Electronic Supplementary Material (ESI) for RSC Advances.


**Supporting Information**

# Application of aziridinium ring opening for preparation of optically active diamine and triamine analogues: Highly efficient synthesis and evaluation of DTPA-based MRI contrast enhancement agents:

Xiang Sun,[1] Yunwei Chen,[1] Ningjie Wu, [1] Chi Soo Kang,[1] Hyun A Song,[1] Shengnan Jin,[1] Yao Fu,[1] Henry Bryant Jr.,[2] Joseph A. Frank,[2] Hyun-Soon Chong[1,*]

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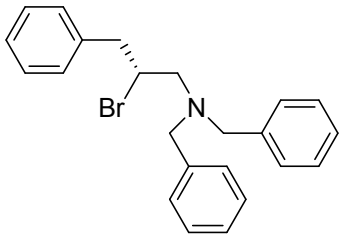
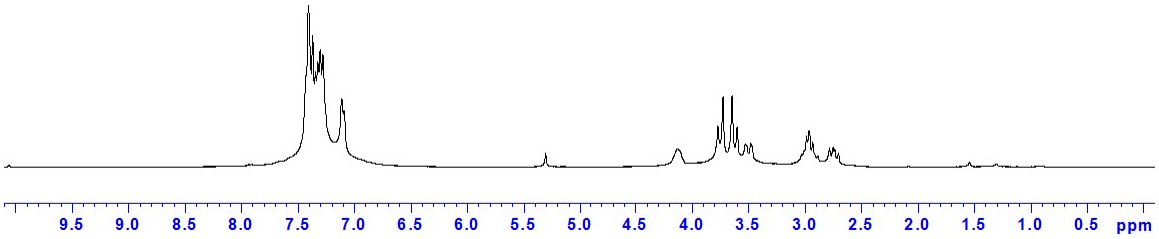
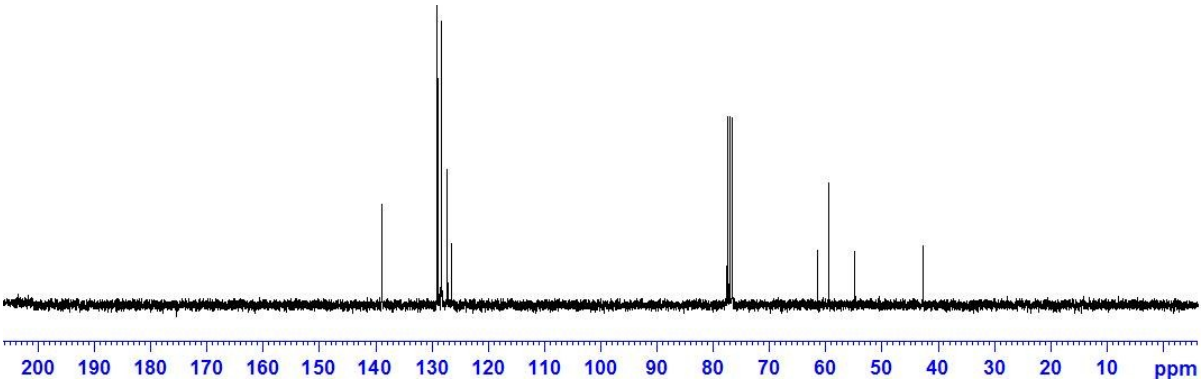
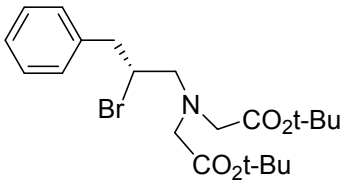
# $^{1}H$ and $^{13}C$ NMR Spectra of Compounds



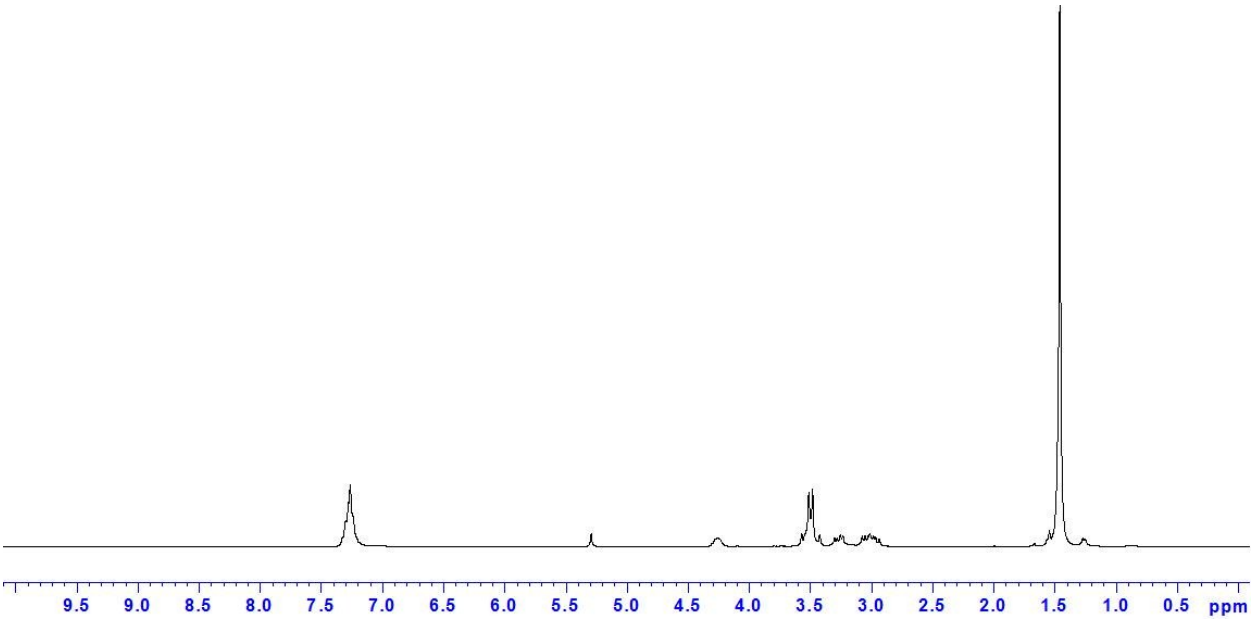

**(*R*)-3a**




Br
N
CO2t-Bu
CO2t-Bu

**(*R*)-3b**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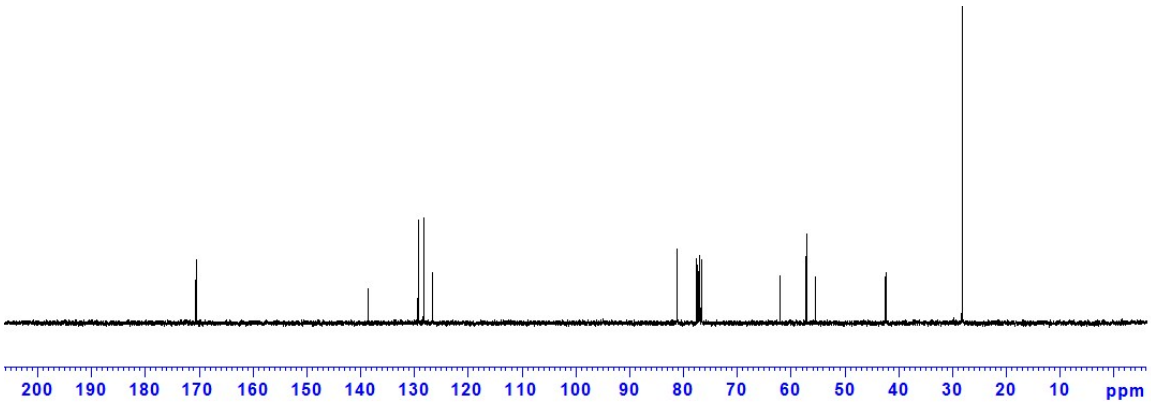
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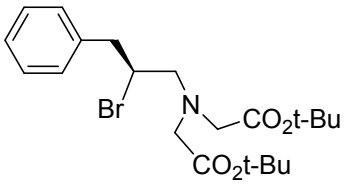
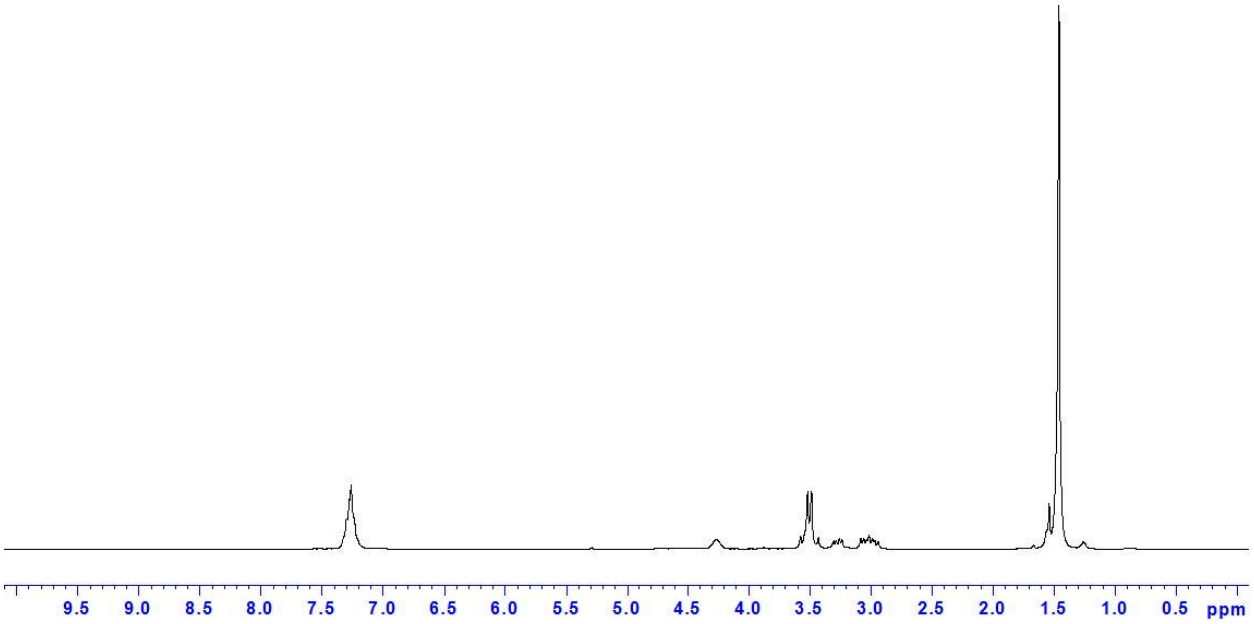

Br
N
CO2t-Bu
CO2t-Bu

**(*S*)-3b**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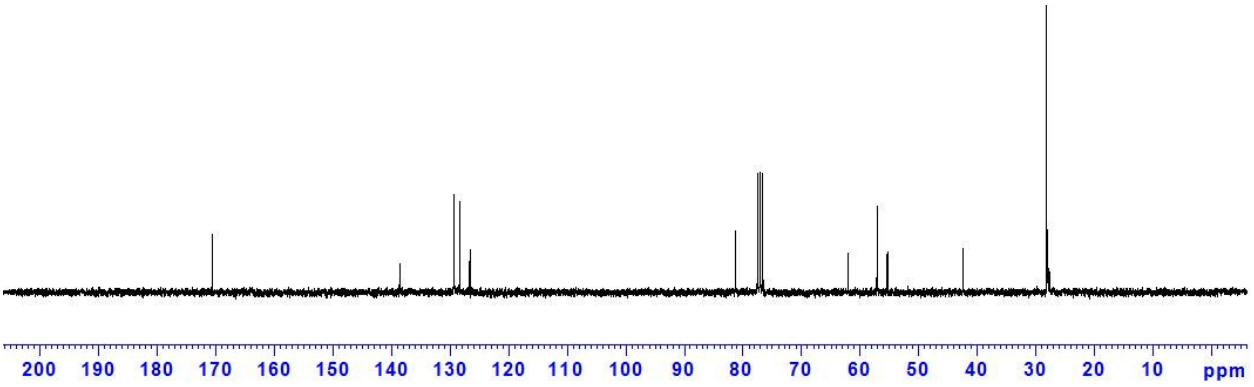
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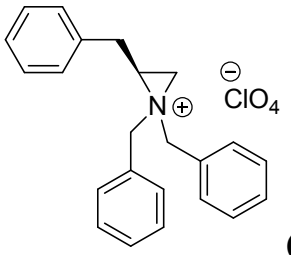

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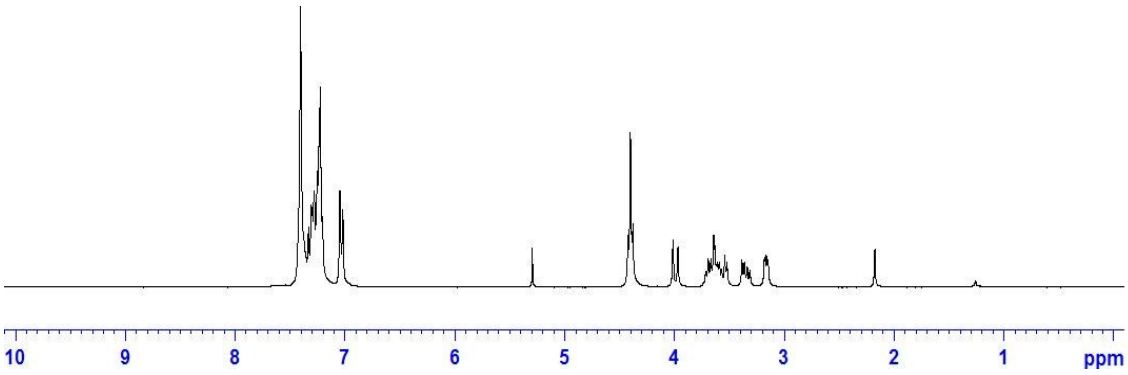
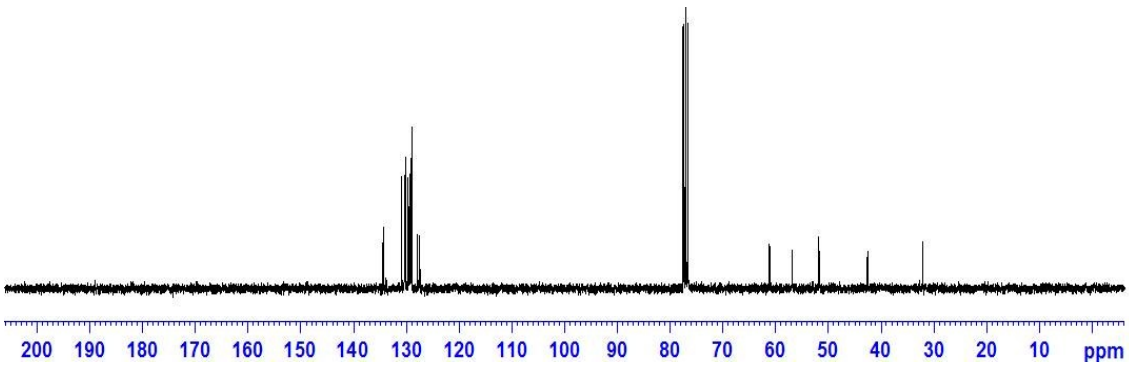
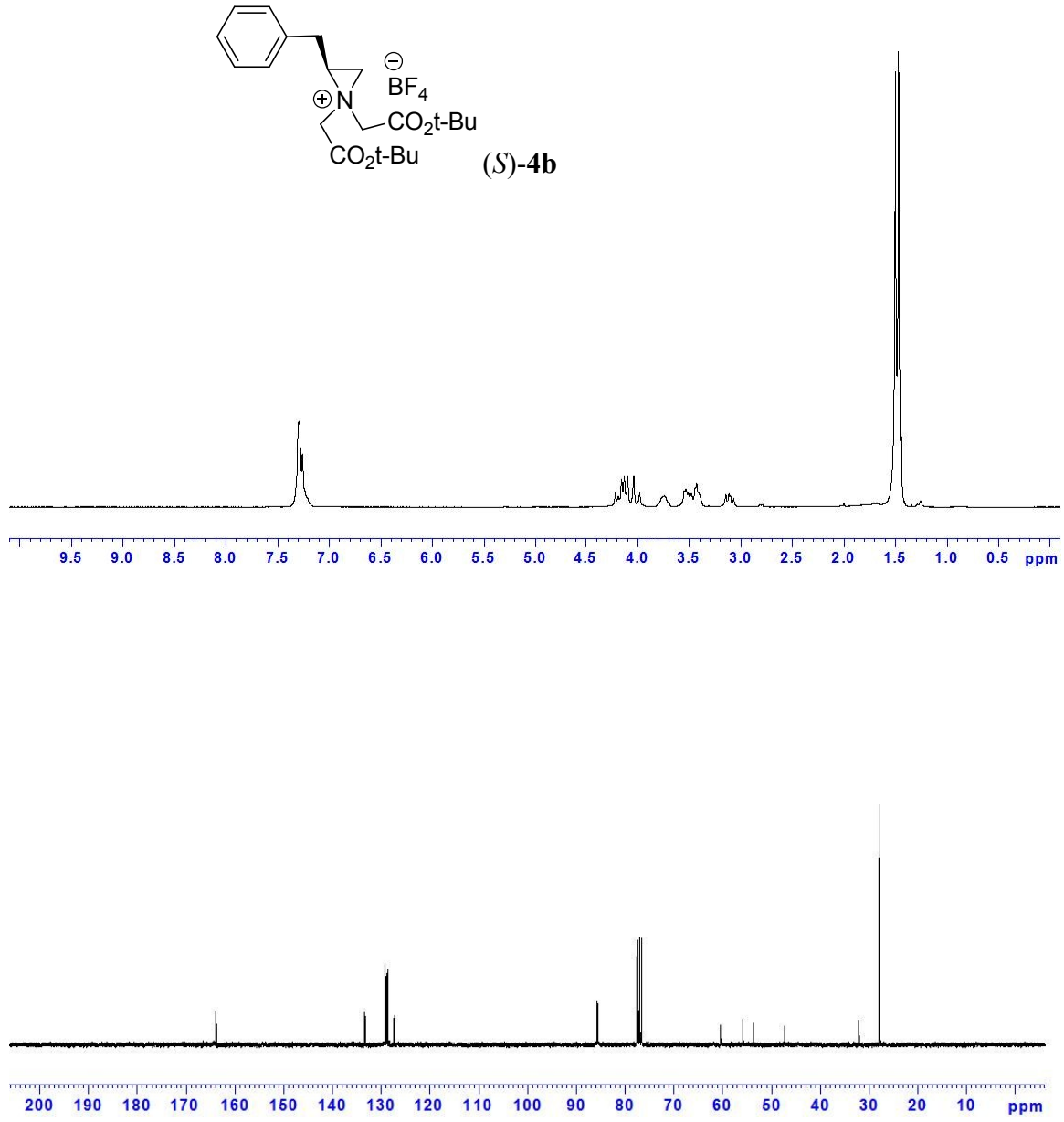
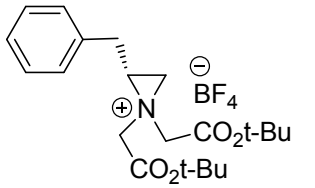

10
9
8
7
6
5
4
3
2
1
ppm

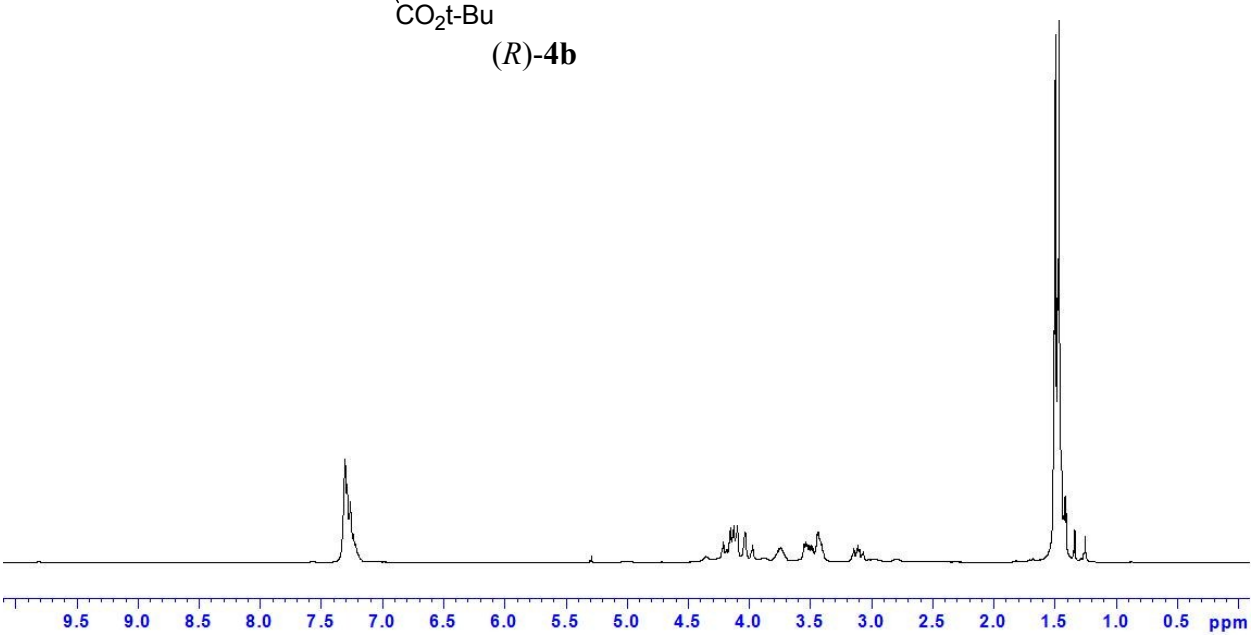

200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


BF4
CO2t-Bu
CO2t-Bu
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

(*S*)-**4b**


BF4
N
CO2t-Bu
CO2t-Bu

(*R*)-**4b**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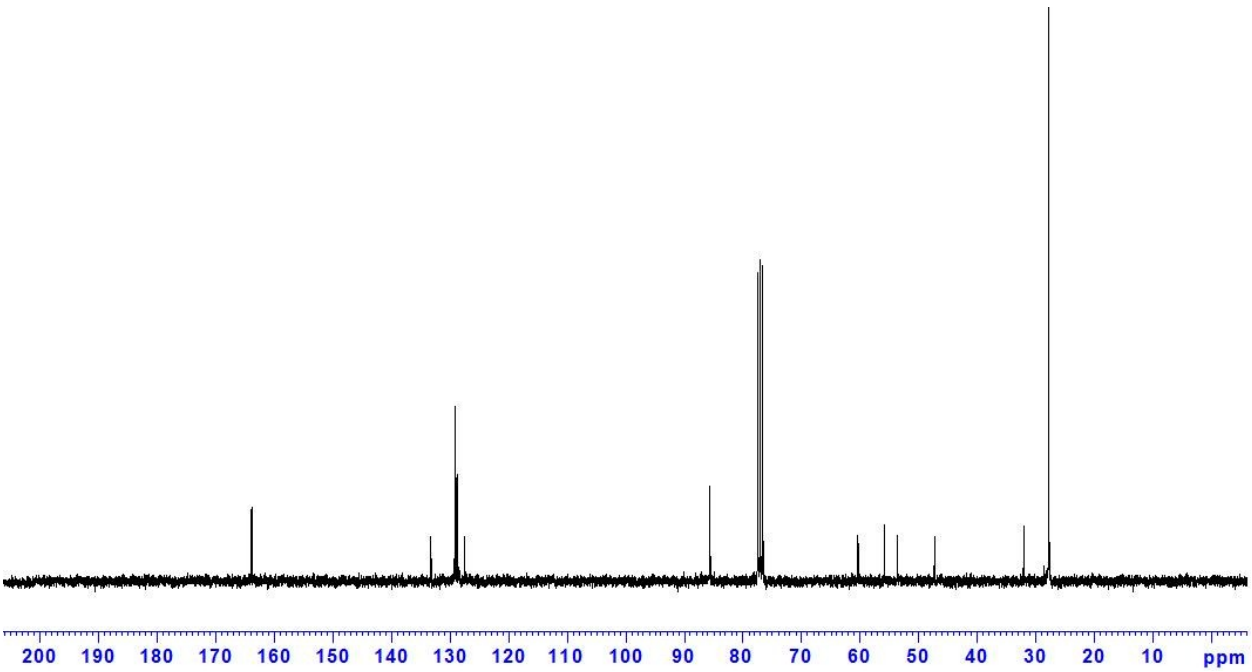
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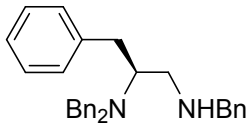
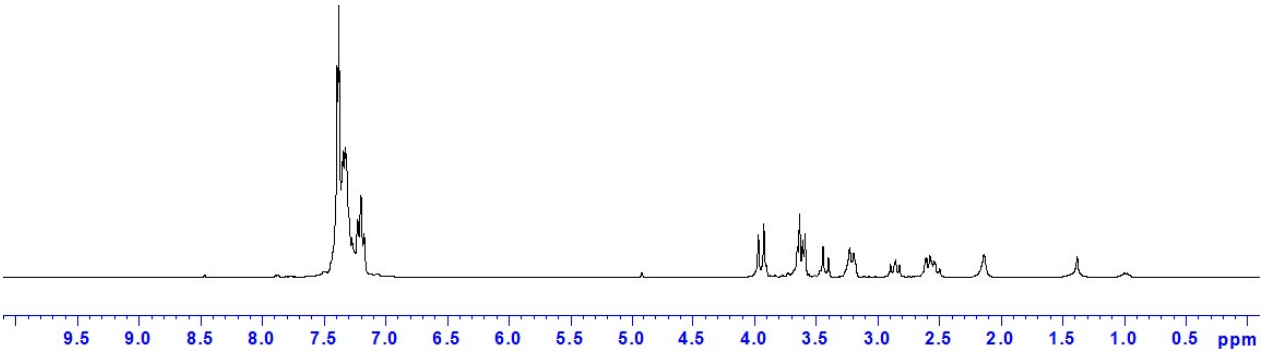

Bn2N
NHBn

**(*S*)-5**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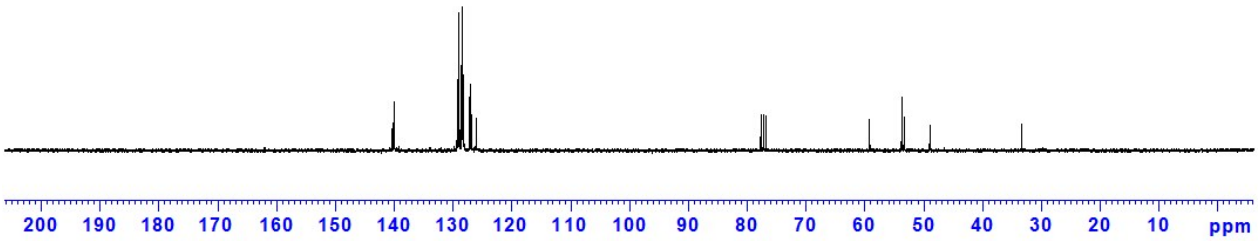
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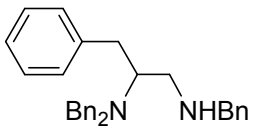
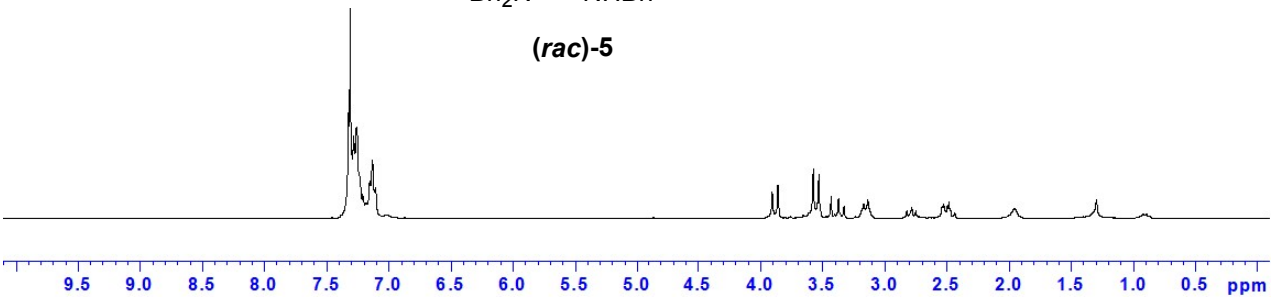

Bn2N
NHBn

**(*rac*)-5**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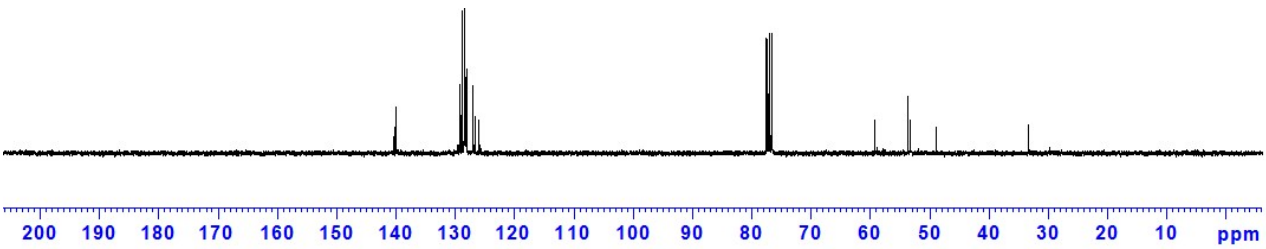
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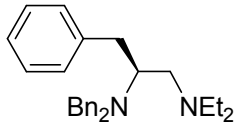
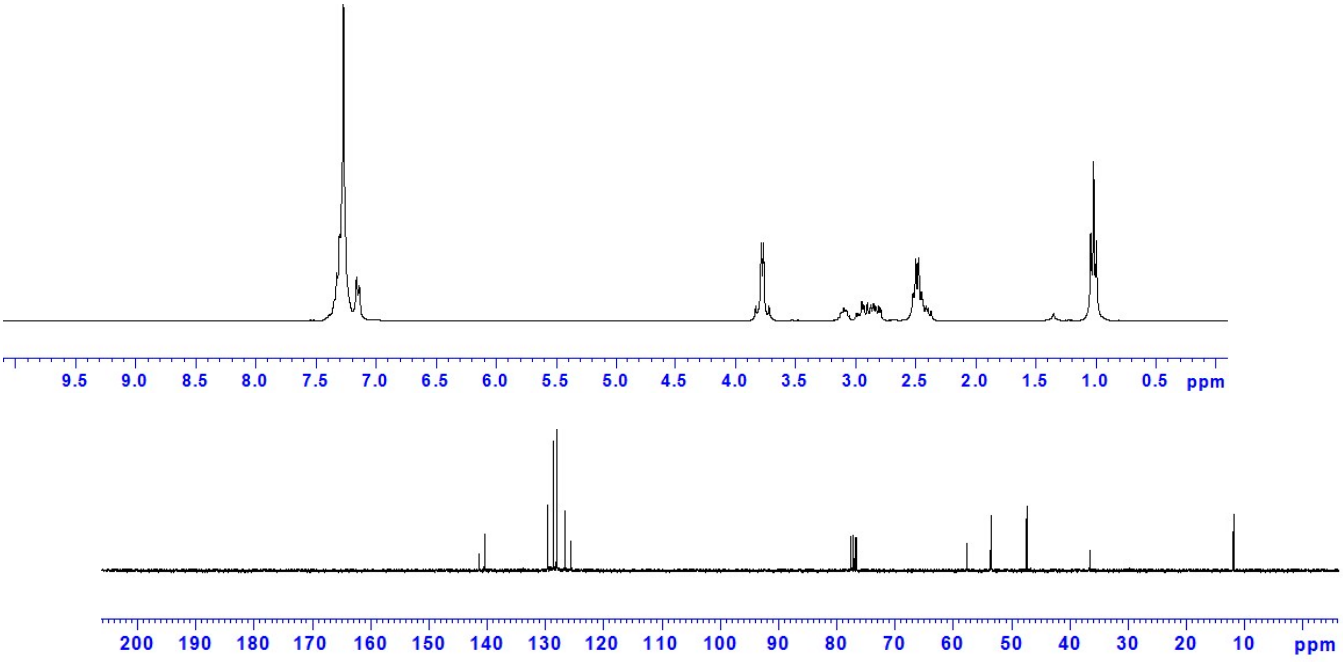

Bn2N
NEt2

**(S)-6**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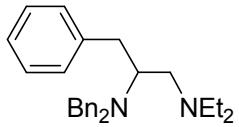
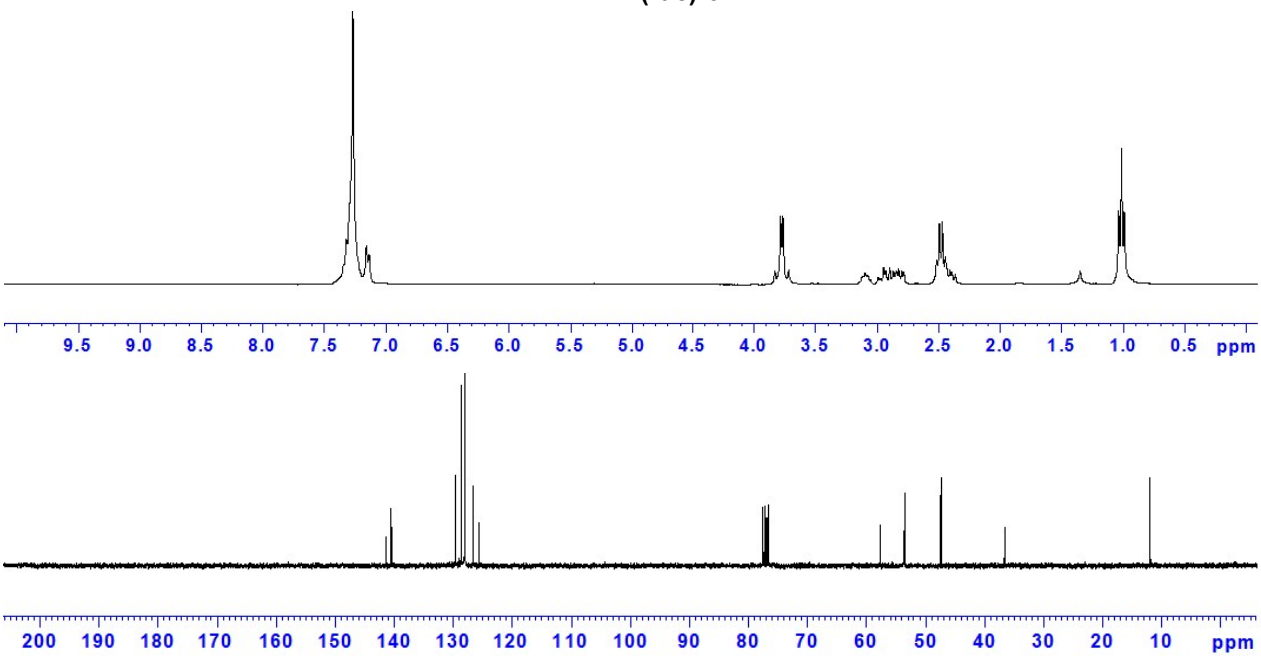

Bn2N
NEt2

**(rac)-6**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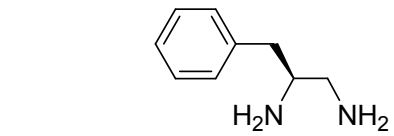
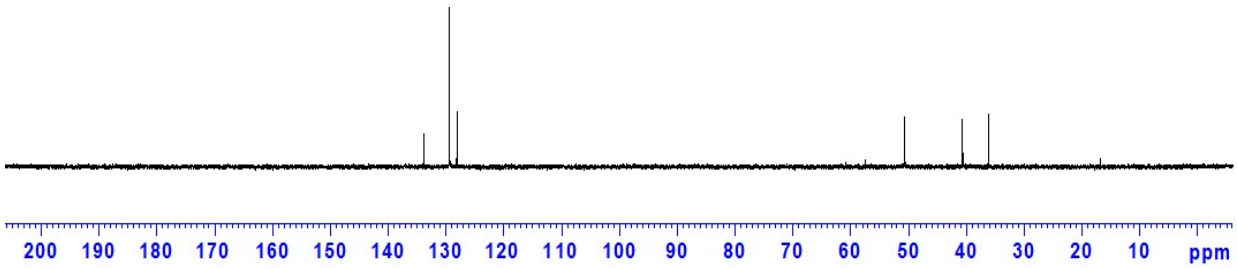

H2N
NH2

**7**


9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm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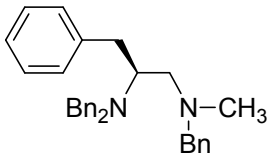
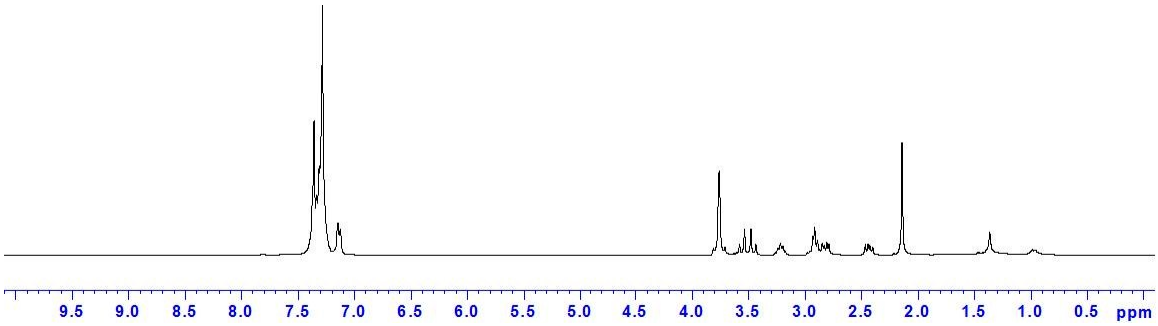

Bn2N
N−CH3
Bn

**(S)-8**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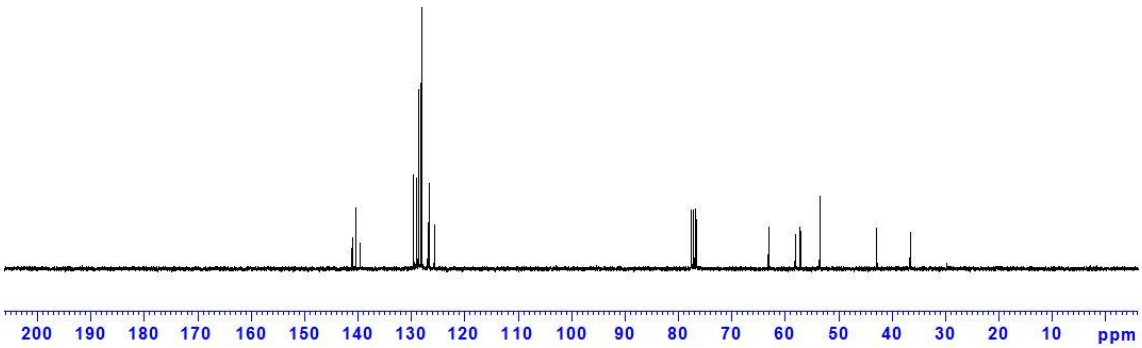
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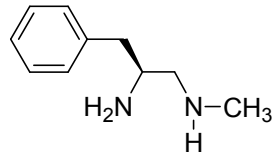
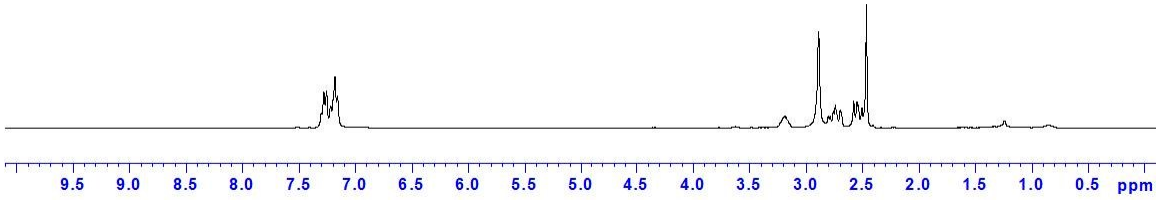

H2N
N
CH3
H

**(S)-9**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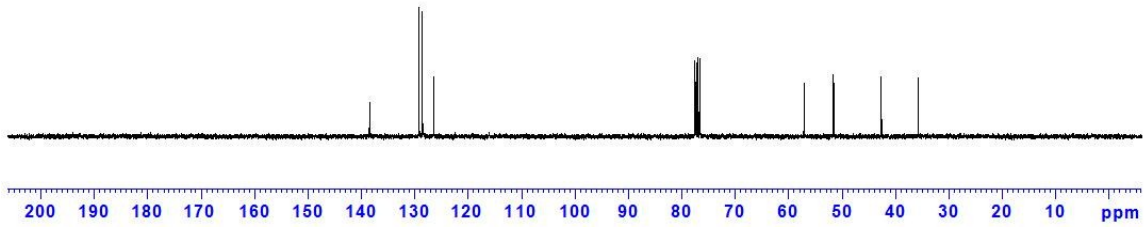
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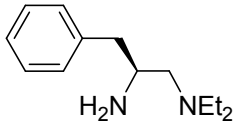
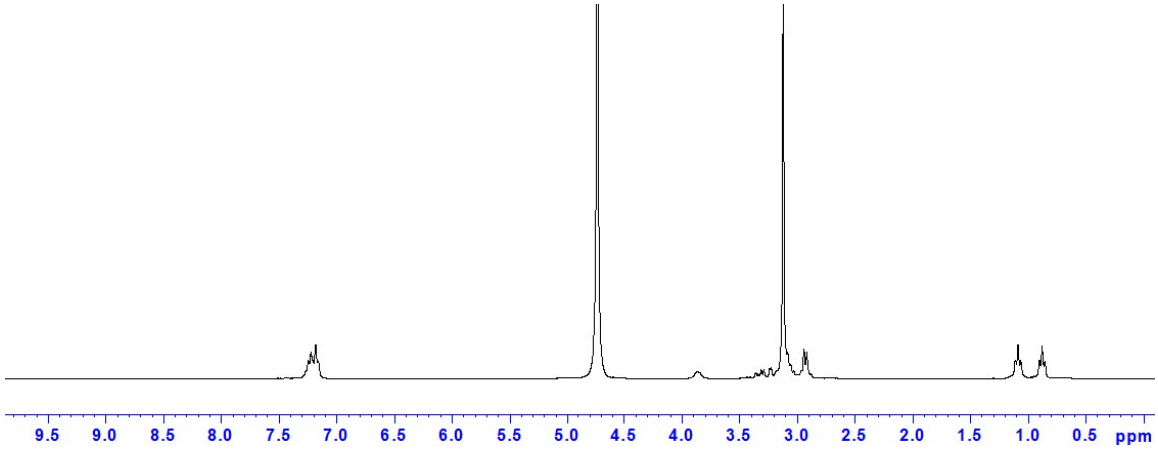

H2N
NEt2

**10**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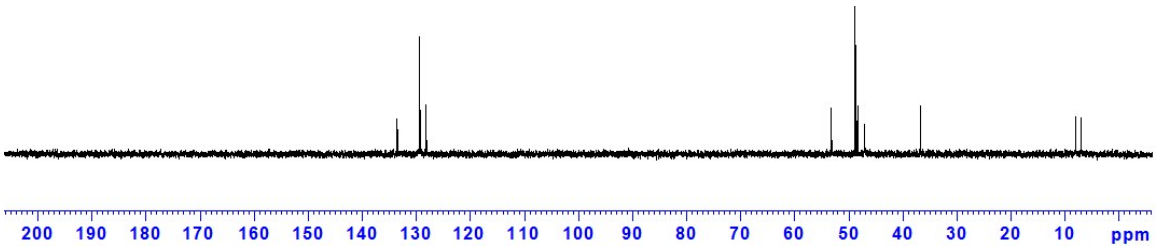
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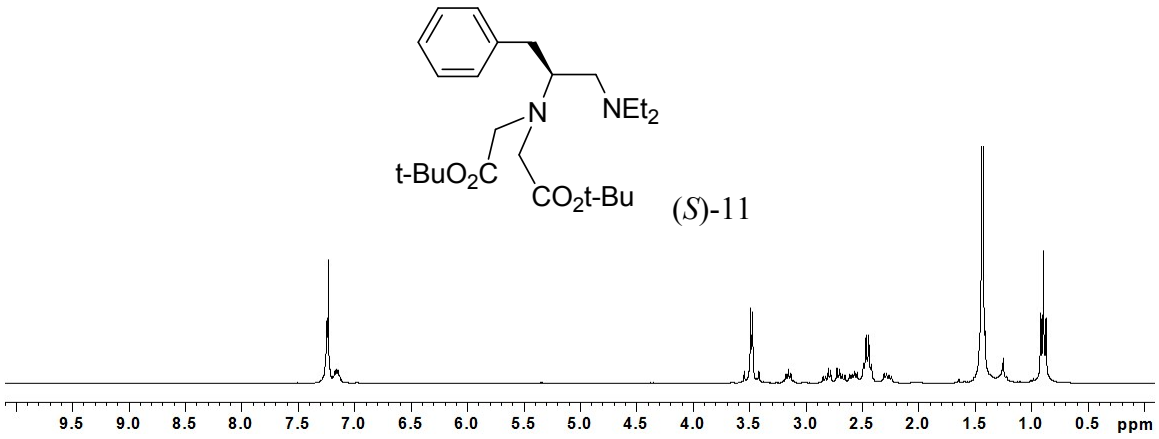
N
NEt2
t-BuO2C
CO2t-Bu

(*S*)-11


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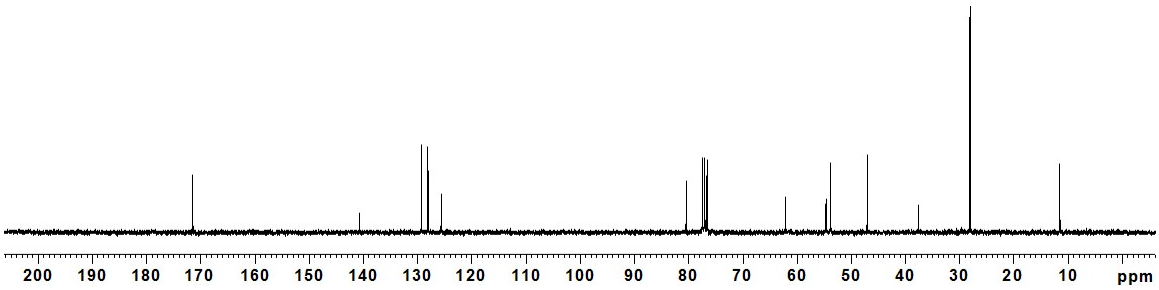
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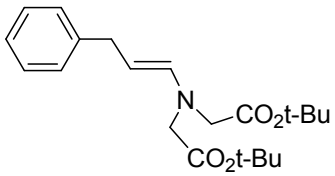
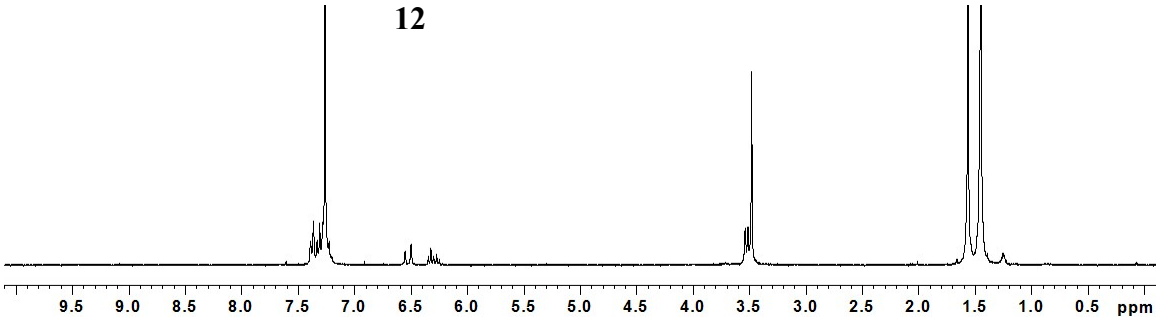

N
CO2t-Bu
CO2t-Bu

**12**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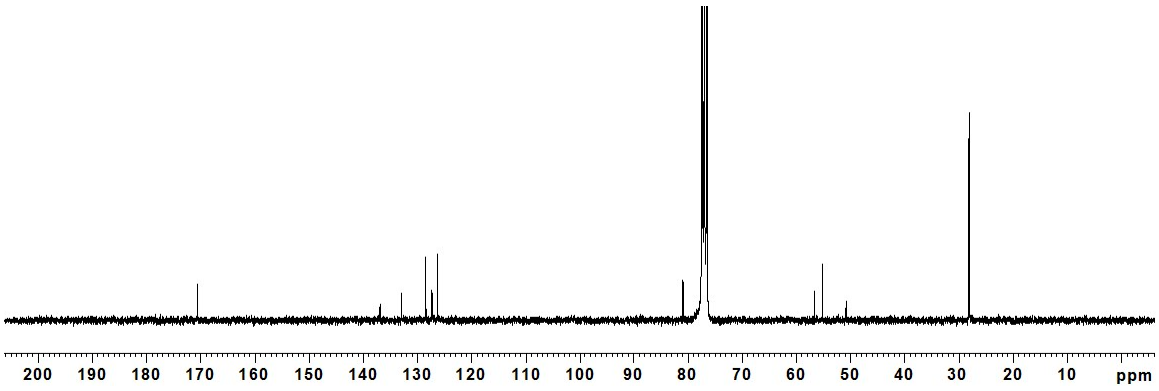
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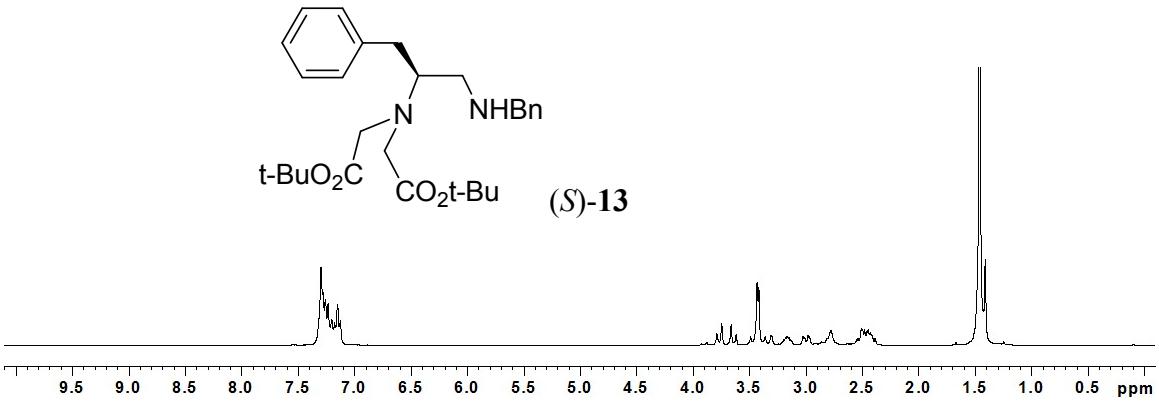
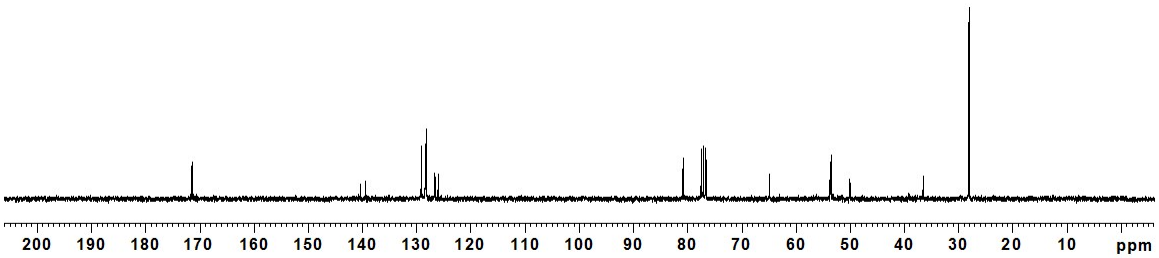

NHBn
N
t-BuO2C
CO2t-Bu
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

(*S*)-**13**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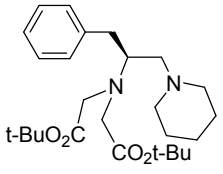
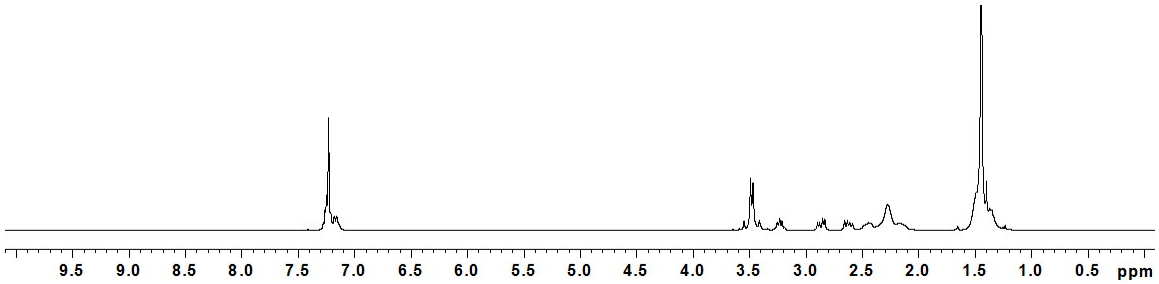

N
N
t-BuO2C
CO2t-Bu

(*S*)-**14**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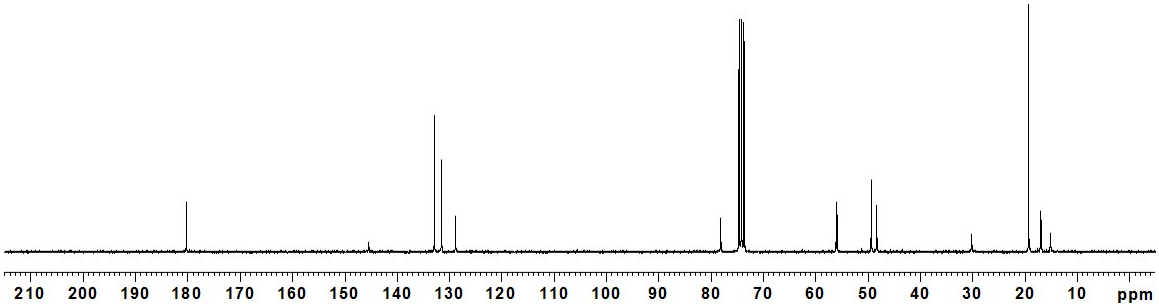
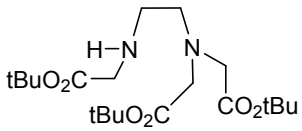
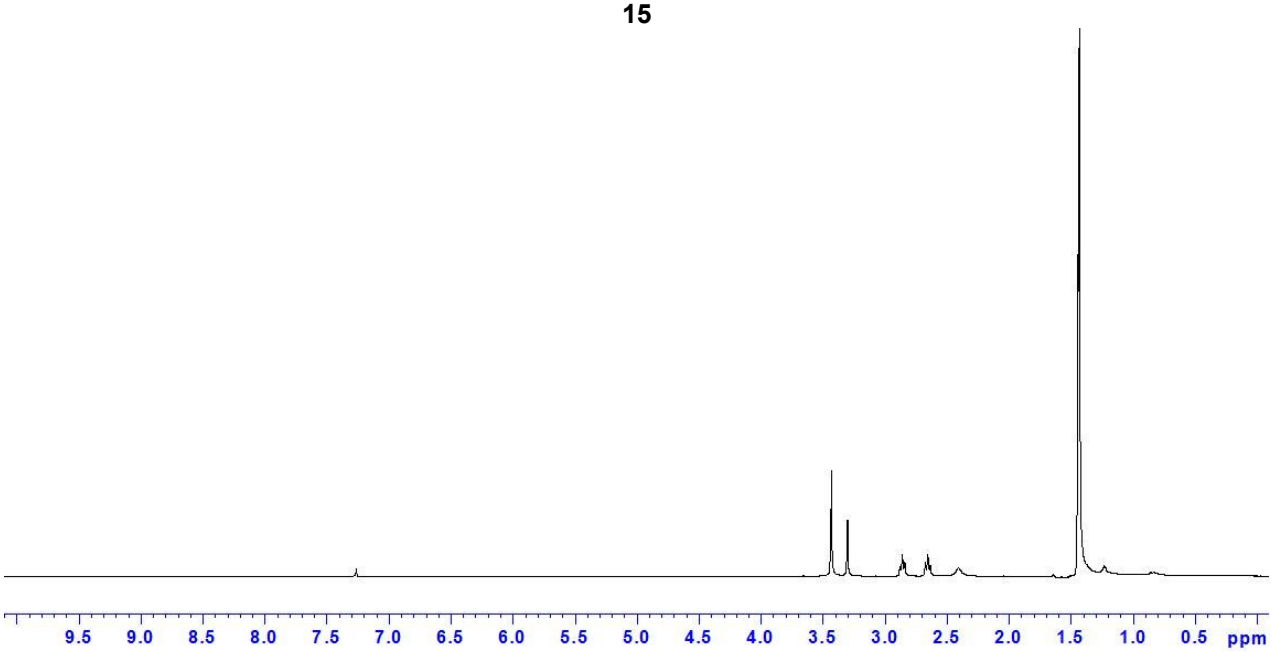
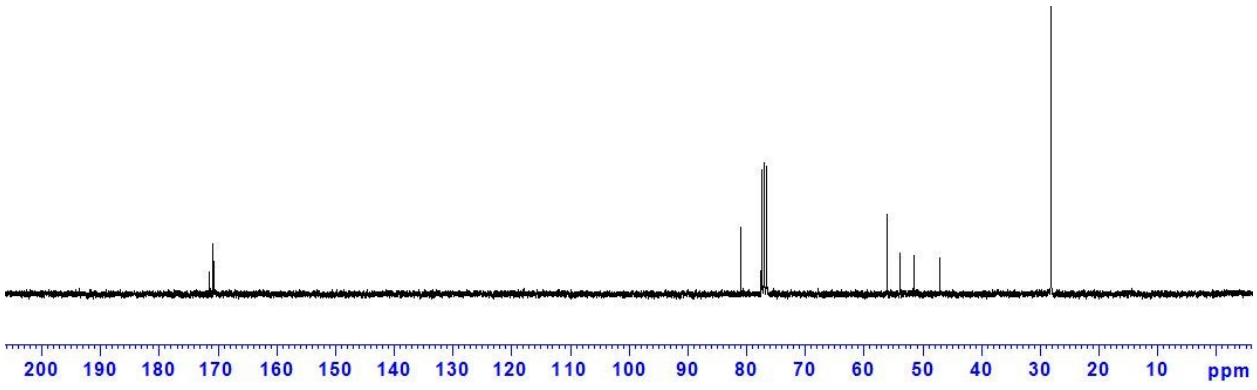
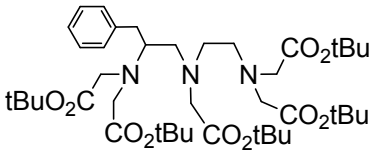

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


H–N
N
tBuO2C
tBuO2C
CO2tBu

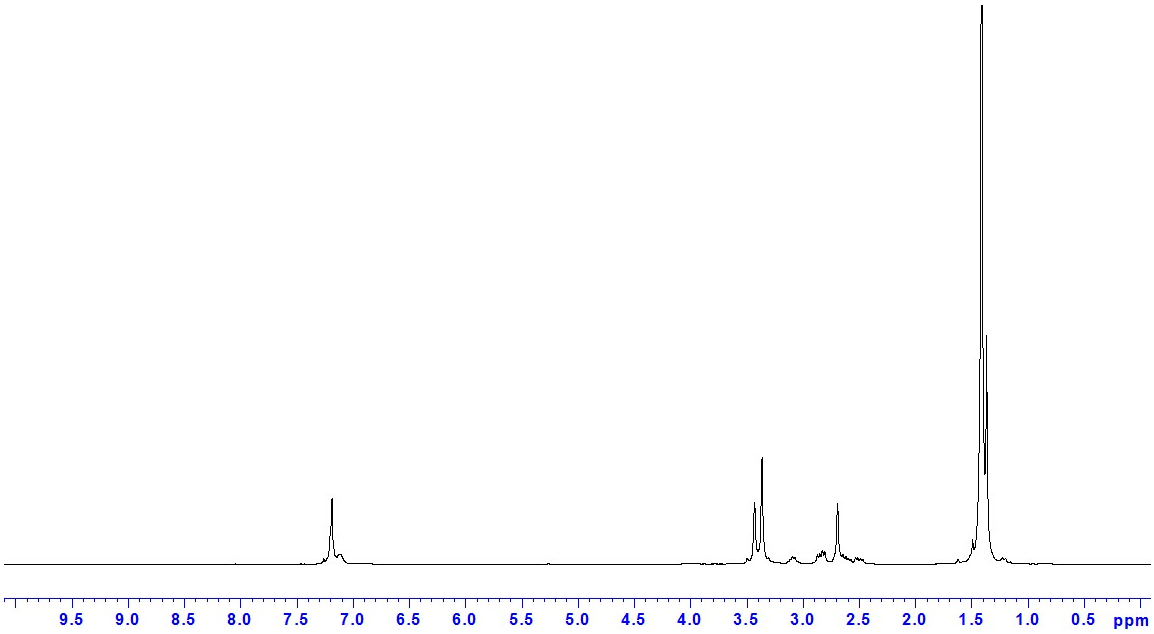
**15**

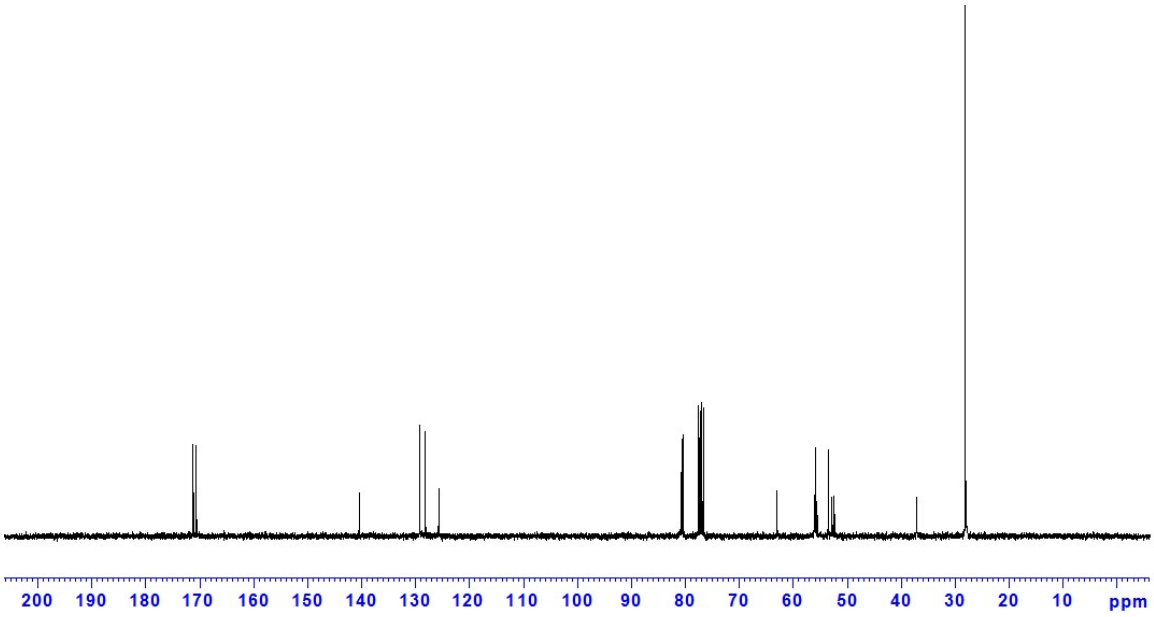

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

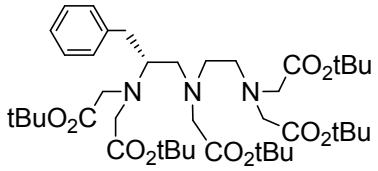

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2tBu
N
N
N
tBuO2C
CO2tBu
CO2tBu
CO2tBu

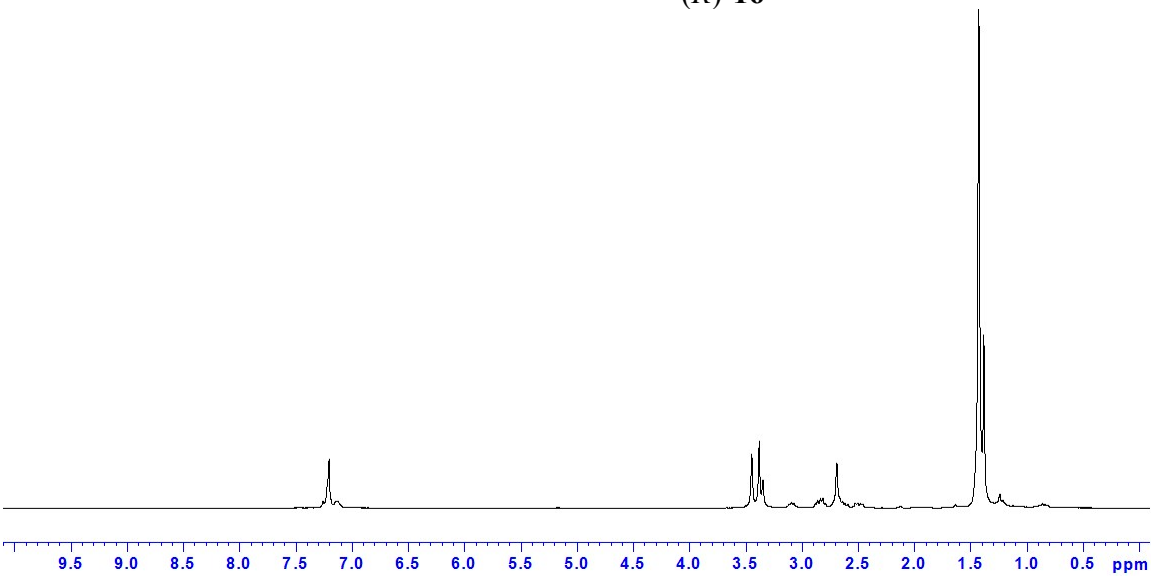
(*rac*)-**16**

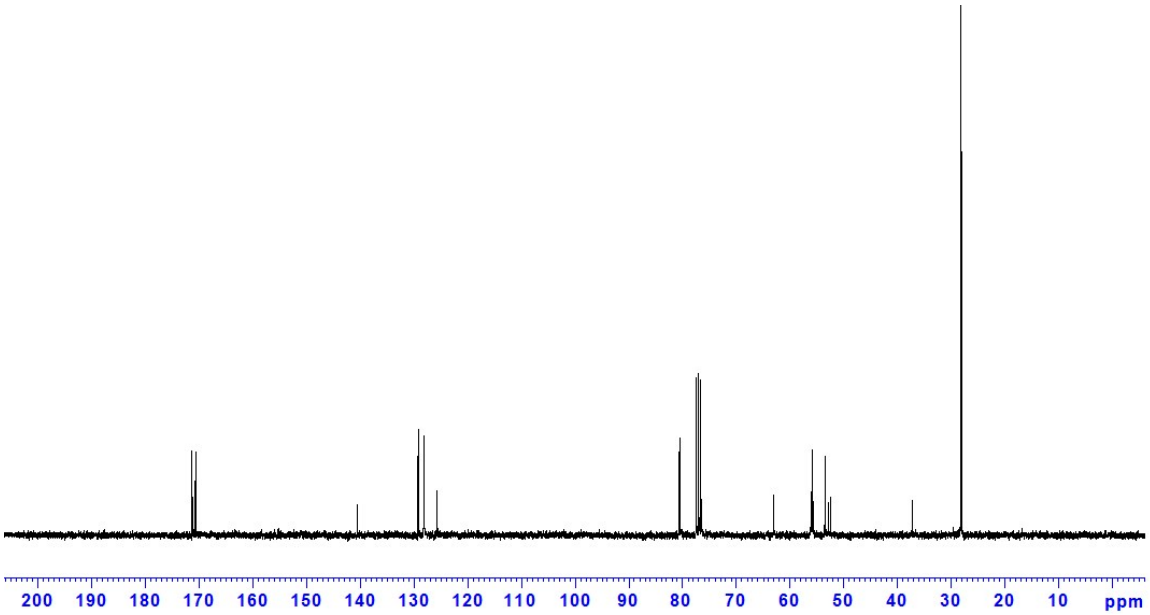

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

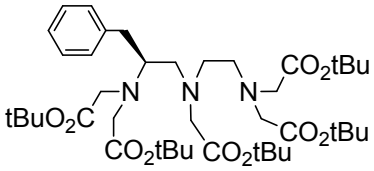

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2tBu
N
N
N
tBuO2C
CO2tBu
CO2tBu
CO2tBu

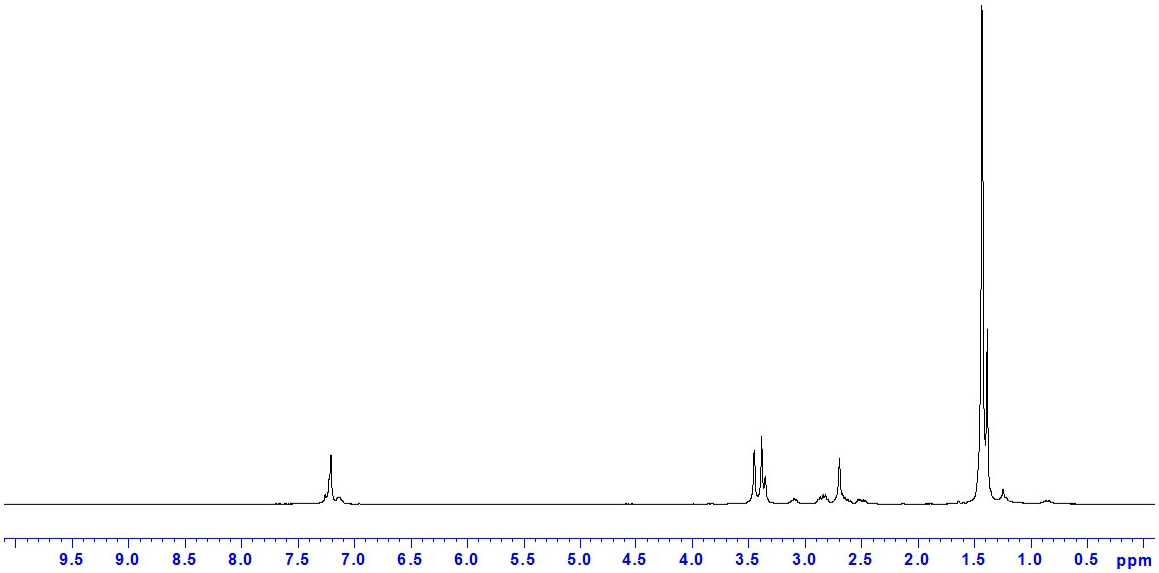
(*R*)-**16**

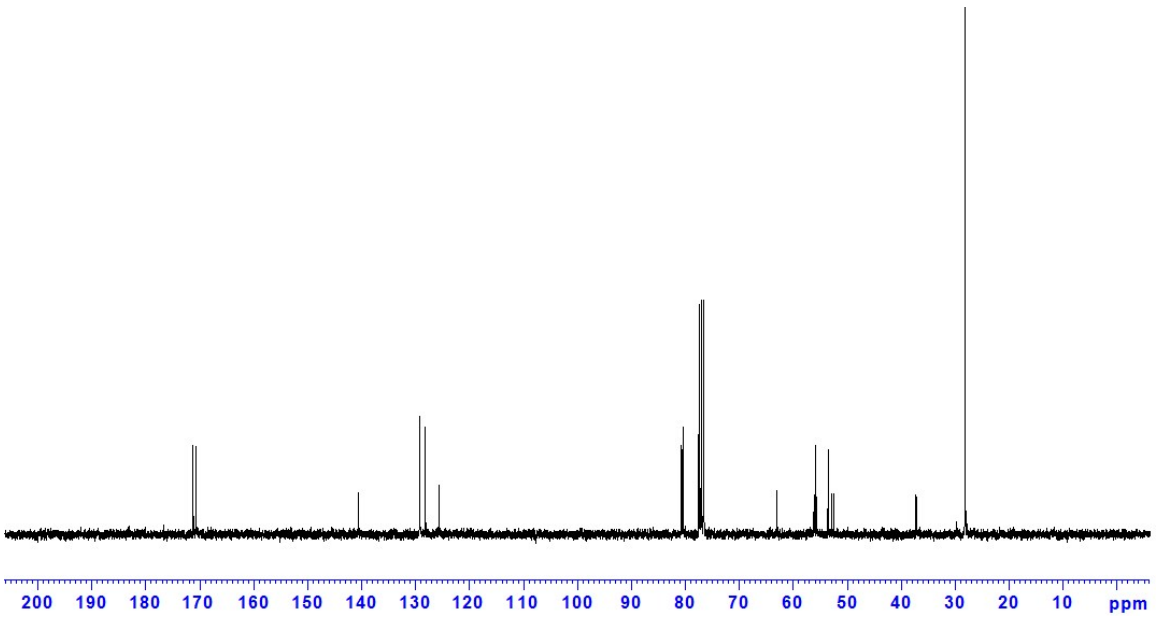

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

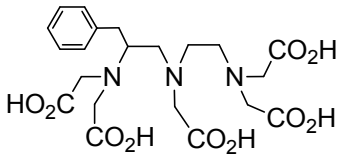

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2tBu
N
N
N
tBuO2C
CO2tBu
CO2tBu
CO2tBu

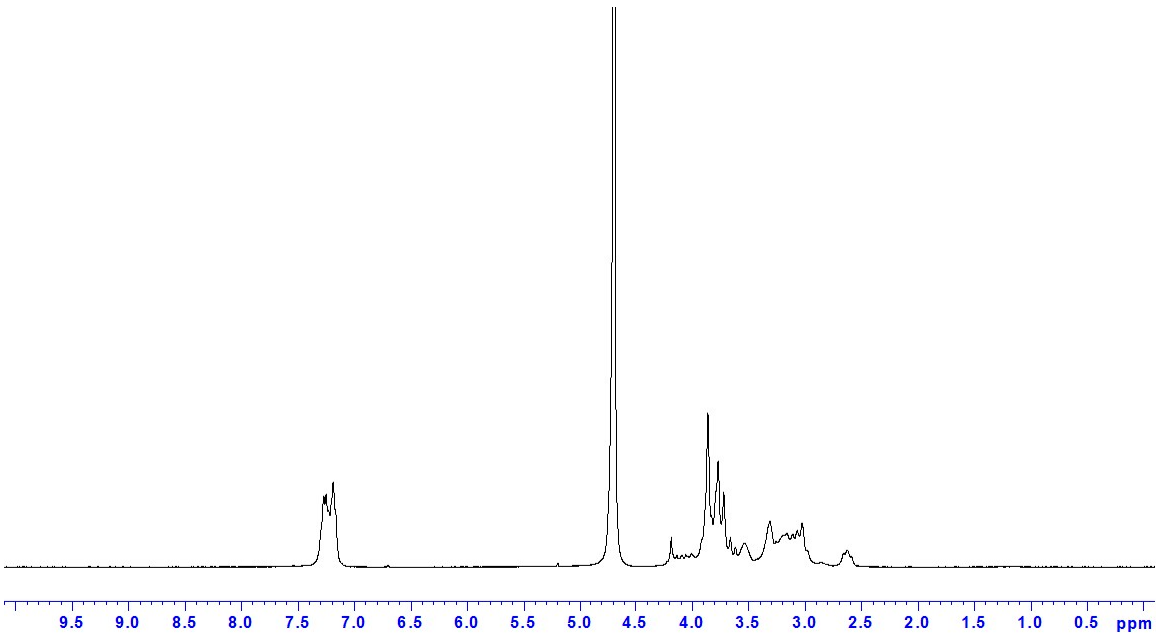
(*S*)-**16**

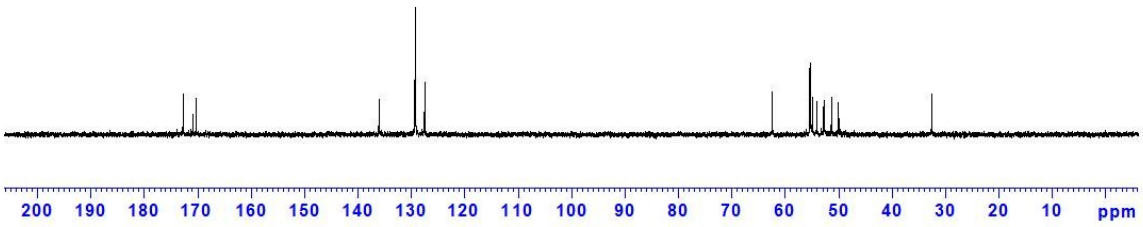

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

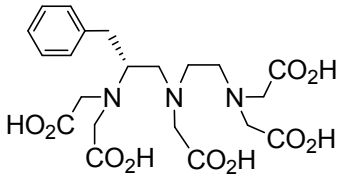

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2H
N
N
N
HO2C
CO2H
CO2H
CO2H

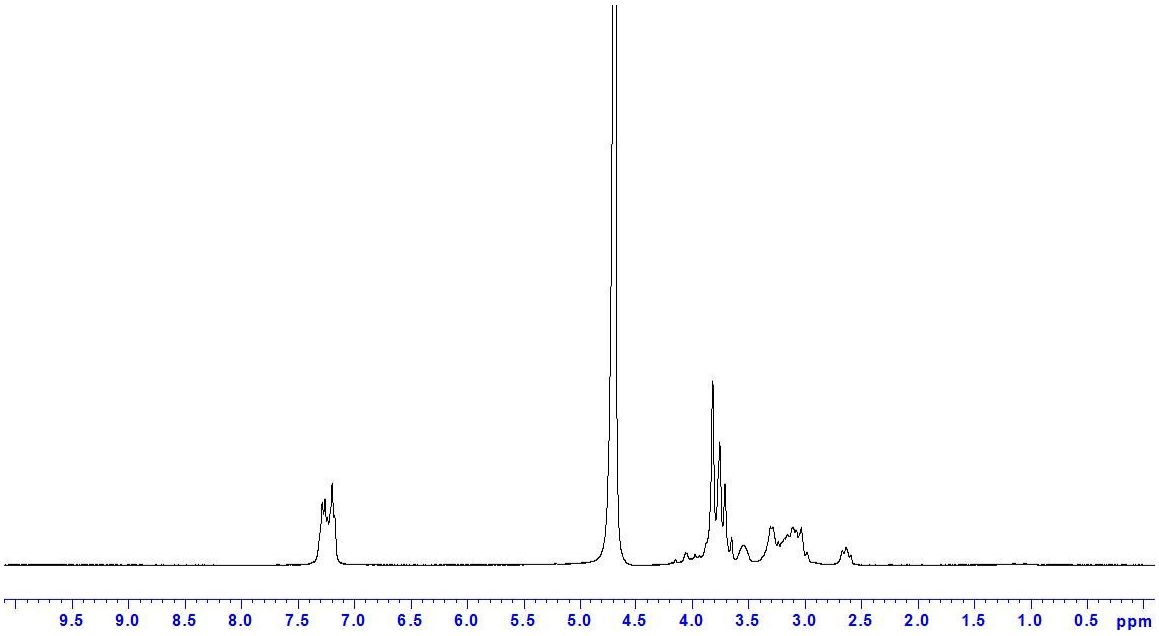
**(*rac*)-Bn-DTPA**

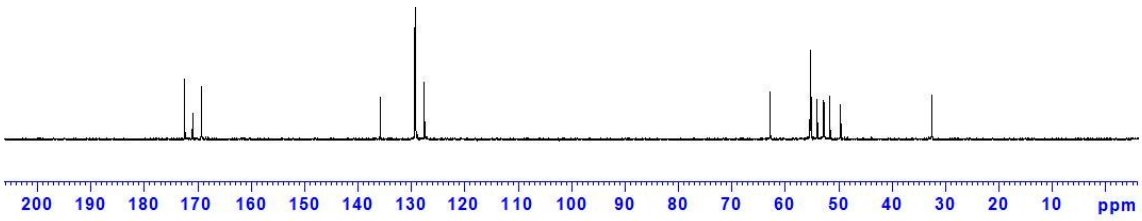

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

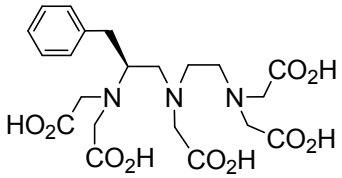

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2H
N
N
N
HO2C
CO2H
CO2H
CO2H

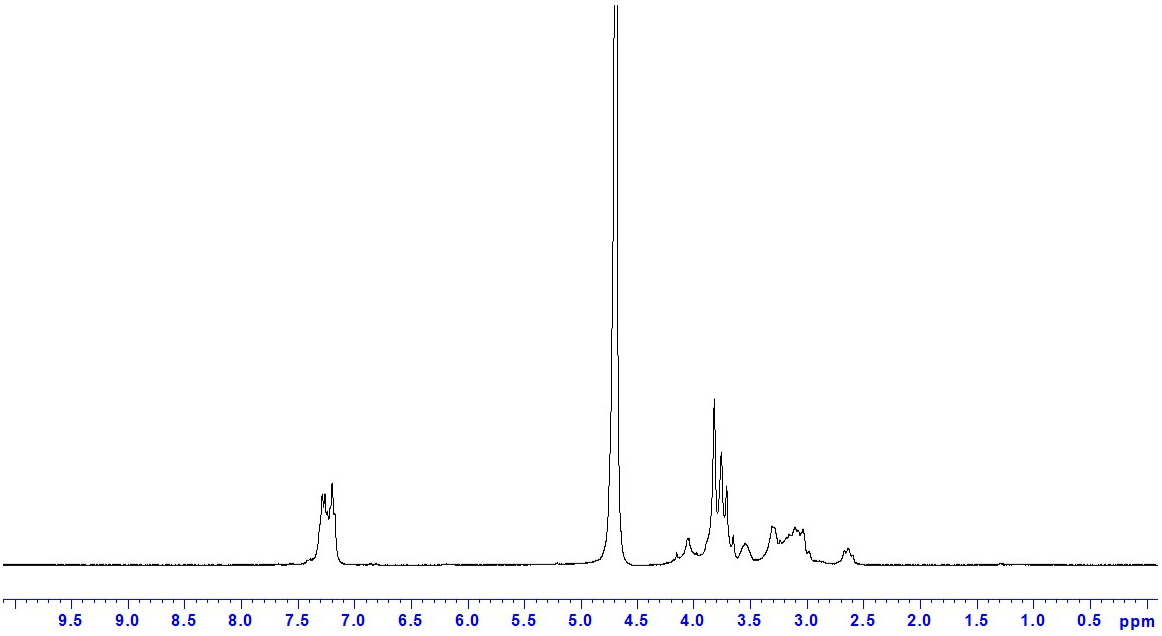
**(*R*)-Bn-DTPA**

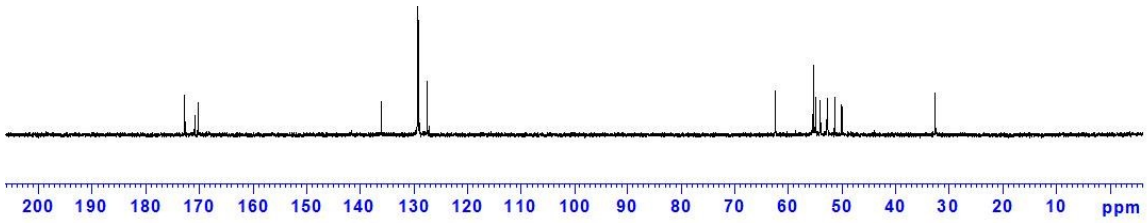

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

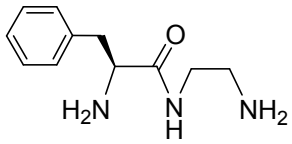

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


CO2H
N
N
N
HO2C
CO2H
CO2H
CO2H

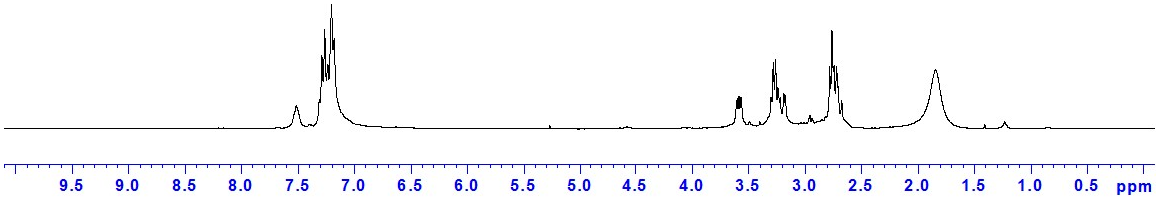
**(*S*)-Bn-DTPA**

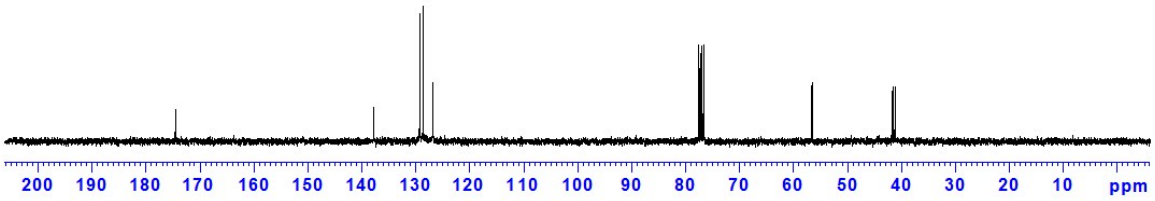

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

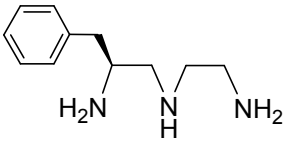

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


O
H2N
N
H
NH2

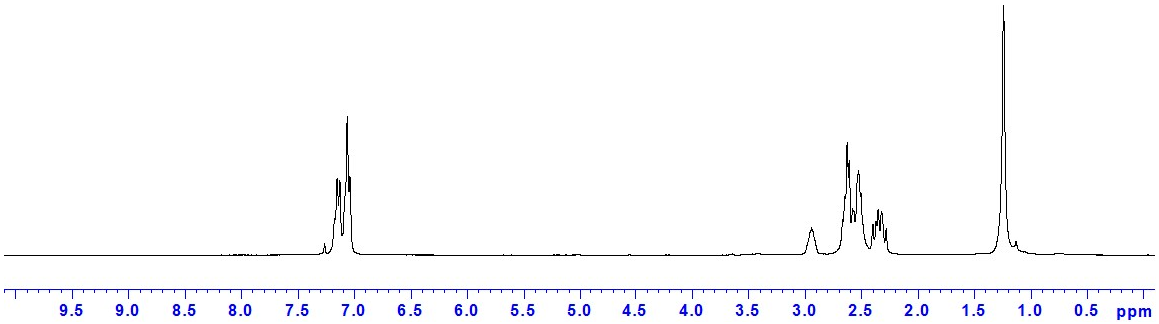
**18**

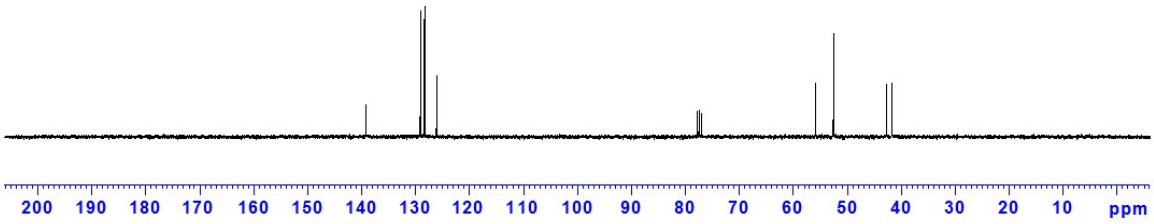

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

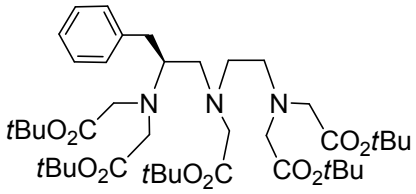

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


H2N
N
H
NH2

**19**

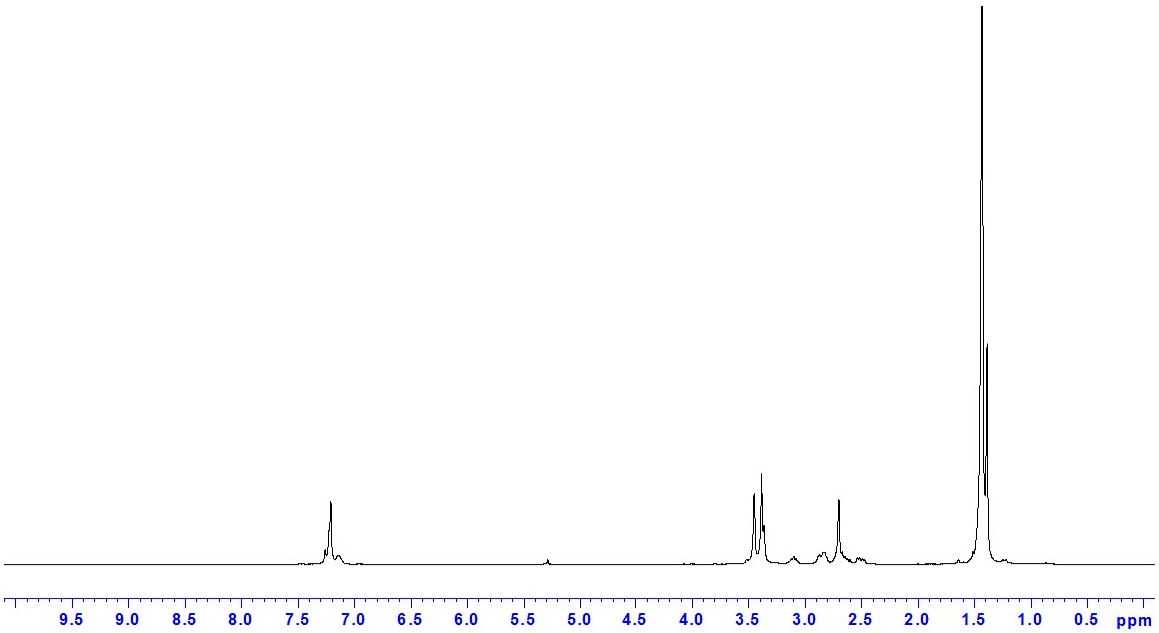

9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm

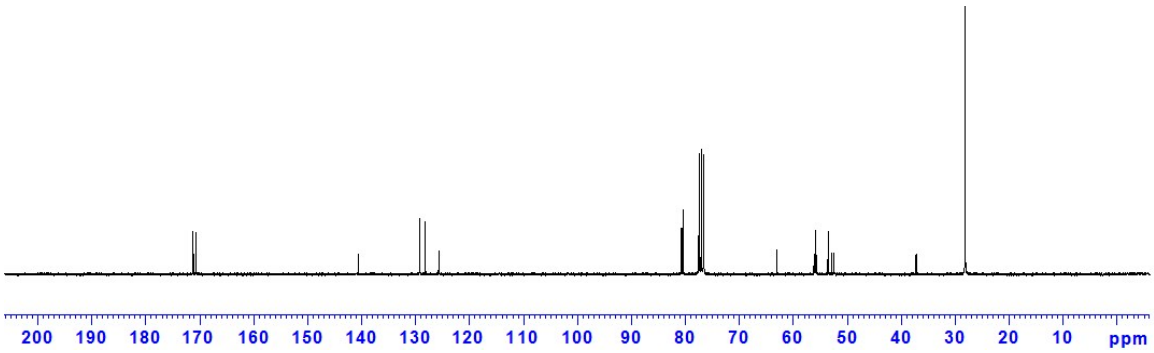

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

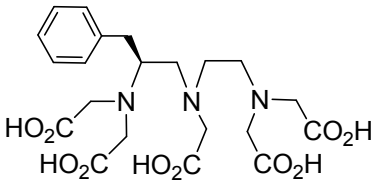



(*S*)-**16**

(prepared from the procedure shown in Scheme 5)

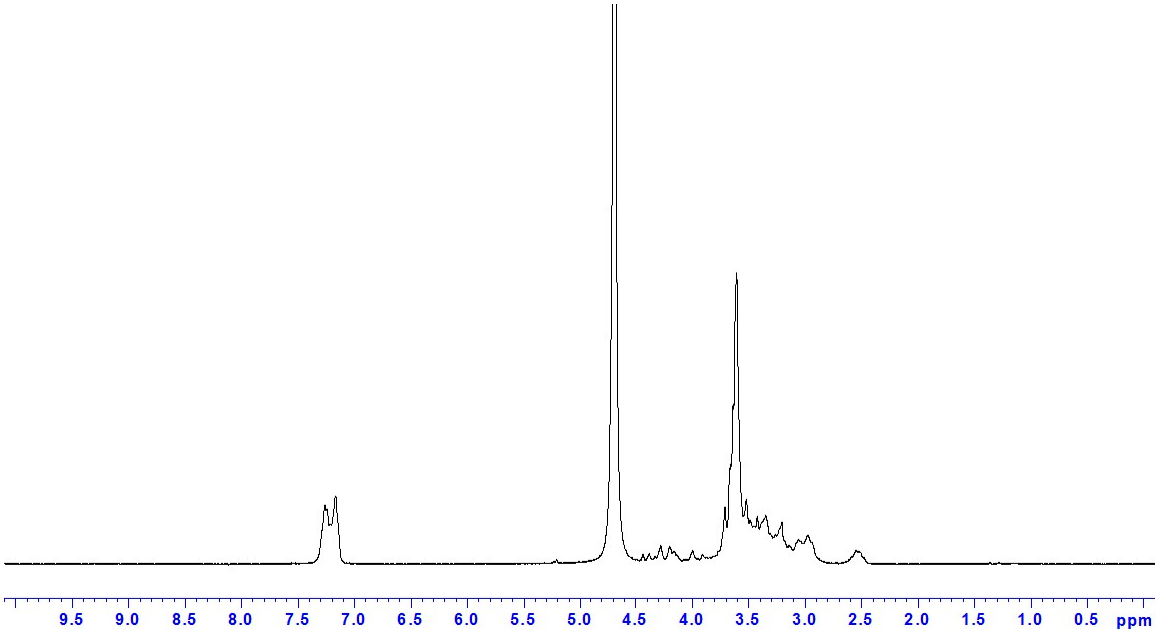


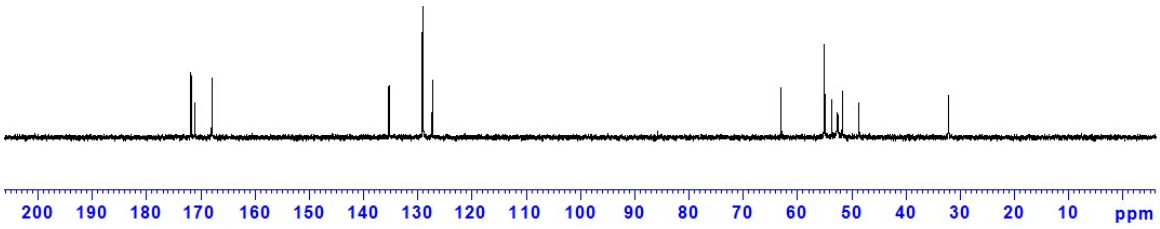





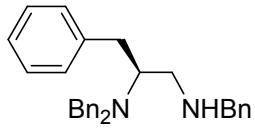

(*S*)-**Bn-DTPA**

(prepared from the procedure shown in Scheme 5)

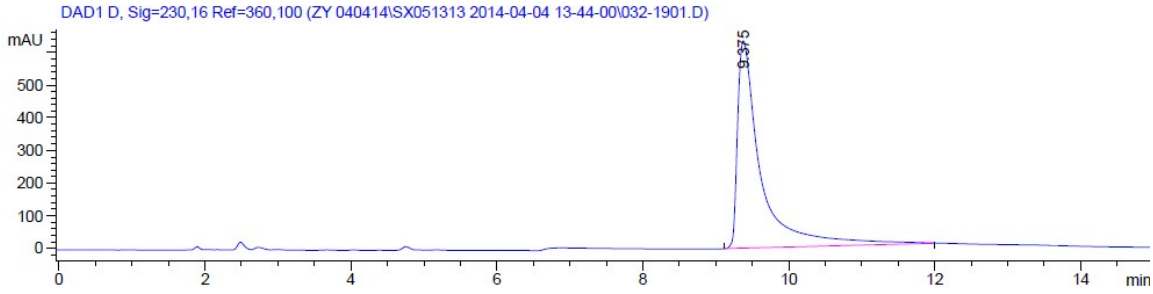


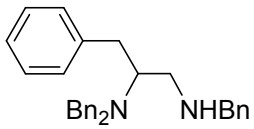
## Chiral HPLC Chromatograms of Compounds



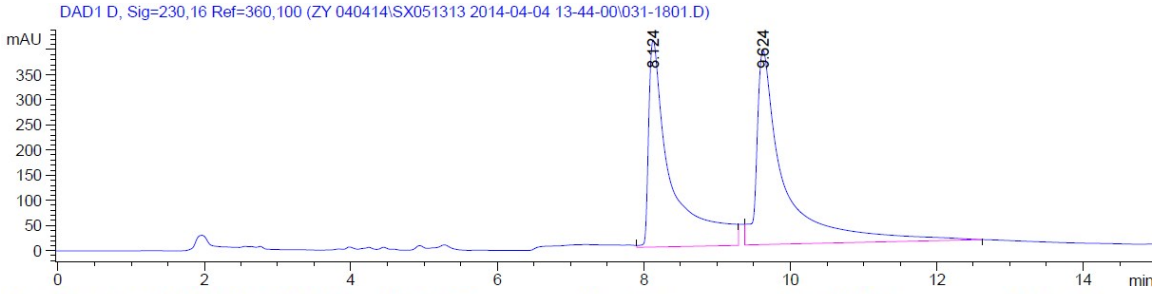

**(*S*)-5** (>99.9%ee)



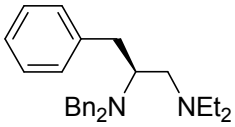

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 9.375 | BB | 0.3229 | 1.43263e4 | 635.74078 | 100.0000 |



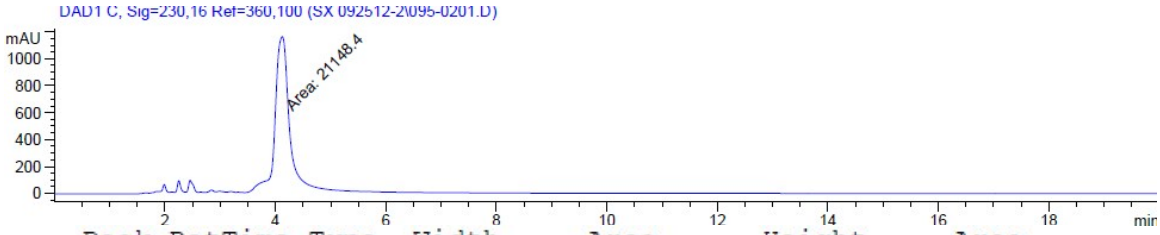

**(*rac*)-5**



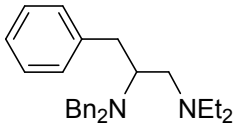

| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 8.124 | VB | 0.2914 | 8827.23340 | 413.00711 | 46.2904 |
| 2 | 9.624 | BB | 0.3580 | 1.02420e4 | 387.95532 | 53.7096 |



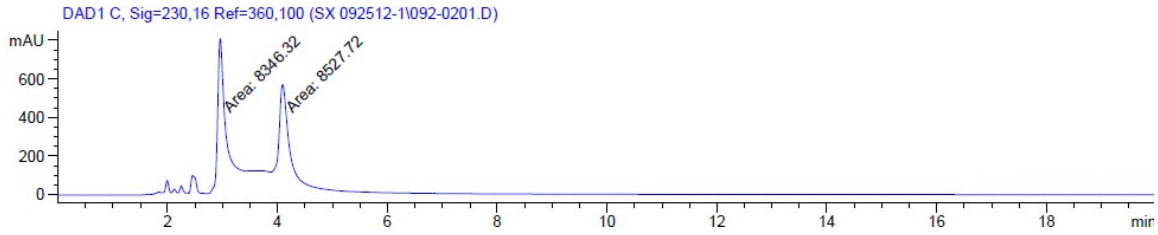

**(S)-6** (>99.9%ee)




| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 4.119 | MM | 0.3053 | 2.11484e4 | 1154.62183 | 100.0000 |




**(*rac*)-6**

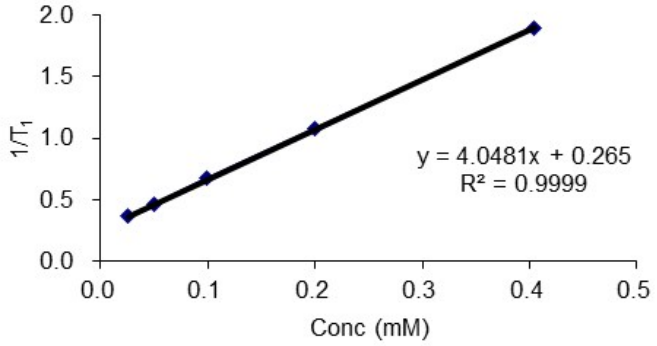



| Peak # | RetTime [min] | Type | Width [min] | Area [mAU*s] | Height [mAU] | Area % |
|---|---|---|---|---|---|---|
| 1 | 2.951 | MM | 0.1717 | 8346.31543 | 810.20258 | 49.4625 |
| 2 | 4.088 | MM | 0.2559 | 8527.71582 | 555.37018 | 50.5375 |

## III. T1 relaxivity of Gd(Bn-DTPA) complexes and ICP-MS measurement

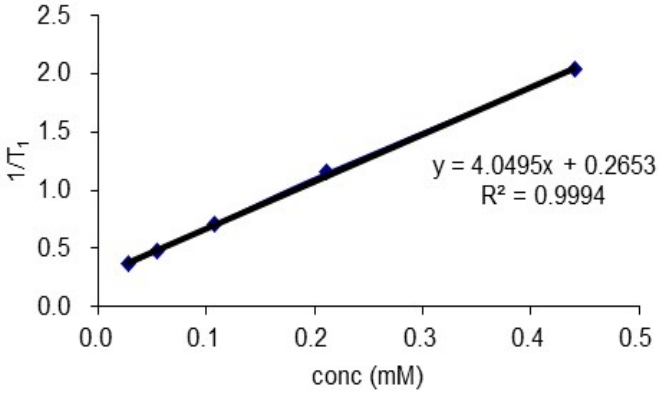
### Gd(III)-(*S*)-Bn-DTPA

| conc (mM) | T1 (sec) | 1/T1 | delay time (sec) |
|---|---|---|---|
| 0.404 | 0.527 | 1.898 | 3 |
| 0.199 | 0.928 | 1.078 | 5 |
| 0.098 | 1.490 | 0.671 | 10 |
| 0.050 | 2.160 | 0.463 | 15 |
| 0.026 | 2.750 | 0.364 | 15 |




### Gd(III)-(*R*)-Bn-DTPA

| conc (mM) | T1 (sec) | 1/T1 | delay time (sec) |
|---|---|---|---|
| 0.441 | 0.491 | 2.037 | 3 |
| 0.212 | 0.869 | 1.151 | 5 |
| 0.107 | 1.423 | 0.703 | 10 |
| 0.055 | 2.080 | 0.481 | 15 |
| 0.027 | 2.750 | 0.364 | 15 |



**Gd(III)-(*rac*)-Bn-DTPA**

| conc. (mM) | T1 (sec) | 1/T1 | delay time (sec) |
|---|---|---|---|
| 0.430 | 0.513 | 1.949 | 3 |
| 0.212 | 0.901 | 1.110 | 5 |
| 0.105 | 1.459 | 0.686 | 10 |
| 0.052 | 2.130 | 0.469 | 15 |
| 0.026 | 2.765 | 0.362 | 15 |