

## Supplementary Material

**Organocatalytic Asymmetric Synthesis of Oxazolidino Spiropyrazolinones via N,O-acetalization/aza Michael addition domino reaction between N-Boc pyrazolinone ketimines and  $\gamma$ -hydroxyenones.**

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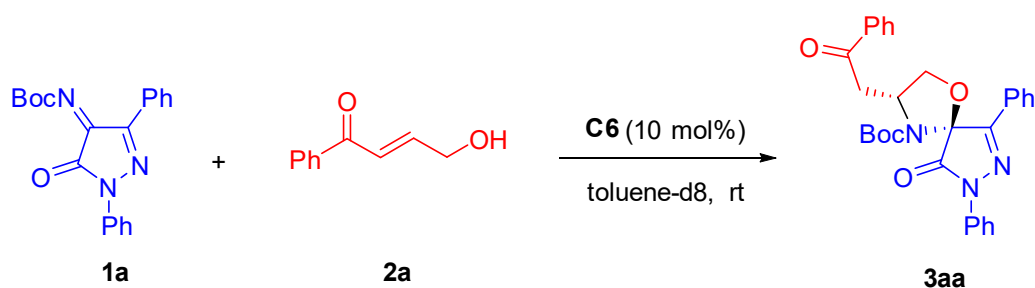
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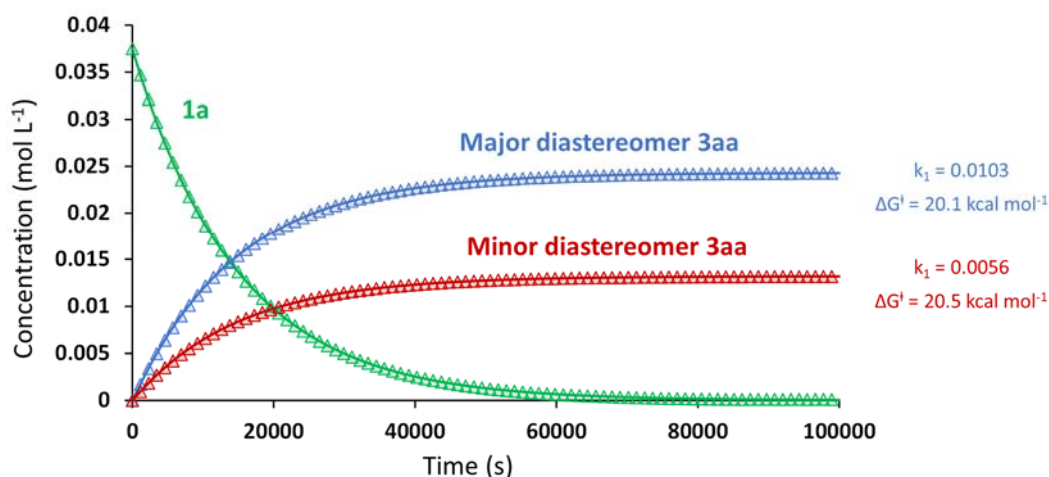
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## 1. <sup>1</sup>H-NMR based kinetic experiment.



The catalyst **C6** (1.9 mg, 0.003 mmol, 0.1 equiv) and N-Boc ketimine **1a** (10 mg, 0.03 mmol) were added inside an NMR tube. Then, toluene-d8 (0.8 mL) was added before the NMR tube was cooled to -25°C. Hydroxyenone **2a** (7.3 mg, 0.045 mmol, 1.5 equiv.) was introduced to the tube. The tube was closed and then, taken out of the cool bath, shaken until total dissolution of starting materials and transferred to the NMR probe.



**Figure ES11.** <sup>1</sup>H-NMR monitoring of the reaction between N-Boc ketimine **1a** and hydroxyenone **2a** at room temperature. Lines represent kinetic fitting of data using COPASI software<sup>1</sup>.

Parameter	Value
$k_1$	0.0103
$k_2$	0.0056

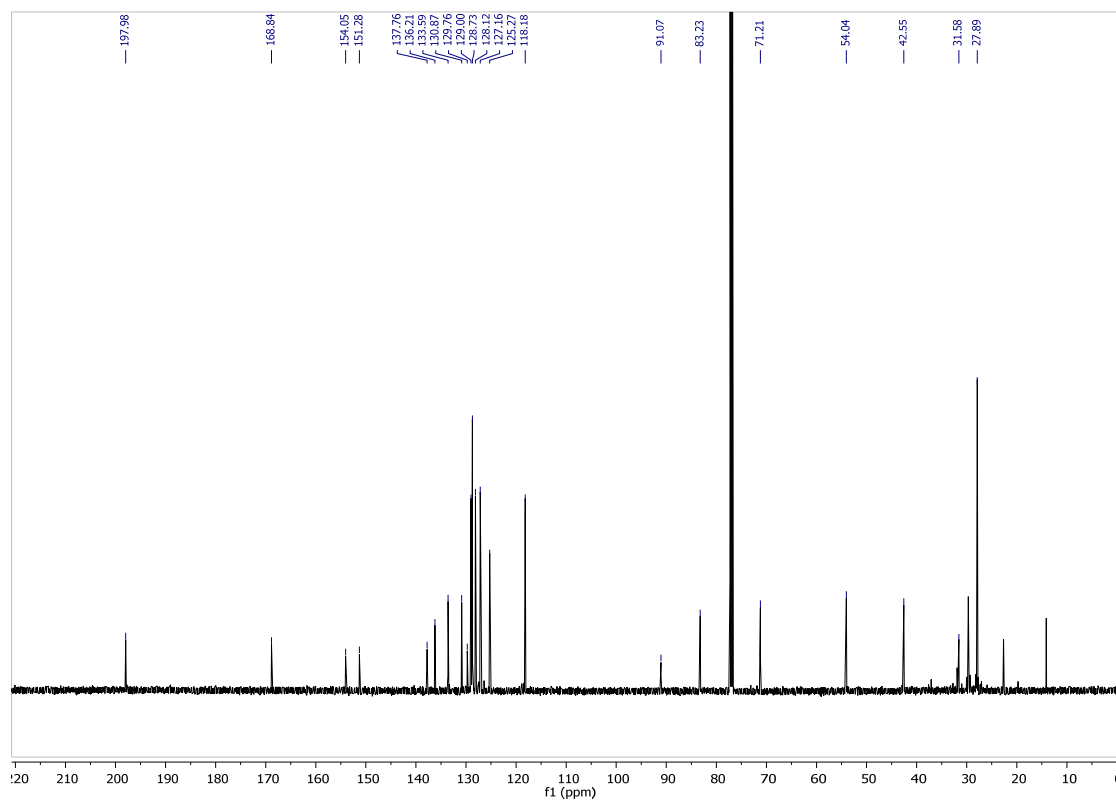
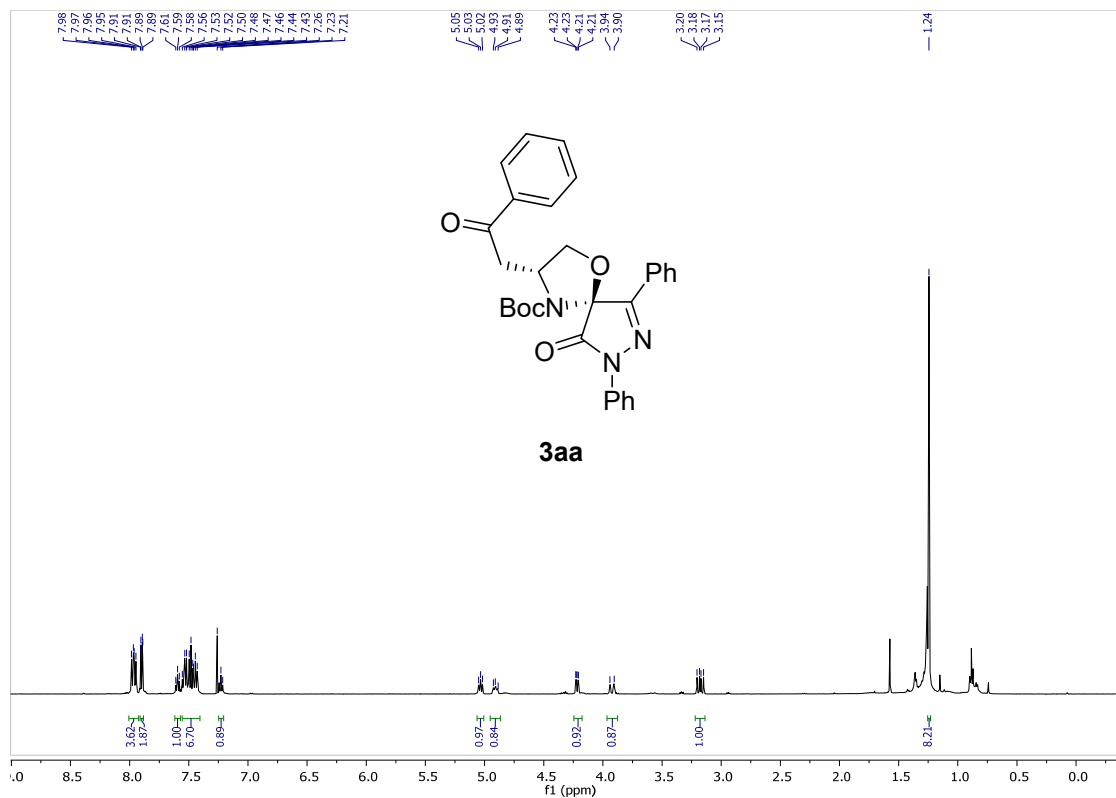
**Table ES11:** Values of kinetic simulations constants.

<sup>1</sup> S. Hoops, S. Sahle, R. Gauges, C. Lee, J. Pahle, N. Simus, M. Singhal, L. Xu, P. Mendes, U. Kummer *Bioinformatics*, **2006**, *22*, 3067-74.

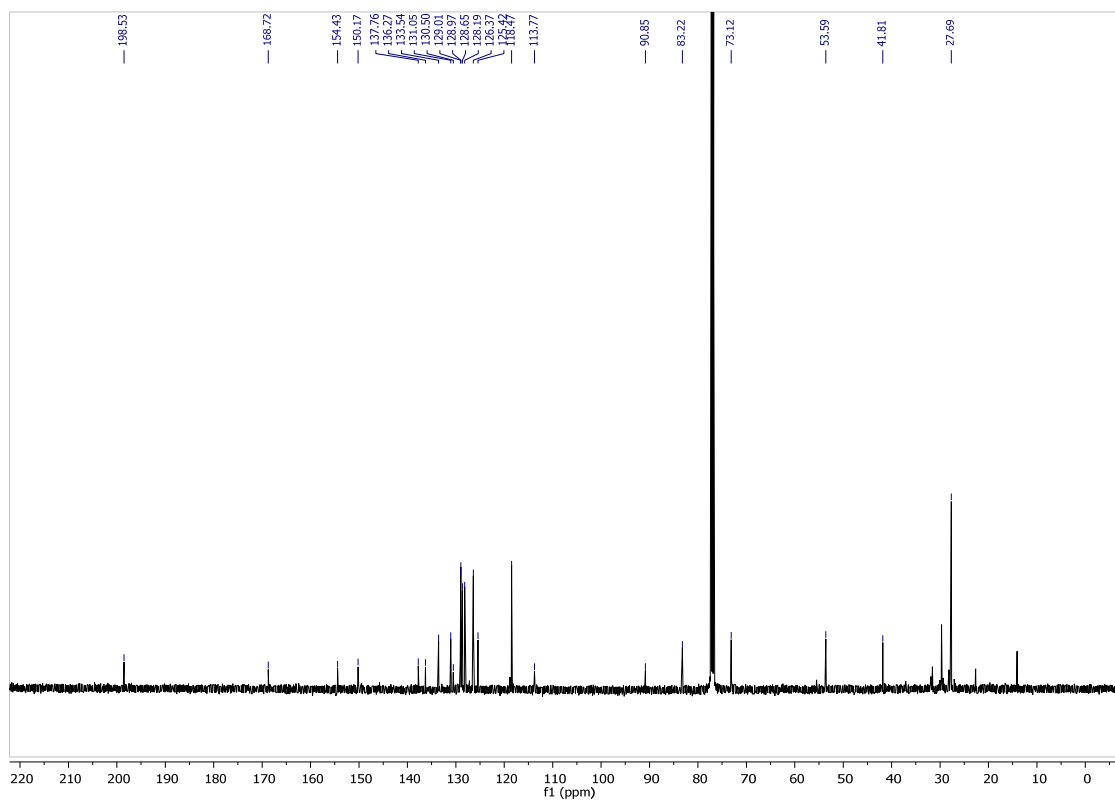
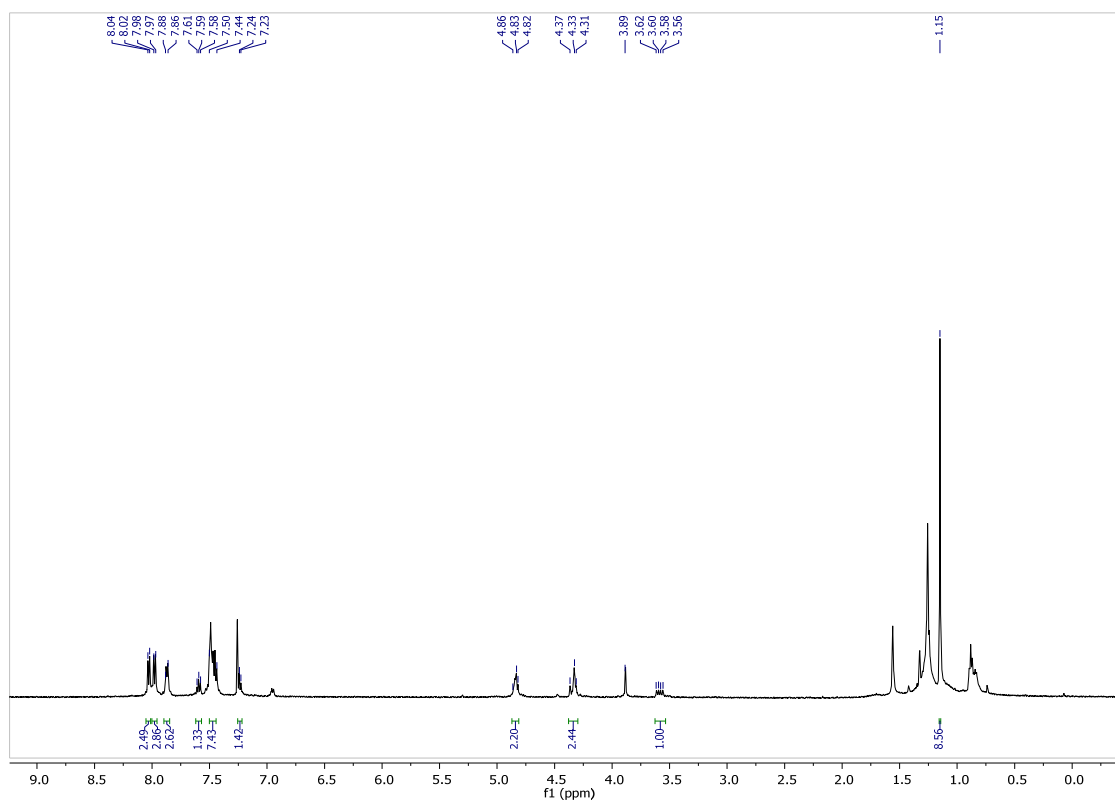
## 2. NMR Spectra for New Compounds.

*tert*-Butyl (3*R*,5*S*)-9-oxo-3-(2-oxo-2-phenylethyl)-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3aa).

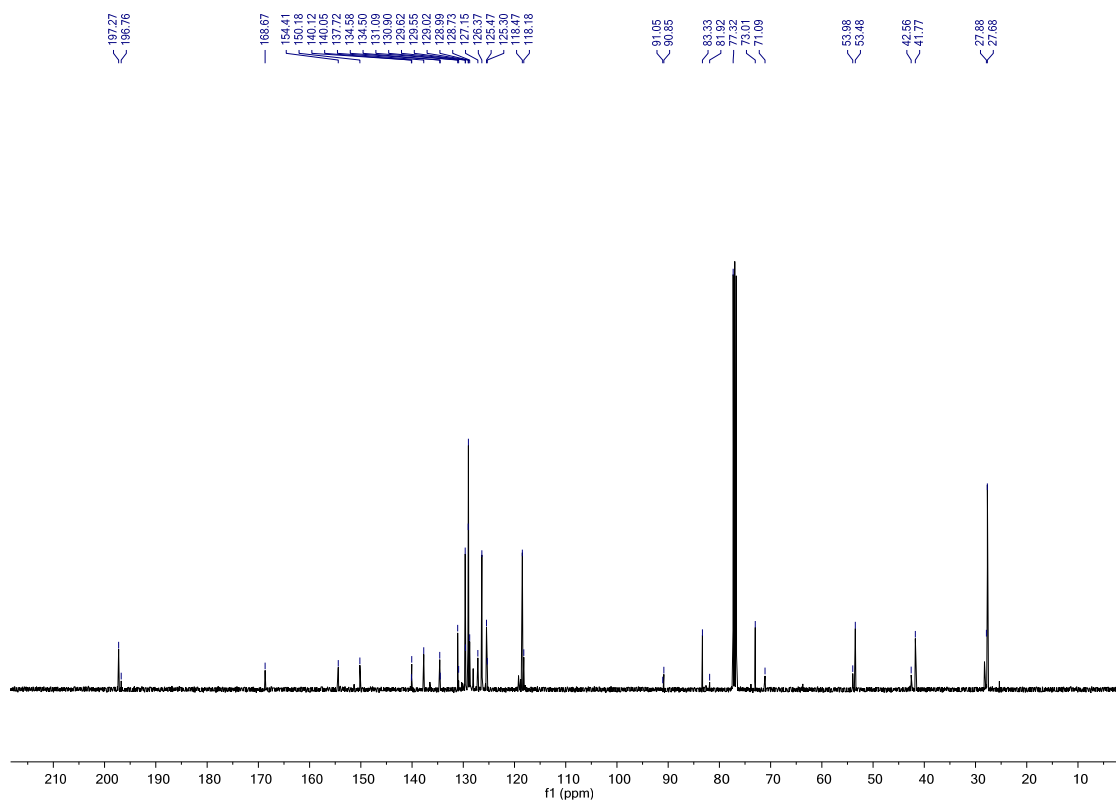
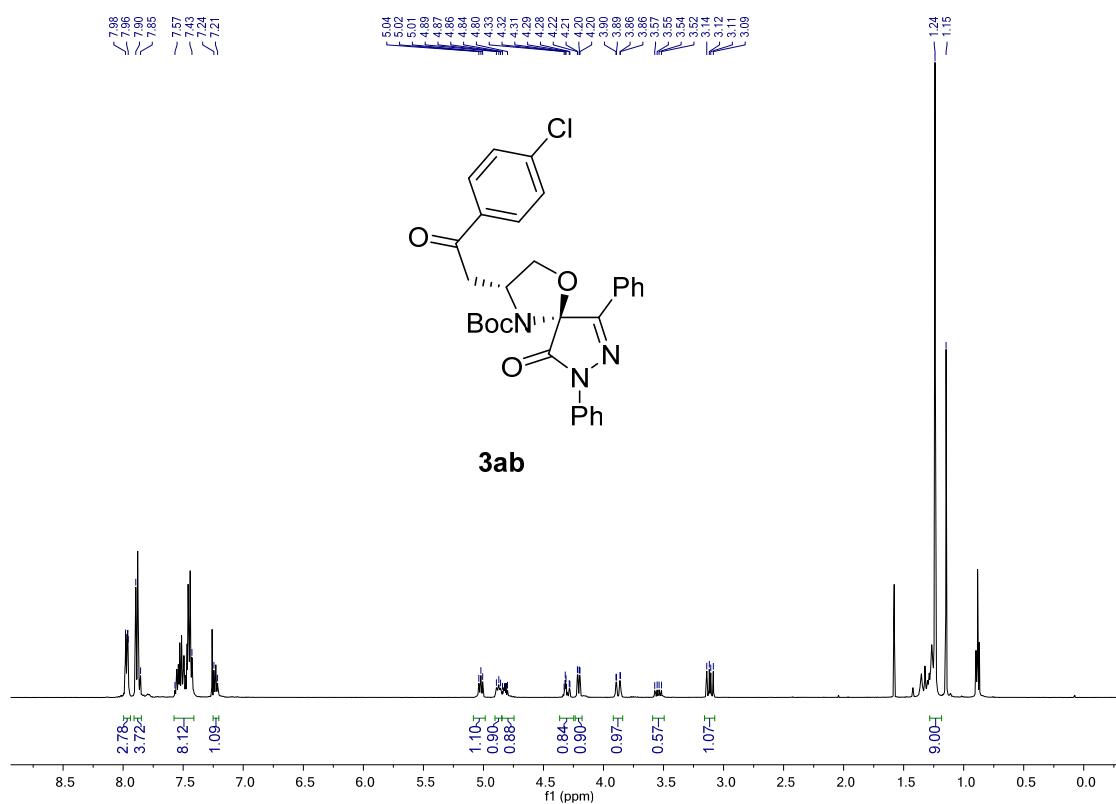
Major diastereomer



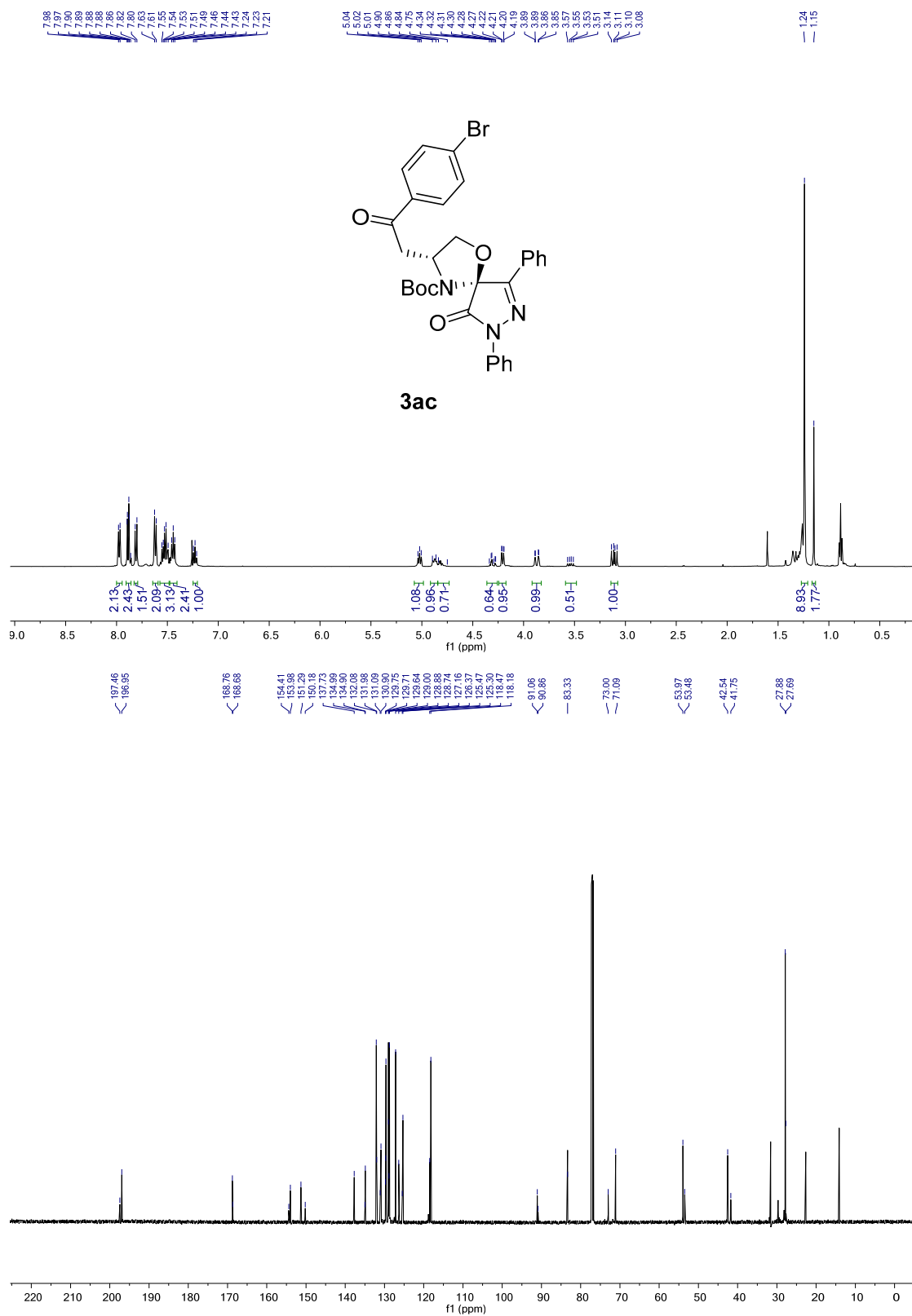
### Minor diastereomer (*epi*-3aa)



**tert-Butyl (3*R*,5*S*)-3-(2-(4-chlorophenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ab).**

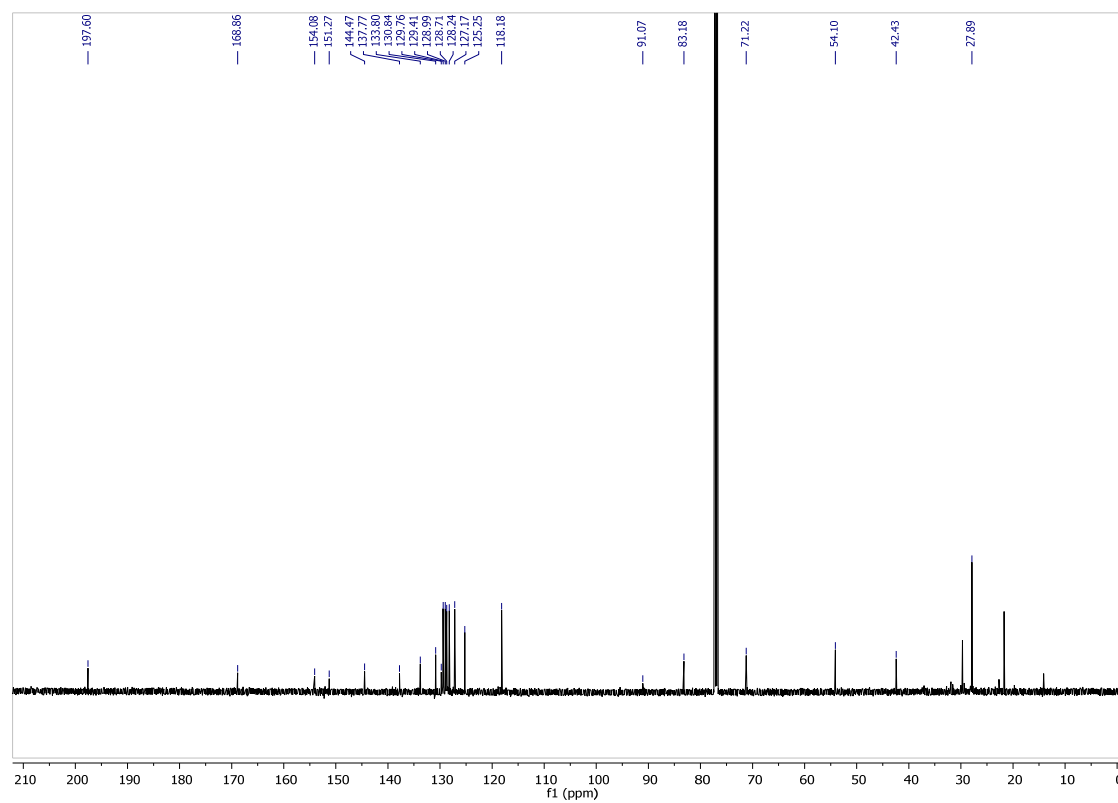
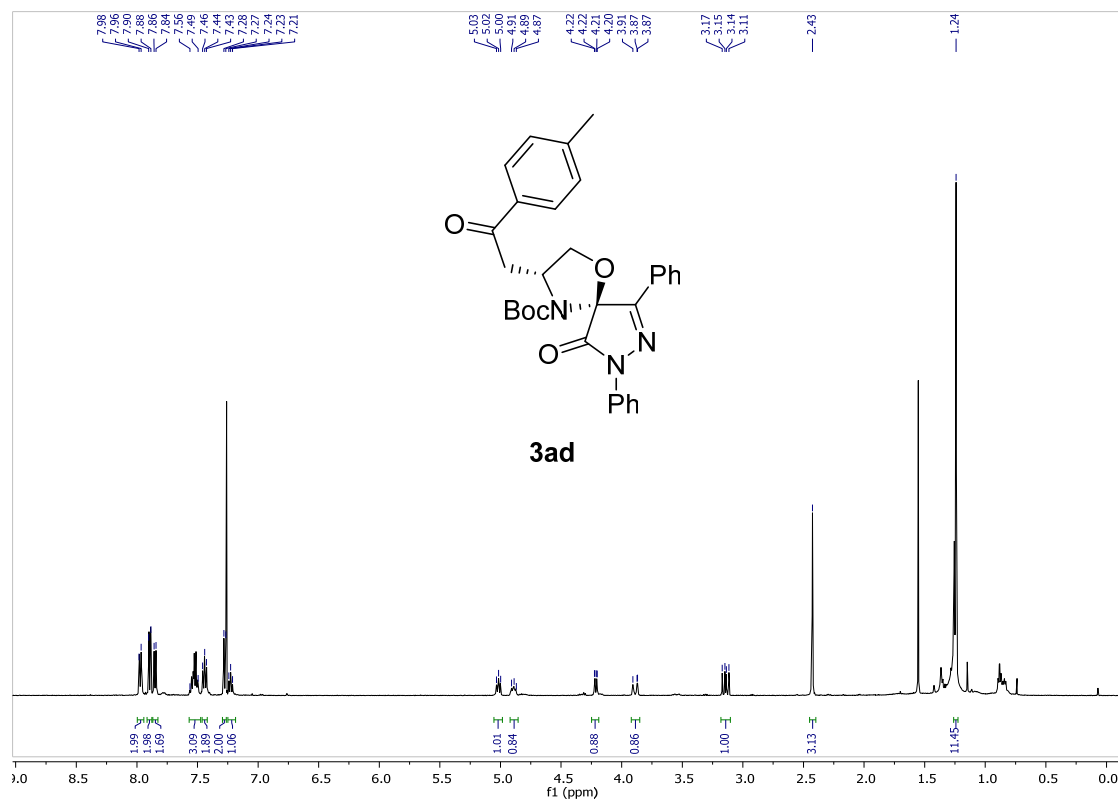


**tert-Butyl (3*R*,5*S*)-3-(2-(4-bromophenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3*c*).**

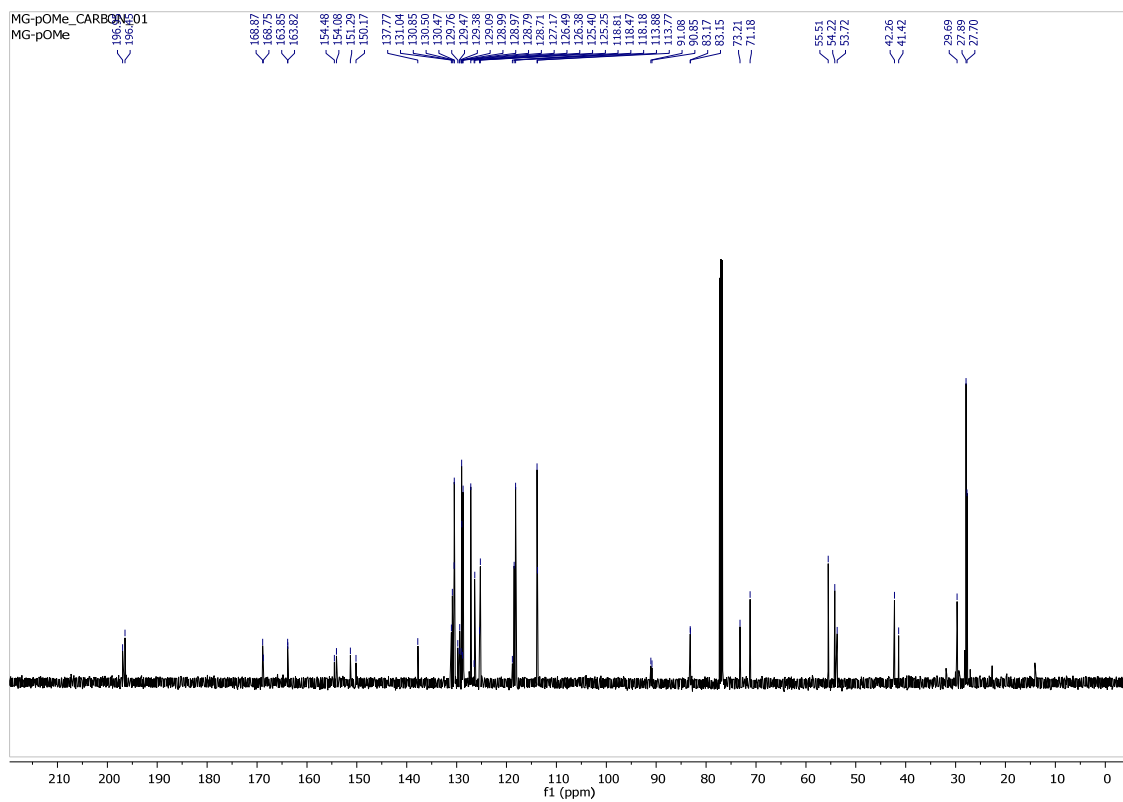
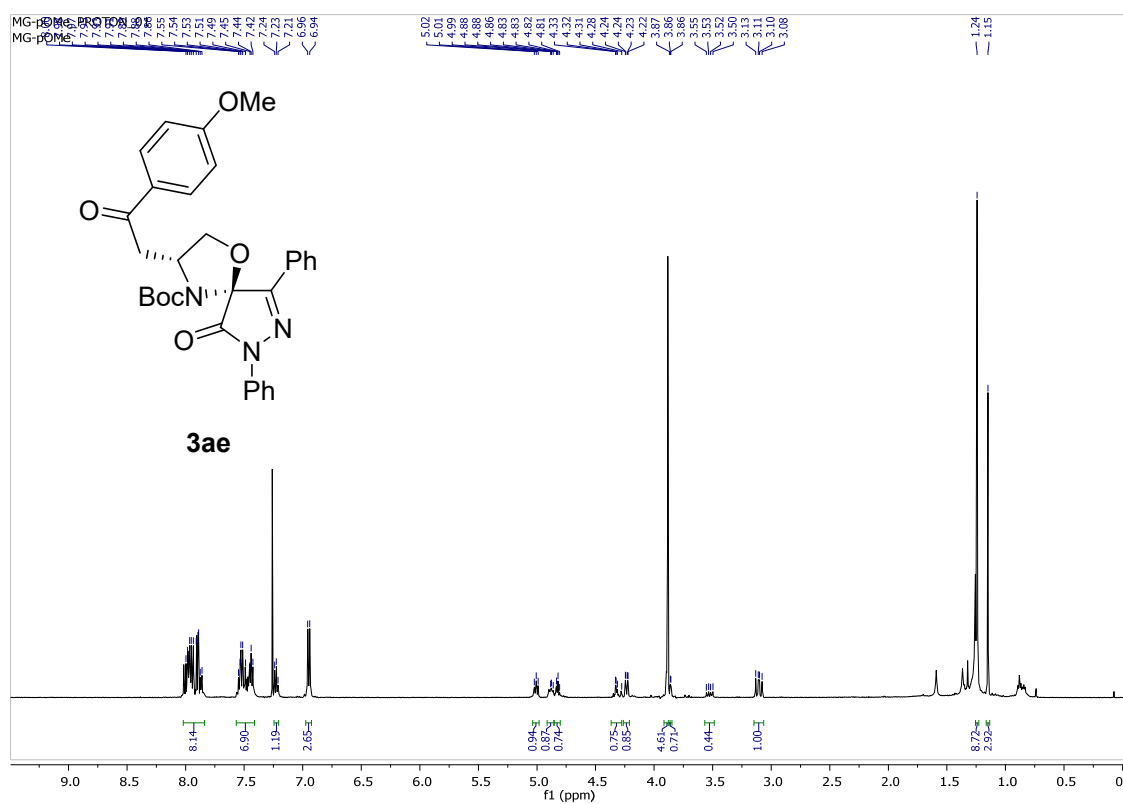


**tert-Butyl (3*R*,5*S*)-9-oxo-3-(2-oxo-2-(*p*-tolyl)ethyl)-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ad).**

**Major diastereomer**

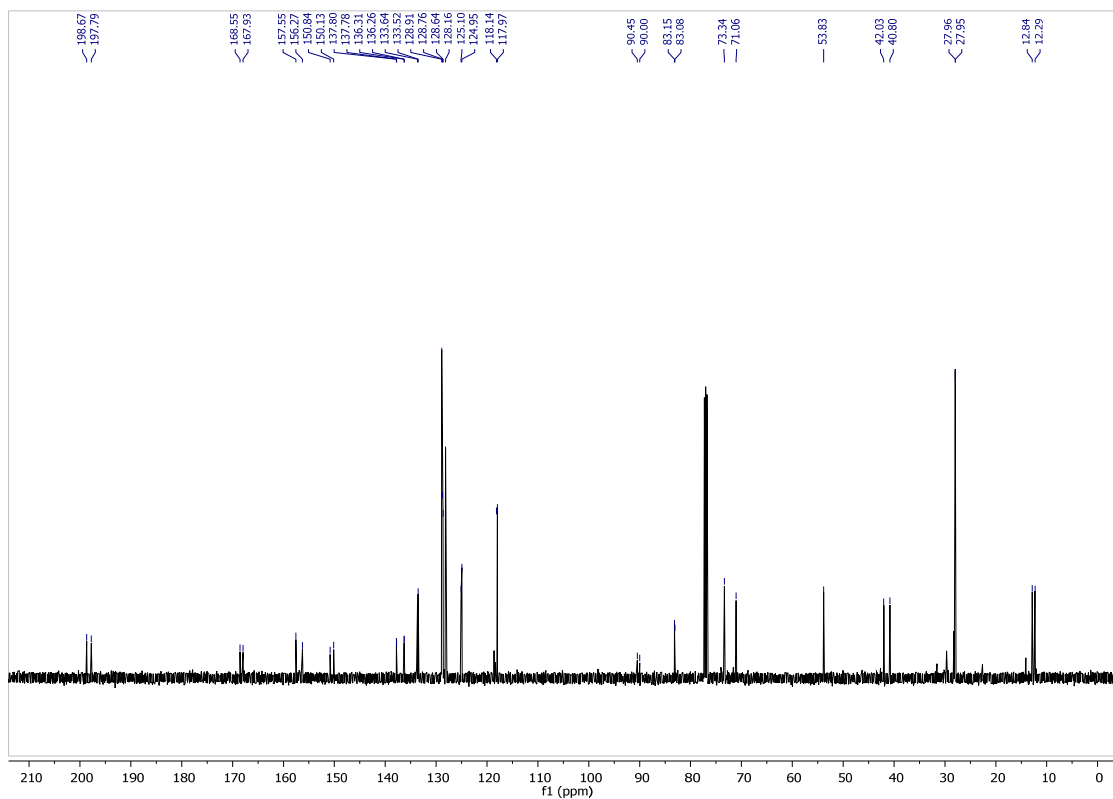
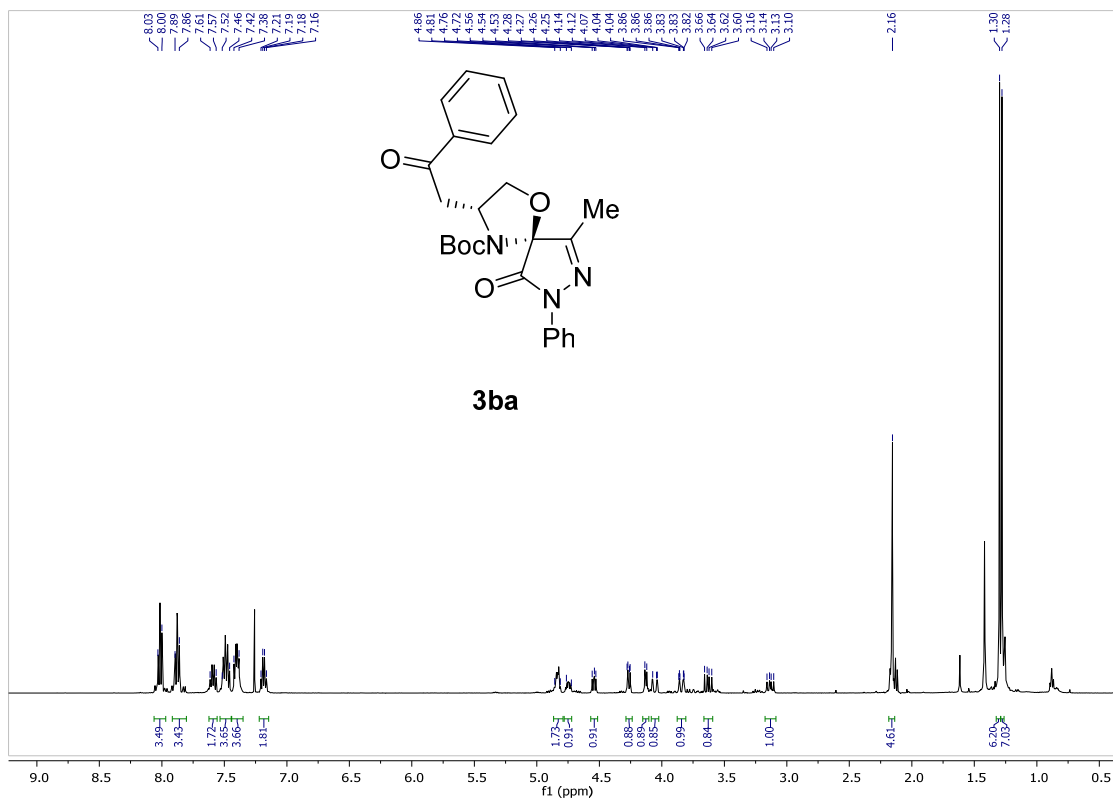


**tert-Butyl (3*R*,5*S*)-3-(2-(4-methoxyphenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ae).**

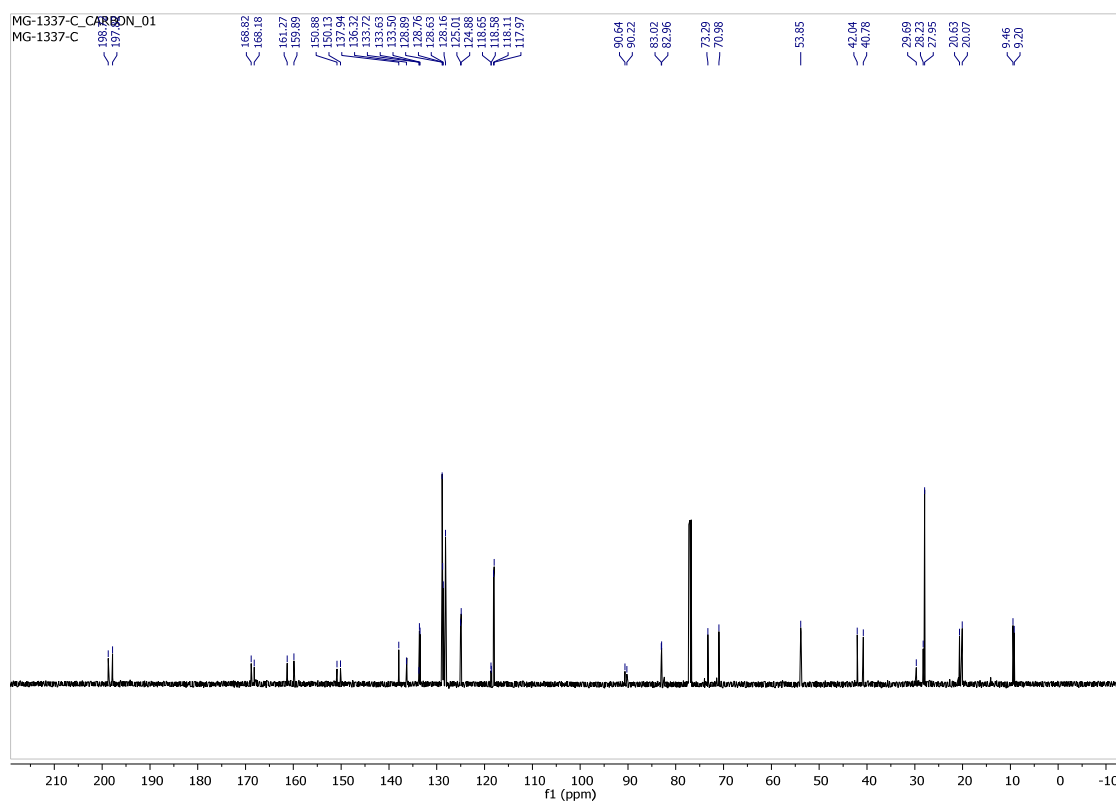
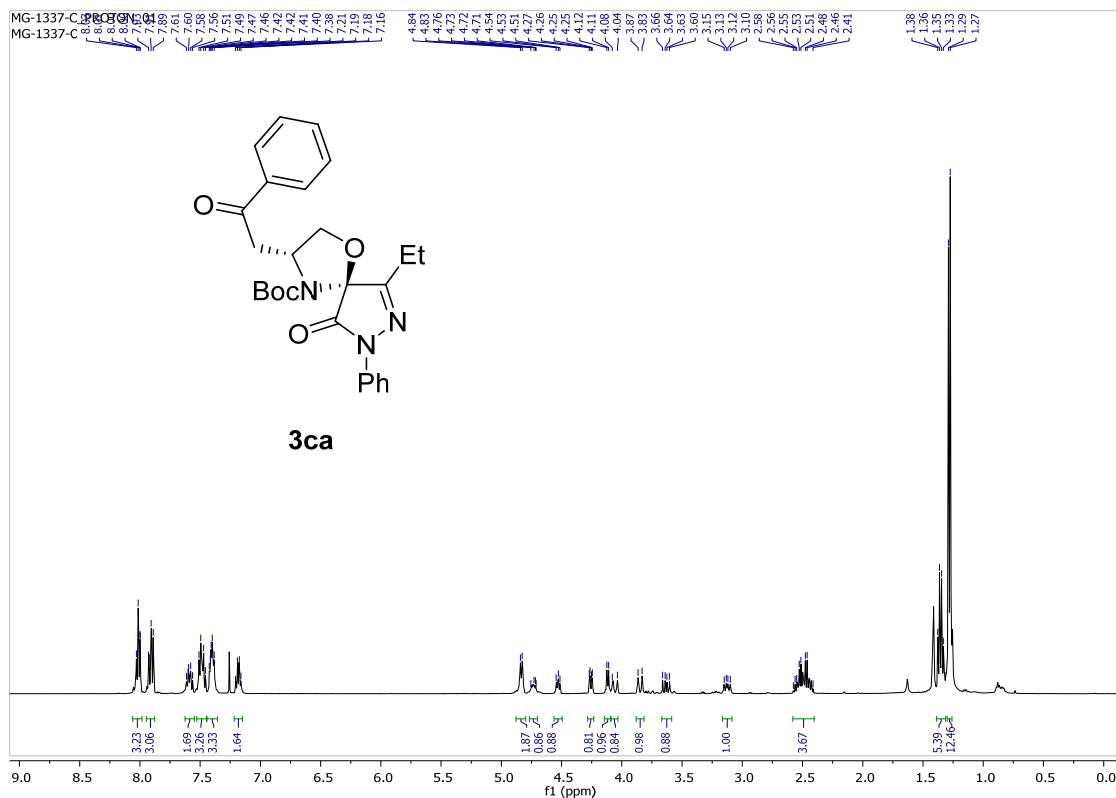




**tert-Butyl (3*R*,5*S*)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ba).**

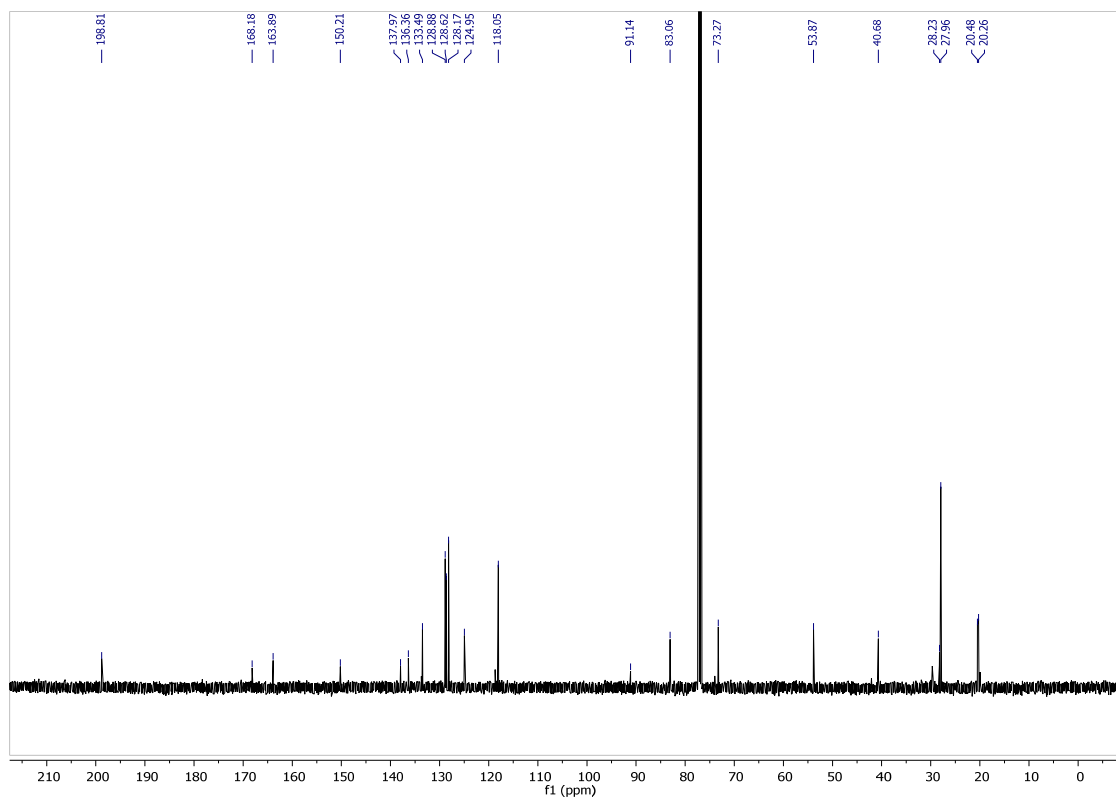
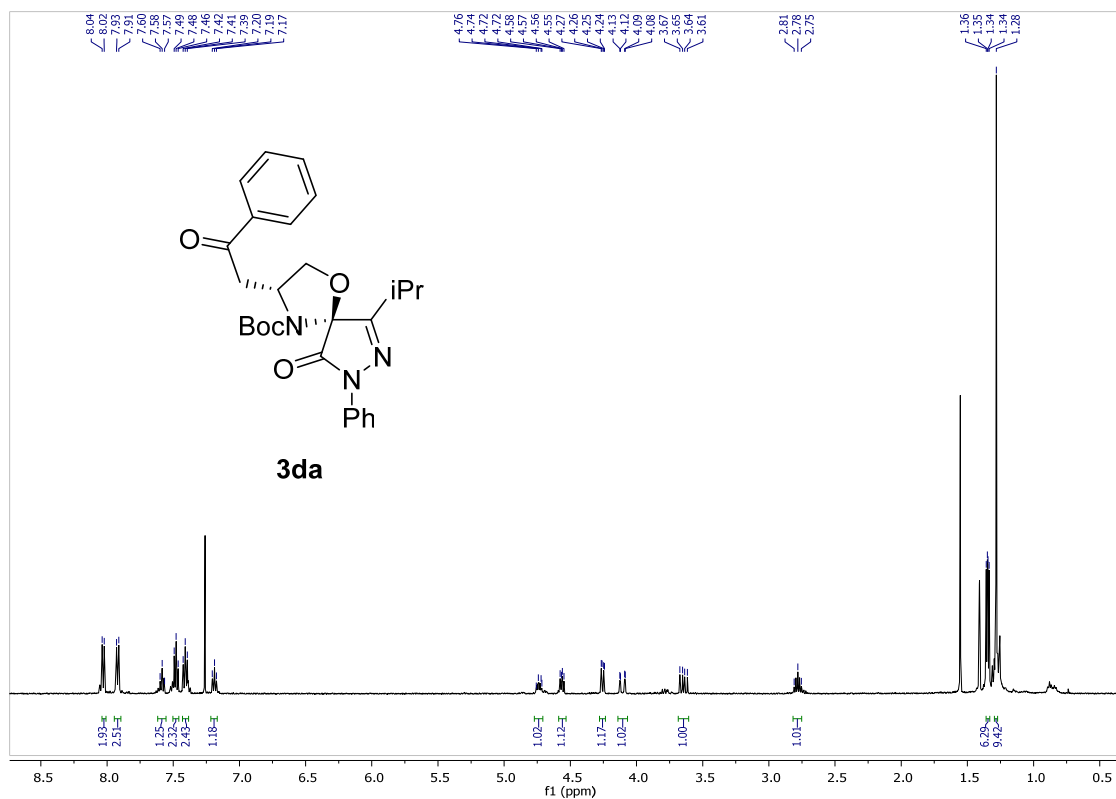


**tert-Butyl (3*R*,5*S*)-6-ethyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ca).**

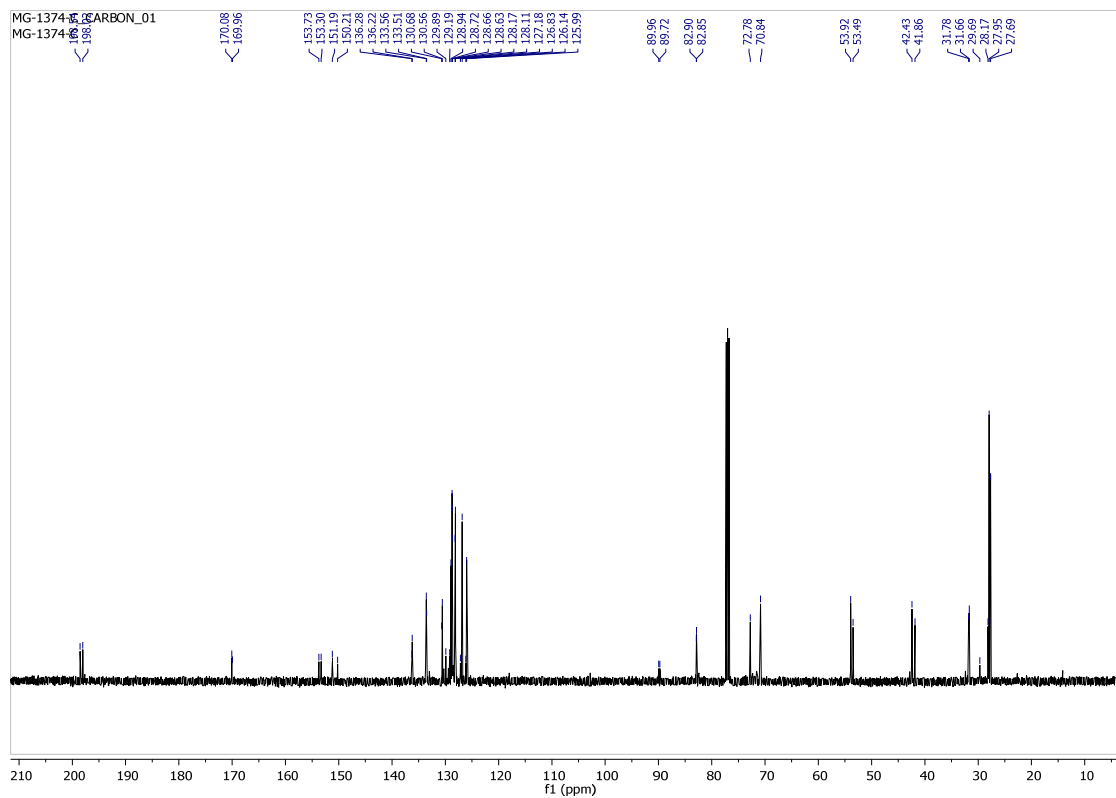
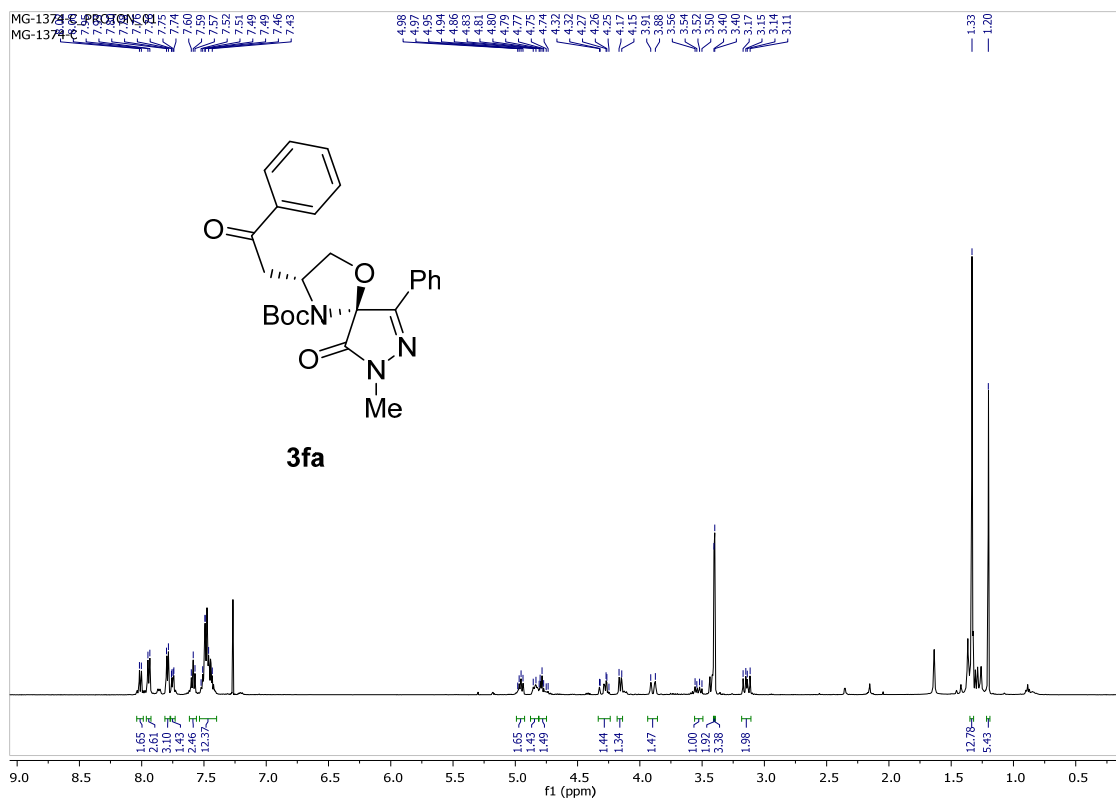


**tert-Butyl (3*R*,5*S*)-6-isopropyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3da).**

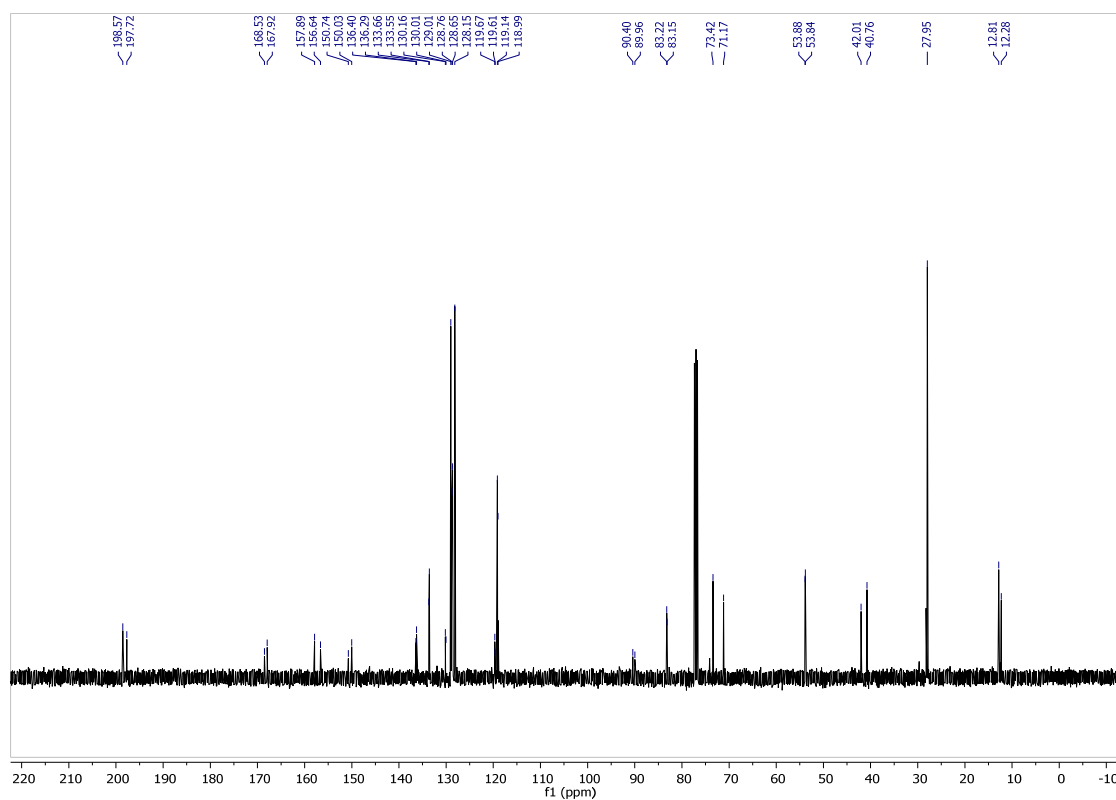
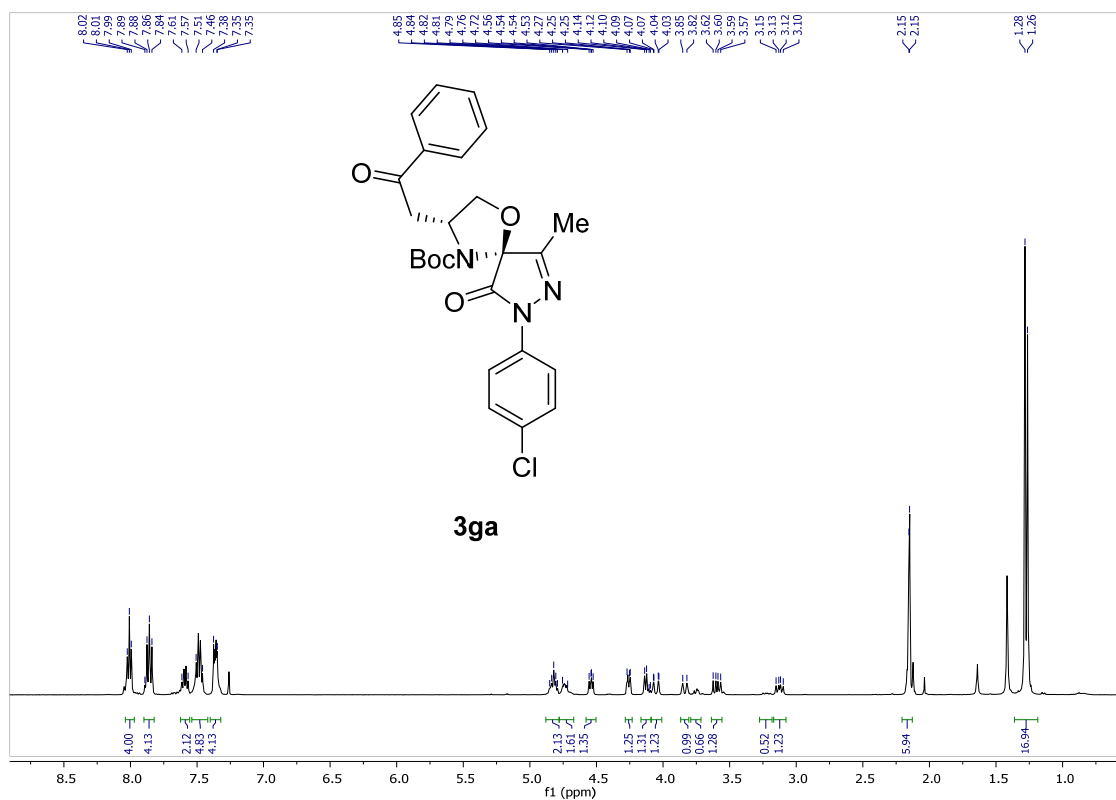
**Major diastereomer**



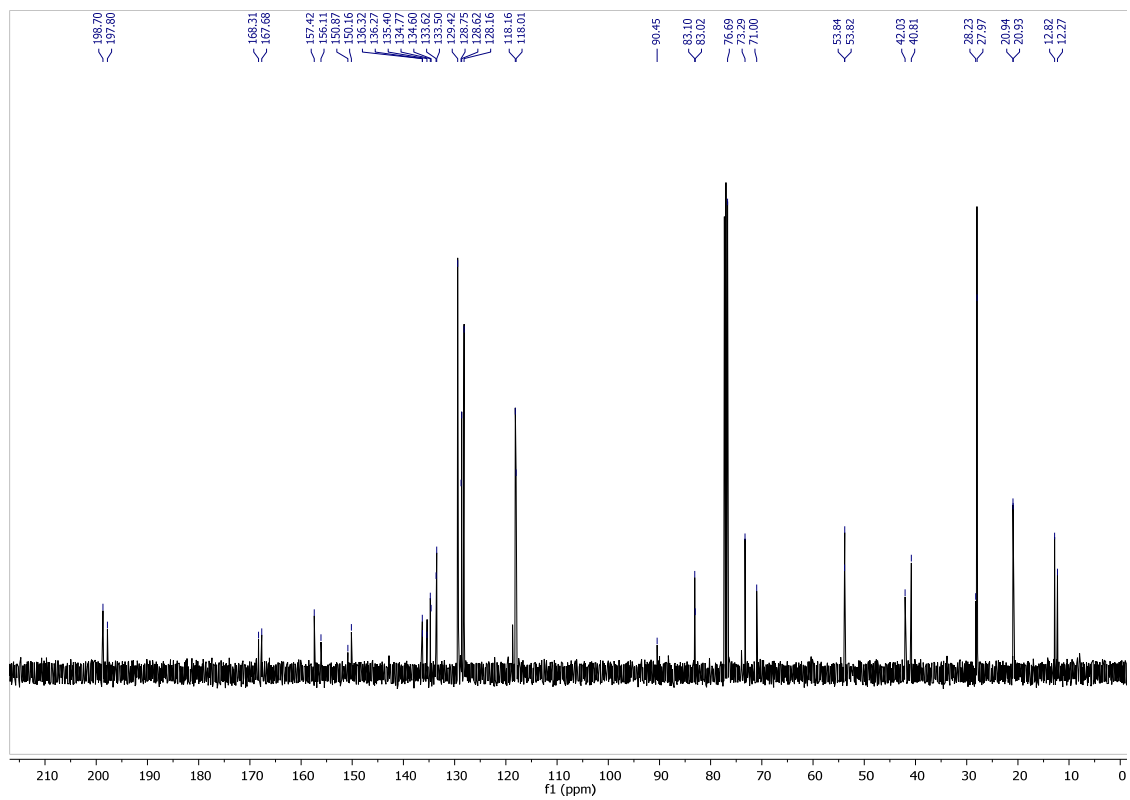
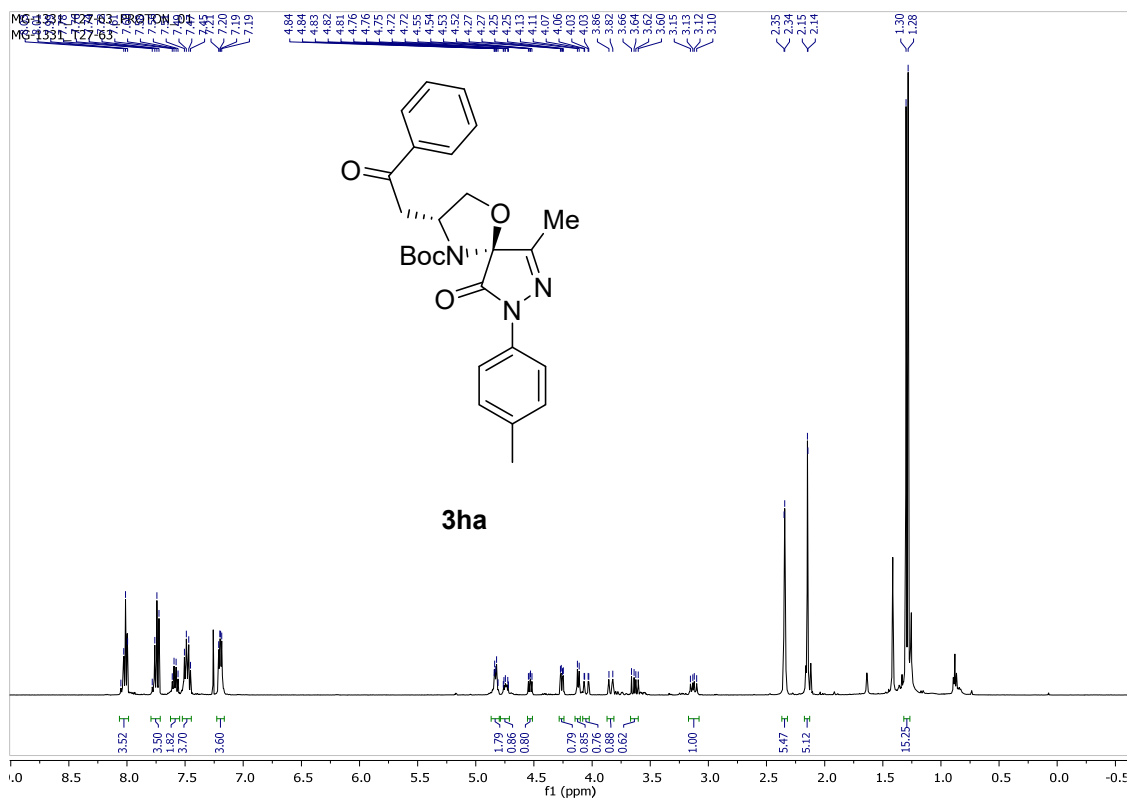
**tert-Butyl (3*R*,5*S*)-8-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-6-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3fa).**



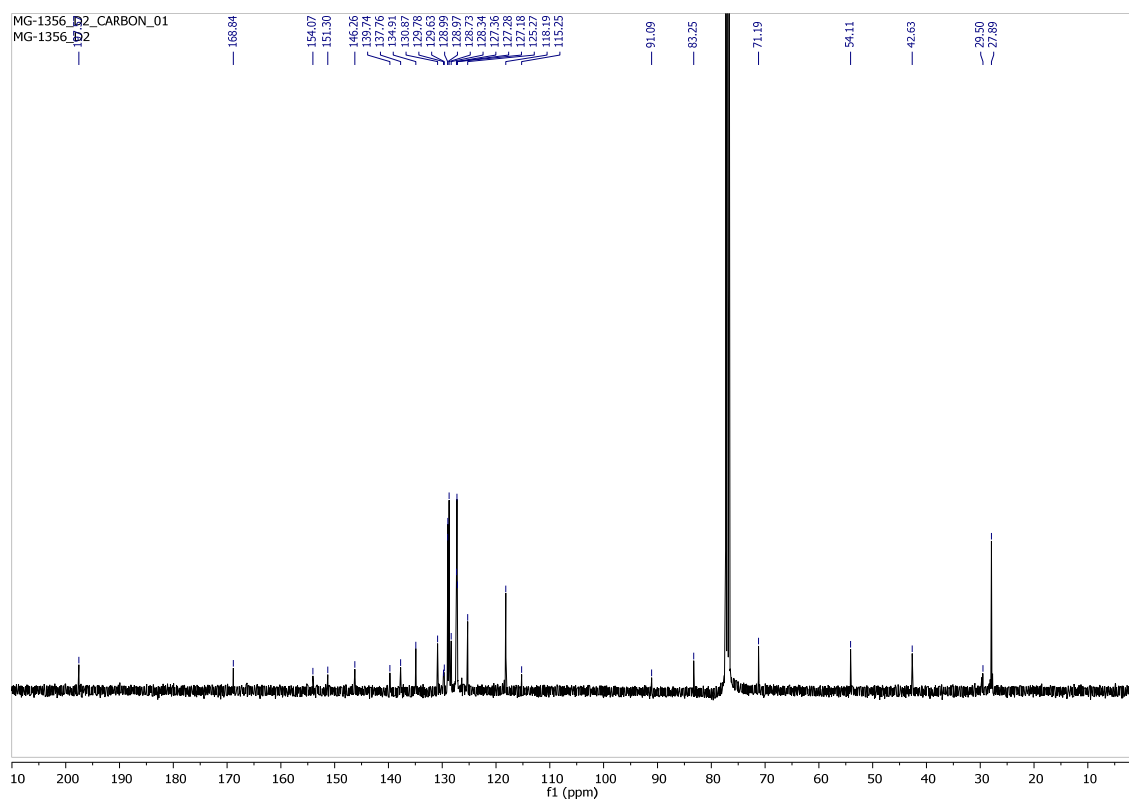
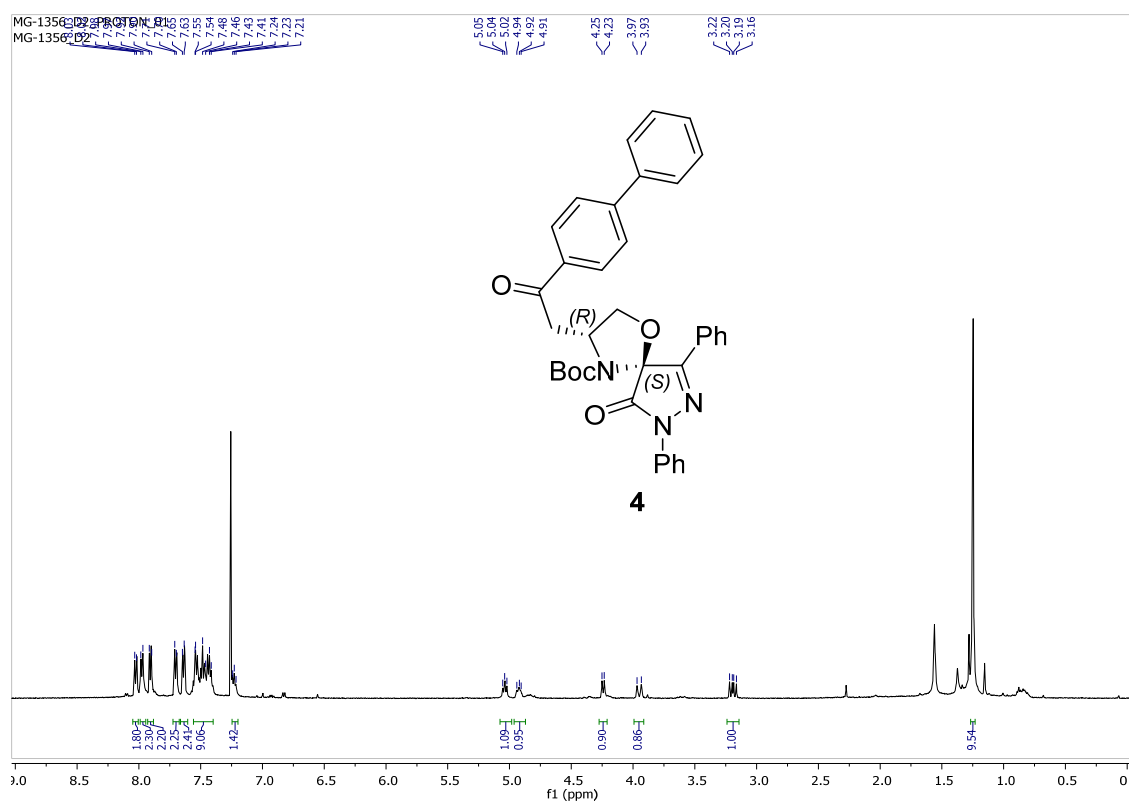
**tert-Butyl (3*R*,5*S*)-8-(4-chlorophenyl)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ga).**



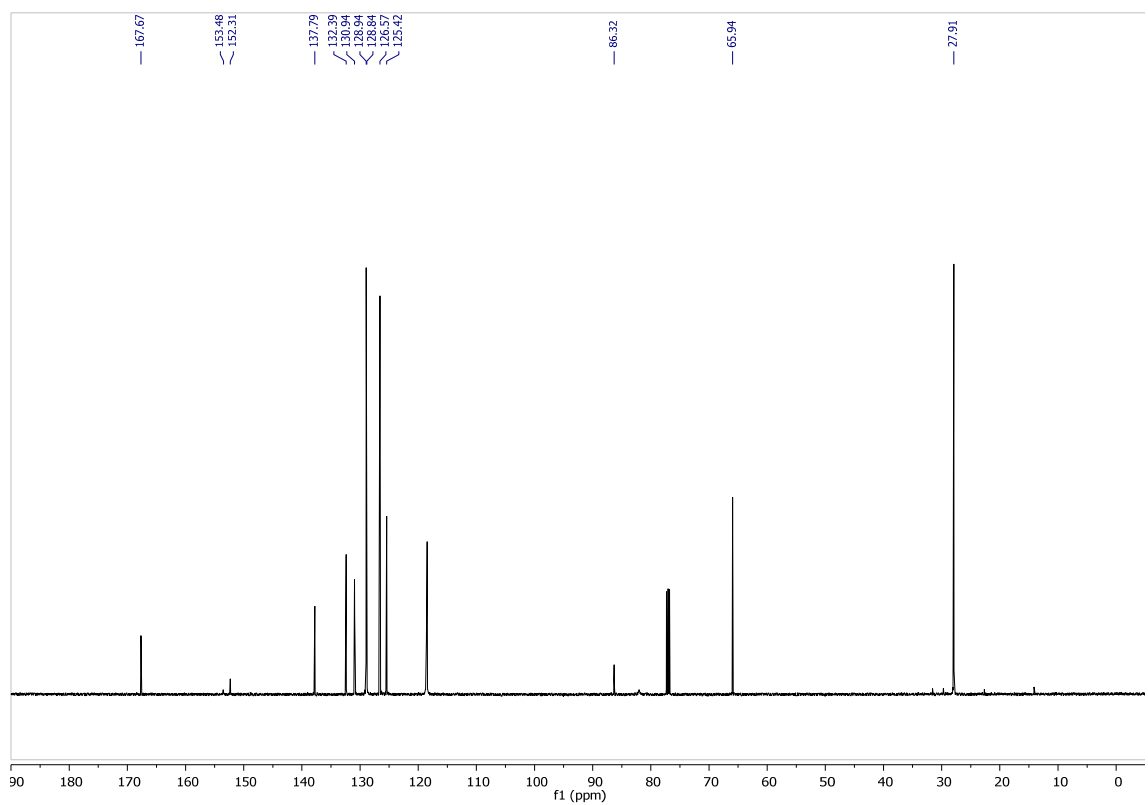
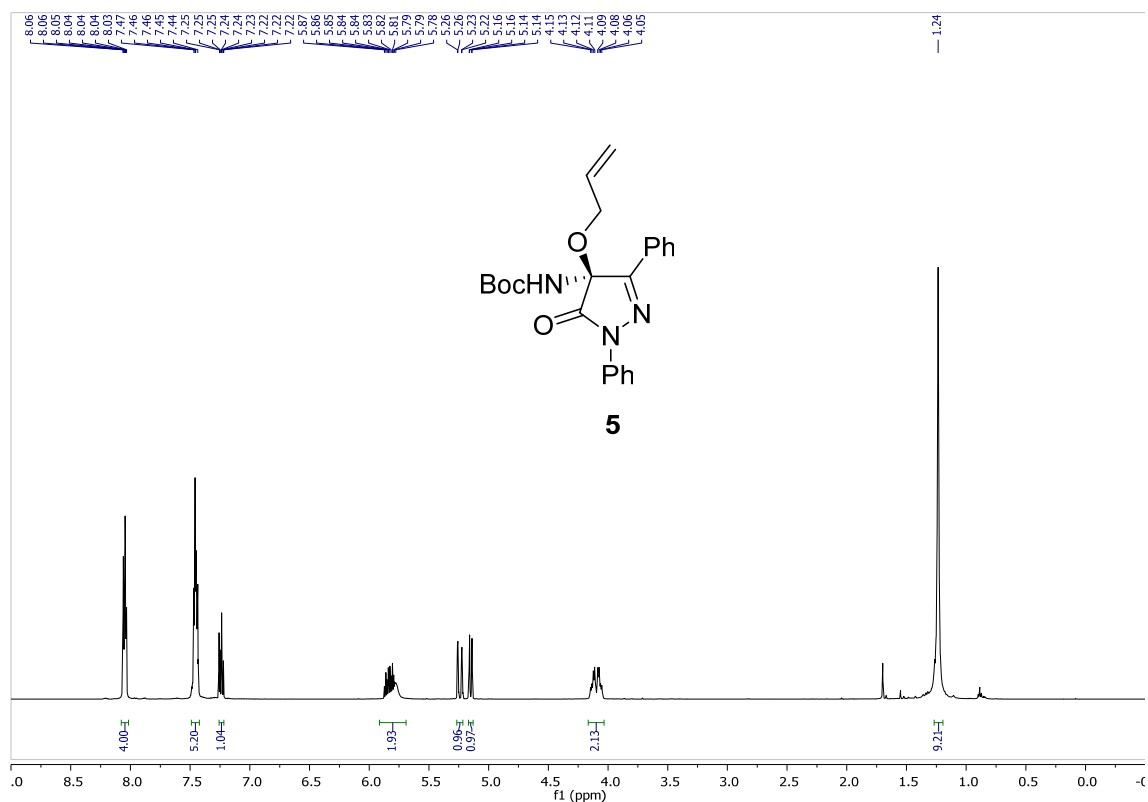
**tert-Butyl (3*R*,5*S*)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-(*p*-tolyl)-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ha).**



**tert-Butyl (3*R*,5*S*)-3-(2-([1,1'-biphenyl]-4-yl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (4).**

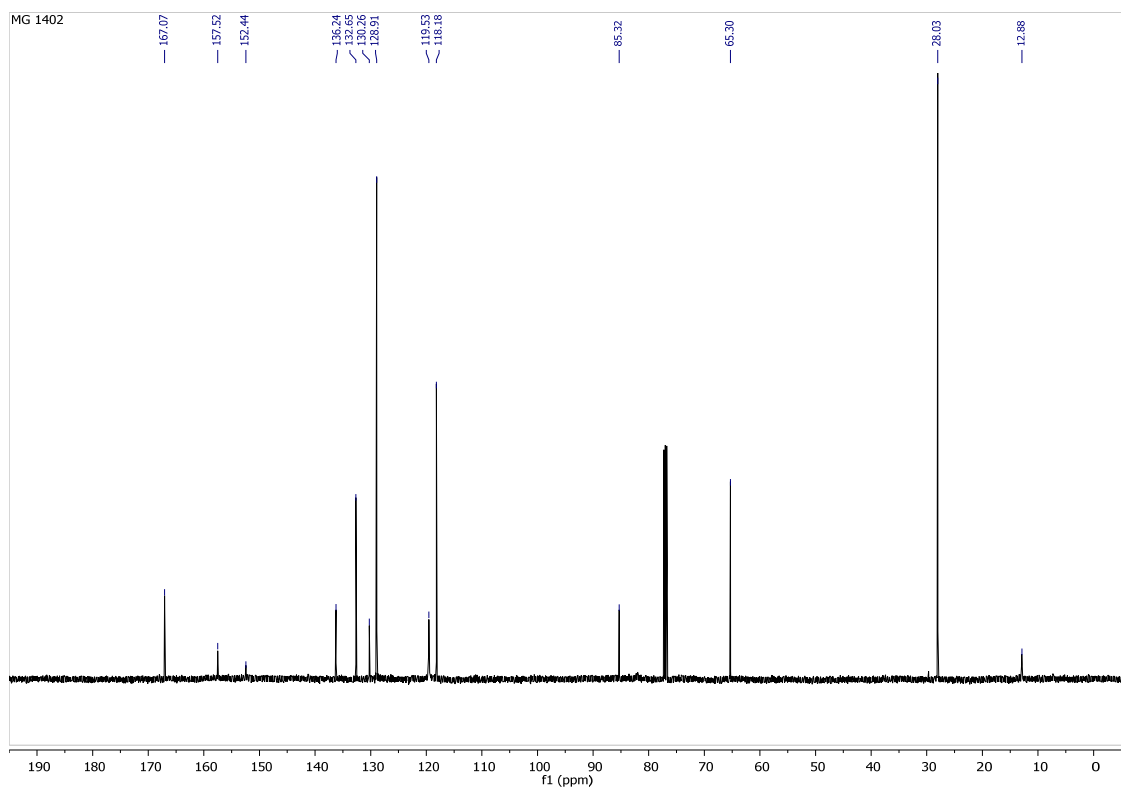
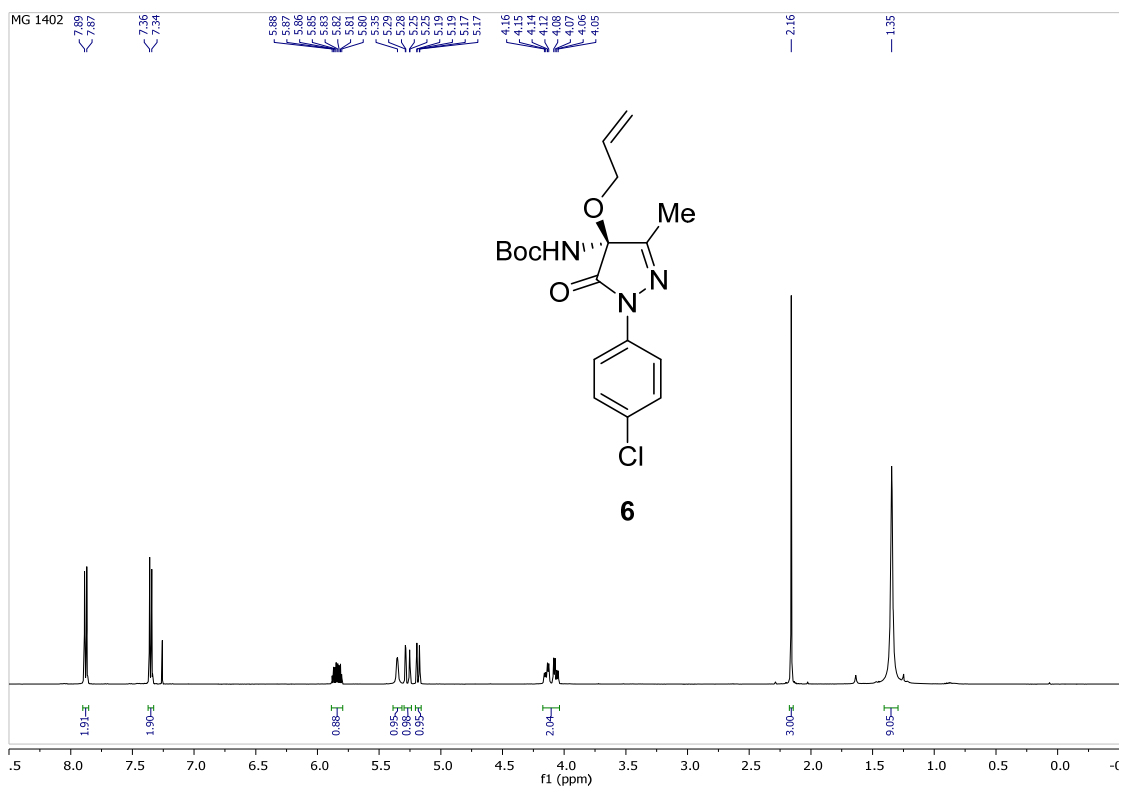


***tert*-Butyl (S)-(4-(allyloxy)-5-oxo-1,3-diphenyl-4,5-dihydro-1H-pyrazol-4-yl)carbamate**  
**(5).**





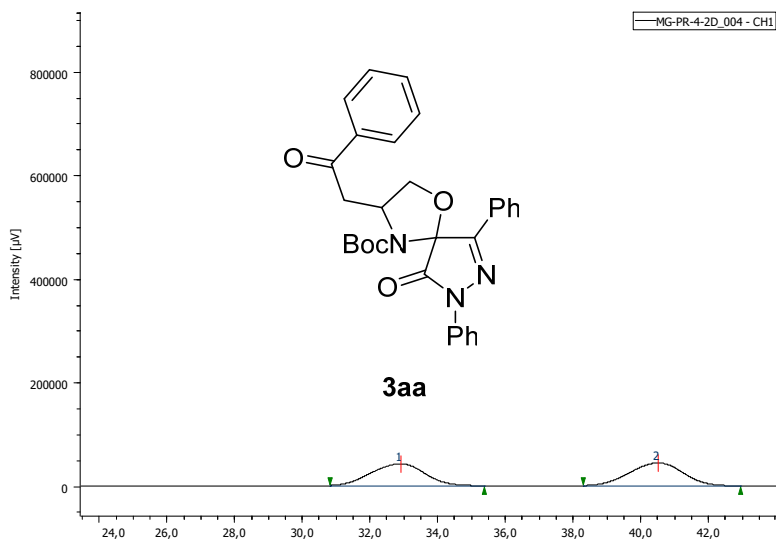
***tert*-Butyl (4-(allyloxy)-1-(4-chlorophenyl)-3-methyl-5-oxo-4,5-dihydro-1*H*-pyrazol-4-yl)carbamate (6).**



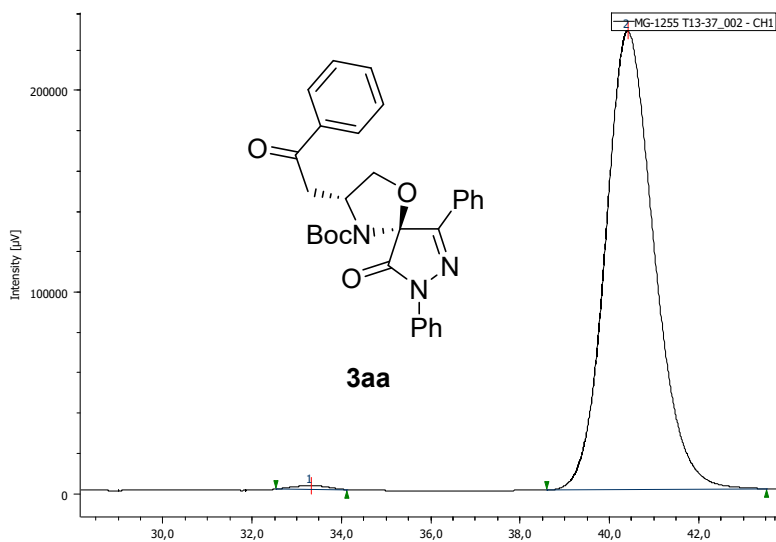
### 3. HPLC Profiles of the isolated compounds

*tert*-Butyl (3*R*,5*S*)-9-oxo-3-(2-oxo-2-phenylethyl)-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (**3aa**).

Major diastereomer (**3aa**).

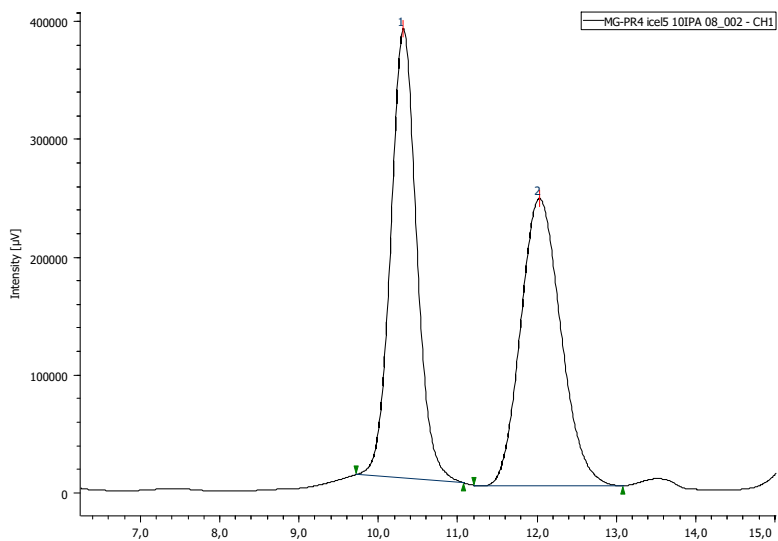


	t <sub>R</sub>	Area	Area%
1	32,900	4647038	48,855
2	40,492	4864824	51,145

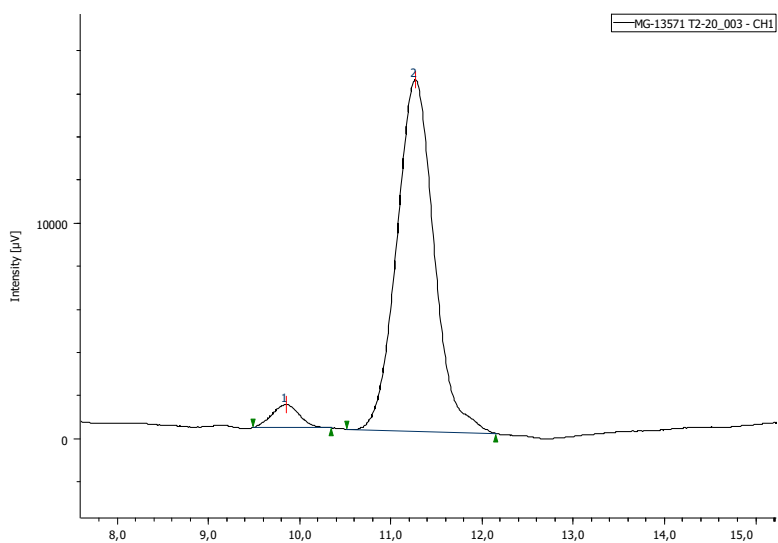


	t <sub>R</sub>	Area	Area%
1	33,317	101705	0,591
2	40,392	17108197	99,409

### Minor diastereomer (*epi*-3aa)

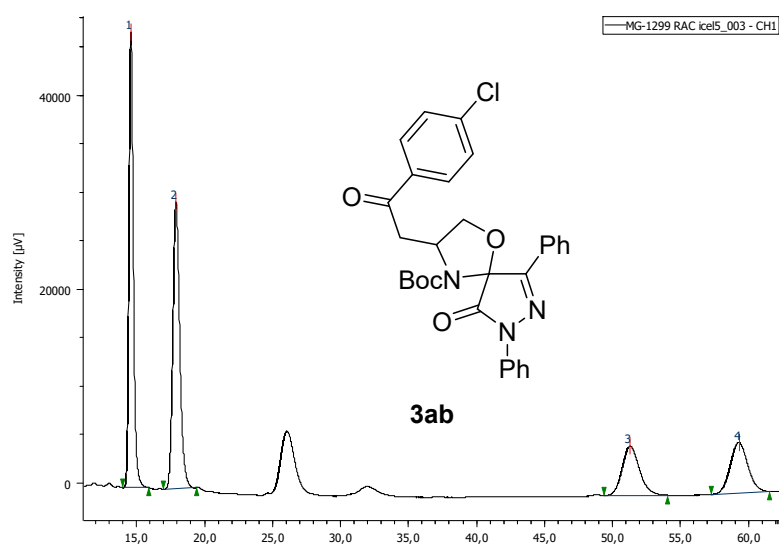


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	10,308	8644570	50,331
2	12,025	8530703	49,669

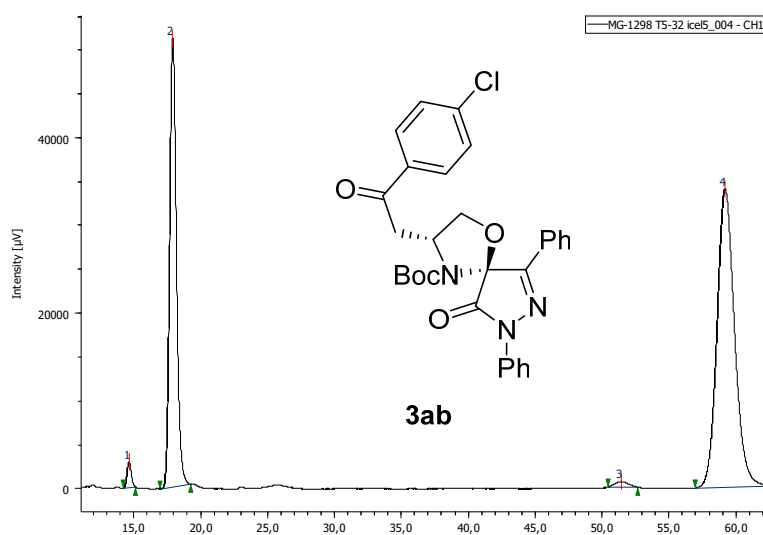


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	9,850	22699	4,678
2	11,267	462574	95,322

**tert-Butyl (3*R*,5*S*)-3-(2-(4-chlorophenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ab).**

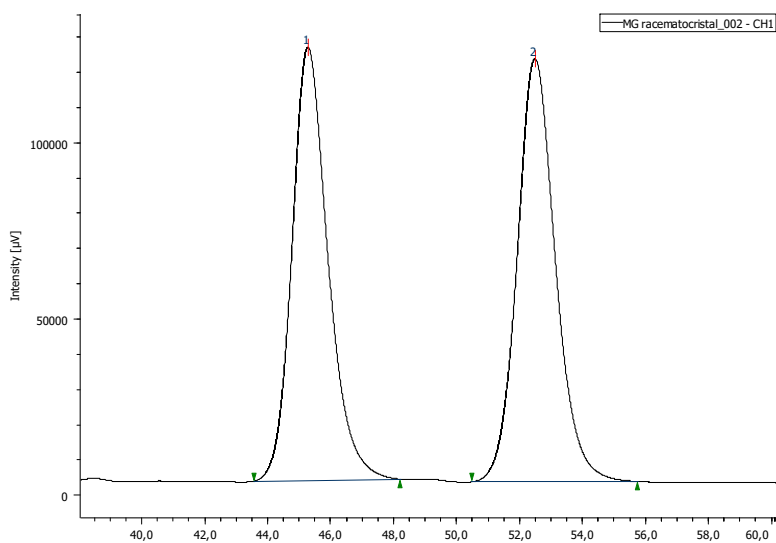


	$t_R$	Area	Area%
1	14,592	1066317	<b>35,164</b>
2	17,900	1051544	<b>34,676</b>
3	51,225	5066	<b>14,813</b>
4	59,233	5188	<b>15,347</b>



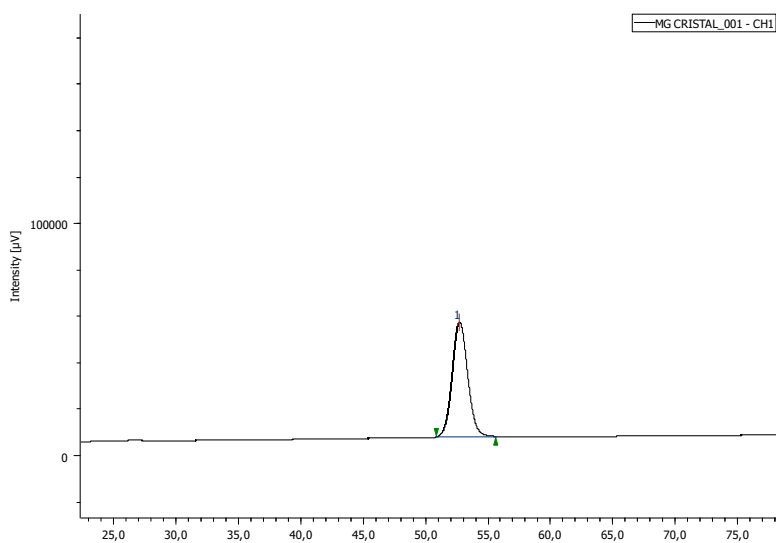
	$t_R$	Area	Area%
1	14,650	64643	<b>1,298</b>
2	17,917	1771023	<b>35,553</b>
3	51,383	44616	<b>0,896</b>
4	59,125	3101130	<b>62,254</b>

### Racemate of major diastereomer



	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	45,275	9734923	<b>49,109</b>
2	52,475	10088078	<b>50,891</b>

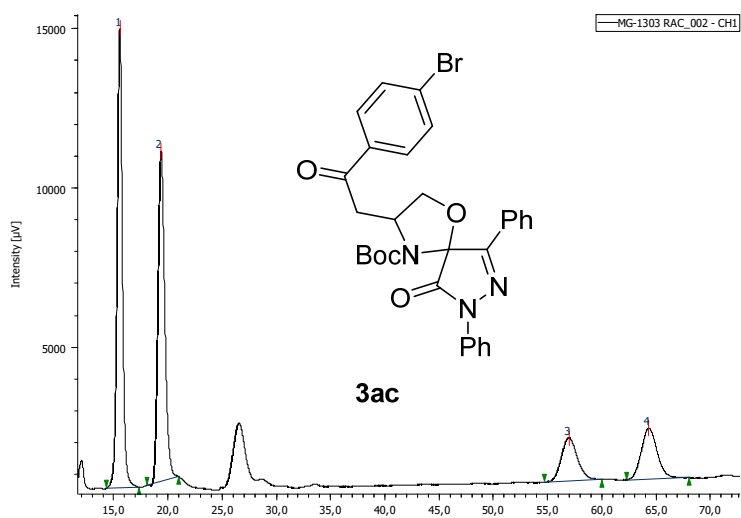
### HPLC profile of enantioenriched 3ab after slow evaporation from hexane-chloroform



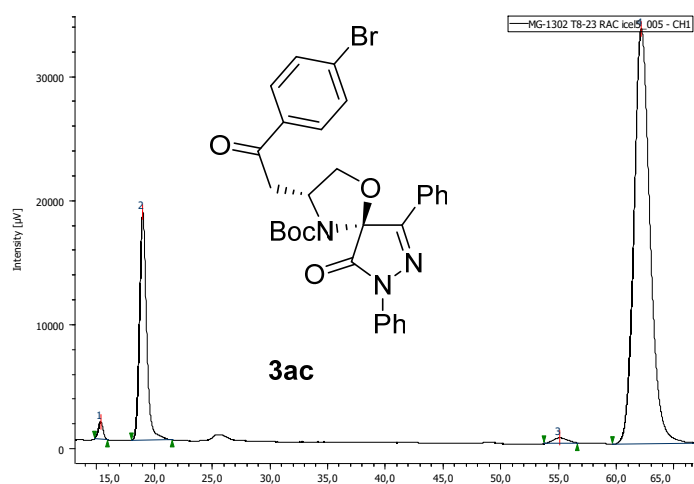
	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	52,692	4248576	<b>100,000</b>

The HPLC of the enantioenriched compound **3ab** was taken and we observed only one peak corresponding to the major diastereomer; there was no peak corresponding to the minor diastereomer.

**tert-Butyl (3R,5S)-3-(2-(4-bromophenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ac).**

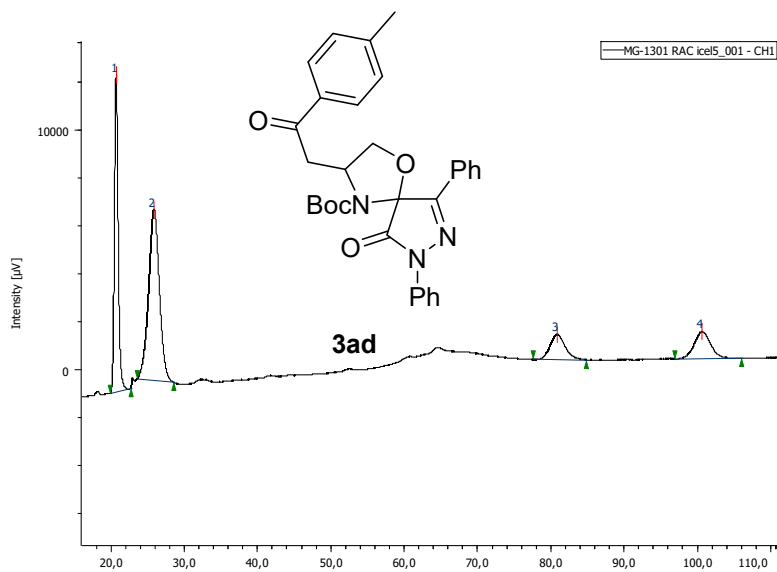


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	15,558	474243	<b>38,645</b>
2	19,358	450410	<b>36,703</b>
3	56,908	139145	<b>11,339</b>
4	64,275	163364	<b>13,312</b>

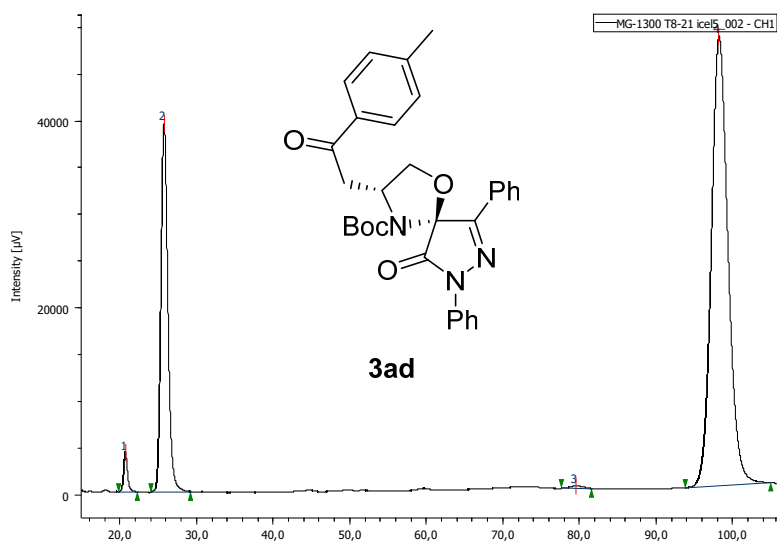


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	15,350	39771	<b>0,977</b>
2	18,983	781687	<b>19,194</b>
3	55,033	36612	<b>0,899</b>
4	62,100	3214477	<b>78,930</b>

**tert-Butyl (3R,5S)-9-oxo-3-(2-oxo-2-(p-tolyl)ethyl)-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ad).**

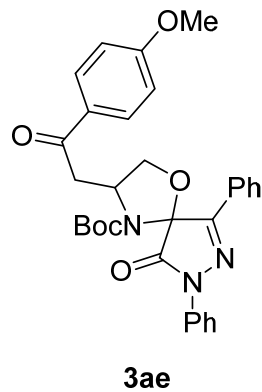
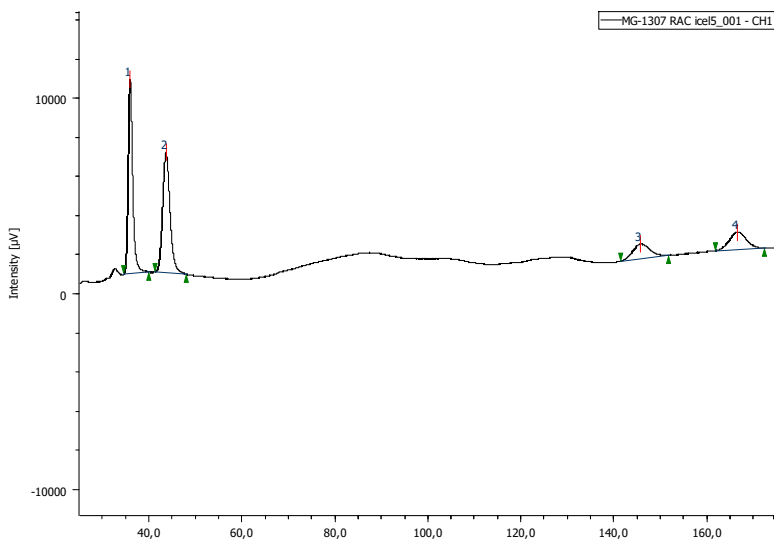


	t <sub>R</sub>	Area	Area%
1	20,717	456578	<b>29,945</b>
2	25,908	738291	<b>48,421</b>
3	80,725	151879	<b>9,961</b>
4	100,483	177993	<b>11,674</b>

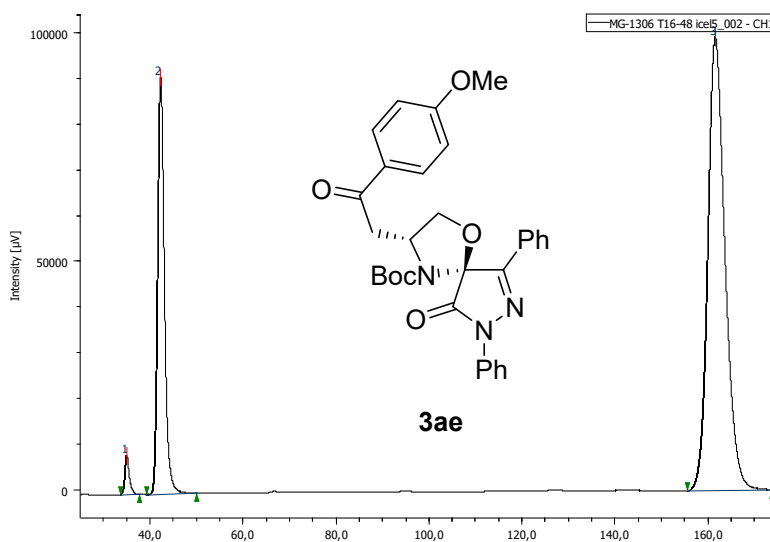


	t <sub>R</sub>	Area	Area%
1	20,692	153178	<b>1,556</b>
2	25,750	2452693	<b>24,922</b>
3	79,500	31259	<b>0,318</b>
4	98,117	7204454	<b>73,204</b>

**tert-Butyl (3*R*,5*S*)-3-(2-(4-methoxyphenyl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ae).**



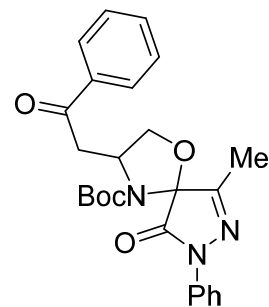
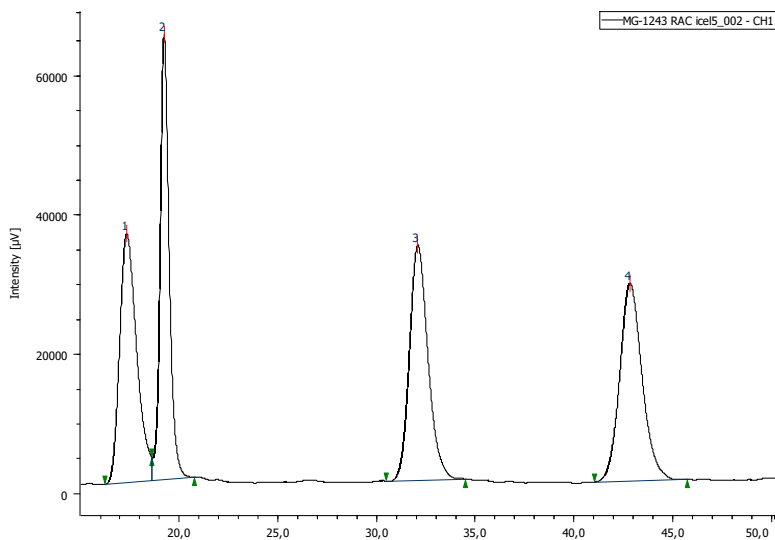
	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	35,983	667316	<b>38,121</b>
2	43,700	667153	<b>38,111</b>
3	145,575	190218	<b>10,866</b>
4	166,467	225846	<b>12,902</b>



	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	35,008	579064	<b>1,661</b>
2	42,300	9052756	<b>25,960</b>
3	161,517	25240037	<b>72,379</b>

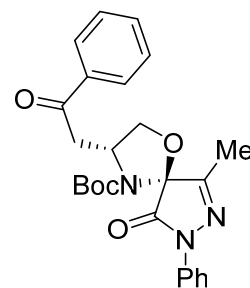
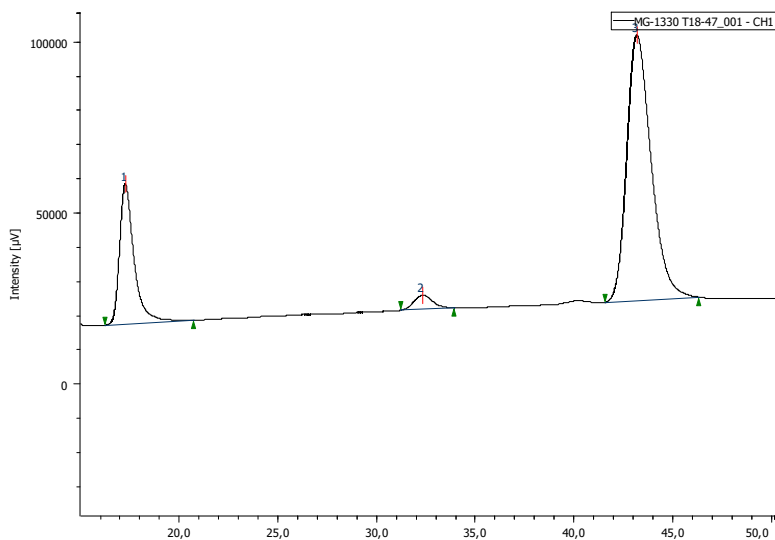


**tert-Butyl (3*R*,5*S*)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ba).**



**3ba**

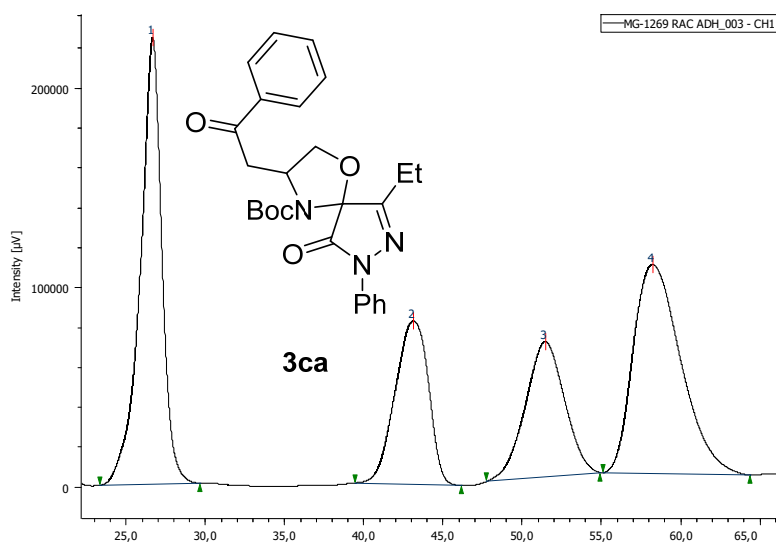
	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	17,342	2142035	<b>24,941</b>
2	19,233	2024575	<b>23,573</b>
3	32,067	2187954	<b>25,475</b>
4	42,800	2233929	<b>26,011</b>



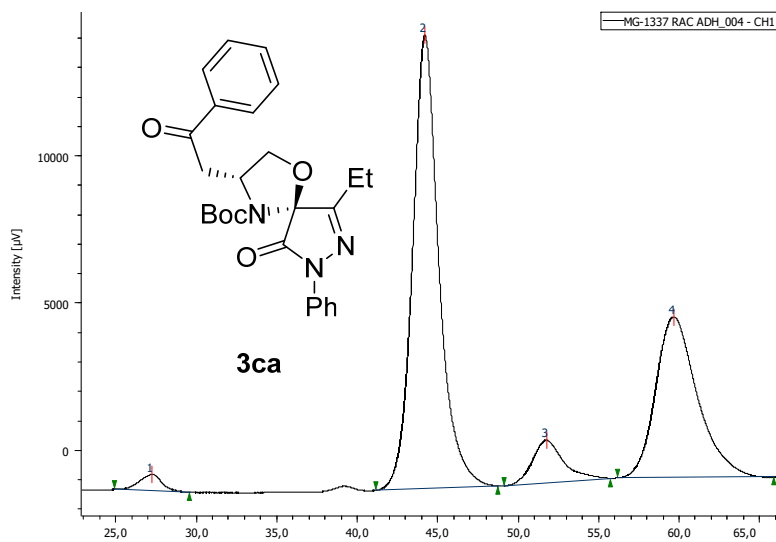
**3ba**

	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	17,267	2072948	<b>23,024</b>
2	32,308	266764	<b>2,963</b>
3	43,158	6663575	<b>74,013</b>

**tert-Butyl (3R,5S)-6-ethyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ca).**

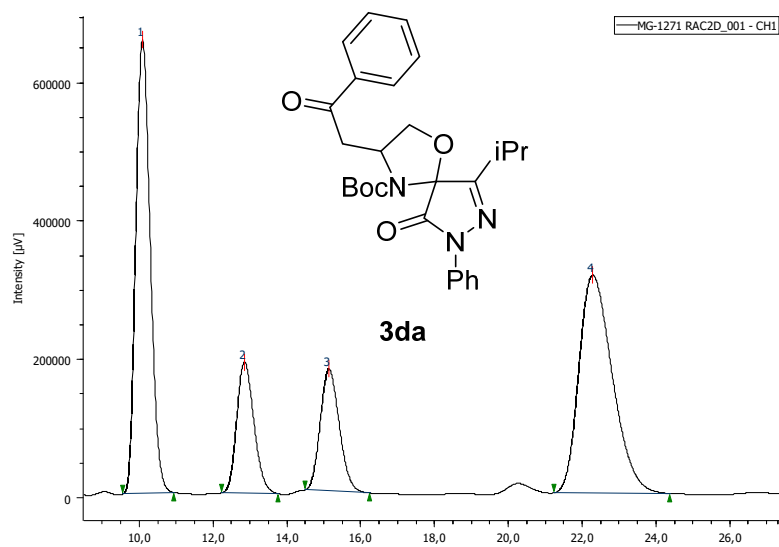


	t <sub>R</sub>	Area	Area%
1	26,658	21163714	<b>31,754</b>
2	43,083	12019288	<b>18,034</b>
3	51,408	11610308	<b>17,420</b>
4	58,175	21856462	<b>32,793</b>

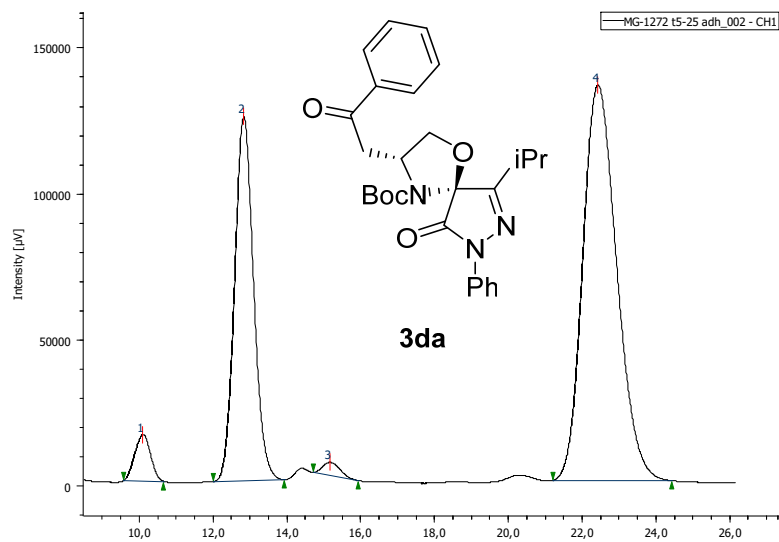


	t <sub>R</sub>	Area	Area%
1	27,242	54712	<b>1,836</b>
2	44,167	1750389	<b>58,744</b>
3	51,708	194718	<b>6,535</b>
4	59,600	979858	<b>32,885</b>

**tert-Butyl (3*R*,5*S*)-6-isopropyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3da).**

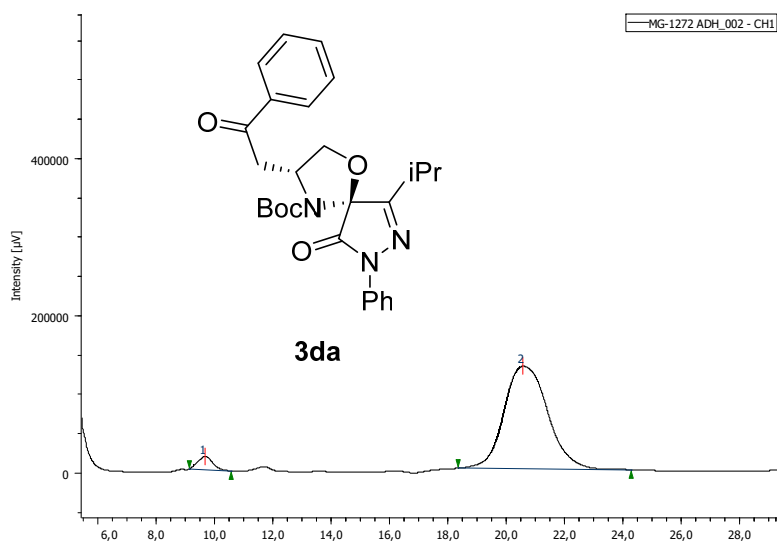


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	10,083	17728052	<b>35,509</b>
2	12,850	6111564	<b>12,241</b>
3	15,133	6299936	<b>12,619</b>
4	22,275	19785865	<b>39,631</b>



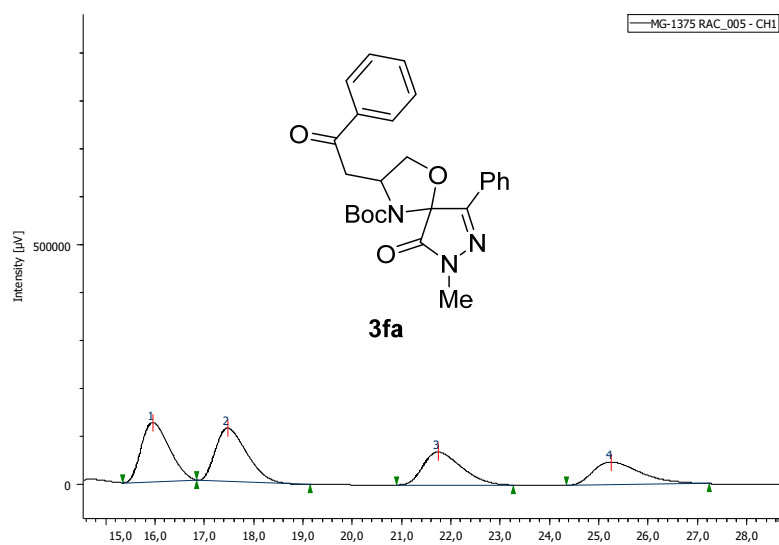
	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	10,100	334307	<b>2,454</b>
2	12,825	4449899	<b>32,665</b>
3	15,158	146499	<b>1,075</b>
4	22,408	8692319	<b>63,806</b>

Major diastereomer.

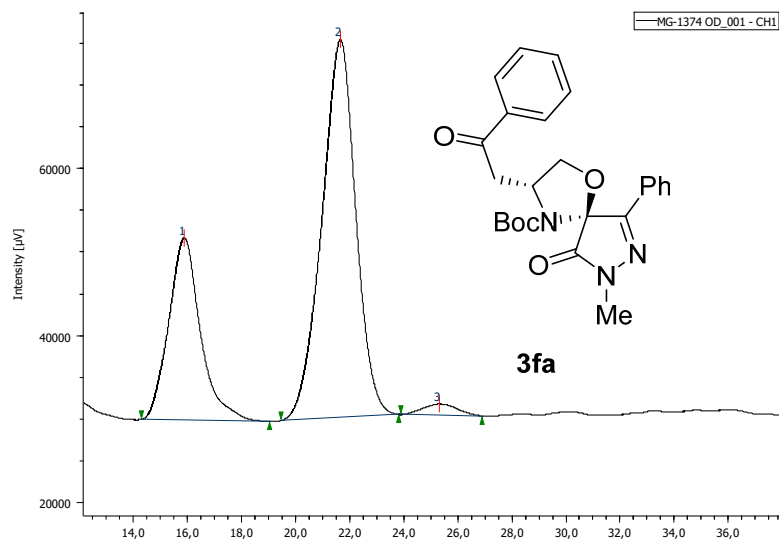


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	9,675	504356	<b>3,889</b>
2	20,558	12465696	<b>96,111</b>

**tert-Butyl (3*R*,5*S*)-8-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-6-phenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3fa).**

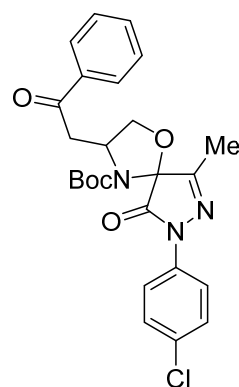
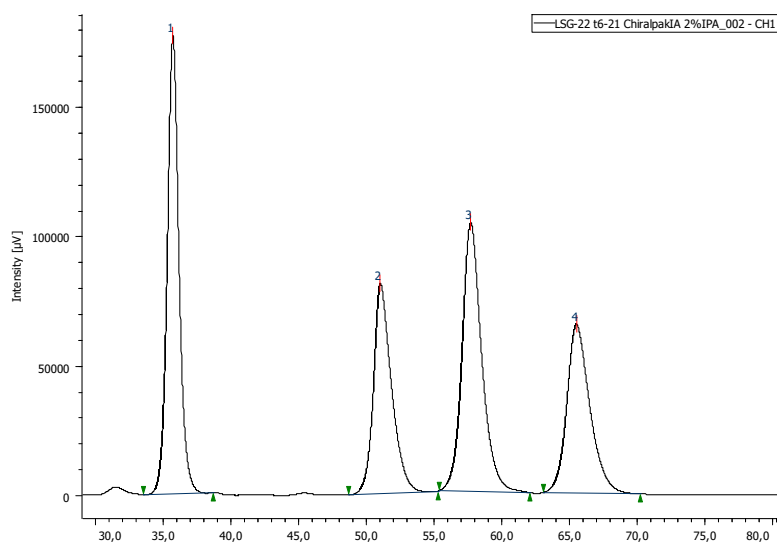


Entry	t <sub>R</sub>	Area	Area%
1	15,950	4847726	<b>29,039</b>
2	17,467	4866248	<b>29,150</b>
3	21,733	3724278	<b>22,309</b>
4	25,242	3255710	<b>19,502</b>



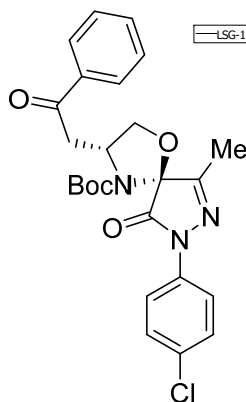
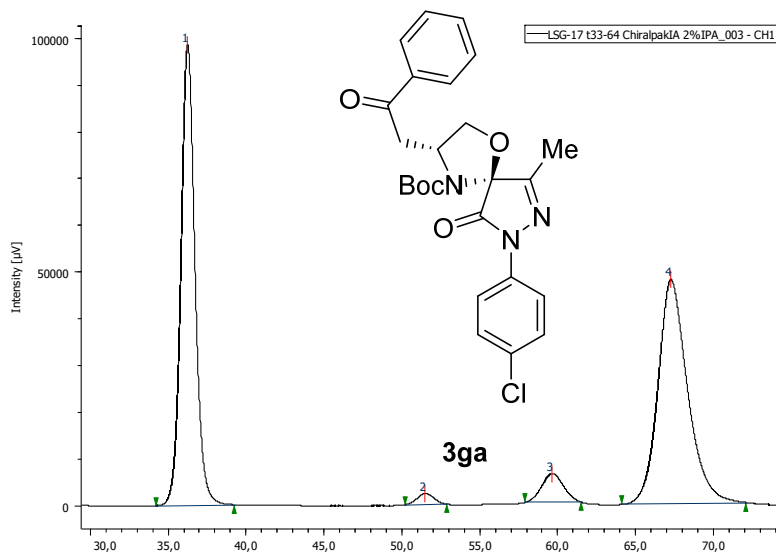
	t <sub>R</sub>	Area	Area%
1	15,875	1770022	<b>30,460</b>
2	21,650	3921811	<b>67,490</b>
3	25,300	119147	<b>2,050</b>

**tert-Butyl (3*R*,5*S*)-8-(4-chlorophenyl)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ga).**



**3ga**

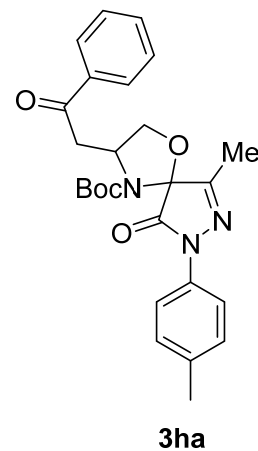
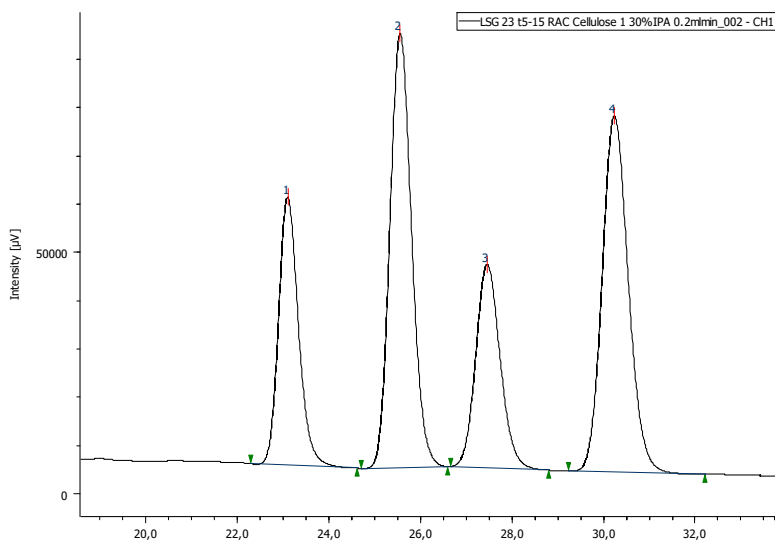
	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	35,683	10564747	<b>29,214</b>
2	50,975	7496291	<b>20,729</b>
3	57,642	10426712	<b>28,833</b>
4	65,442	7675119	<b>21,224</b>



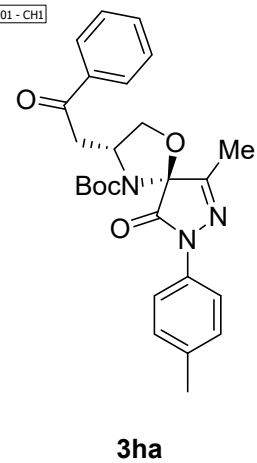
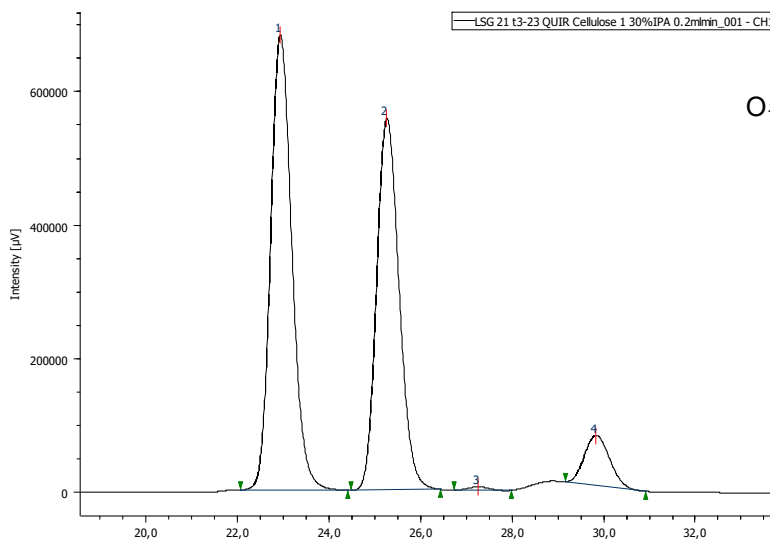
**3ga**

	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	36,250	6141275	<b>46,509</b>
2	51,467	176686	<b>1,338</b>
3	59,592	600392	<b>4,547</b>
4	67,208	6286030	<b>47,606</b>

**tert-Butyl (3R,5S)-6-methyl-9-oxo-3-(2-oxo-2-phenylethyl)-8-(p-tolyl)-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (3ha).**

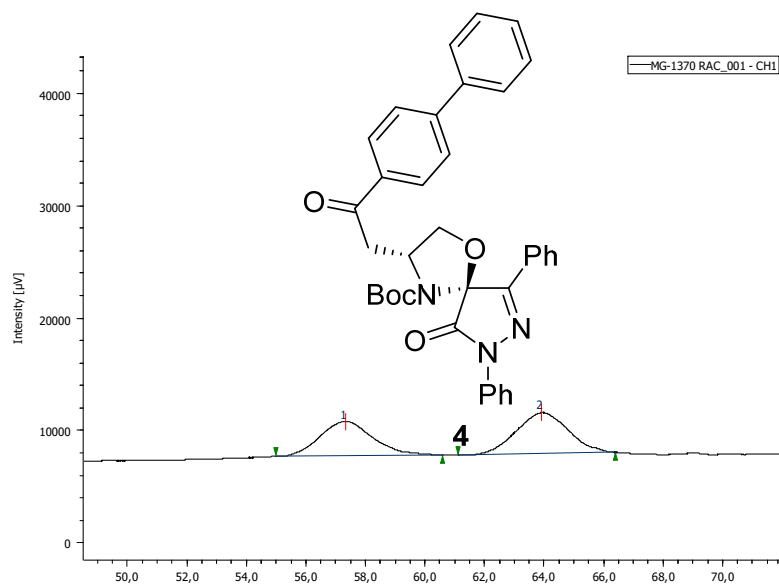


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	23,092	1679660	<b>18,431</b>
2	25,542	2940943	<b>32,272</b>
3	27,442	1563701	<b>17,159</b>
4	30,217	2928780	<b>32,138</b>

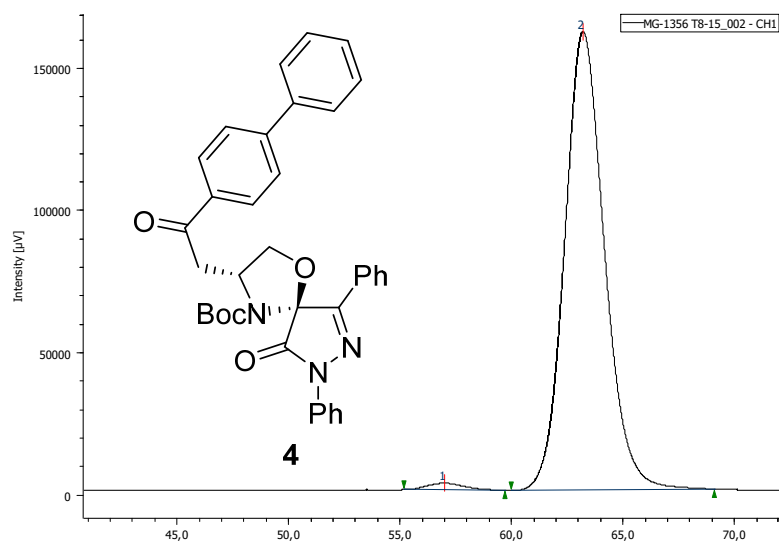


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	22,925	21992085	<b>50,080</b>
2	25,250	18917536	<b>43,078</b>
3	27,242	153703	<b>0,350</b>
4	29,817	2850989	<b>6,492</b>

**tert-Butyl (3R,5S)-3-(2-([1,1'-biphenyl]-4-yl)-2-oxoethyl)-9-oxo-6,8-diphenyl-1-oxa-4,7,8-triazaspiro[4.4]non-6-ene-4-carboxylate (4).**



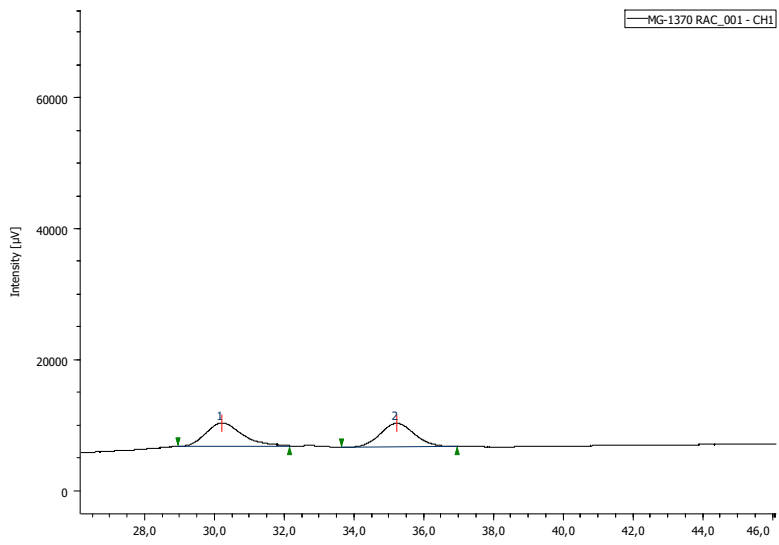
	$t_R$	Area	Area%
1	57,333	379367	46,504
2	63,908	436401	53,496



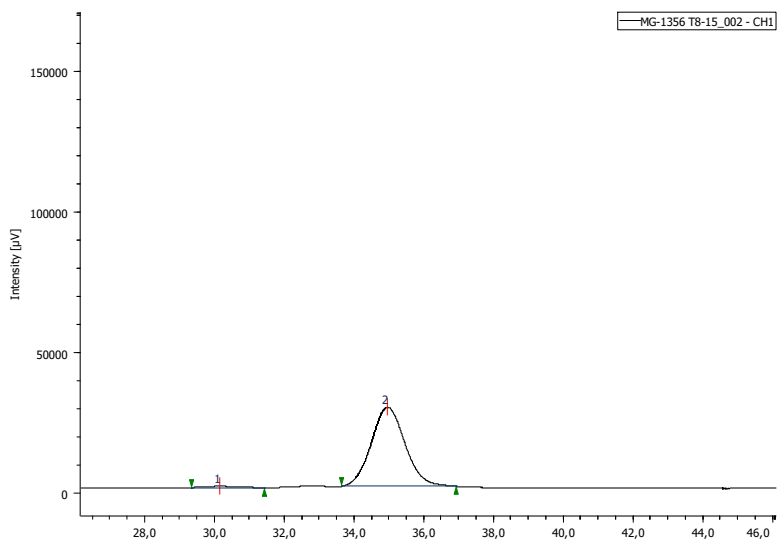
	$t_R$	Area	Area%
1	56,983	274058	1,356
2	63,175	19932052	98,644



## Minor diastereomer

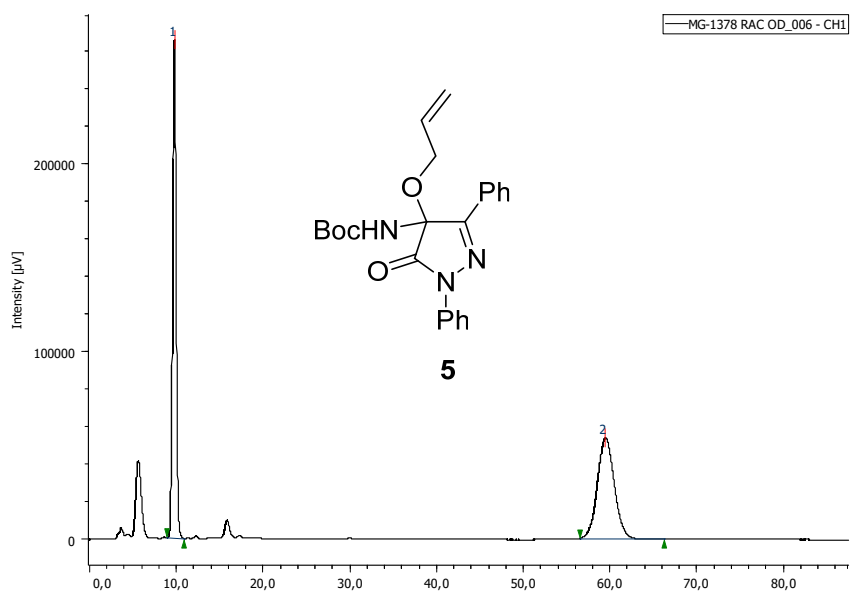


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	30,208	253594	<b>50,712</b>
2	35,217	246477	<b>49,288</b>

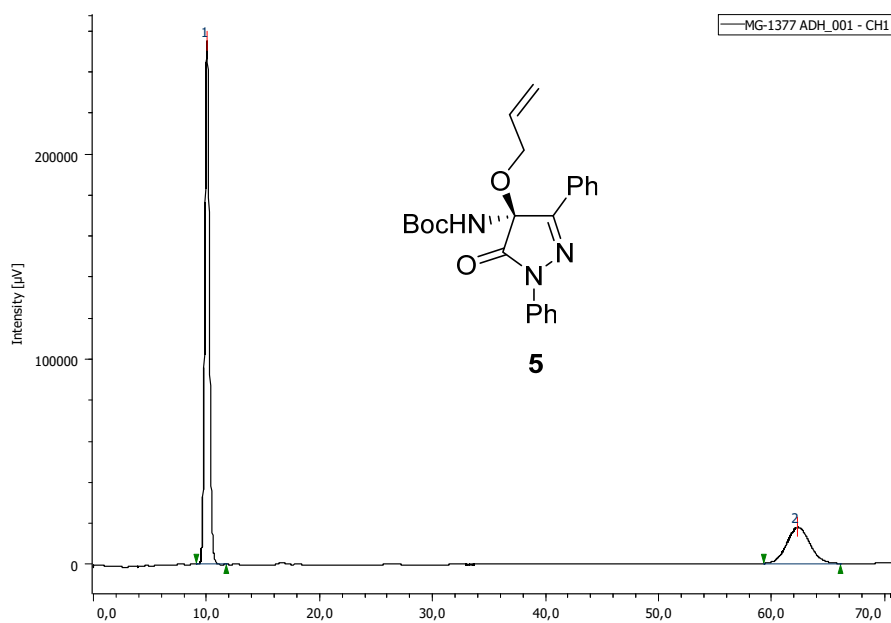


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	30,142	33268	<b>1,729</b>
2	34,958	1890386	<b>98,271</b>

***tert*-Butyl (S)-(4-(allyloxy)-5-oxo-1,3-diphenyl-4,5-dihydro-1*H*-pyrazol-4-yl)carbamate (5).**

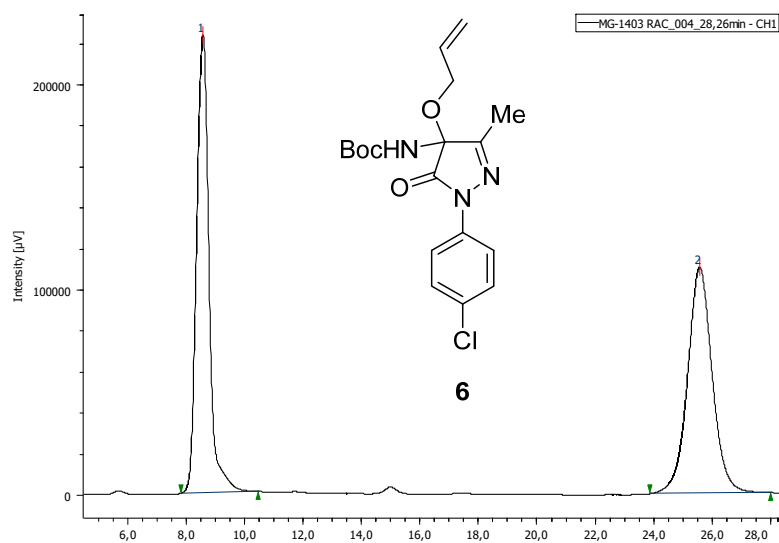


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	9,767	7502077	50,867
2	59,408	7246325	49,133

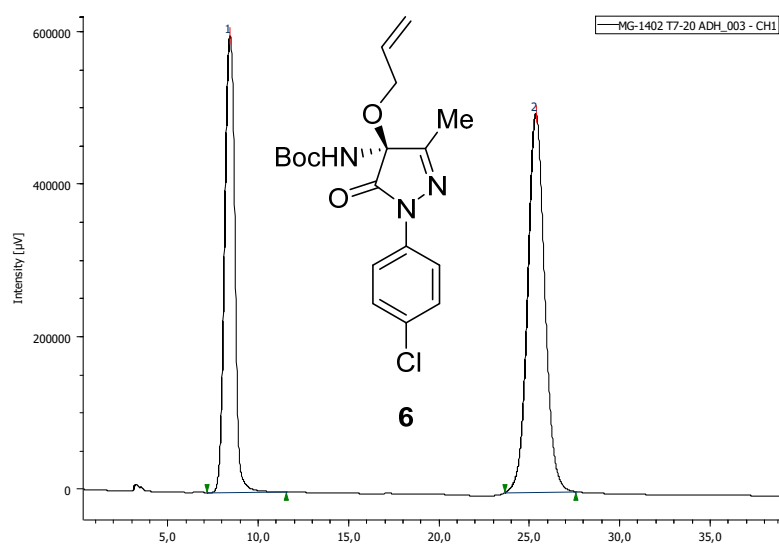


	<b>t<sub>R</sub></b>	<b>Area</b>	<b>Area%</b>
1	10,050	7200580	74,258
2	62,242	2496154	25,742

***tert*-Butyl (4-(allyloxy)-1-(4-chlorophenyl)-3-methyl-5-oxo-4,5-dihydro-1*H*-pyrazol-4-yl)carbamate (6).**

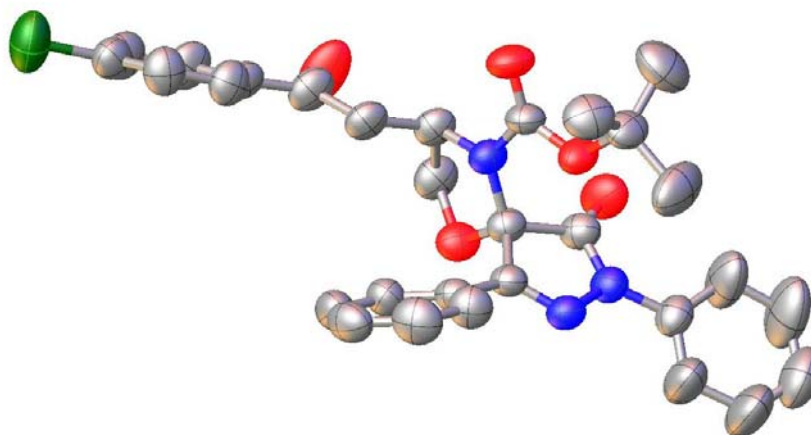


	$t_R$	Area	Area%
1	8,567	6571775	50,571
2	25,542	6423384	49,429



	$t_R$	Area	Area%
1	8,442	23652866	42,058
2	25,325	32585857	57,942

#### 4. Crystallographic data of spirocycle 3ab.



#### Crystal data and structure refinement for spirocycle 3ab.

Identification code	<b>3ab</b>
Empirical formula	C <sub>30</sub> H <sub>28</sub> ClN <sub>3</sub> O <sub>5</sub>
Formula weight	546.00
Temperature/K	298
Crystal system	orthorhombic
Space group	P2 <sub>1</sub> 2 <sub>1</sub> 2 <sub>1</sub>
a/Å	8.3506(2)
b/Å	11.0548(3)
c/Å	35.8931(9)
α/°	90
β/°	90
γ/°	90
Volume/Å <sup>3</sup>	3313.44(15)
Z	4
ρ <sub>calc</sub> /cm <sup>3</sup>	1.095
μ/mm <sup>-1</sup>	1.327
F(000)	1144.0
Crystal size/mm <sup>3</sup>	0.737 × 0.372 × 0.3
Radiation	Cu Kα (λ = 1.54184)
2θ range for data collection/°	8.37 to 150.626
Index ranges	-10 ≤ h ≤ 10, -13 ≤ k ≤ 13, -44 ≤ l ≤ 44
Reflections collected	26672
Independent reflections	6729 [R <sub>int</sub> = 0.0520, R <sub>sigma</sub> = 0.0308]
Data/restraints/parameters	6729/0/355
Goodness-of-fit on F <sup>2</sup>	1.140
Final R indexes [I ≥ 2σ (I)]	R <sub>1</sub> = 0.0932, wR <sub>2</sub> = 0.2551

Final R indexes [all data]  $R_1 = 0.1009$ ,  $wR_2 = 0.2768$   
Largest diff. peak/hole /  $e \text{ \AA}^{-3}$  1.30/-0.42  
Flack parameter 0.004(12)