

Steroidal glycosides from *Allium Tuberosum* seeds and their roles in promoting testosterone production of rat leydig cells

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Abstract: A systematic phytochemical study on the components in the seeds of *Allium tuberosum* was performed, leading to the isolation of 27 steroidal glycosides (1–27). The structures of all compounds were established mainly by NMR and MS experiments as well as the necessary chemical evidence, of which 1–10 and 22–26 (Allituberosides A–O) are new steroidal saponin analogues. An in vitro bioassay indicated that 1, 2, 7, 8, 10, 13–15, 20, 23, and 26 displayed the promotional roles in testosterone production of rat Leydig cells with the EC₅₀ values of 1.0 to 4.5 μ M, respectively.

Table 1. ¹³C NMR data for compounds 11–16 and 27 (150 MHz, δ in pyridine-*d*₅).

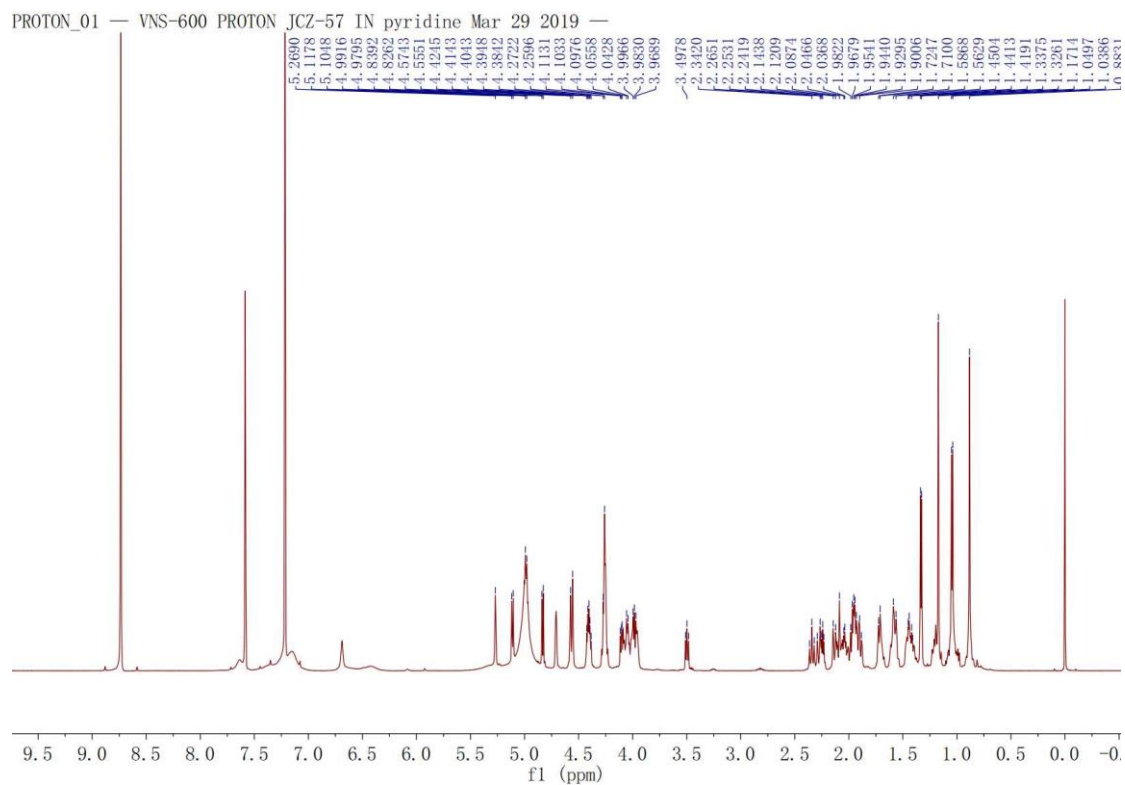
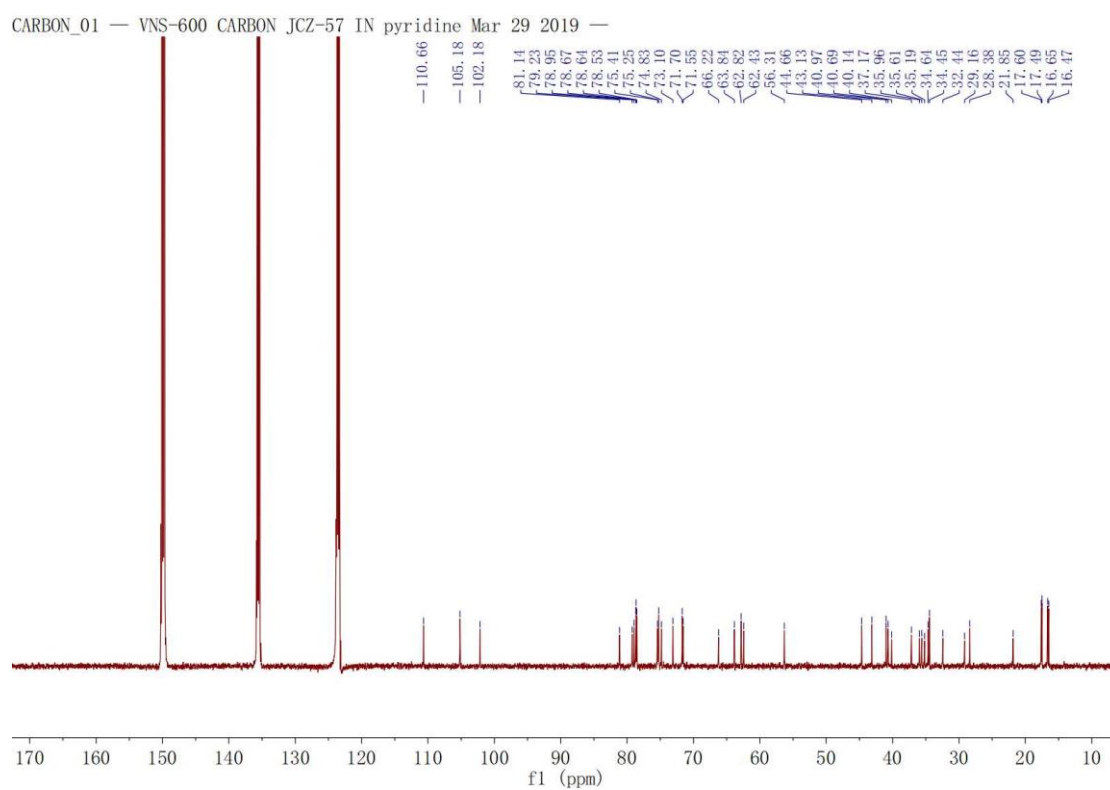
POS.	11	12	13	14	15	16
1	45.7	45.9	45.9	37.2	45.9	45.9
2	70.4	70.7	70.7	29.9	70.7	70.5
3	85.0	85.5	85.5	77.2	85.4	85.0
4	33.9	33.7	33.7	34.5	33.7	33.4
5	44.7	44.7	44.7	44.6	44.7	44.6
6	28.1	28.2	28.2	29.0	28.2	28.2
7	32.3	32.3	32.3	32.4	32.4	32.4
8	34.6	34.6	34.6	35.3	34.4	34.4
9	54.4	54.4	54.4	54.5	54.4	54.4
10	36.9	36.9	36.9	35.9	36.9	36.9
11	21.5	21.5	21.5	21.3	21.6	21.6
12	40.1	40.1	40.1	40.2	39.8	39.8
13	41.1	41.1	41.1	41.1	43.7	43.7
14	56.3	56.3	56.3	56.4	54.7	54.6
15	32.4	32.4	32.4	32.5	34.4	34.3
16	81.1	81.1	81.1	81.1	84.5	84.5
17	63.9	63.9	63.9	64.0	64.6	64.6
18	16.7	16.7	16.7	16.7	14.4	14.4
19	13.4	13.5	13.5	12.4	13.5	13.5
20	40.7	40.7	40.7	40.7	103.6	103.6
21	16.5	16.5	16.5	16.5	11.8	11.8
22	110.6	110.6	110.6	110.6	152.4	152.4

23	37.2	37.2	37.2	37.2	31.4	31.4
24	28.4	28.3	28.3	28.4	23.7	23.7
25	34.4	34.4	34.4	34.5	33.6	33.8
26	75.2	75.2	75.2	75.4	75.2	75.0
27	17.5	17.5	17.5	17.5	17.2	17.2
	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc
1	103.0	101.3	101.3	99.9	101.3	100.8
2'	75.4	78.0	78.0	78.0	78.0	77.9
3'	76.6	79.6	79.6	78.7	79.6	78.7
4'	78.3	71.9	71.9	78.1	71.9	77.9
5'	77.4	78.4	78.4	77.0	78.5	77.0
6'	61.3	62.5	62.5	61.3	62.5	61.1
	4'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha
1''	102.7	102.2	102.2	102.2	102.2	102.1
2''	72.6	72.5	72.5	72.5	72.5	72.4
3''	72.8	72.8	72.8	72.8	72.8	72.7
4''	74.0	74.2	74.2	74.1	74.0	74.1
5''	70.5	69.5	69.5	69.5	69.5	69.5
6''	18.6	18.6	18.6	18.7	18.6	18.6
	26-O-Glc	26-O-Glc	26-O-Glc	4'-O-Rha	26-O-Glc	4'-O-Rha
1'''	105.2	105.2	105.2	102.9	105.2	102.9
2'''	75.2	75.4	75.4	72.6	75.4	72.5
3'''	78.6	78.6	78.6	72.8	78.6	72.8
4'''	71.7	71.7	71.7	74.0	71.7	73.9
5'''	78.5	78.5	78.5	70.4	78.6	70.5
6'''	62.8	62.8	62.8	18.5	62.8	18.5
				26-O-Glc		26-O-Glc
1''''				105.2		105.2
2''''				75.3		75.3
3''''				78.6		78.6
4''''				71.7		71.7
5''''				78.5		78.5
6''''				62.8		62.9

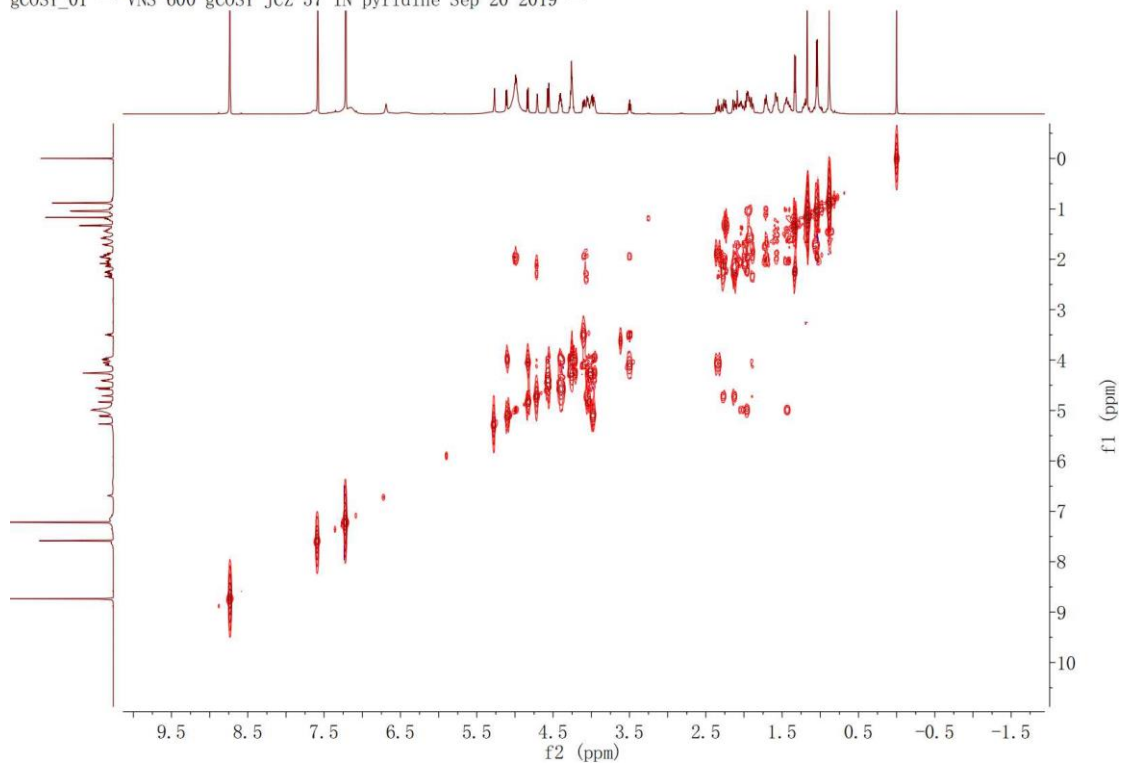
Table 2. ^{13}C NMR data for compounds **17–21** and **27** (150 MHz, δ in pyridine- d_5).

POS.	17	18	19	20	21	27
1	37.6	30.9	30.9	37.5	37.6	45.9
2	30.2	27.0	27.0	30.2	30.2	70.6
3	77.1	75.4	75.3	77.8	77.7	85.0
4	34.5	30.7	30.7	39.0	39.0	33.5
5	44.6	36.8	36.8	140.8	140.8	44.6
6	29.0	26.8	26.8	121.9	121.8	28.2
7	32.6	26.8	26.8	32.4	32.4	32.1
8	35.0	35.5	35.5	31.7	31.5	34.6
9	54.4	40.4	40.4	50.4	50.3	54.4

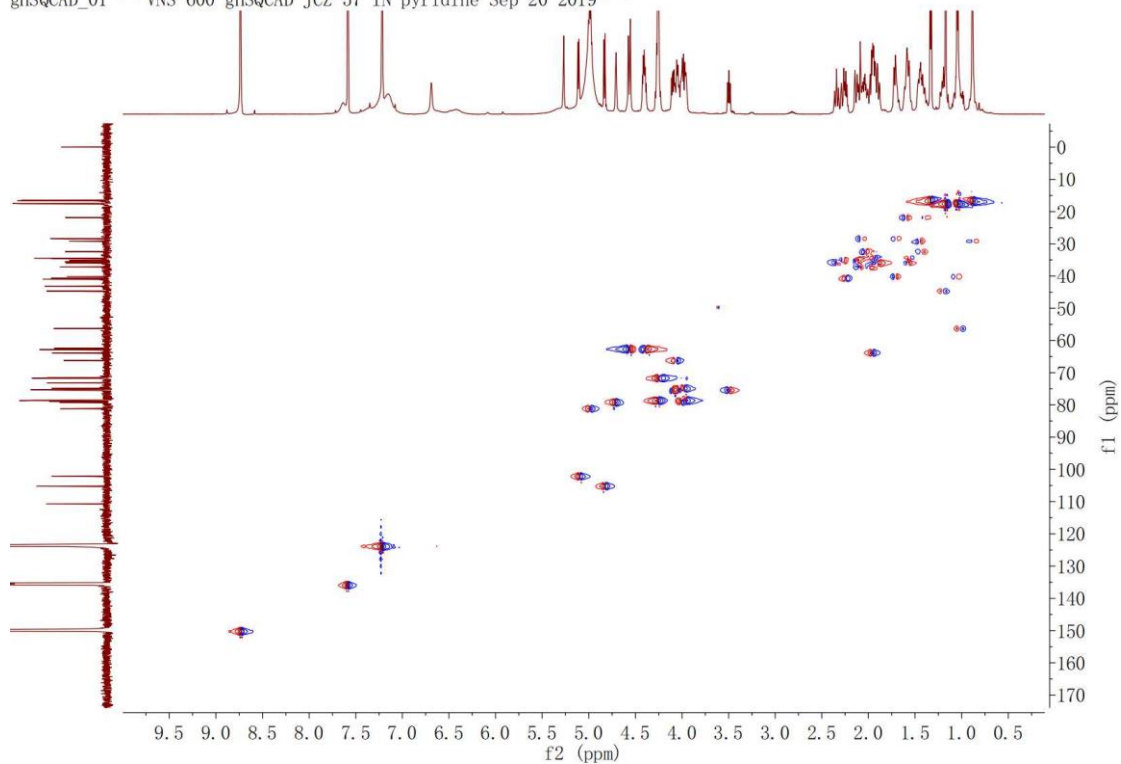
10	35.9	35.3	35.3	37.2	37.1	36.9
11	21.5	21.2	21.2	21.1	21.3	21.5
12	39.9	40.3	40.3	39.9	39.7	40.1
13	43.7	40.7	40.7	40.8	43.4	40.8
14	54.8	56.5	56.5	56.6	55.0	56.3
15	34.4	32.5	32.5	32.5	34.5	32.3
16	84.5	81.3	81.3	81.1	84.5	81.2
17	64.6	64.1	64.1	63.8	64.5	63.7
18	14.4	16.8	16.8	16.5	14.1	16.6
19	12.4	24.0	24.0	19.4	19.4	13.6
20	103.6	41.3	41.3	40.7	103.6	42.0
21	11.8	16.5	16.5	16.5	11.8	15.0
22	152.4	110.7	110.7	110.7	152.4	109.5
23	31.4	37.2	37.2	37.2	31.4	31.3
24	23.7	28.4	28.4	28.3	23.7	24.0
25	33.7	34.5	34.5	34.5	33.5	36.7
26	75.2	75.3	75.3	75.4	75.2	62.9
27	17.2	17.5	17.5	17.5	17.4	72.0
	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc	3-O-Glc
1	99.8	101.9	101.9	100.3	100.3	100.8
2'	78.0	82.9	82.9	77.8	78.0	78.0
3'	78.7	77.1	77.1	78.6	78.7	78.6
4'	78.0	77.3	77.3	78.0	78.0	77.9
5'	77.0	76.5	76.5	77.0	77.0	77.2
6'	61.3	61.3	61.3	61.3	61.3	61.1
	2'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha	2'-O-Rha
1''	102.2	105.7	105.7	102.0	102.0	102.2
2''	72.5	77.1	77.1	72.7	72.6	72.5
3''	72.8	78.0	78.0	72.8	72.8	72.8
4''	74.1	71.9	71.9	74.0	74.2	74.1
5''	69.5	78.6	78.6	70.4	69.5	69.5
6''	18.7	63.0	63.0	18.7	18.7	18.6
	4'-O-Rha	4'-O-Rha	4'-O-Rha	4'-O-Rha	4'-O-Rha	4'-O-Rha
1'''	102.9	102.5	102.5	102.9	102.9	103.0
2'''	72.6	72.6	72.6	72.6	72.6	72.6
3'''	72.8	72.8	72.8	72.9	72.9	72.8
4'''	74.0	74.1	74.1	74.2	74.0	74.0
5'''	70.4	70.3	70.3	70.4	70.4	70.5
6'''	18.5	18.6	18.6	18.5	18.5	18.6
	26-O-Glc	26-O-Glc	26-O-Glc	26-O-Glc	26-O-Glc	27-O-Glc
1''''	104.9	105.2	105.0	105.2	104.9	105.1
2''''	75.2	75.4	75.4	75.3	75.2	75.2
3''''	78.6	78.7	78.7	78.5	78.6	78.6
4''''	71.7	71.7	71.7	71.7	71.7	71.7
5''''	78.6	78.6	78.6	78.5	78.6	78.6
6''''	62.9	62.8	62.8	62.8	62.9	62.9

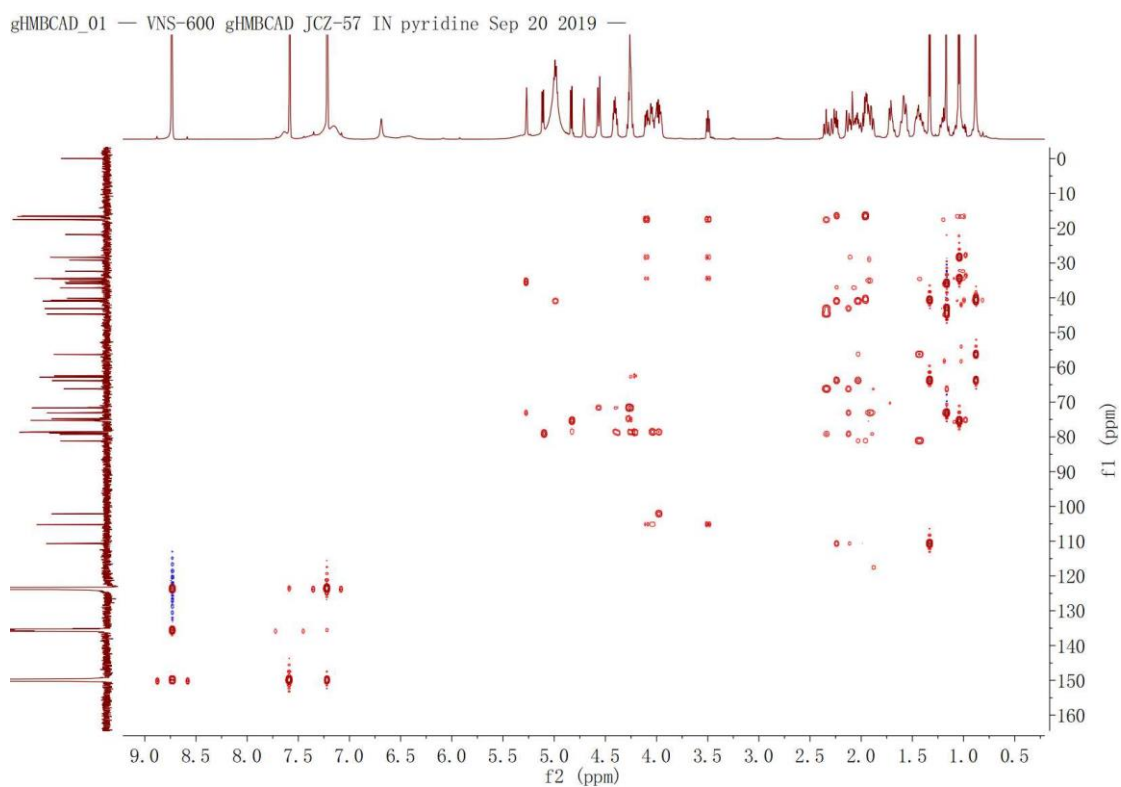
¹H NMR spectrum of 1.¹³C NMR spectrum of 1.

gCOSY_01 — VNS-600 gCOSY JCZ-57 IN pyridine Sep 20 2019 —

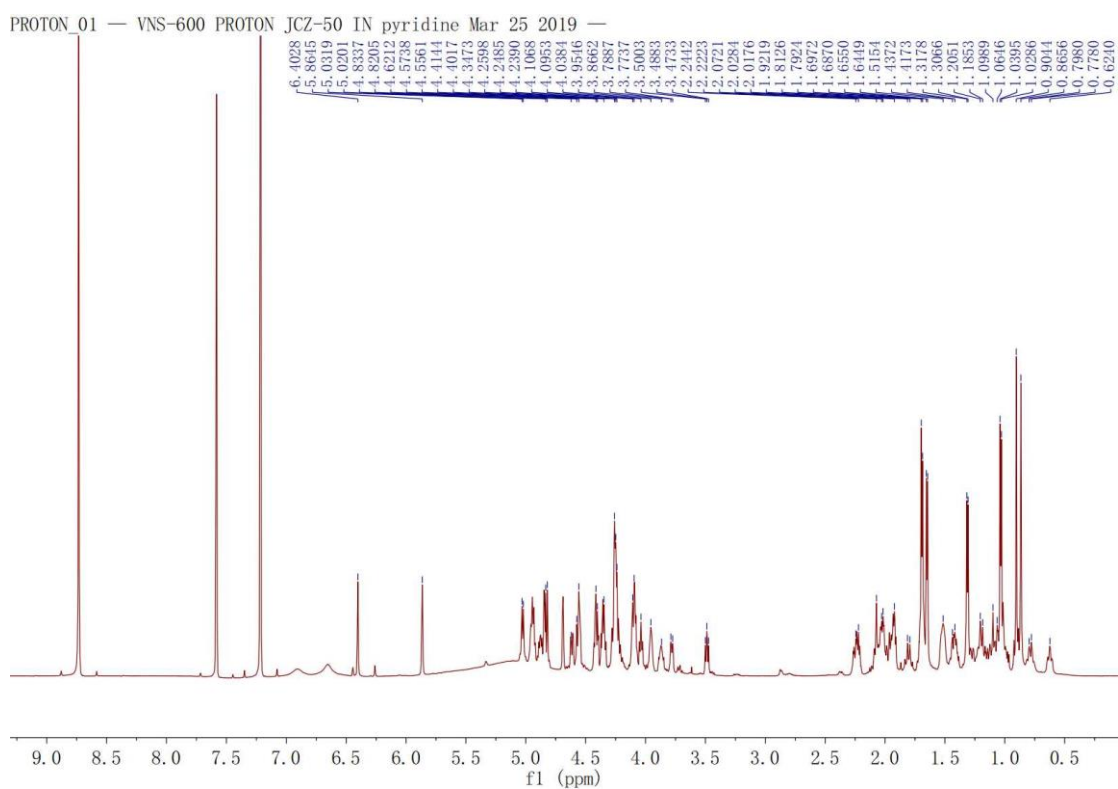
 **^1H - ^1H COSY spectrum of 1.**

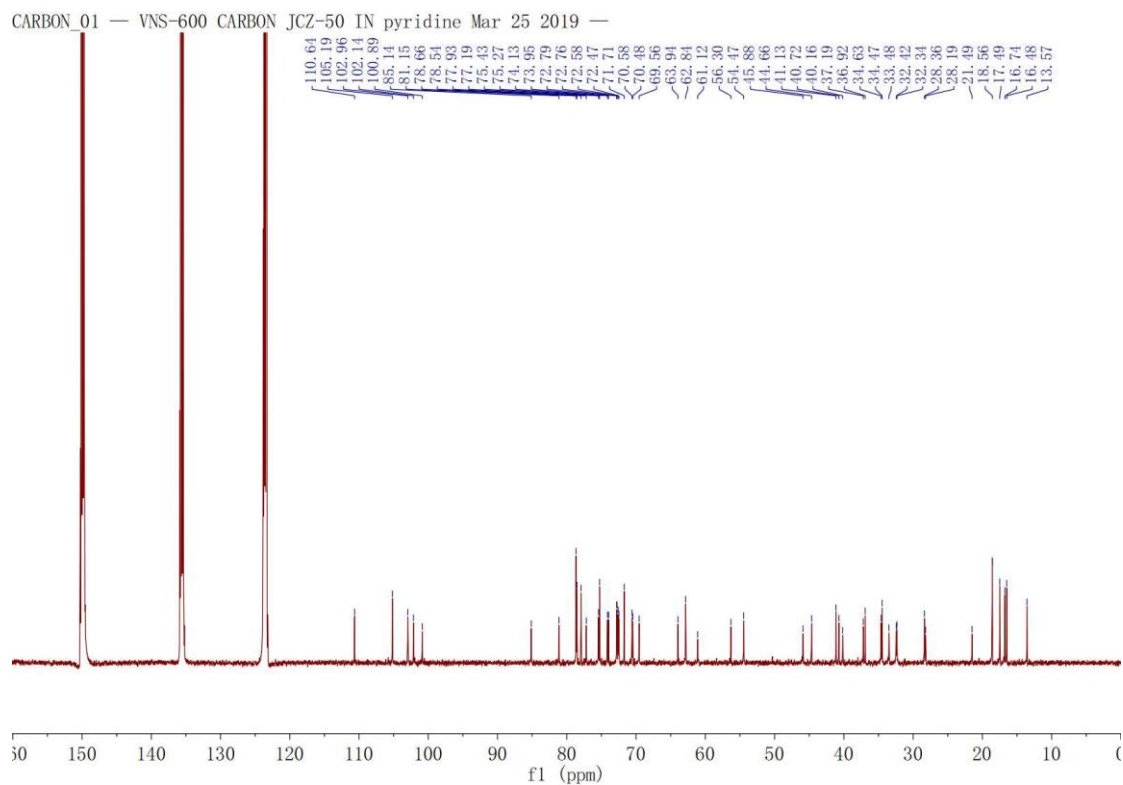
gHSQCAD_01 — VNS-600 gHSQCAD JCZ-57 IN pyridine Sep 20 2019 —

**HSQC spectrum of 1.**

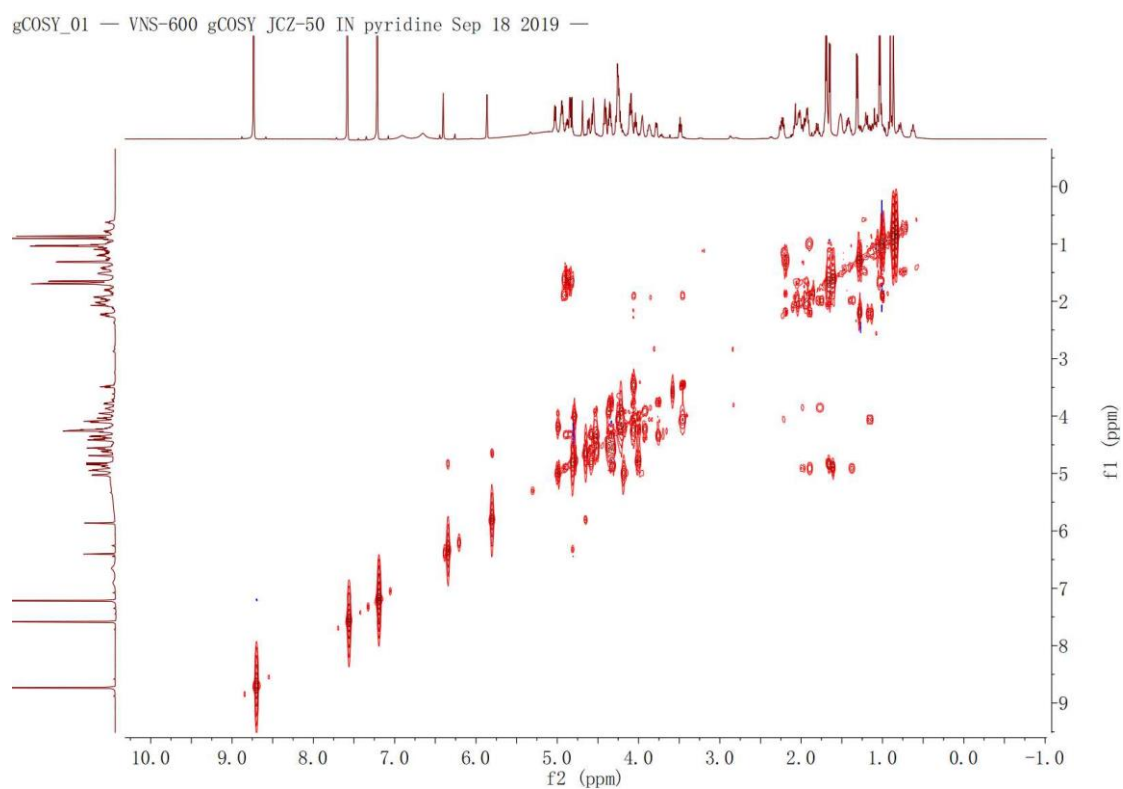


HMBC spectrum of 1.

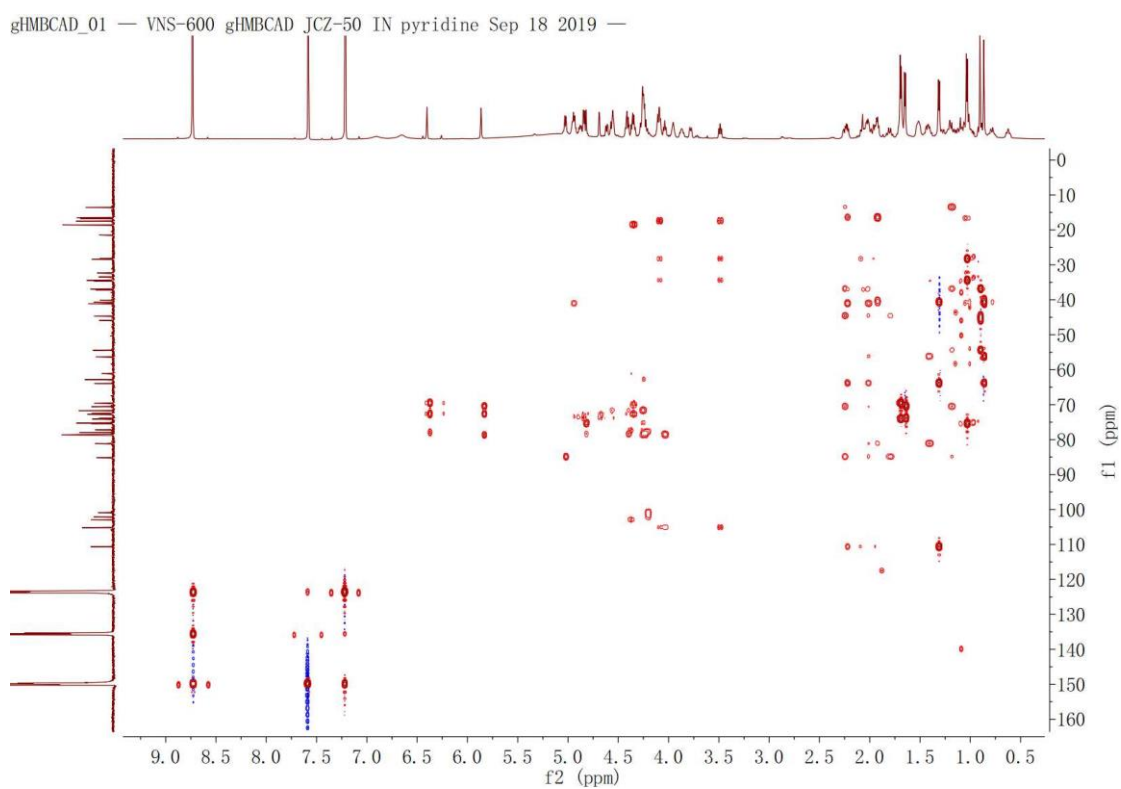
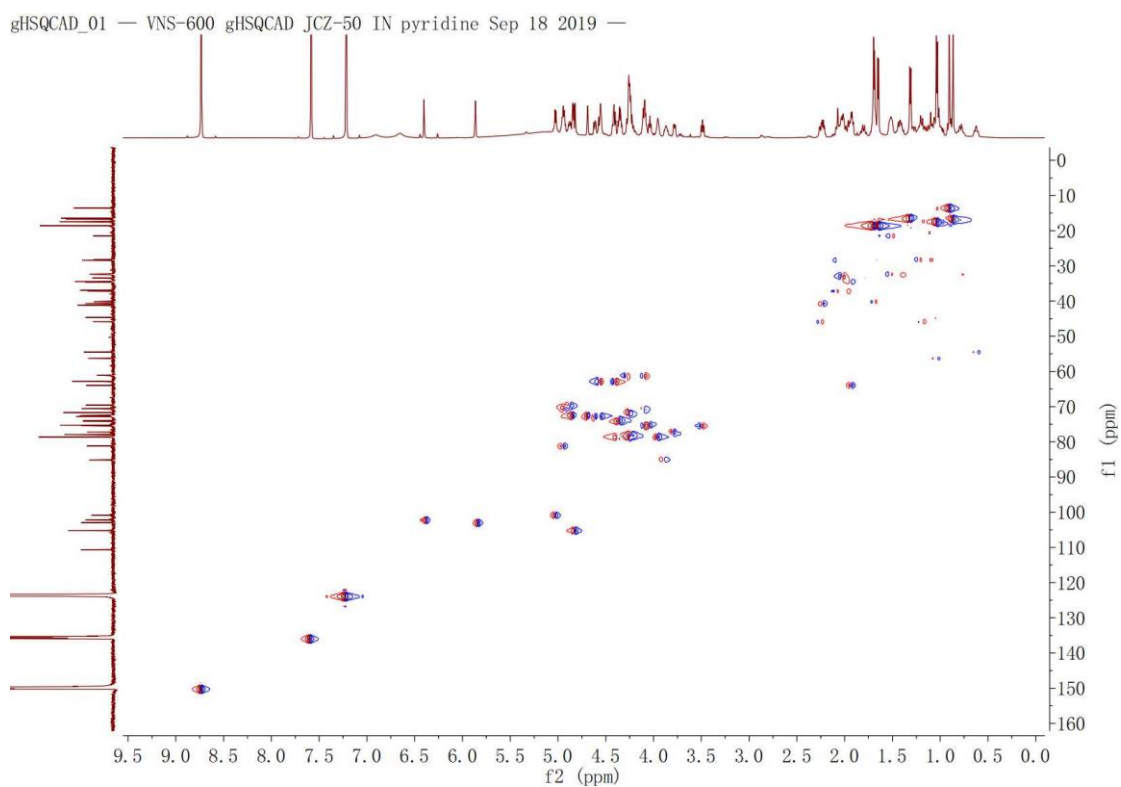
 ^1H NMR spectrum of 2.

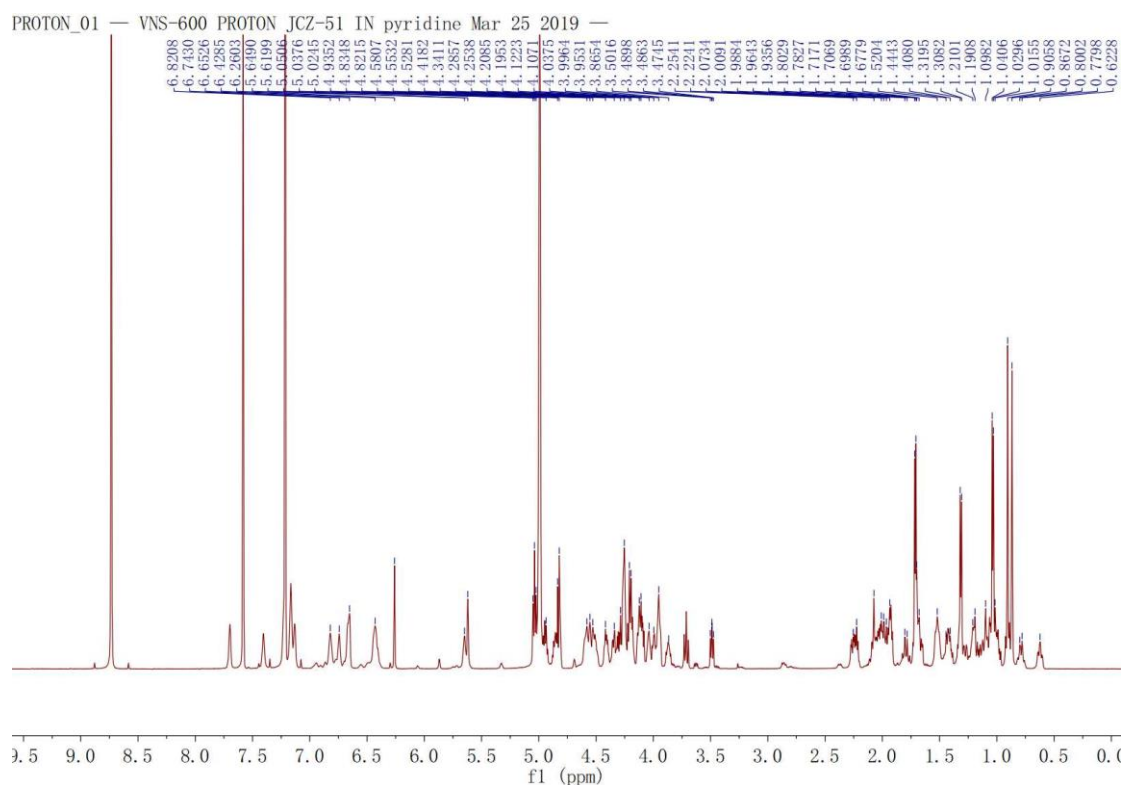


¹³C NMR spectrum of 2.

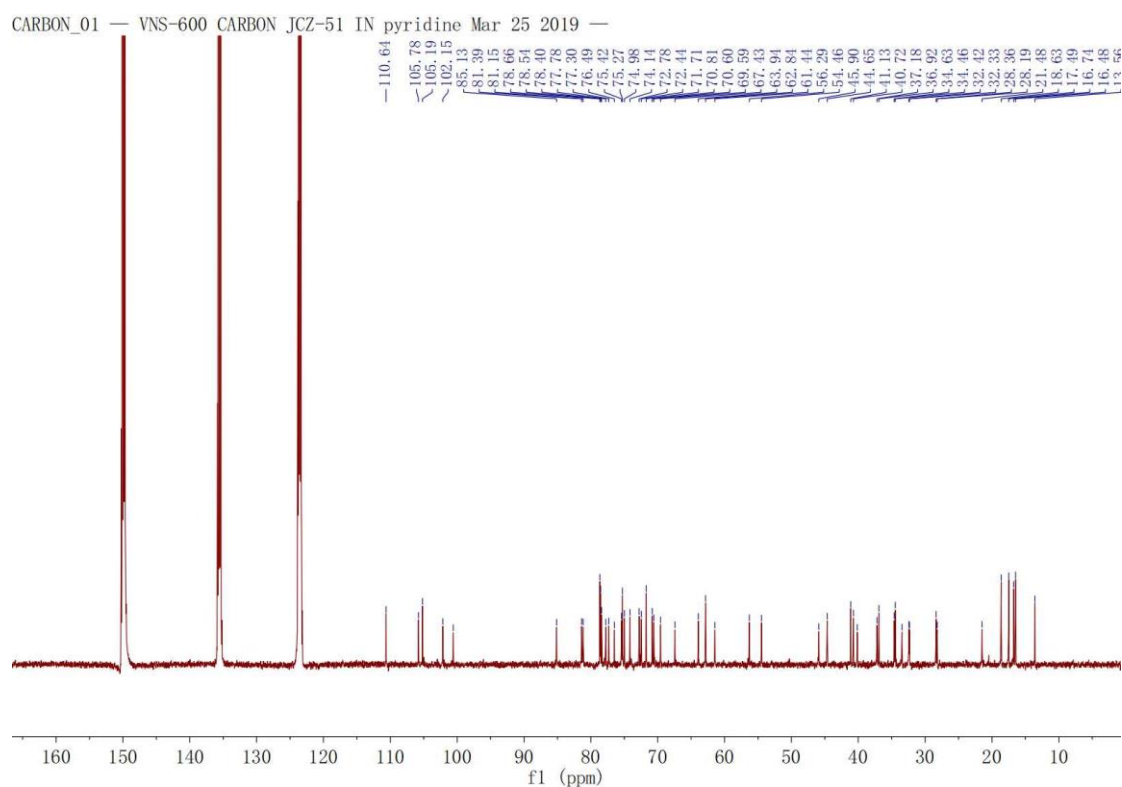


¹H-¹H COSY spectrum of 2.

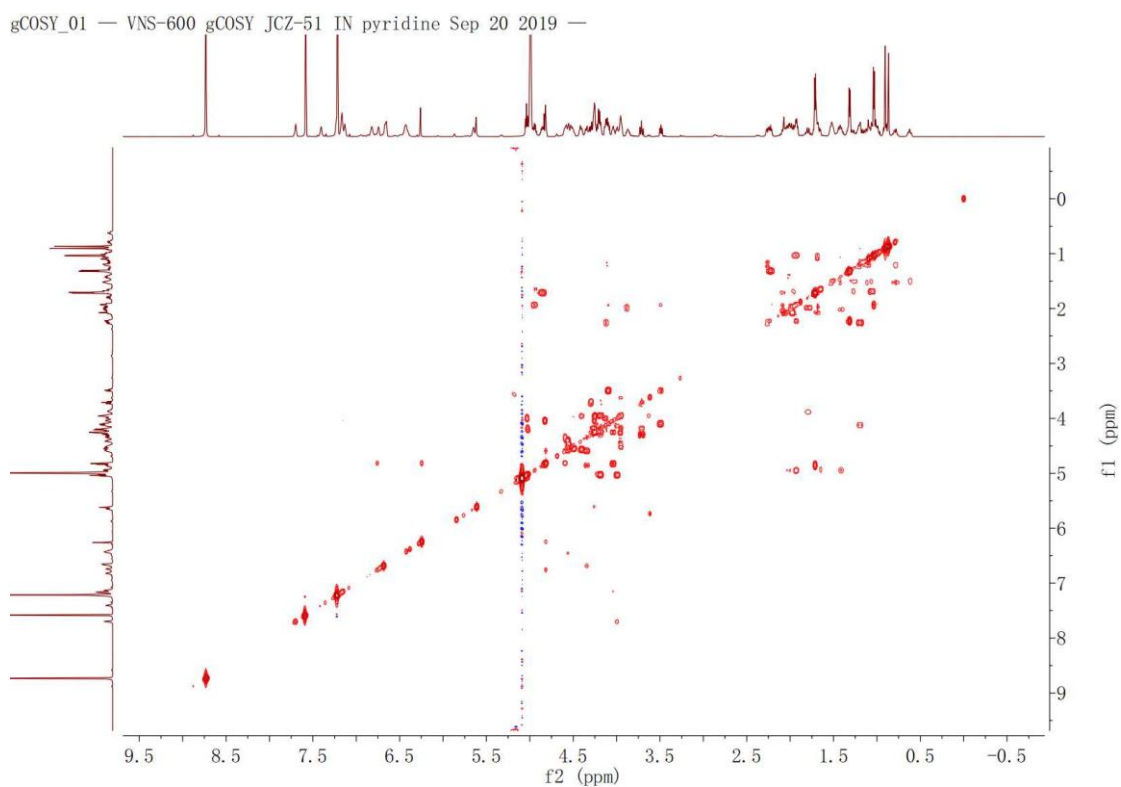




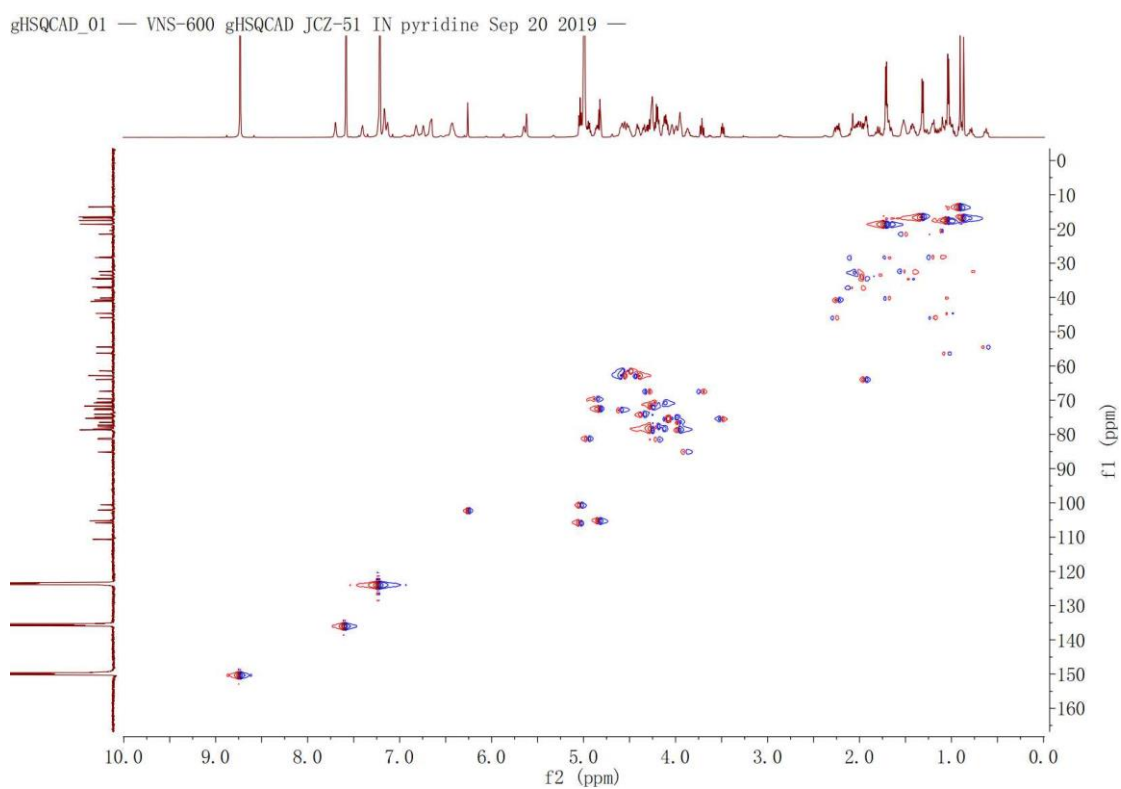
¹H NMR spectrum of 3.



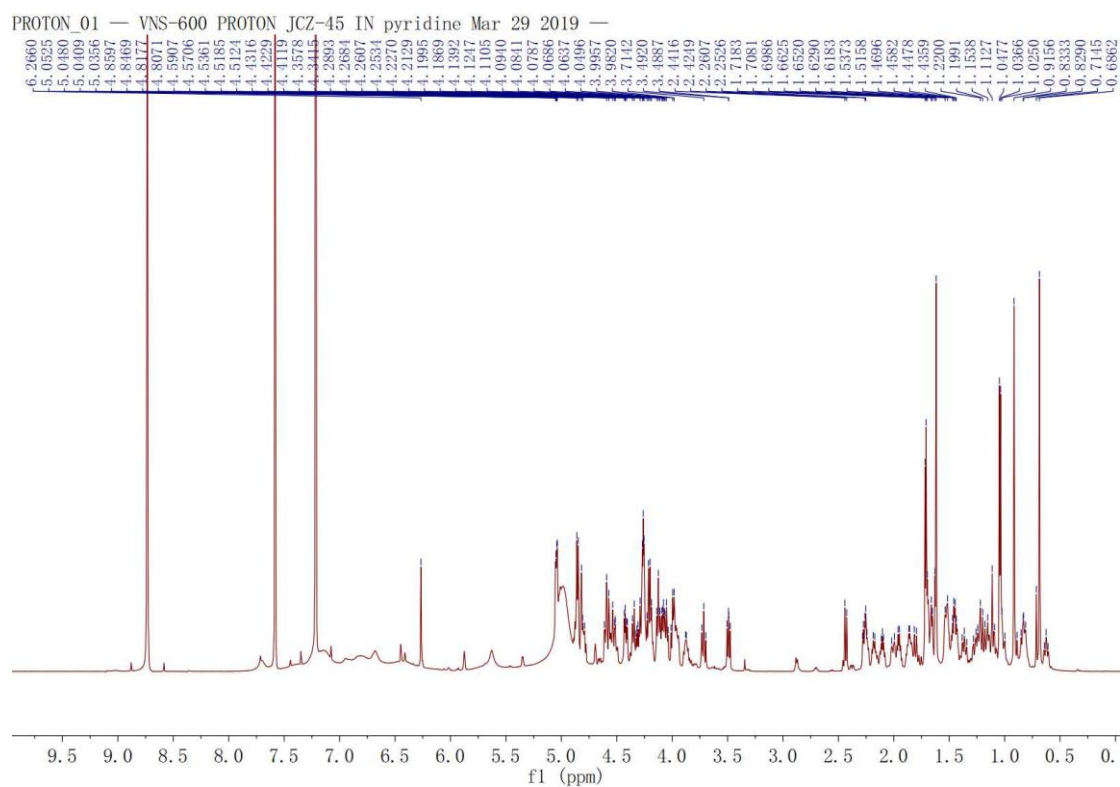
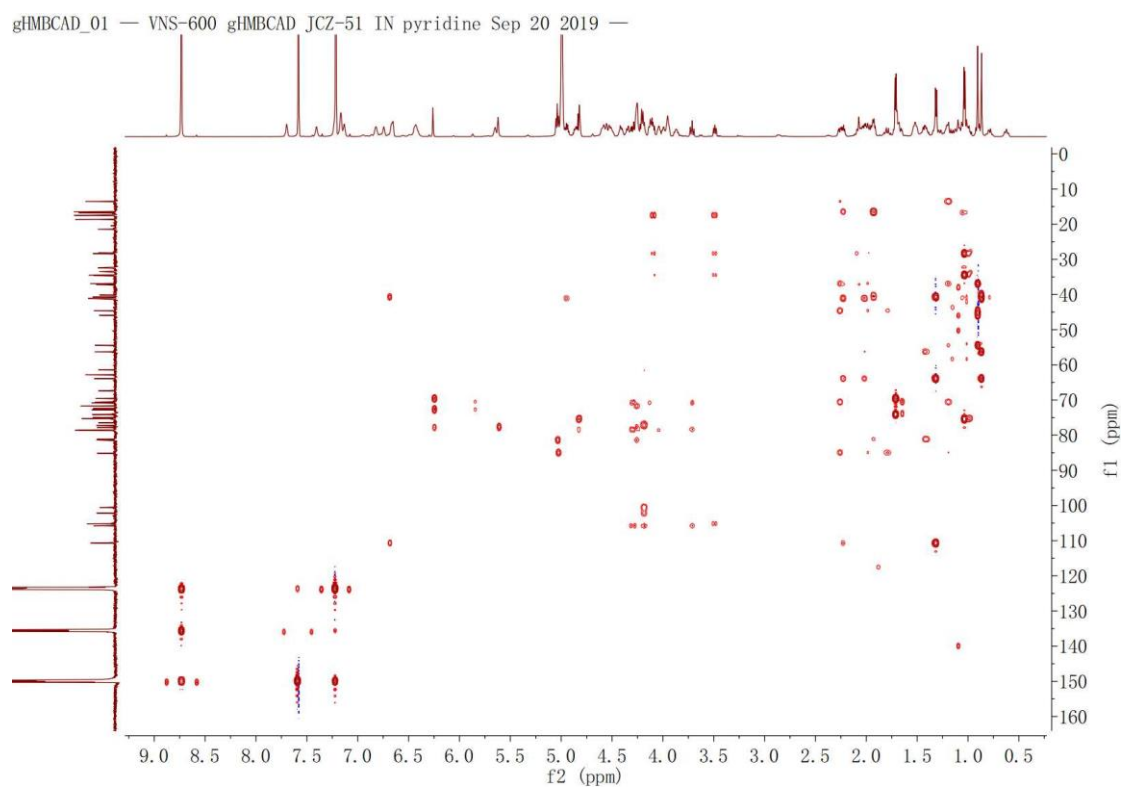
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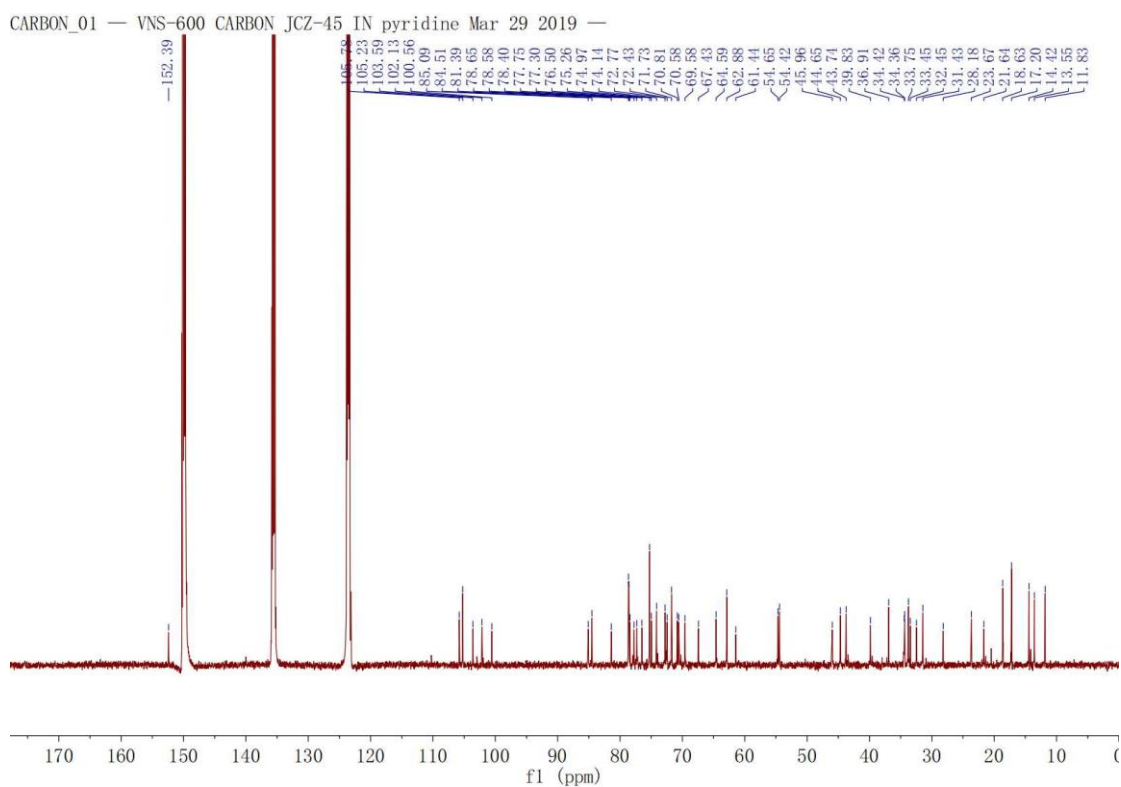


^1H - ^1H COSY spectrum of 3.

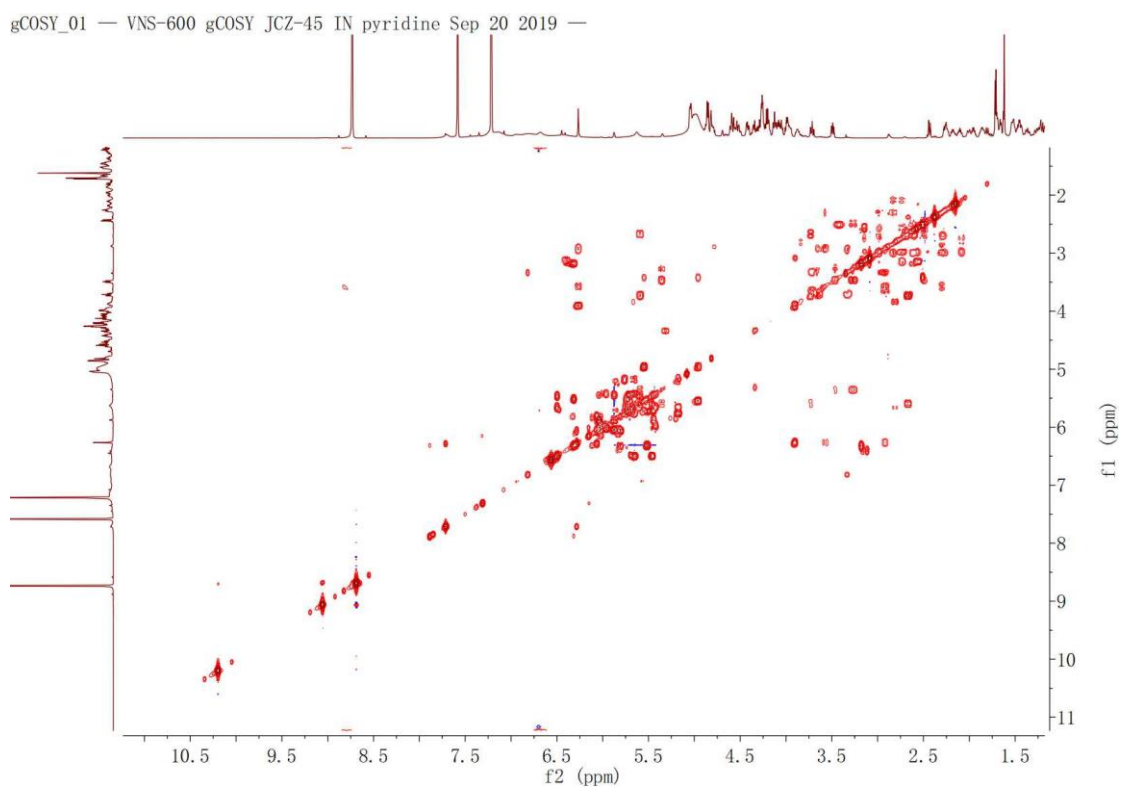


HSQC spectrum of 3.

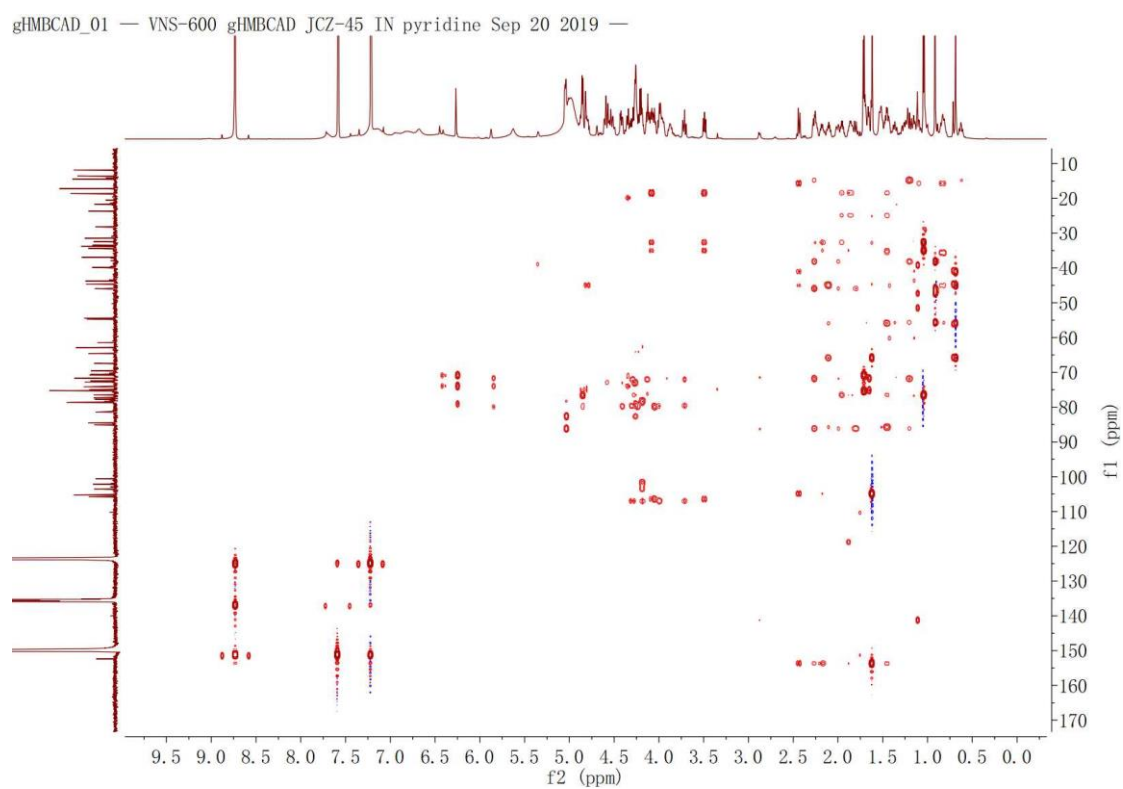
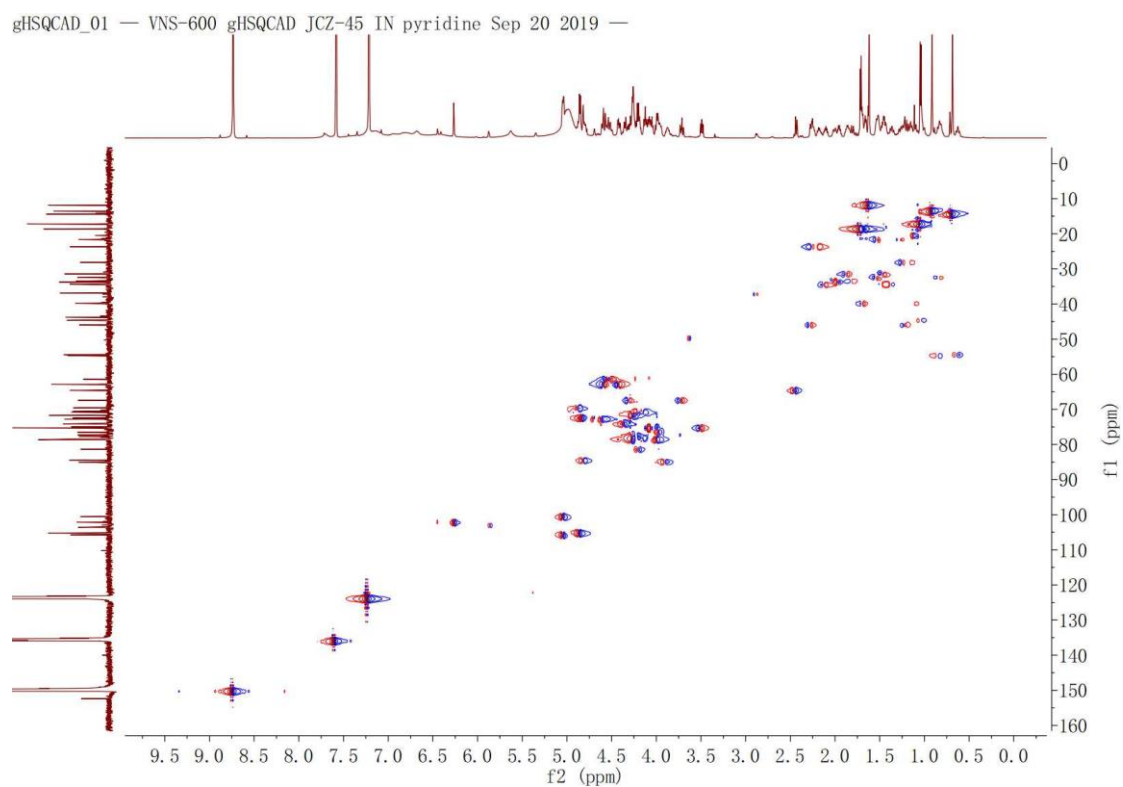


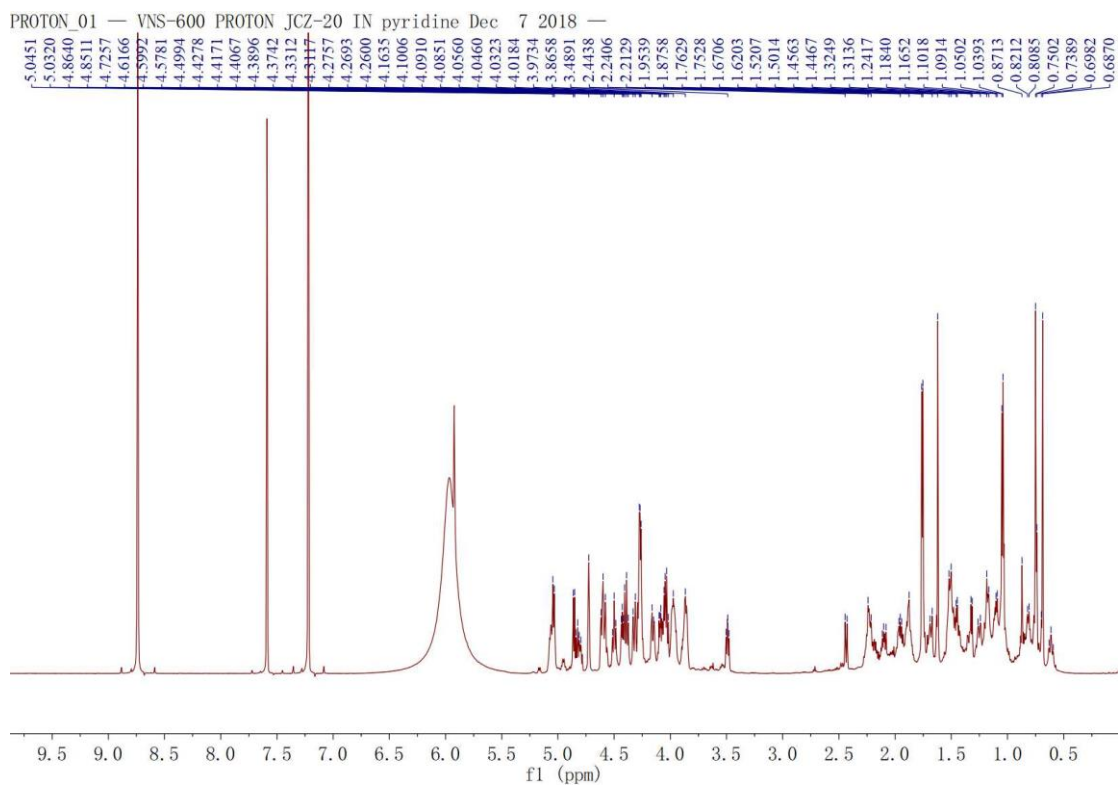


¹³C NMR spectrum of 4.

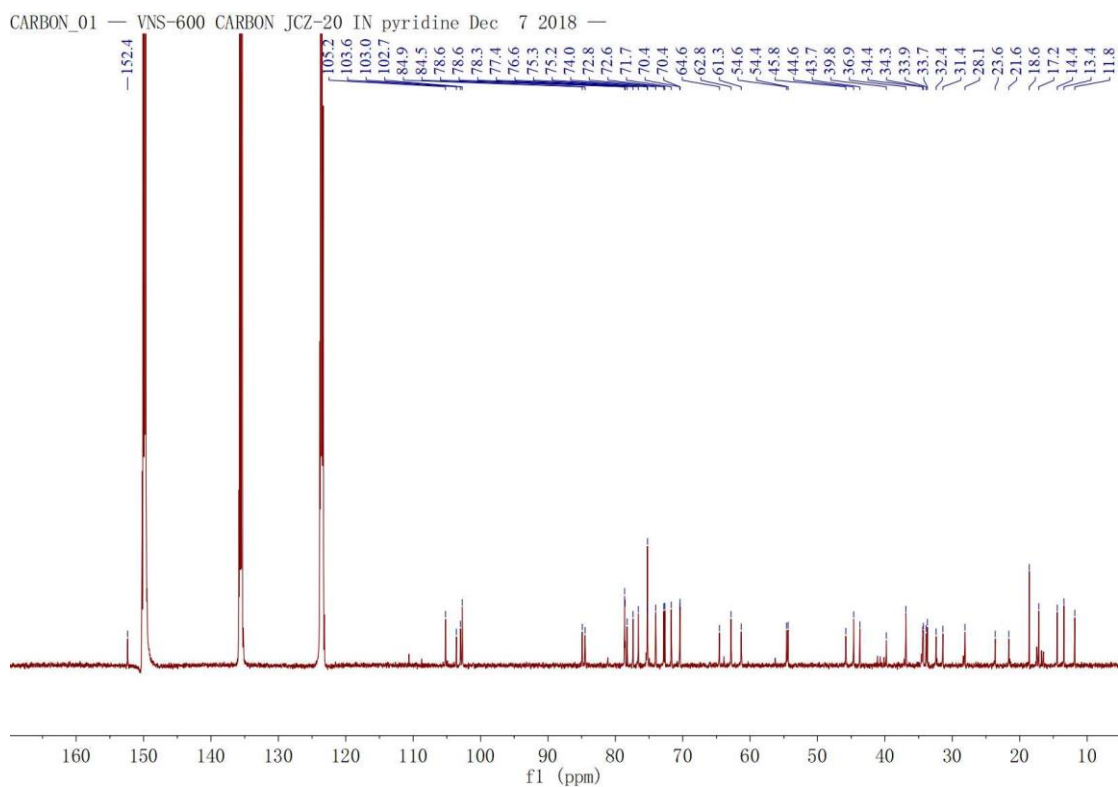


¹H-¹H COSY spectrum of 4.

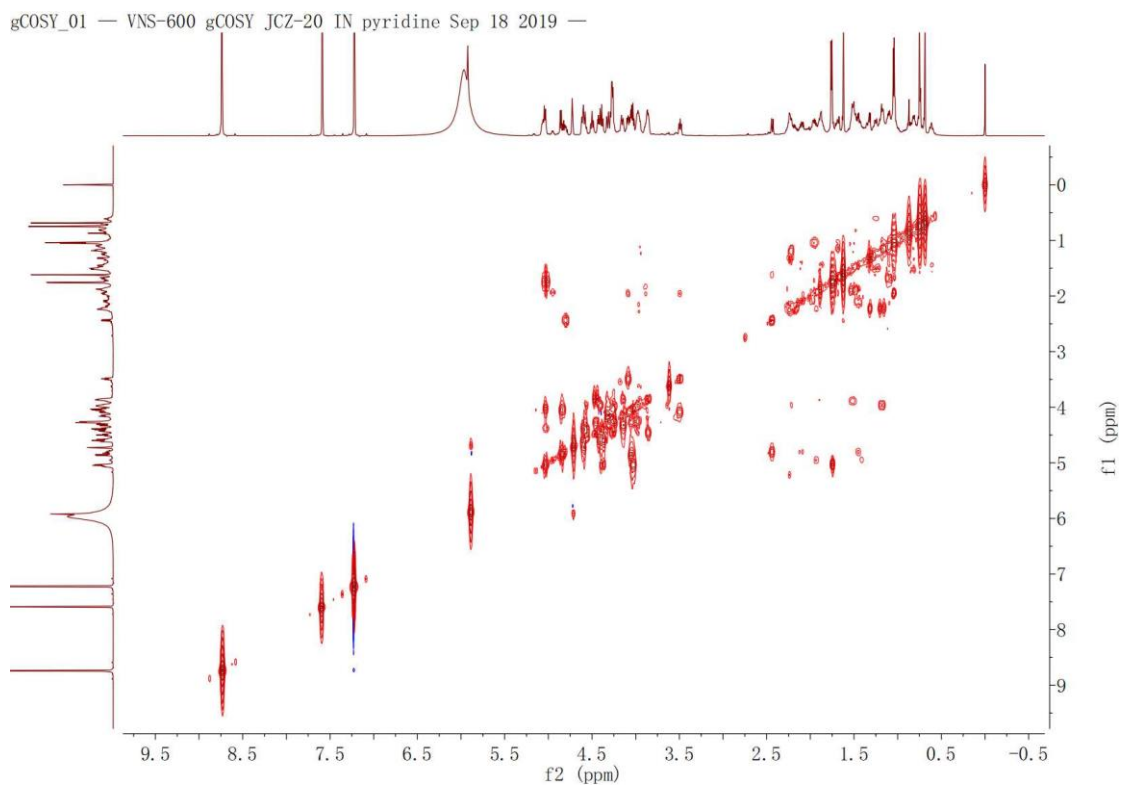
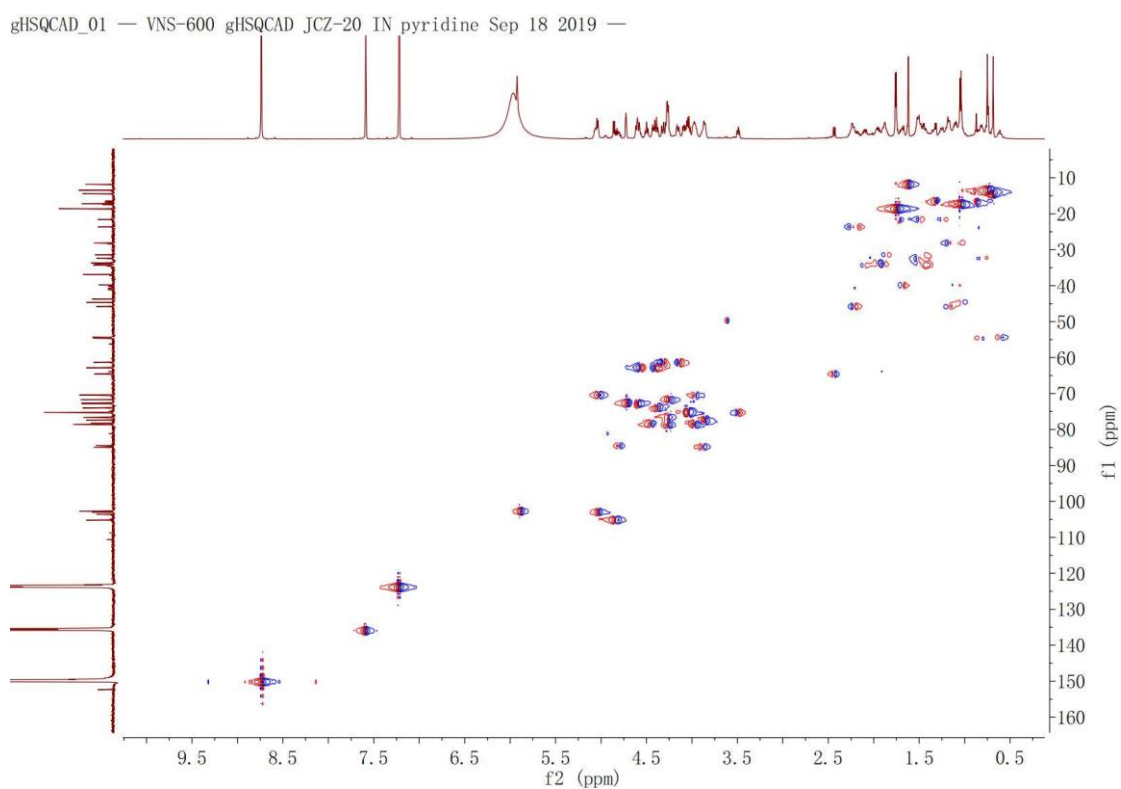


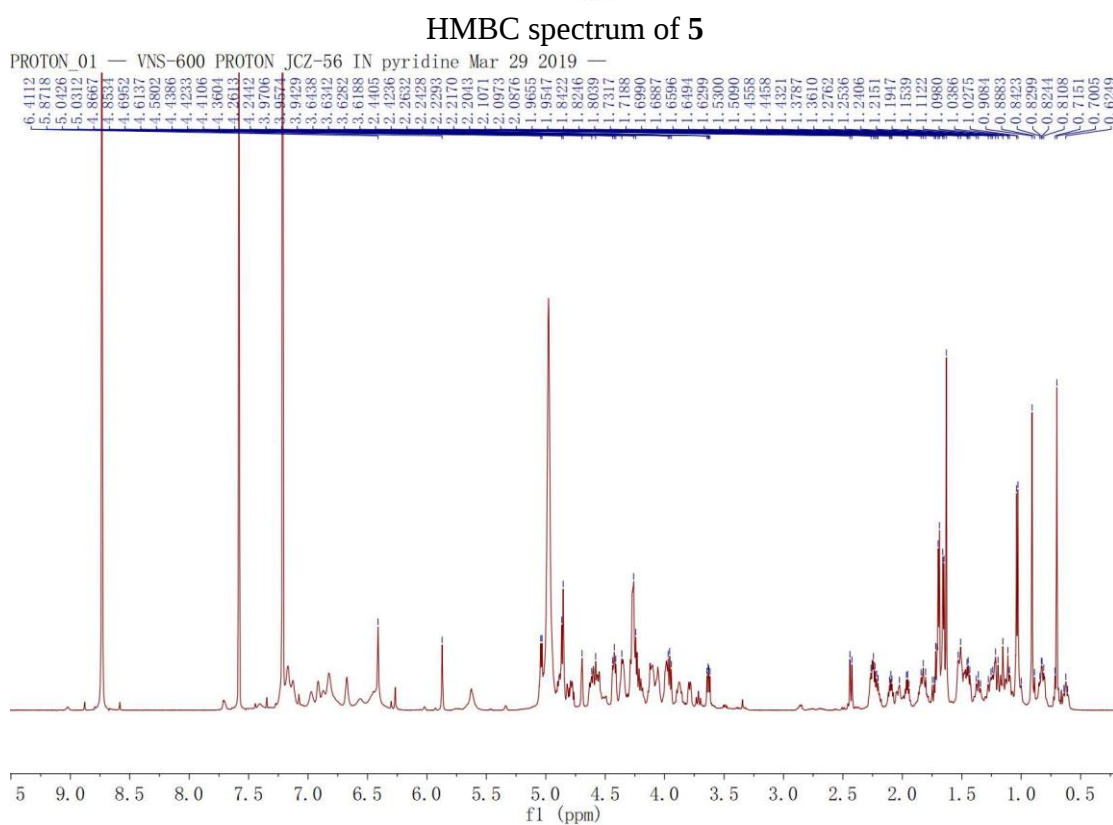
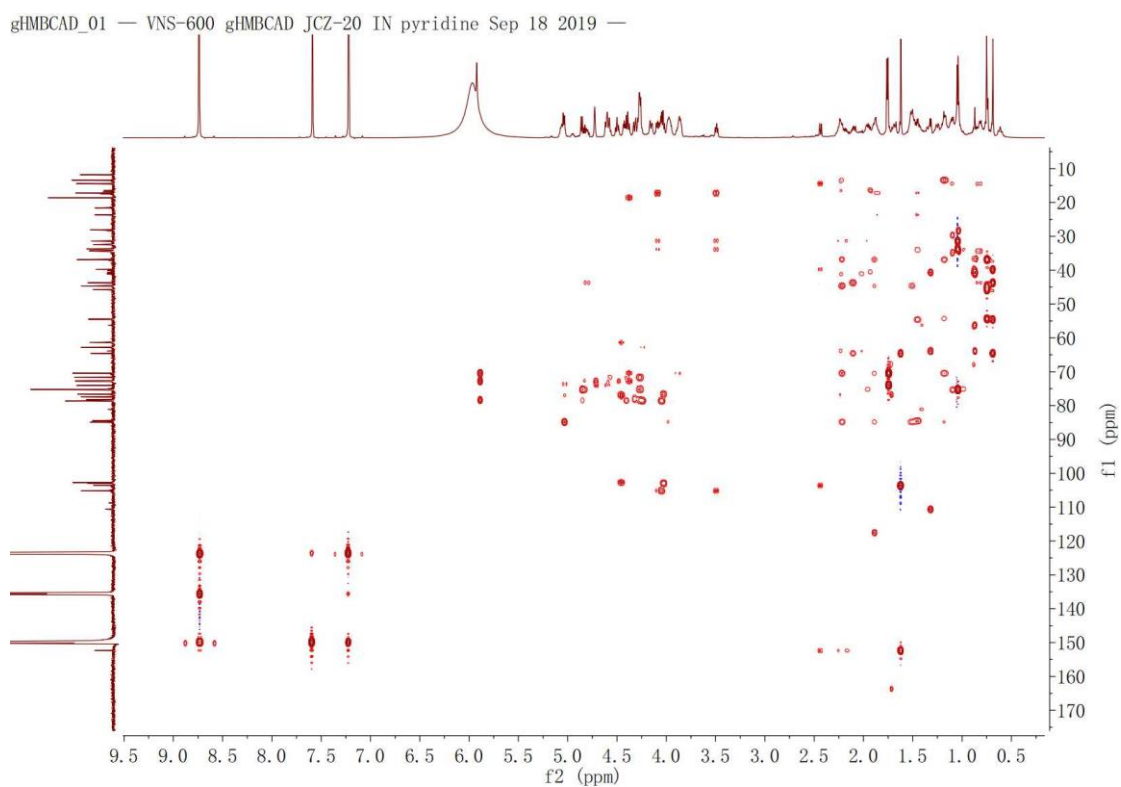


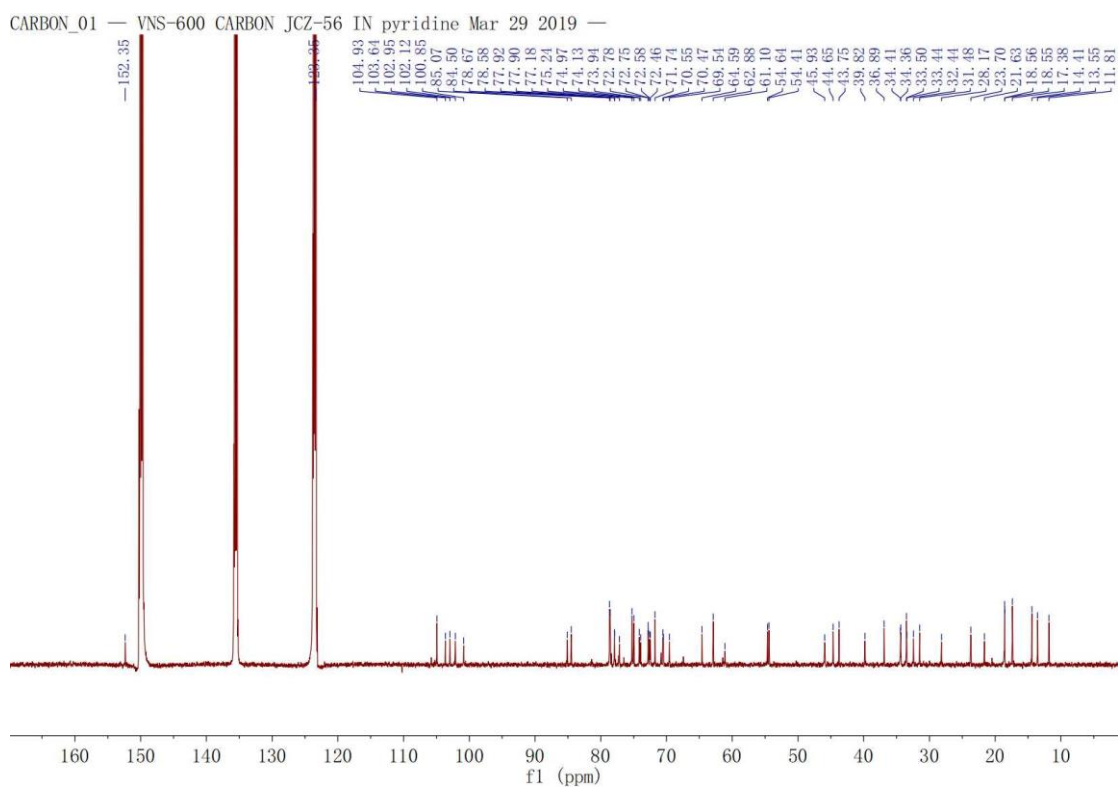
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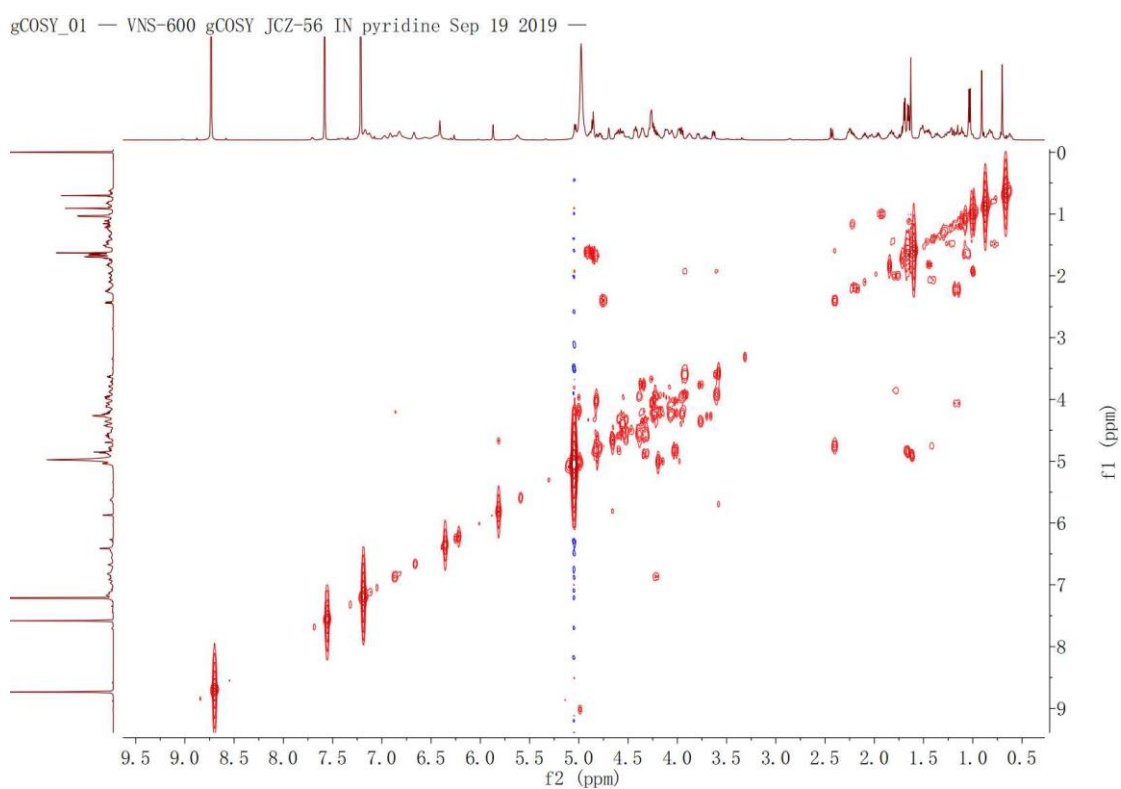
¹³C NMR spectrum of 5.

 **^1H - ^1H COSY spectrum of 5.****HSQC spectrum of 5.**

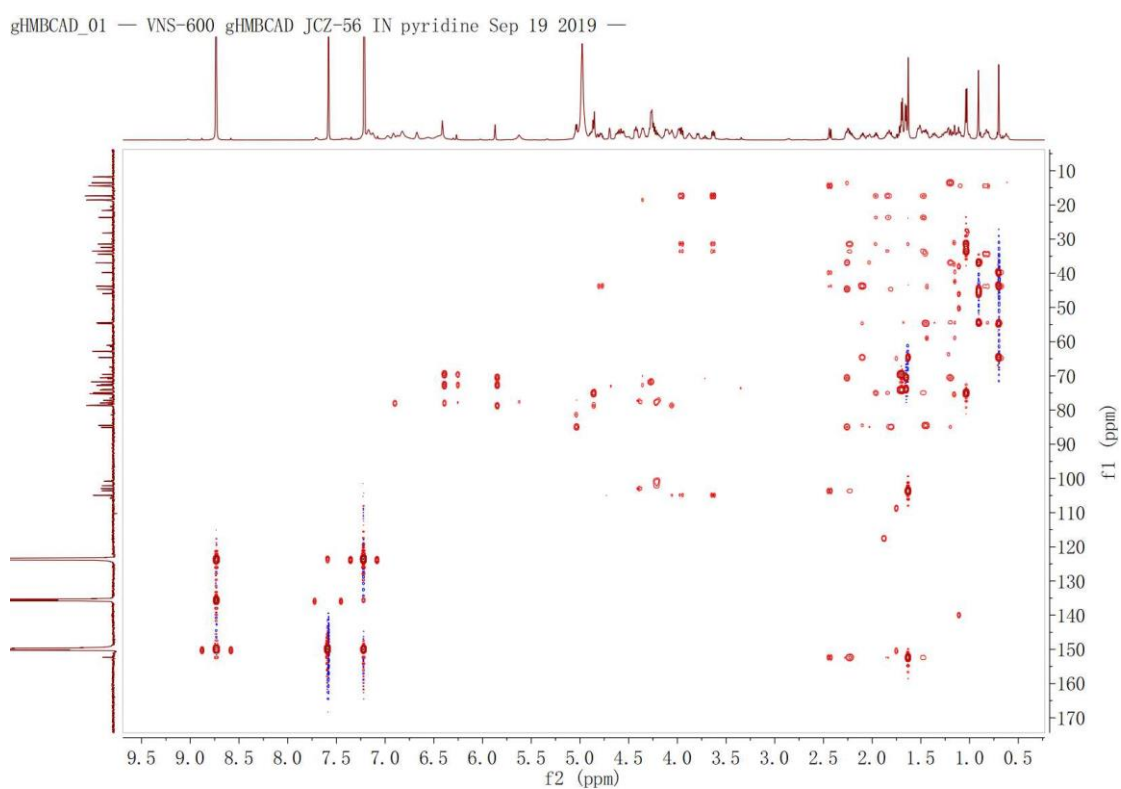
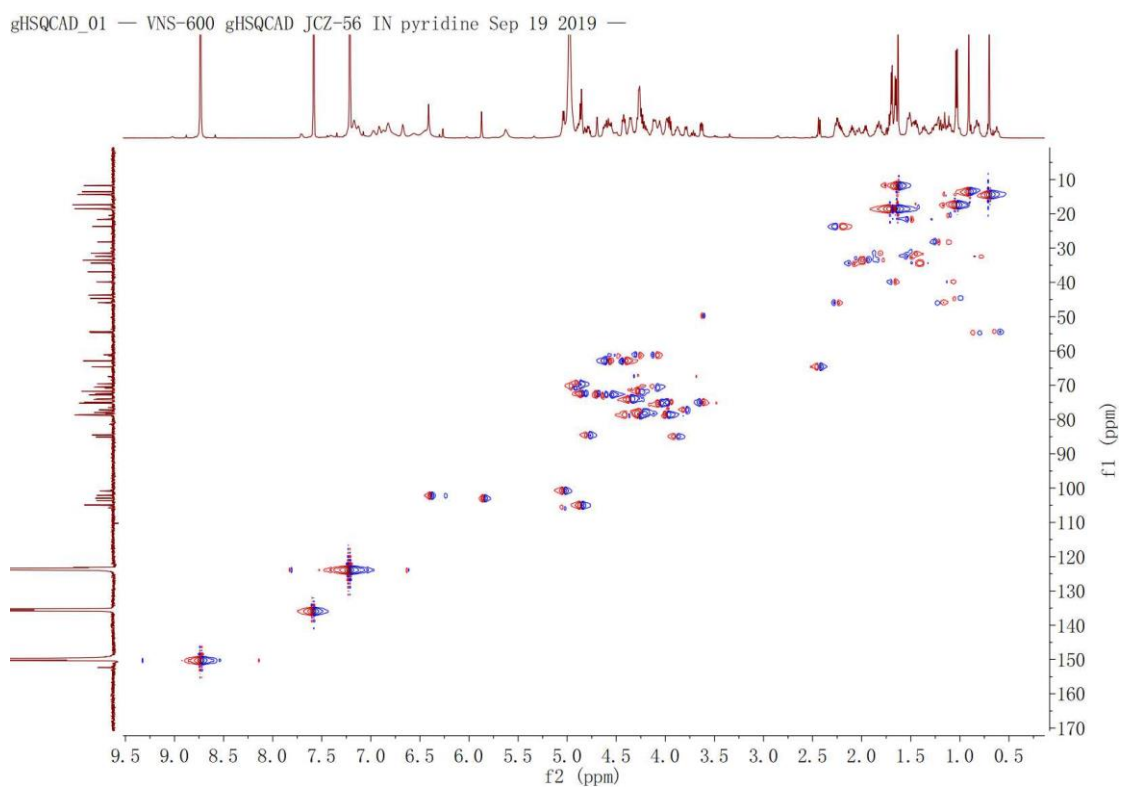


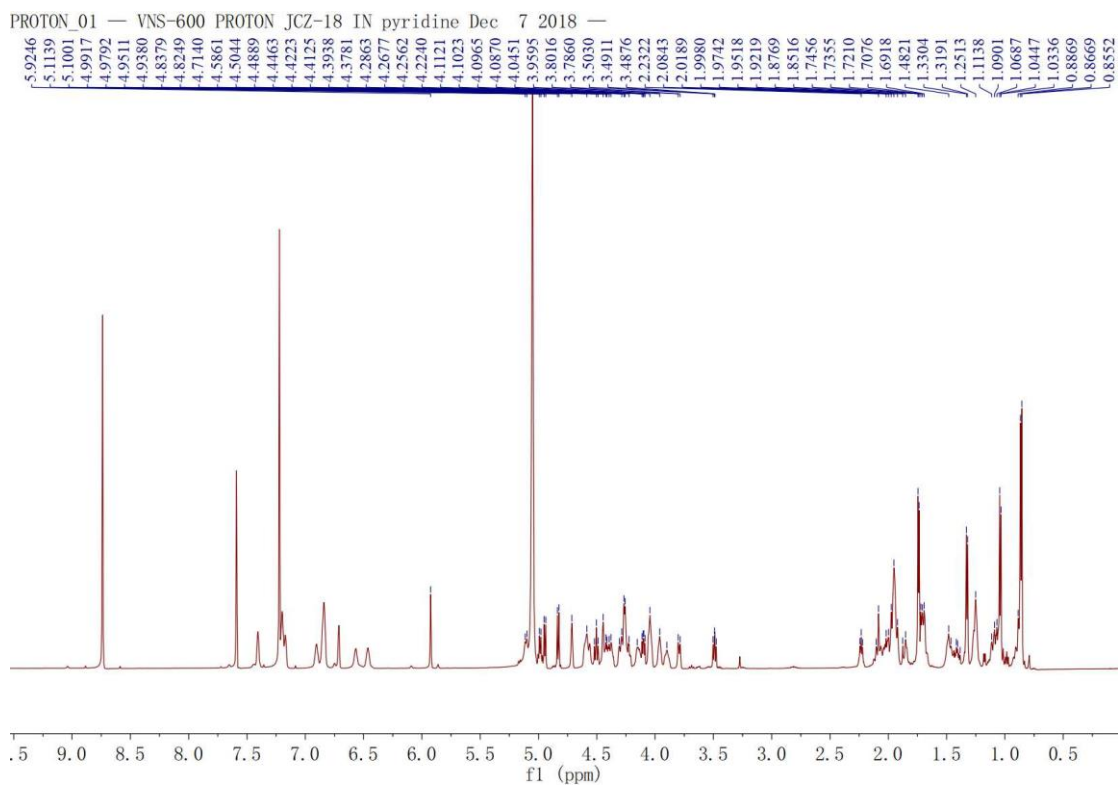


^{13}C NMR spectrum of **6**

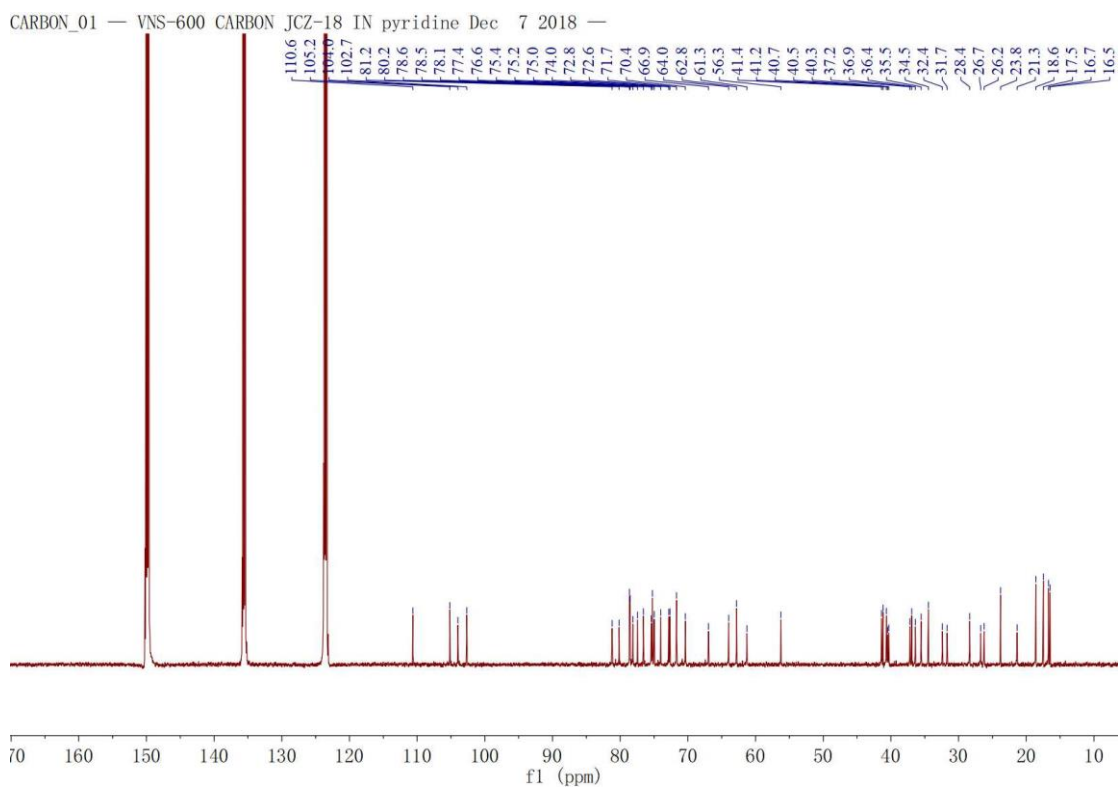


^1H - ^1H COSY spectrum of **6**.

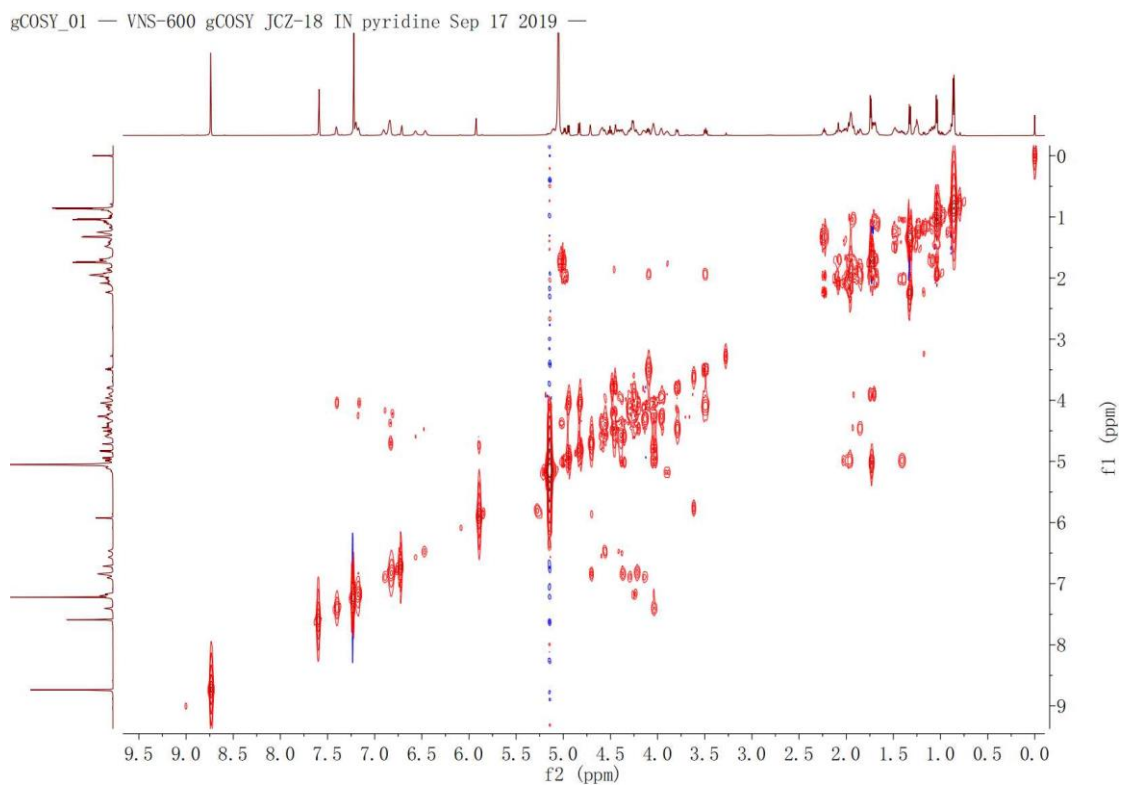




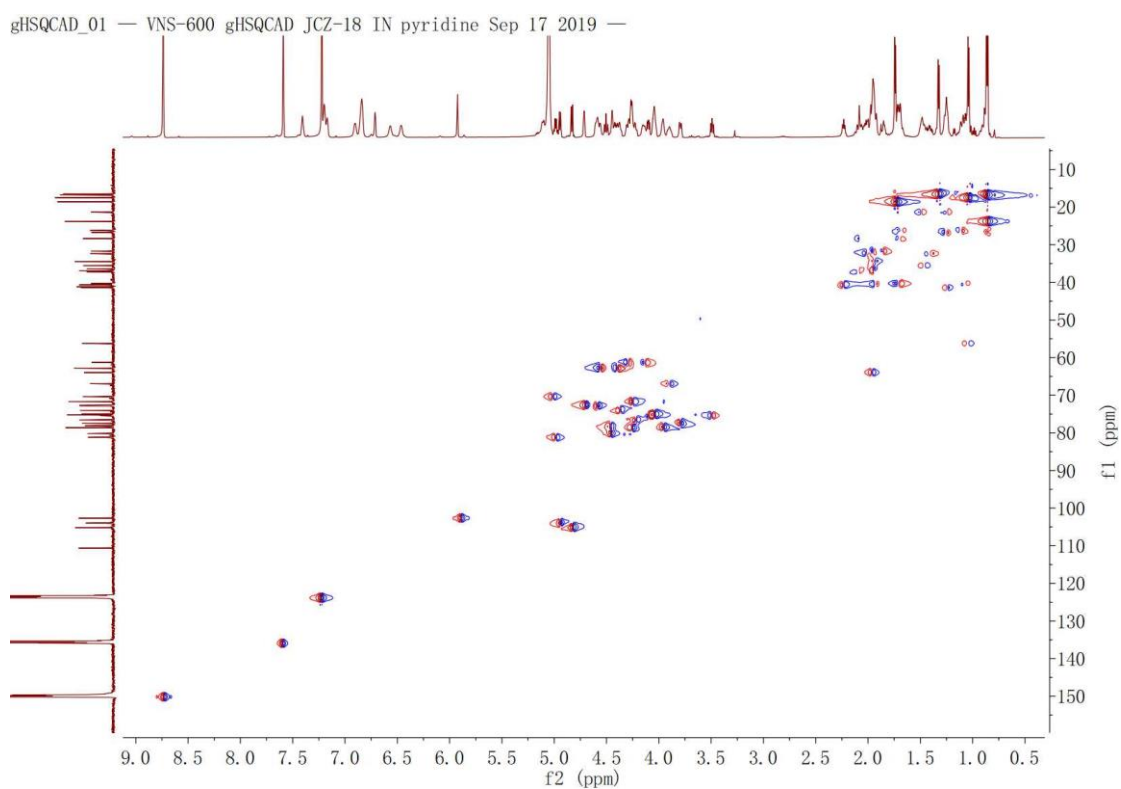
¹H NMR spectrum of 7.



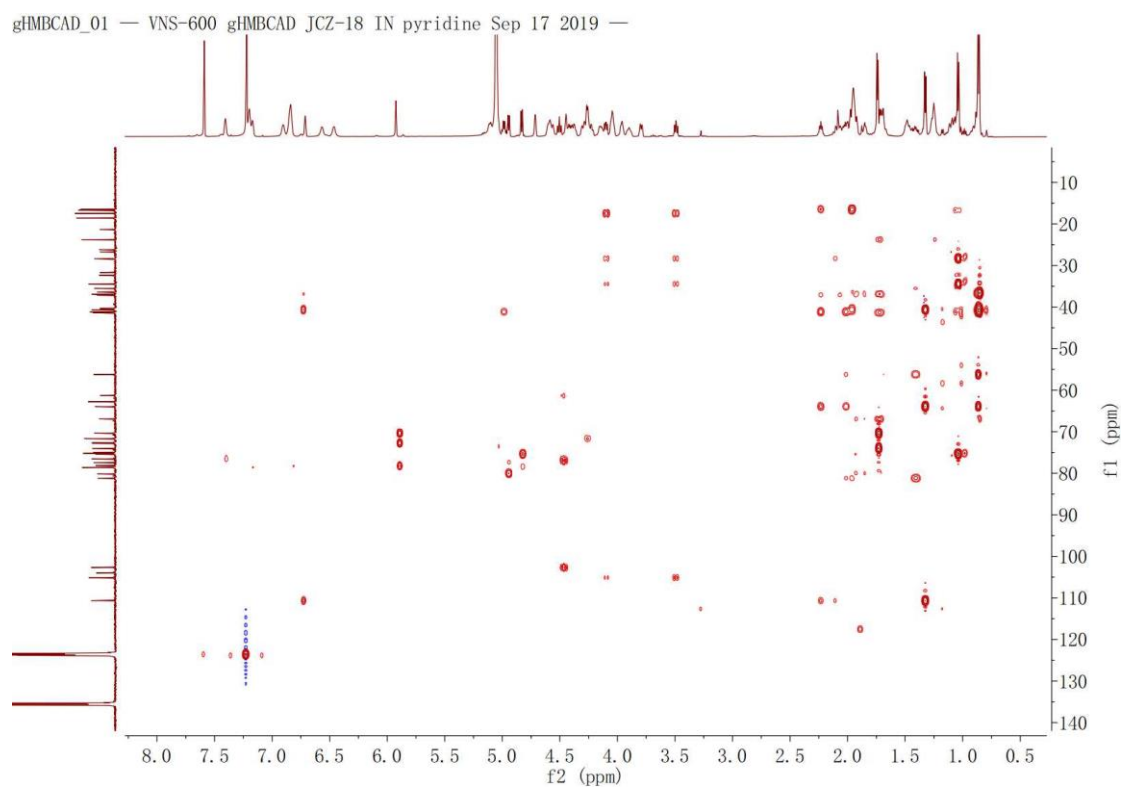
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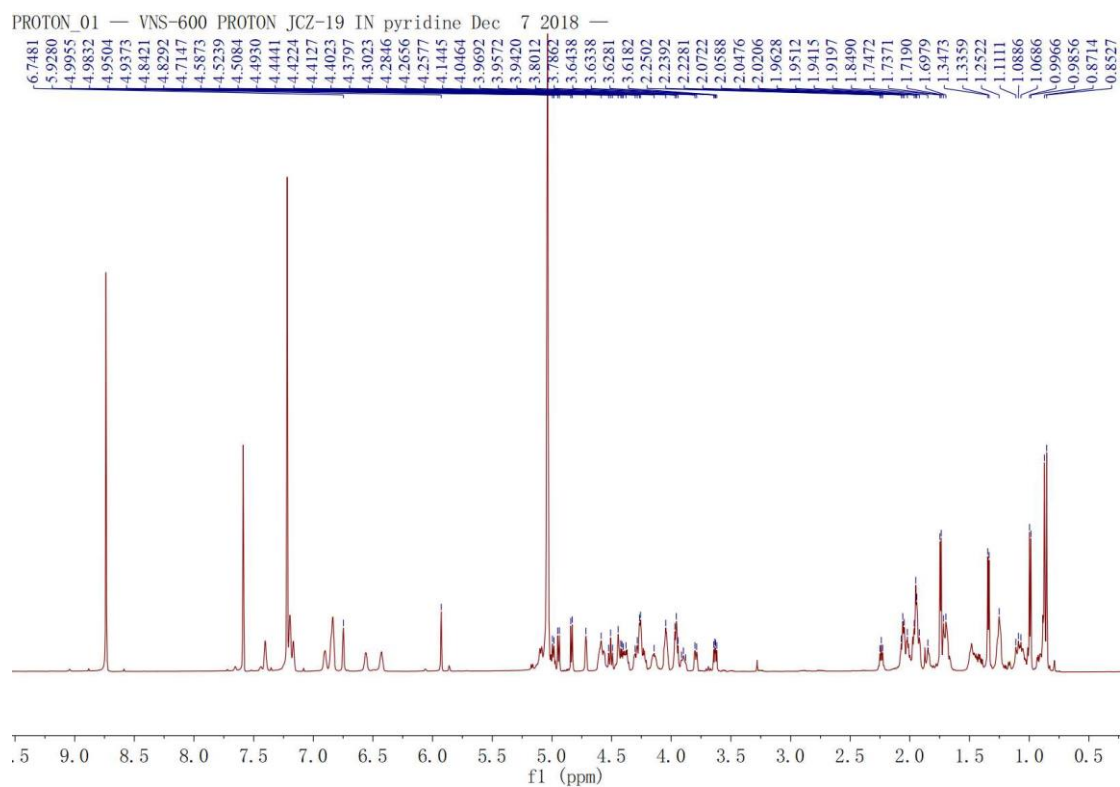
^1H - ^1H COSY spectrum of 7.

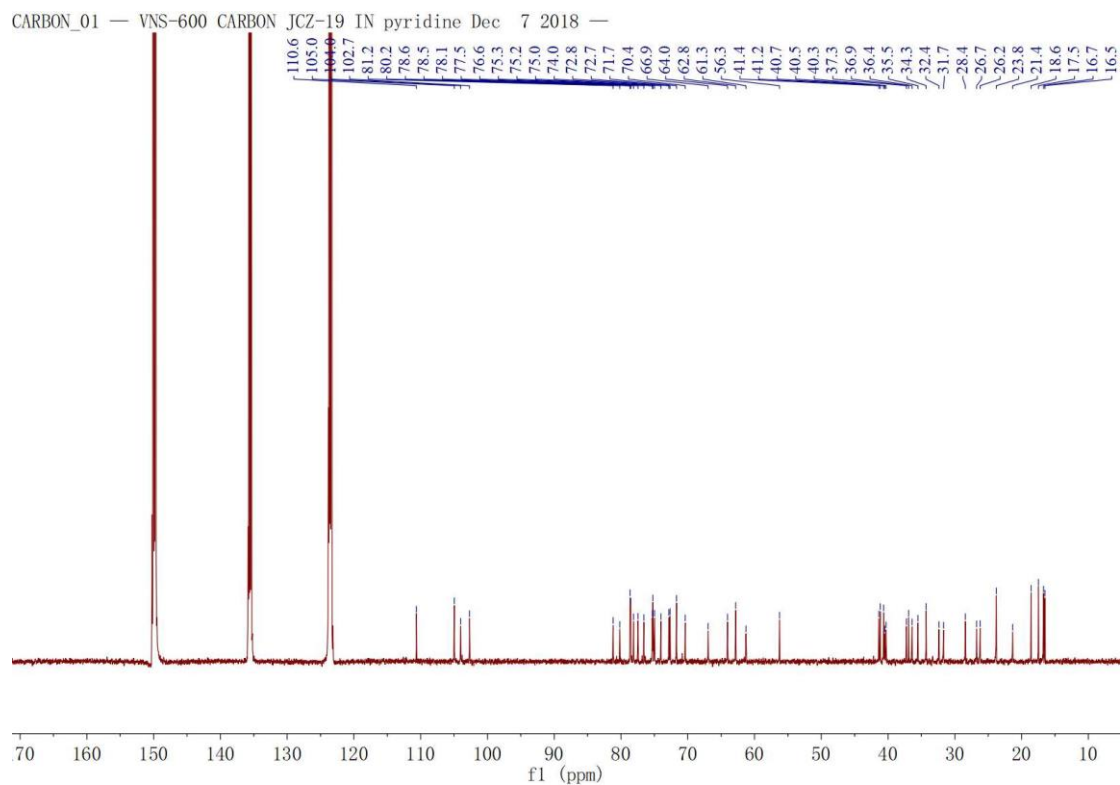


HSQC spectrum of 7.

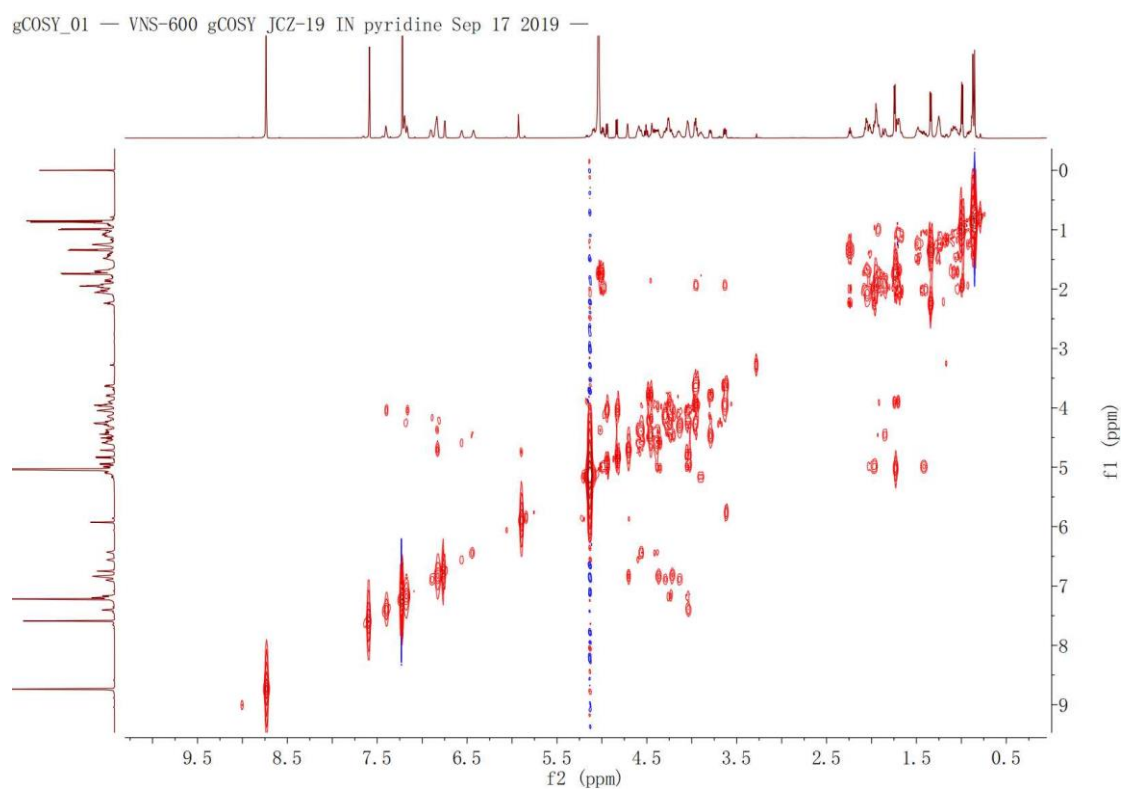


HMBC spectrum of 7.

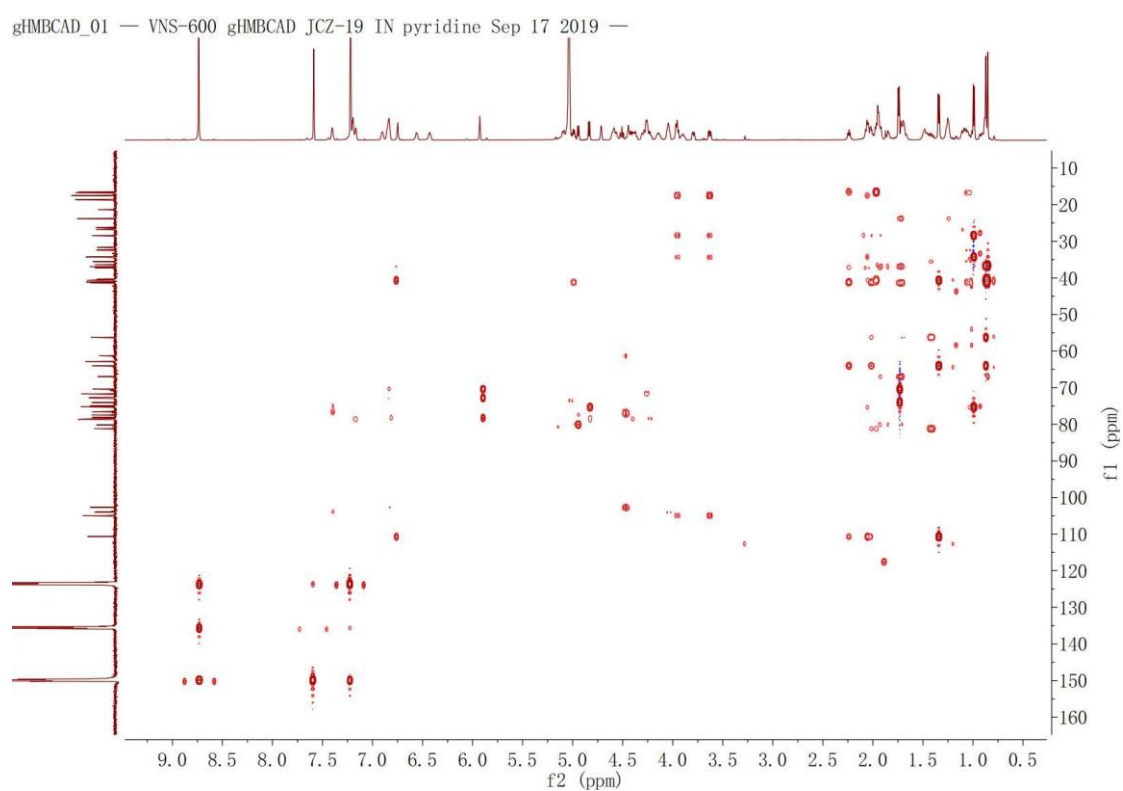
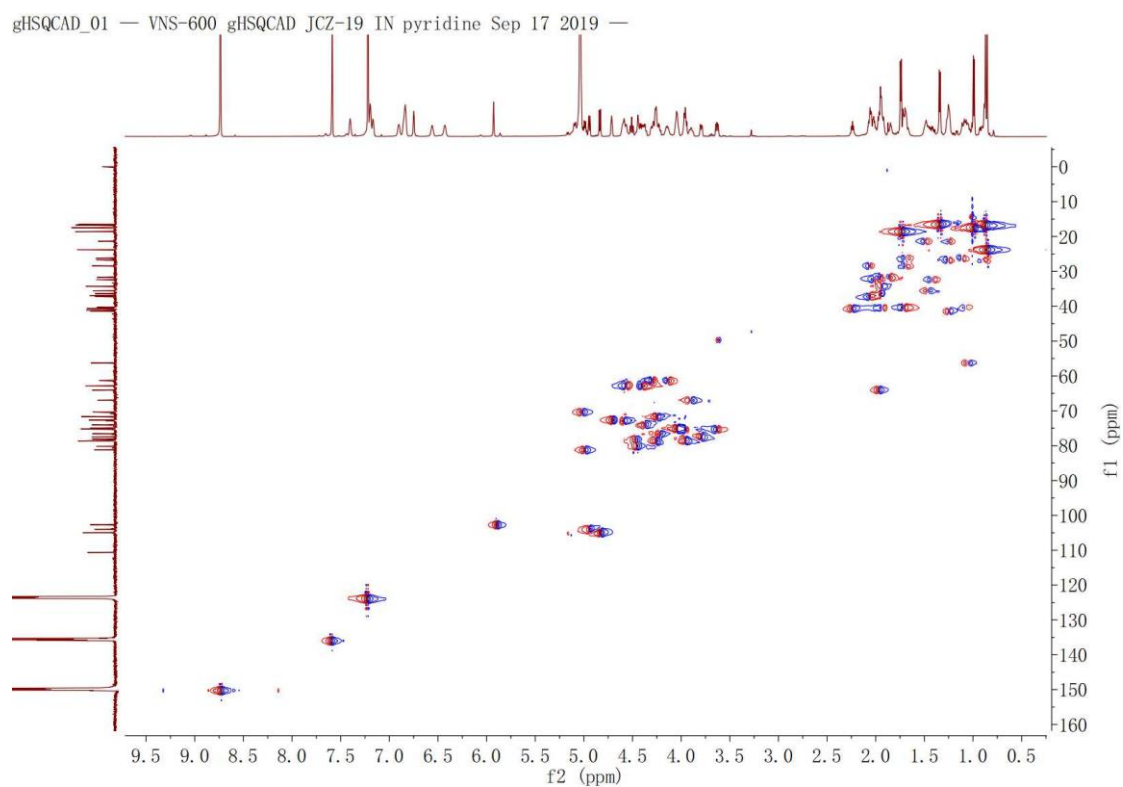
 ^1H NMR spectrum of 8.

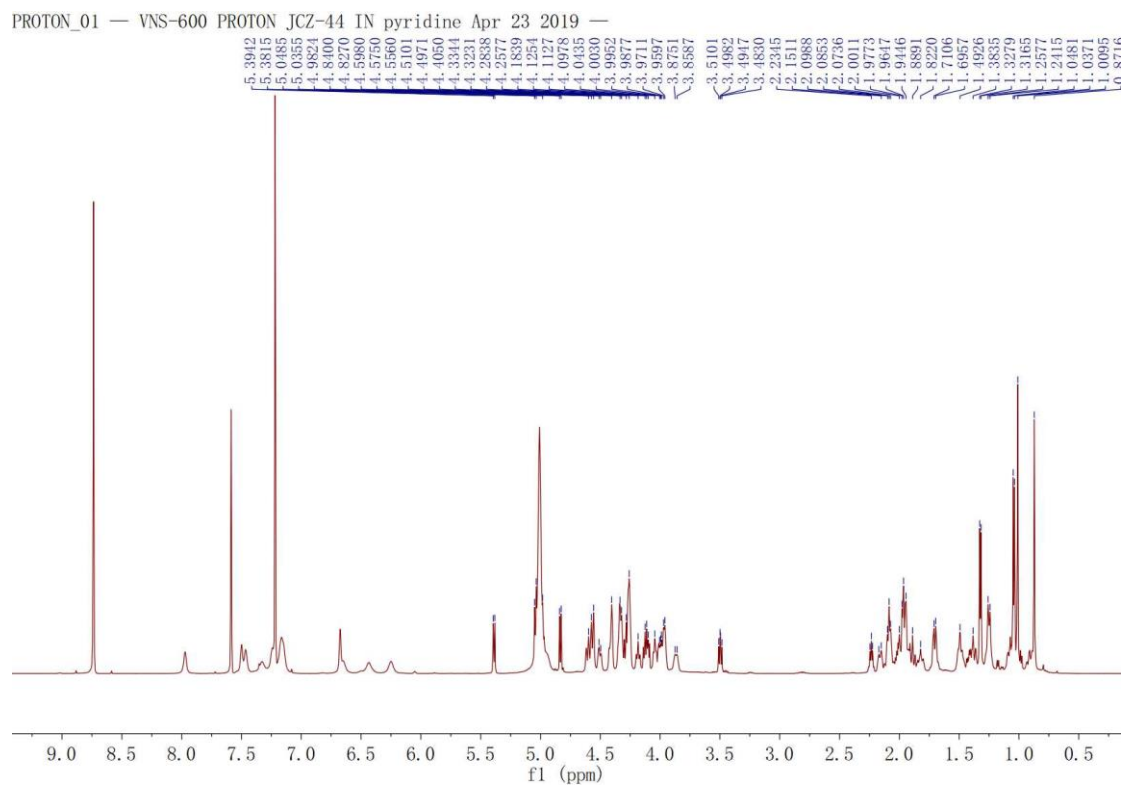


¹³C NMR spectrum of 8.

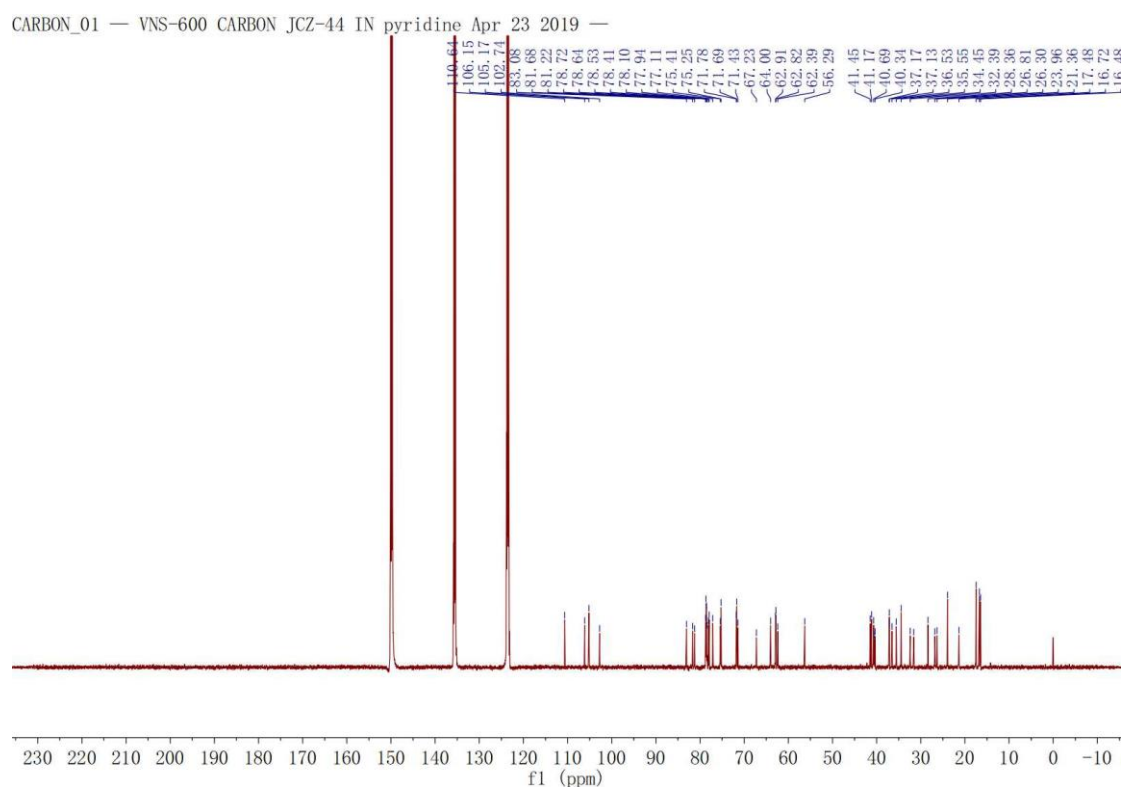


¹H-¹H COSY spectrum of 8.



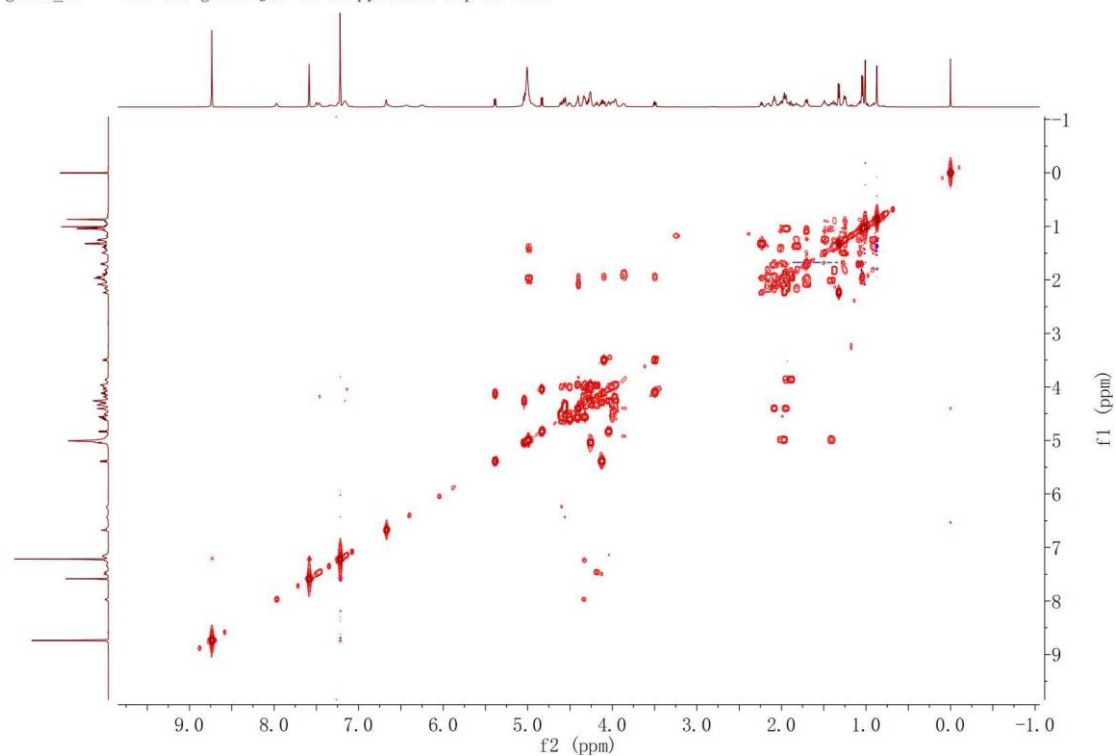


¹H NMR spectrum of 9.

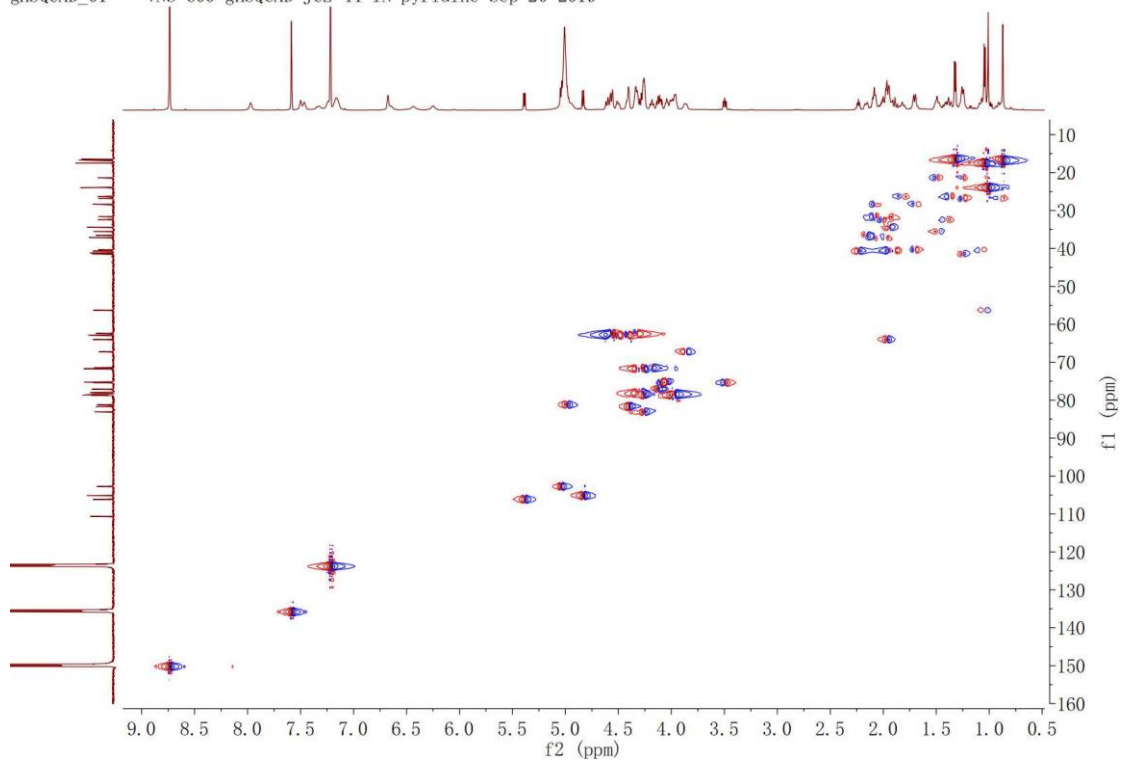


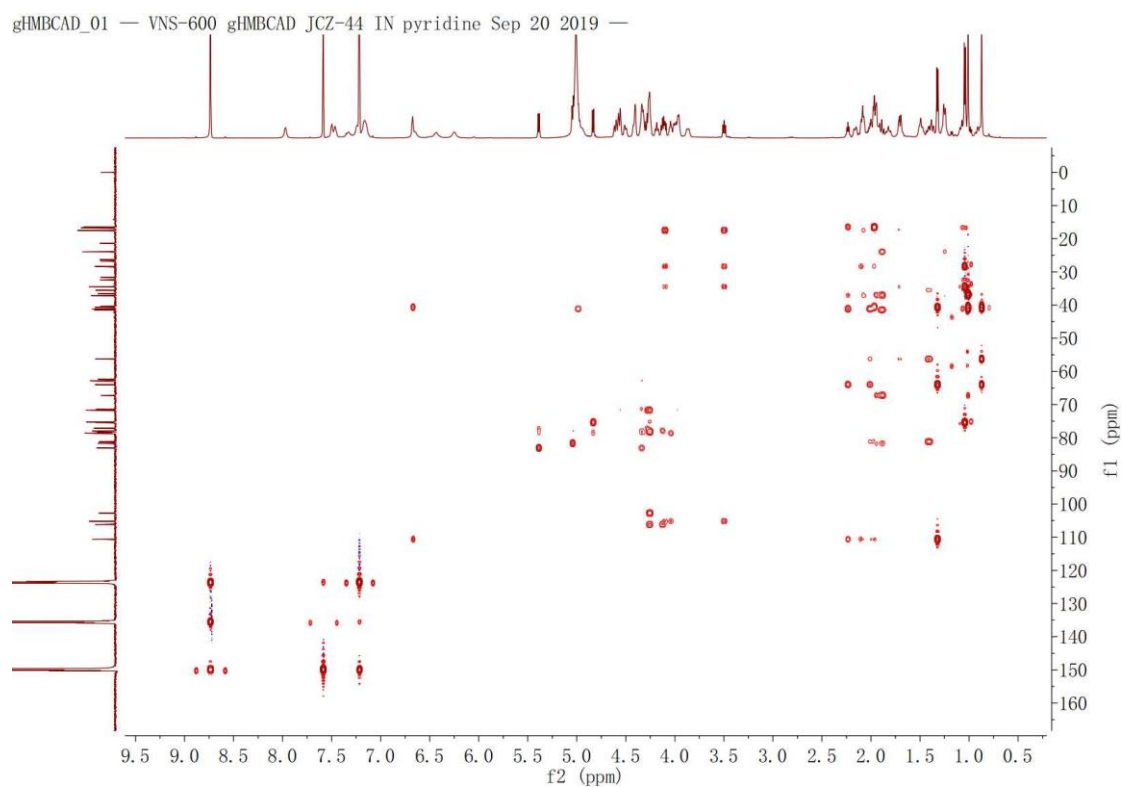
¹³C NMR spectrum of 9.

gCOSY_01 — VNS-600 gCOSY JCZ-44 IN pyridine Sep 20 2019 —

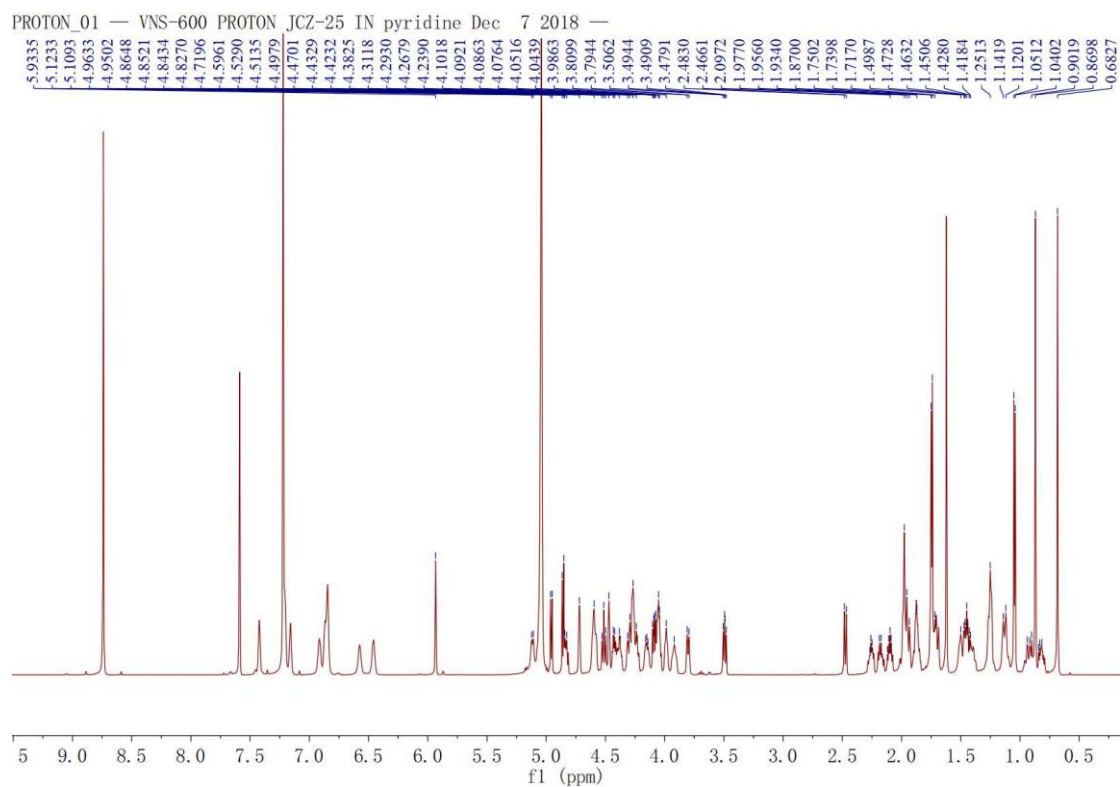
 **^1H - ^1H COSY spectrum of 9.**

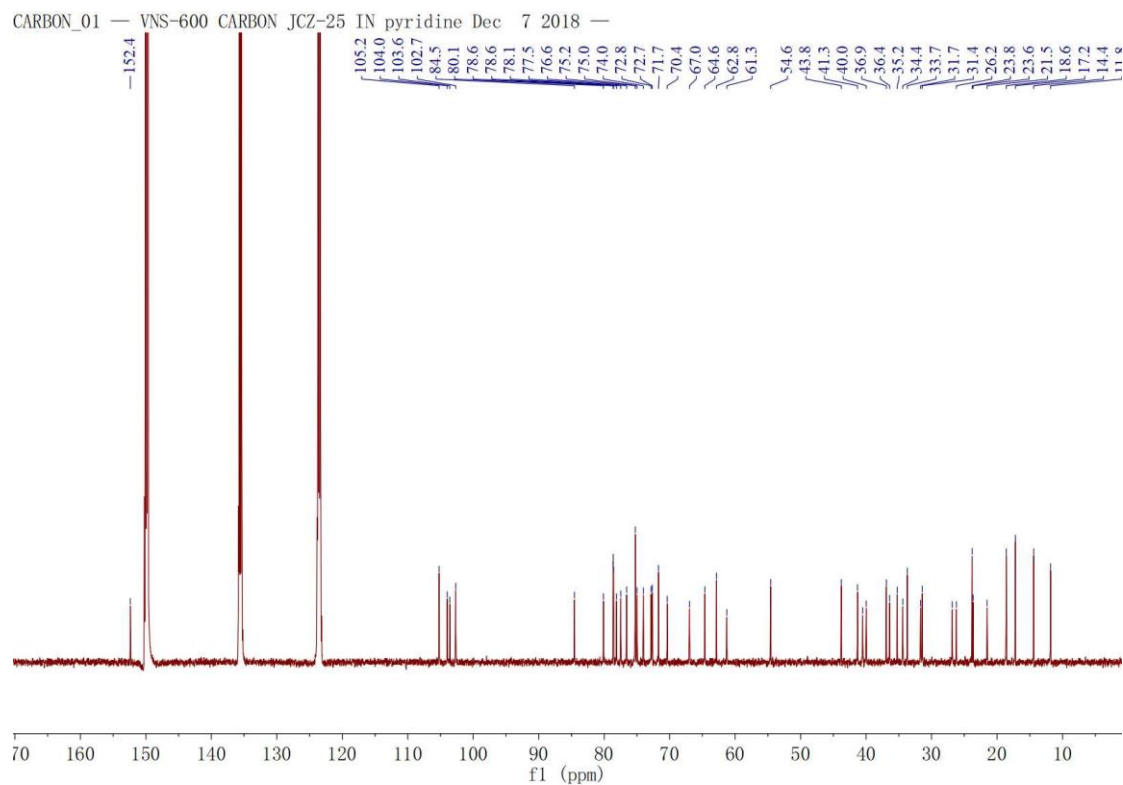
gHSQCAD_01 — VNS-600 gHSQCAD JCZ-44 IN pyridine Sep 20 2019 —

**HSQC spectrum of 9.**

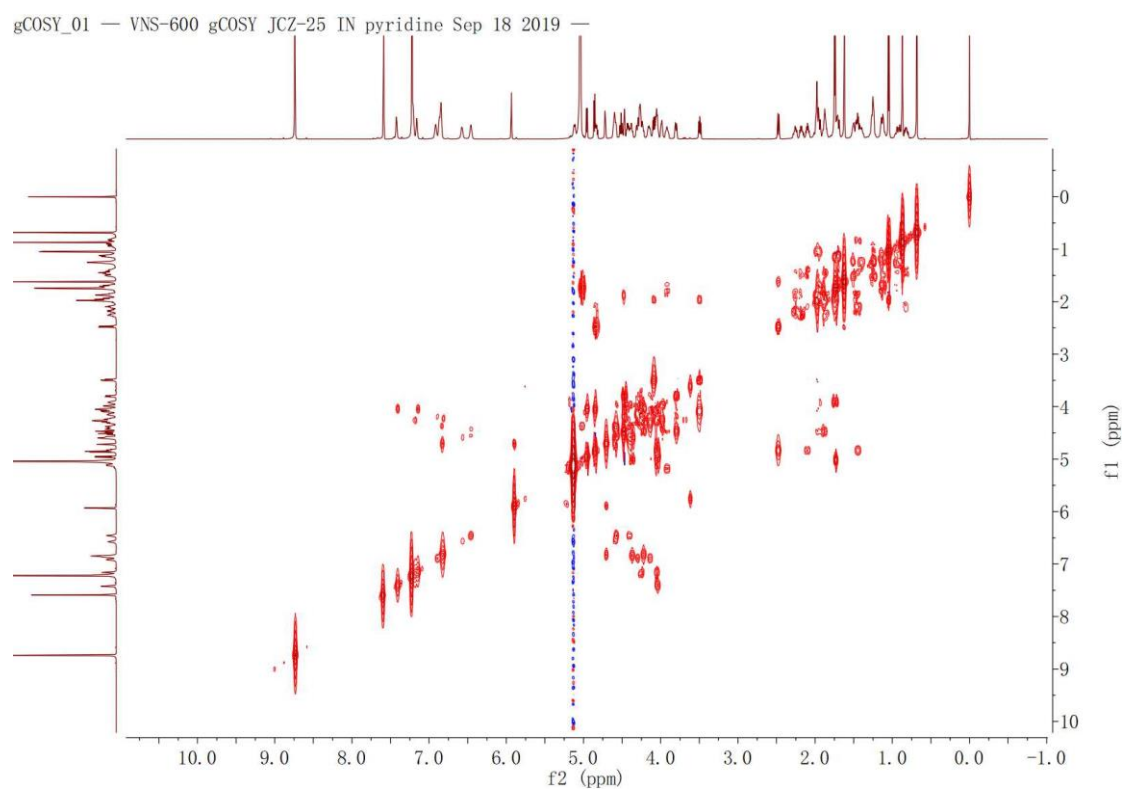


HMBC spectrum of 9.

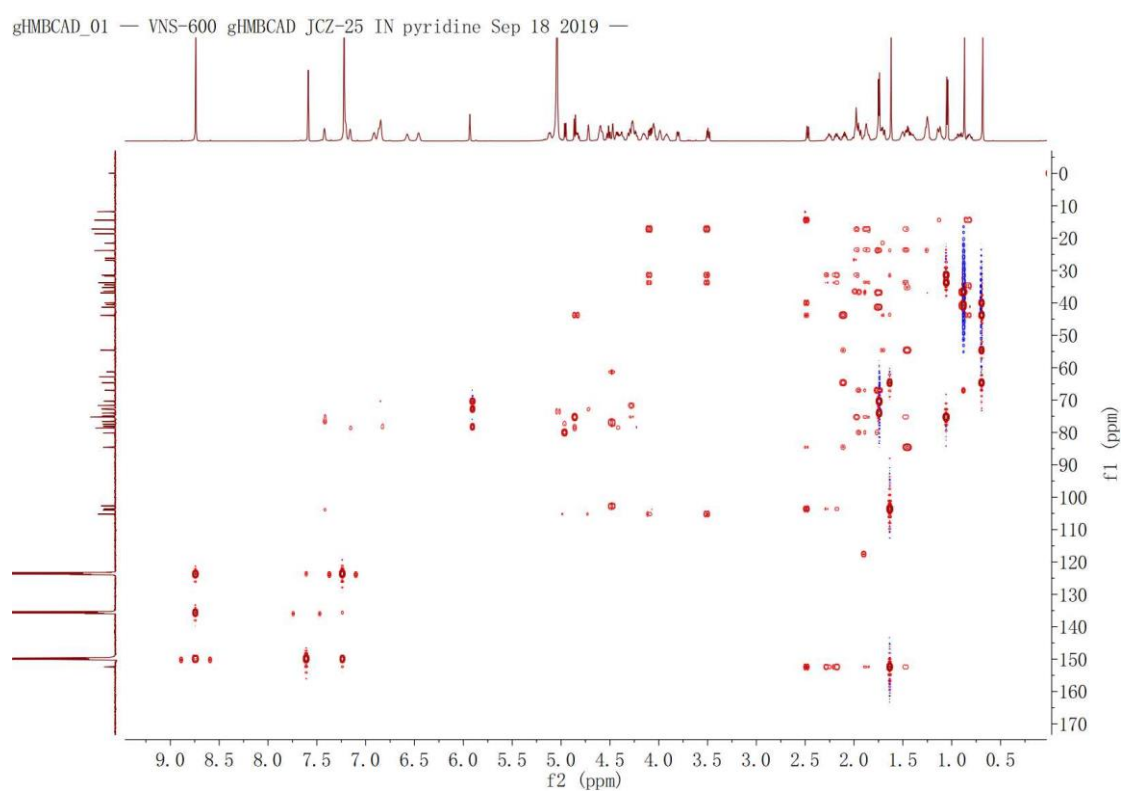
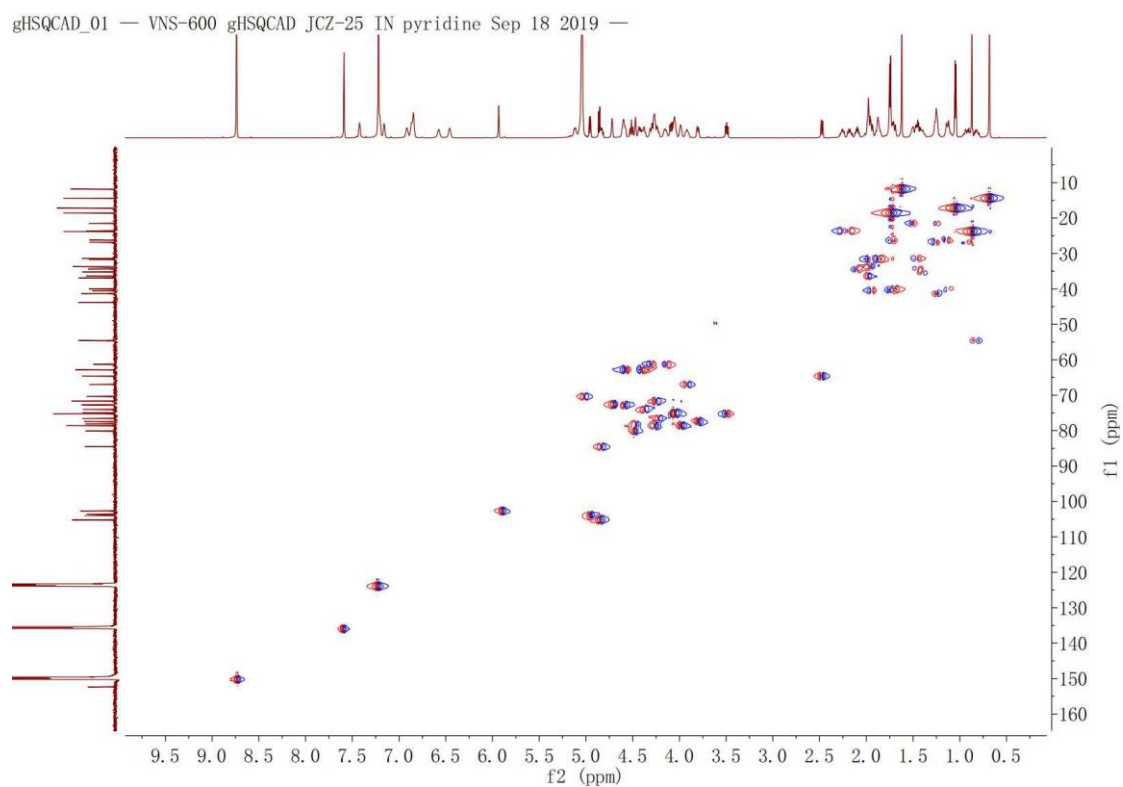
 ^1H NMR spectrum of 10.

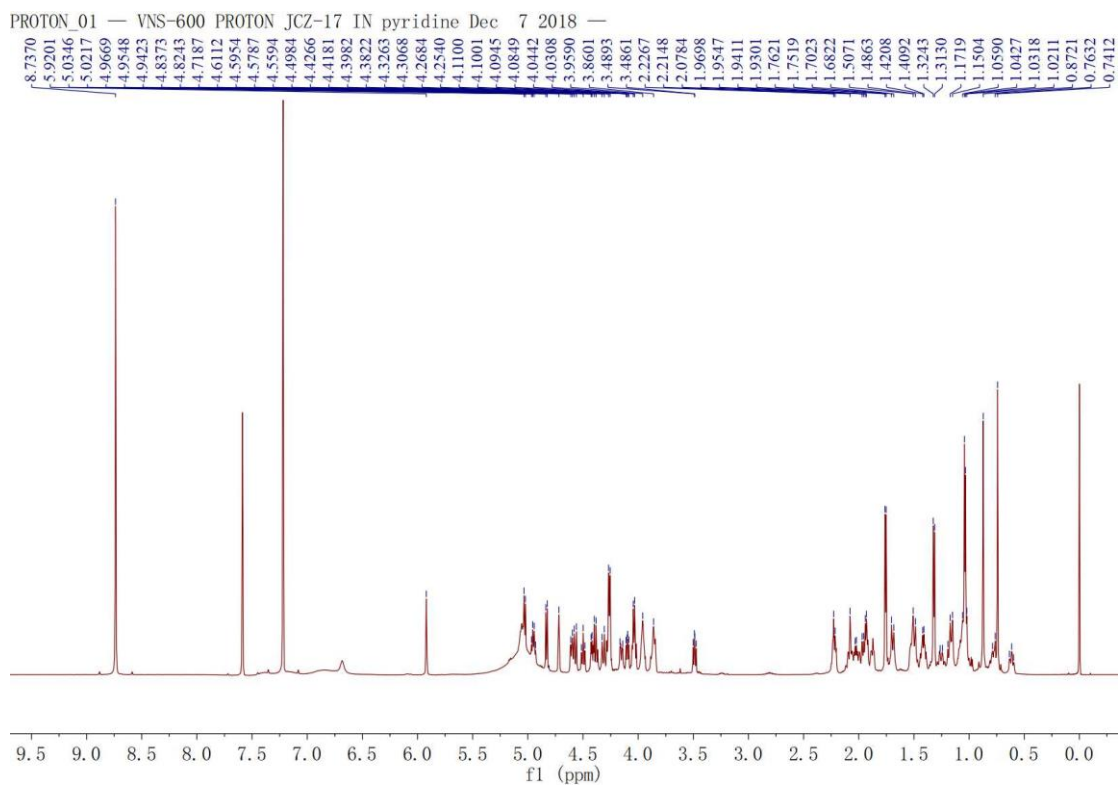


^{13}C NMR spectrum of 10.

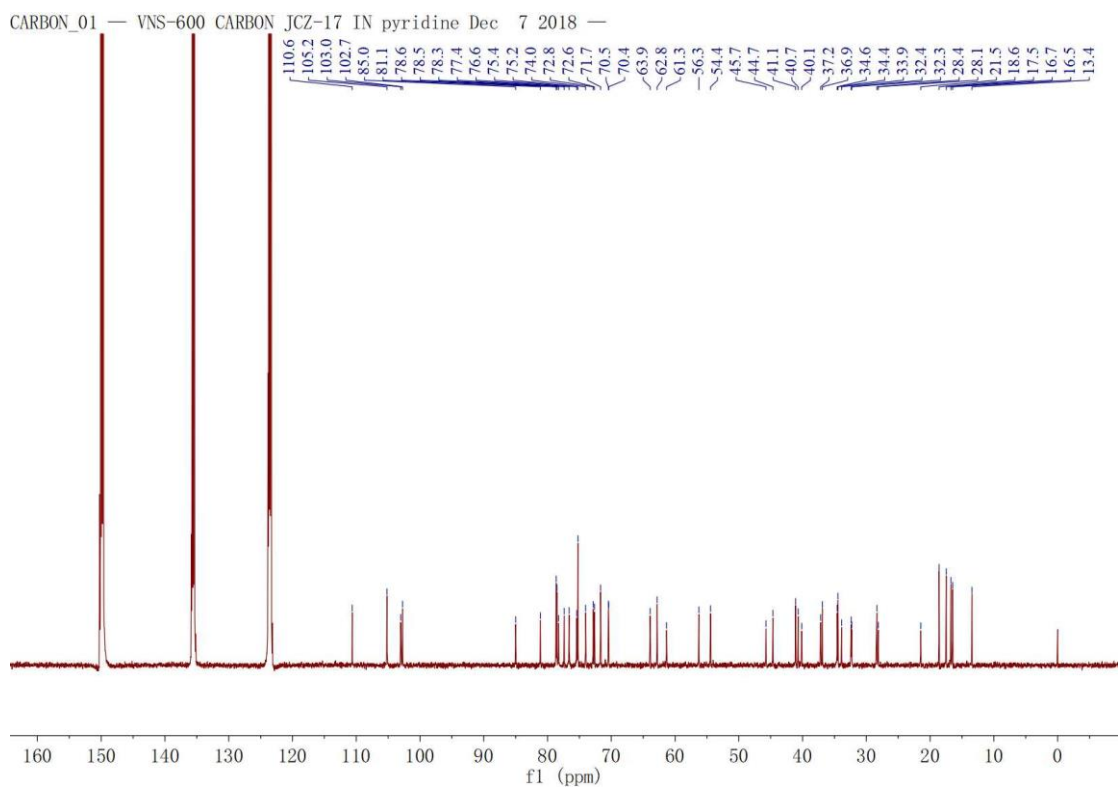


^1H - ^1H COSY spectrum of 10.

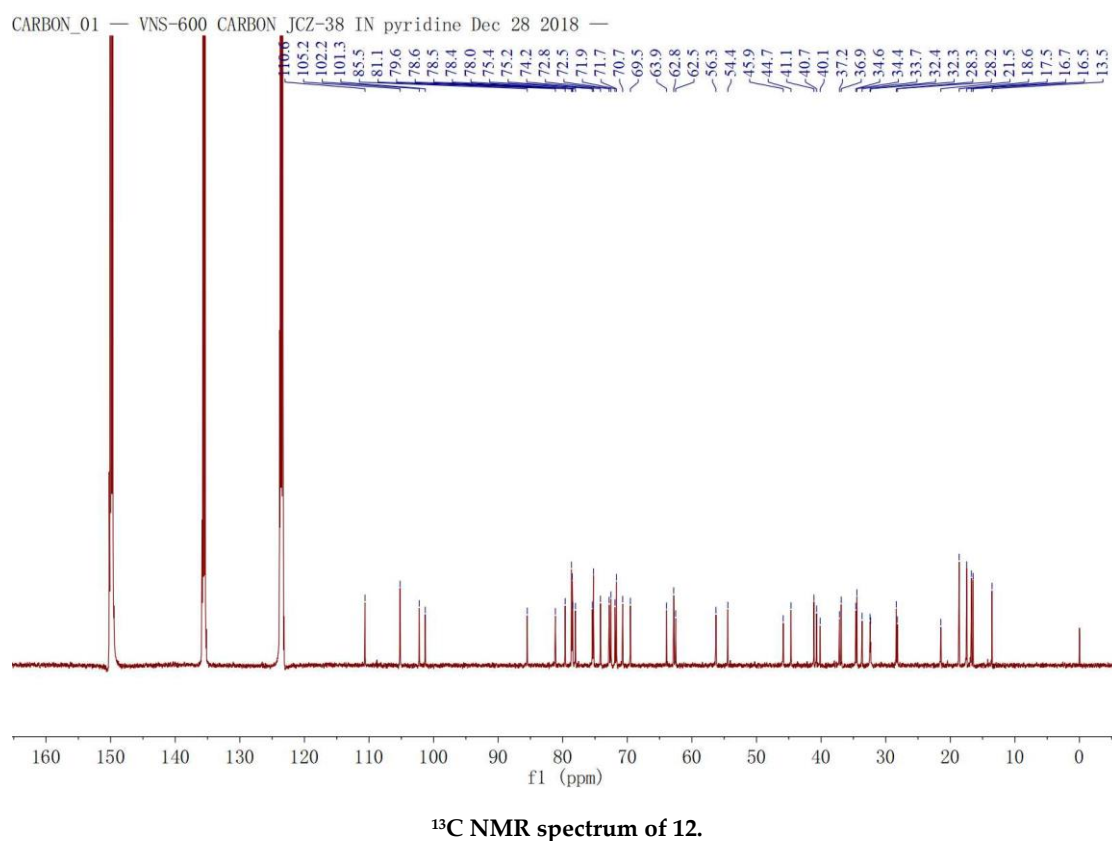
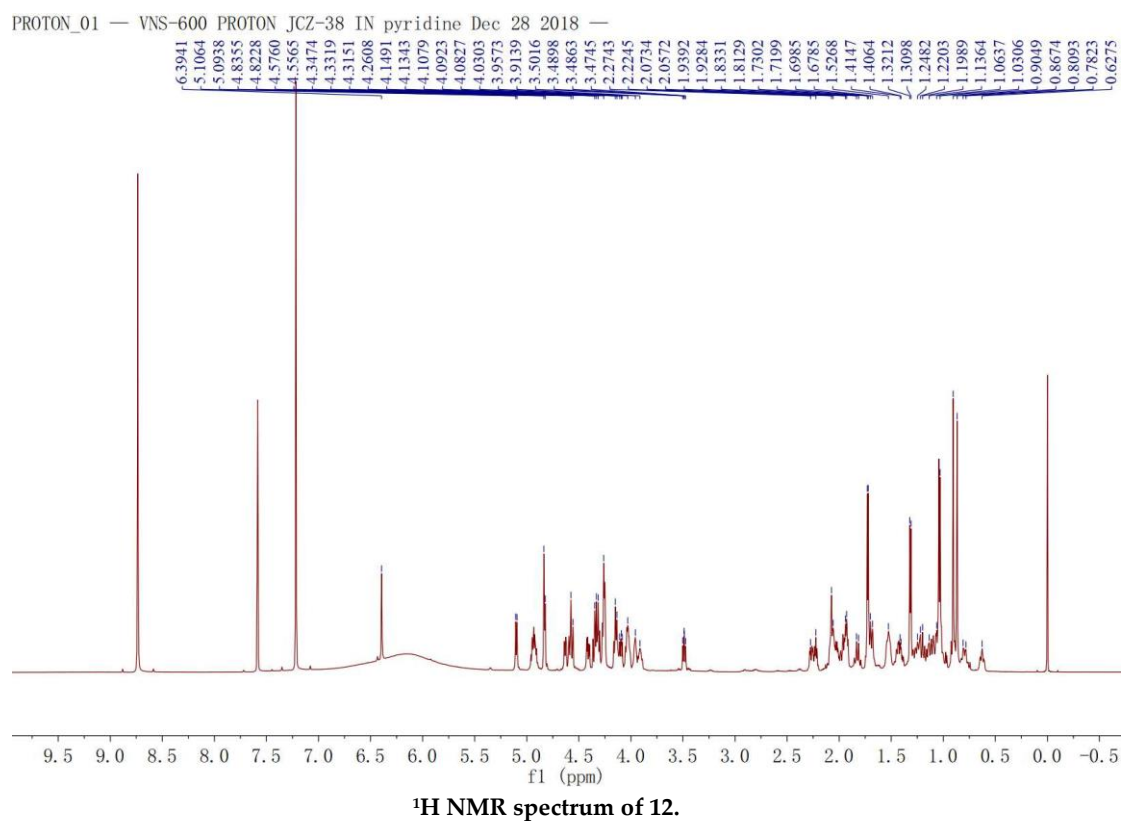


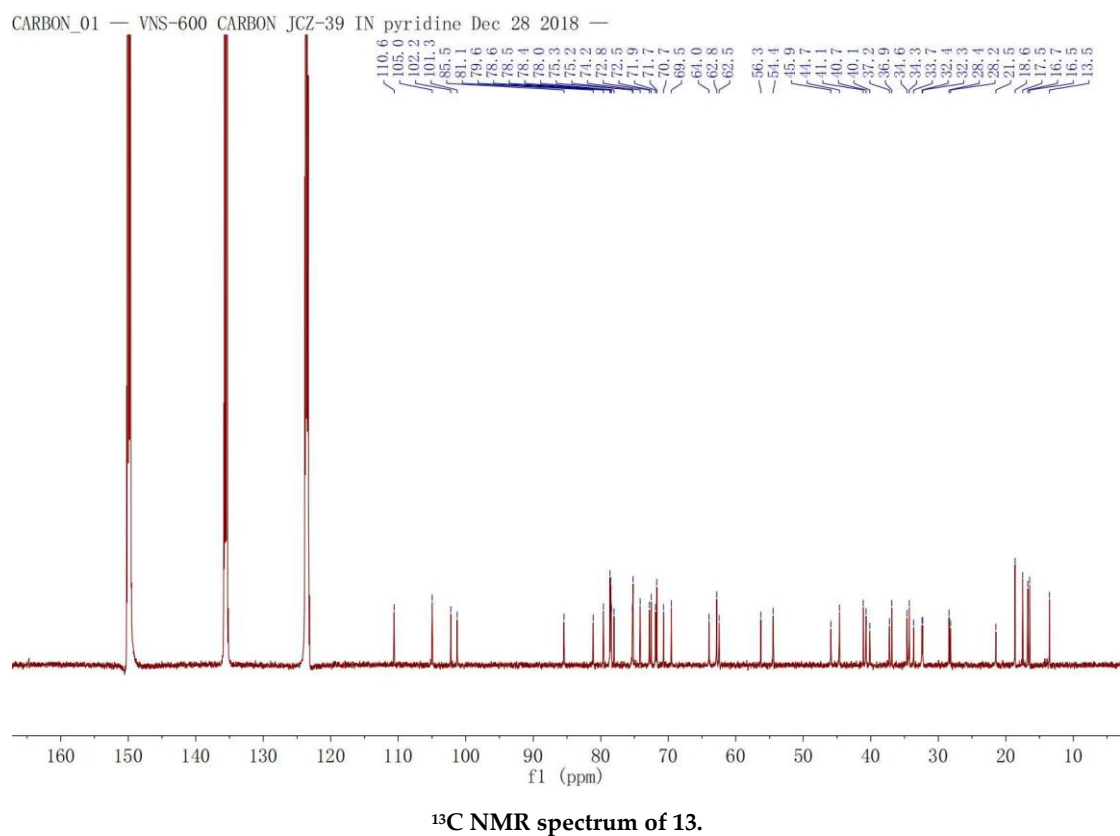
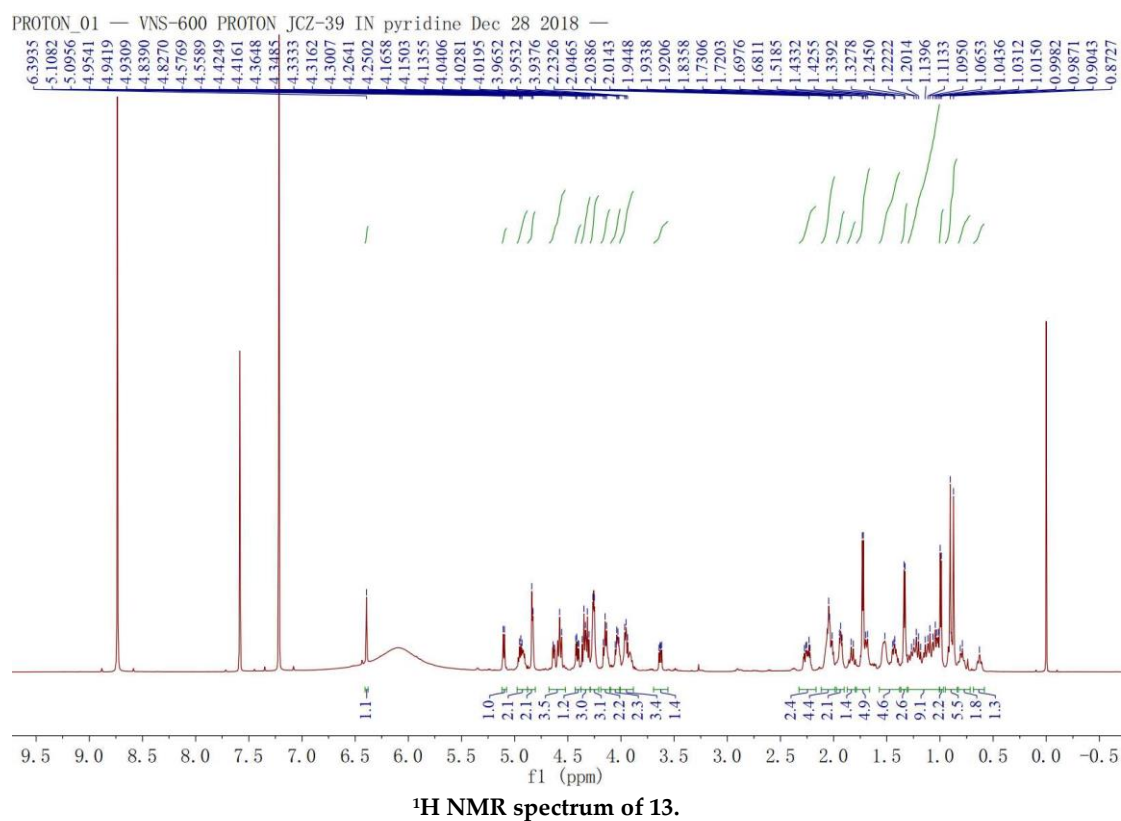


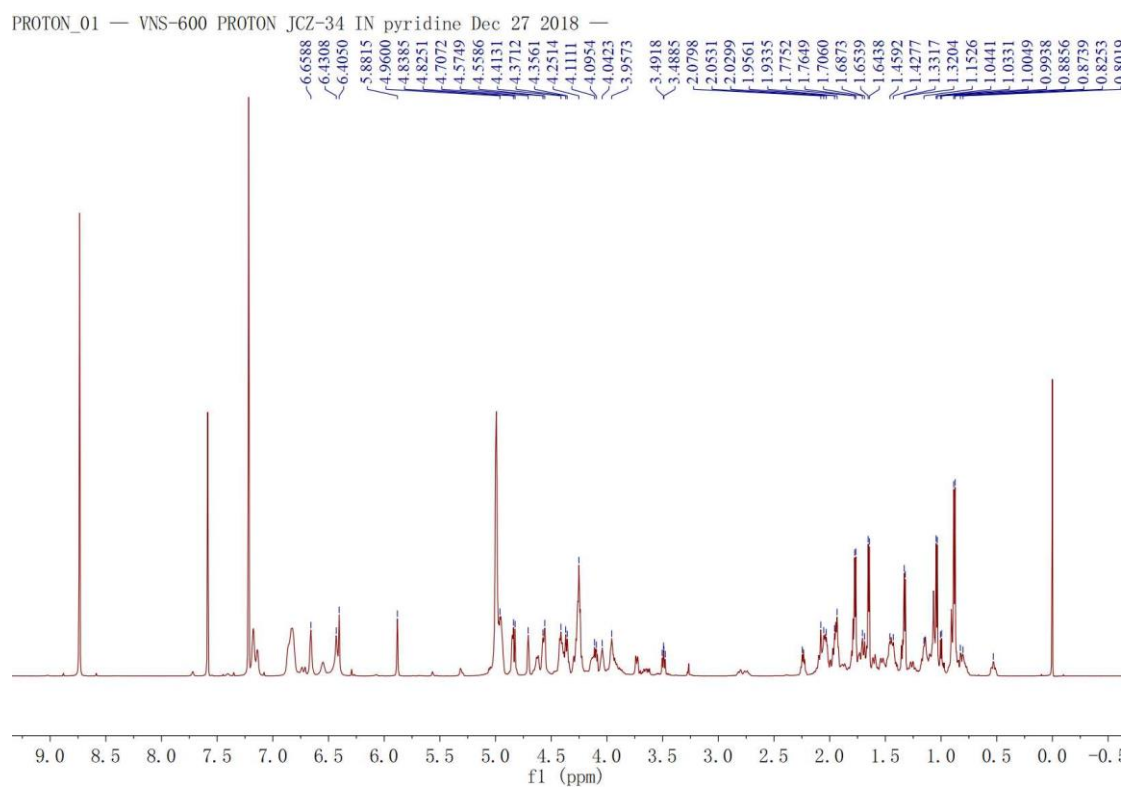
¹H NMR spectrum of 11.



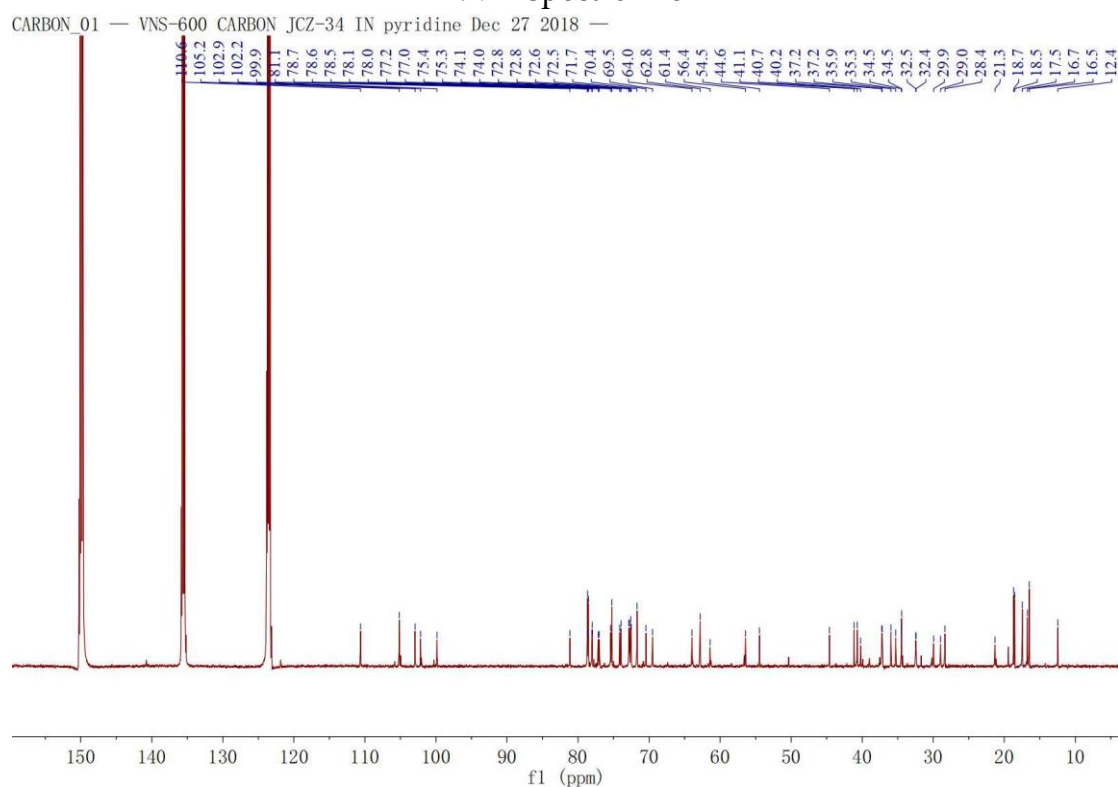
¹³C NMR spectrum of 11.



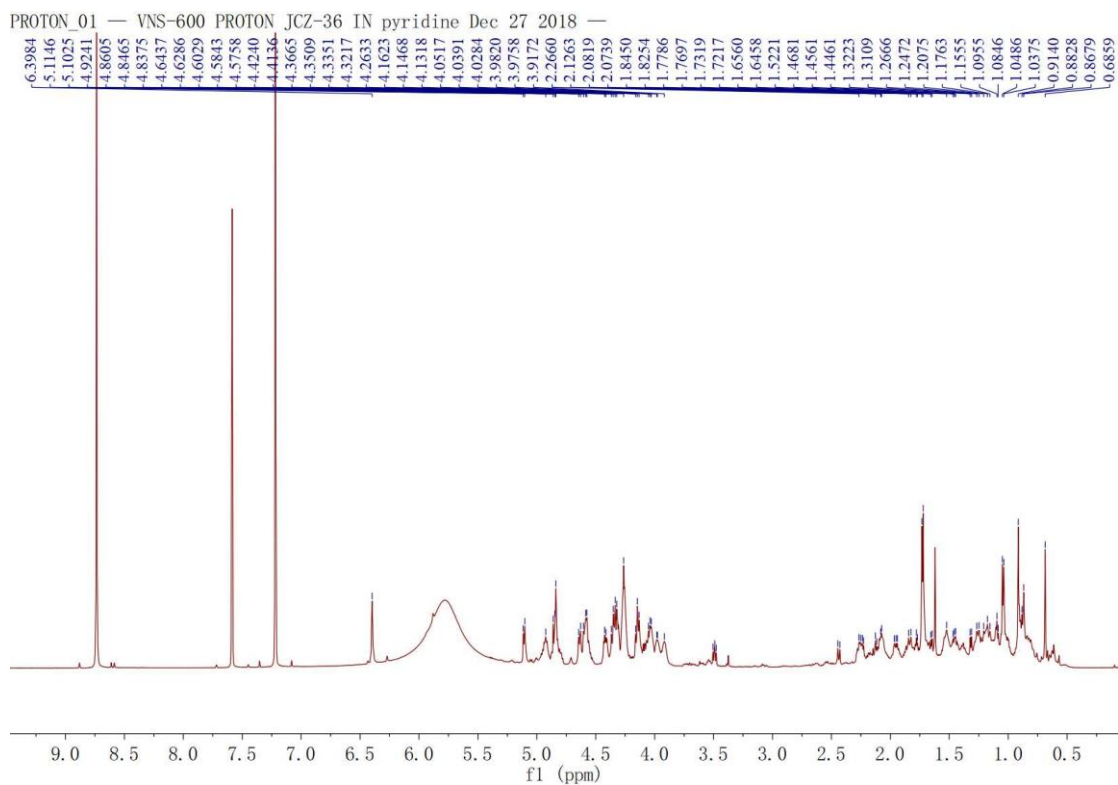




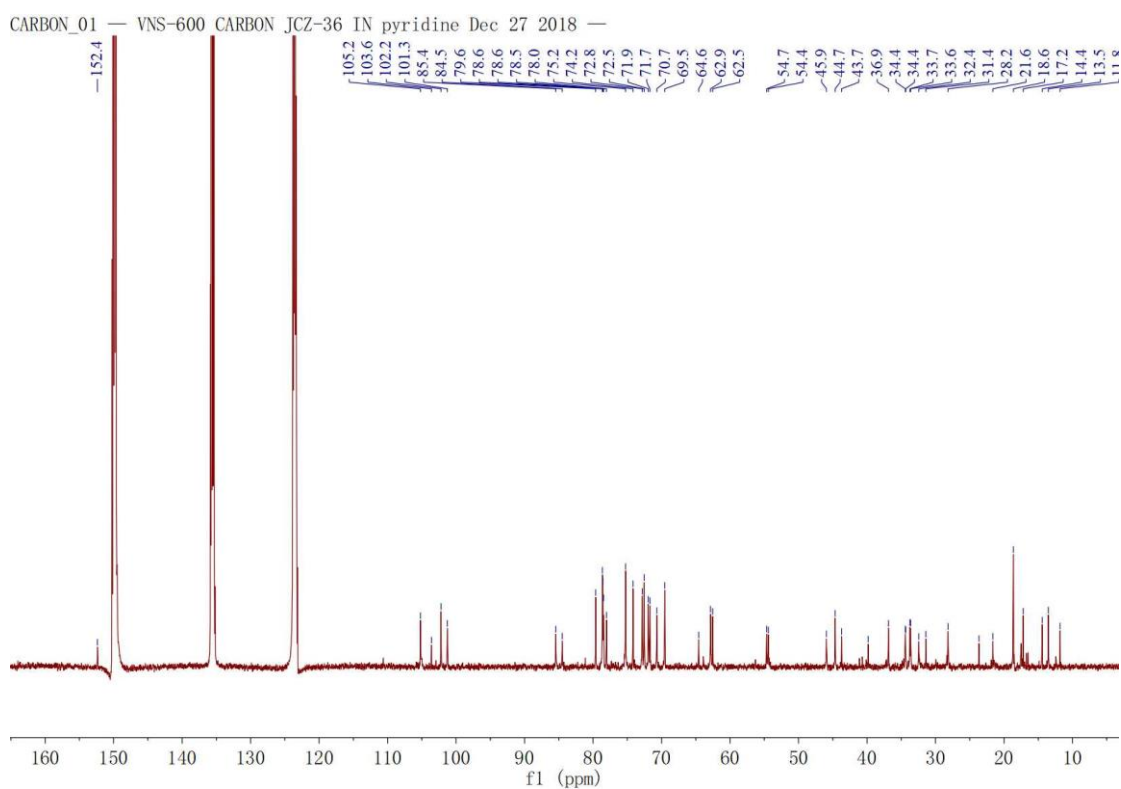
^1H NMR spectrum of **14**



^{13}C NMR spectrum of **14**.

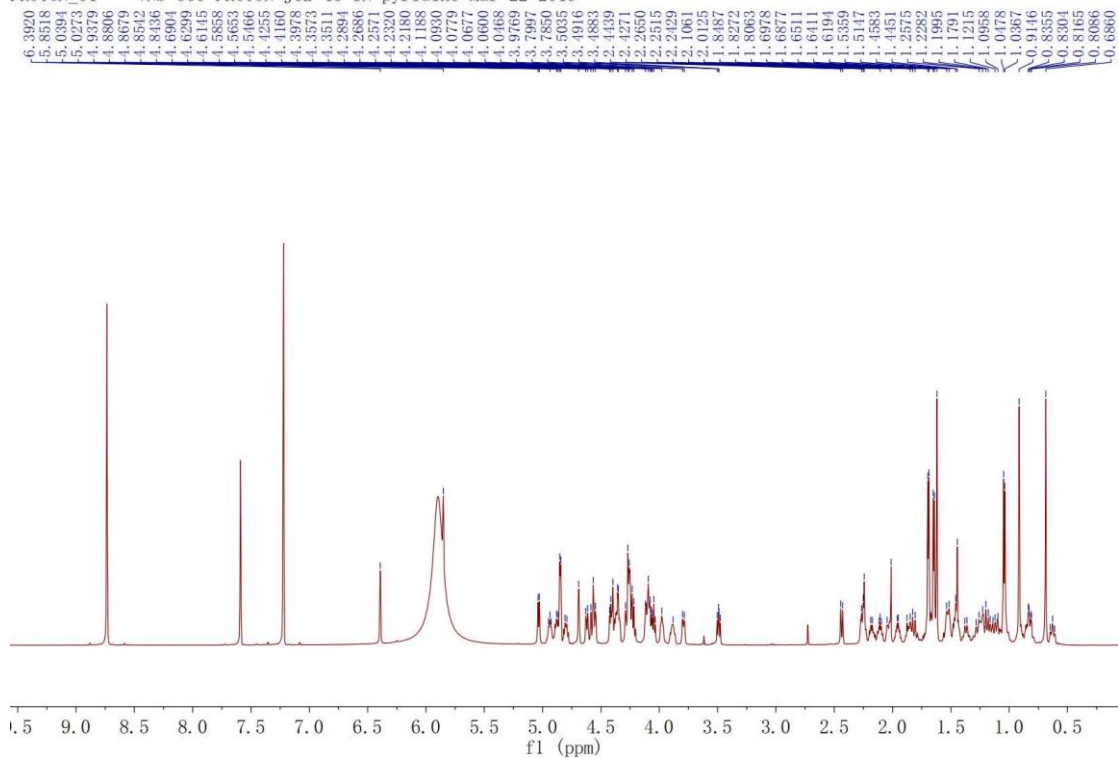


¹H NMR spectrum of 15.

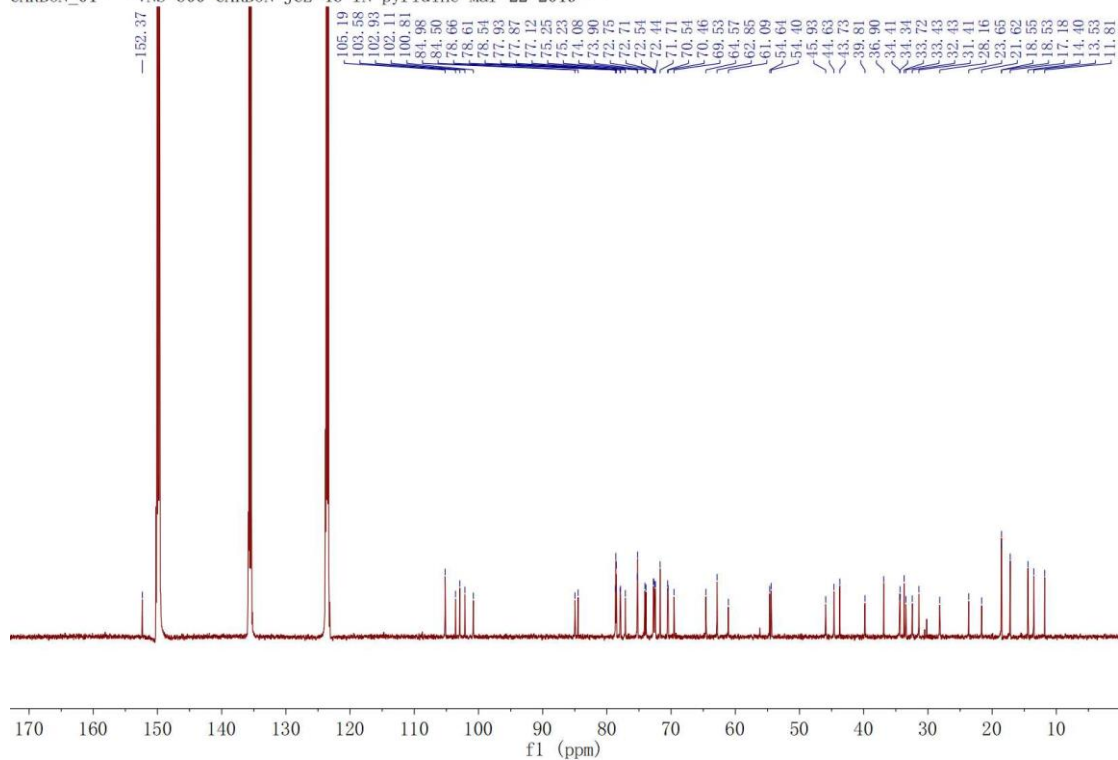


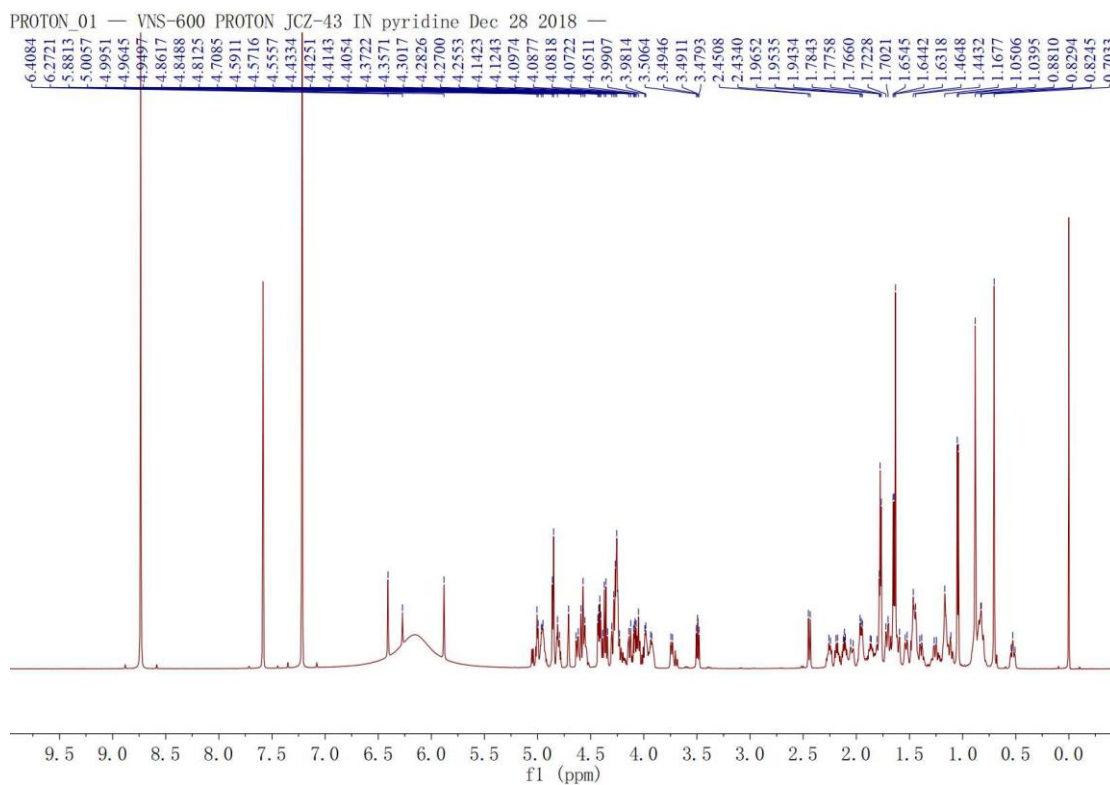
¹³C NMR spectrum of 15.

PROTON_01 — VNS-600 PROTON JCZ-46 IN pyridine Mar 22 2019 —

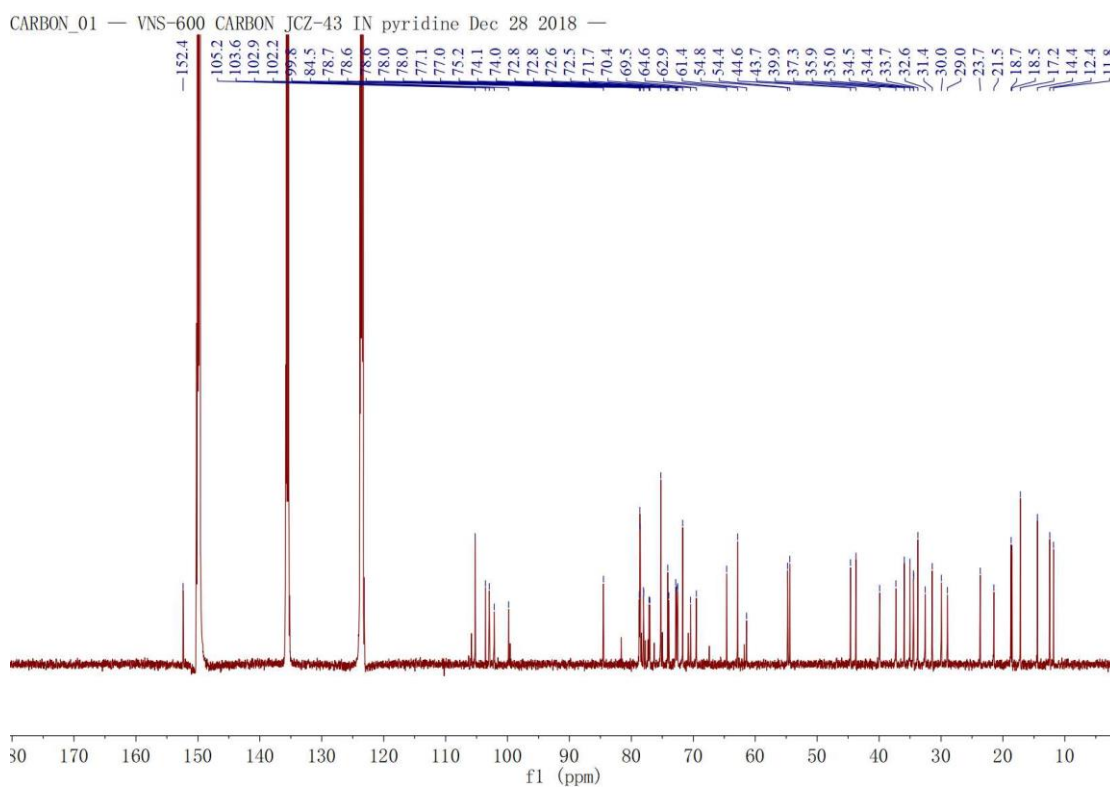
¹H NMR spectrum of 16.

CARBON_01 — VNS-600 CARBON JCZ-46 IN pyridine Mar 22 2019 —

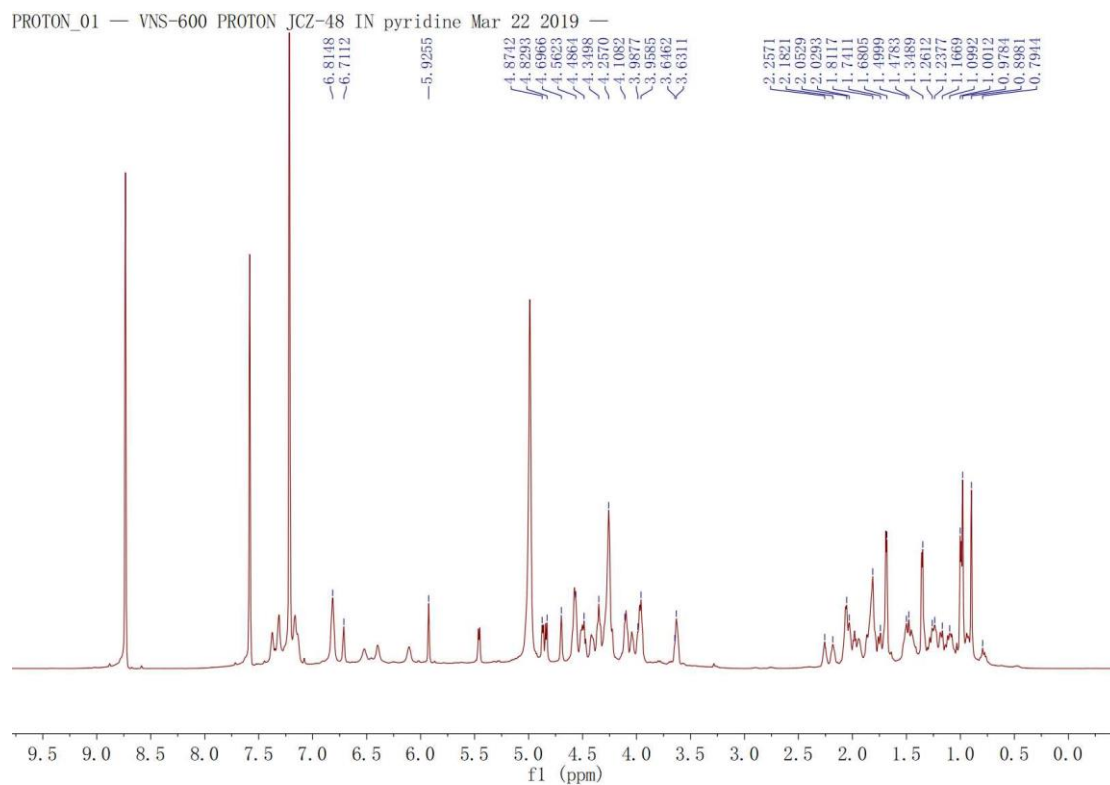
¹³C NMR spectrum of 16.



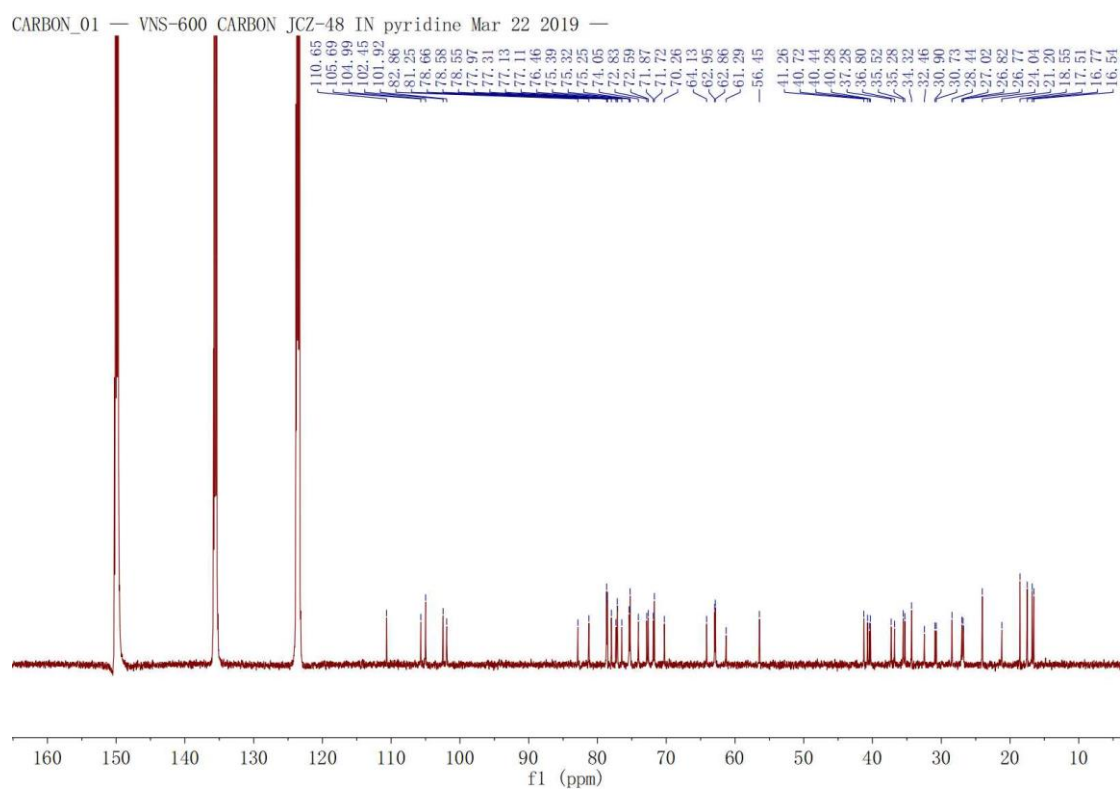
¹H NMR spectrum of 17.



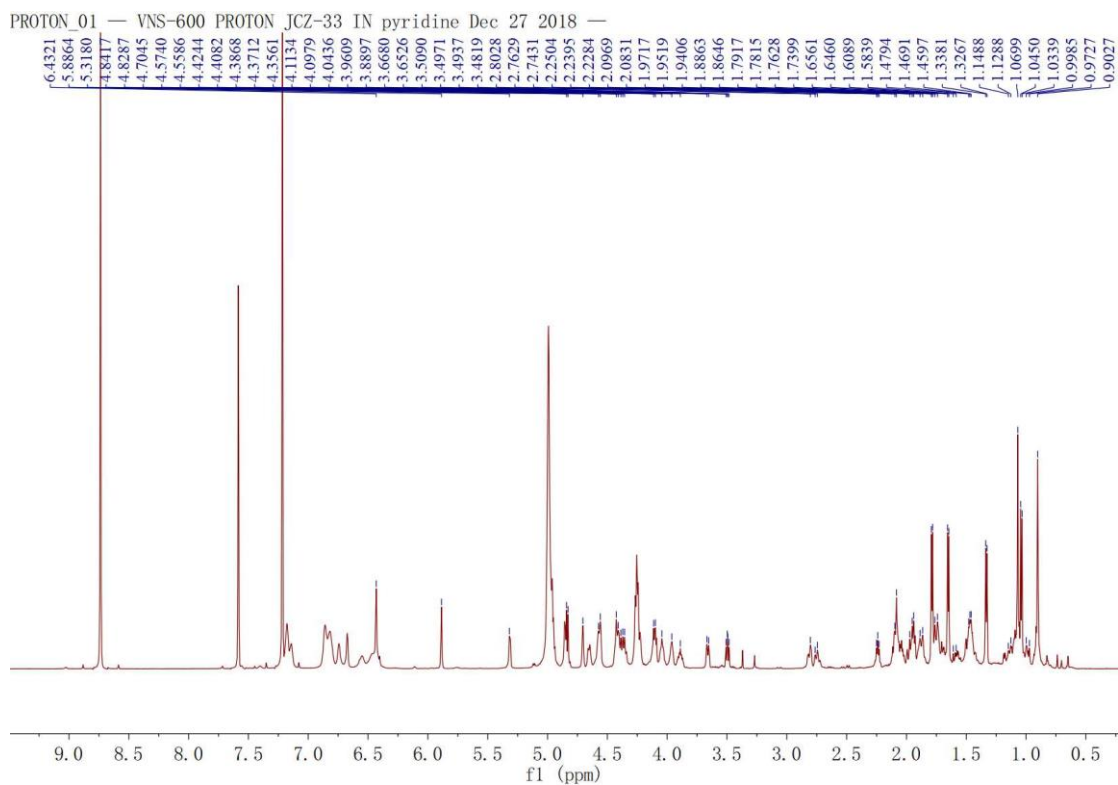
¹³C NMR spectrum of 17.



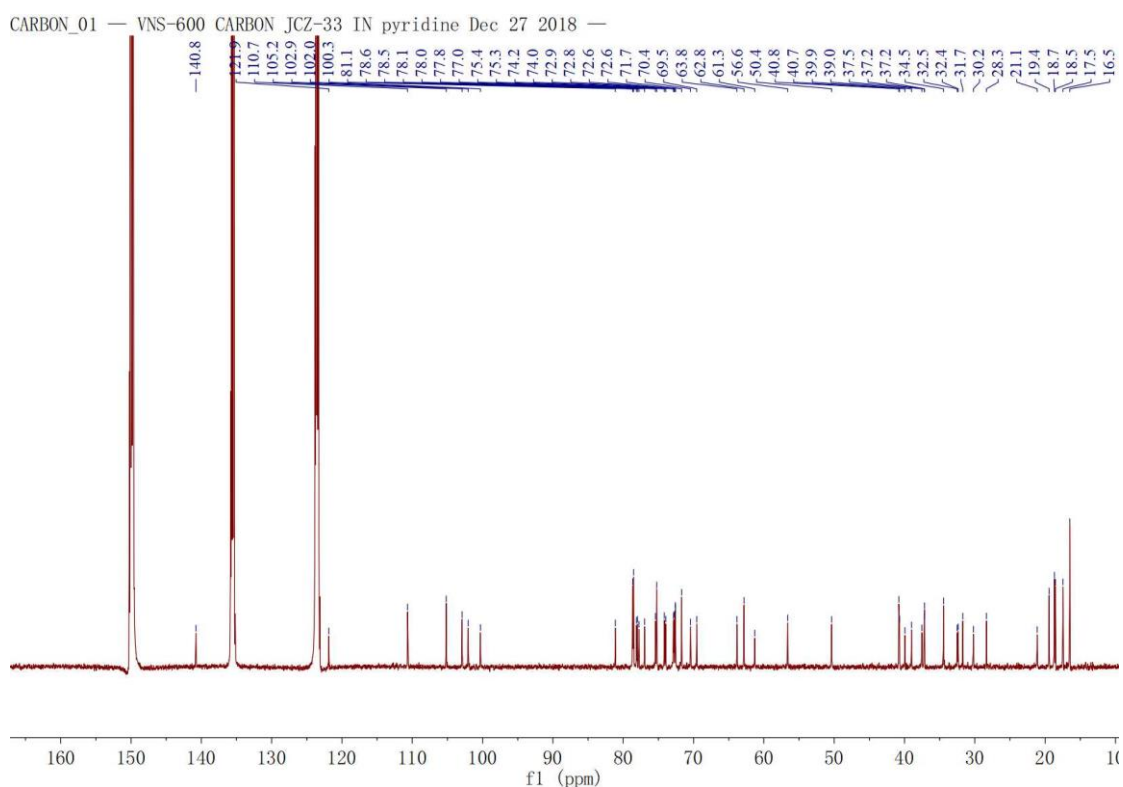
¹H NMR spectrum of 18.



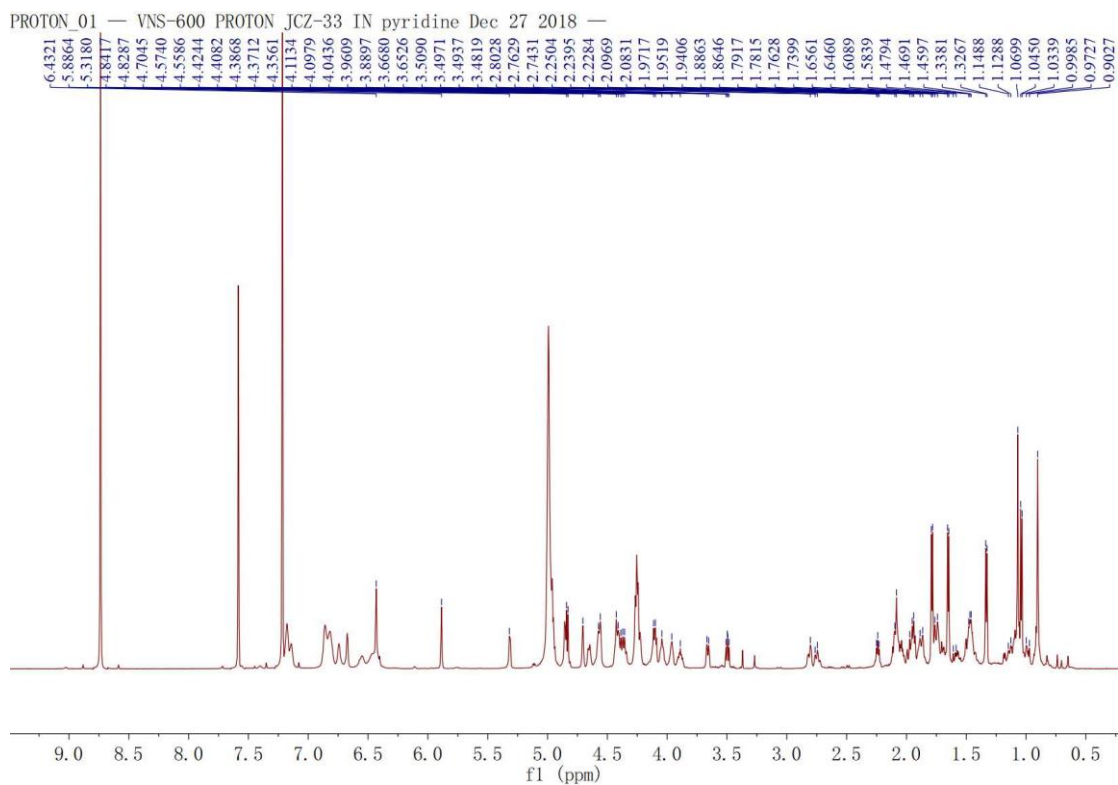
¹³C NMR spectrum of 18.



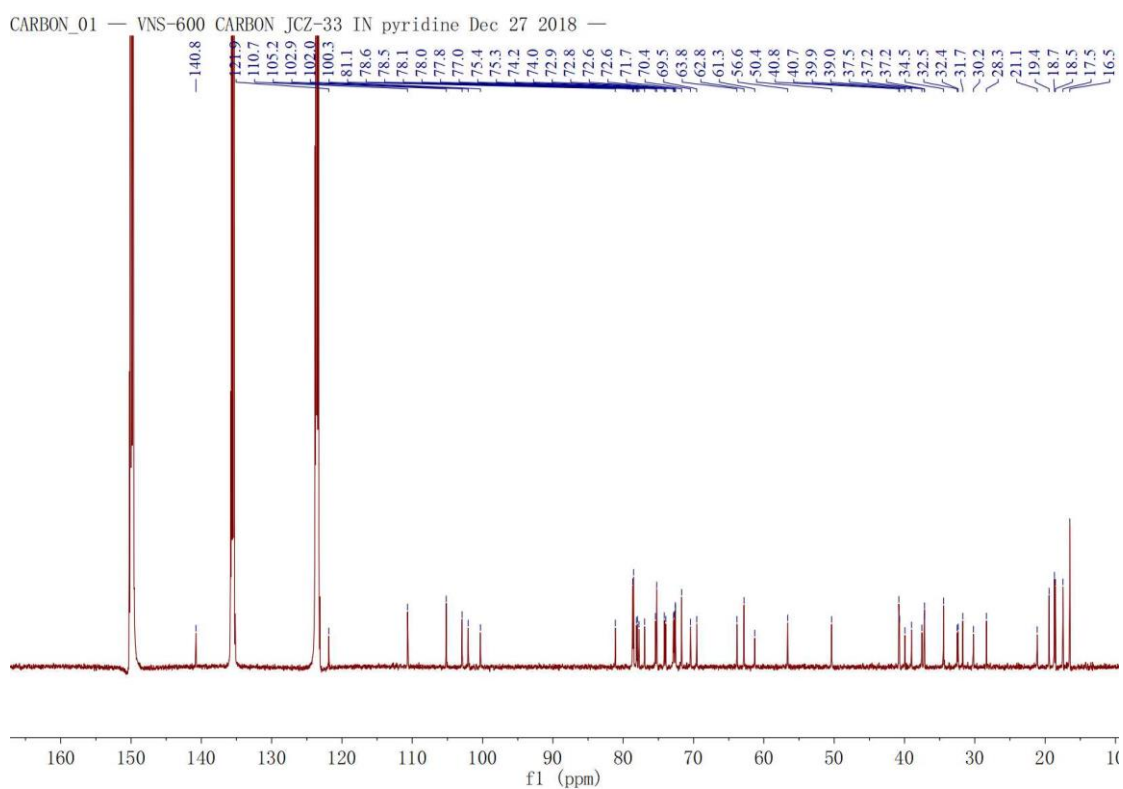
¹H NMR spectrum of 19.



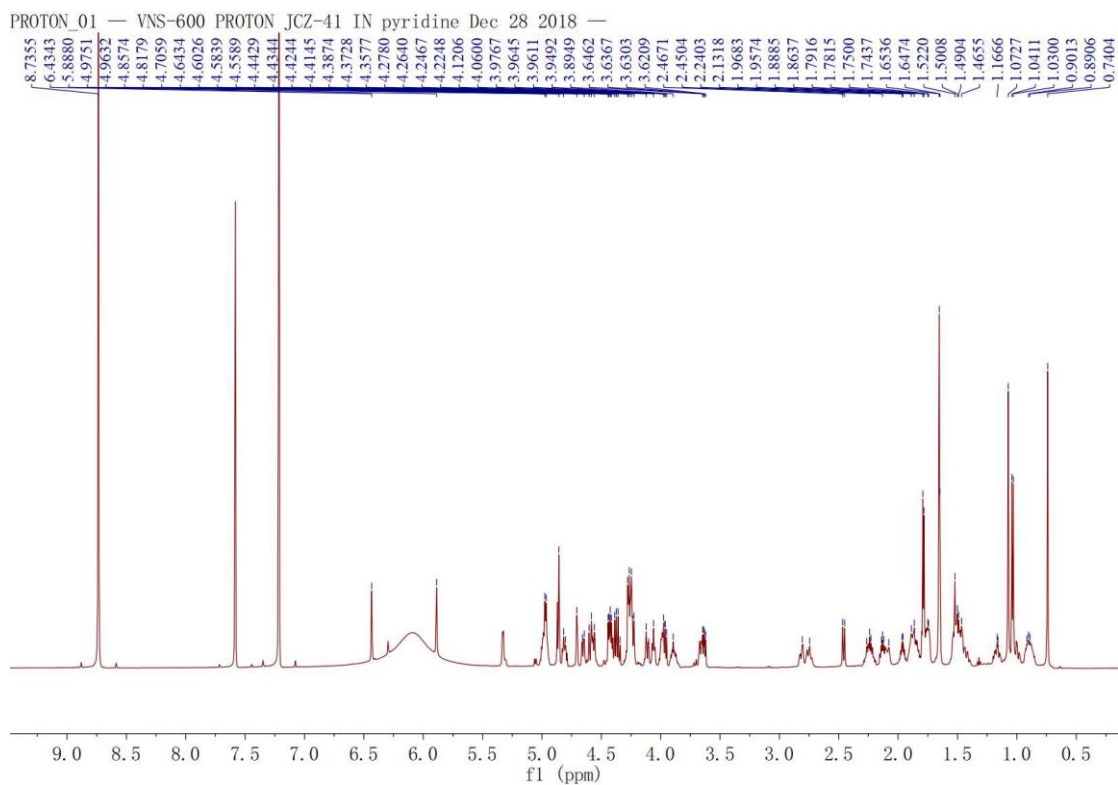
¹³C NMR spectrum of 19.



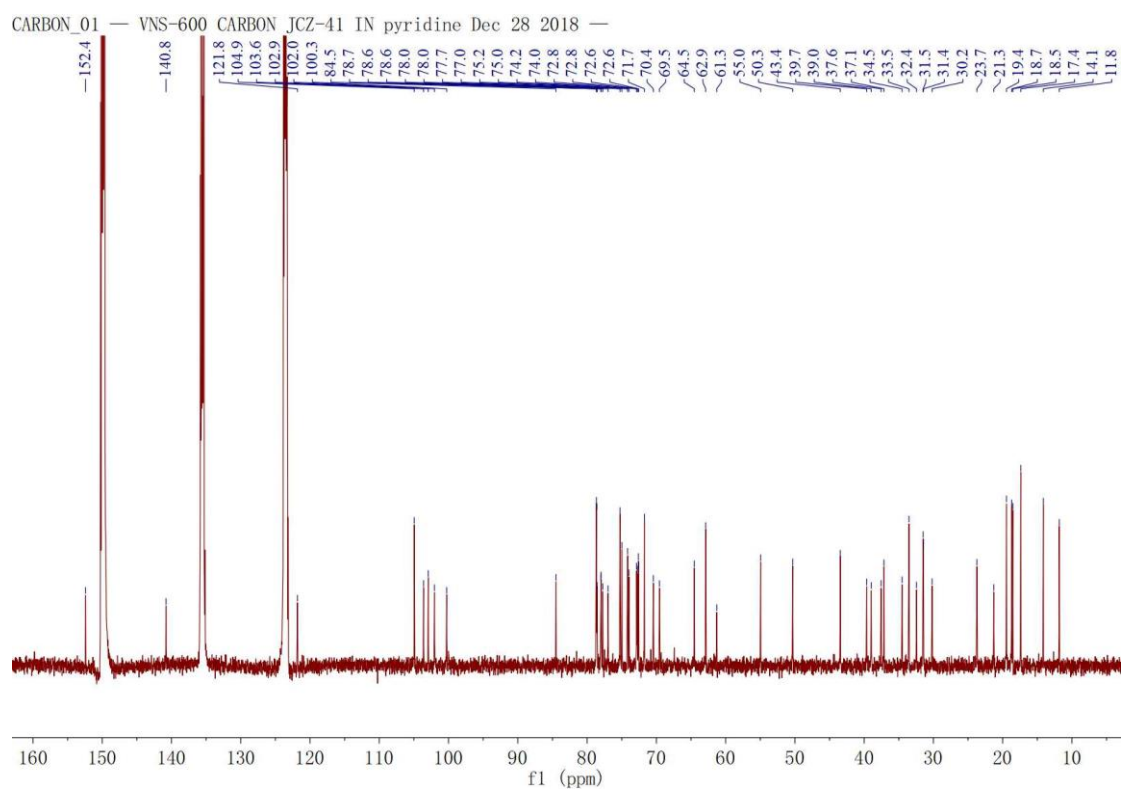
¹H NMR spectrum of 20.



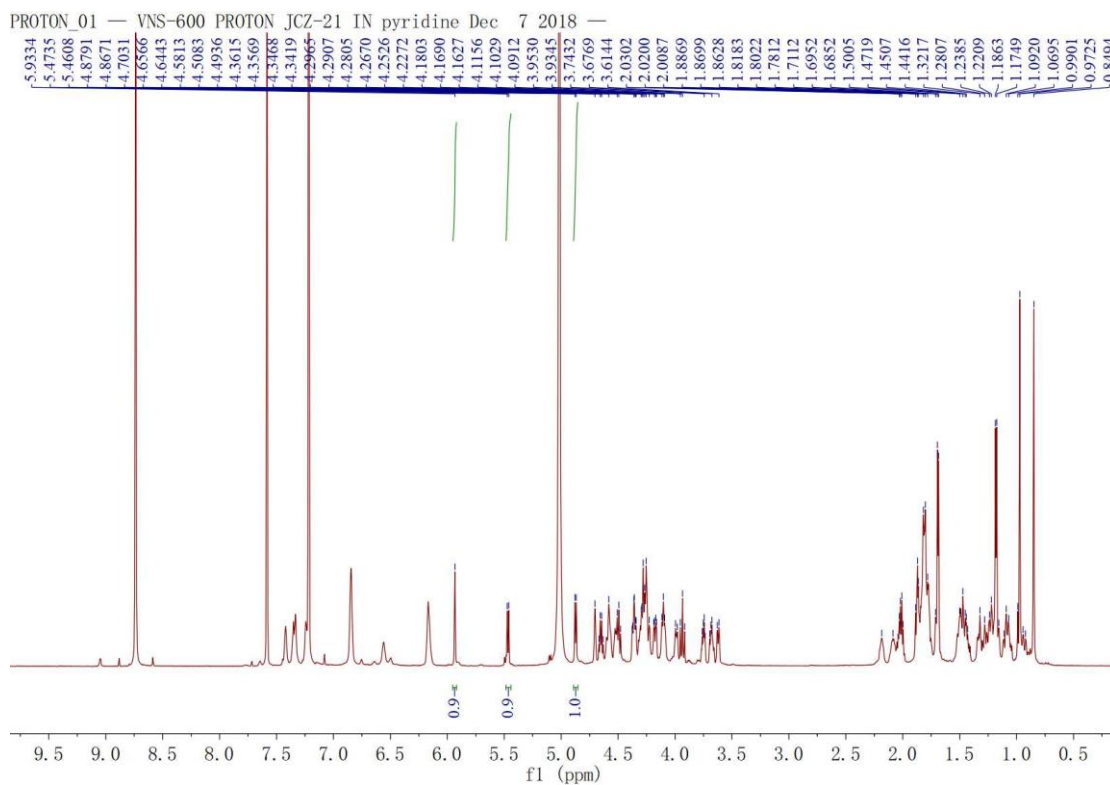
¹³C NMR spectrum of 20.



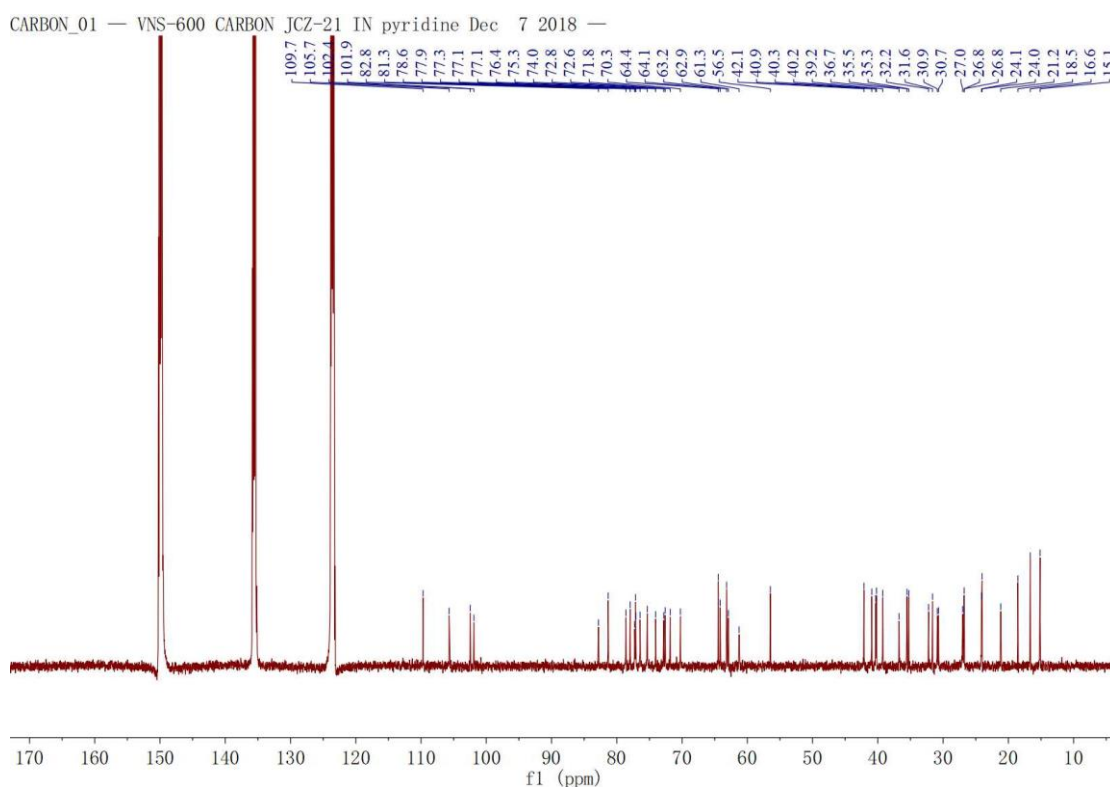
¹H NMR spectrum of 21.



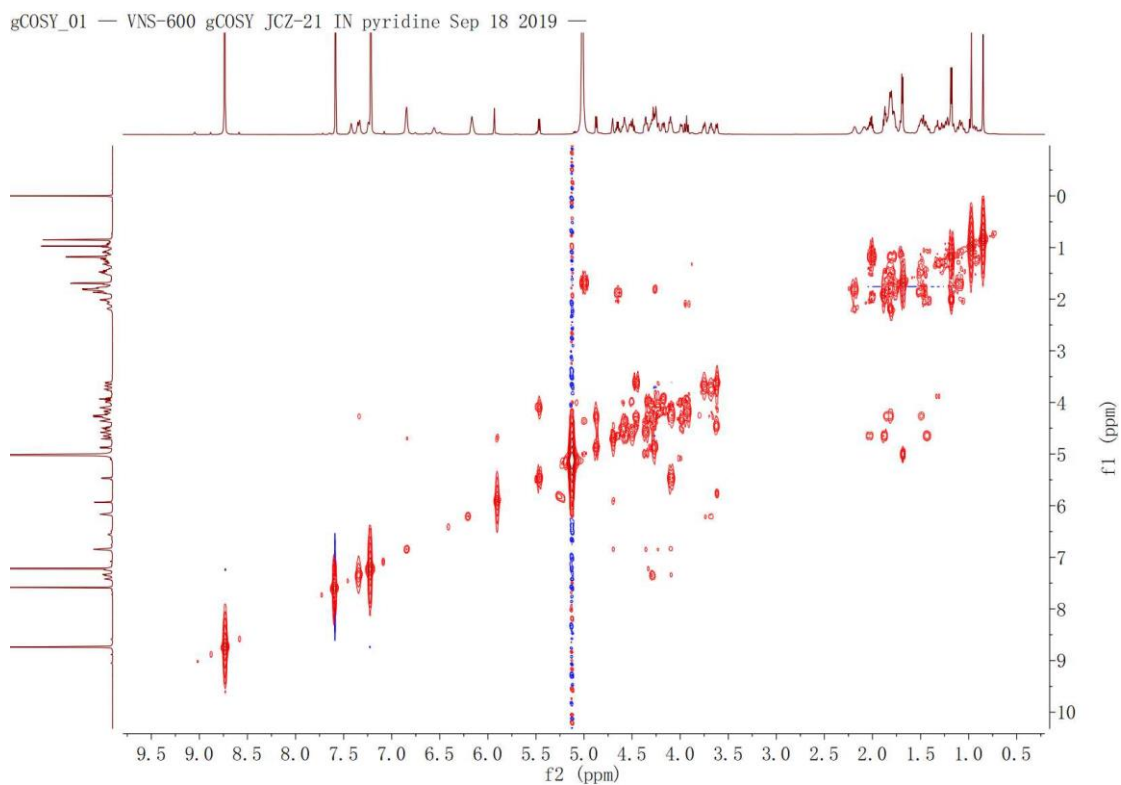
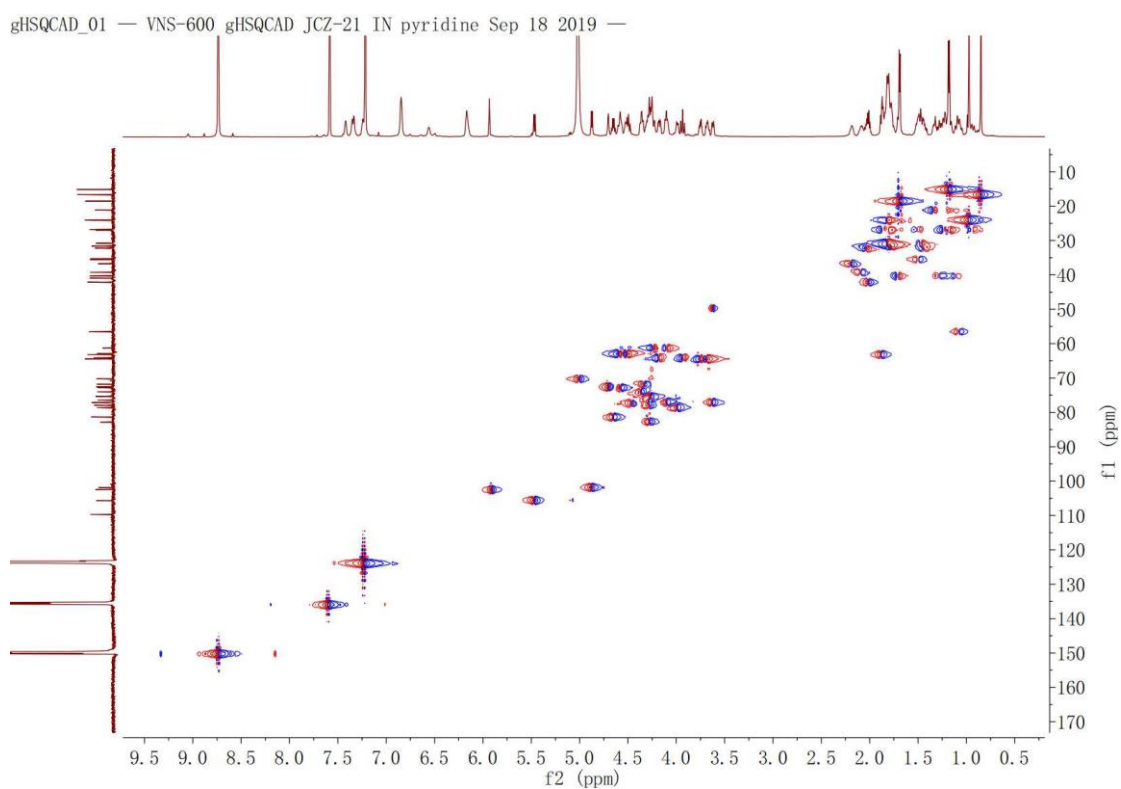
¹³C NMR spectrum of 21.

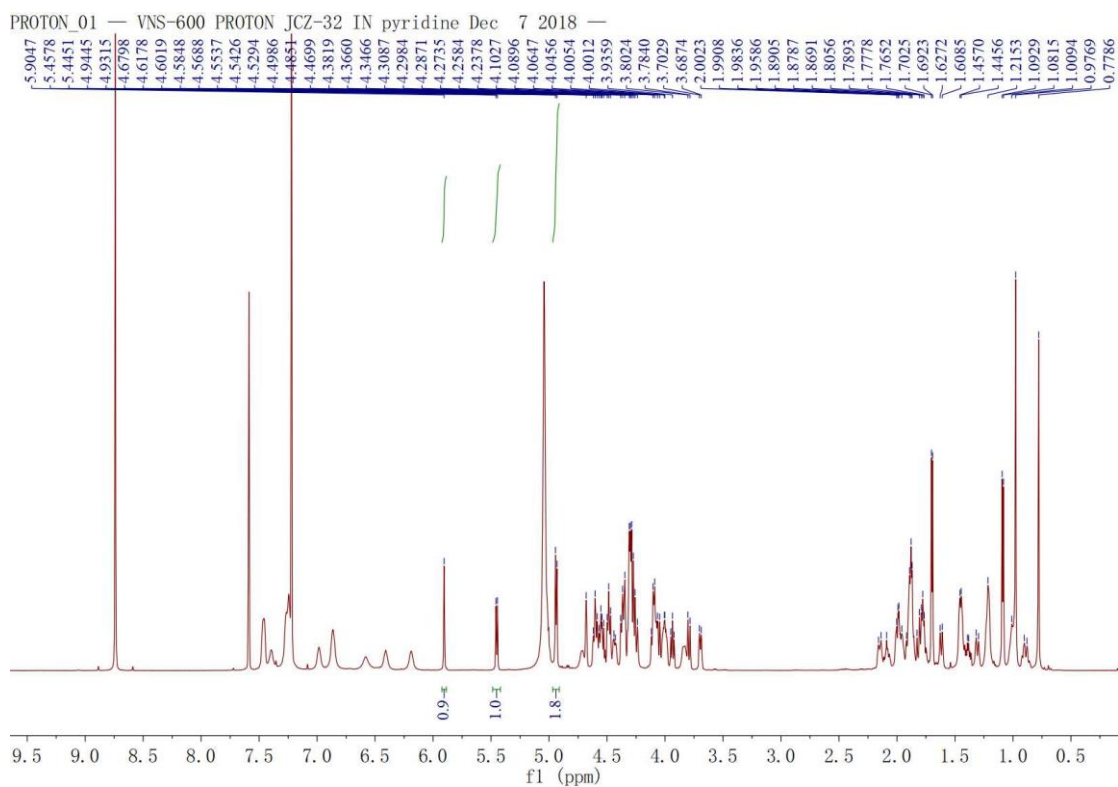
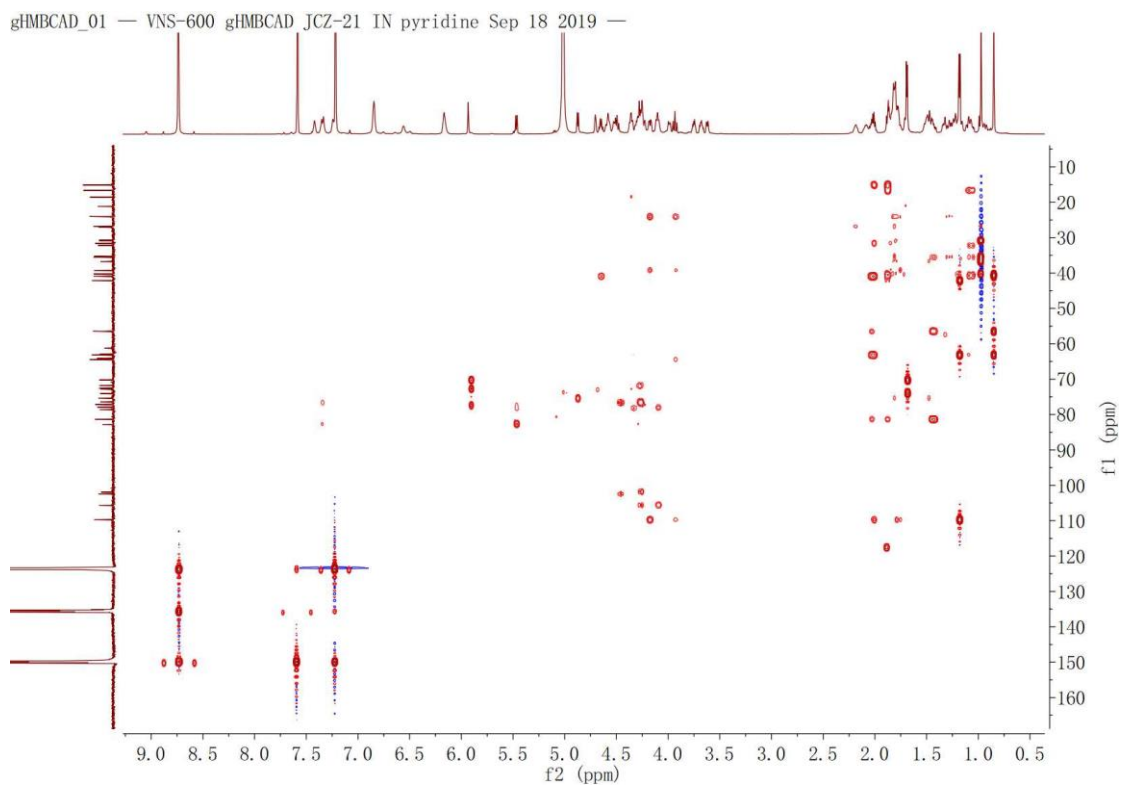


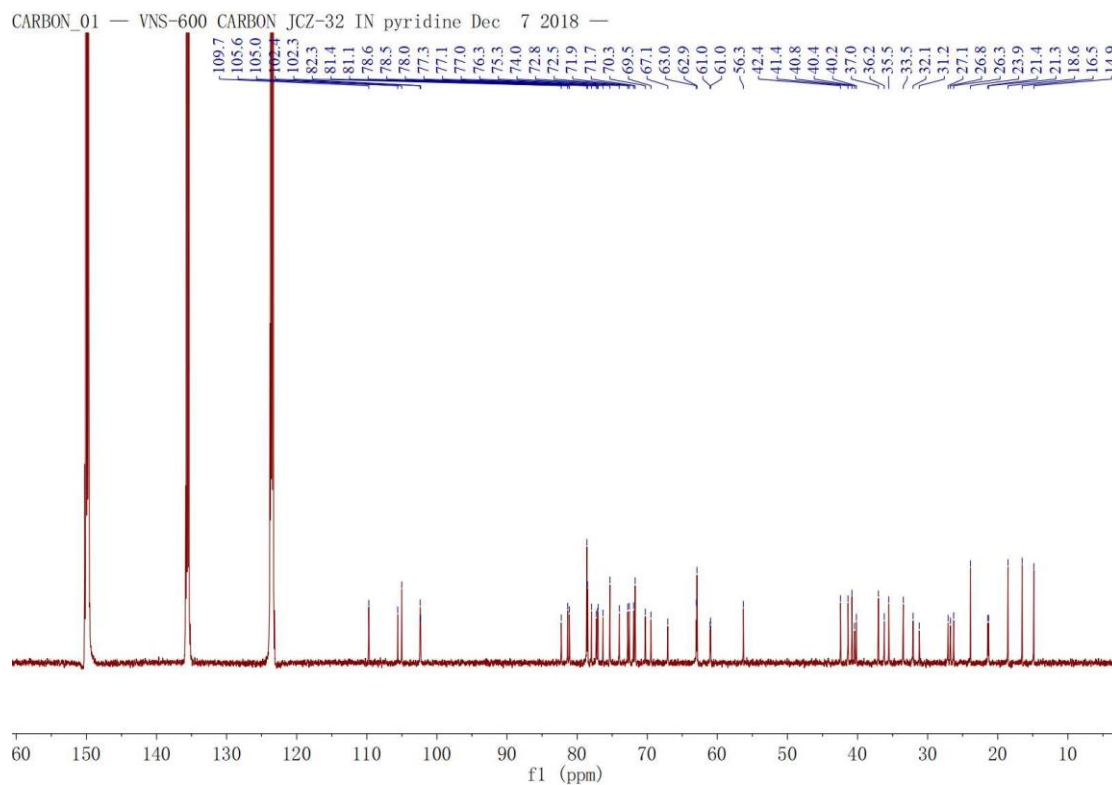
¹H NMR spectrum of 22.



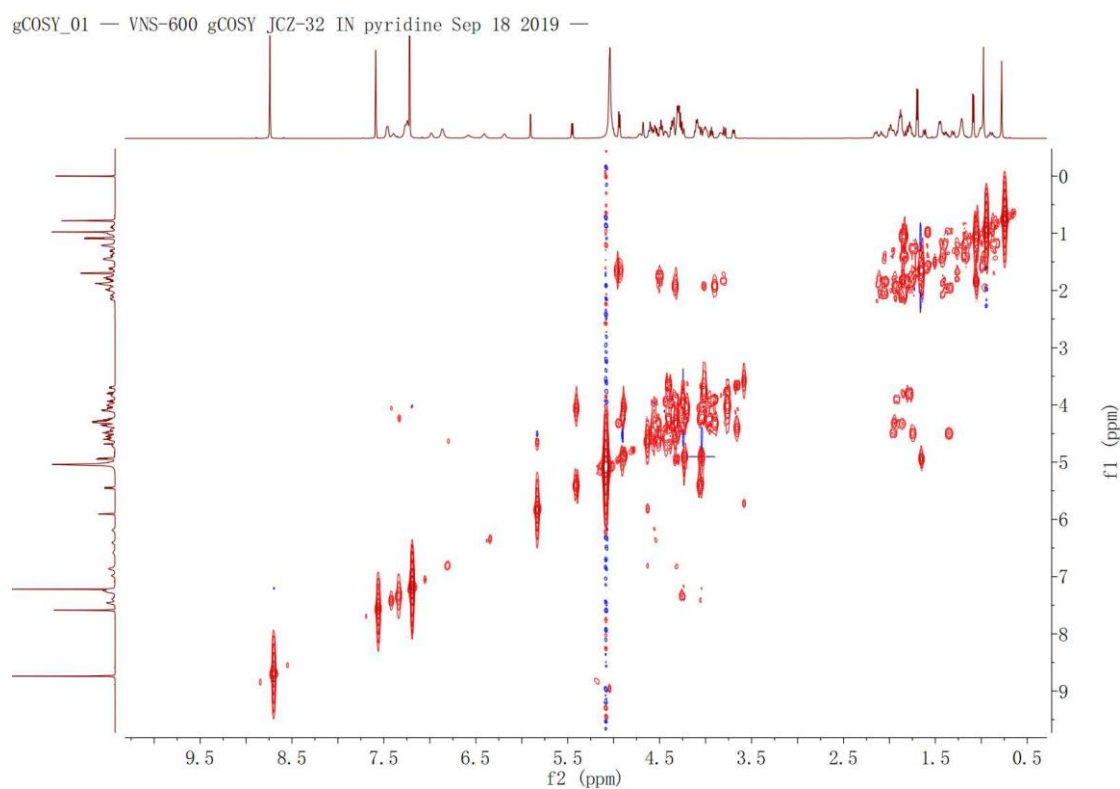
¹³C NMR spectrum of 22.

 **^1H - ^1H COSY spectrum of 22.****HSQC spectrum of 22.**

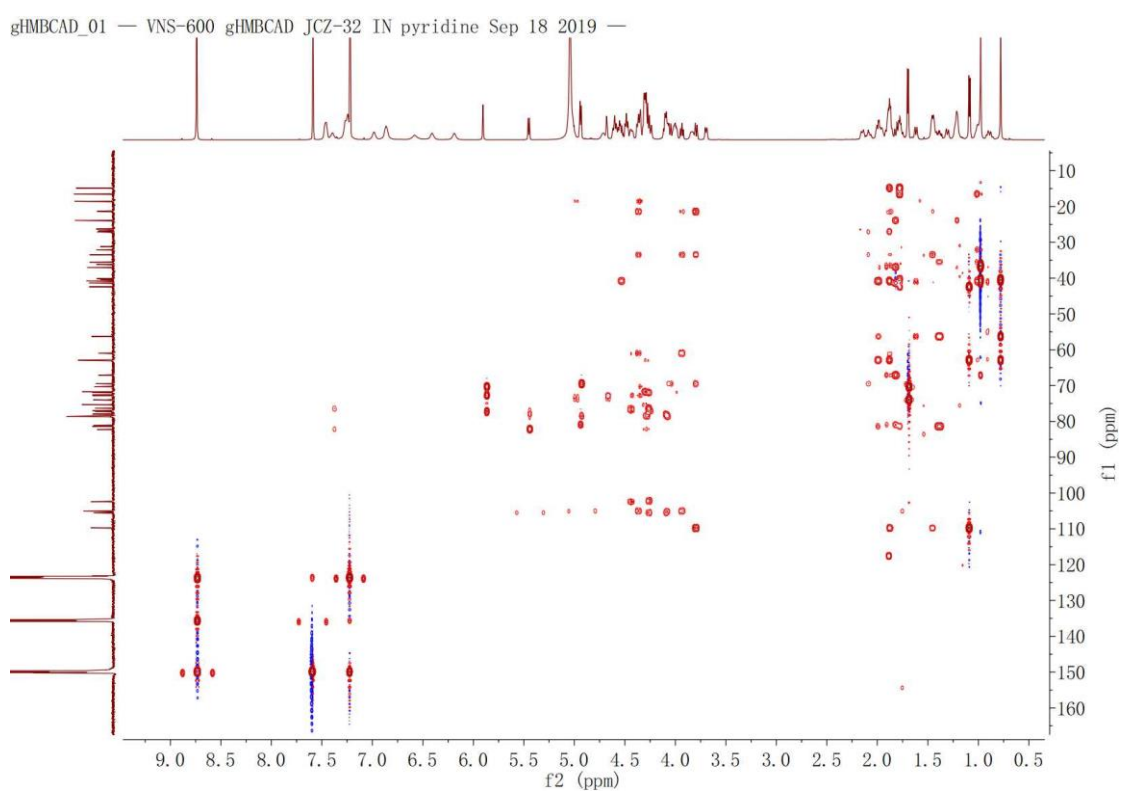
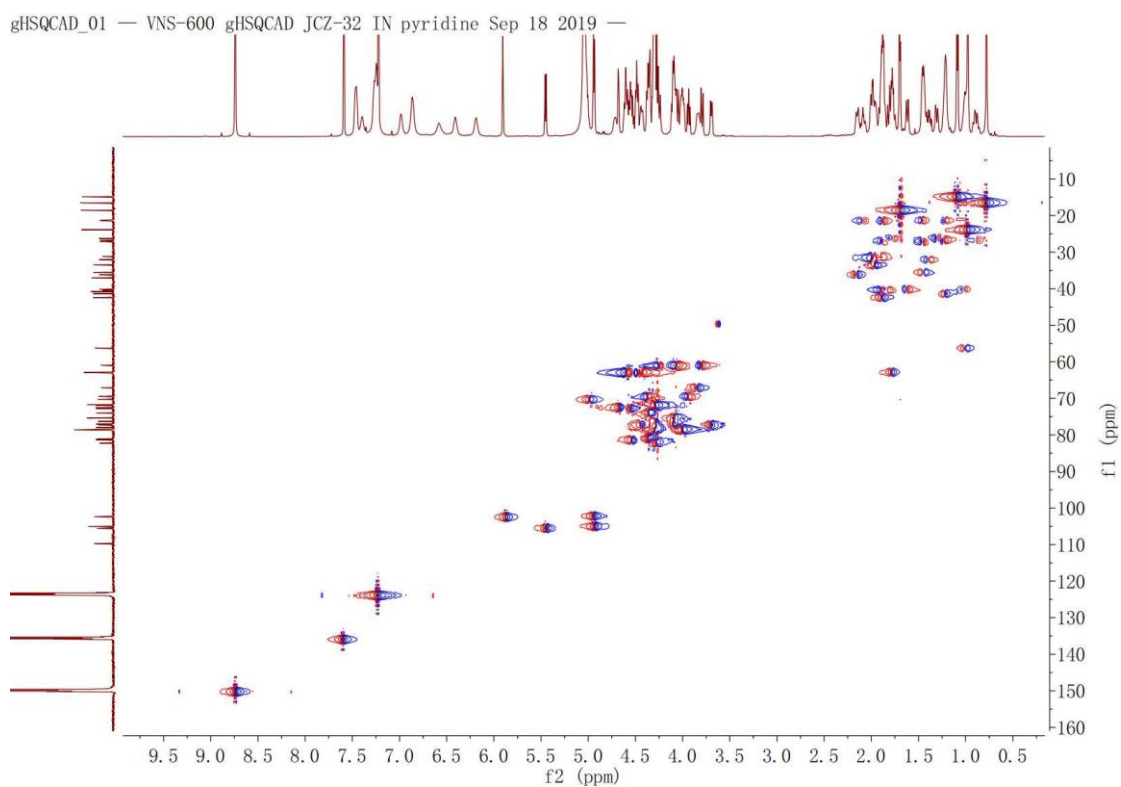


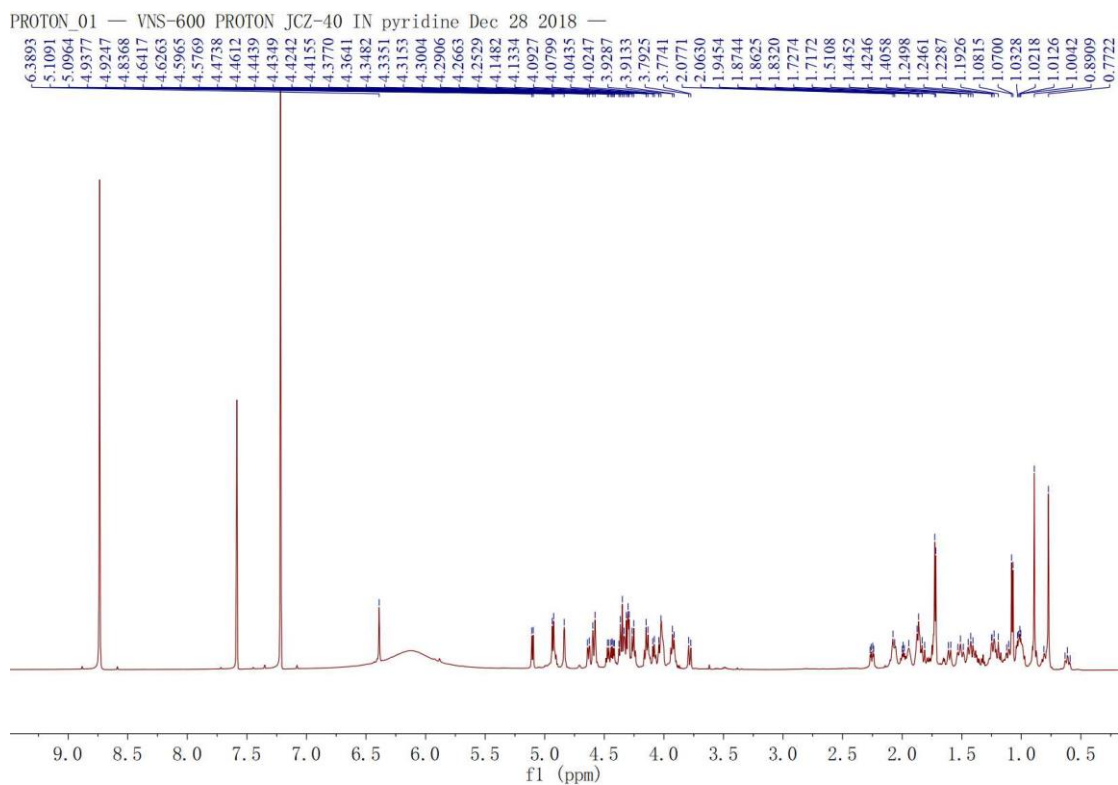


^{13}C NMR spectrum of 23.

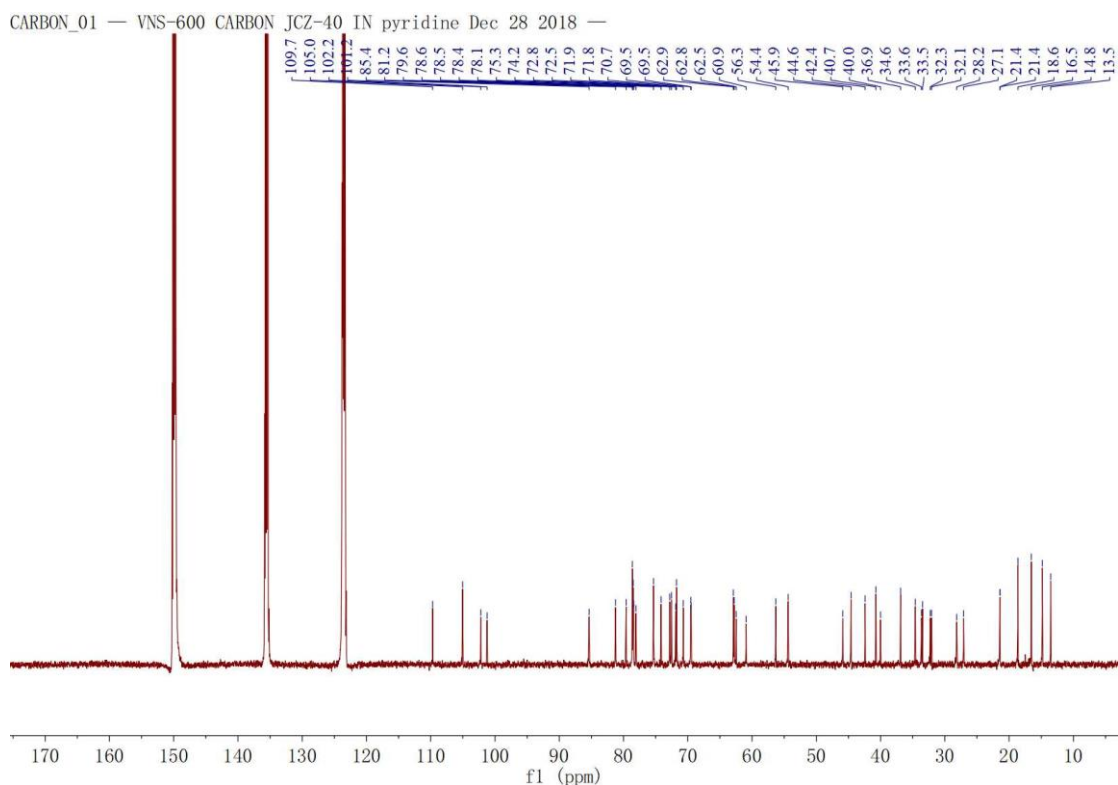


^1H - ^1H COSY spectrum of 23.



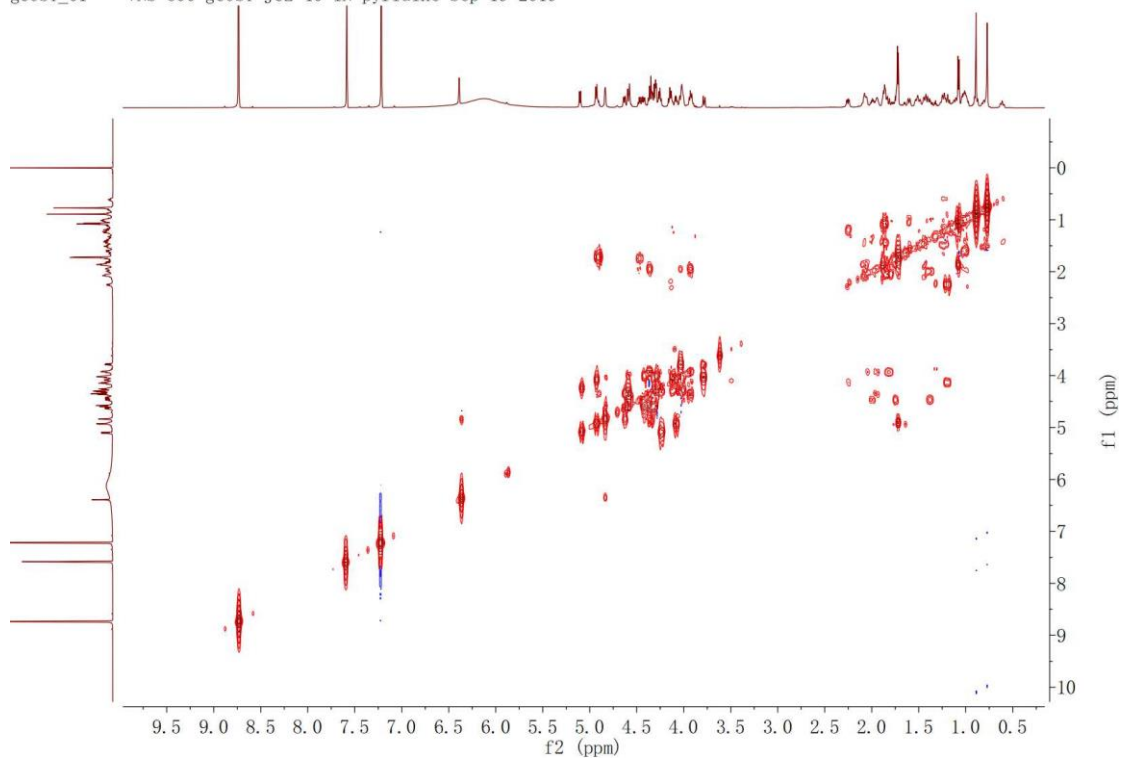


¹H NMR spectrum of 24.

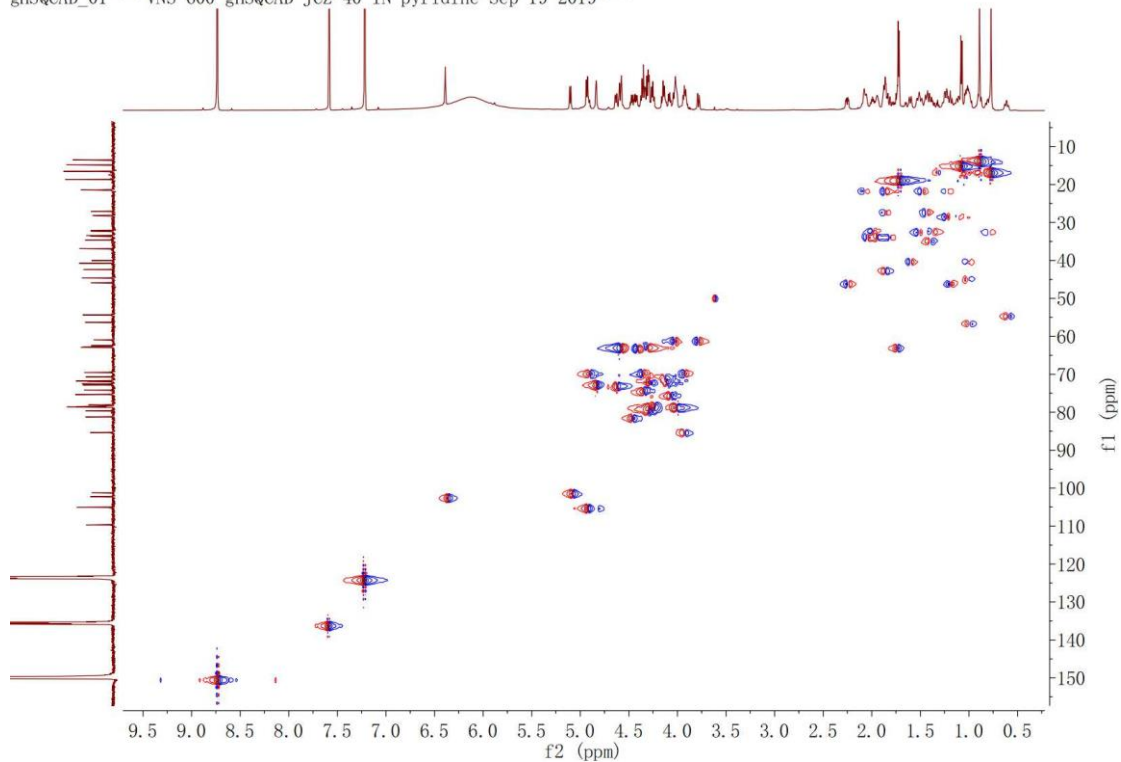


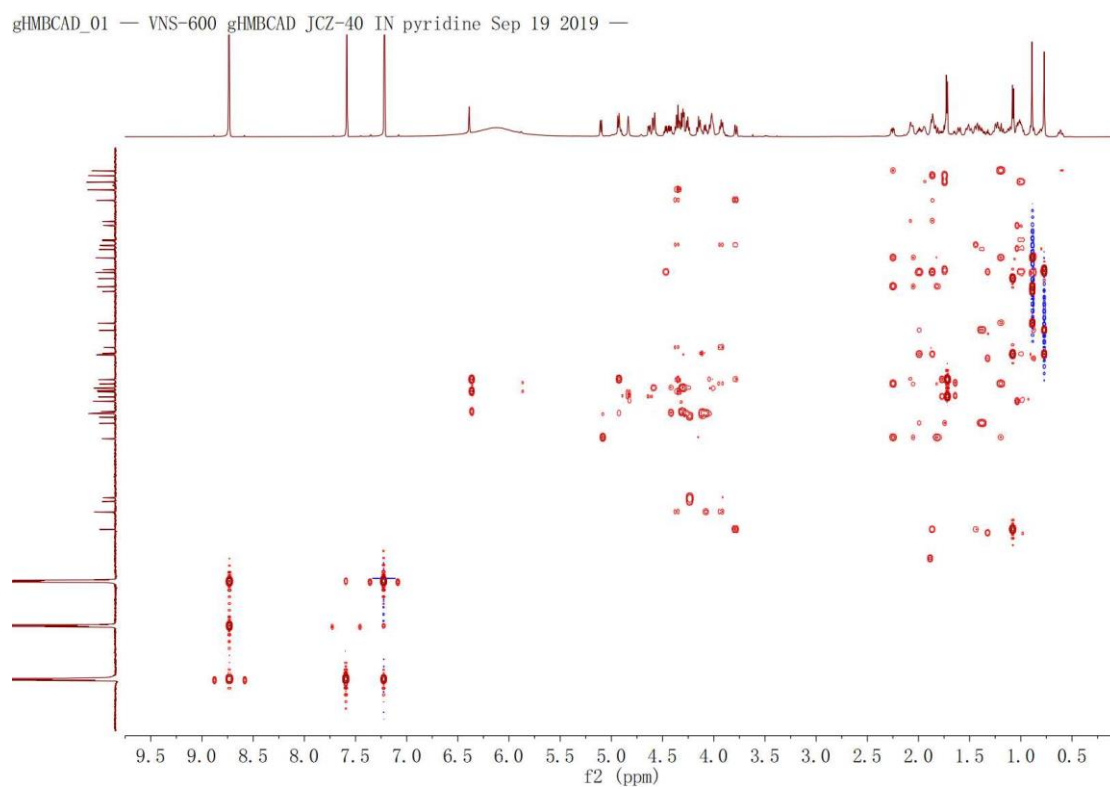
¹³C NMR spectrum of 24.

gCOSY_01 — VNS-600 gCOSY JCZ-40 IN pyridine Sep 19 2019 —

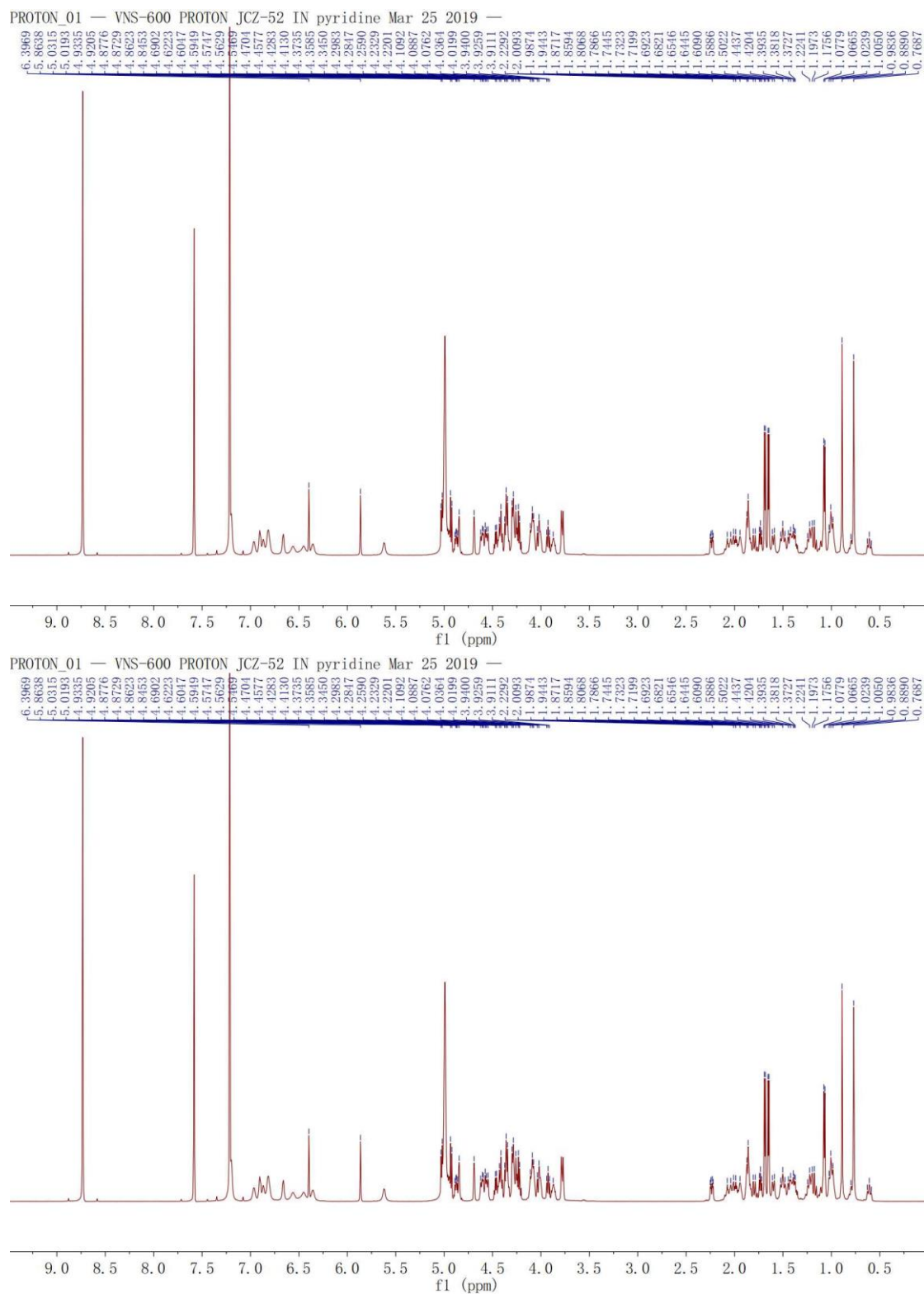
 **^1H - ^1H COSY spectrum of 24.**

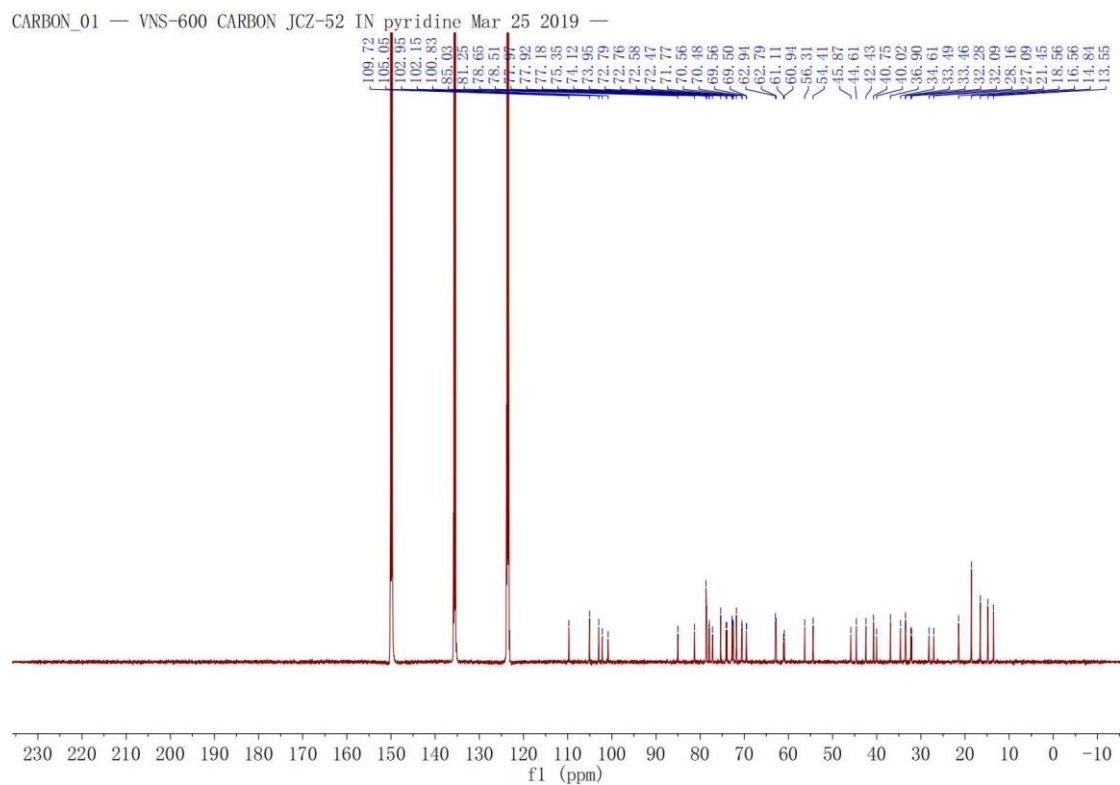
gHSQCAD_01 — VNS-600 gHSQCAD JCZ-40 IN pyridine Sep 19 2019 —

**HSQC spectrum of 24.**

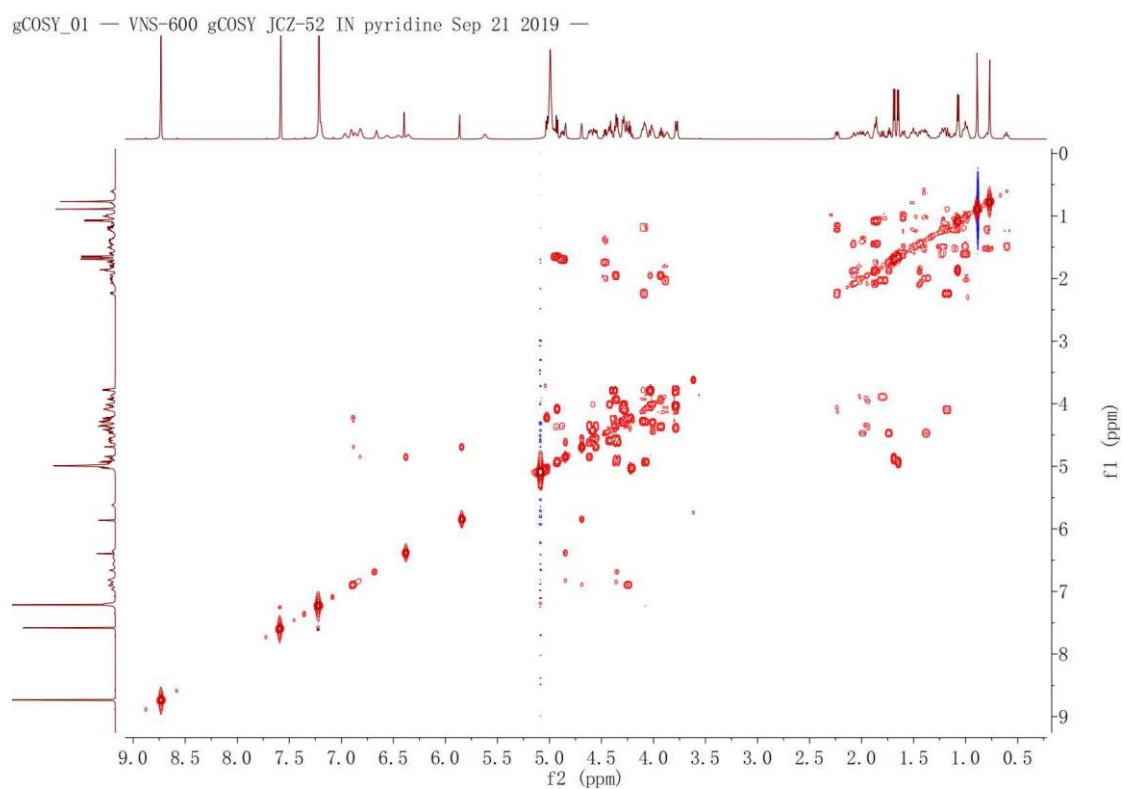


HMBC spectrum of 24.

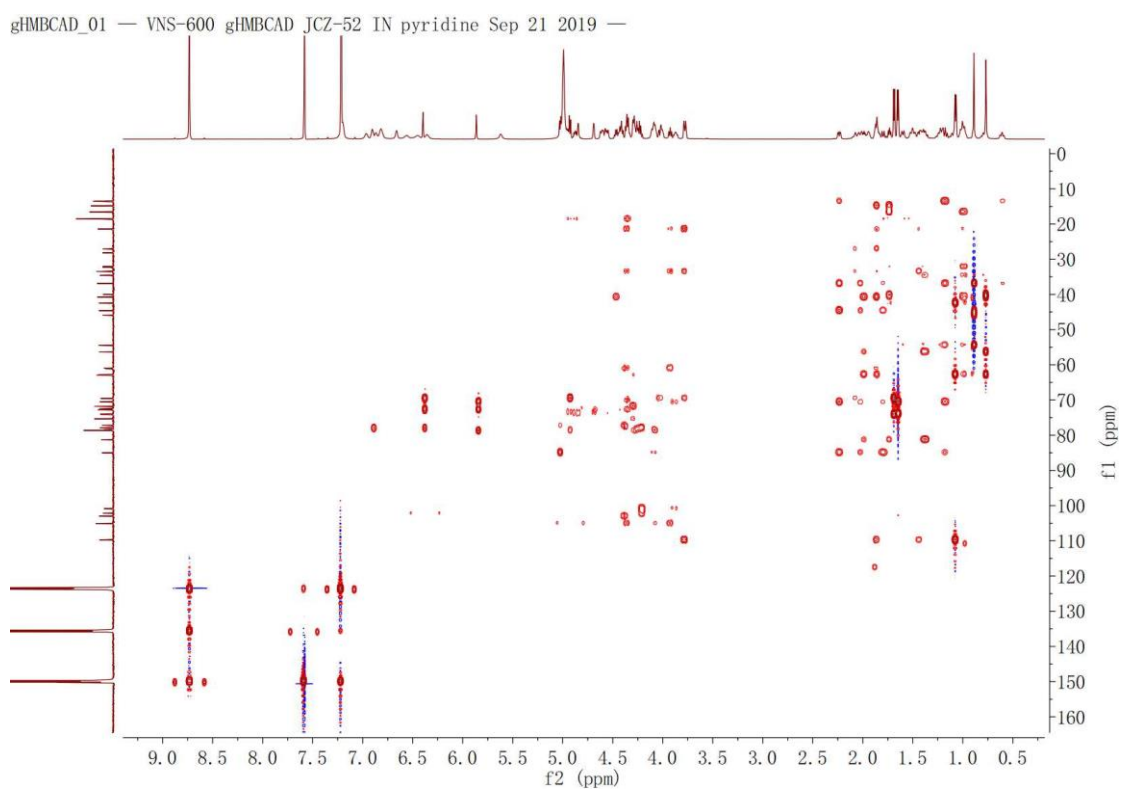
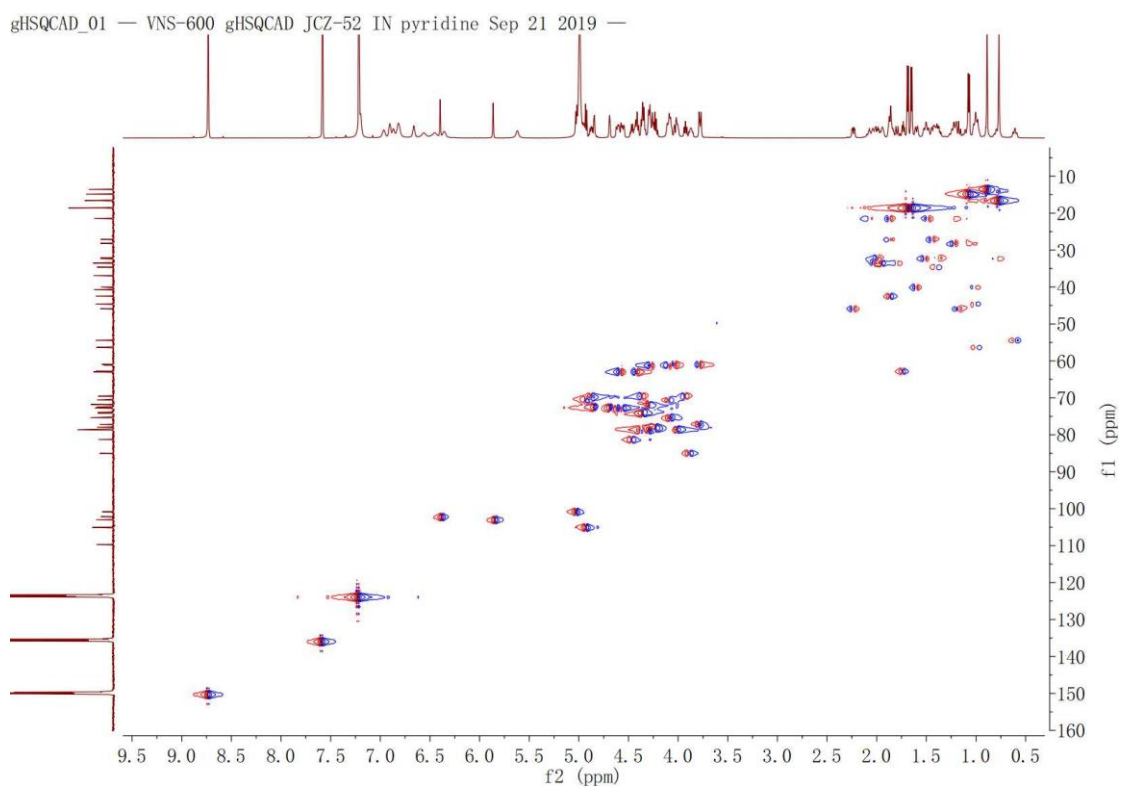
¹H NMR spectrum of 25.

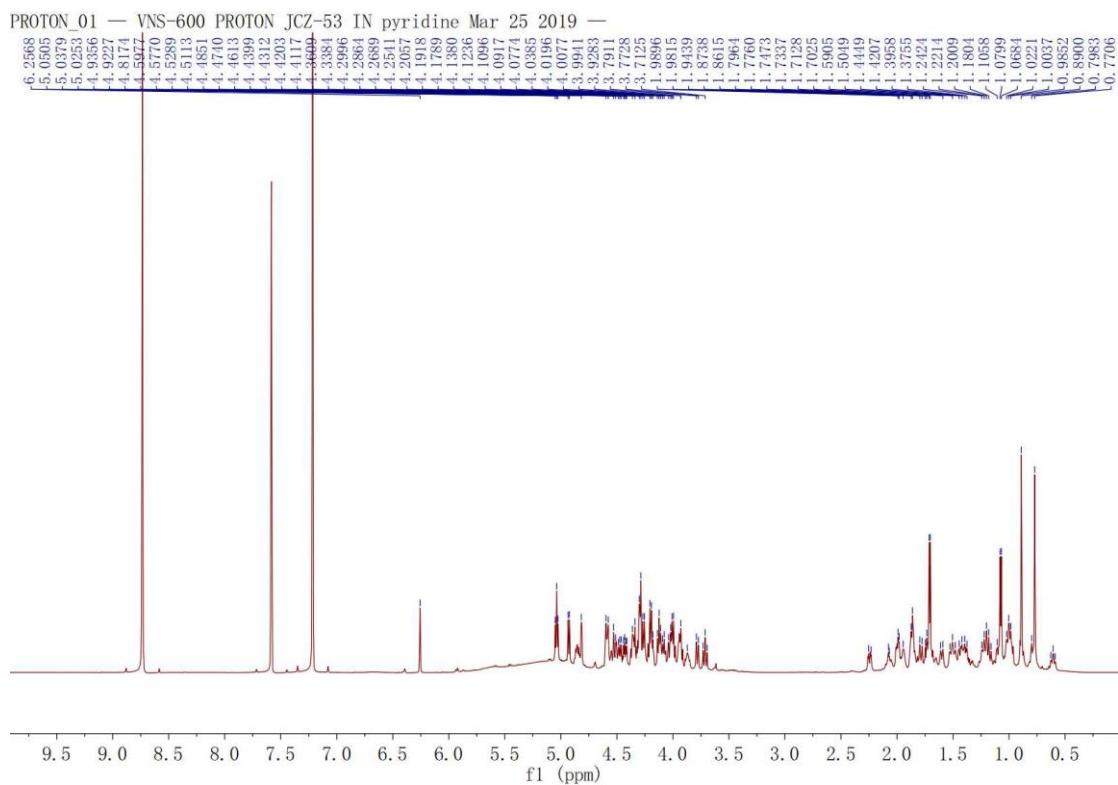


^{13}C NMR spectrum of 25.

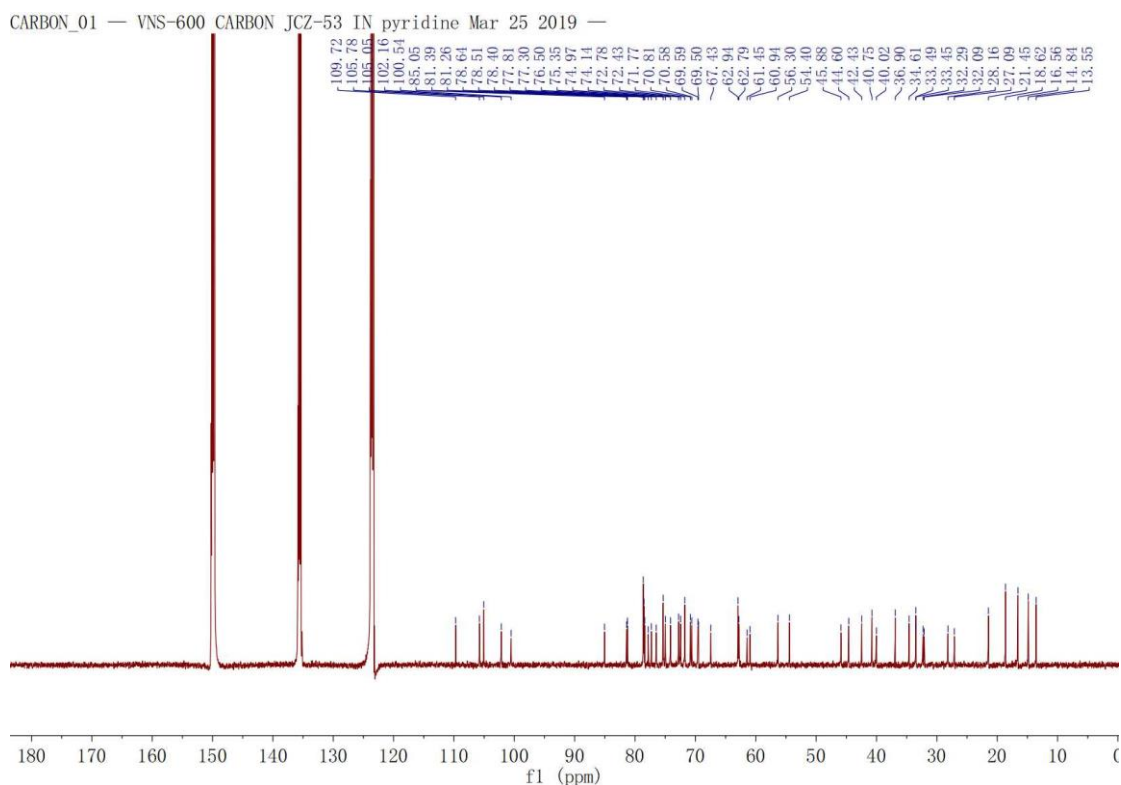


^1H - ^1H COSY spectrum of 25.



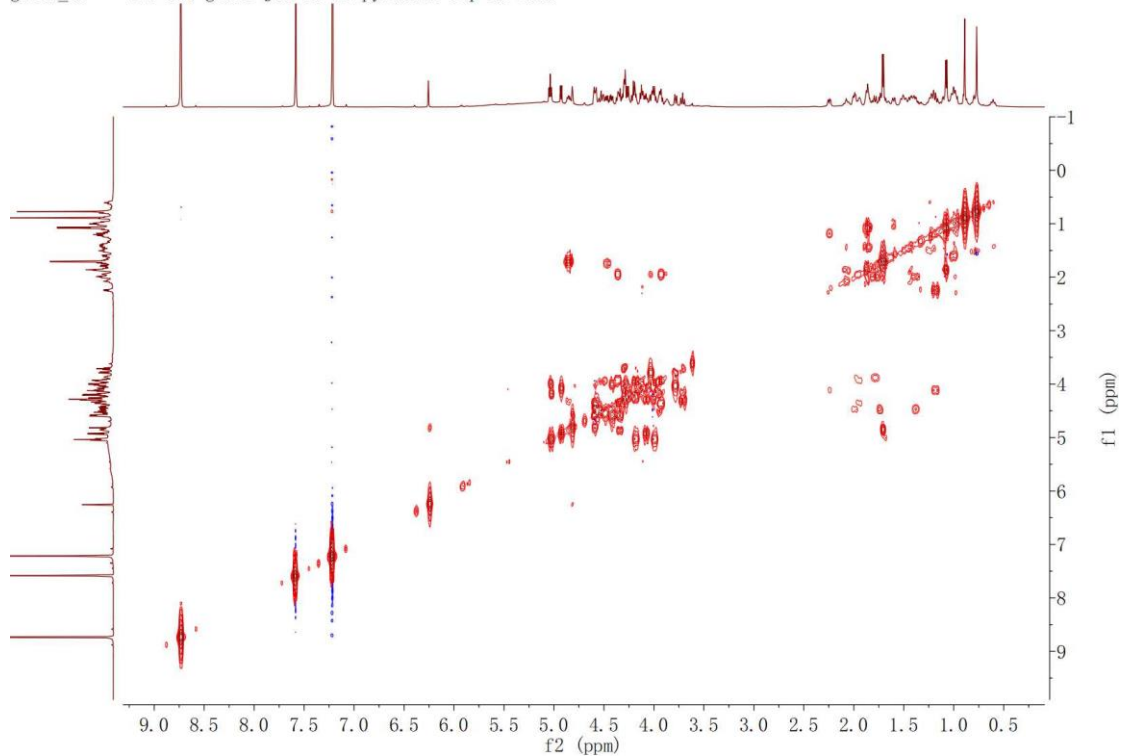


¹H NMR spectrum of 26.

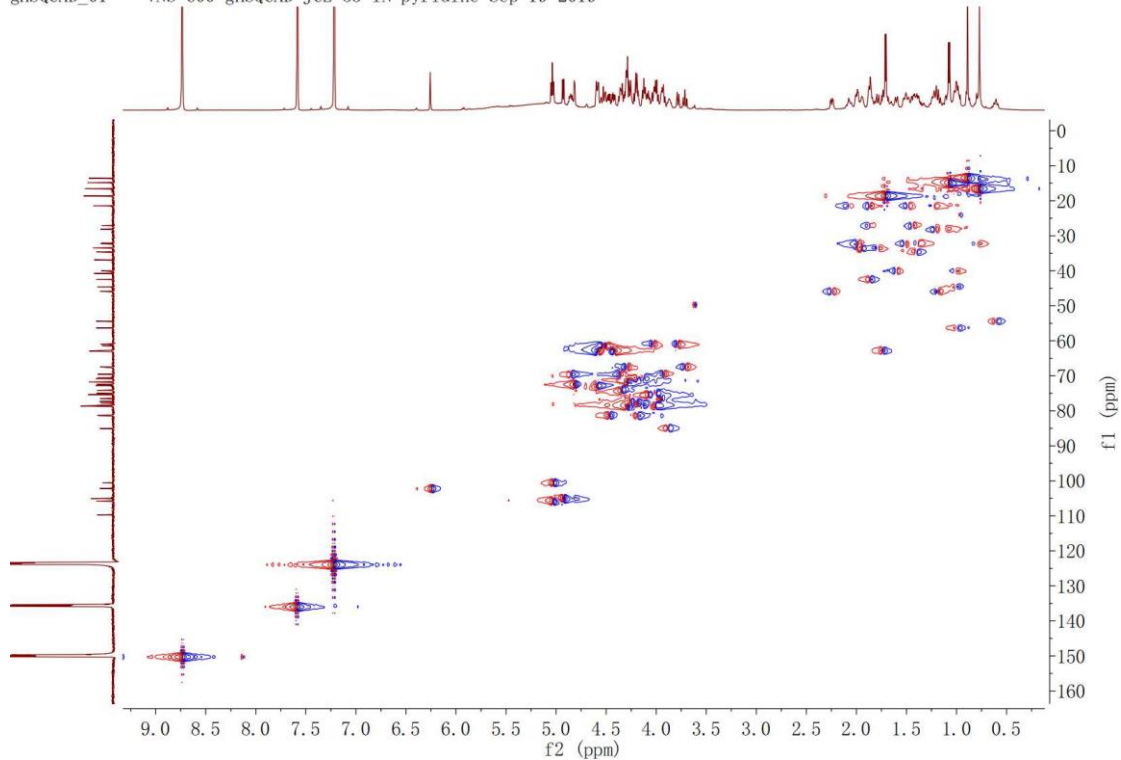


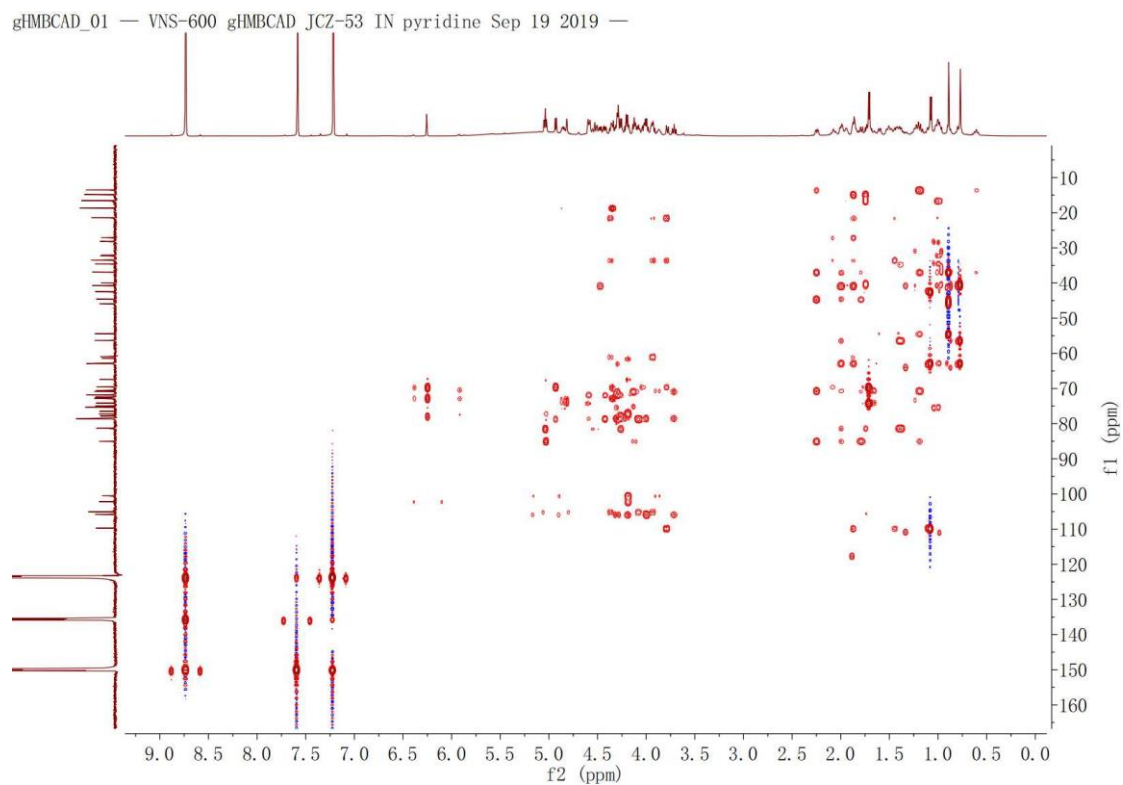
¹³C NMR spectrum of 26.

gCOSY_01 — VNS-600 gCOSY JCZ-53 IN pyridine Sep 19 2019 —

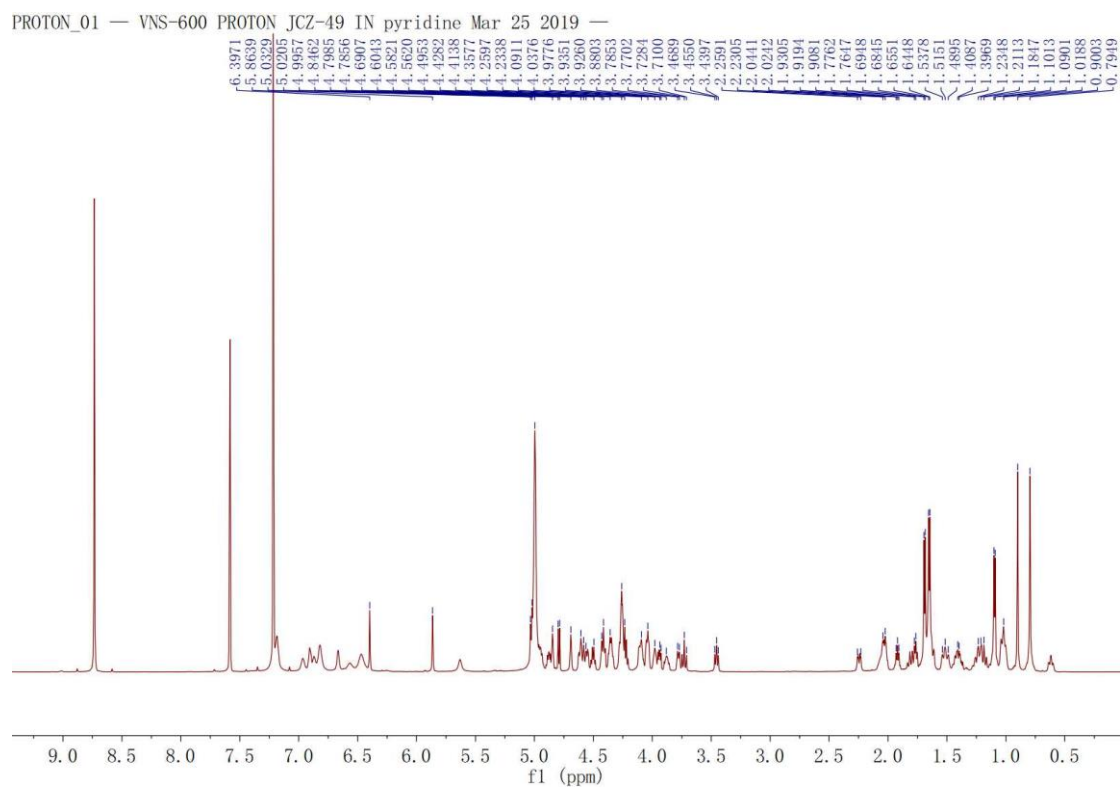
 **^1H - ^1H COSY spectrum of 26.**

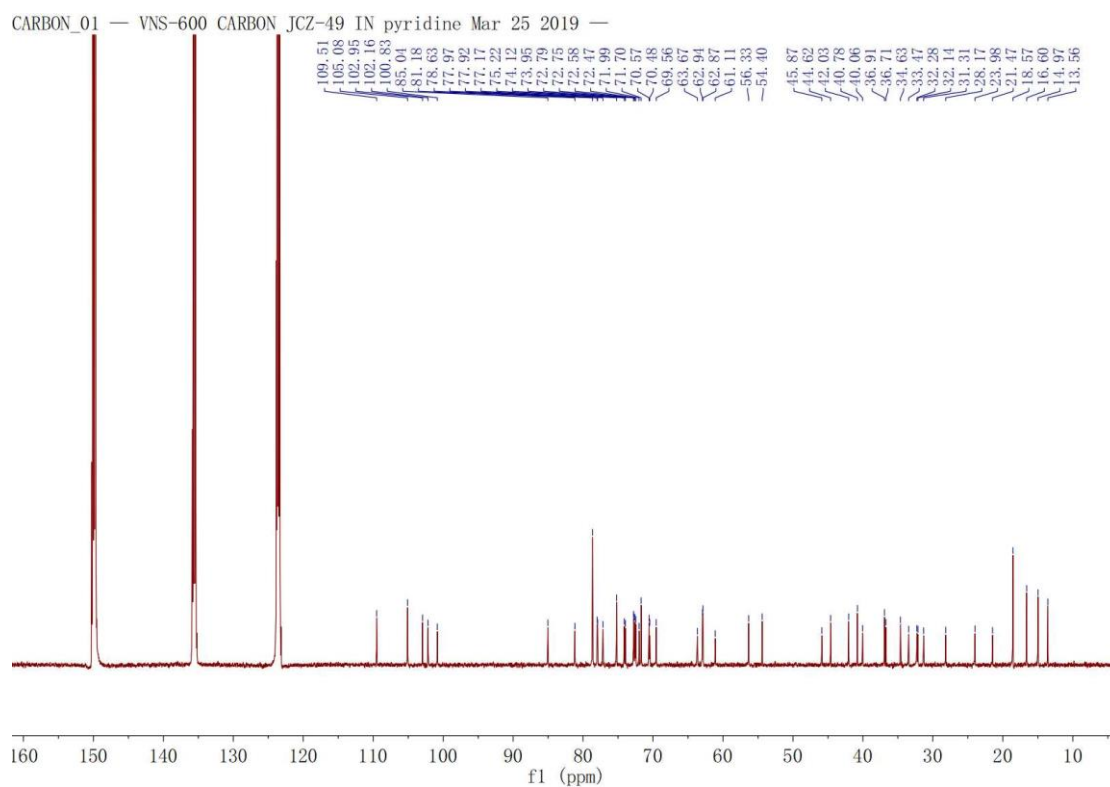
gHSQCAD_01 — VNS-600 gHSQCAD JCZ-53 IN pyridine Sep 19 2019 —

**HSQC spectrum of 26.**



HMBC spectrum of 26.

 ^1H NMR spectrum of 27.



¹³C NMR spectrum of 27.