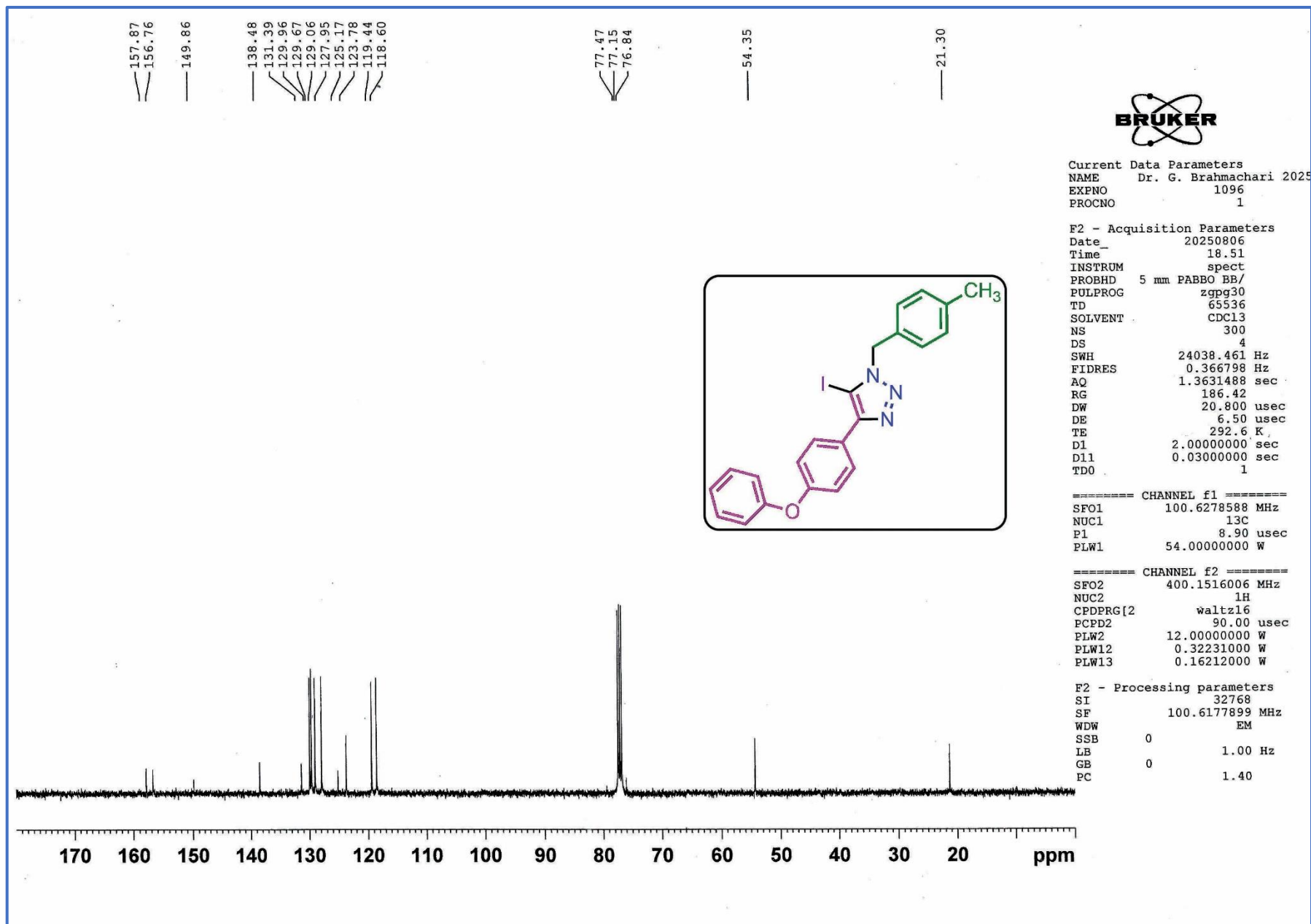


Figure S29.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(4-phenoxyphenyl)-1H-1,2,3-triazole (**4q**)

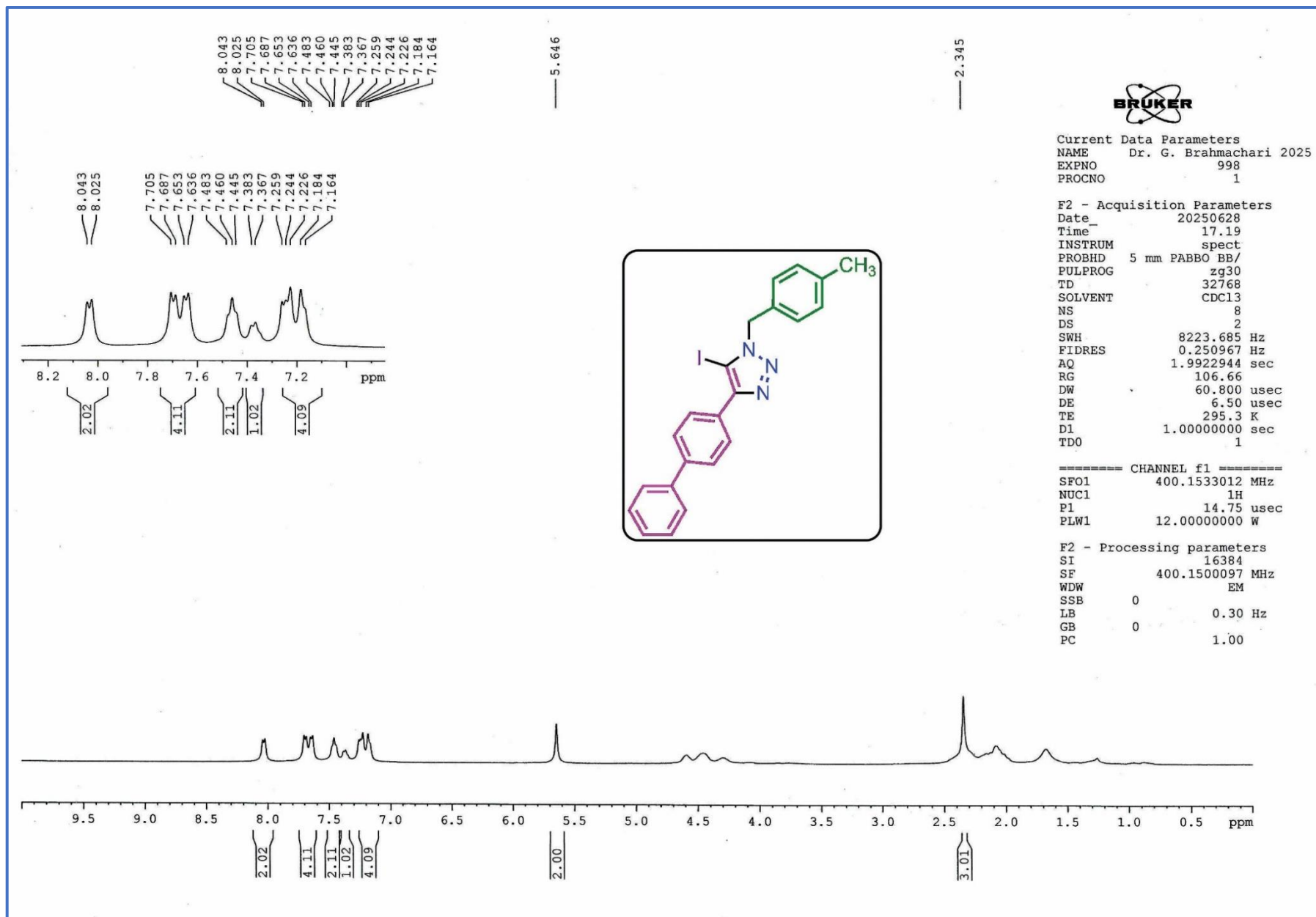


Figure S30. <sup>1</sup>H-NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (**4r**)

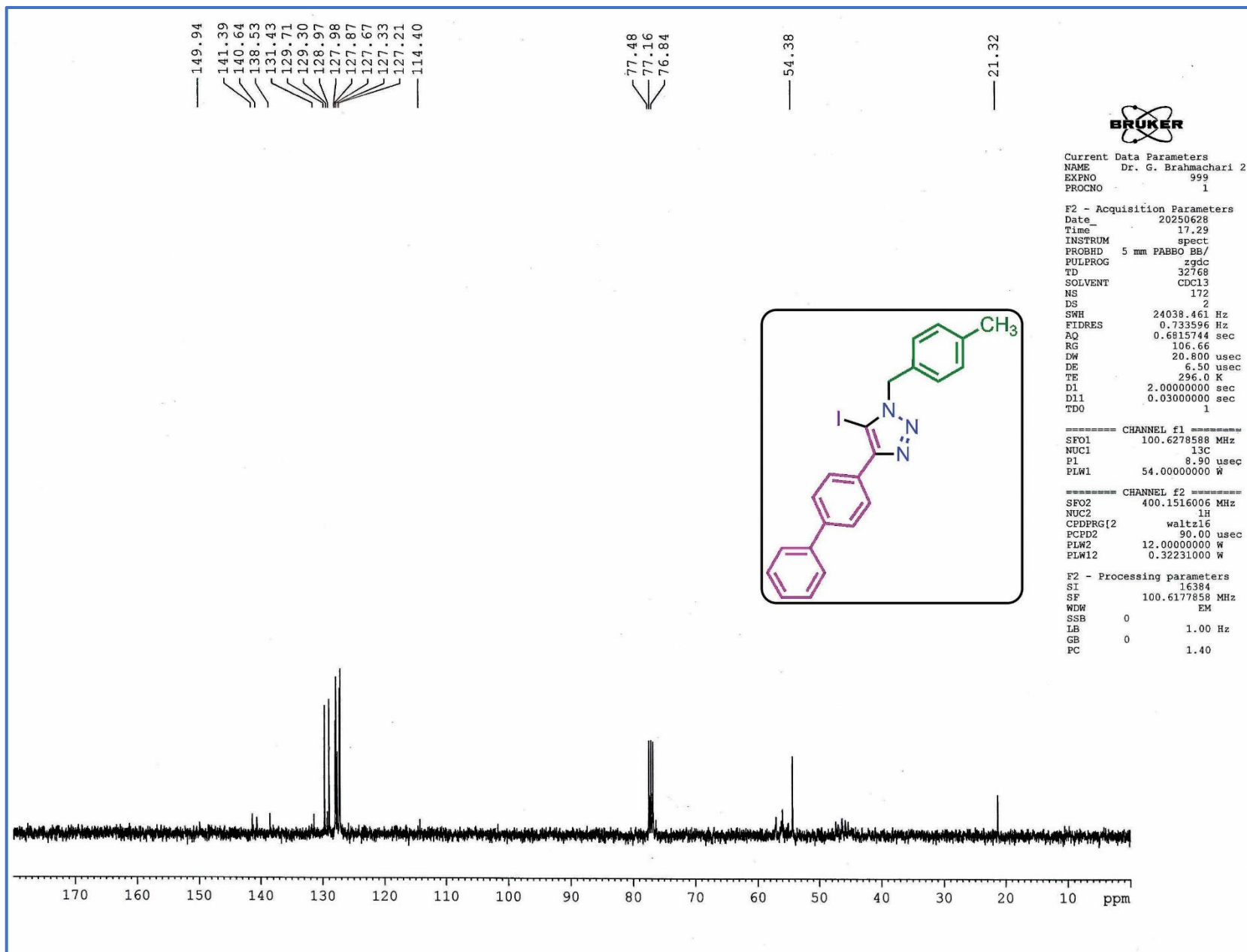


Figure S31.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-5-iodo-1-(4-methylbenzyl)-1H-1,2,3-triazole (**4r**)

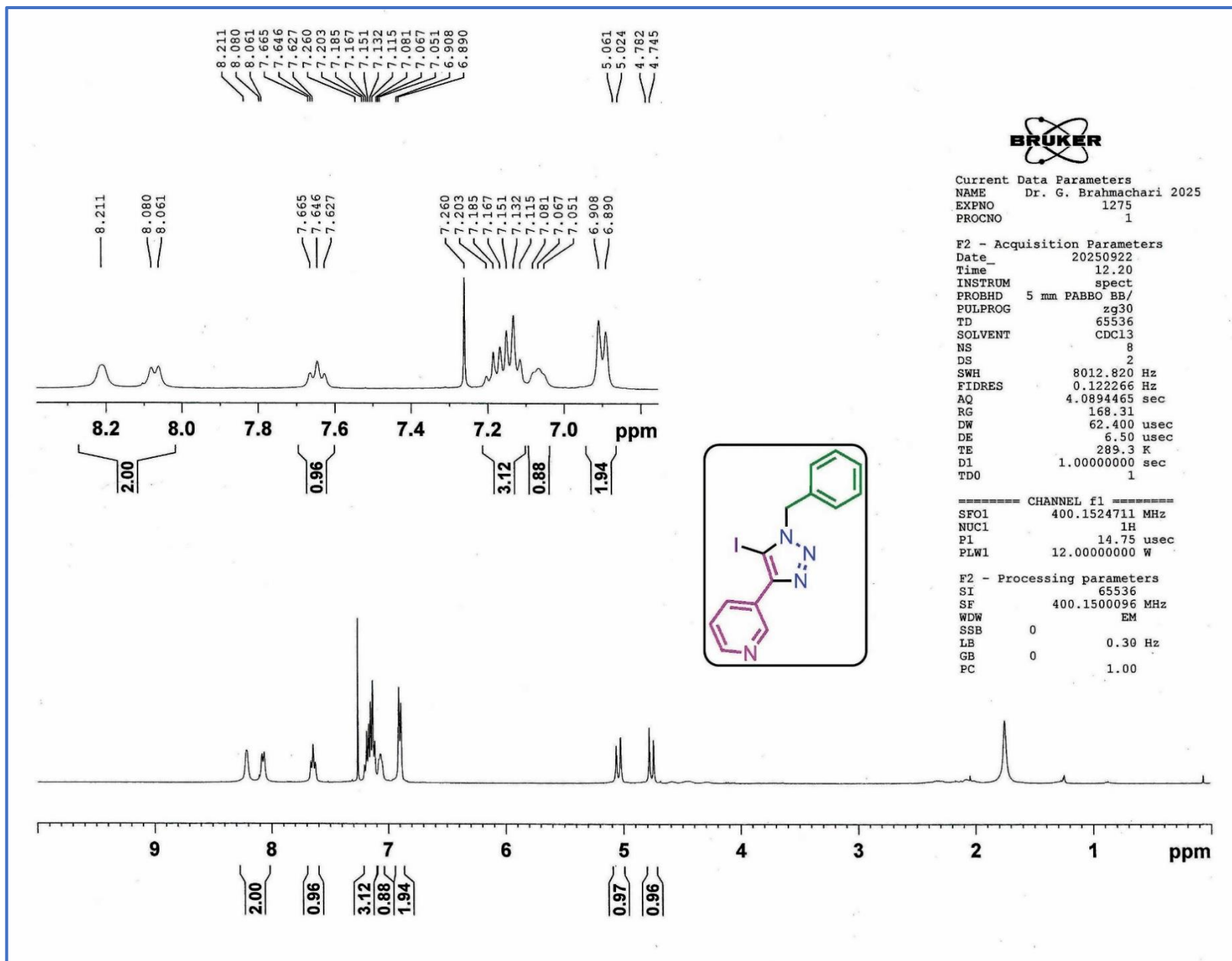


Figure S32. <sup>1</sup>H-NMR spectrum of 3-(1-Benzyl-5-iodo-1H-1,2,3-triazol-4-yl)-pyridine (**4s**)

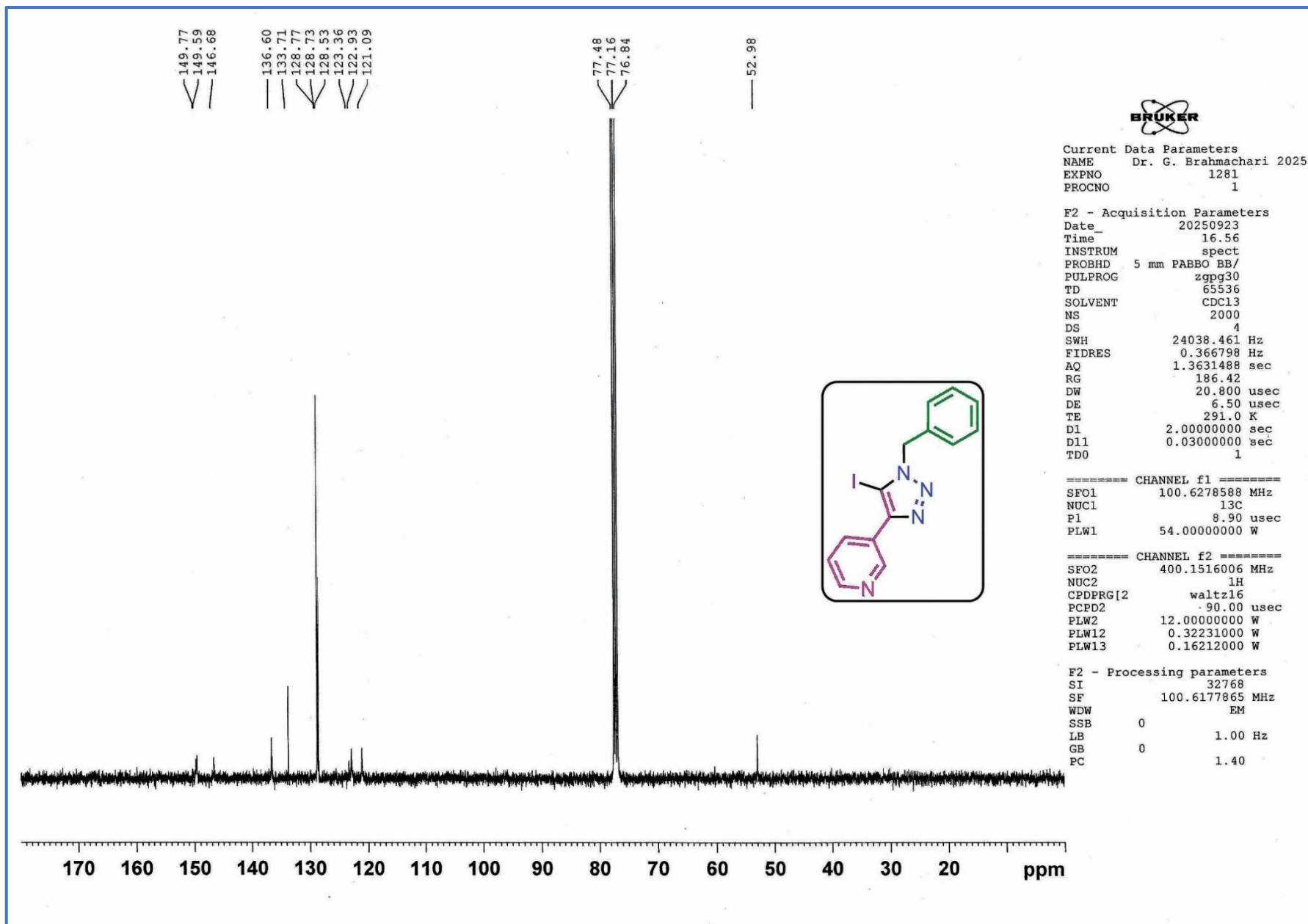


Figure S33.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 3-(1-Benzyl-5-iodo-1H-1,2,3-triazol-4-yl)-pyridine (**4s**)

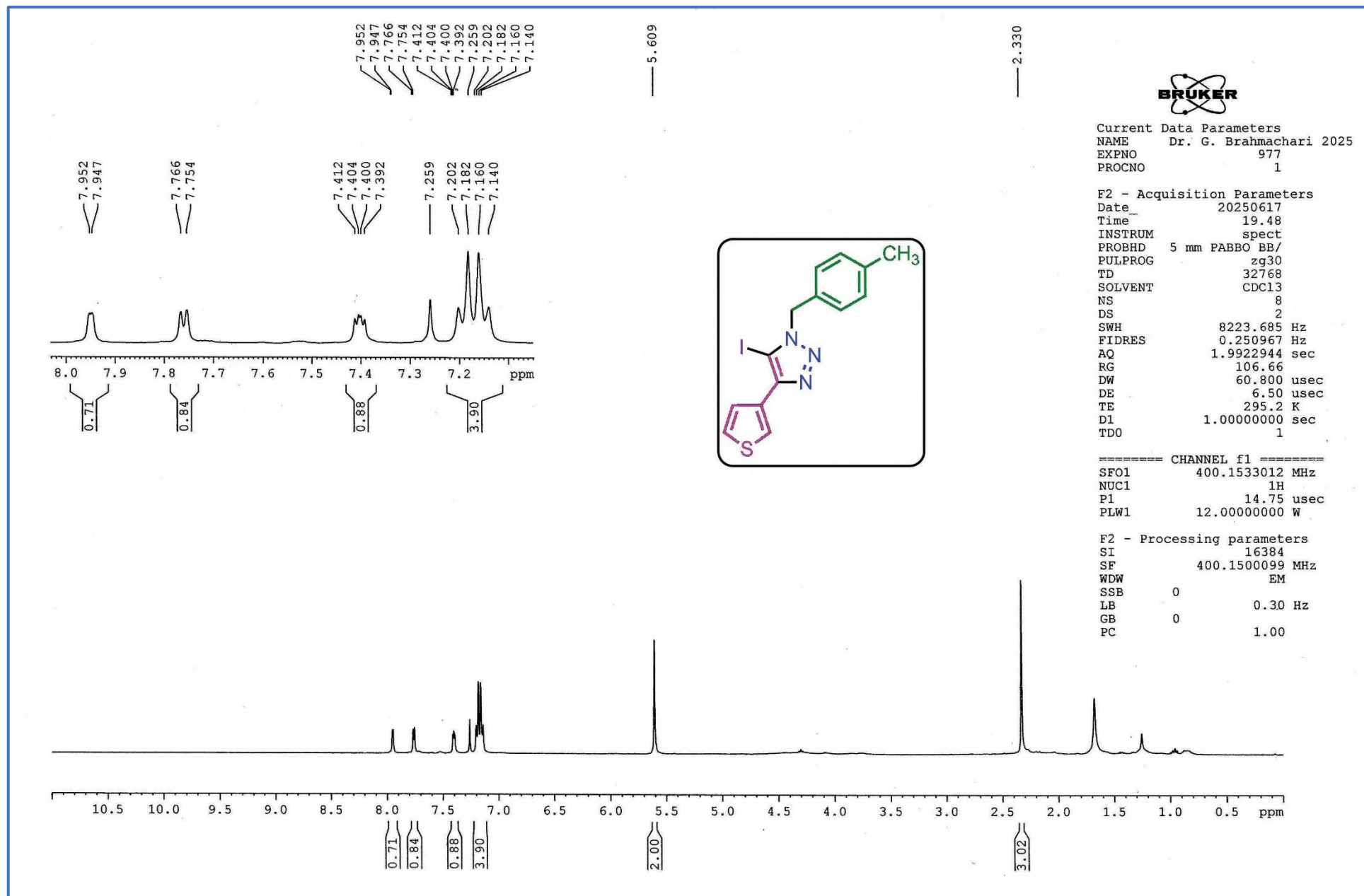


Figure S34. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(thiophen-3-yl)-1H-1,2,3-triazole (**4t**)

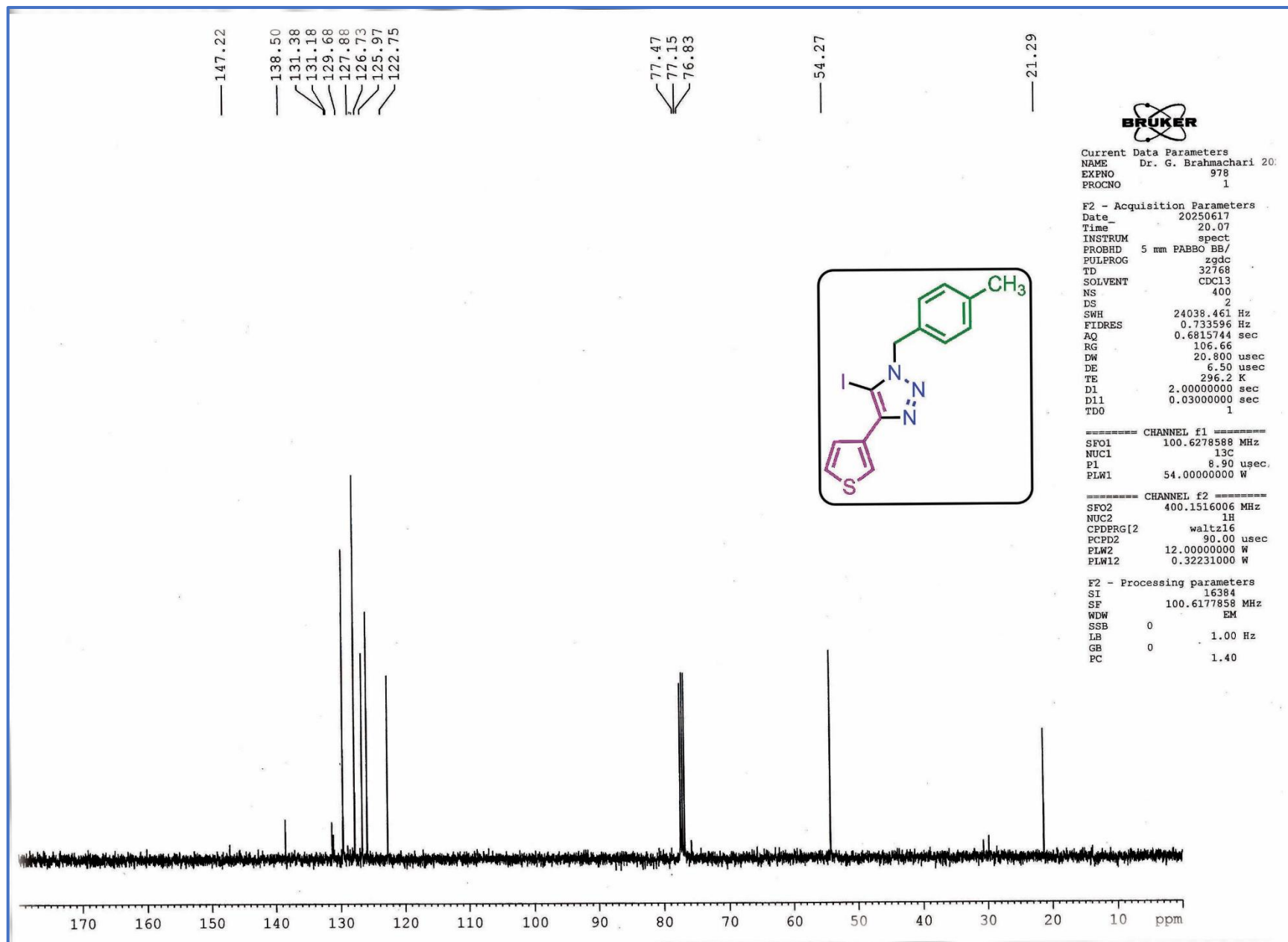


Figure S35.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(4-methylbenzyl)-4-(thiophen-3-yl)-1H-1,2,3-triazole (**4t**)

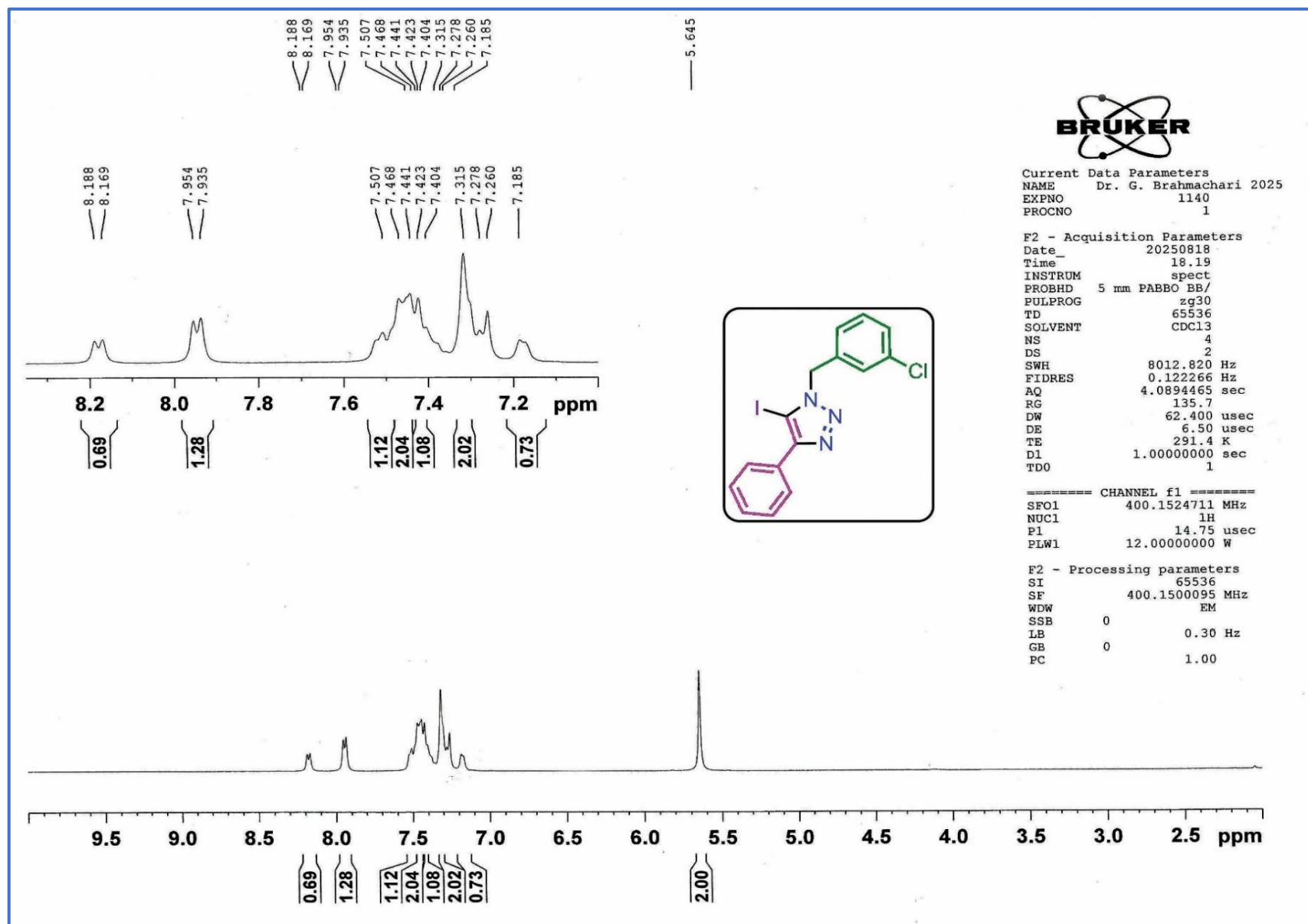


Figure S36. <sup>1</sup>H-NMR spectrum of 1-(3-Chlorobenzyl)-5-iodo-4-phenyl-1*H*-1,2,3-triazole (**4u**)

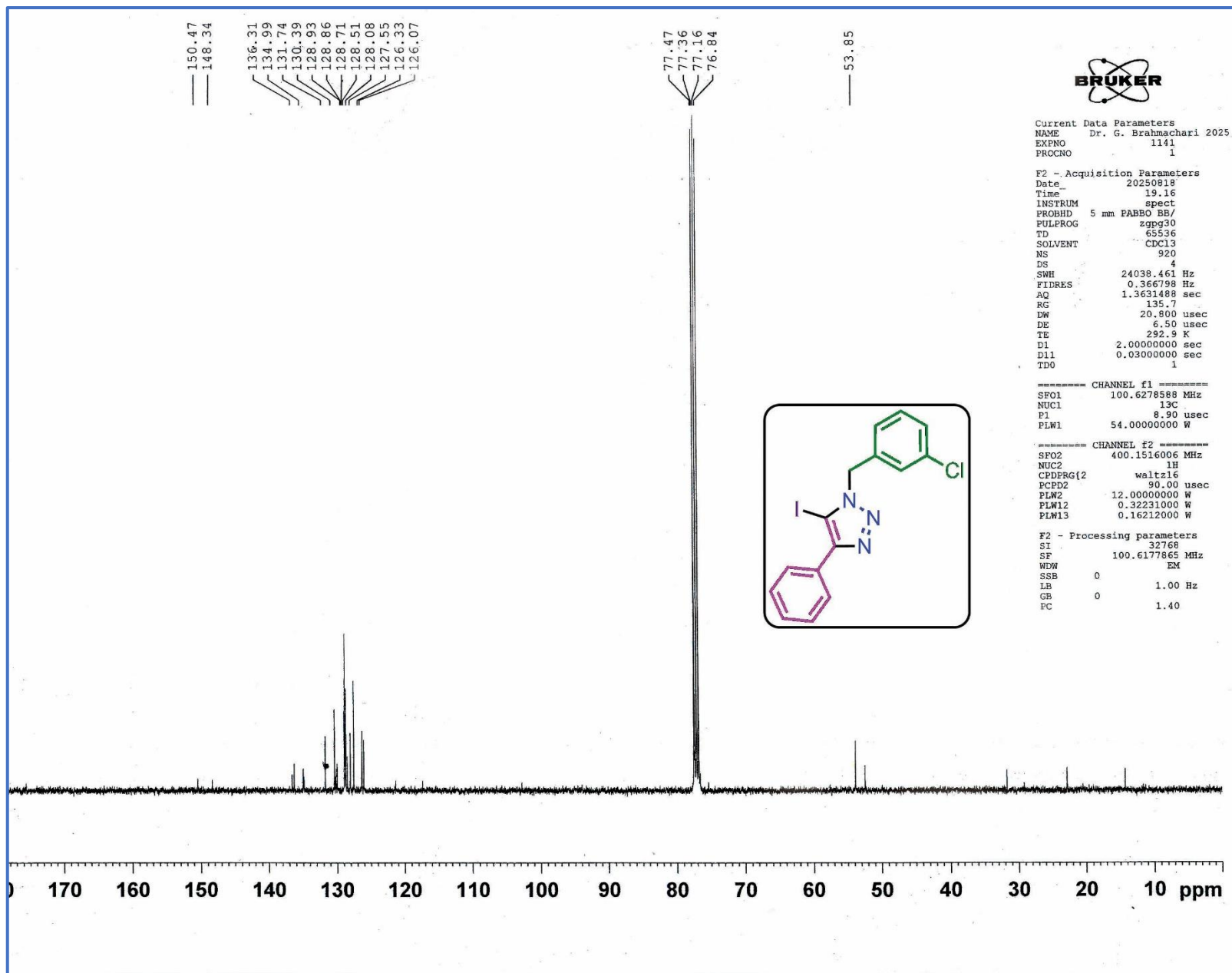


Figure S37.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-(3-Chlorobenzyl)-5-iodo-4-phenyl-1H-1,2,3-triazole (**4u**)

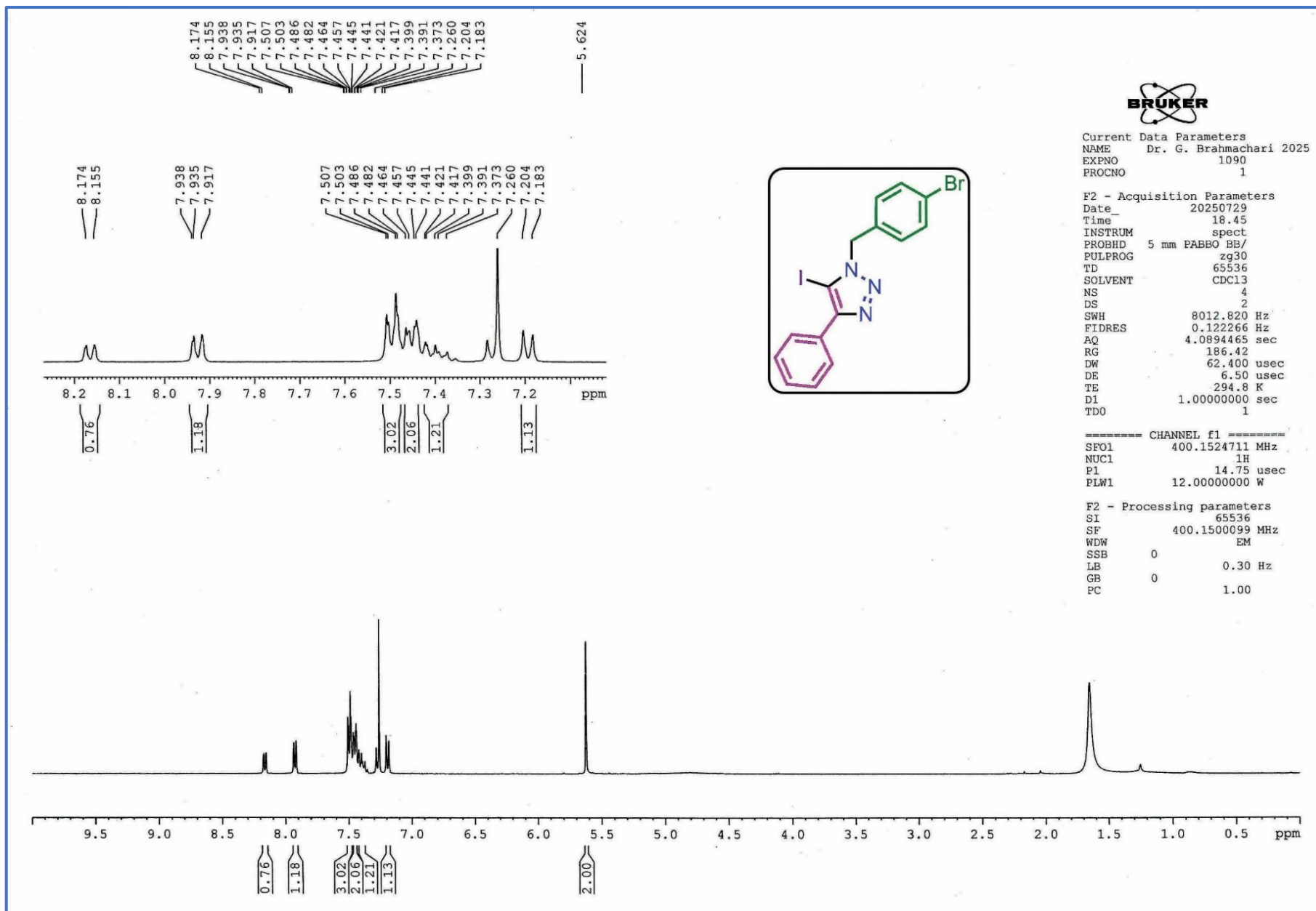


Figure S38. <sup>1</sup>H-NMR spectrum of 1-(4-Bromobenzyl)-5-iodo-4-phenyl-1H-1,2,3-triazole (**4v**)

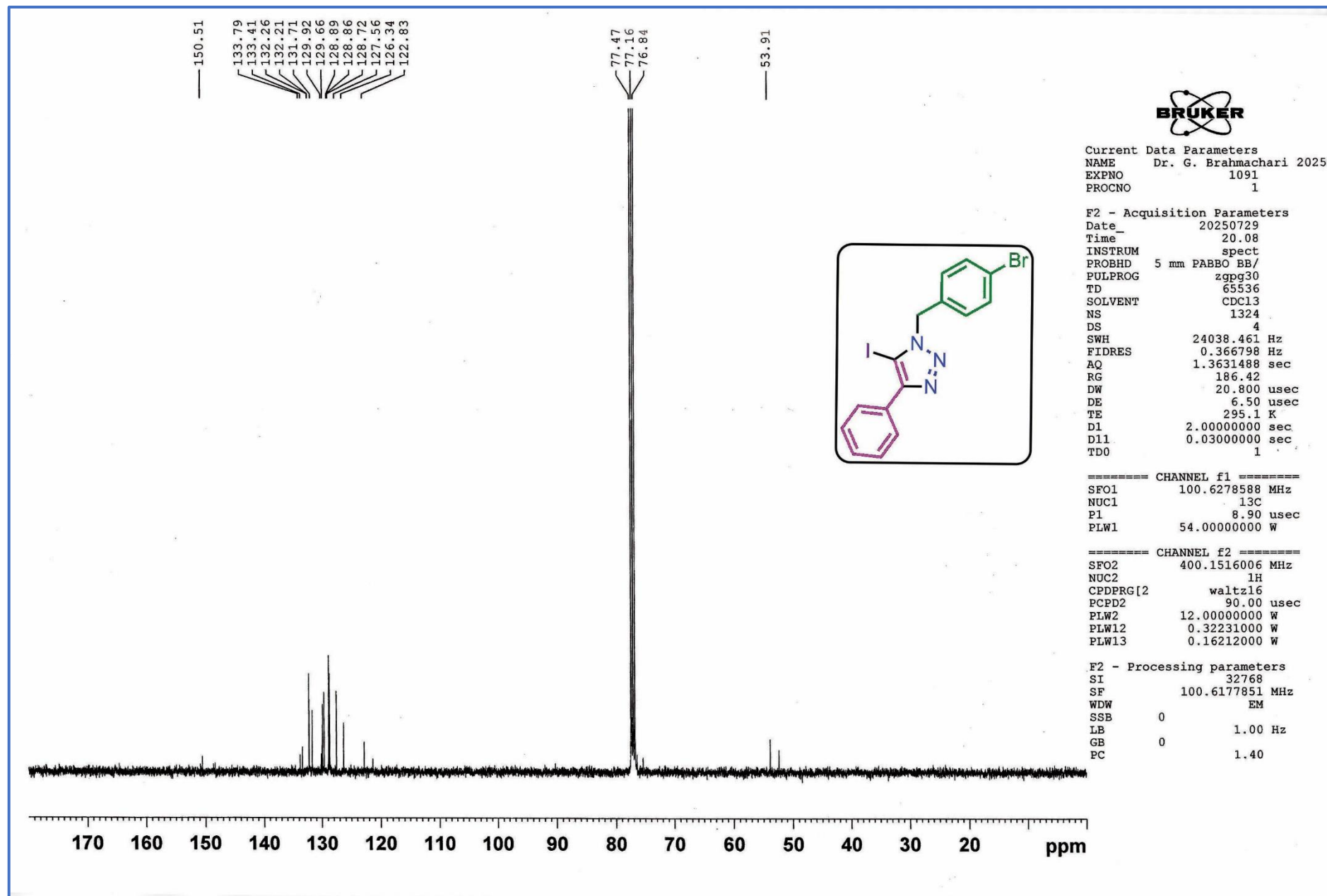


Figure S39.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-(4-Bromobenzyl)-5-iodo-4-phenyl-1H-1,2,3-triazole (4v)

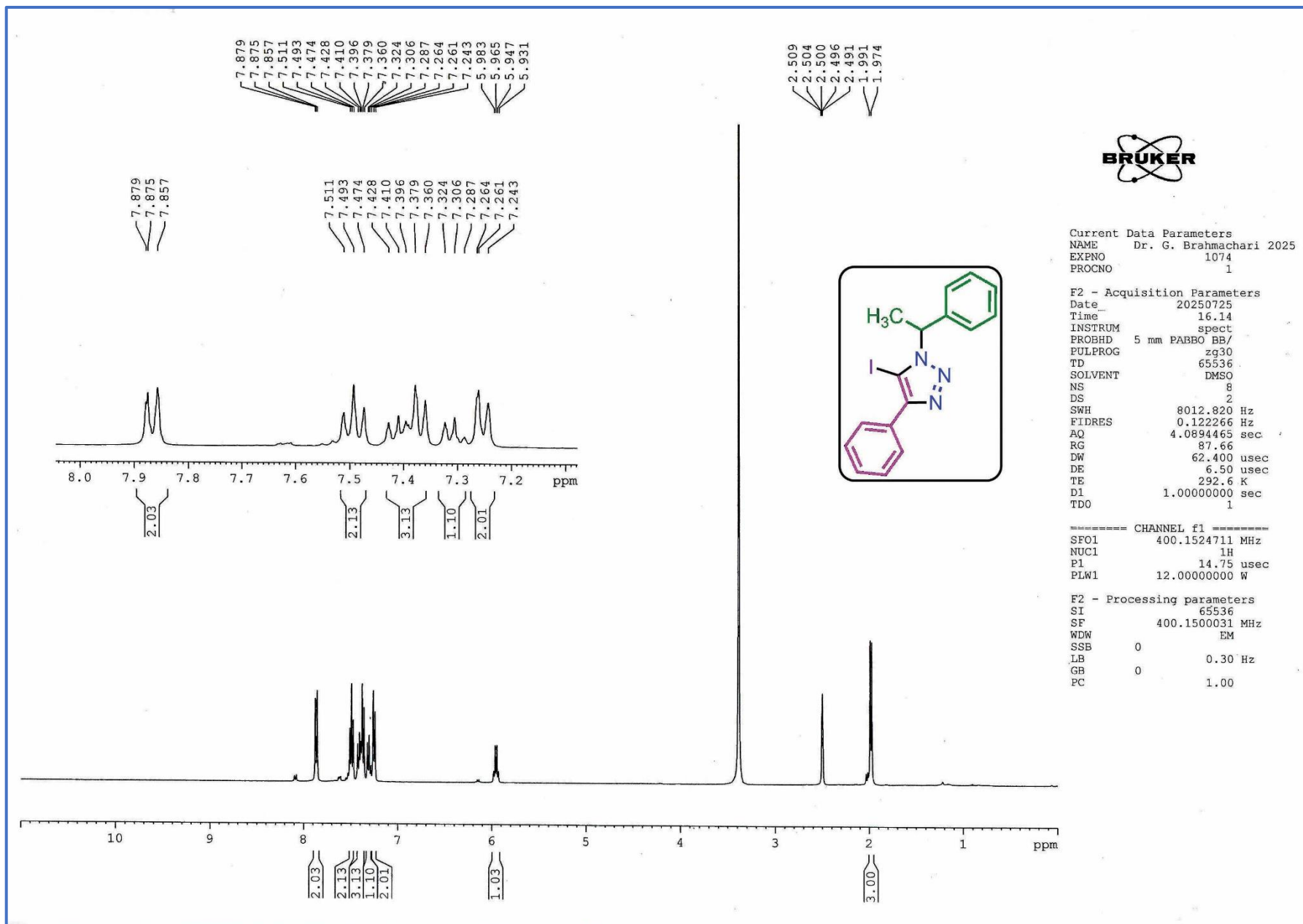


Figure S40. <sup>1</sup>H-NMR spectrum of 5-Iodo-4-phenyl-1-(1-phenylethyl)-1H-1,2,3-triazole (**4w**)

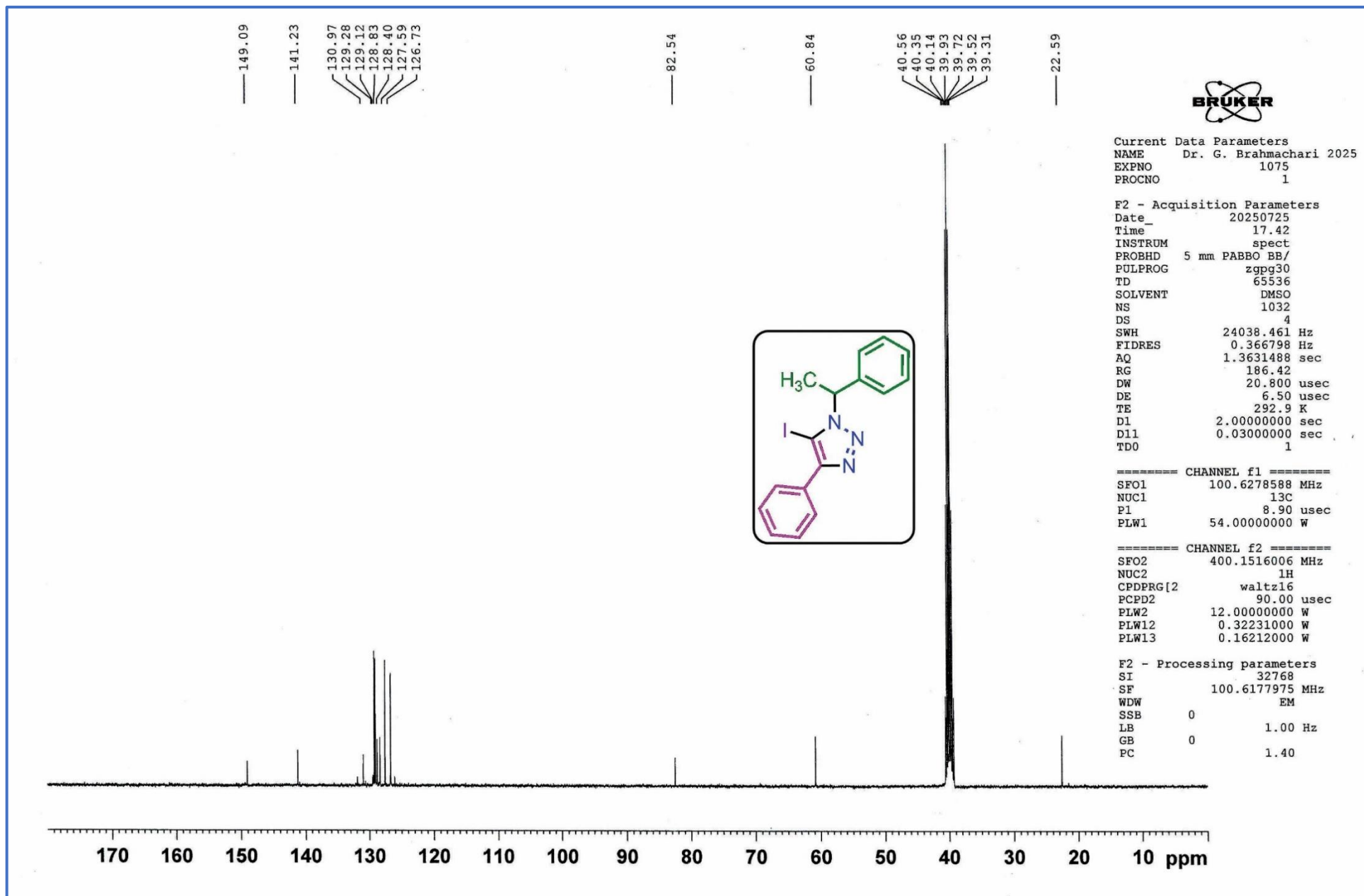


Figure S41.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-4-phenyl-1-(1-phenylethyl)-1H-1,2,3-triazole (4w)

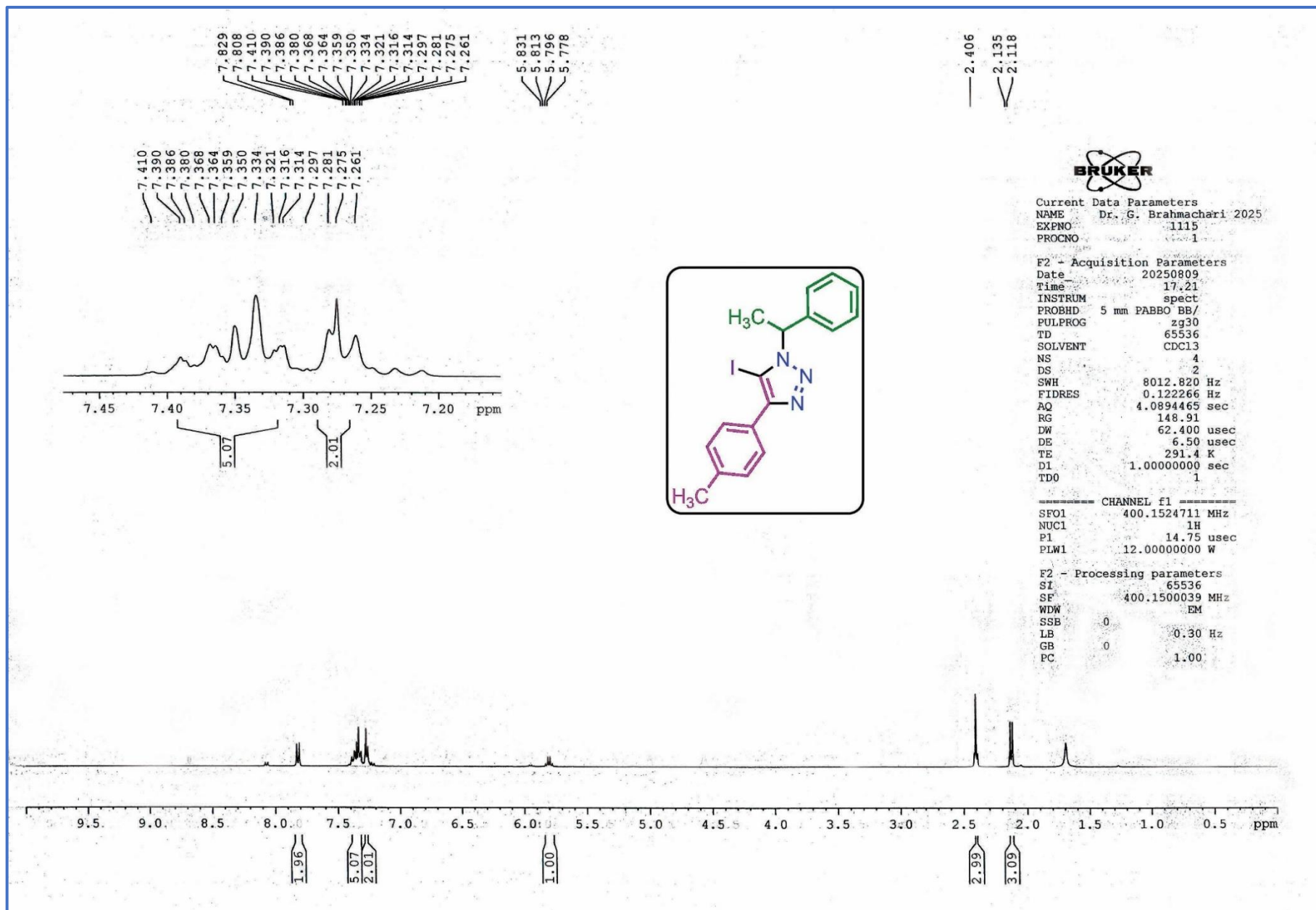


Figure S42. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(1-phenylethyl)-4-(*p*-tolyl)-1H-1,2,3-triazole (**4x**)

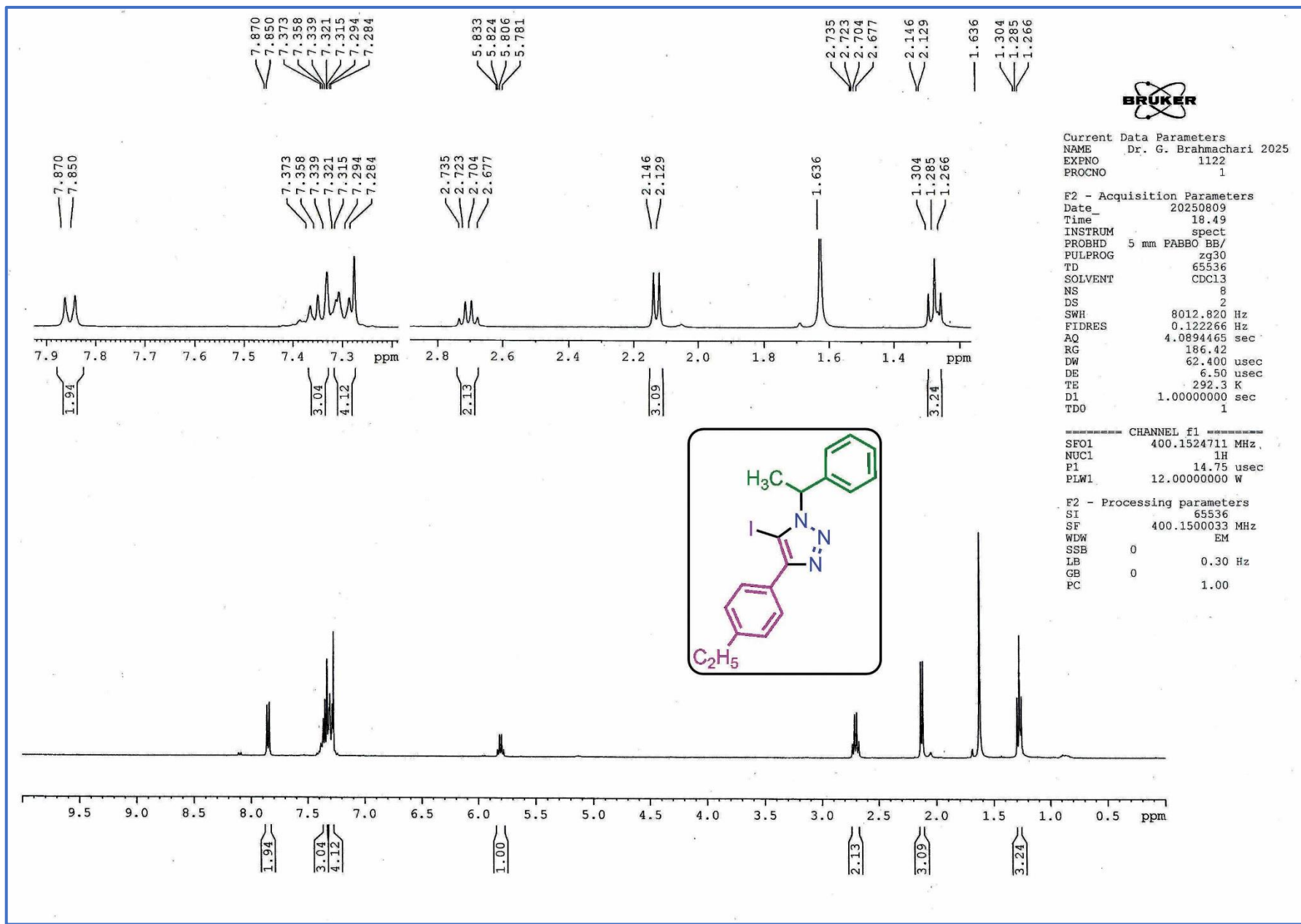


Figure S43. <sup>1</sup>H-NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(1-phenylethyl)-1H-1,2,3-triazole (**4y**)

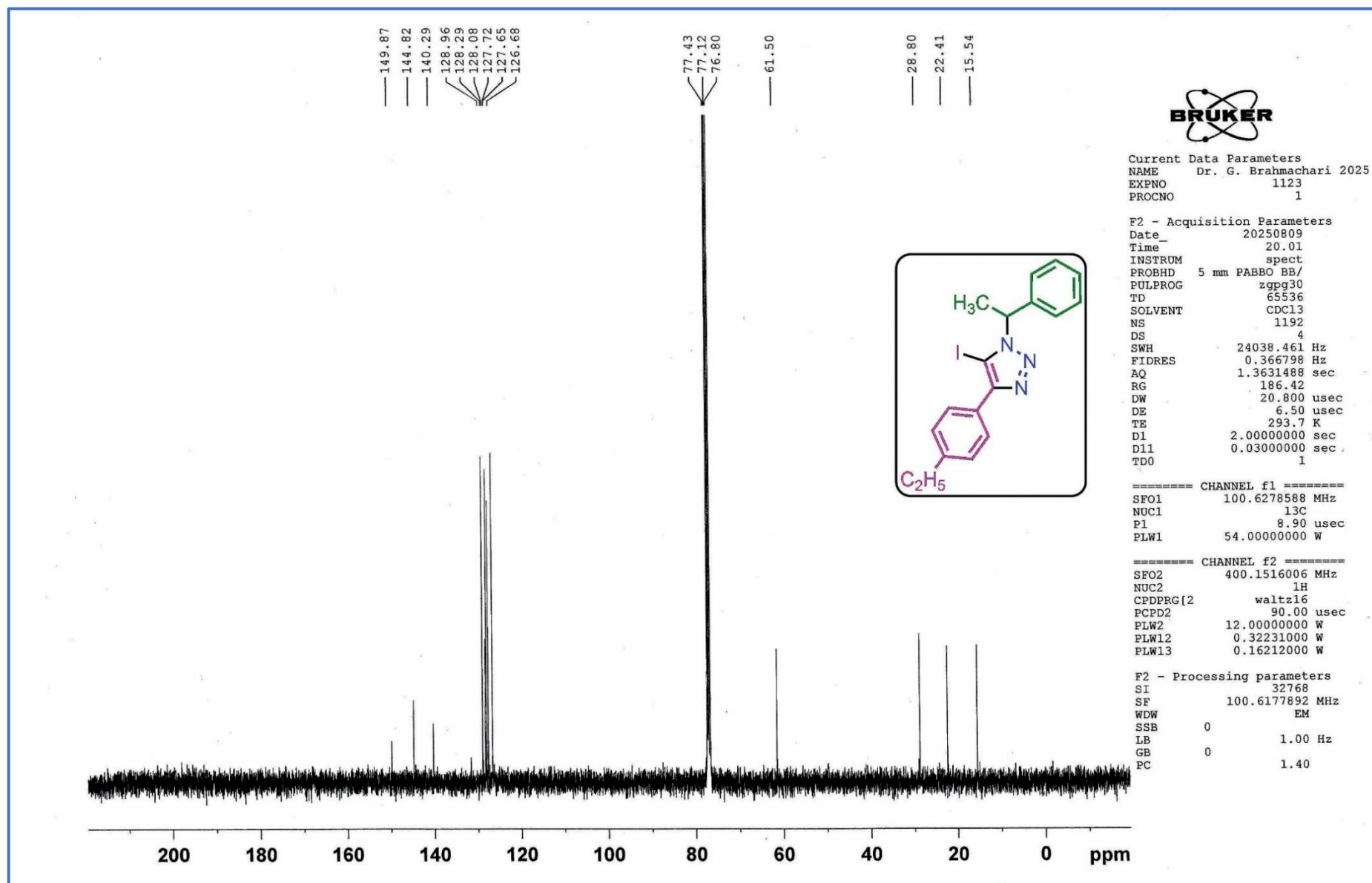


Figure S44. <sup>13</sup>C{<sup>1</sup>H} NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(1-phenylethyl)-1H-1,2,3-triazole (**4y**)

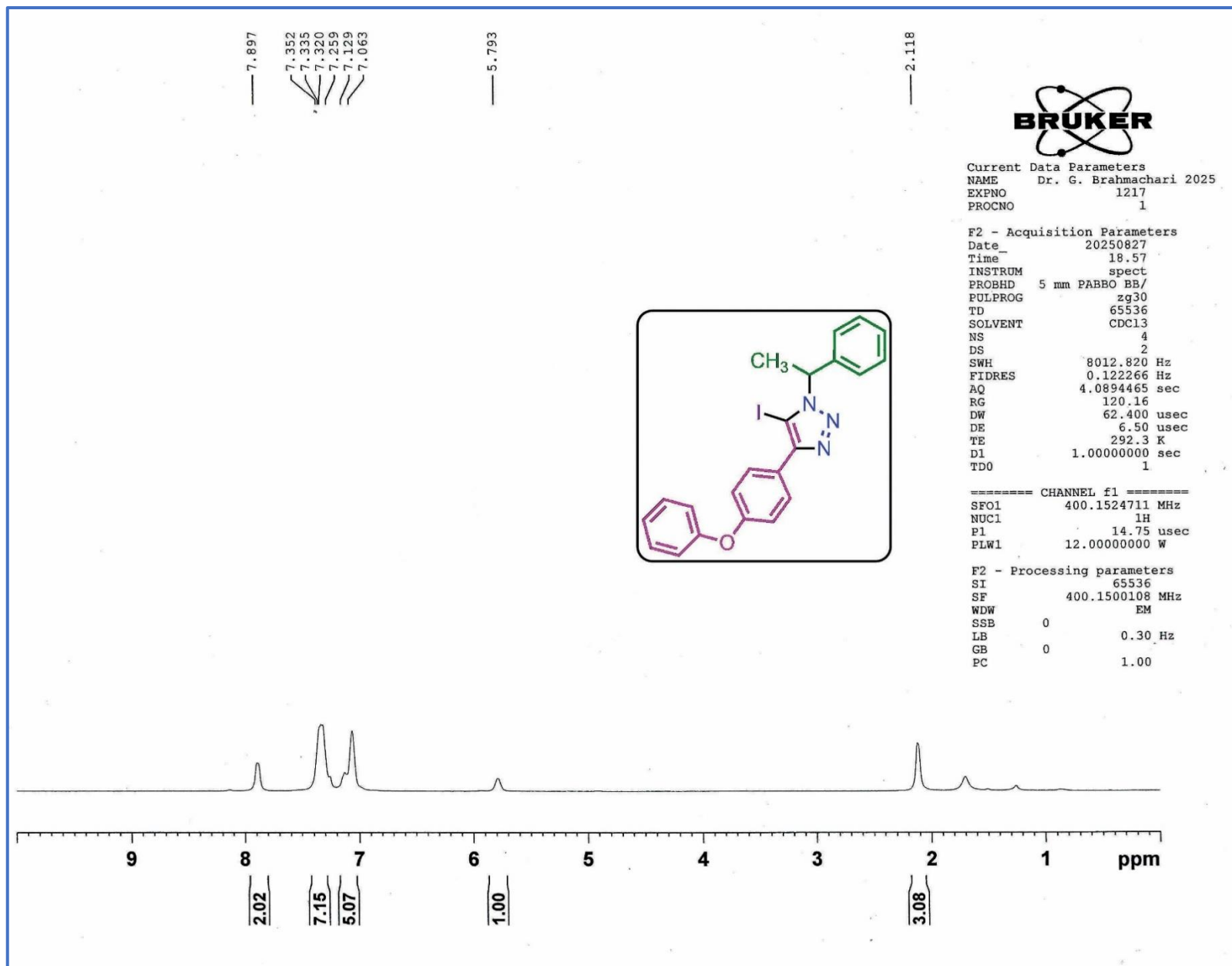


Figure S45. <sup>1</sup>H-NMR spectrum of 5-Iodo-4-(4-phenoxyphenyl)-1-(1-phenylethyl)-1H-1,2,3-triazole (**4z**)

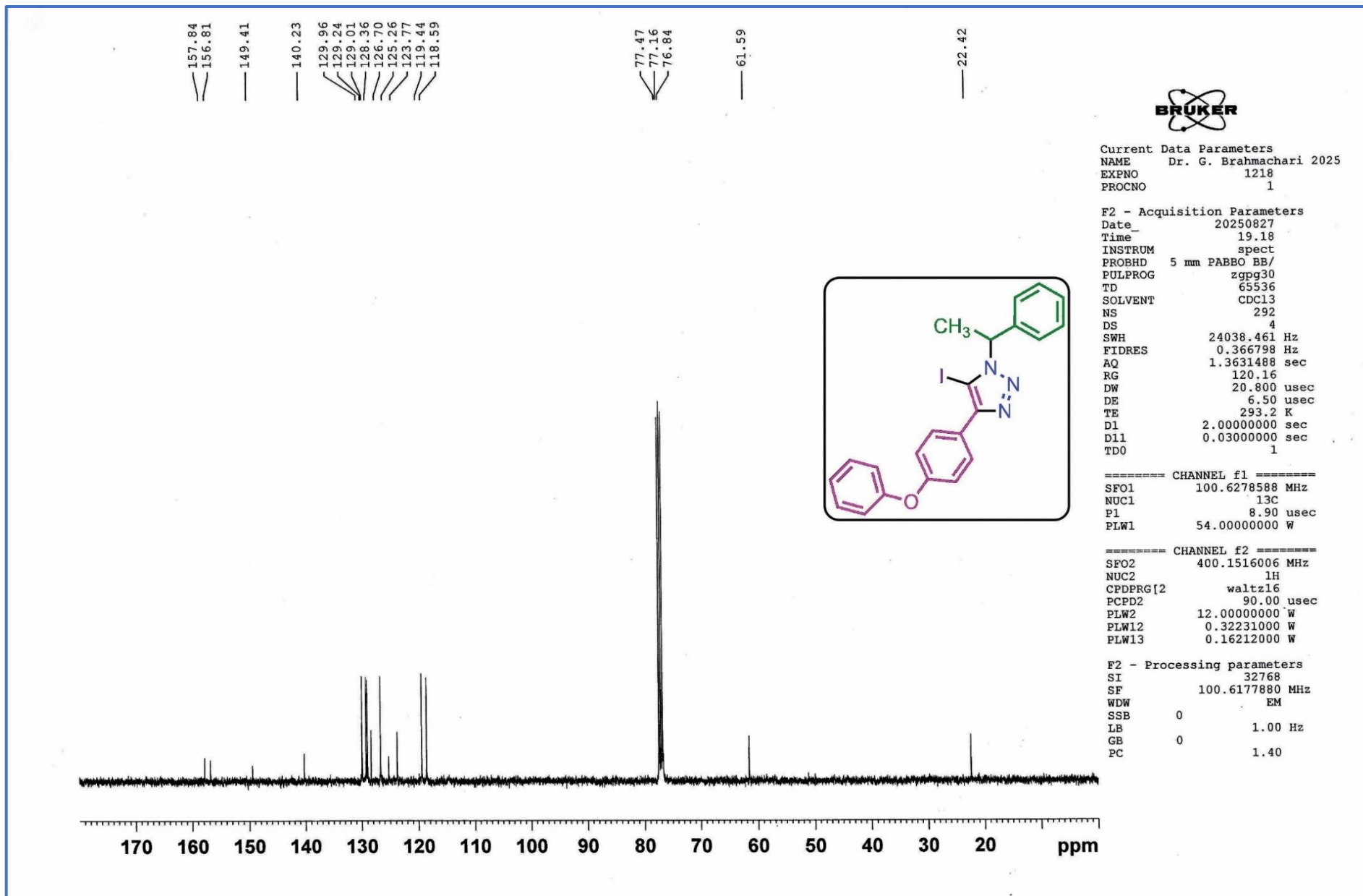


Figure S46.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-4-(4-phenoxyphenyl)-1-(1-phenylethyl)-1H-1,2,3-triazole (**4z**)

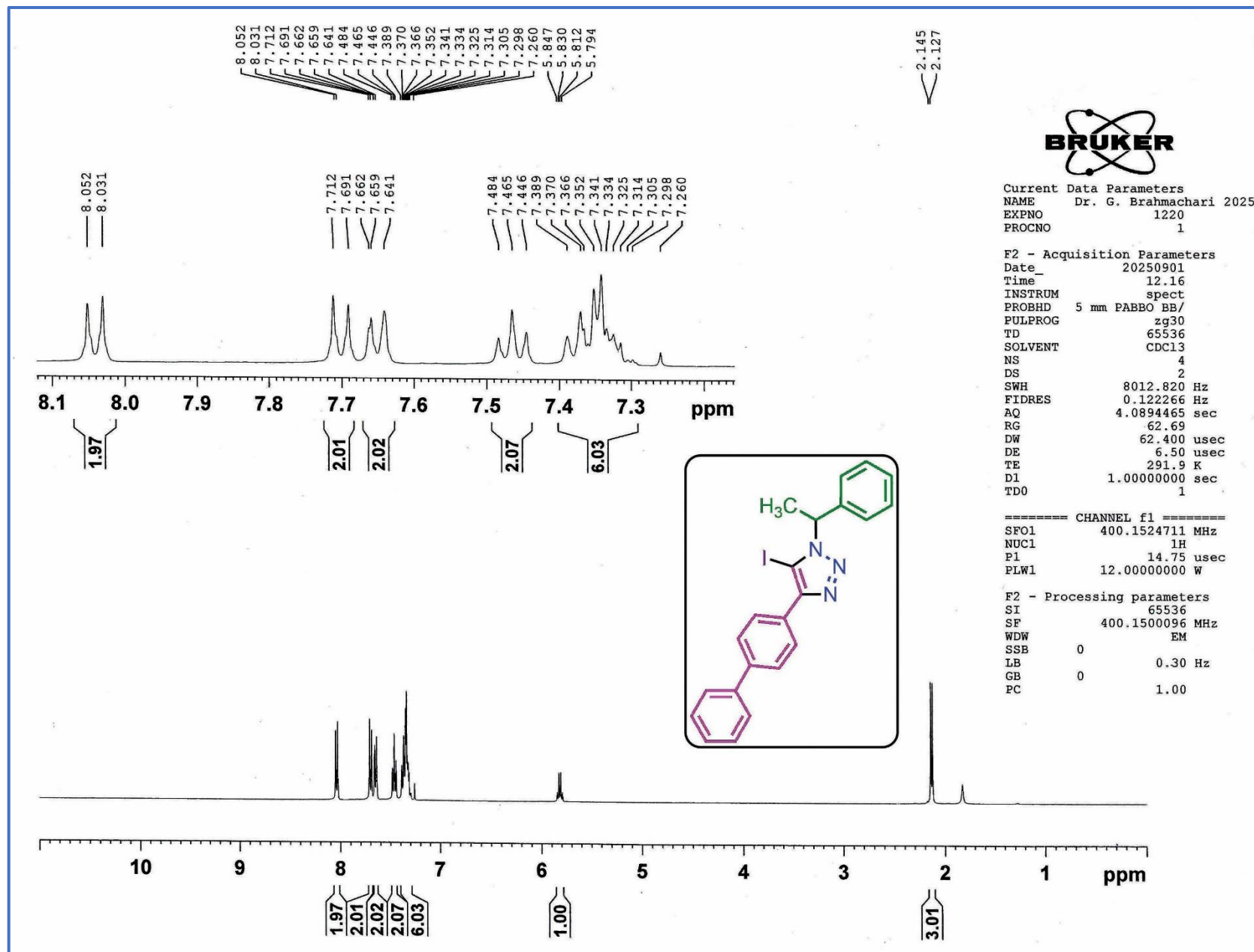


Figure S47. <sup>1</sup>H-NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-5-iodo-1-(1-phenylethyl)-1H-1,2,3-triazole (**4a'**)

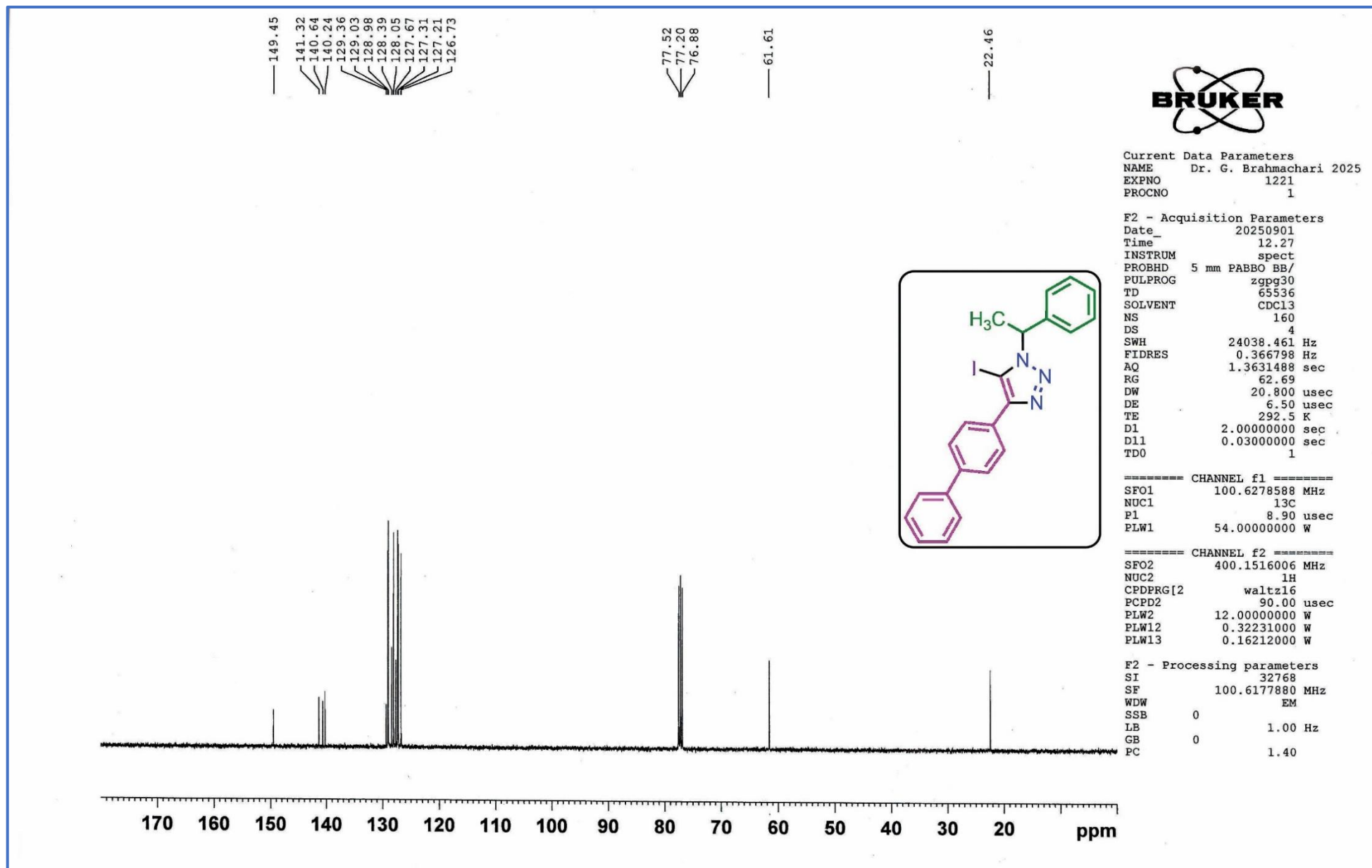


Figure S48.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-([1,1'-Biphenyl]-4-yl)-5-iodo-1-(1-phenylethyl)-1H-1,2,3-triazole (**4a'**)

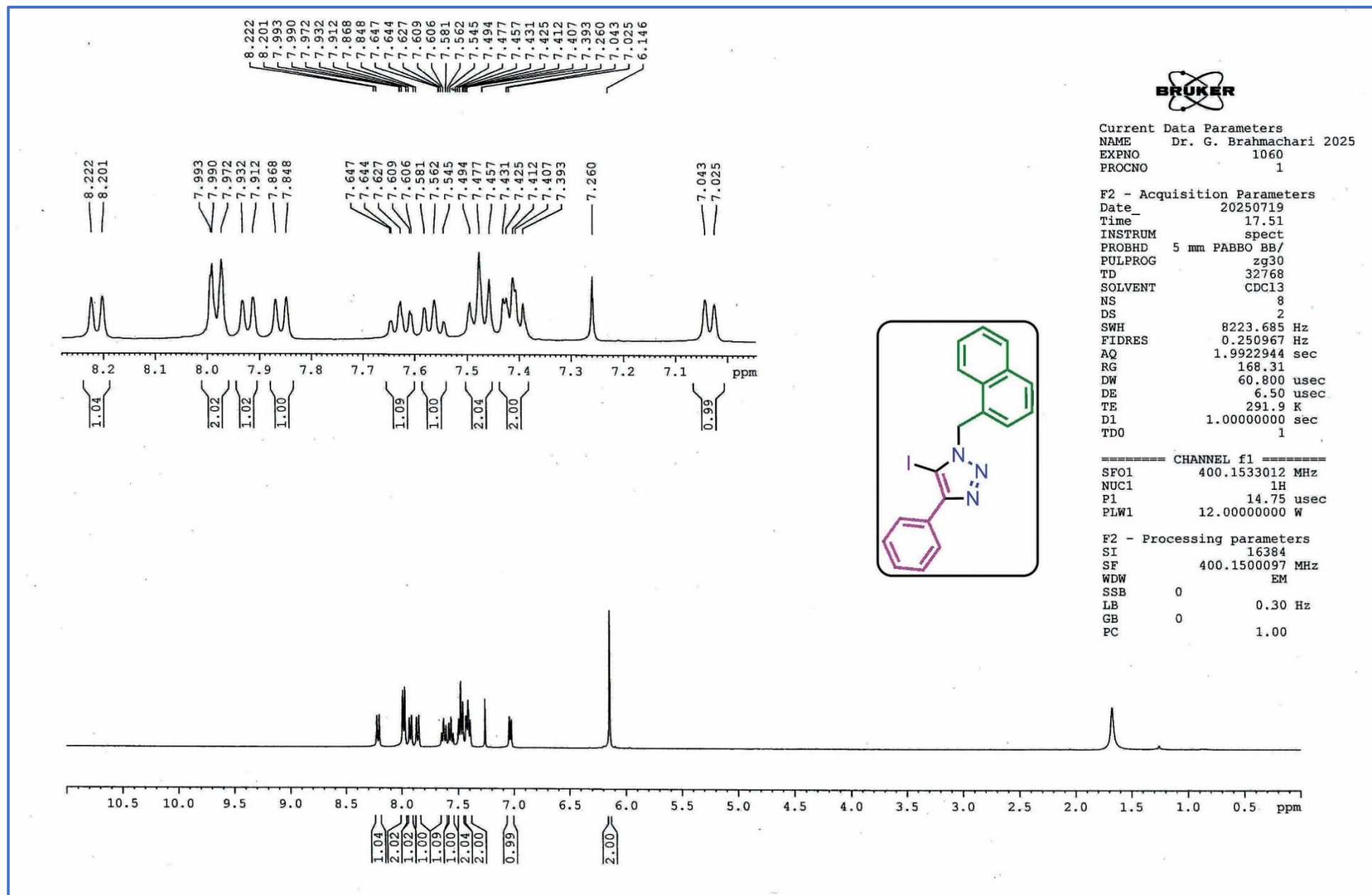


Figure S49. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(naphthalen-2-ylmethyl)-4-phenyl-1H-1,2,3-triazole (**4b'**)

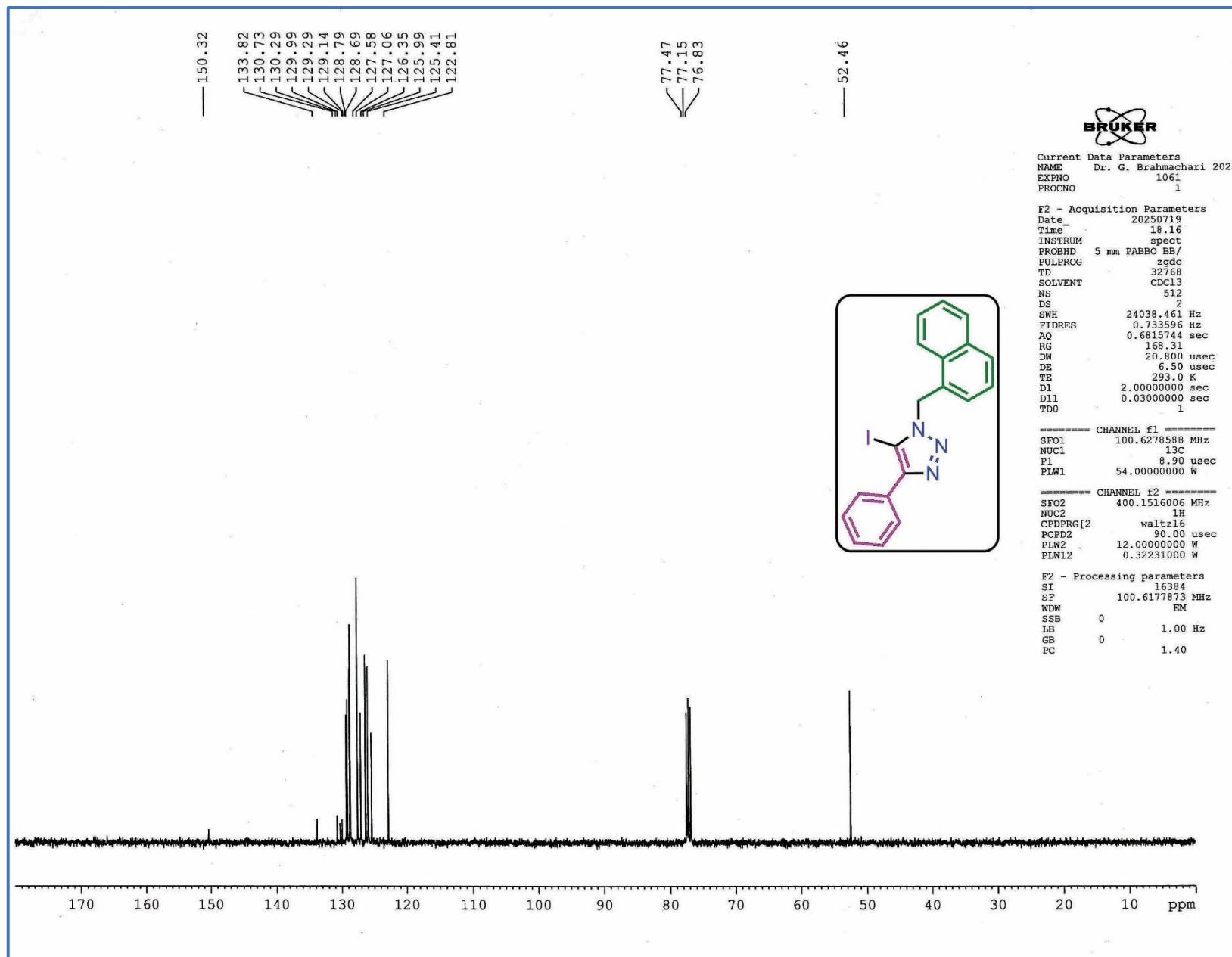


Figure S50.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(naphthalen-2-ylmethyl)-4-phenyl-1H-1,2,3-triazole (**4b'**)

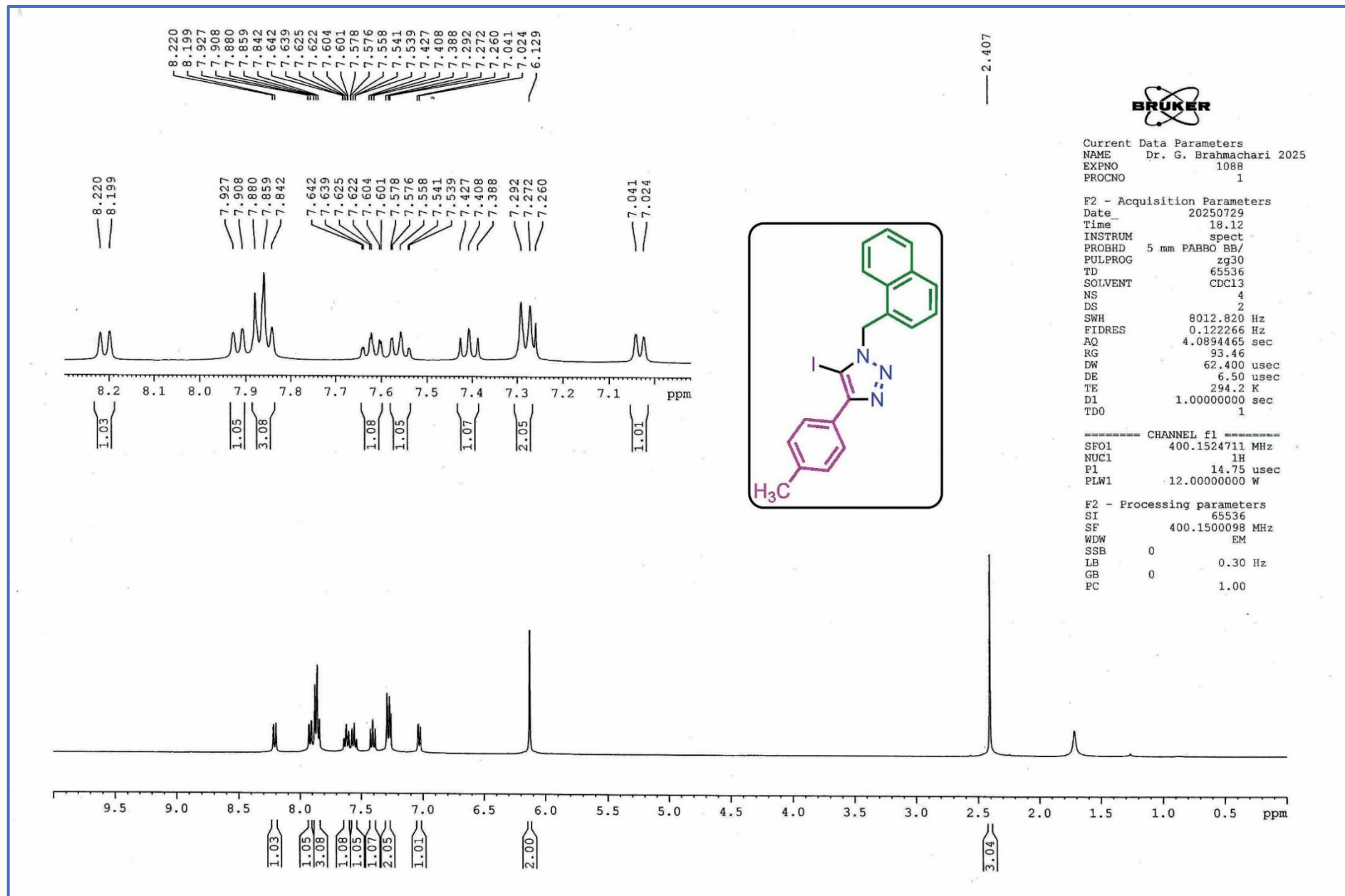


Figure S51. <sup>1</sup>H-NMR spectrum of 5-Iodo-1-(naphthalen-2-ylmethyl)-4-(*p*-tolyl)-1H-1,2,3-triazole (**4c'**)

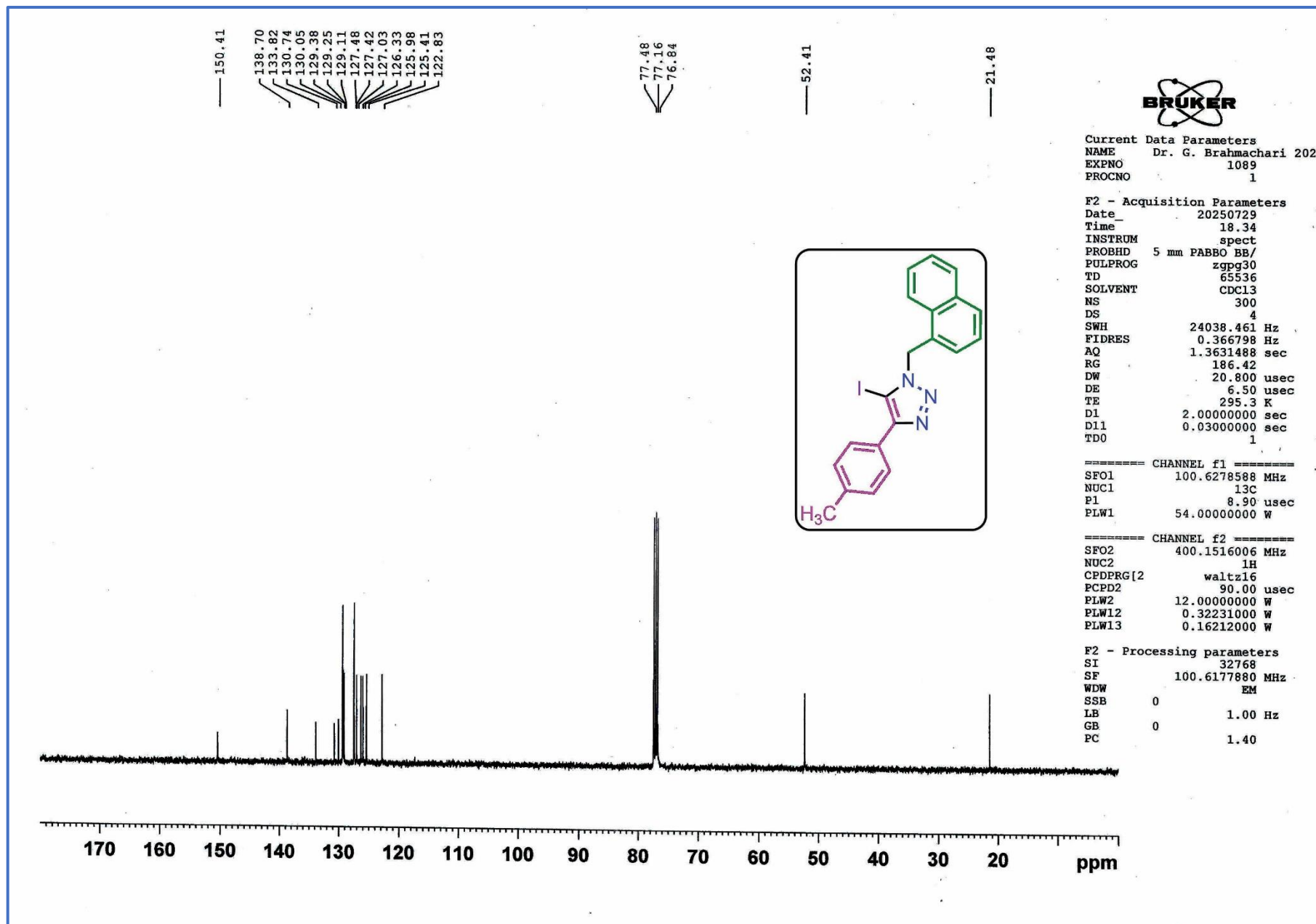


Figure S52.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 5-Iodo-1-(naphthalen-2-ylmethyl)-4-(*p*-tolyl)-1*H*-1,2,3-triazole (**4c'**)

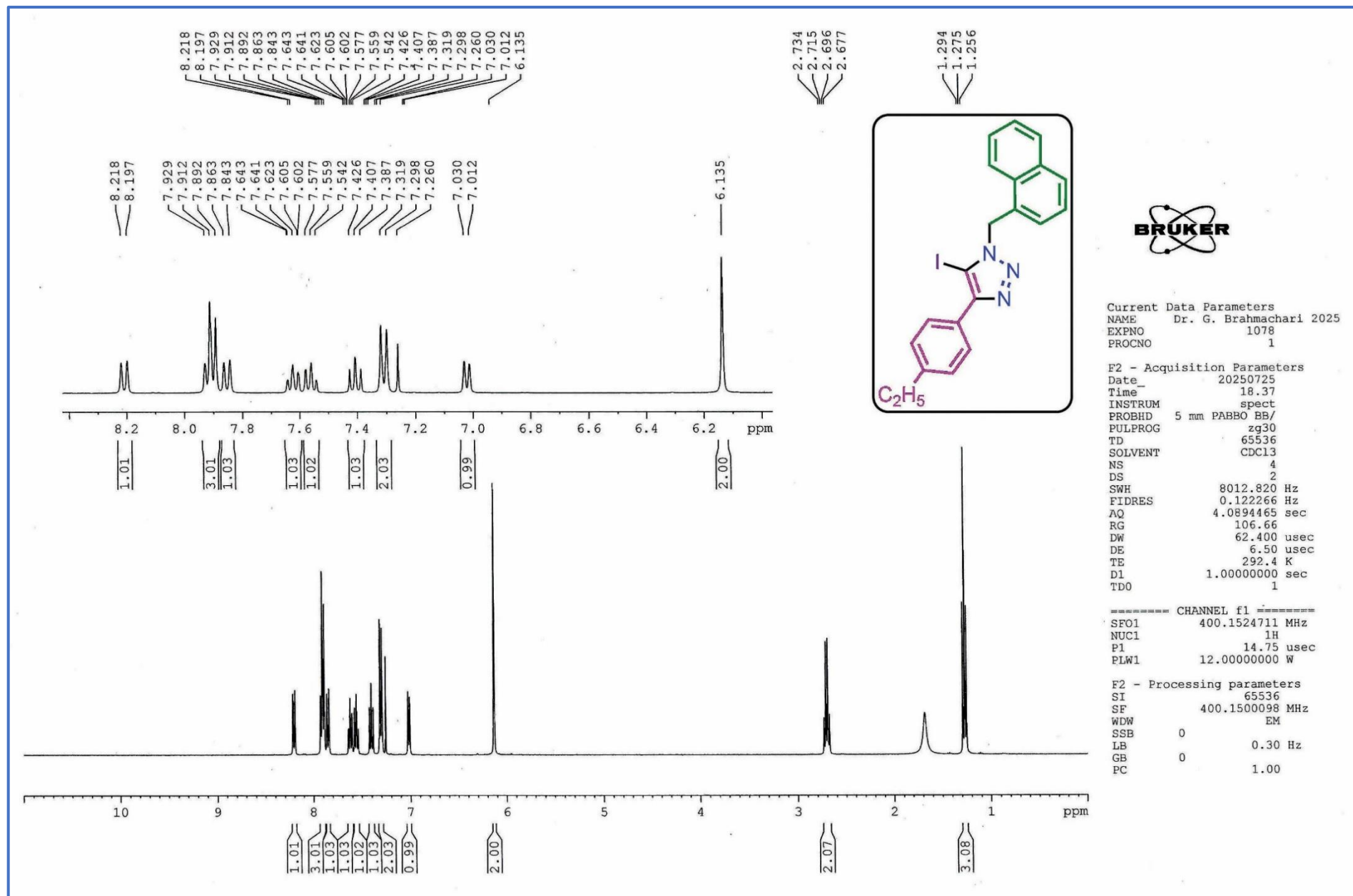


Figure S53. <sup>1</sup>H-NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(naphthalen-1-ylmethyl)-1H-1,2,3-triazole (**4d'**)

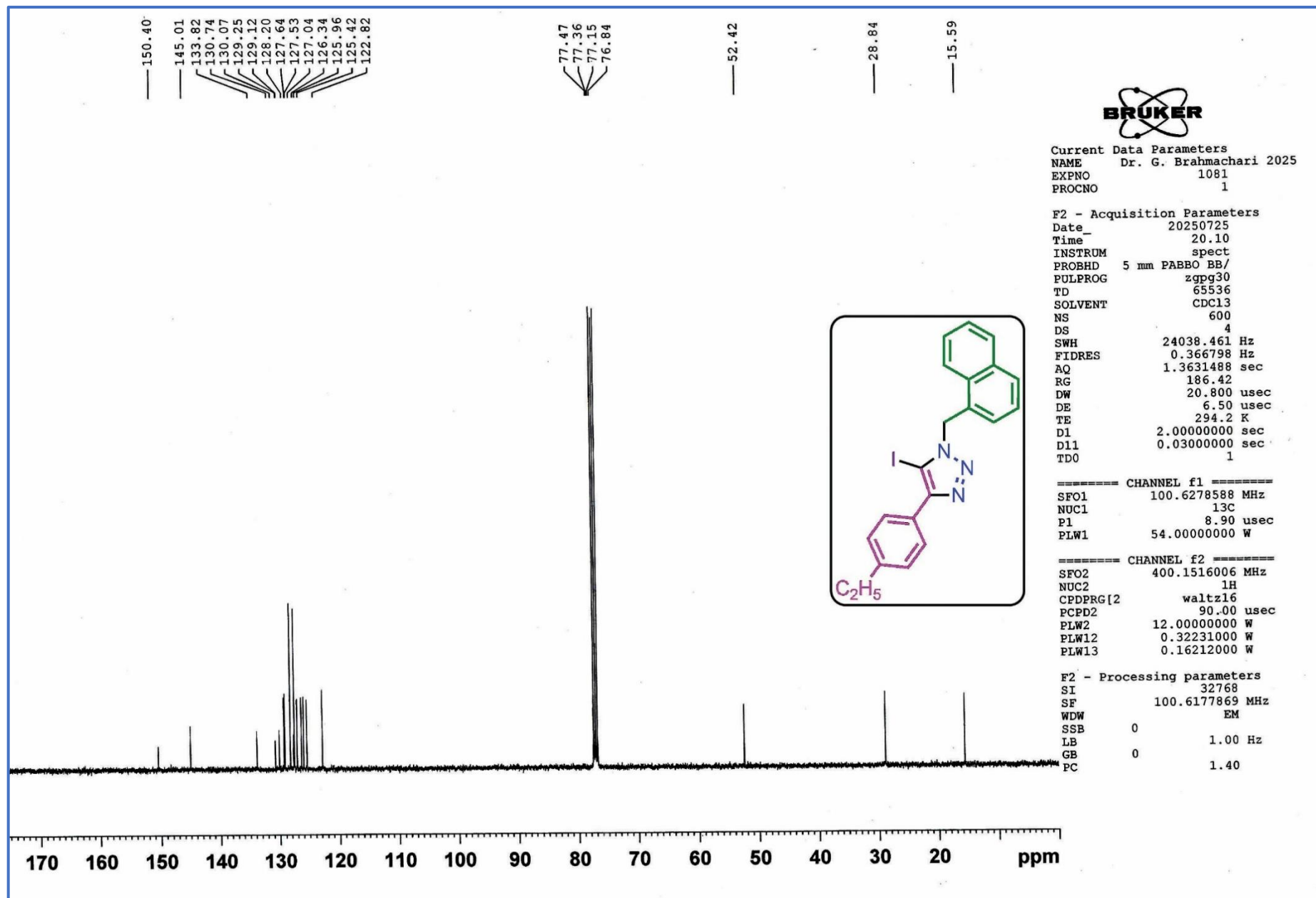


Figure S54.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-(4-Ethylphenyl)-5-iodo-1-(naphthalen-1-ylmethyl)-1H-1,2,3-triazole ( $4d'$ )

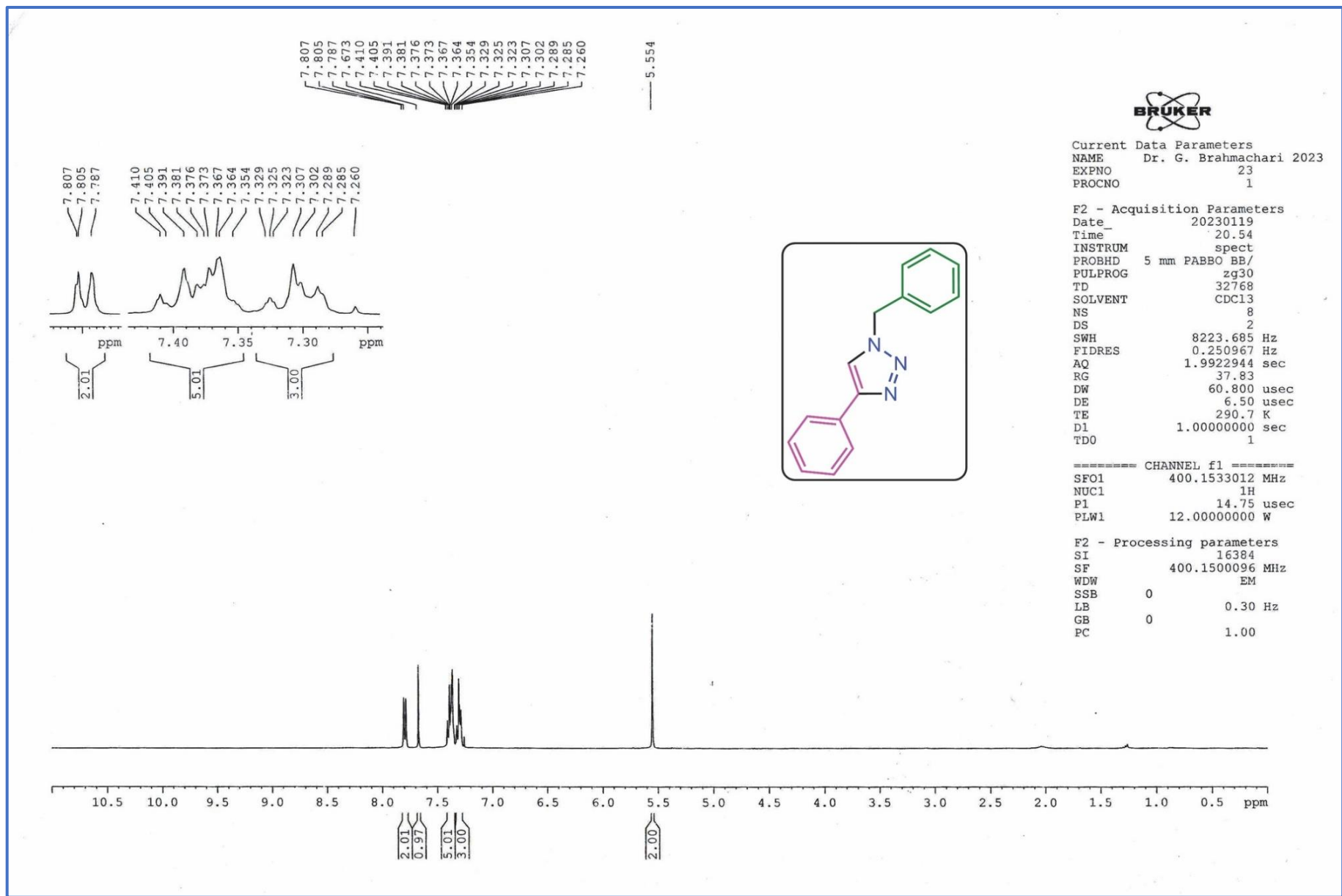


Figure S55. <sup>1</sup>H-NMR spectrum of 1-benzyl-4-phenyl-1H-1,2,3-triazole (**5**)

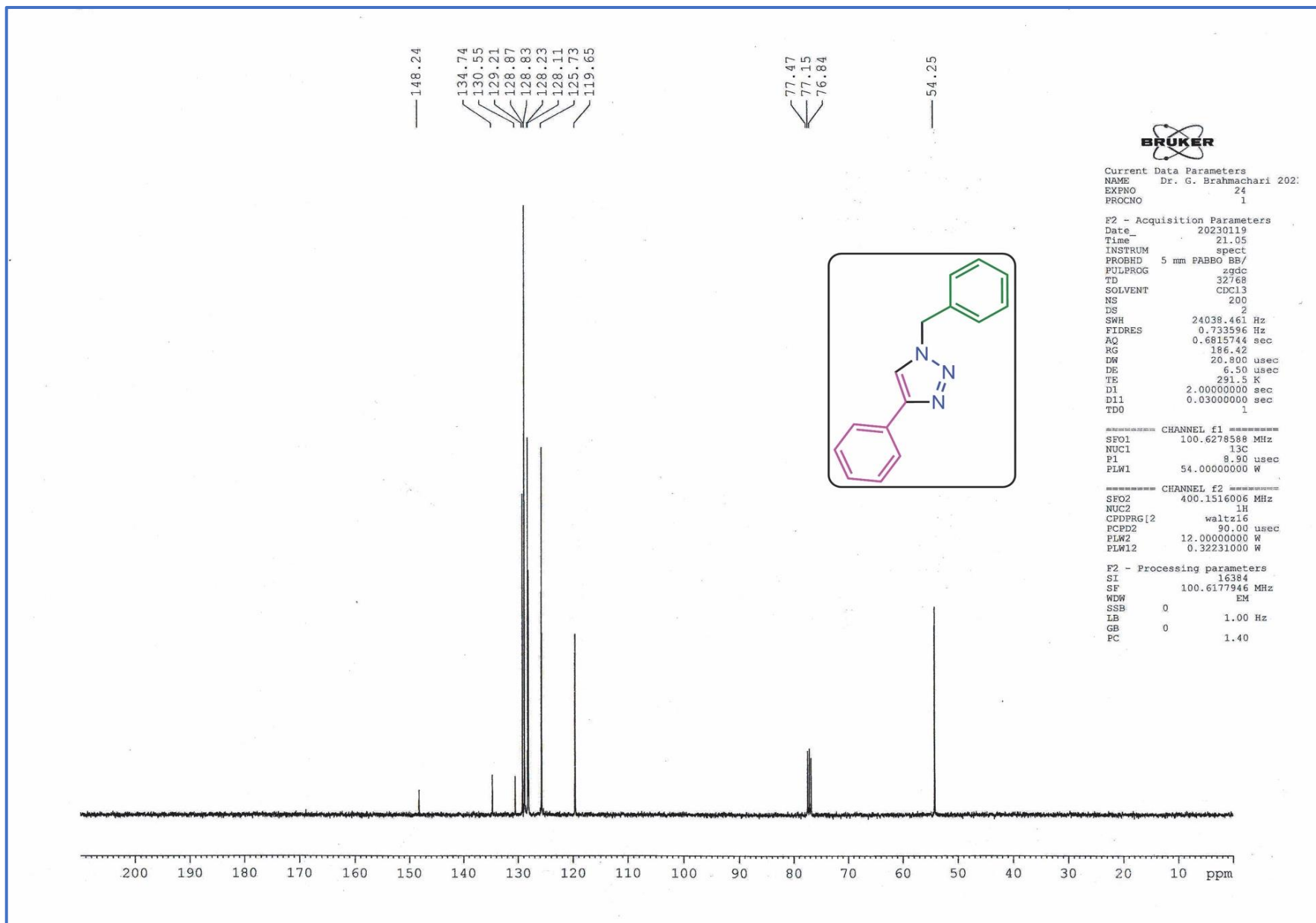


Figure S56.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-benzyl-4-phenyl-1H-1,2,3-triazole (5)

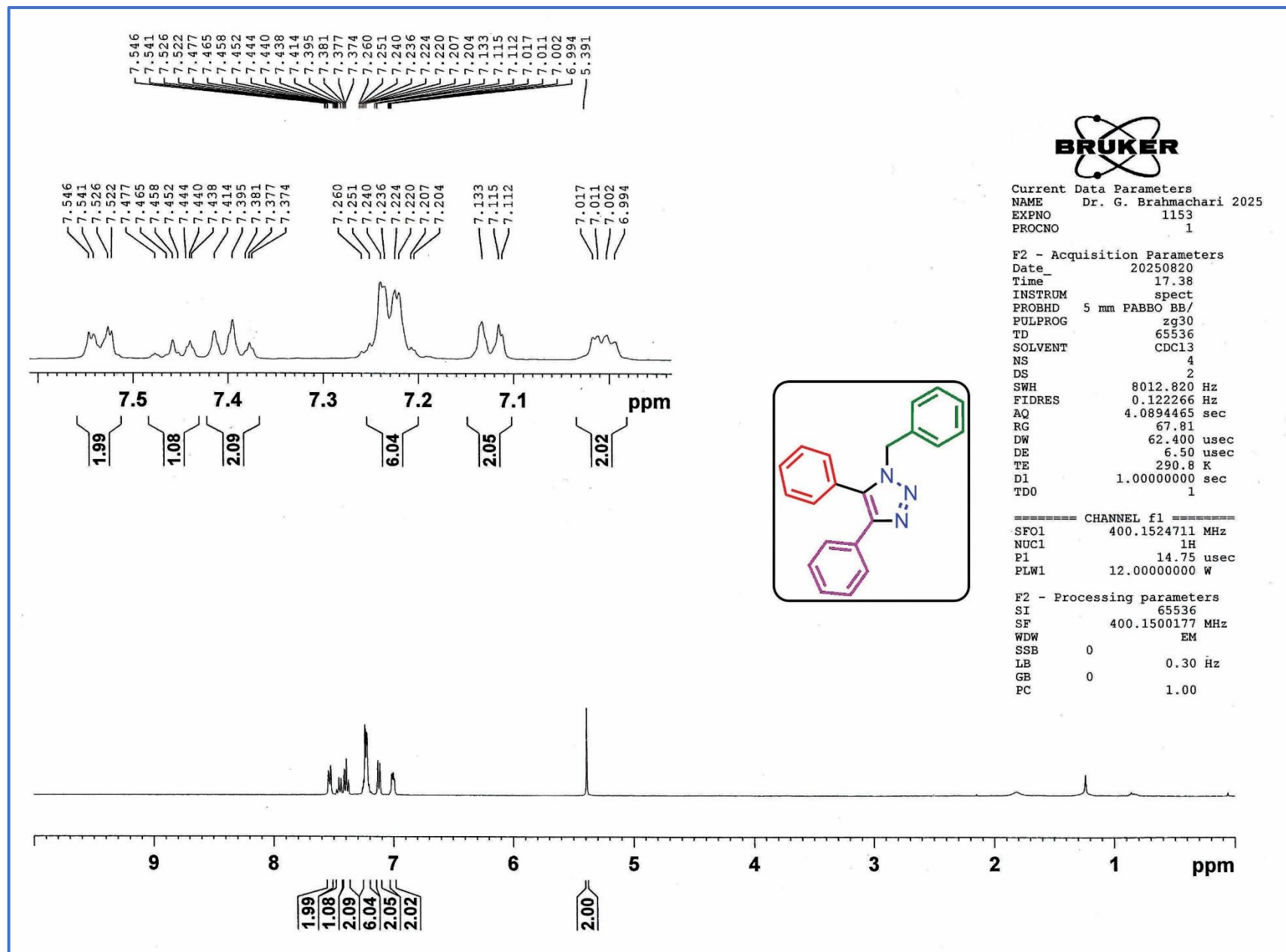


Figure S57. <sup>1</sup>H-NMR spectrum of 1-Benzyl-4,5-diphenyl-1H-1,2,3-triazole (**12a**)

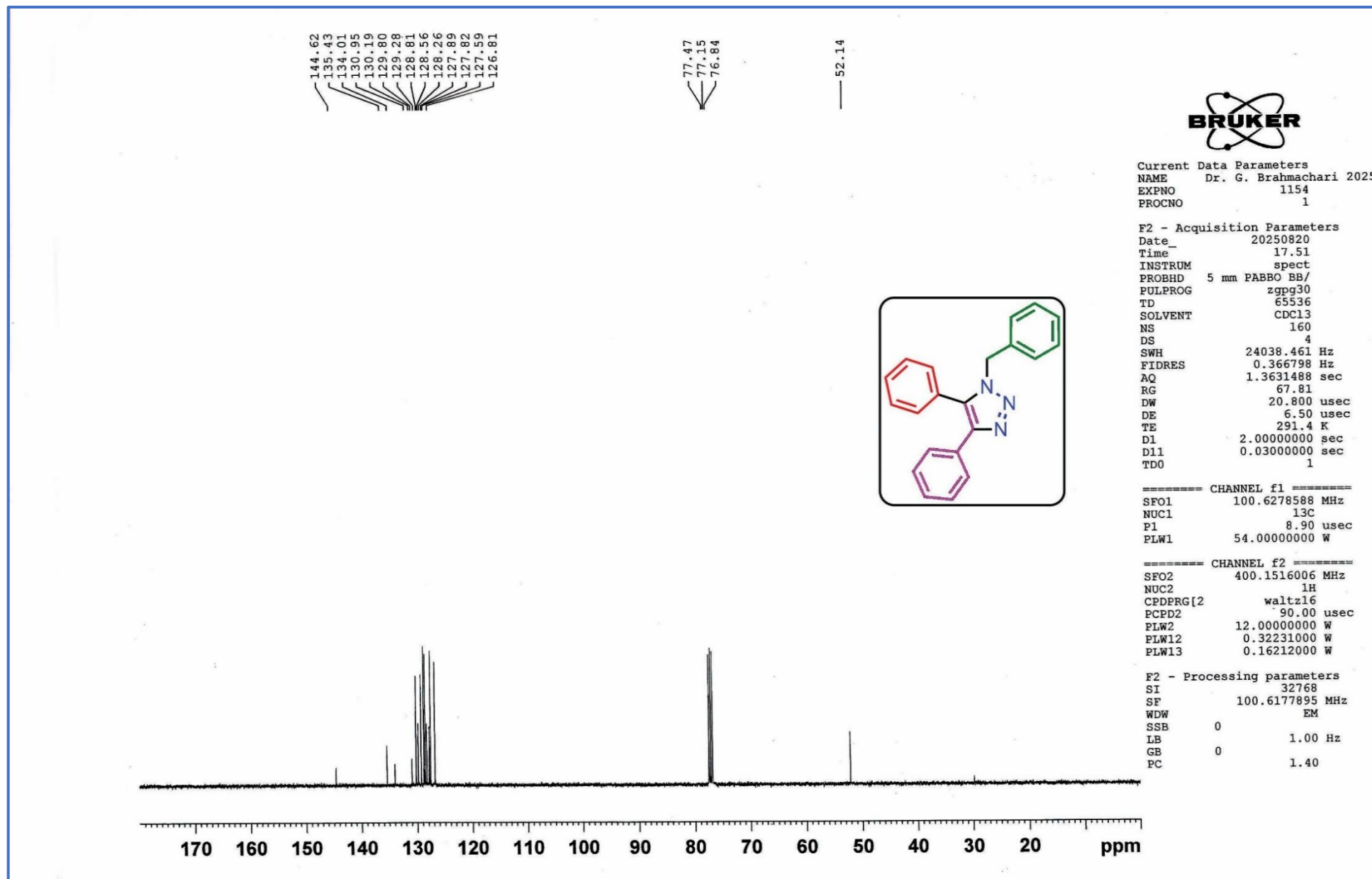


Figure S58.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum 1-Benzyl-4,5-diphenyl-1H-1,2,3-triazole (**12a**)

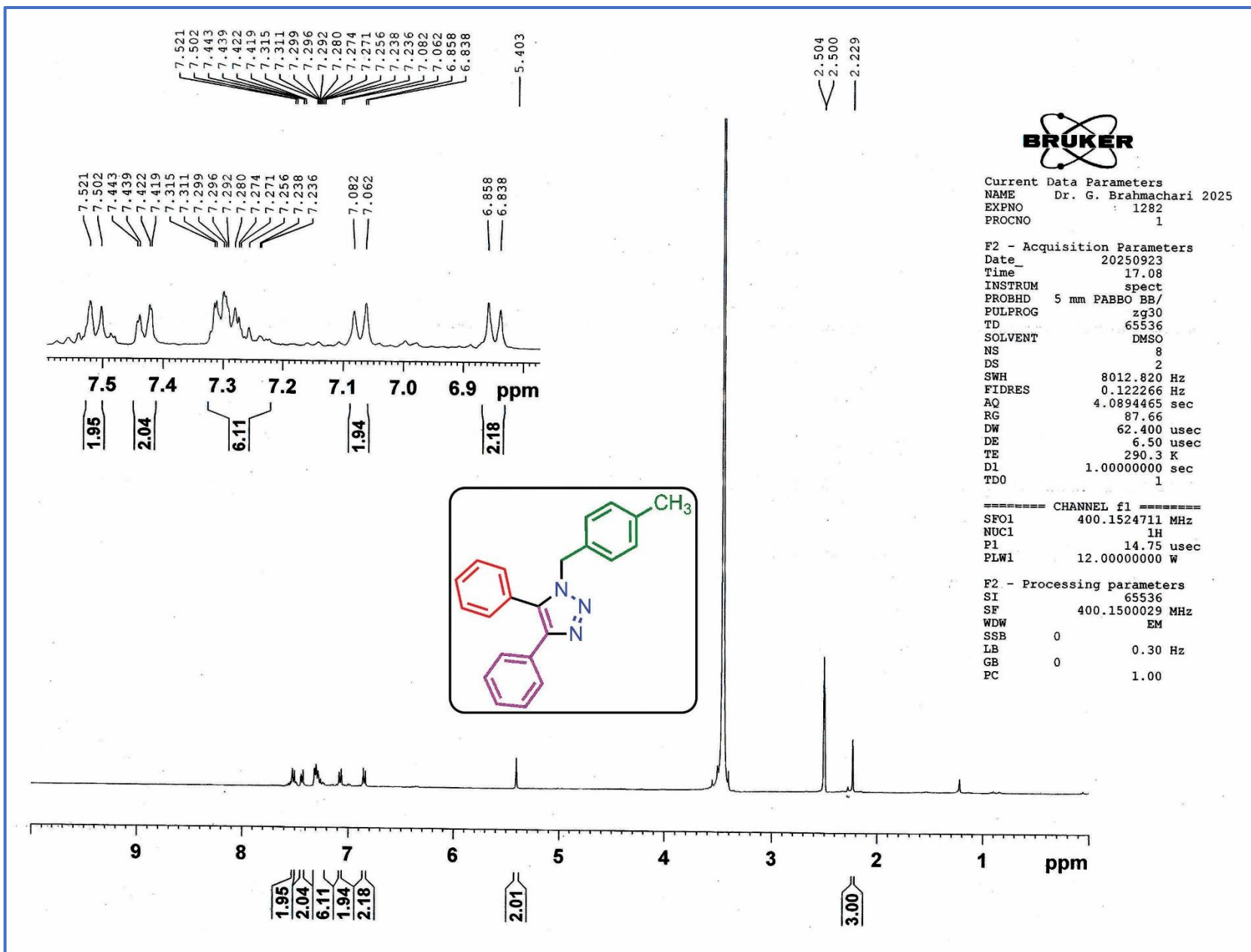


Figure S59. <sup>1</sup>H-NMR spectrum of 1-(4-Methylbenzyl)-4,5-diphenyl-1H-1,2,3-triazole (**12m**)

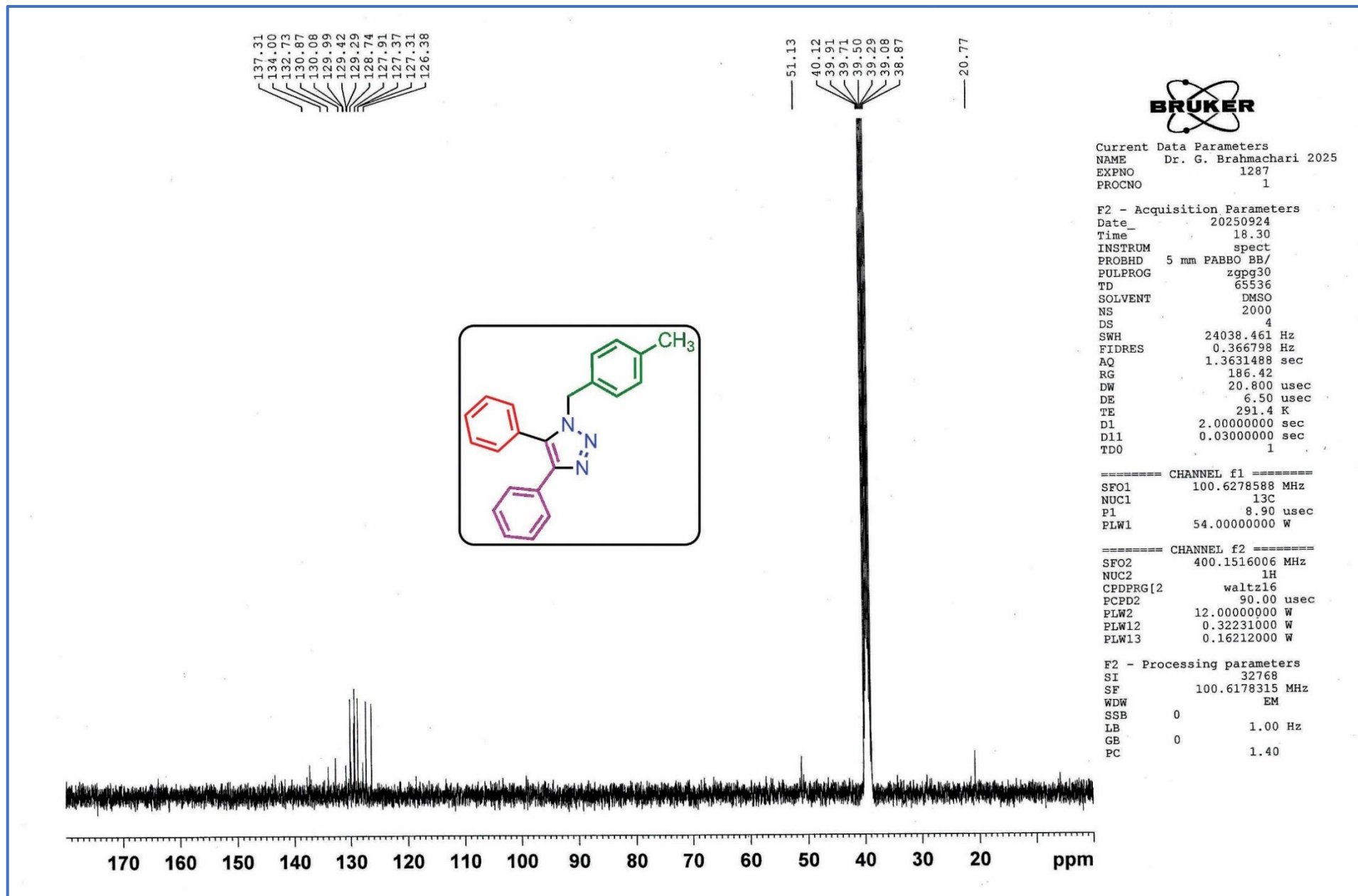


Figure S60.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 1-(4-Methylbenzyl)-4,5-diphenyl-1H-1,2,3-triazole (**12m**)

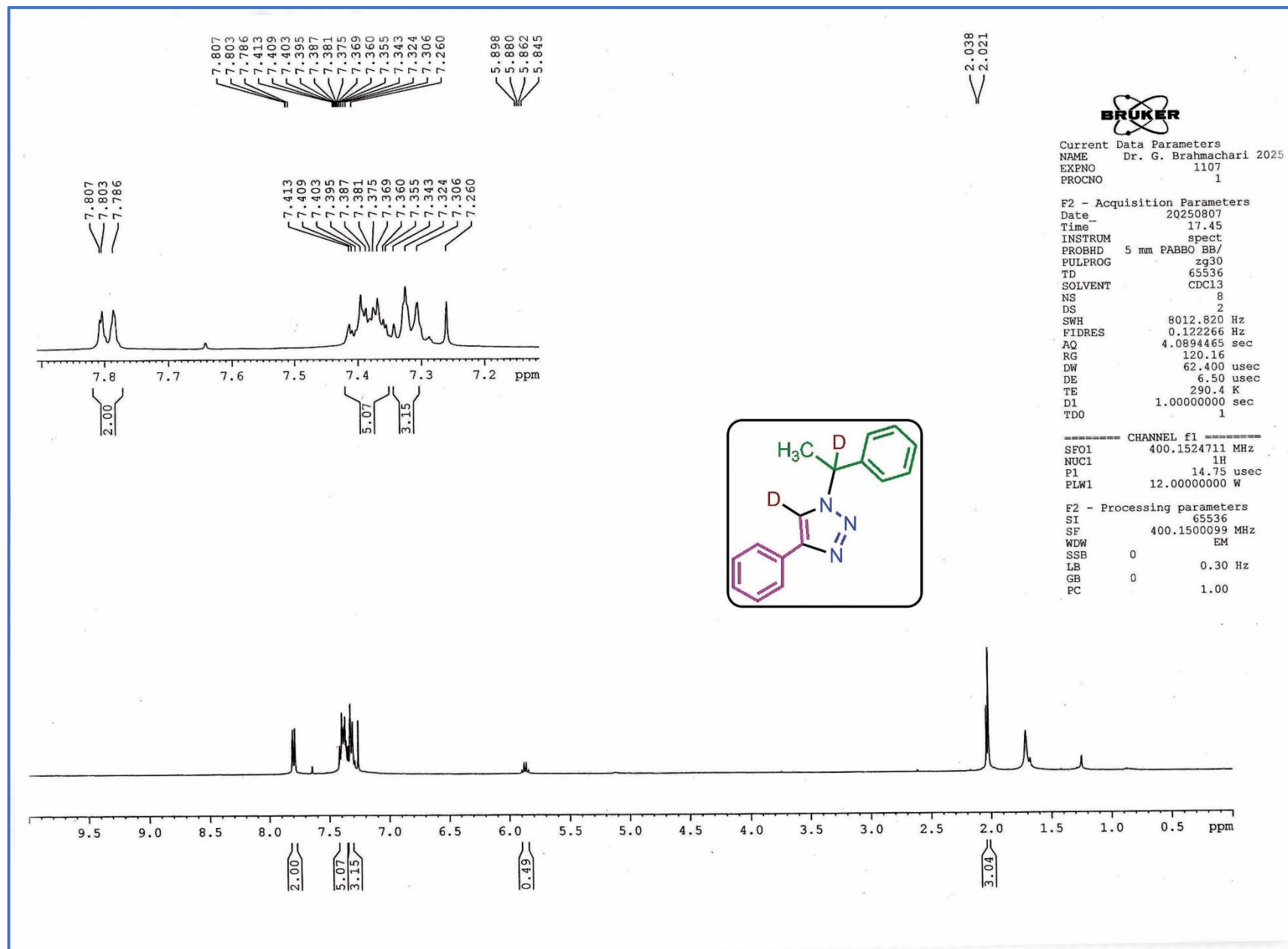


Figure S61. <sup>1</sup>H-NMR spectrum of 4-Phenyl-1-(1-phenylethyl-1-d)-1H-1,2,3-triazole-5-d (**4w-d<sub>2</sub>**)

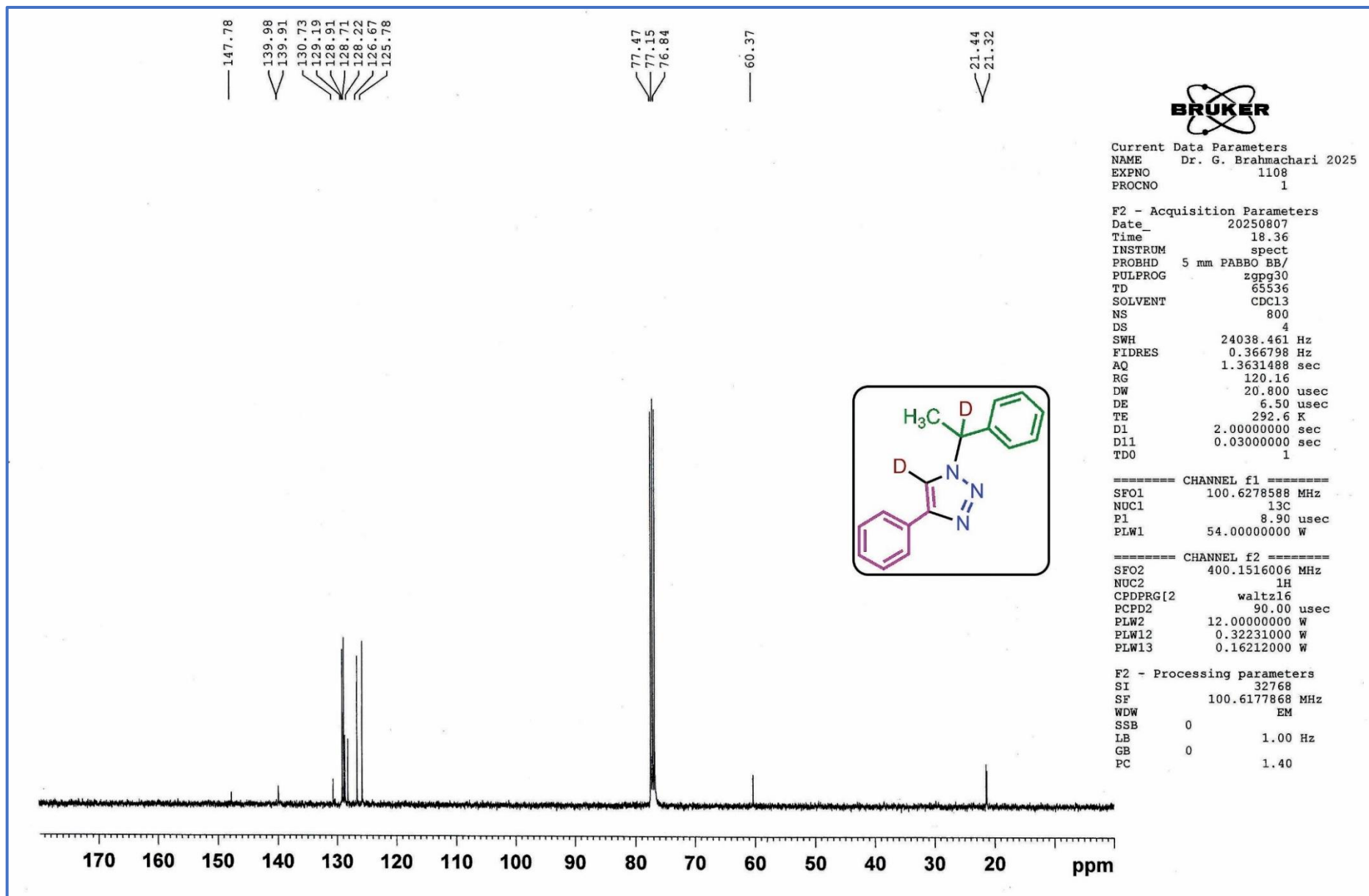


Figure S62.  $^{13}\text{C}\{^1\text{H}\}$  NMR spectrum of 4-Phenyl-1-(1-phenylethyl-1-d)-1H-1,2,3-triazole-5-d (**4w-d<sub>2</sub>**)

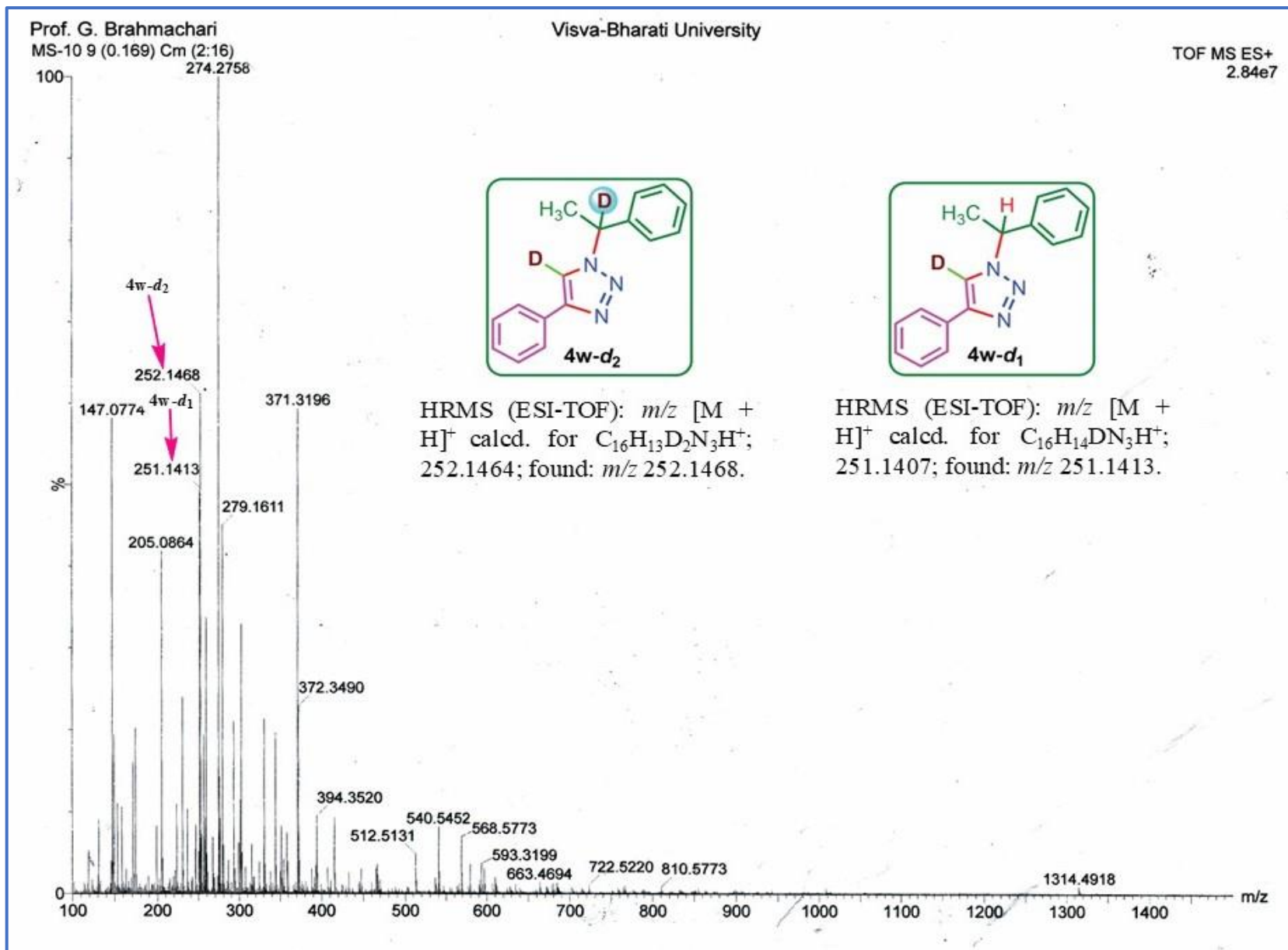


Figure S63. HRMS spectrum of 4-Phenyl-1-(1-phenylethyl)-1H-1,2,3-triazole-5-d (**4w-d<sub>1</sub>**) + 4-Phenyl-1-(1-phenylethyl-1-d)-1H-1,2,3-triazole-5-d (**4w-d<sub>2</sub>**)

#### 4. Calculation of E-factors for all the Synthesized Compounds (4a-4z and 4a'-4d')

The following formulae were used for calculating E-factor.<sup>1-4</sup> Calculated data for compounds 4 (4a-4z and 4a'-4d') are presented in Table S3.

$$\text{E-factor} = \frac{\text{Total mass of wastes}}{\text{Mass of product}} = \frac{\text{Mass of raw materials} - \text{Mass of product}}{\text{Mass of product}}$$

#### Documentation of Calculations of Green Metric (E-factor) for One Representative Entry, viz. 1-benzyl-5-iodo-4-phenyl-1*H*-1,2,3-triazole (4a):

$$\begin{aligned} \text{E-factor (for Sonochemistry; Method A)} &= \frac{\text{Mass of wastes}}{\text{Mass of product}} = \frac{\text{Mass of raw materials} - \text{Mass of product}}{\text{Mass of product}} \\ &= \frac{(0.034 \text{ g} + 0.020 \text{ g} + 0.042 \text{ g} + 0.013 \text{ g}) - 0.064 \text{ g}}{0.064} = 0.70 \text{ (g/g)} \end{aligned}$$

$$\begin{aligned} \text{E-factor (for Mechanochemistry; Method B)} &= \frac{\text{Mass of wastes}}{\text{Mass of product}} = \frac{\text{Mass of raw materials} - \text{Mass of product}}{\text{Mass of product}} \\ &= \frac{(0.034 \text{ g} + 0.020 \text{ g} + 0.042 \text{ g} + 0.013 \text{ g}) - 0.065 \text{ g}}{0.065} = 0.68 \text{ (g/g)} \end{aligned}$$

**Table S1.** Calculated E-factors for the compounds (4a-4z and 4a'-4d')

Sl. No	Products	E-Factor (g/g) for Sonochemistry (Method A)	E-Factor (g/g) for Mechanochemistry (Method B)
1	<b>4a</b>	0.70	0.68
2	<b>4b</b>	0.80	0.77
3	<b>4c</b>	0.91	0.85
4	<b>4d</b>	0.98	0.92
5	<b>4e</b>	0.91	0.85
6	<b>4f</b>	0.93	0.87
7	<b>4g</b>	0.84	0.81
8	<b>4h</b>	0.82	0.79
9	<b>4i</b>	0.92	0.89
10	<b>4j</b>	0.87	0.81
11	<b>4k</b>	0.82	0.79
12	<b>4l</b>	0.78	0.75
13	<b>4m</b>	0.62	0.64
14	<b>4n</b>	0.79	0.76
15	<b>4o</b>	0.90	0.96
16	<b>4p</b>	0.57	0.55
17	<b>4q</b>	0.88	0.80
18	<b>4r</b>	0.84	0.81
19	<b>4s</b>	0.94	0.87
20	<b>4t</b>	0.66	0.63
21	<b>4u</b>	0.91	0.85

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22	<b>4v</b>	0.87	0.79
23	<b>4w</b>	0.89	0.89
24	<b>4x</b>	0.94	0.88
25	<b>4y</b>	0.96	0.87
26	<b>4z</b>	0.66	0.62
27	<b>4a'</b>	0.58	0.54
28	<b>4b'</b>	0.70	0.63
29	<b>4c'</b>	0.48	0.44
30	<b>4d'</b>	0.95	0.89

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#Lower is the value, greener is the process

## 5. References

- 1 R. A. Sheldon, *ACS Sustainable Chem. Eng.*, 2018, **6**, 32-48.
- 2 N. J. Willis, C. A. Fisher, C. M. Alder, A. Harsanyi, L. Shukla, J. P. Adams and G. Sandford, *Green Chem.*, 2016, **18**, 1313-1318.
- 3 F. Roschangar, A. Sheldon and C. H. Senanayake, *Green Chem.*, 2015, **17**, 752-768.
- 4 C. Jiménez-González, D. J. C. Constable and C. S. Ponder, *Chem. Soc. Rev.*, 2012, **41**, 1485-1498.