Supporting Information

Acid-promoted cyclization of 2,4-diaryl-1,1,1-trifluorobut-3-en-2-oles and their TMS-ethers into CF_3-indenes

Matvei Yu. Martynov,[a] Roman O. Iakovenko,[a] Anna N. Kazakova,[a] Irina A. Boyarskaya,[a] and Aleksander V. Vasilyev*[a,b]

[a]*Institute of Chemistry, Saint Petersburg State University, Universitetskaya nab., 7/9, Saint Petersburg, 199034, Russia.*

[b]*Department of Chemistry, Saint Petersburg State Forest Technical University, Institutsky per., 5, Saint Petersburg, 194021, Russia.*

*Corresponding author: A.V. Vasilyev. *E-mail:* aleksvasil@mail.ru

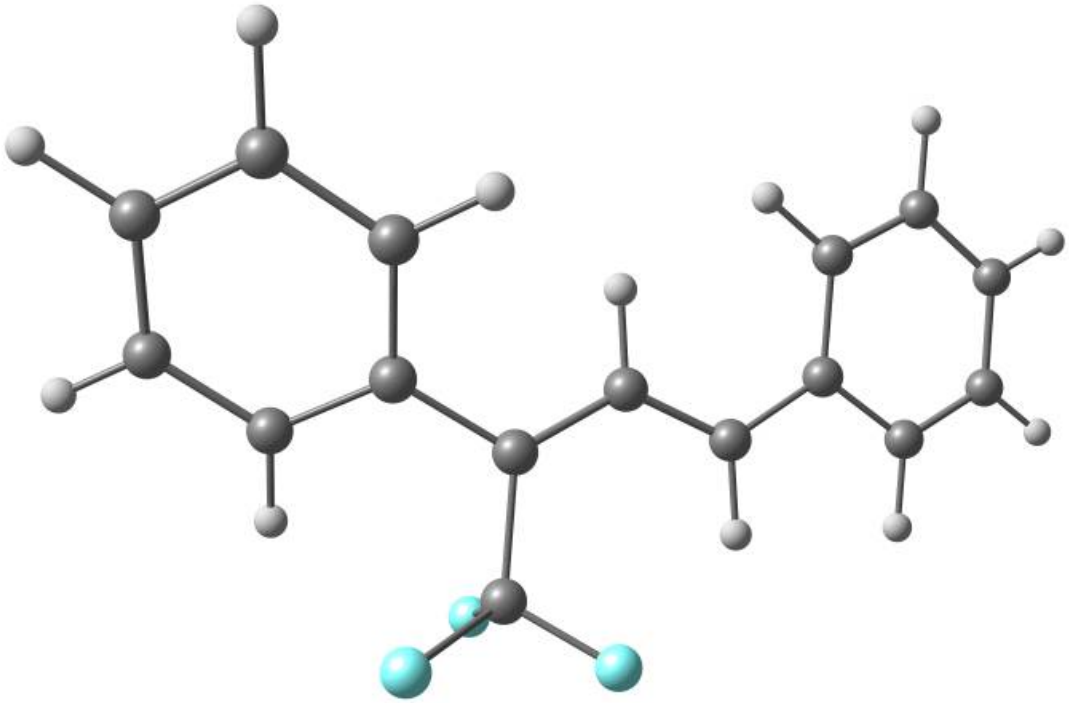
Contents

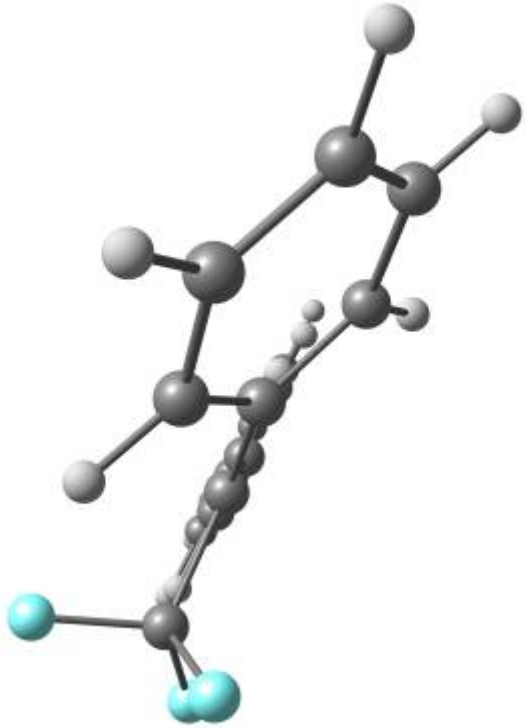
1. Data on DFT calculations of cation A

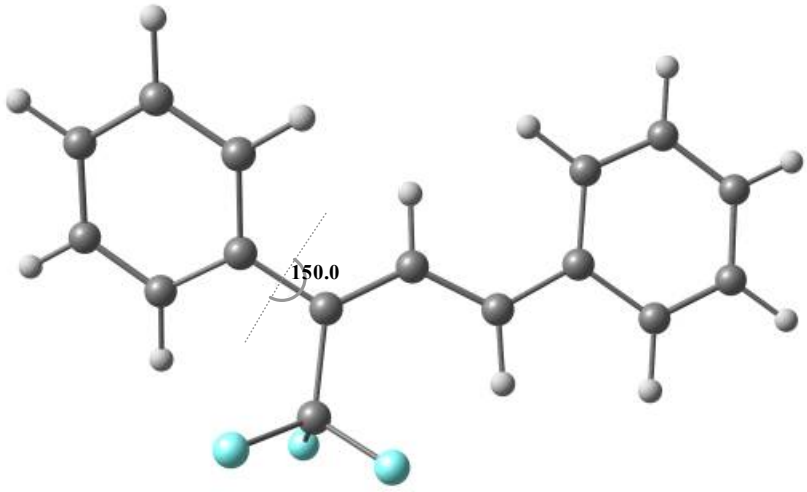
E=-916.530602263 h, G^{298} =-916.339535 h, μ=7.05 D

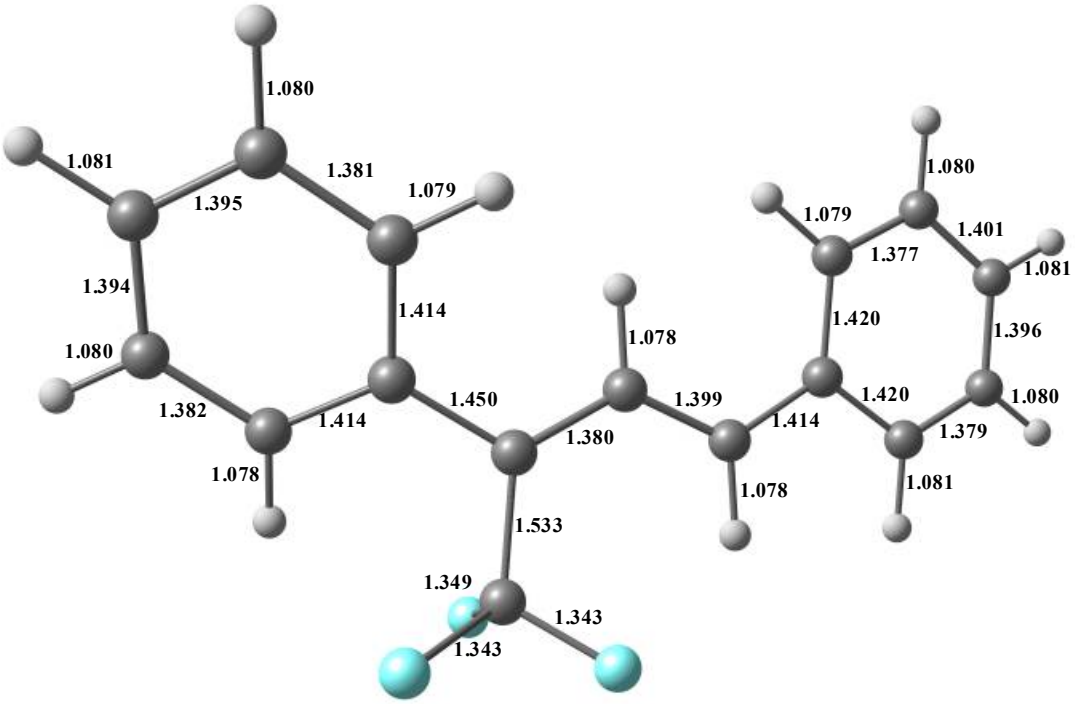
Cartesian coordinates, Å

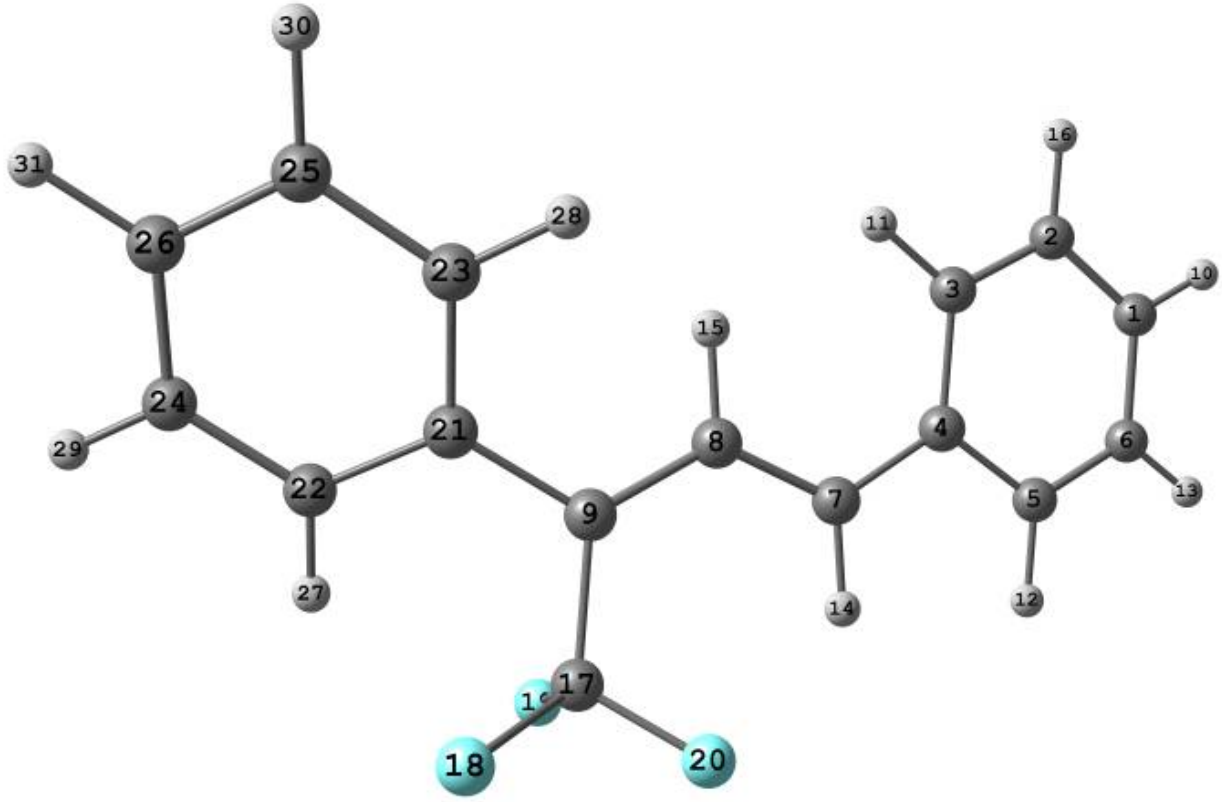
N	atom	x	y	z
1	C	-5.397132	-1.075974	-0.134101
2	C	-4.306689	-1.952376	-0.067347
3	C	-3.024212	-1.454745	-0.018045
4	C	-2.803526	-0.051683	-0.033934
5	C	-3.925426	0.816236	-0.101676
6	C	-5.206097	0.306872	-0.151261
7	C	-1.522437	0.544144	0.026660
8	C	-0.305900	-0.144410	0.068690
9	C	0.968646	0.384906	0.094019
10	H	-6.399929	-1.477573	-0.172496
11	H	-2.192738	-2.140114	0.034677
12	H	-3.761497	1.884400	-0.112591
13	H	-6.055650	0.971298	-0.202145
14	H	-1.516679	1.622209	0.016792
15	H	-0.353411	-1.219669	0.004856
16	H	-4.474281	-3.019007	-0.054205
17	C	1.224992	1.895414	0.139007
18	F	2.331909	2.184168	0.842202
19	F	1.391770	2.383440	-1.107130
20	F	0.228639	2.589354	0.712437
21	C	2.133825	-0.476316	0.033465
22	C	3.346549	-0.042658	-0.550468
23	C	2.064972	-1.797514	0.532590
24	C	4.421968	-0.904918	-0.656162
25	C	3.156125	-2.640429	0.450456
26	C	4.335341	-2.201597	-0.151944
27	H	3.434122	0.950439	-0.960255
28	H	1.172233	-2.143667	1.030176
29	H	5.331881	-0.566975	-1.130029
30	H	3.094274	-3.637773	0.860499
31	H	5.184817	-2.865949	-0.222554






150.0


1.080
1.081
1.381
1.395
1.079
1.394
1.414
1.080
1.078
1.080
1.079
1.401
1.377
1.081
1.420
1.396
1.382
1.450
1.399
1.420
1.080
1.414
1.414
1.380
1.379
1.078
1.078
1.081
1.533
1.349
1.343
1.343


30
31
25
26
28
23
16
11
2
3
10
1
15
24
21
8
4
6
29
22
9
7
5
13
27
14
12
17
18
20

Summary of Natural Population Analysis:

Atom	No	Natural Charge	Natural Population: Core	Valence	Rydberg	Total
C	1	-0.08065	1.99918	4.06222	0.01925	6.08065
C	2	-0.20953	1.99917	4.18812	0.02225	6.20953
C	3	-0.11044	1.99893	4.07575	0.03576	6.11044
C	4	-0.13647	1.99904	4.11124	0.02619	6.13647
C	5	-0.08882	1.99910	4.07051	0.01922	6.08882
C	6	-0.21006	1.99914	4.19079	0.02014	6.21006
C	7	0.04694	1.99894	3.91142	0.04271	5.95306
C	8	-0.25500	1.99900	4.21347	0.04253	6.25500
C	9	-0.20596	1.99890	3.97715	0.22992	6.20596
H	10	0.22808	0.00000	0.77052	0.00140	0.77192
H	11	0.22284	0.00000	0.77430	0.00286	0.77716
H	12	0.22909	0.00000	0.76903	0.00187	0.77091
H	13	0.23331	0.00000	0.76501	0.00168	0.76669
H	14	0.23144	0.00000	0.76496	0.00359	0.76856
H	15	0.22968	0.00000	0.76383	0.00649	0.77032
H	16	0.23256	0.00000	0.76585	0.00159	0.76744
C	17	0.83203	1.99912	2.15460	1.01425	5.16797
F	18	-0.48102	1.99989	7.41223	0.06890	9.48102
F	19	-1.19863	1.99984	5.25428	2.94451	10.19863
F	20	-0.51243	1.99478	7.25155	0.26610	9.51243
C	21	-0.16306	1.97872	3.76478	0.41956	6.16306
C	22	-0.15294	1.98815	3.57660	0.58819	6.15294
C	23	-0.15669	1.98931	3.59225	0.57514	6.15669
C	24	-0.21819	1.98650	3.82007	0.41162	6.21819
C	25	-0.20215	1.98655	3.75173	0.46386	6.20215
C	26	-0.12788	1.98852	3.22041	0.91895	6.12788
H	27	0.19106	0.00000	0.64873	0.16021	0.80894
H	28	0.22495	0.00000	0.59285	0.18220	0.77505
H	29	0.22775	0.00000	0.60861	0.16364	0.77225
H	30	0.22865	0.00000	0.75743	0.01392	0.77135
H	31	0.22508	0.00000	0.77236	0.00255	0.77492
* Total *		-0.92647	37.90276	89.35263	8.67107	135.92647

2. Copies of ^{1}H, ^{13}C, ^{19}F NMR spectra of compounds 1, 2, 3, 4

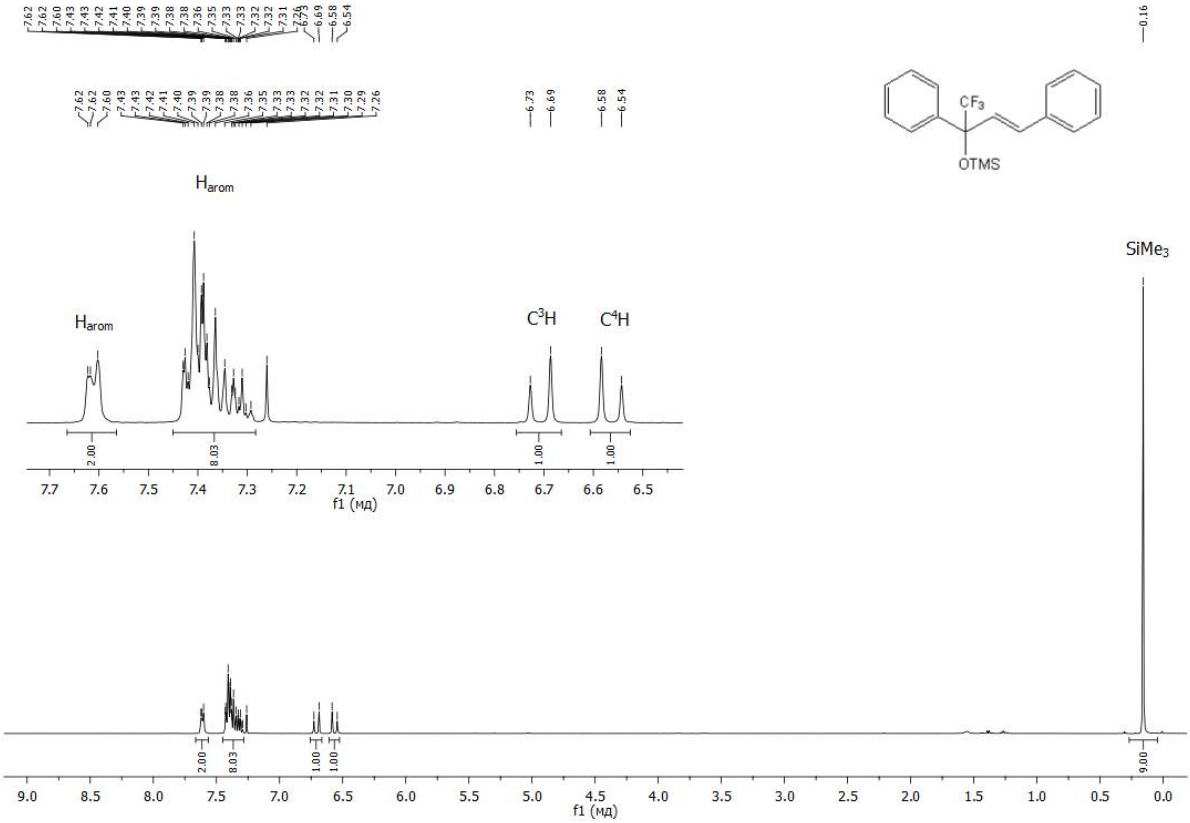


Fig. S1. ^{1}H NMR spectrum of the compound **1a** ($CDCl_3$, 400 MHz).

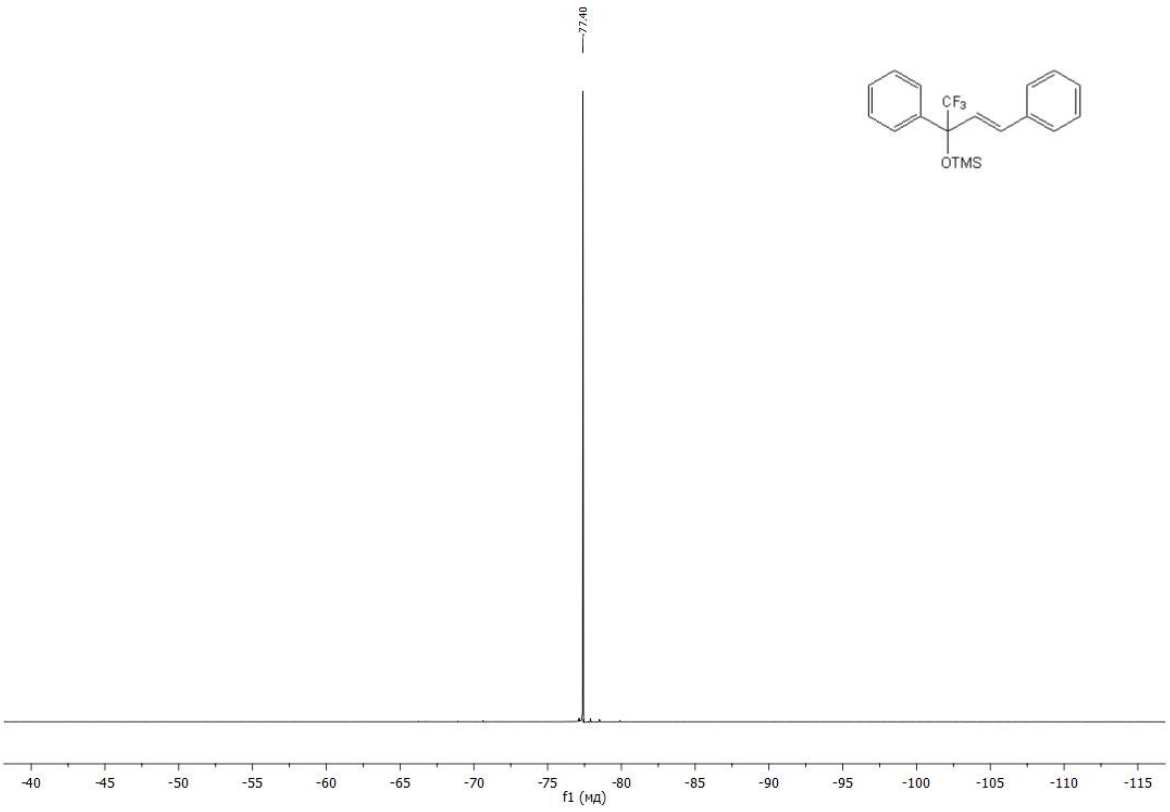


Fig. S2. ^{19}F NMR spectrum of the compound **1a** ($CDCl_3$, 376 MHz).

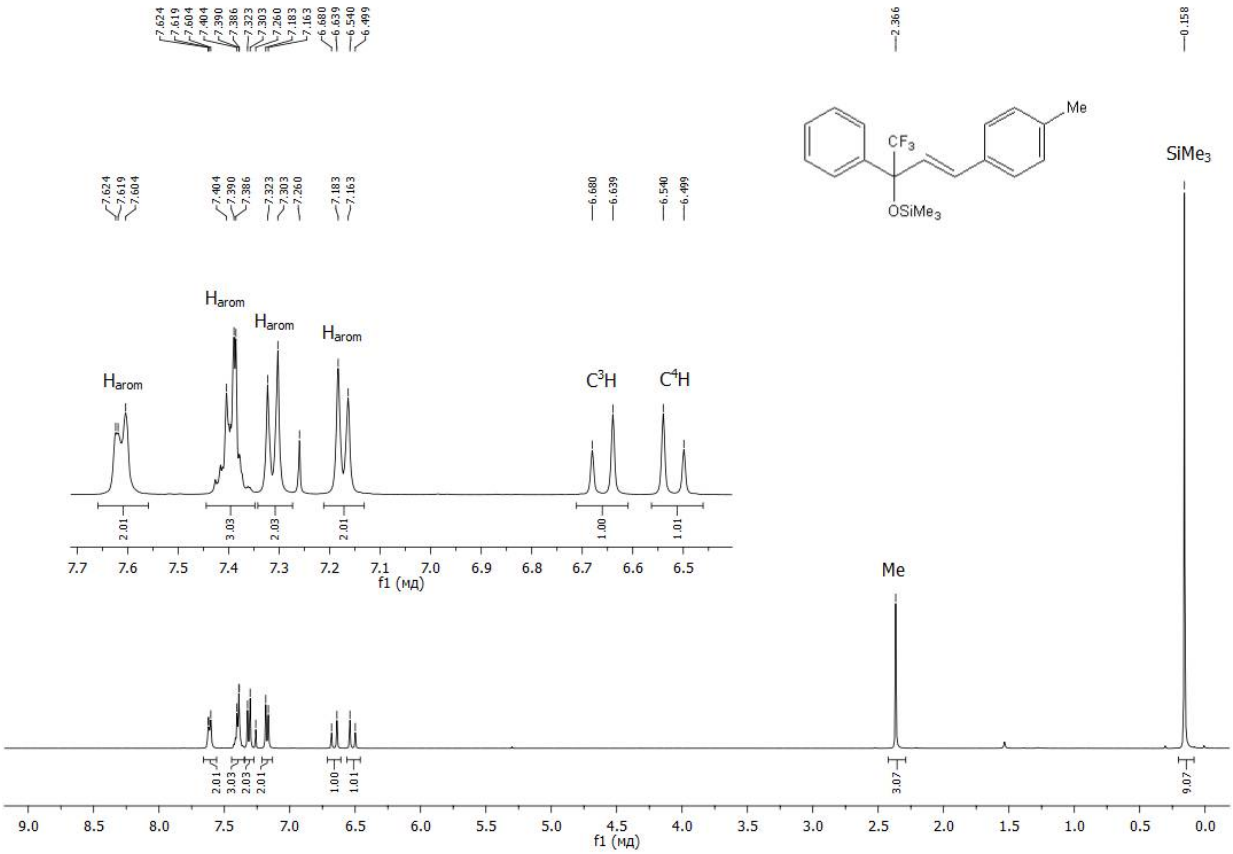


Fig. S3. ^{1}H NMR spectrum of the compound **1b** ($CDCl_3$, 400 MHz).

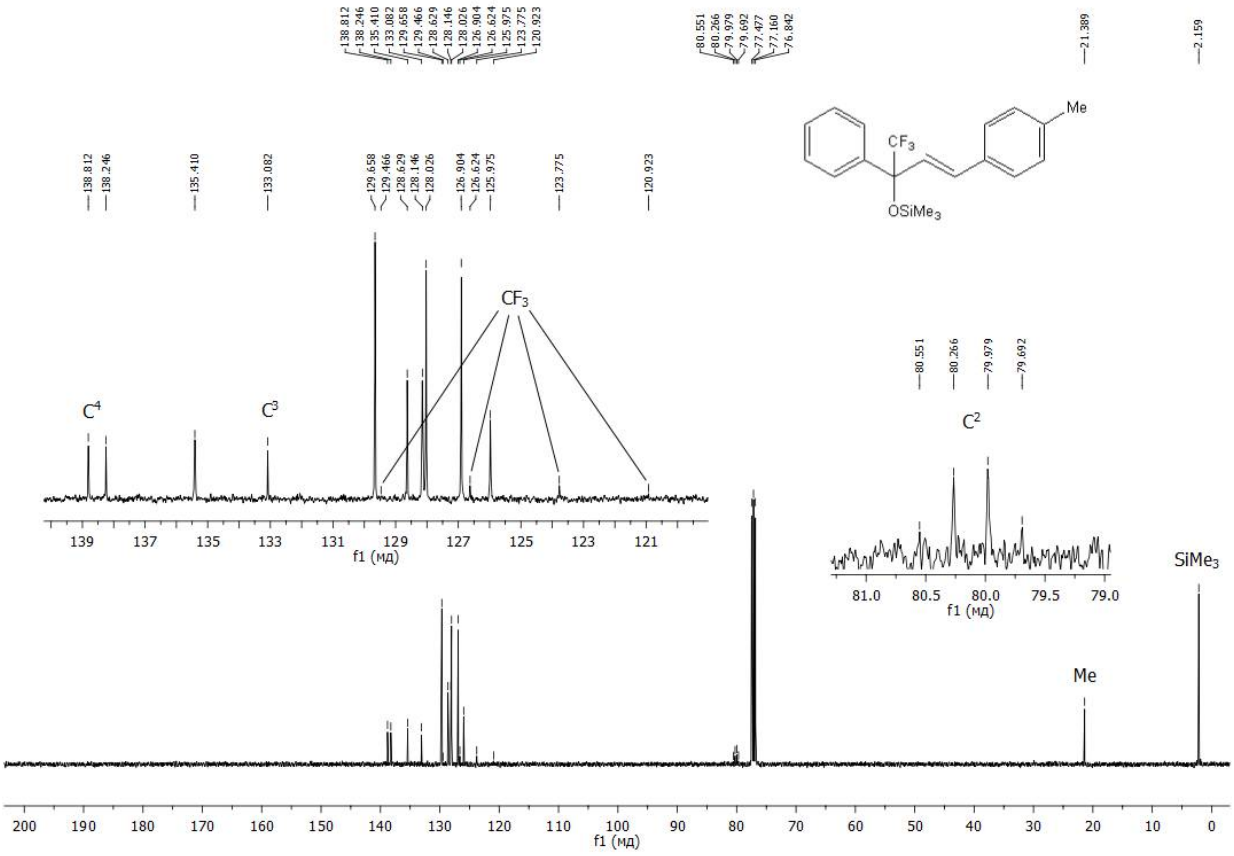


Fig. S4. ^{13}C NMR spectrum of the compound **1b** ($CDCl_3$, 100 MHz).

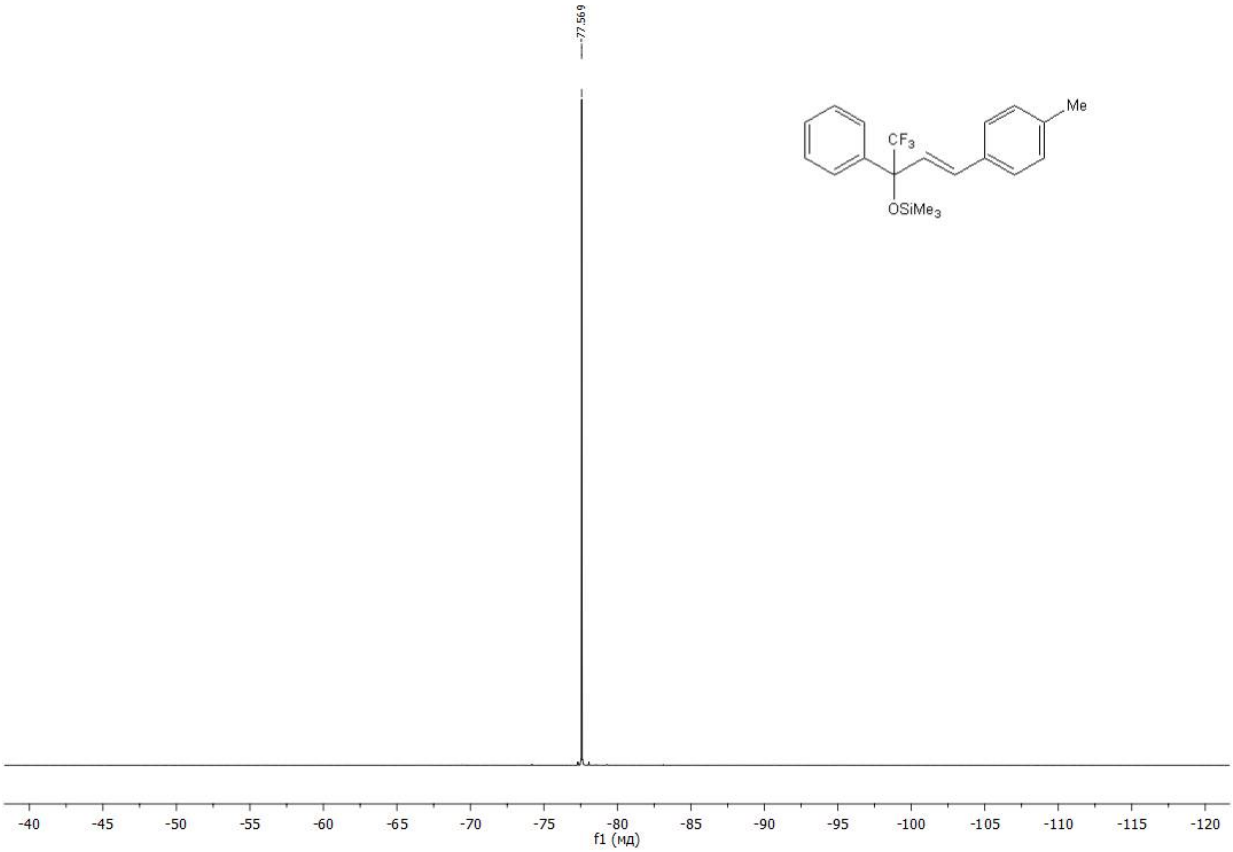


Fig. S5. ^{19}F NMR spectrum of the compound **1b** ($CDCl_3$, 376 MHz).

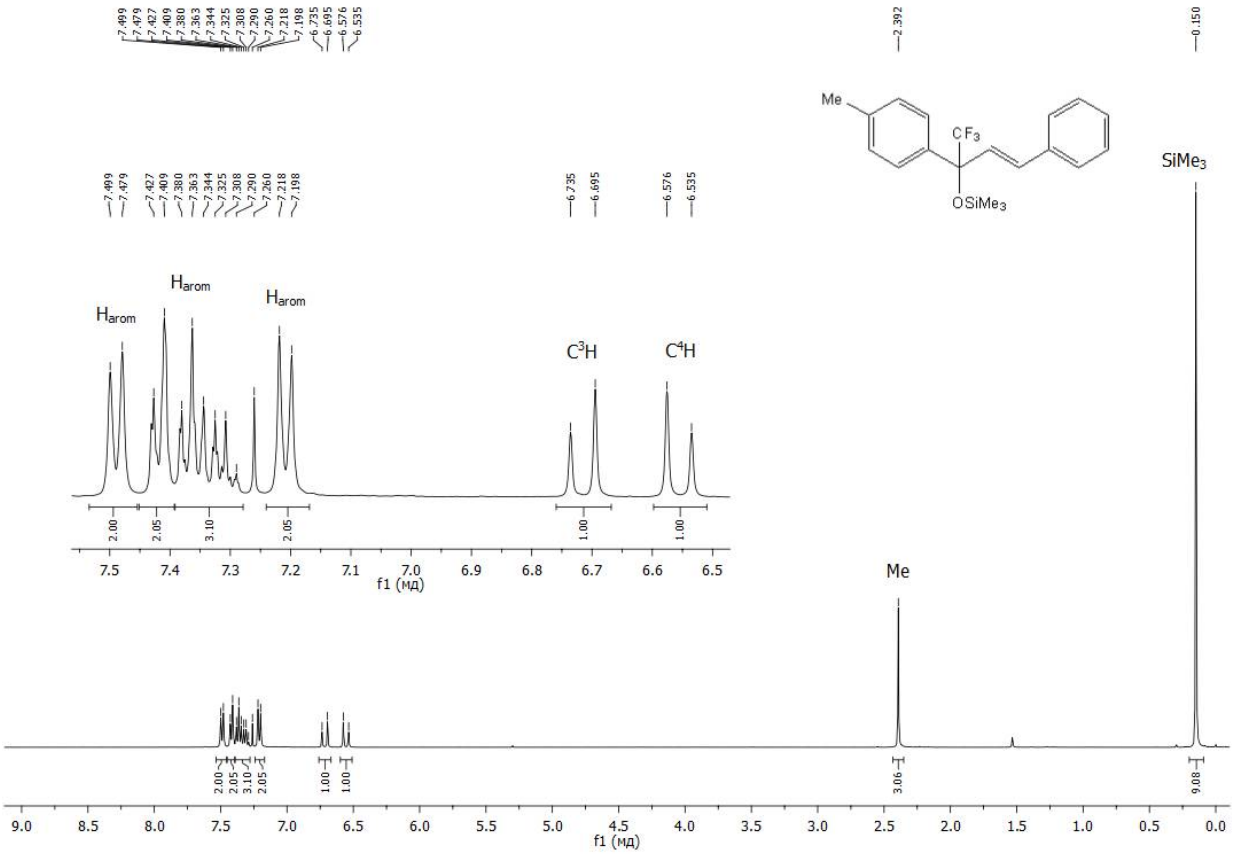


Fig. S6. ^{1}H NMR spectrum of the compound **1c** ($CDCl_3$, 400 MHz).

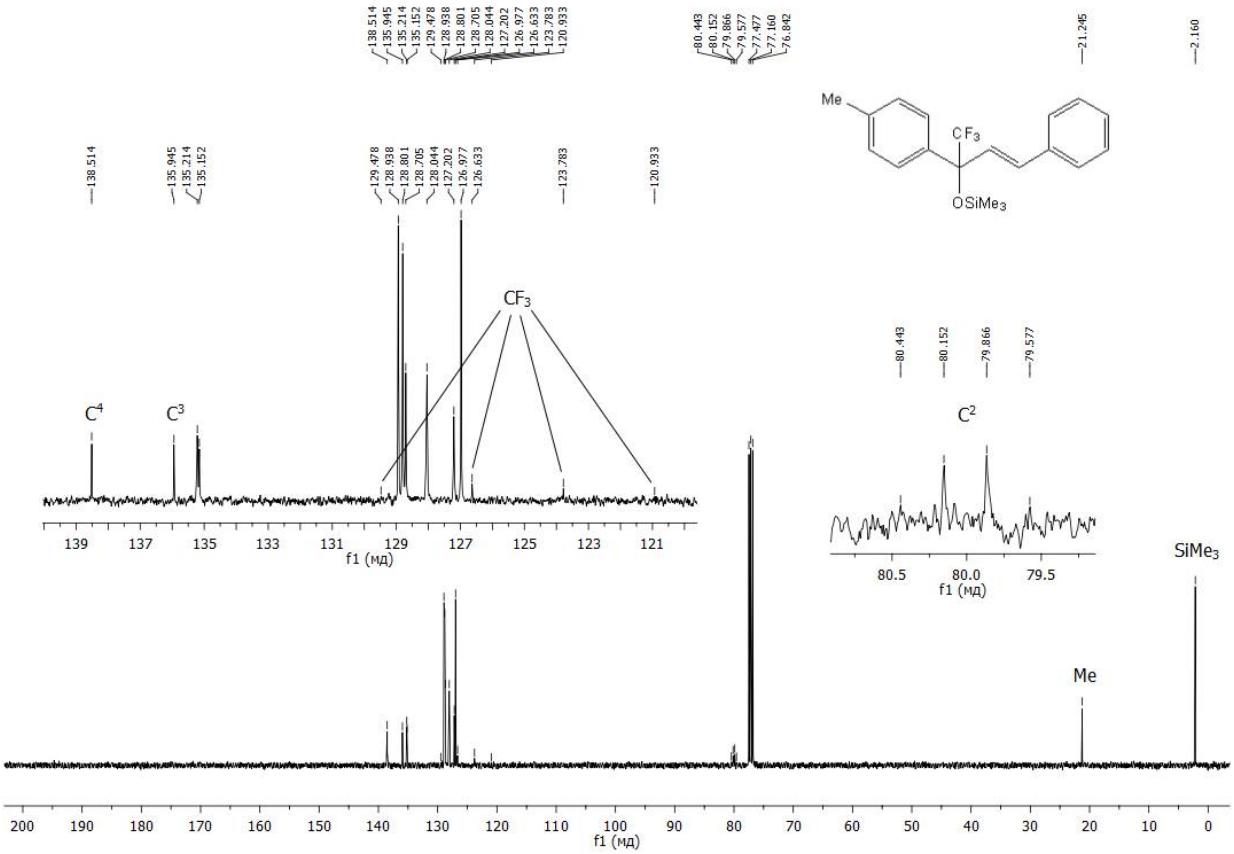


Fig. S7. ^{13}C NMR spectrum of the compound **1c** ($CDCl_3$, 100 MHz).

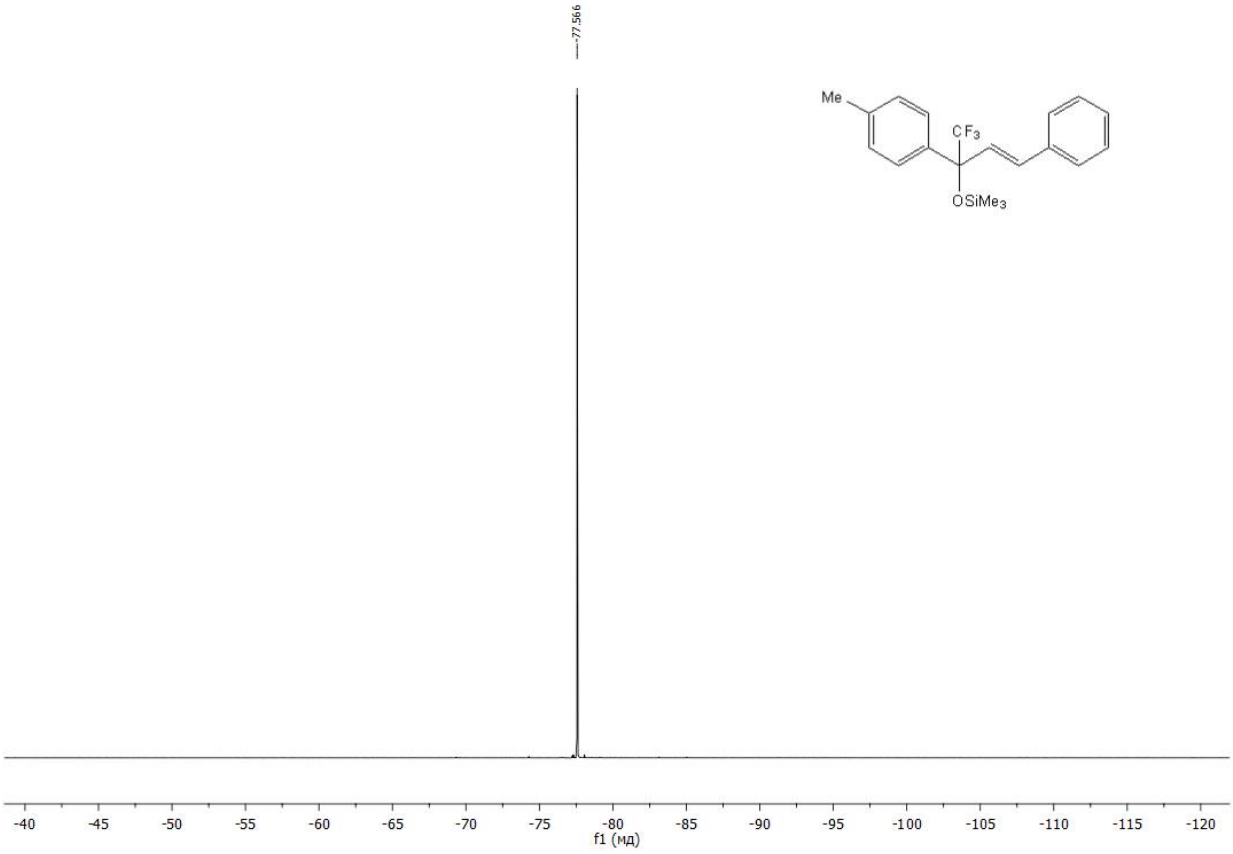


Fig. S8. ^{19}F NMR spectrum of the compound **1c** ($CDCl_3$, 376 MHz).

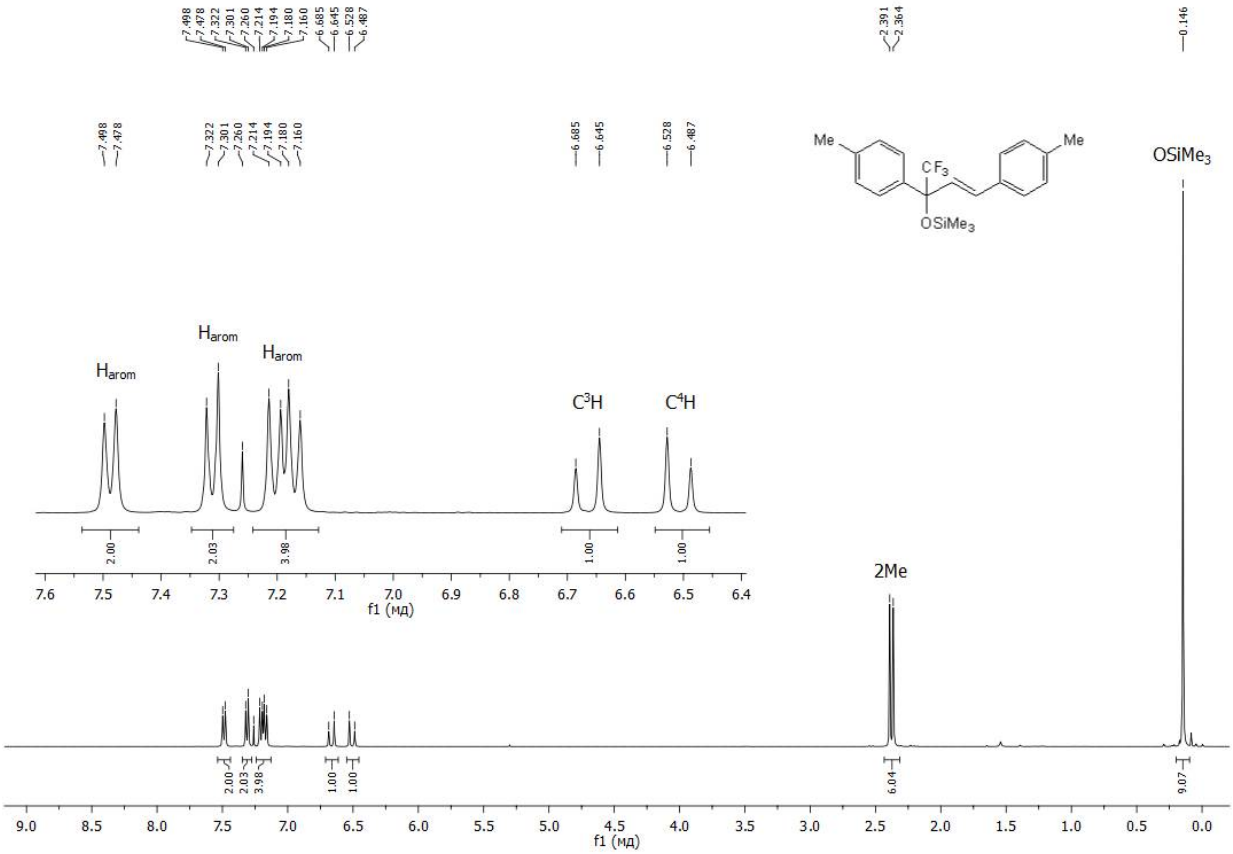


Fig. S9. ^{1}H NMR spectrum of the compound **1d** ($CDCl_3$, 400 MHz).

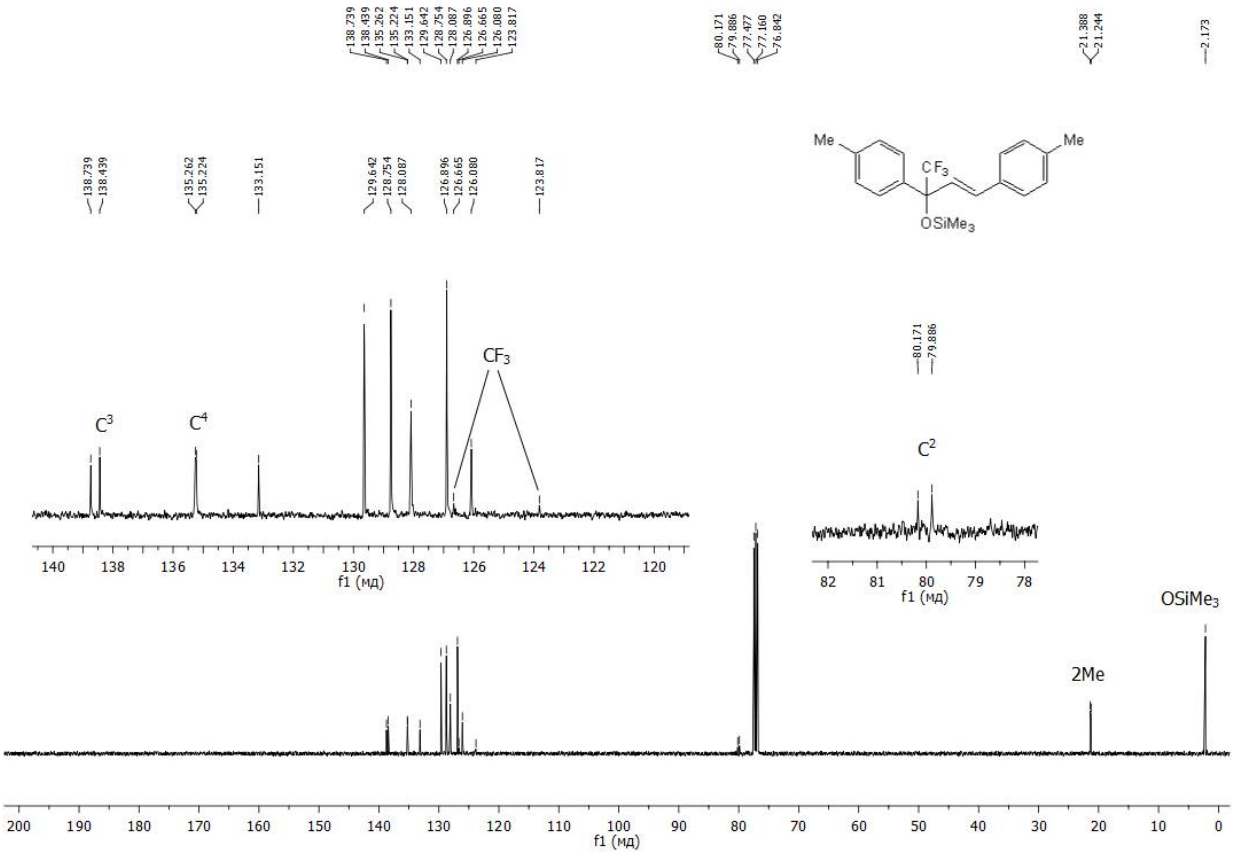


Fig. S10. ^{13}C NMR spectrum of the compound **1d** ($CDCl_3$, 100 MHz).

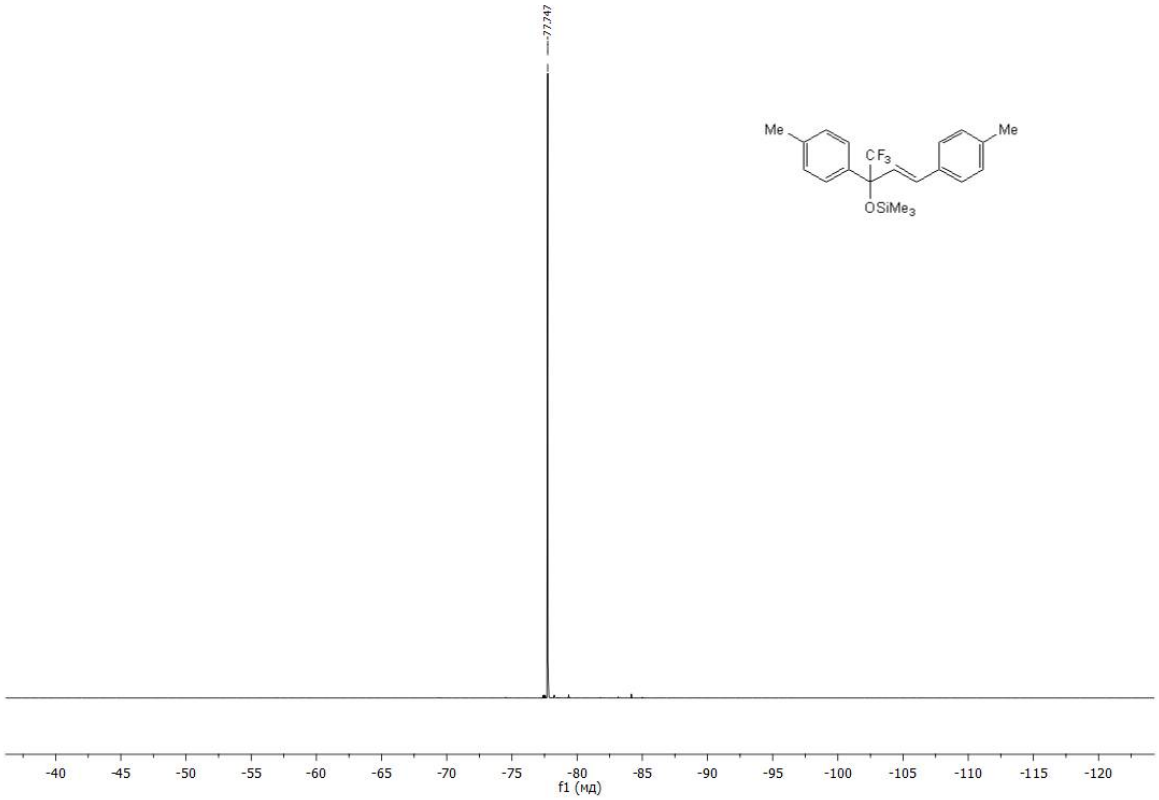


Fig. S11. ^{19}F NMR spectrum of the compound **1d** ($CDCl_3$, 376 MHz).

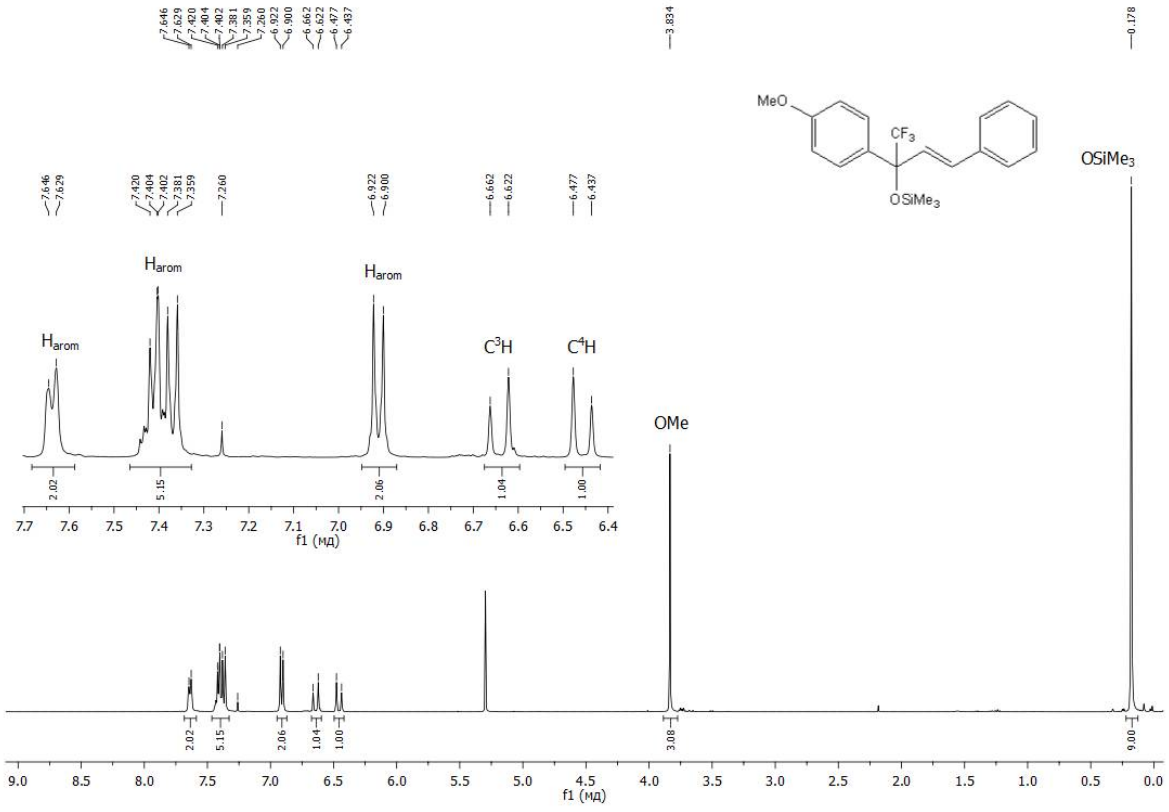


Fig. S12. ^{1}H NMR spectrum of the compound **1e** ($CDCl_3$, 400 MHz).

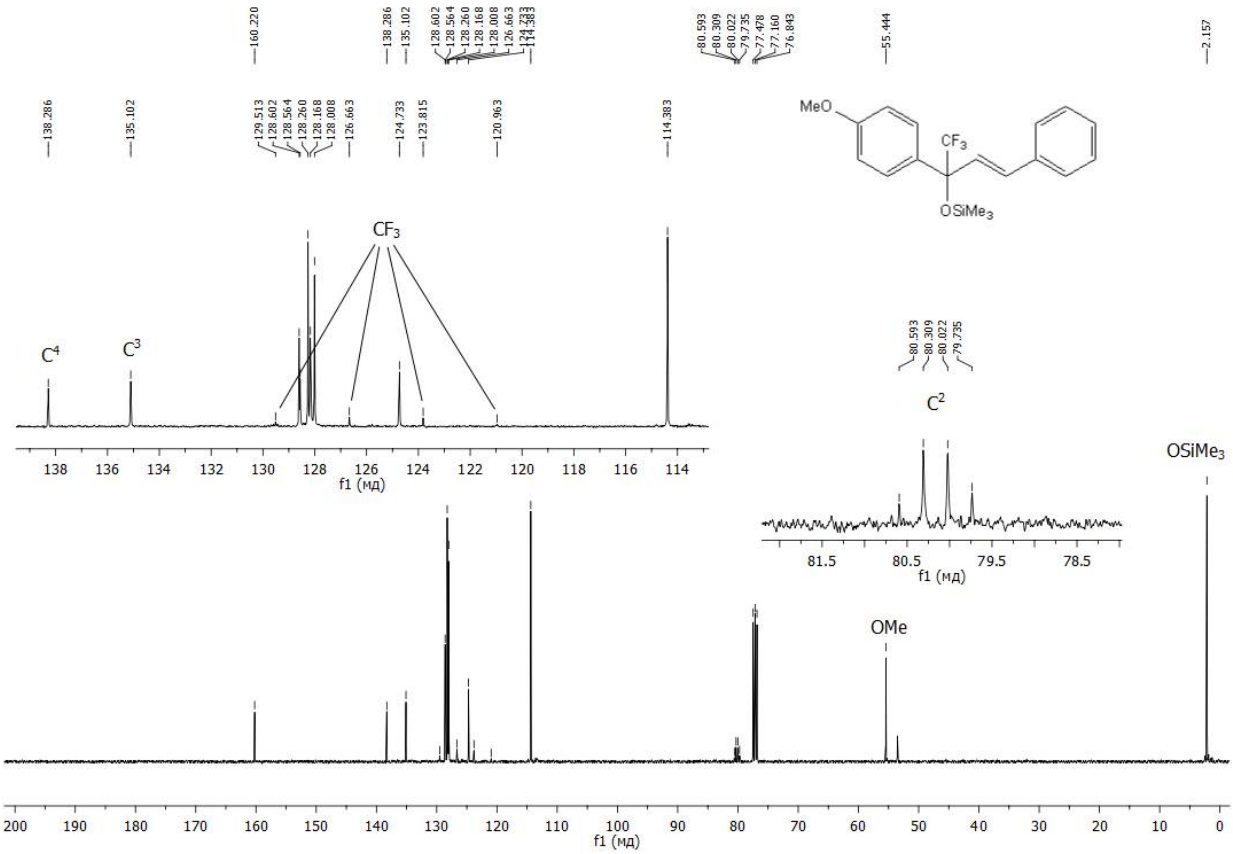


Fig. S13. ^{13}C NMR spectrum of the compound **1e** ($CDCl_3$, 100 MHz).

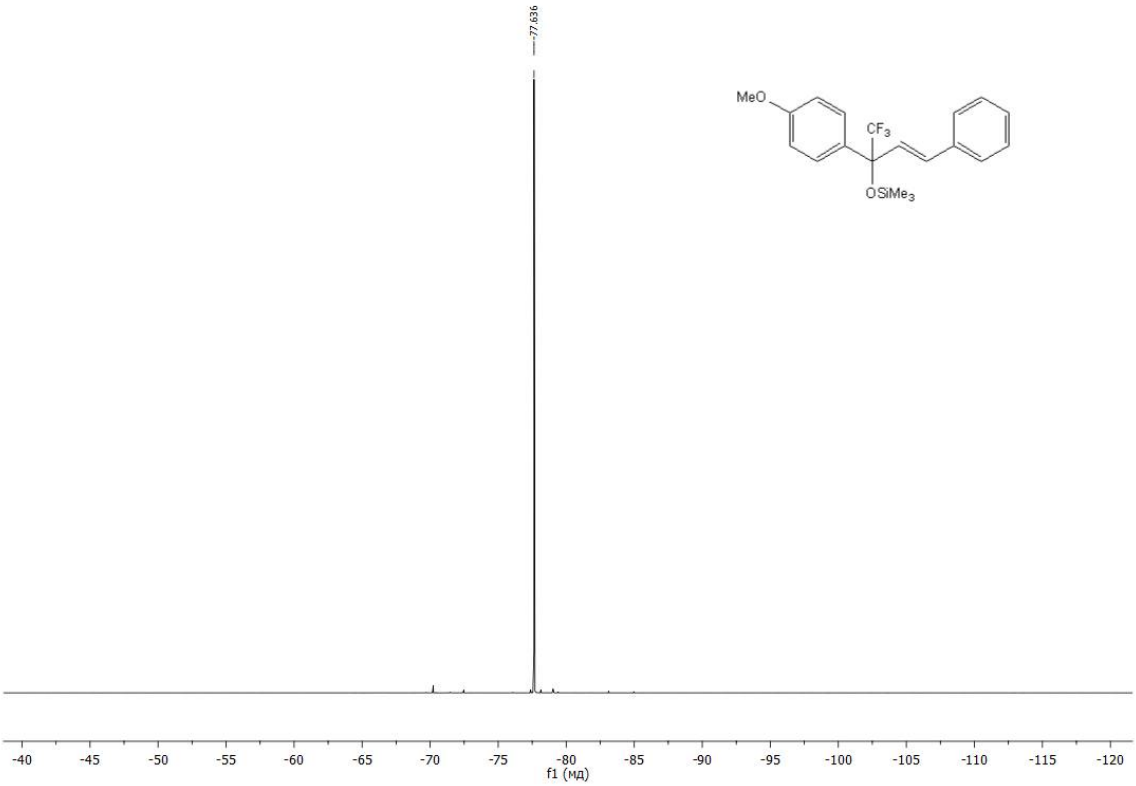


Fig. S14. ^{19}F NMR spectrum of the compound **1e** ($CDCl_3$, 376 MHz).

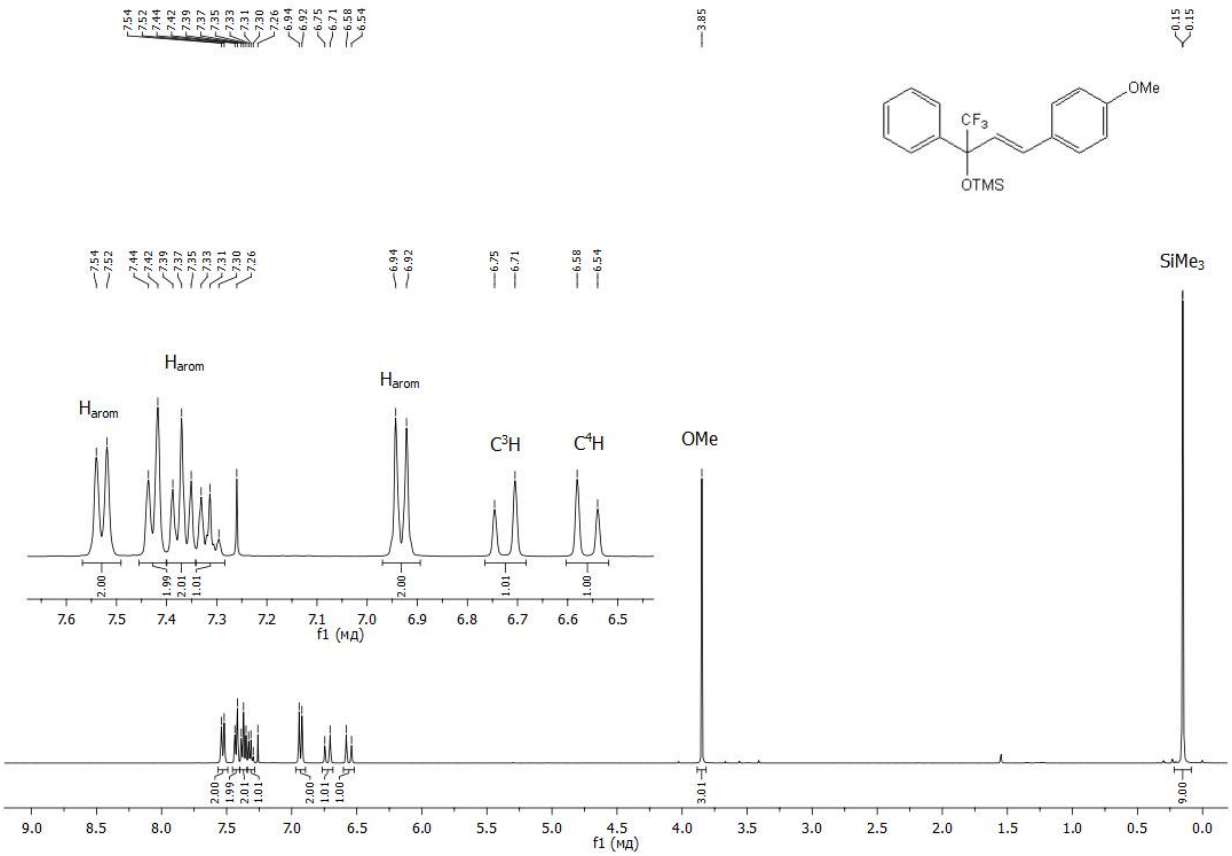


Fig. S15. ^{1}H NMR spectrum of the compound **1f** ($CDCl_3$, 400 MHz).

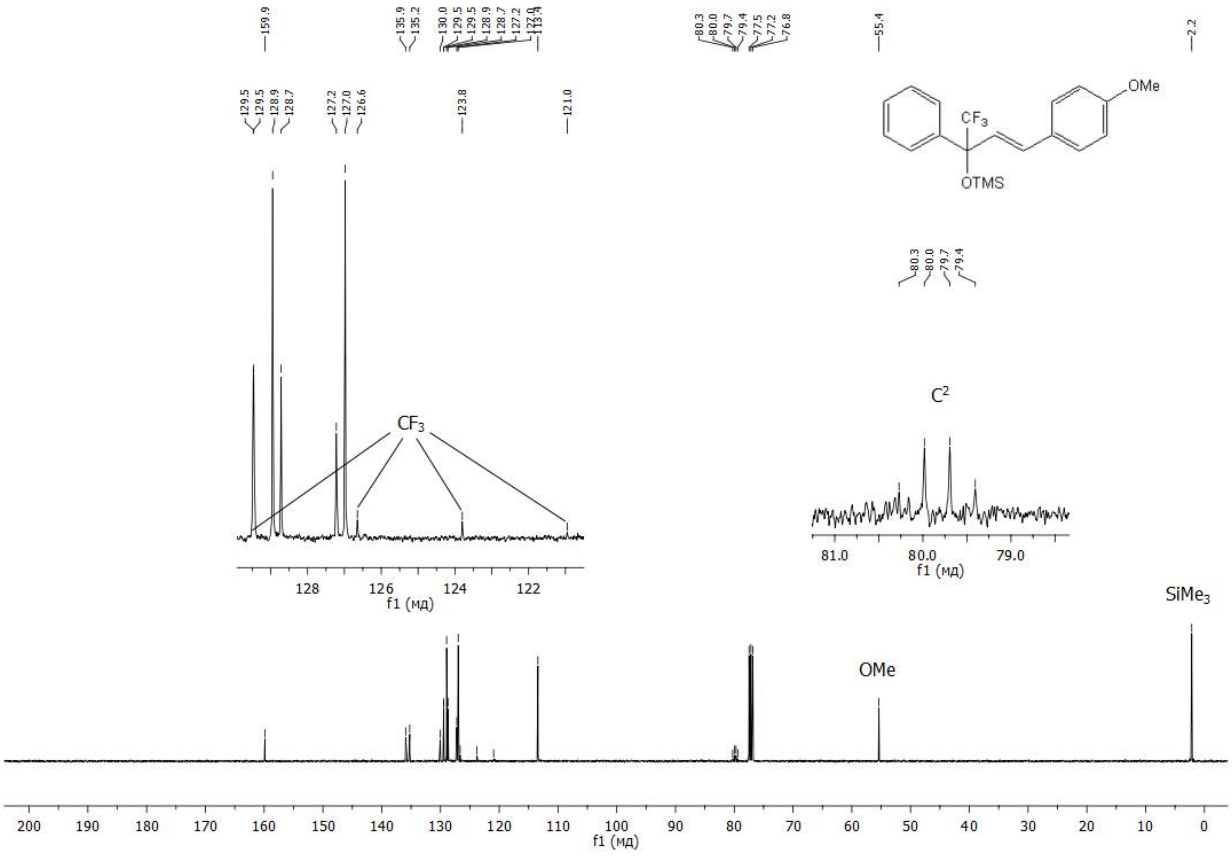


Fig. S16. ^{13}C NMR spectrum of the compound **1f** ($CDCl_3$, 100 MHz).

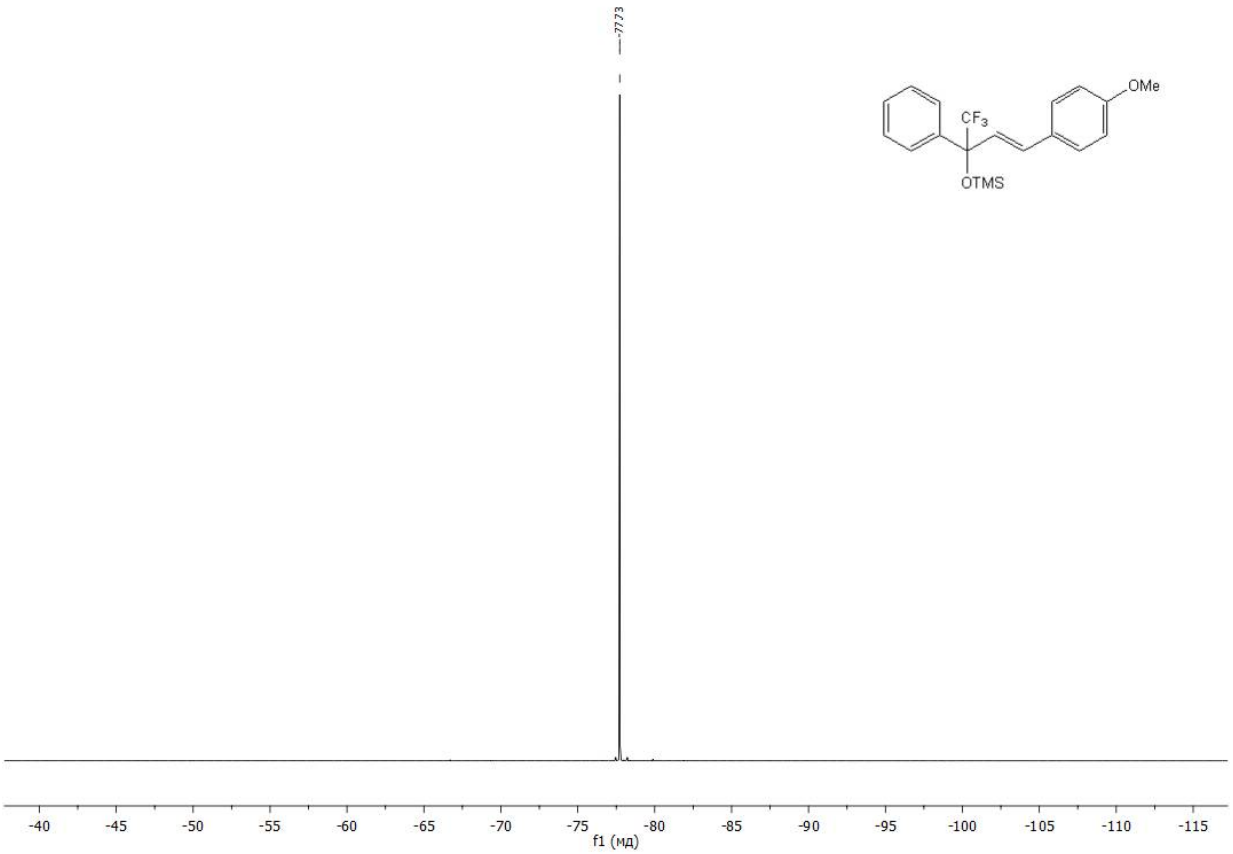


Fig. S17. ^{19}F NMR spectrum of the compound **1f** ($CDCl_3$, 376 MHz).

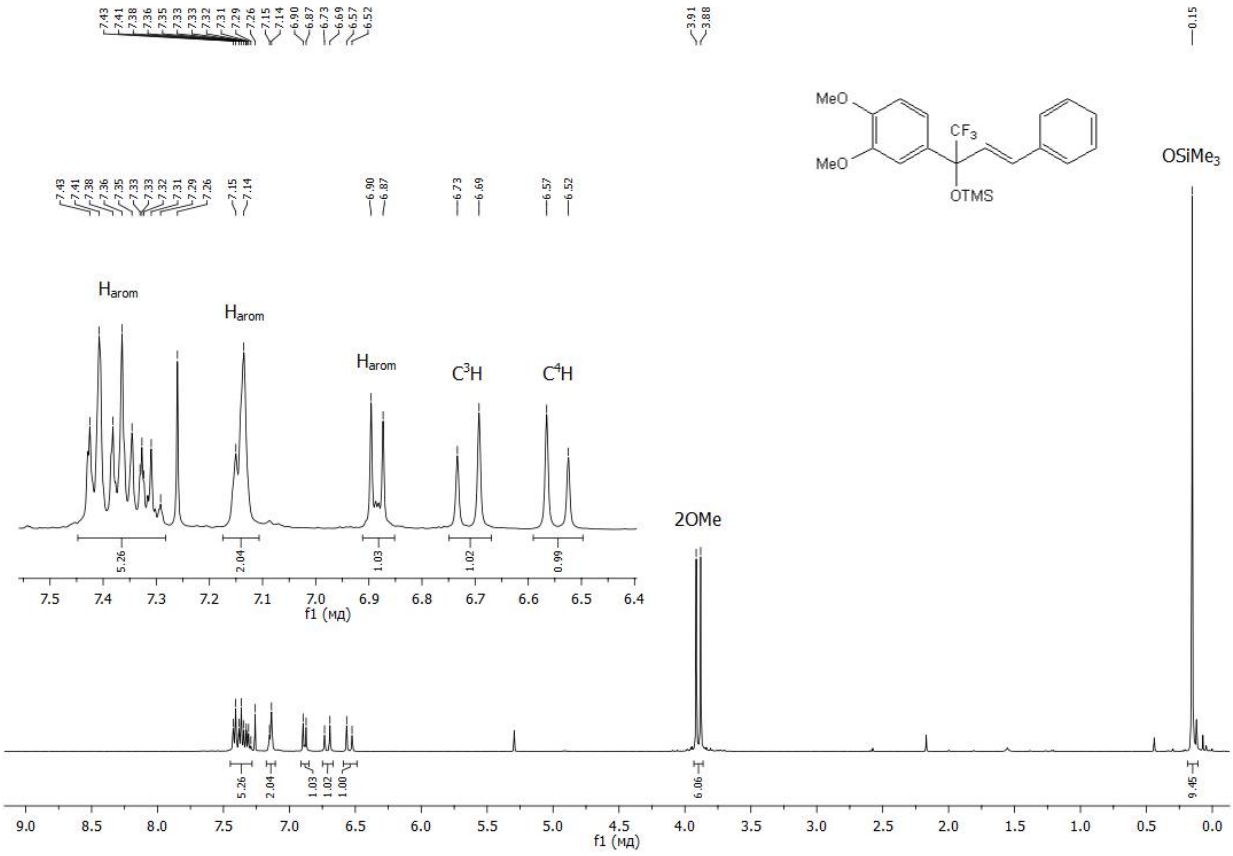


Fig. S18. ^{1}H NMR spectrum of the compound **1g** ($CDCl_3$, 400 MHz).

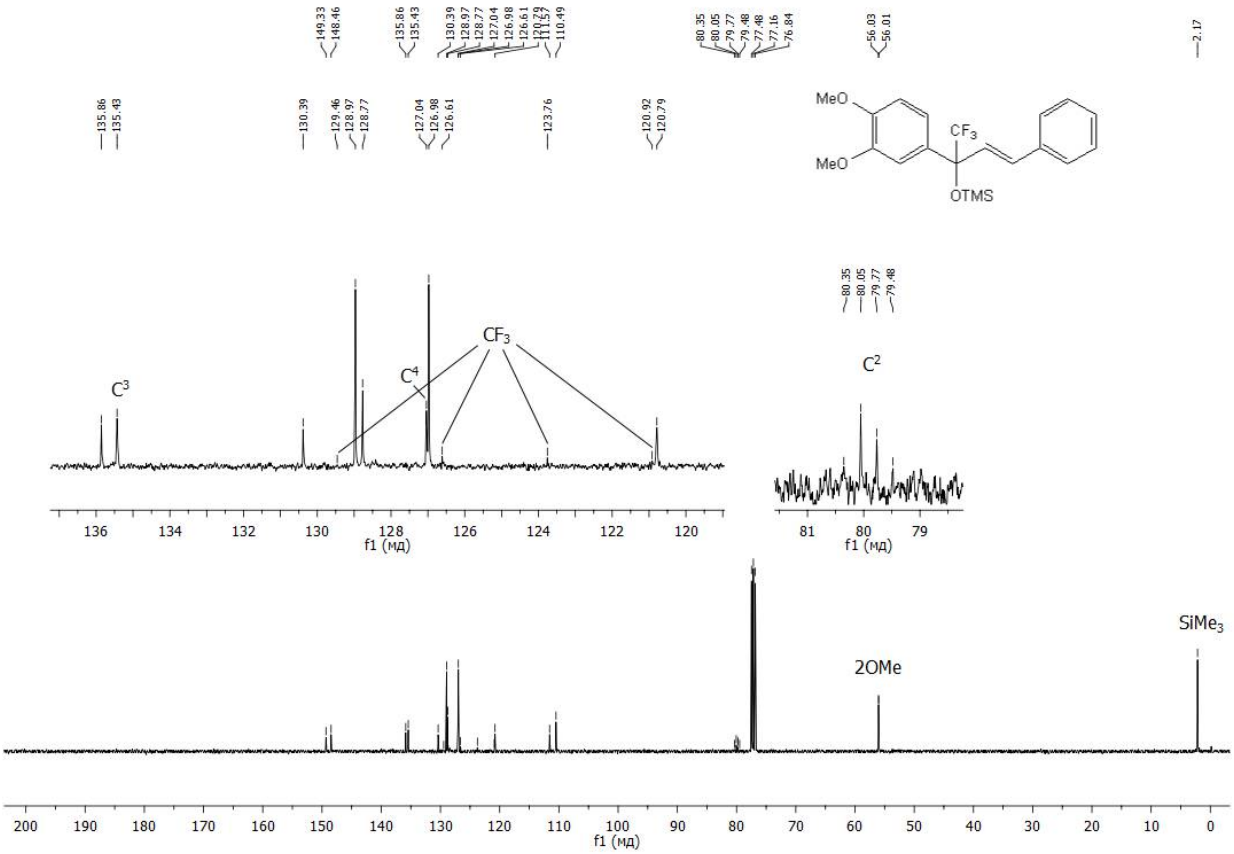


Fig. S19. ^{13}C NMR spectrum of the compound **1g** ($CDCl_3$, 100 MHz).

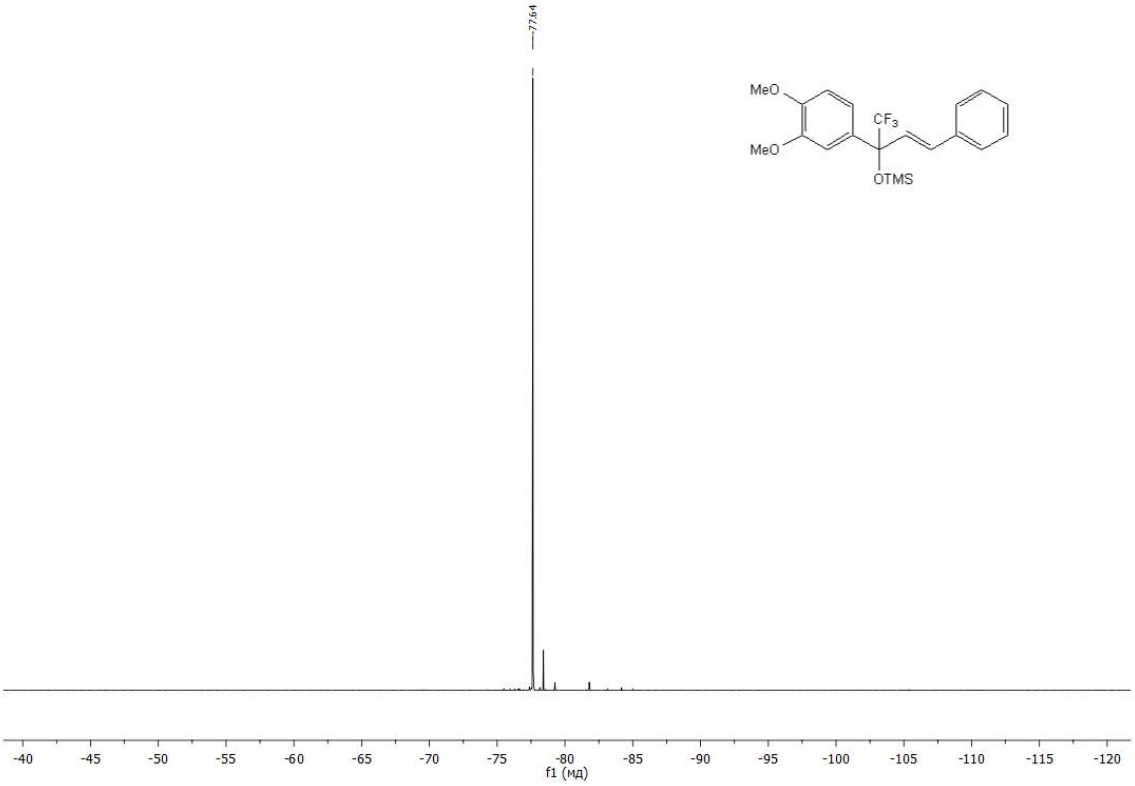


Fig. S20. ^{19}F NMR spectrum of the compound **1g** ($CDCl_3$, 376 MHz).

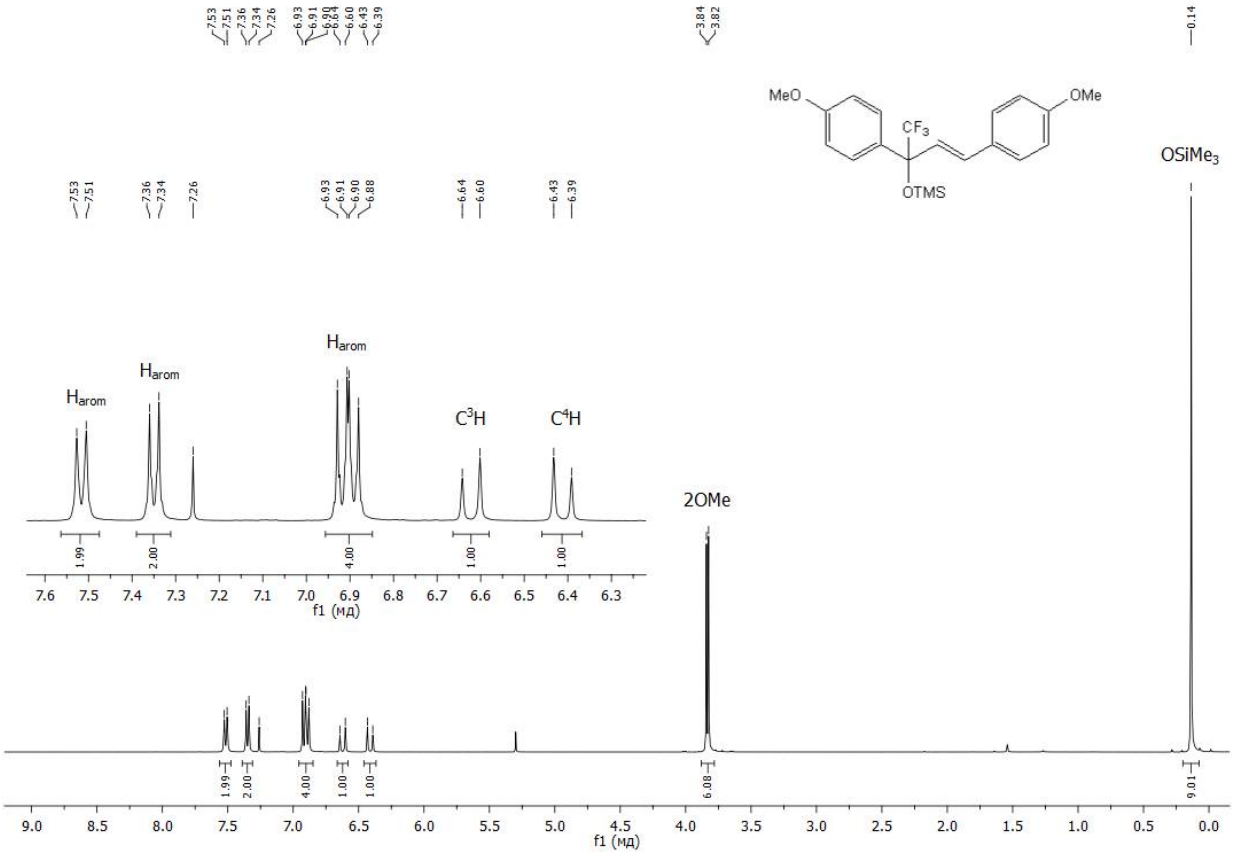


Fig. S21. ^{1}H NMR spectrum of the compound **1h** ($CDCl_3$, 400 MHz).

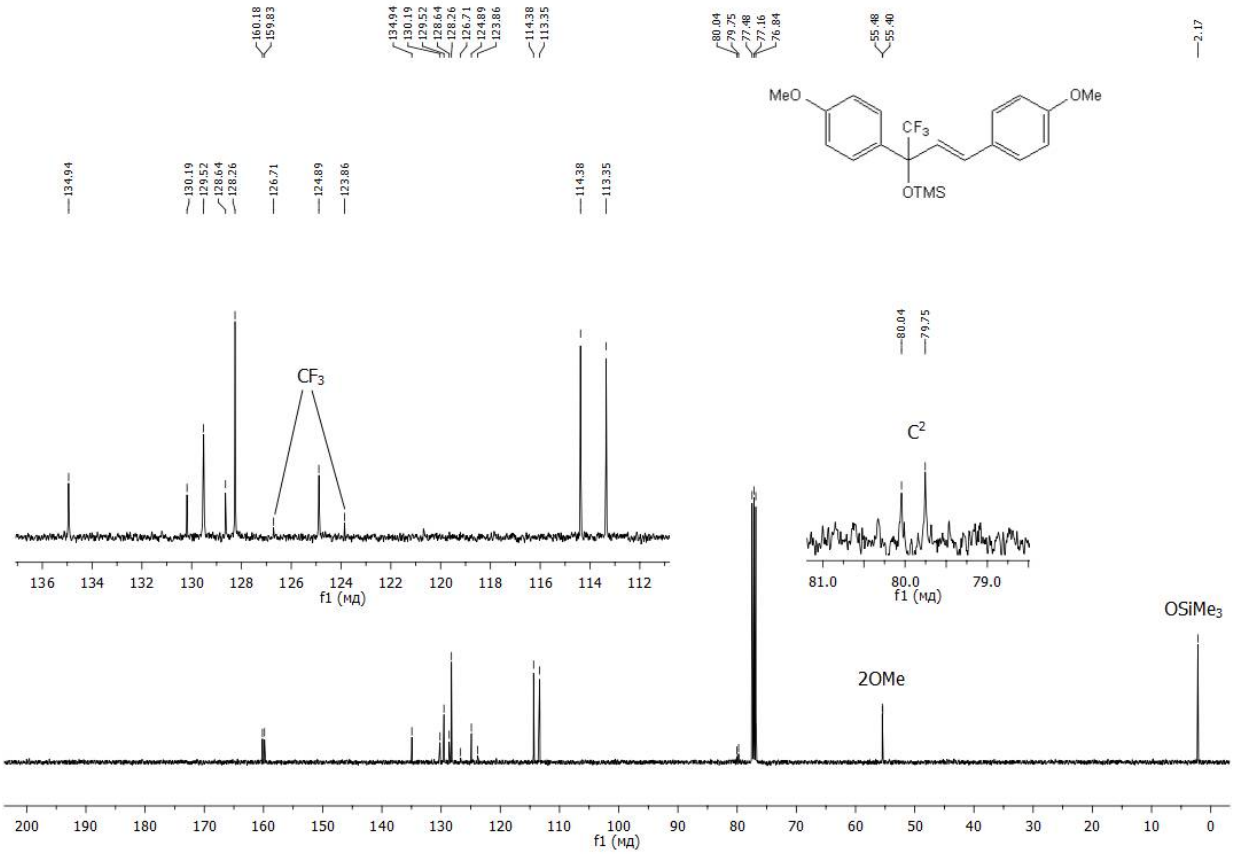


Fig. S22. ^{13}C NMR spectrum of the compound **1h** ($CDCl_3$, 100 MHz).

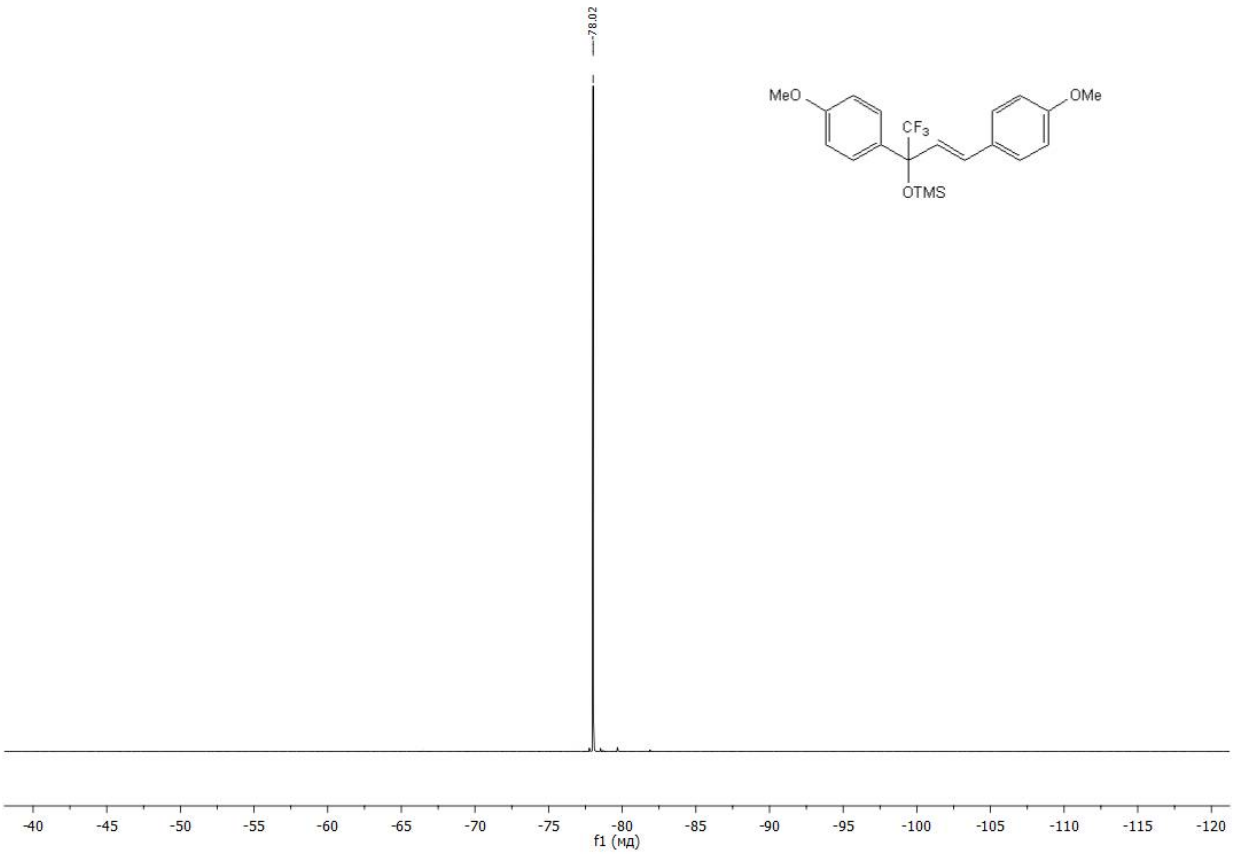


Fig. S23. ^{19}F NMR spectrum of the compound **1h** ($CDCl_3$, 376 MHz).

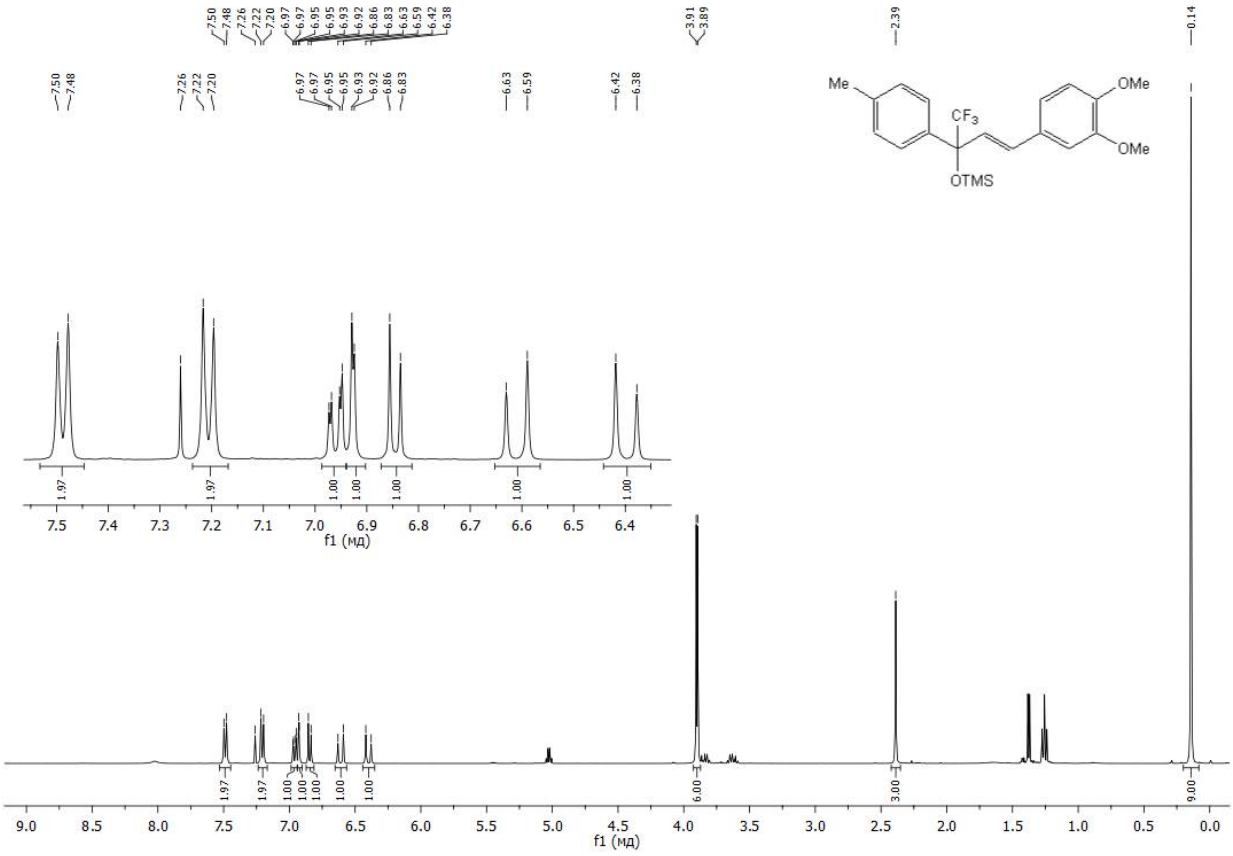


Fig. S24. ^{1}H NMR spectrum of the compound **1i** ($CDCl_3$, 400 MHz).

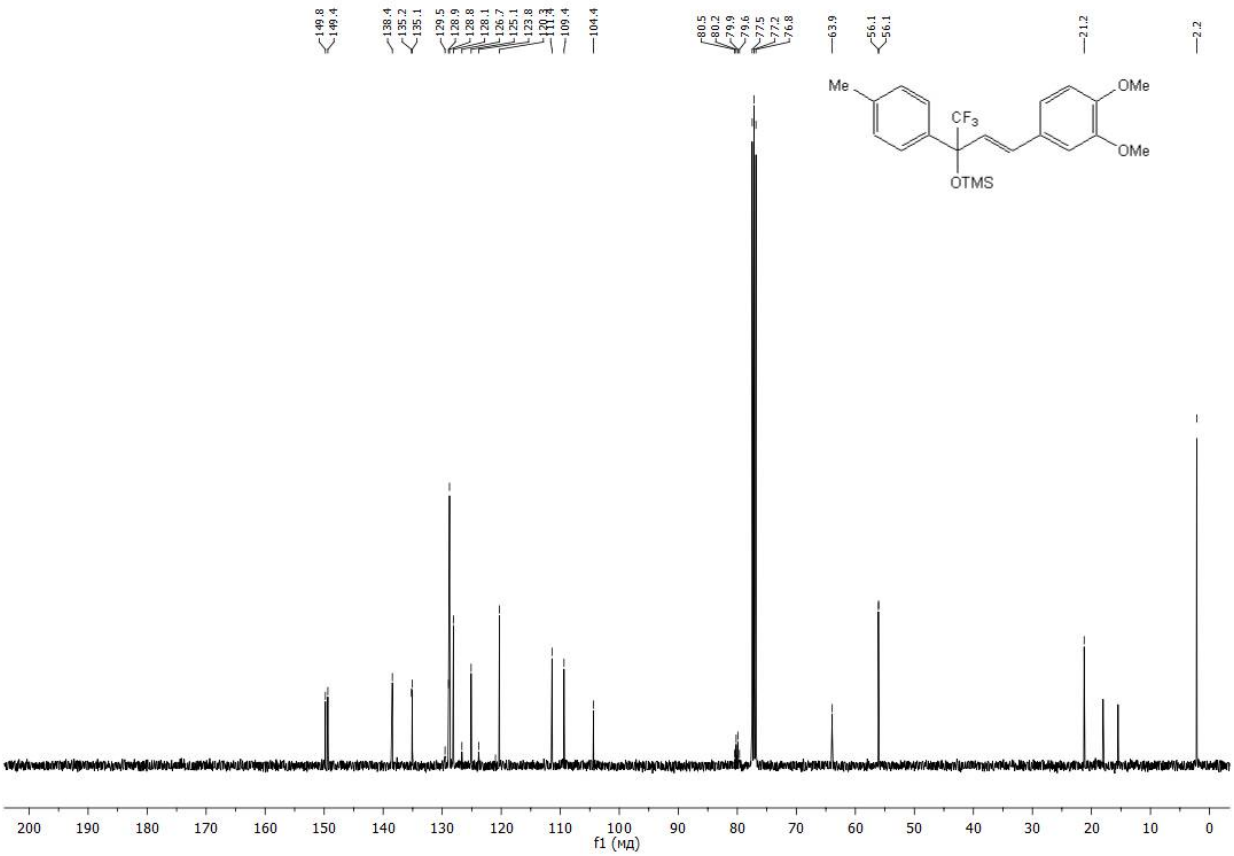


Fig. S25. ^{13}C NMR spectrum of the compound **1i** ($CDCl_3$, 100 MHz).

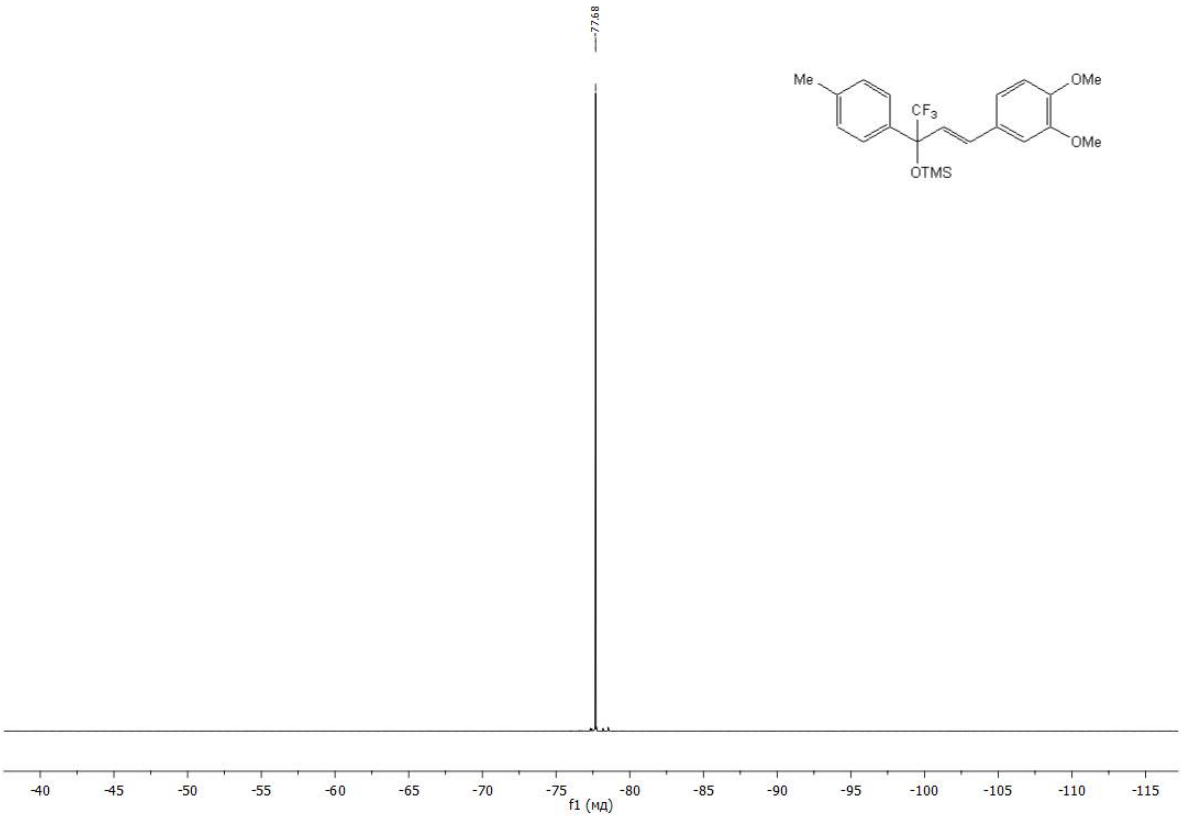


Fig. S26. ^{19}F NMR spectrum of the compound **1i** ($CDCl_3$, 376 MHz).

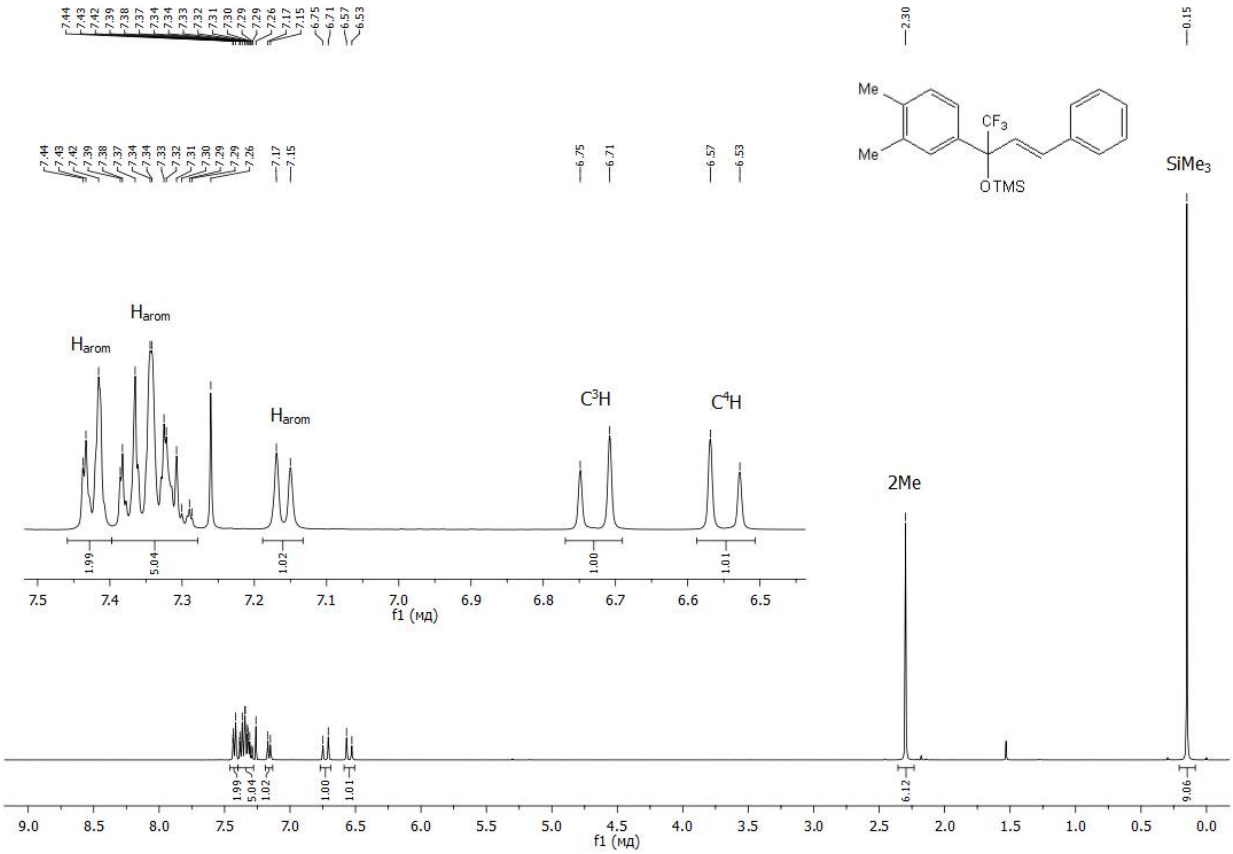


Fig. S27. ^{1}H NMR spectrum of the compound **1j** ($CDCl_3$, 400 MHz).

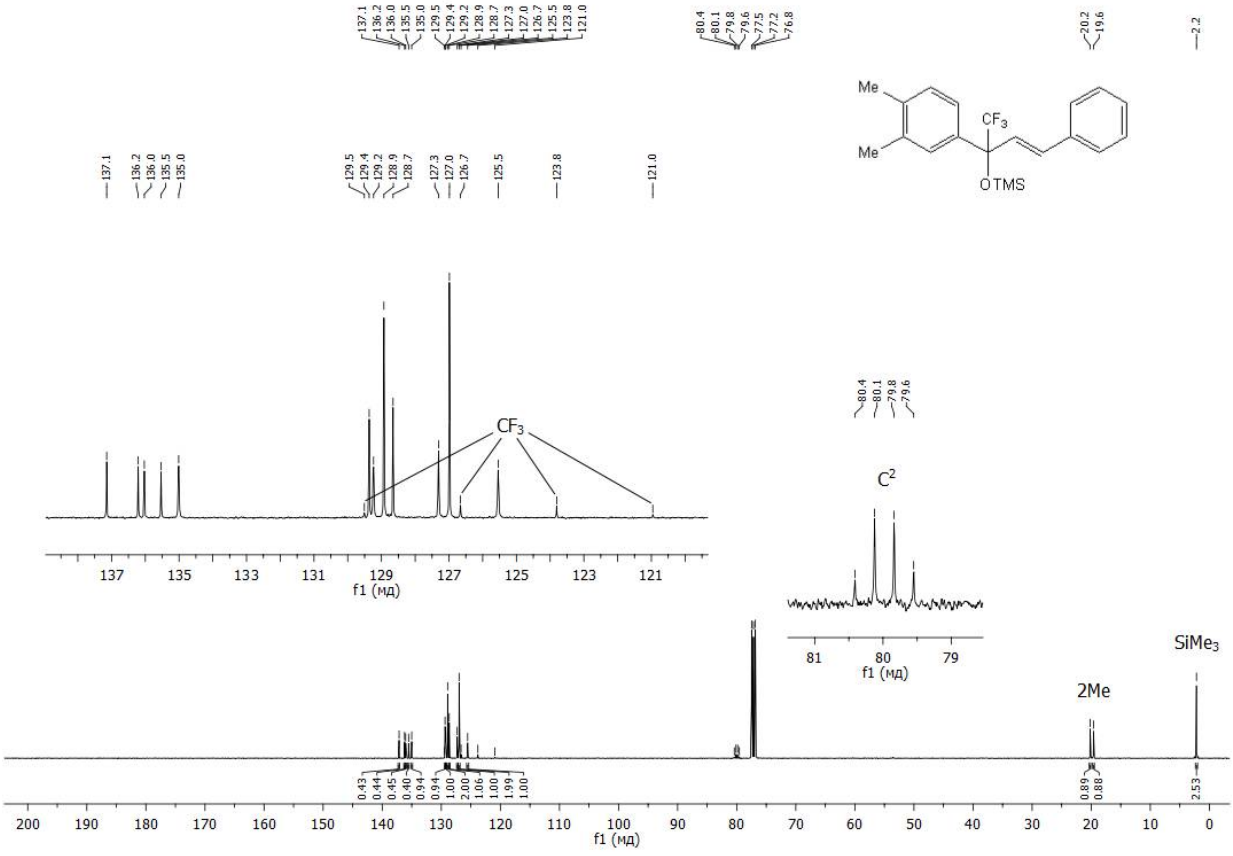


Fig. S28. ^{13}C NMR spectrum of the compound **1j** ($CDCl_3$, 100 MHz).

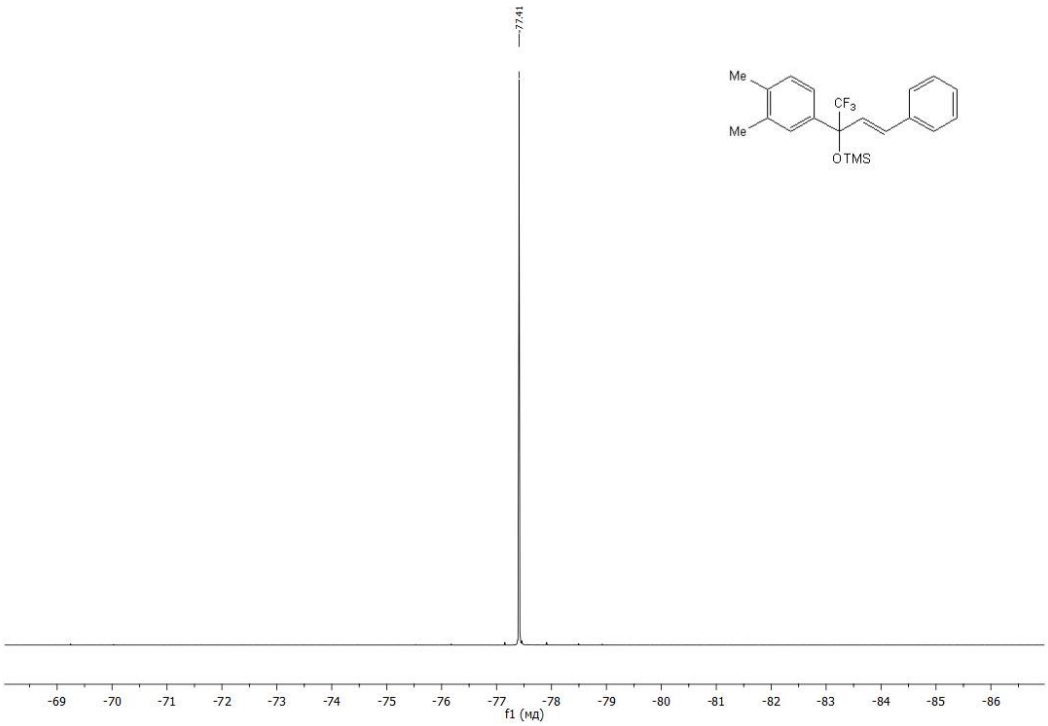


Fig. S29. ^{19}F NMR spectrum of the compound **1j** ($CDCl_3$, 376 MHz).

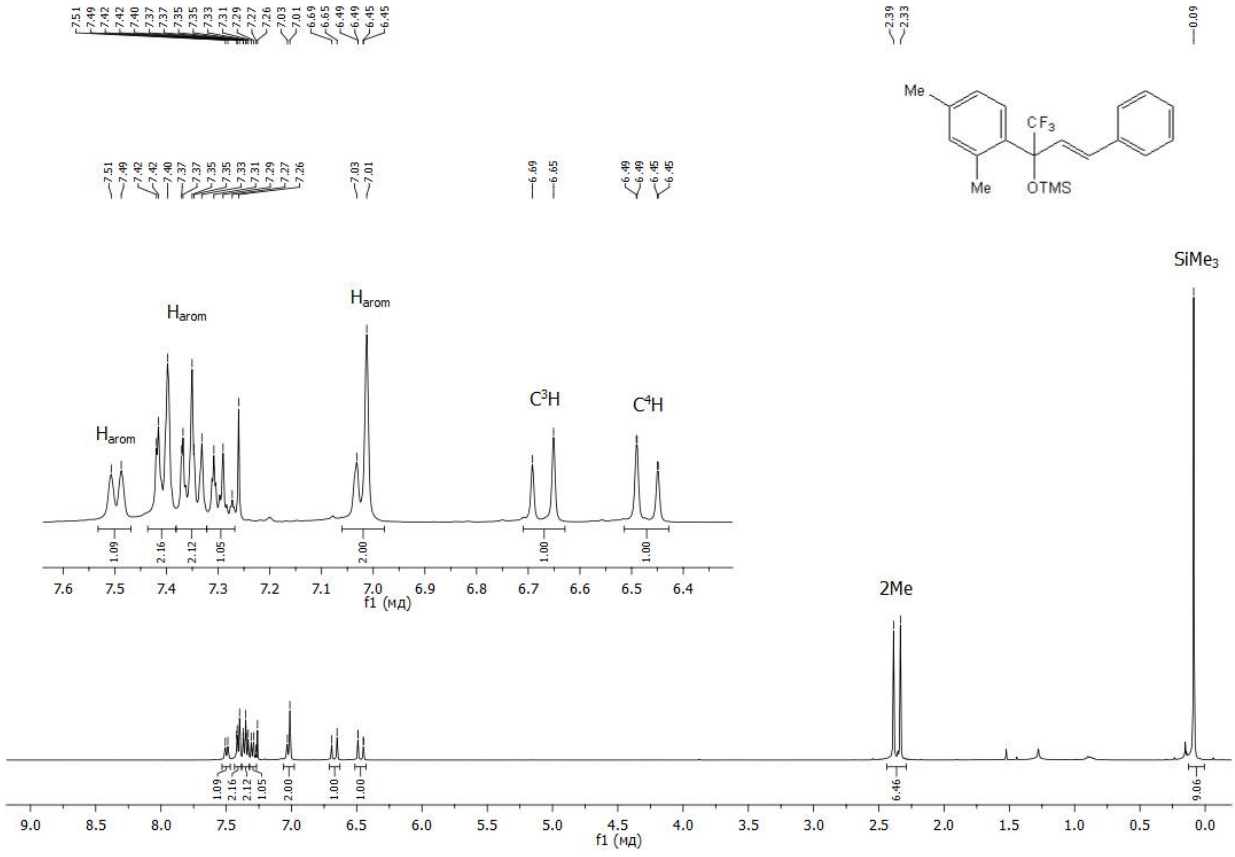


Fig. S30. ^{1}H NMR spectrum of the compound **1k** ($CDCl_3$, 400 MHz).

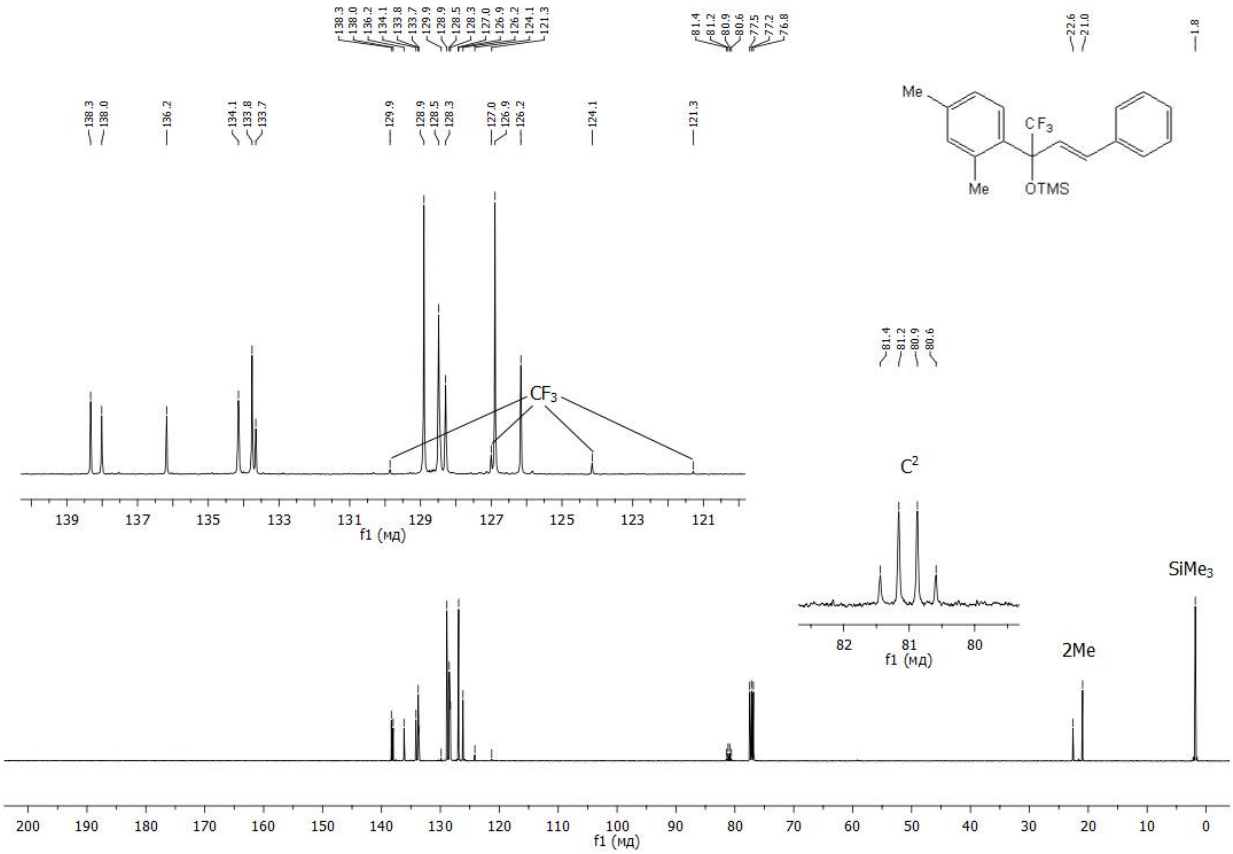


Fig. S31. ^{13}C NMR spectrum of the compound **1k** ($CDCl_3$, 100 MHz).

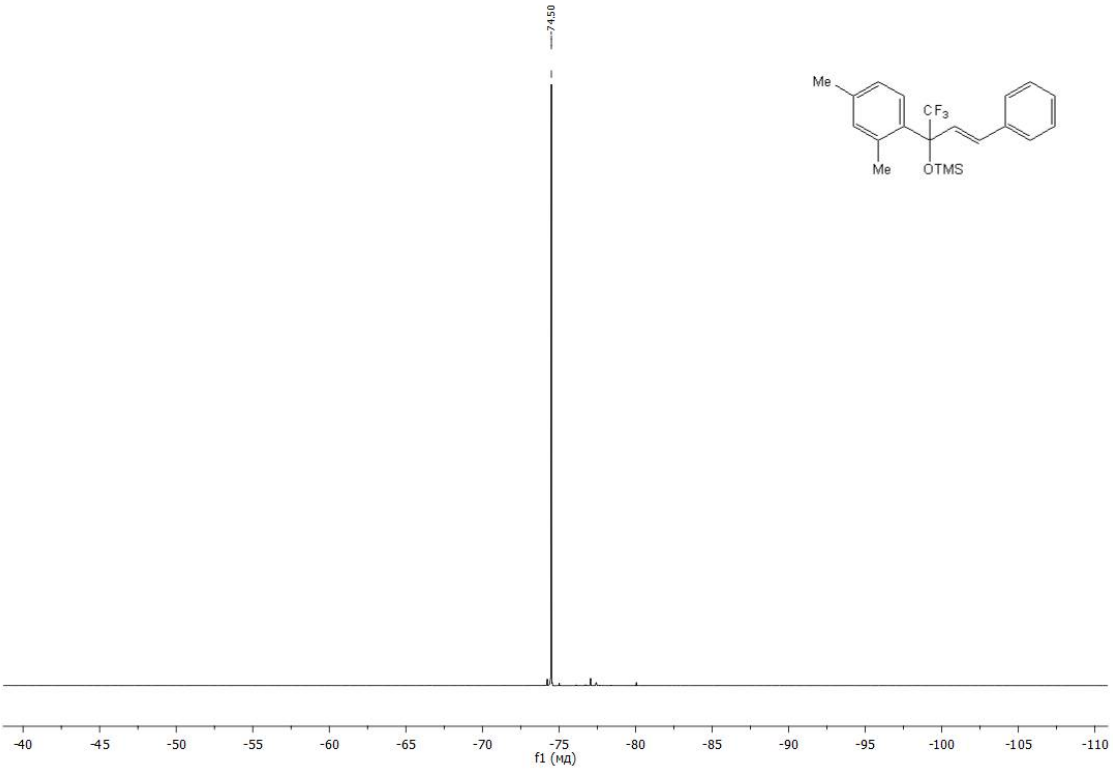


Fig. S32. ^{19}F NMR spectrum of the compound **1k** ($CDCl_3$, 376 MHz).

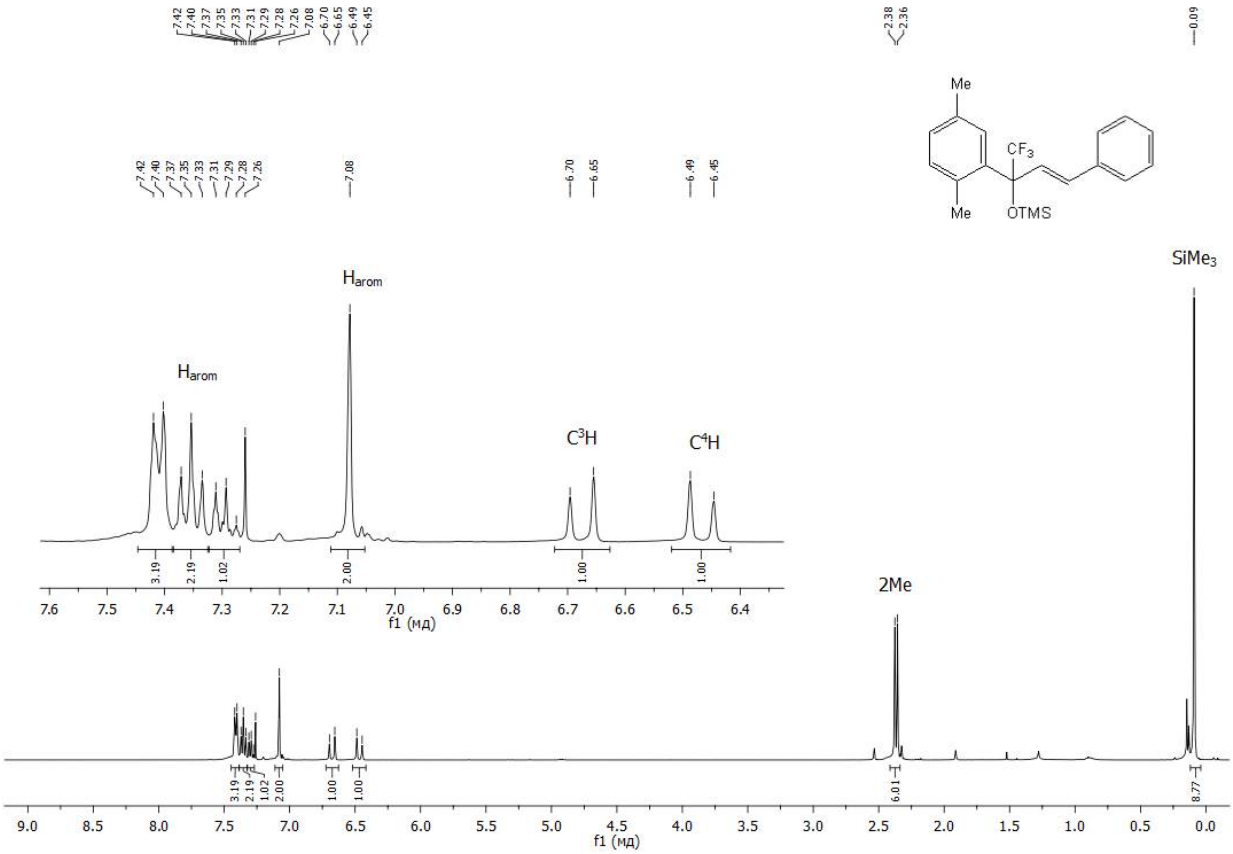


Fig. S33. ^{1}H NMR spectrum of the compound **1l** ($CDCl_3$, 400 MHz).

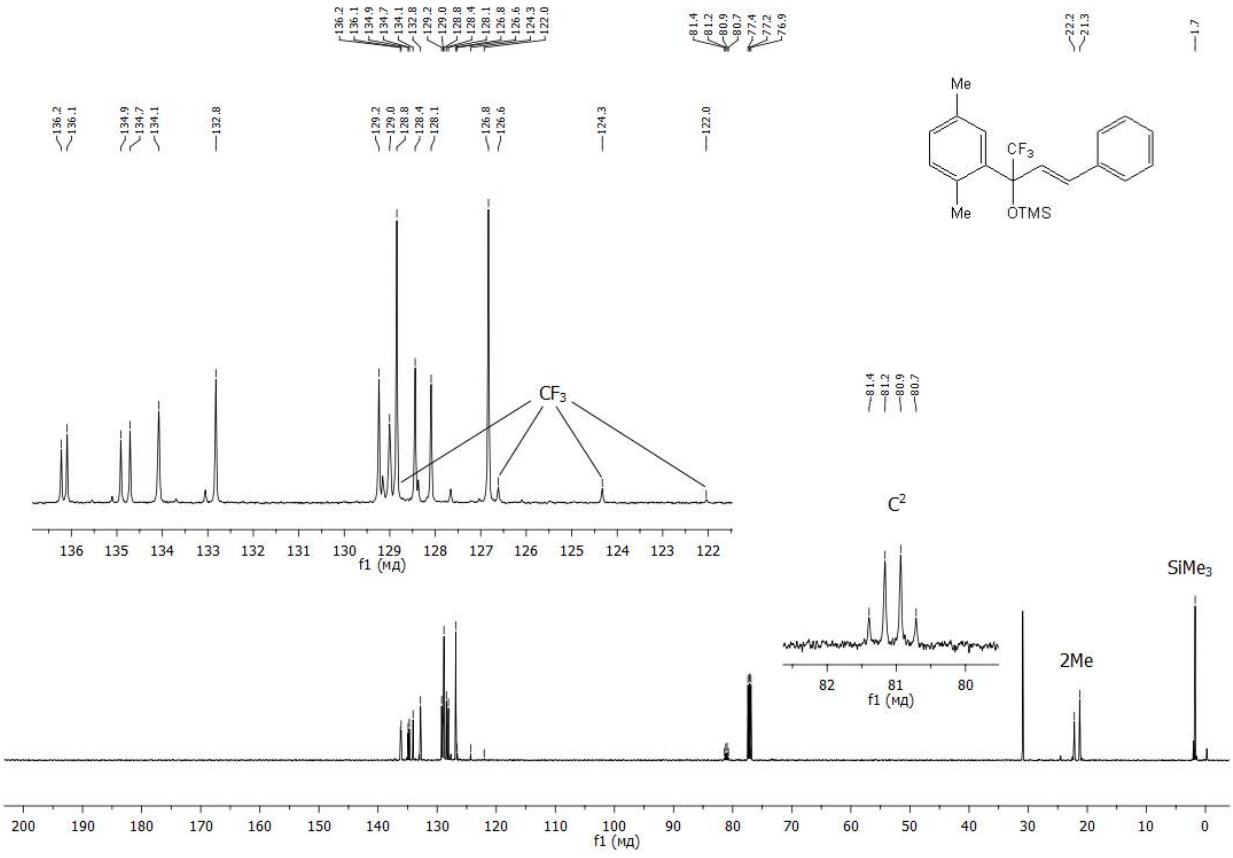


Fig. S34. ^{13}C NMR spectrum of the compound **1l** ($CDCl_3$, 100 MHz).

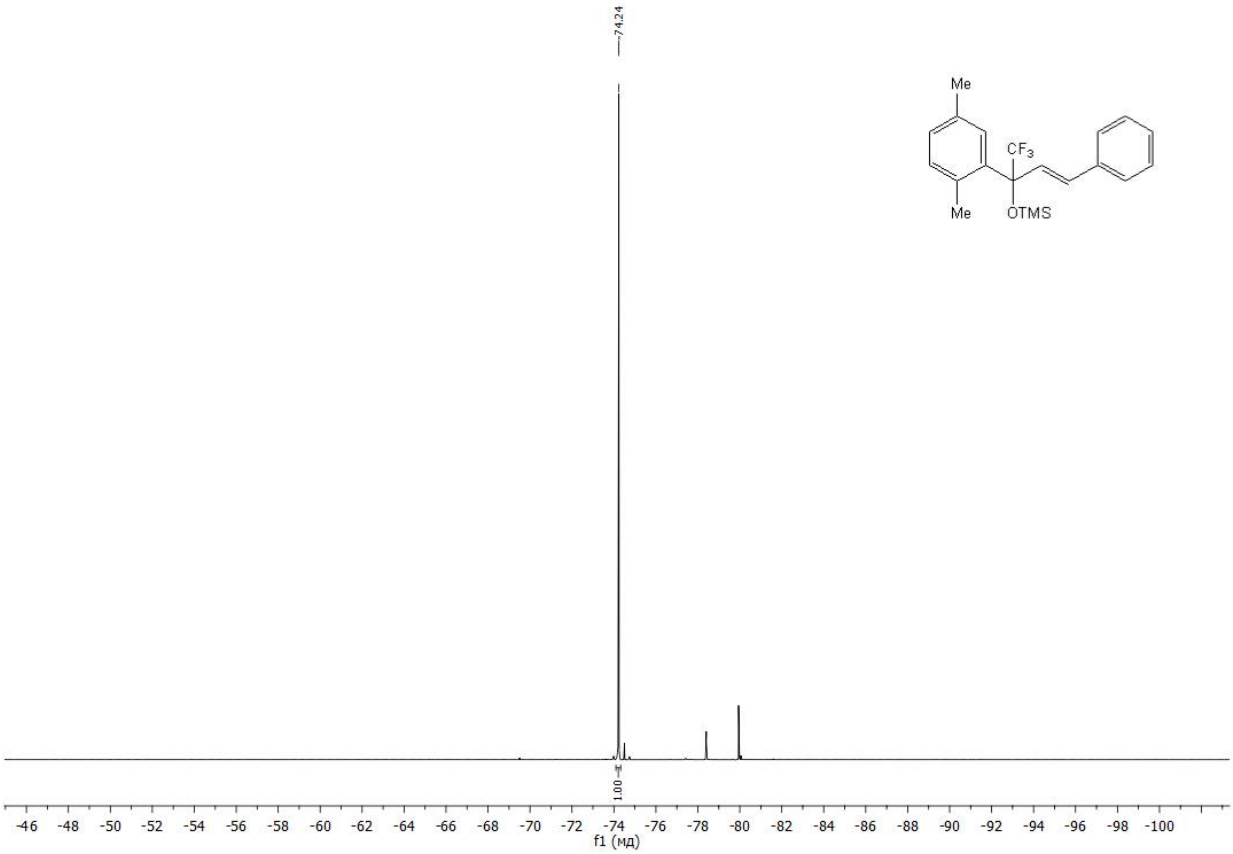


Fig. S35. ^{19}F NMR spectrum of the compound **1l** ($CDCl_3$, 376 MHz).

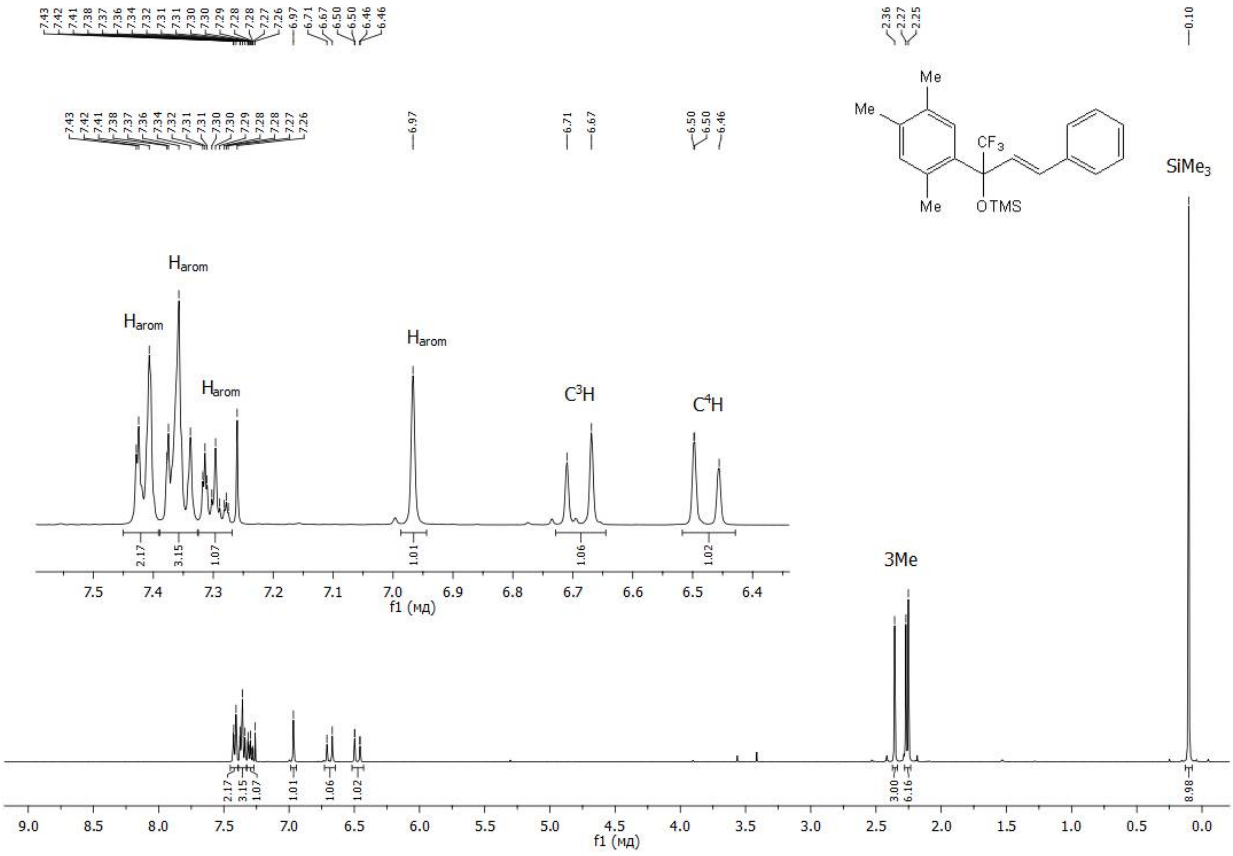


Fig. S36. ^{1}H NMR spectrum of the compound **1m** ($CDCl_3$, 400 MHz).

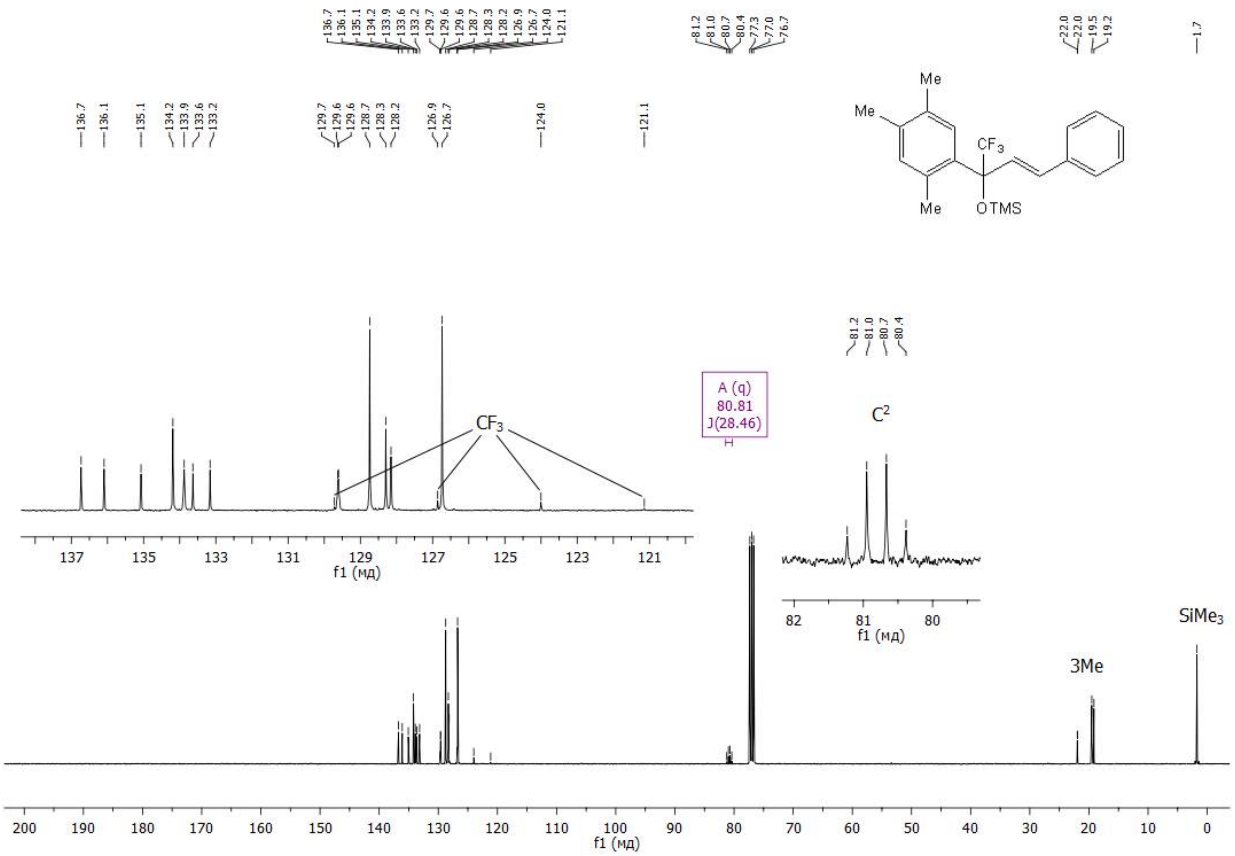


Fig. S37. ^{13}C NMR spectrum of the compound **1m** ($CDCl_3$, 100 MHz).

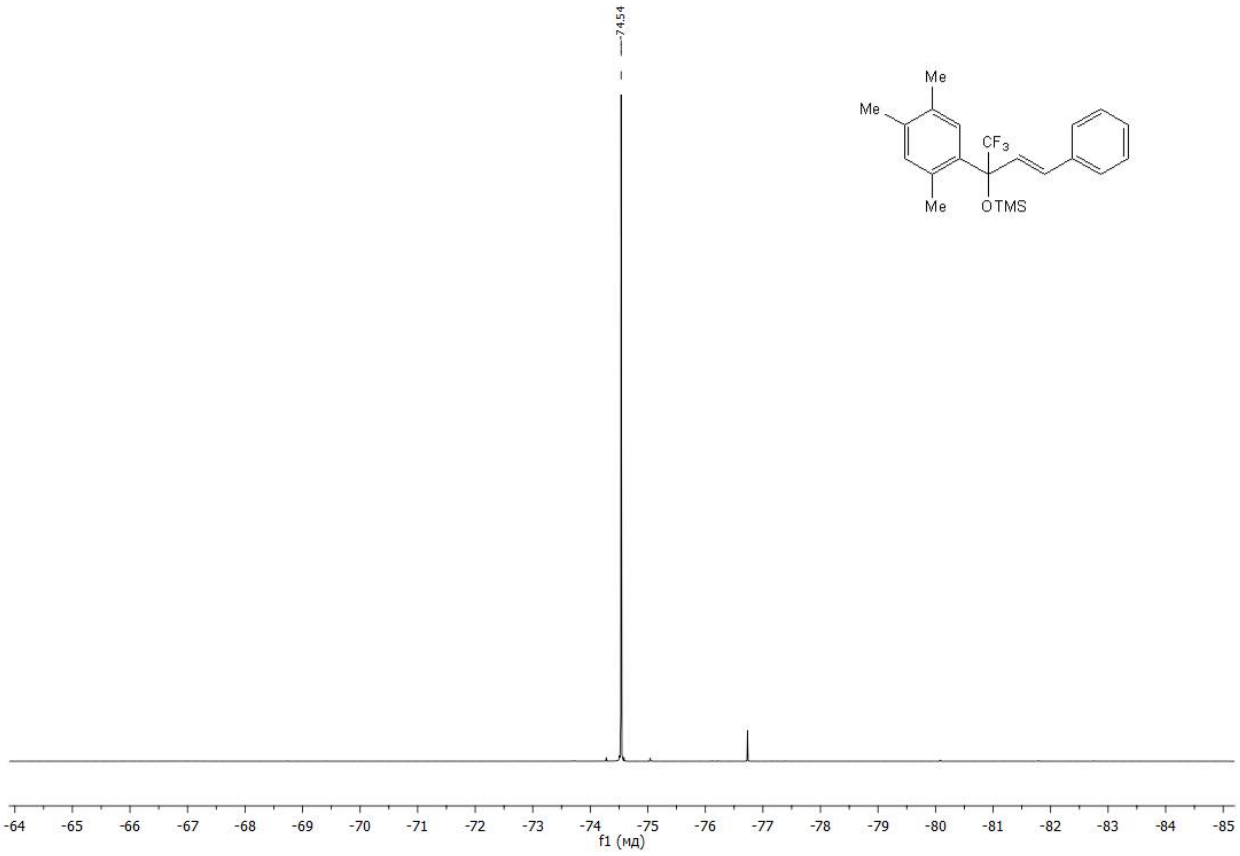


Fig. S38. ^{19}F NMR spectrum of the compound **1m** ($CDCl_3$, 376 MHz).

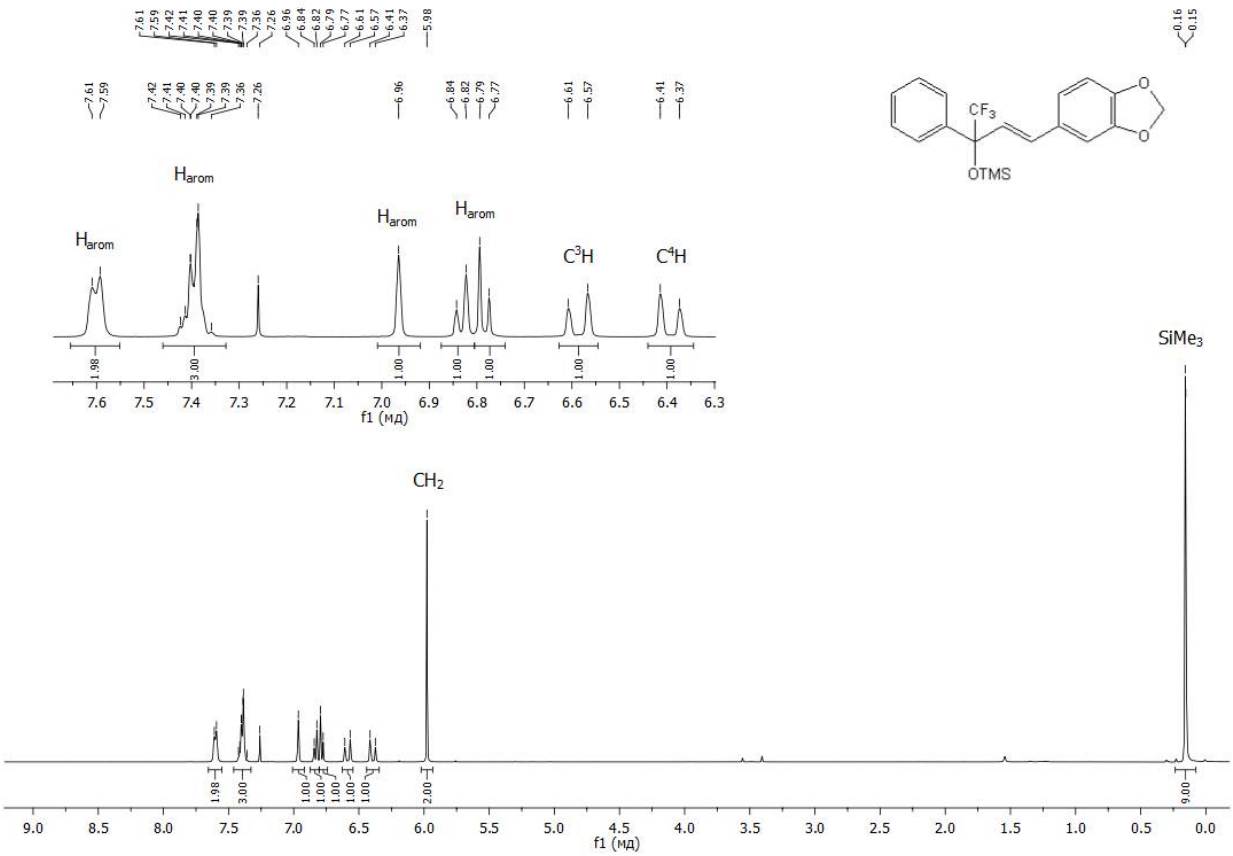


Fig. S39. ^{1}H NMR spectrum of the compound **1n** ($CDCl_3$, 400 MHz).

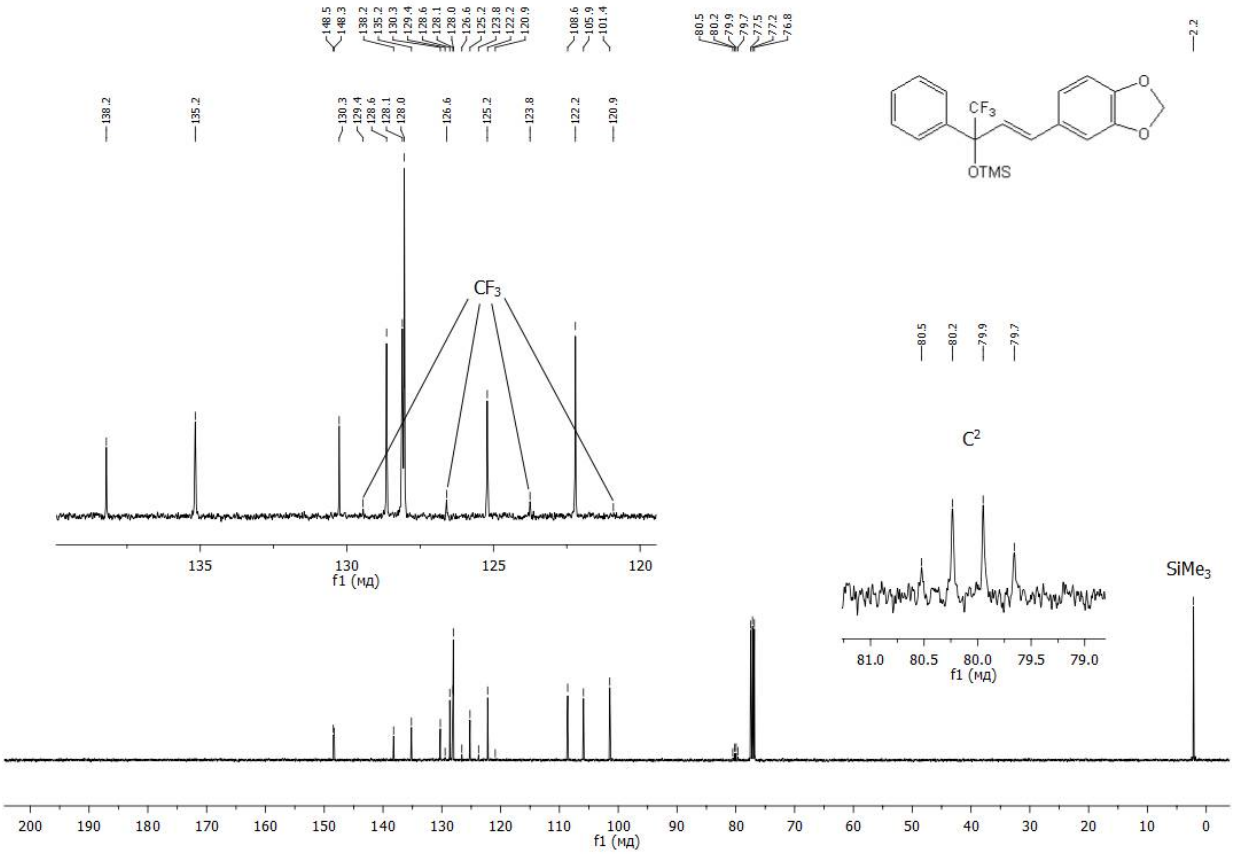


Fig. S40. ^{13}C NMR spectrum of the compound **1n** ($CDCl_3$, 100 MHz).

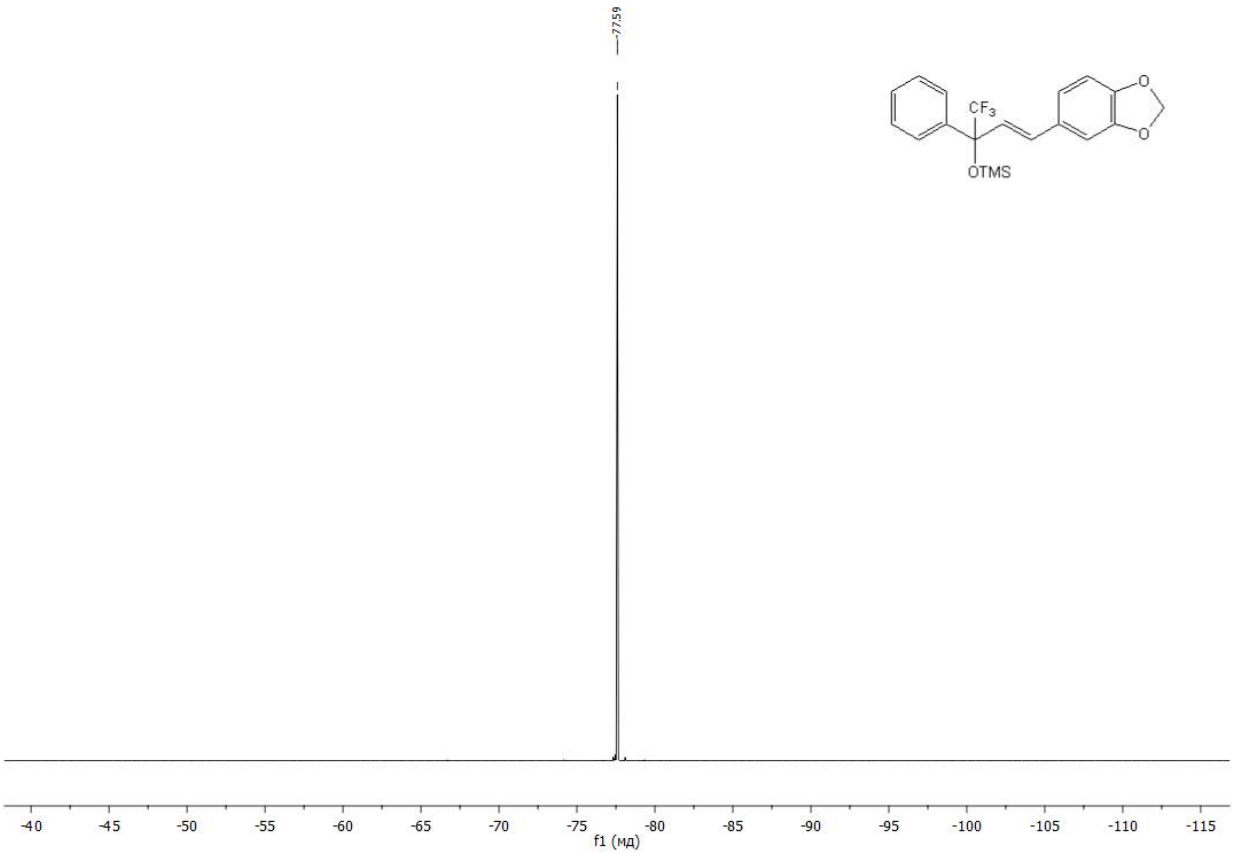


Fig. S41. ^{19}F NMR spectrum of the compound **1n** ($CDCl_3$, 376 MHz).

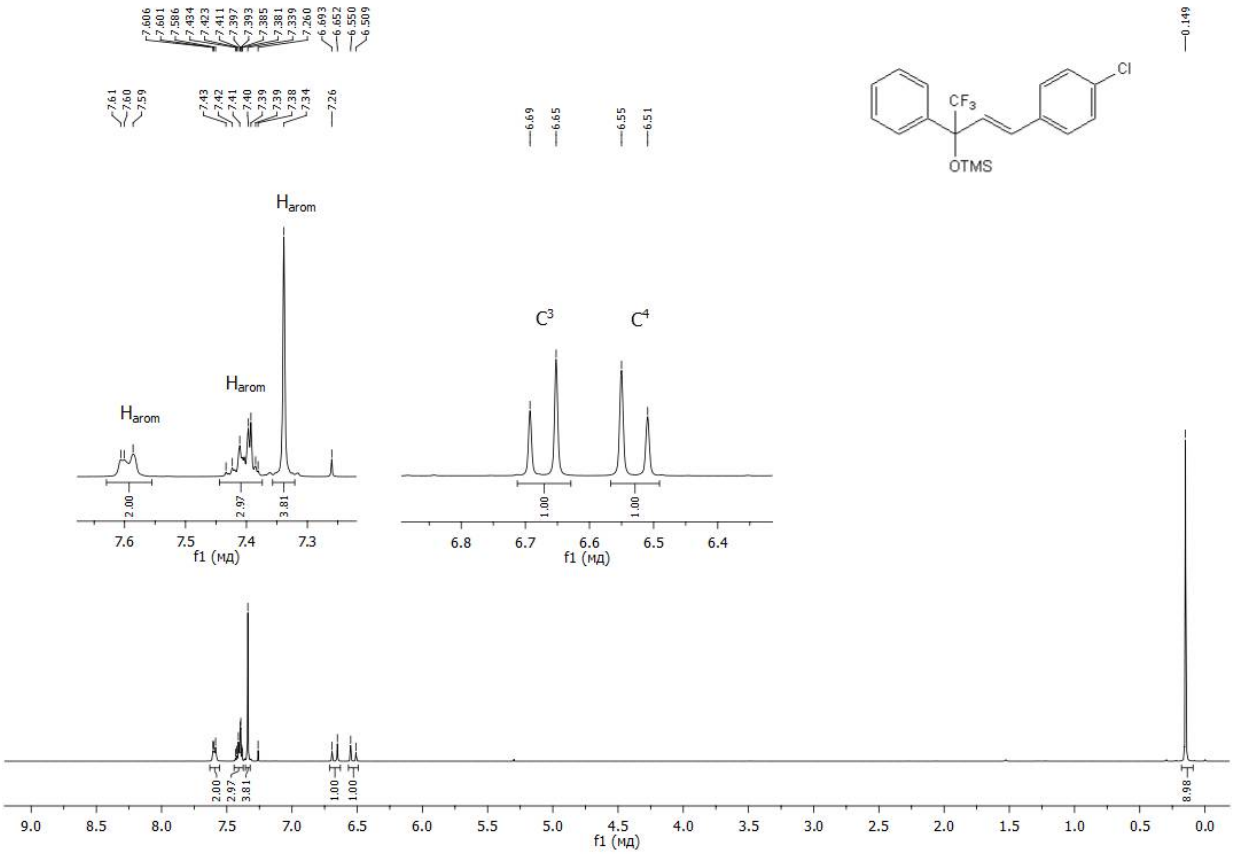


Fig. S42. ^{1}H NMR spectrum of the compound **1o** ($CDCl_3$, 400 MHz).

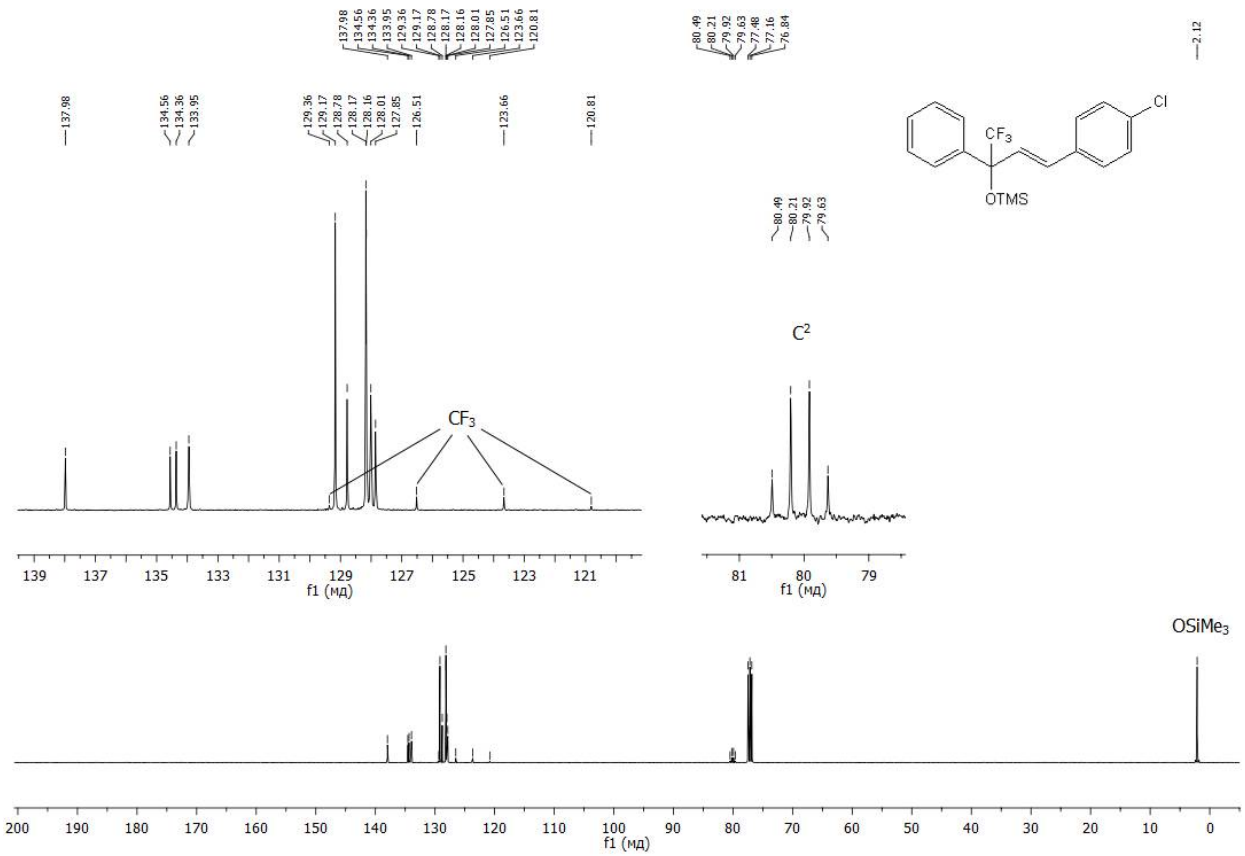


Fig. S43. ^{13}C NMR spectrum of the compound **1o** ($CDCl_3$, 100 MHz).

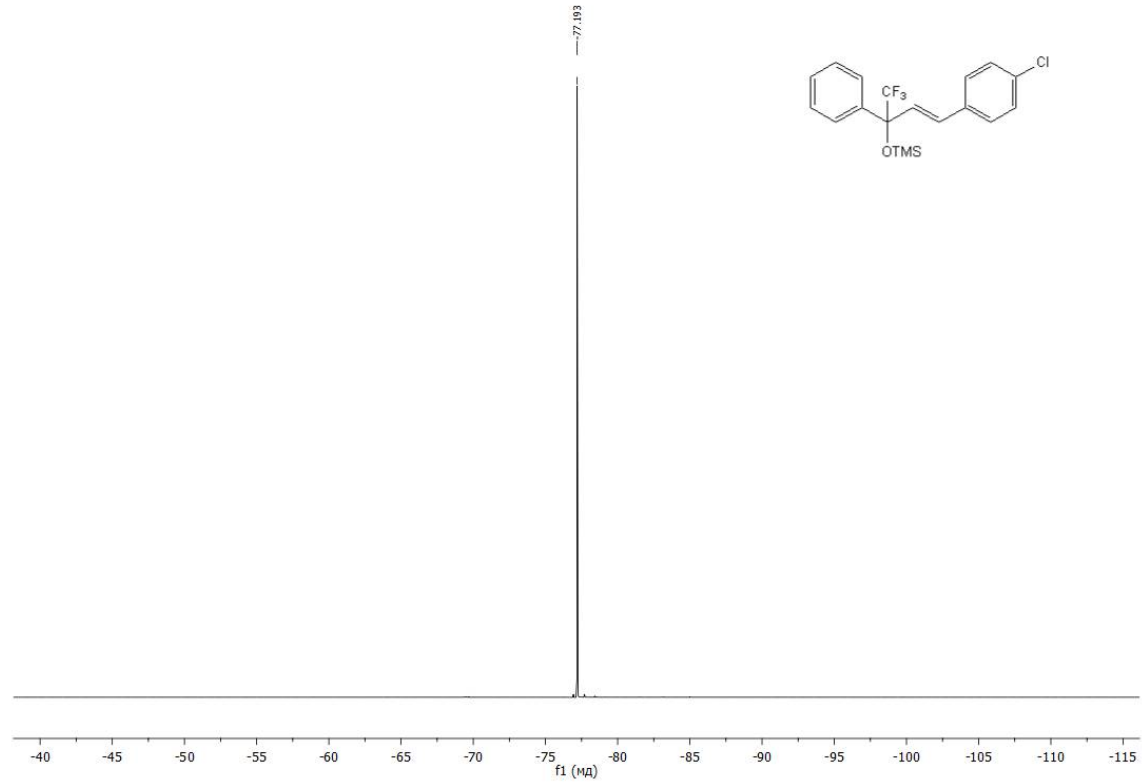


Fig. S44. ^{19}F NMR spectrum of the compound **1o** ($CDCl_3$, 376 MHz).

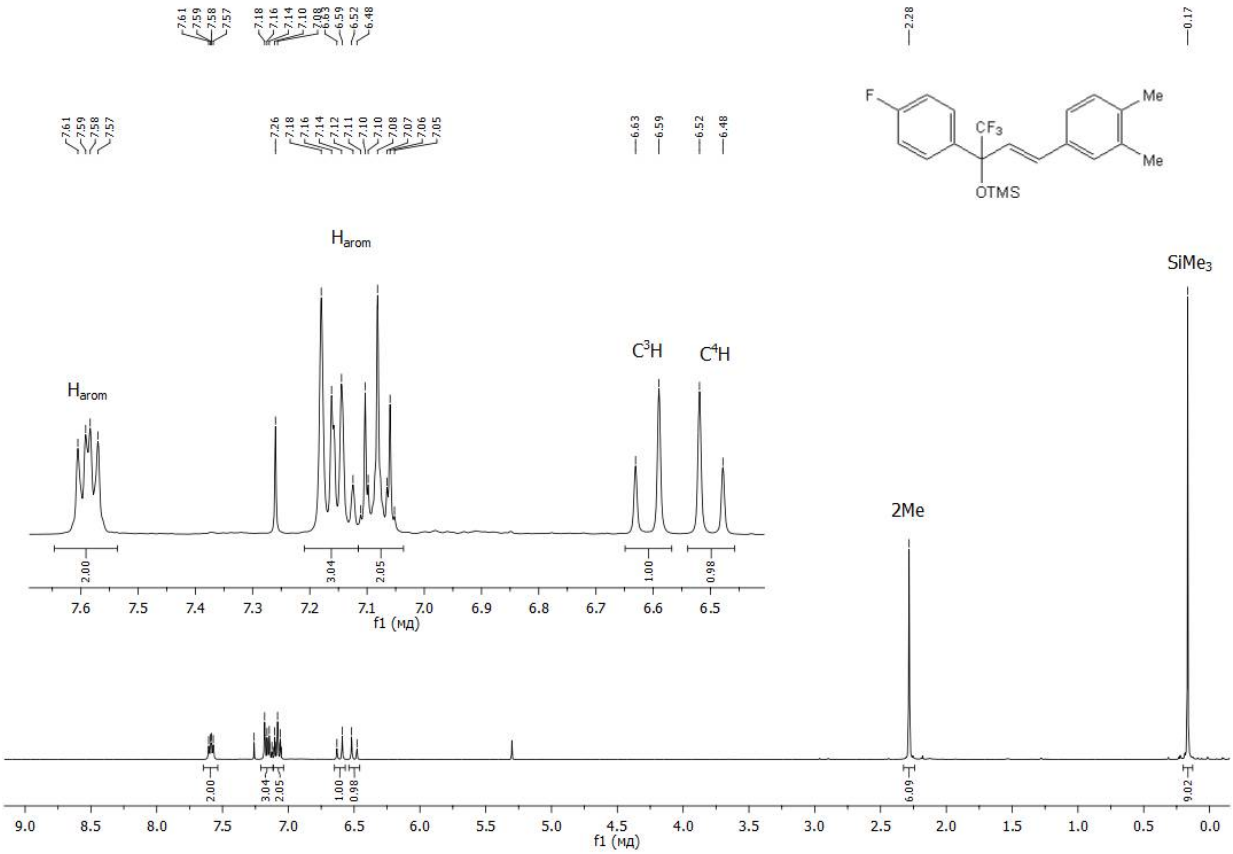


Fig. S45. ^{1}H NMR spectrum of the compound **1p** ($CDCl_3$, 400 MHz).

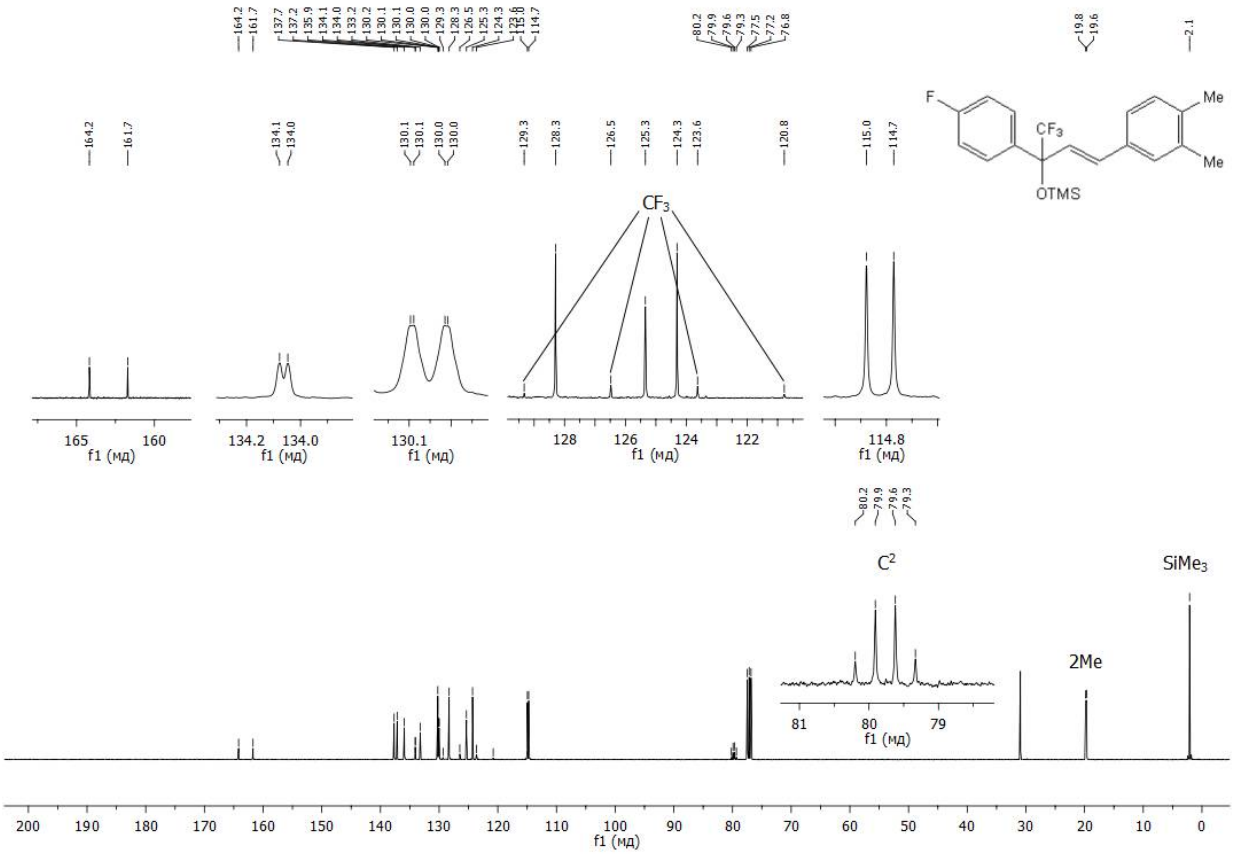


Fig. S46. ^{13}C NMR spectrum of the compound **1p** ($CDCl_3$, 100 MHz).

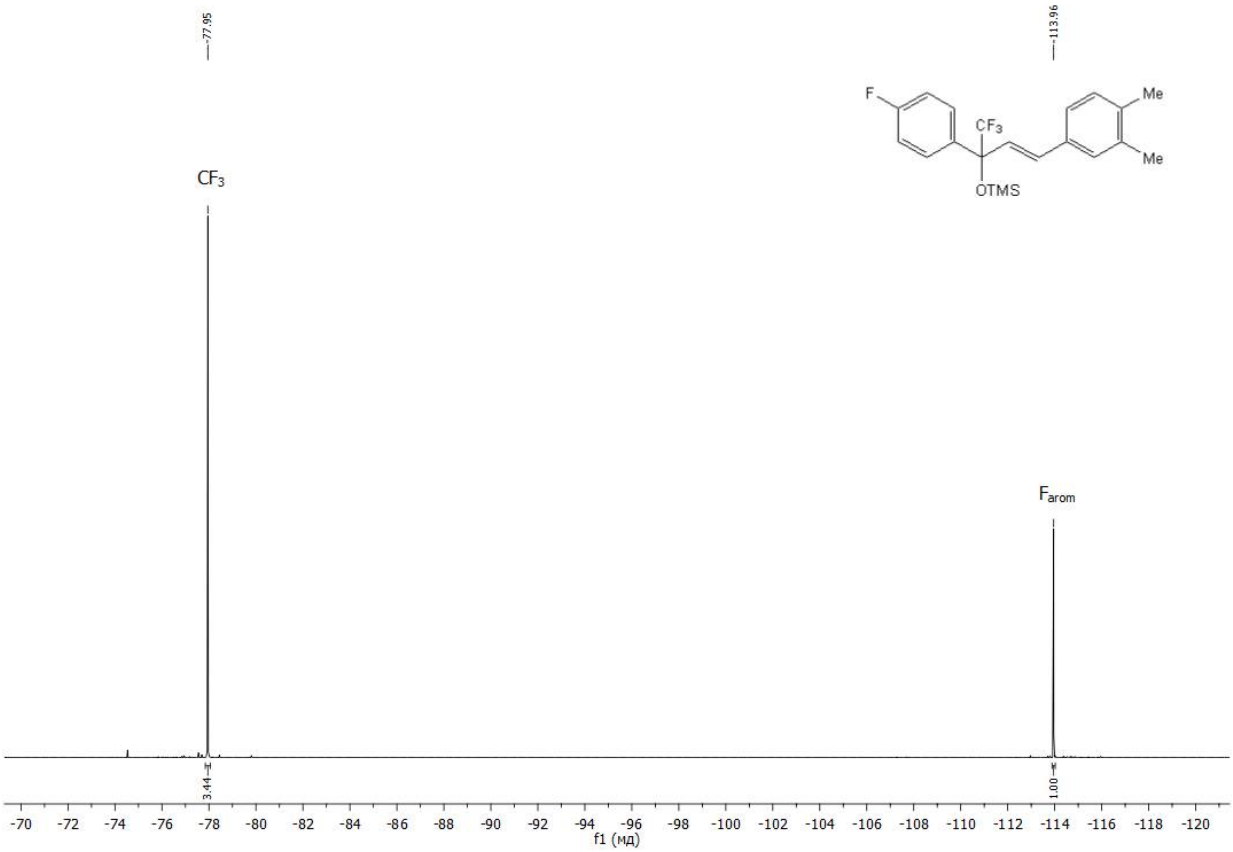


Fig. S47. ^{19}F NMR spectrum of the compound **1p** ($CDCl_3$, 376 MHz).

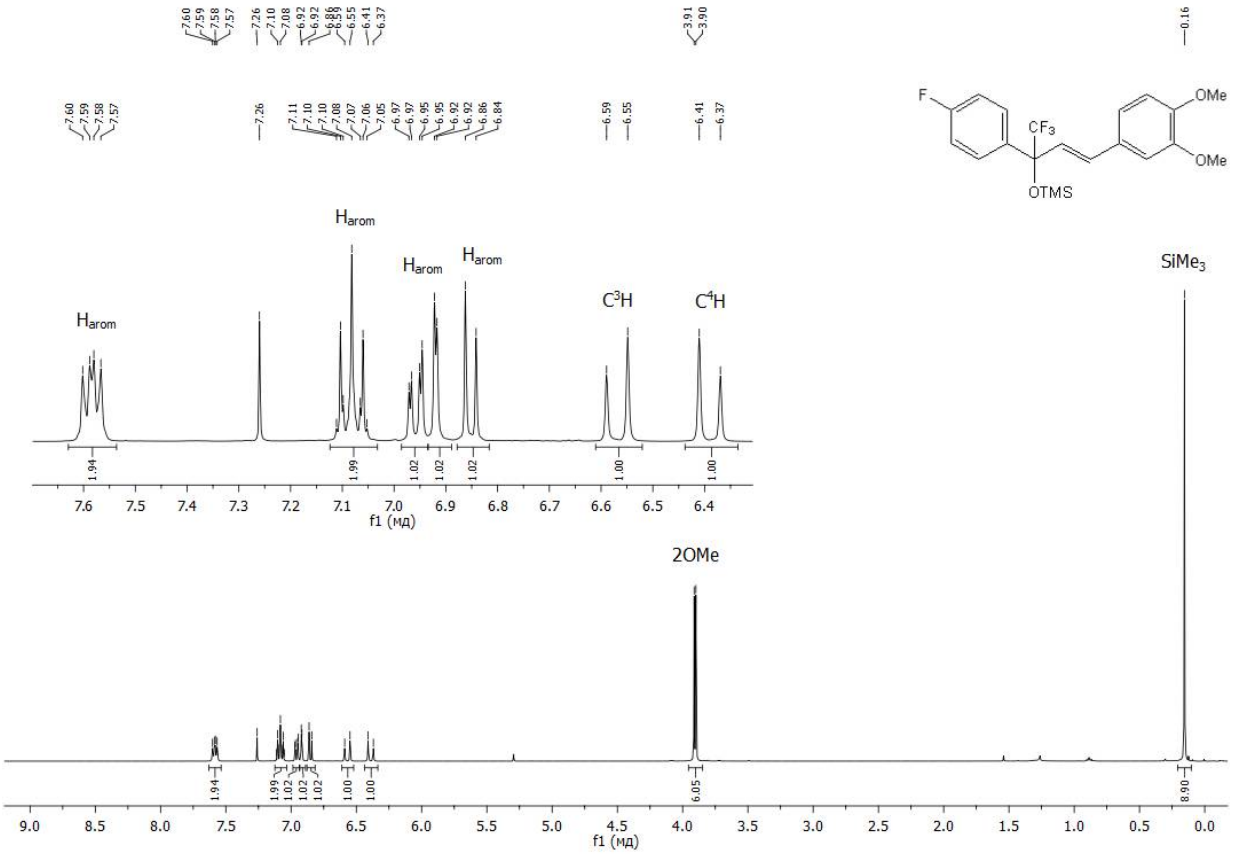


Fig. S48. ^{1}H NMR spectrum of the compound **1q** ($CDCl_3$, 400 MHz).

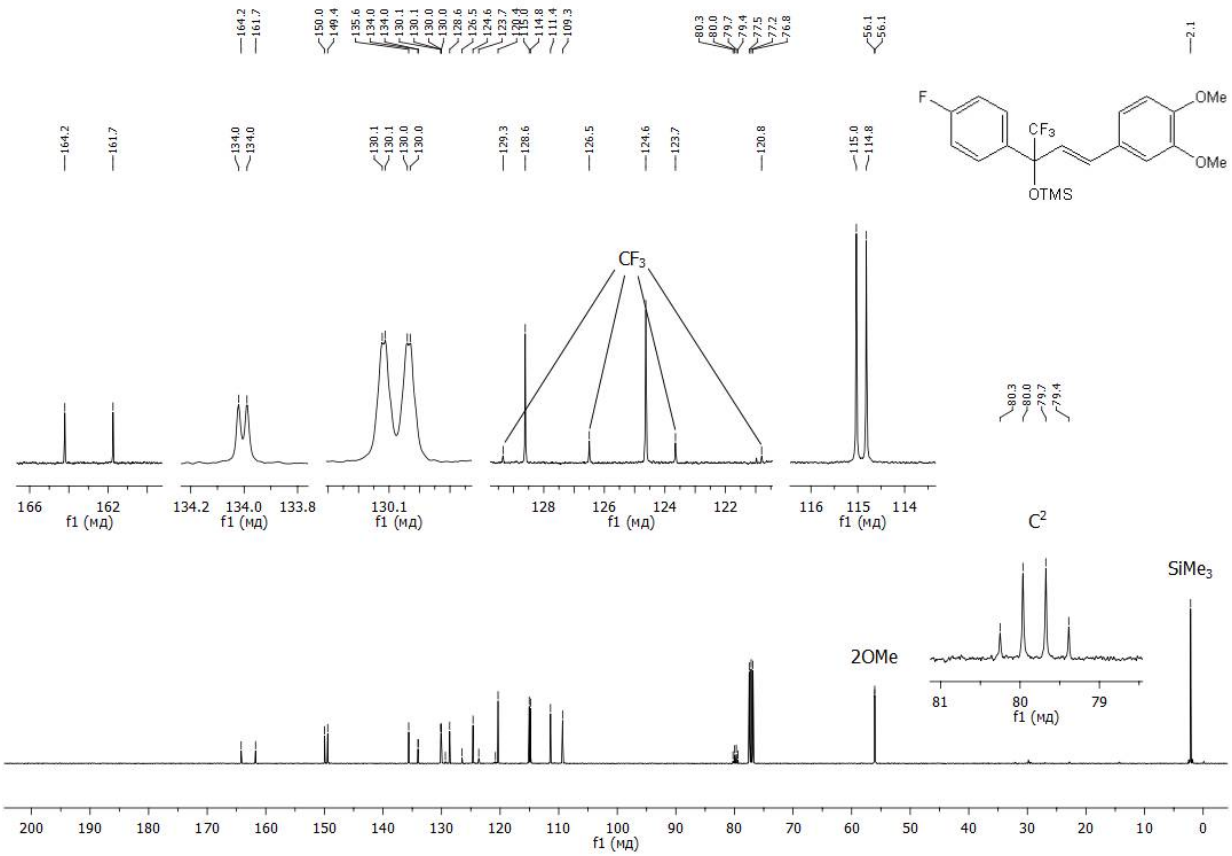


Fig. S49. ^{13}C NMR spectrum of the compound **1q** ($CDCl_3$, 100 MHz).

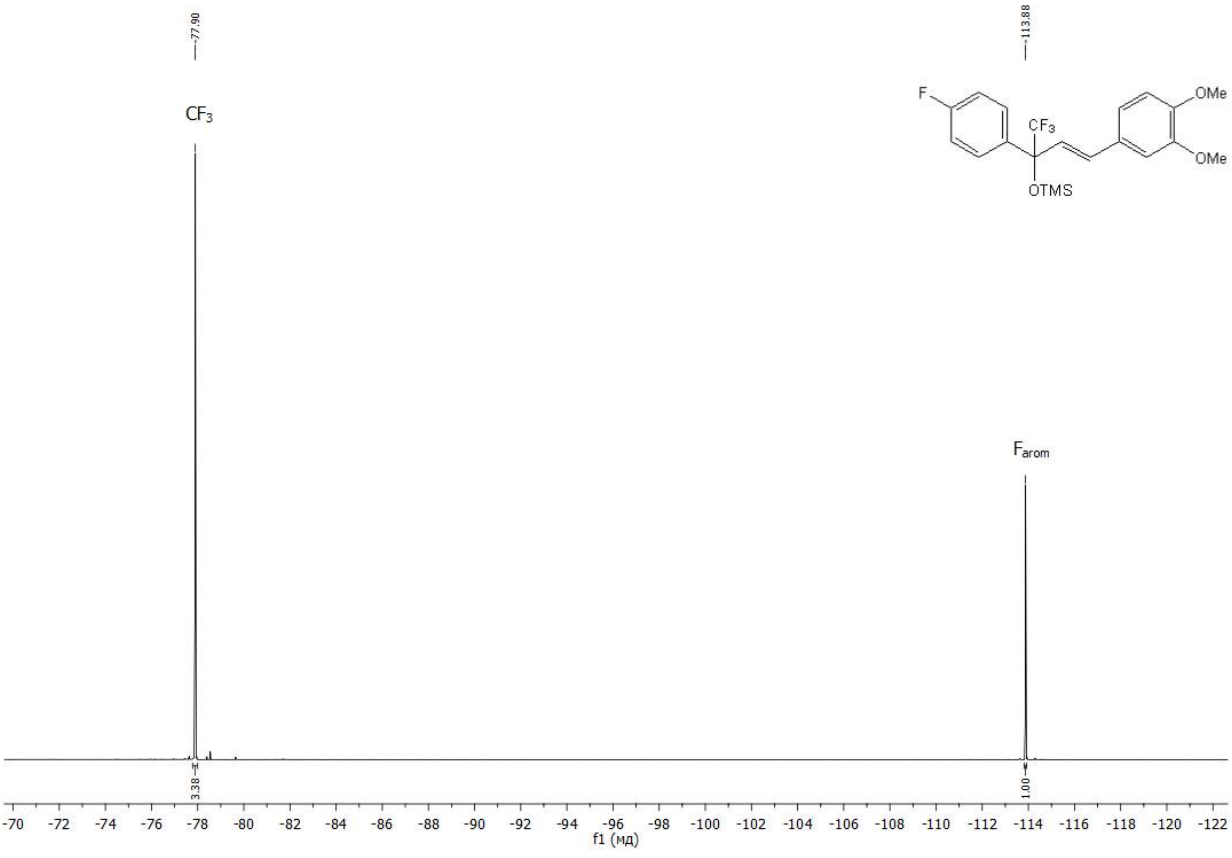


Fig. S50. ^{19}F NMR spectrum of the compound **1q** ($CDCl_3$, 376 MHz).

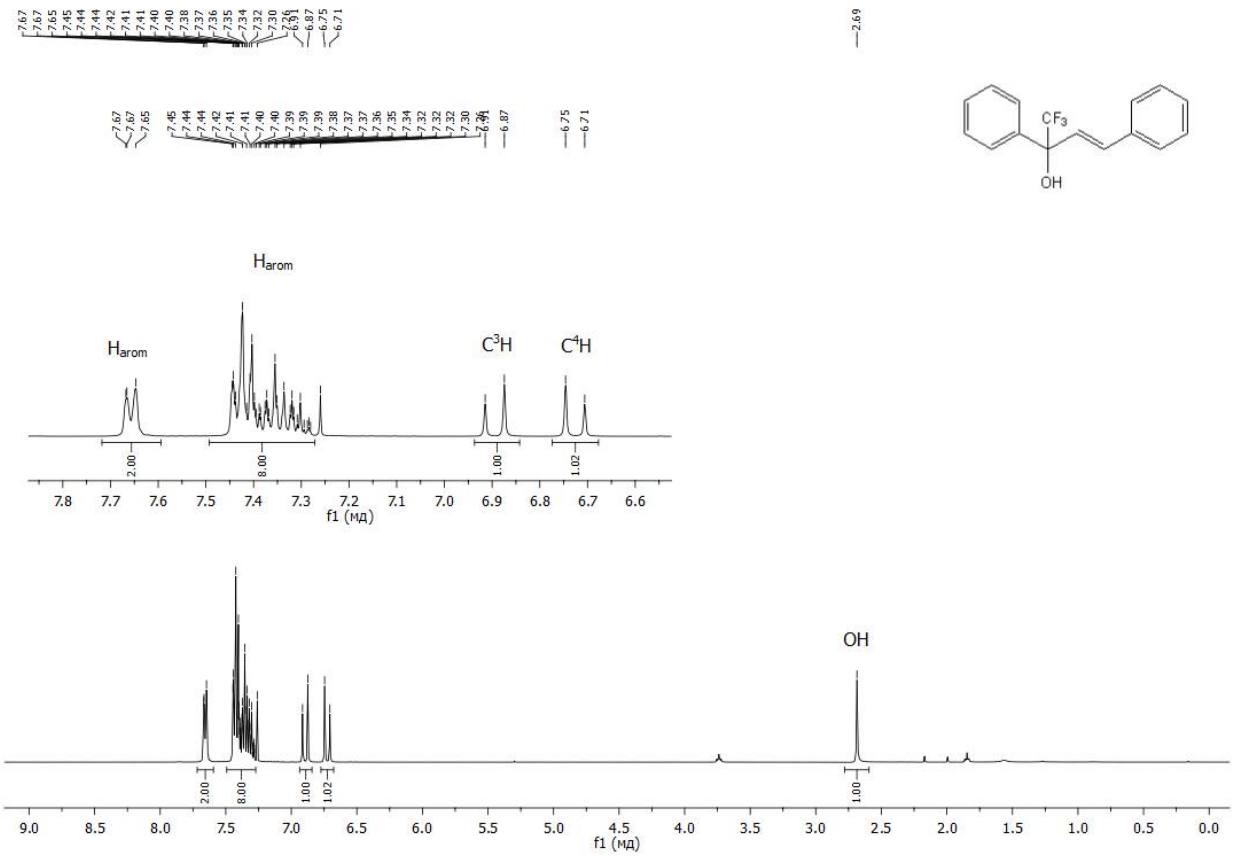


Fig. S51. ^{1}H NMR spectrum of the compound **2a** ($CDCl_3$, 400 MHz).

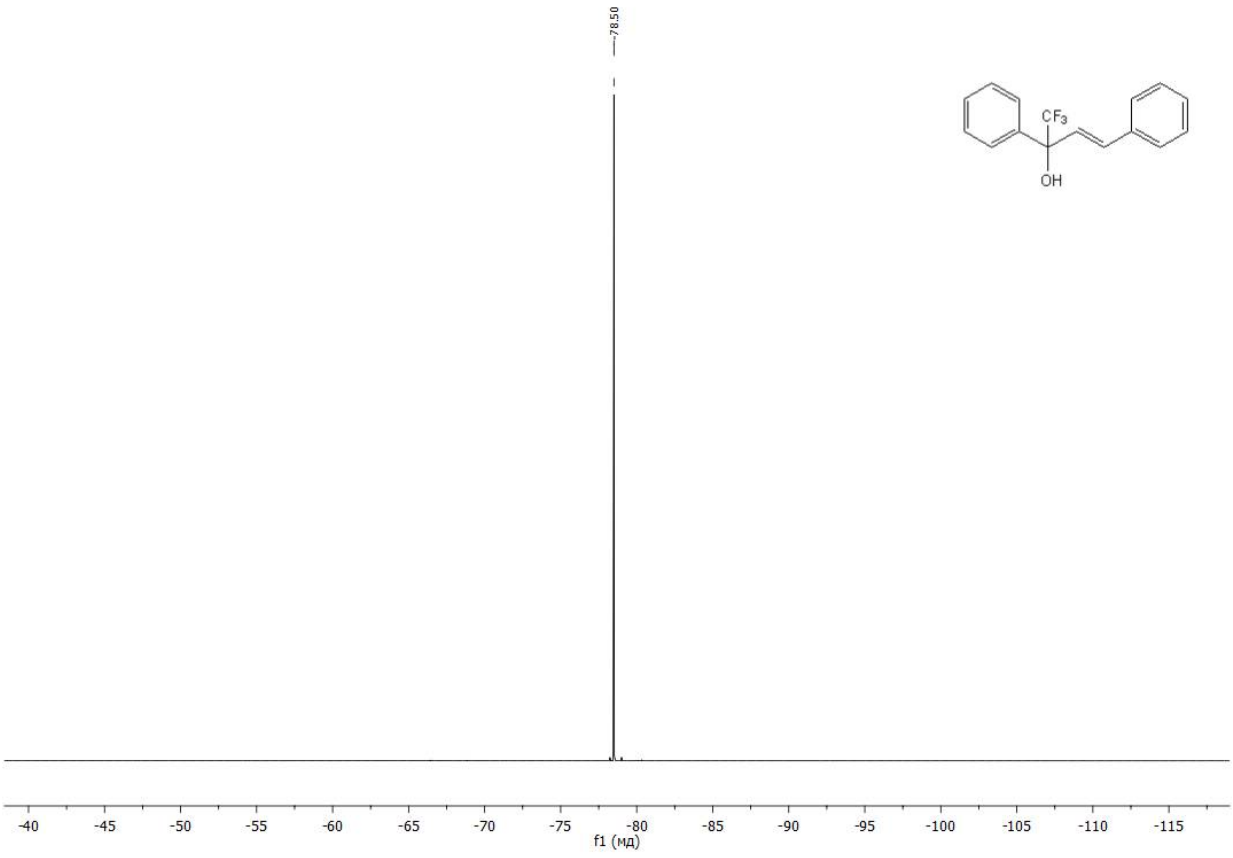


Fig. S52. ^{19}F NMR spectrum of the compound **2a** ($CDCl_3$, 376 MHz).

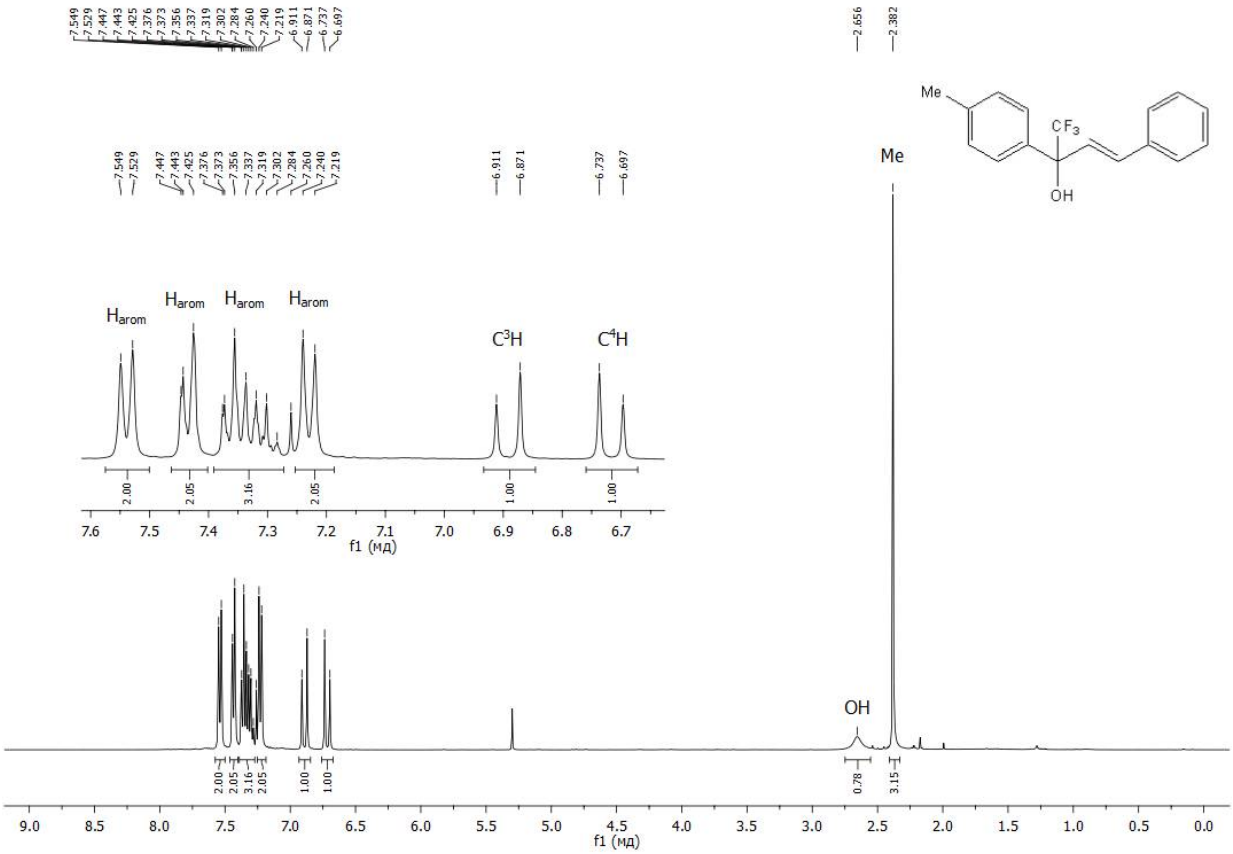


Fig. S53. ^{1}H NMR spectrum of the compound **2b** ($CDCl_3$, 400 MHz).

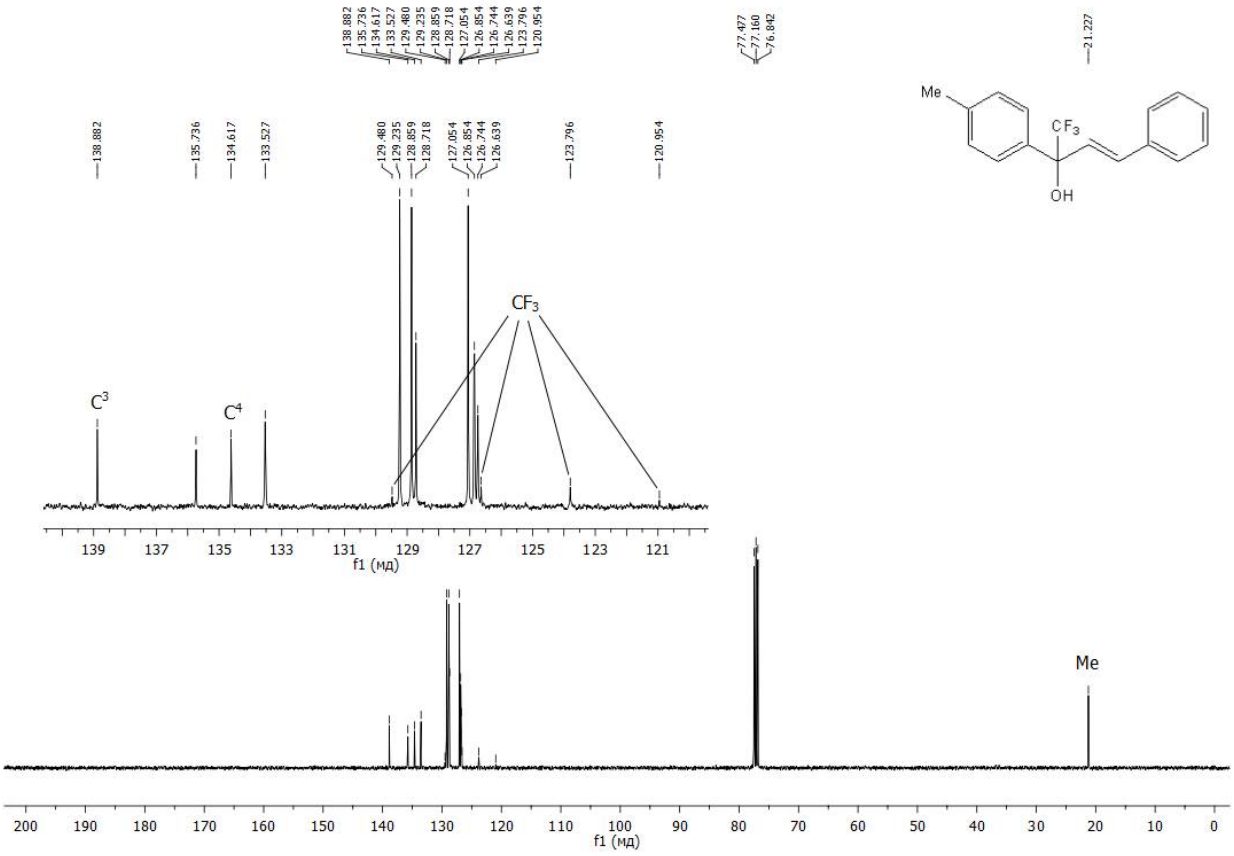


Fig. S54. ^{13}C NMR spectrum of the compound **2b** ($CDCl_3$, 100 MHz).

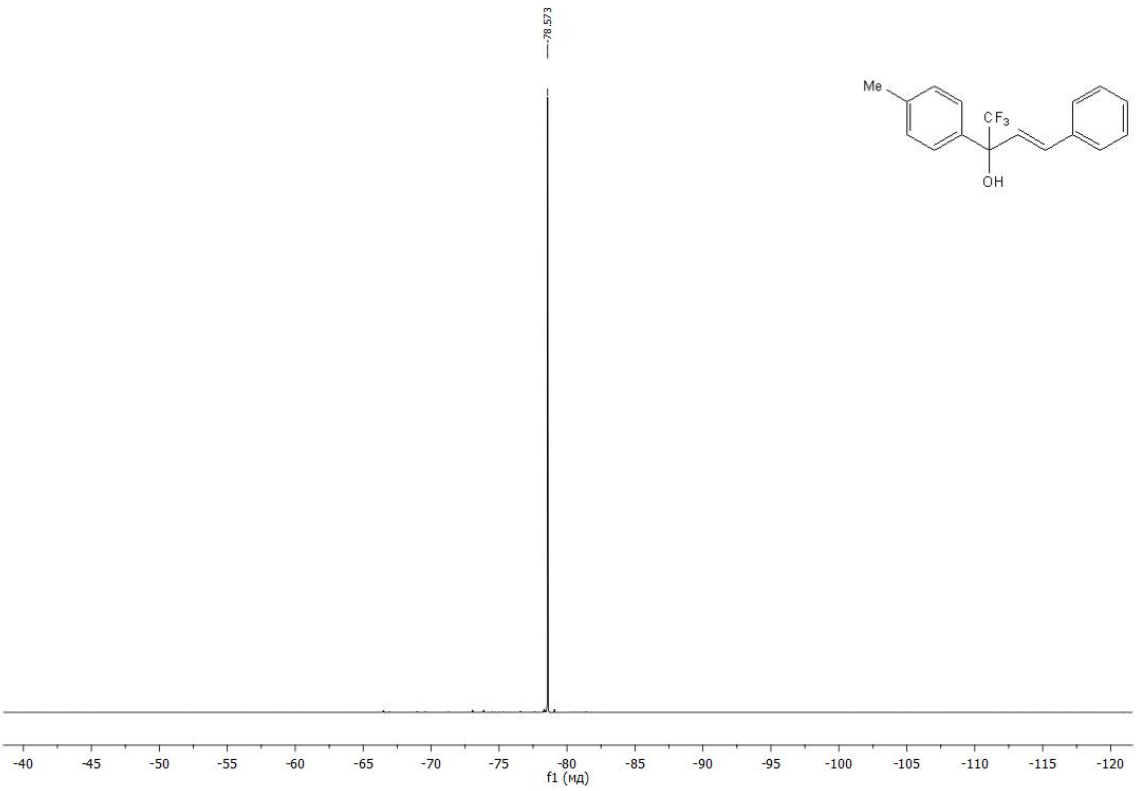


Fig. S55. ^{19}F NMR spectrum of the compound **2b** ($CDCl_3$, 376 MHz).

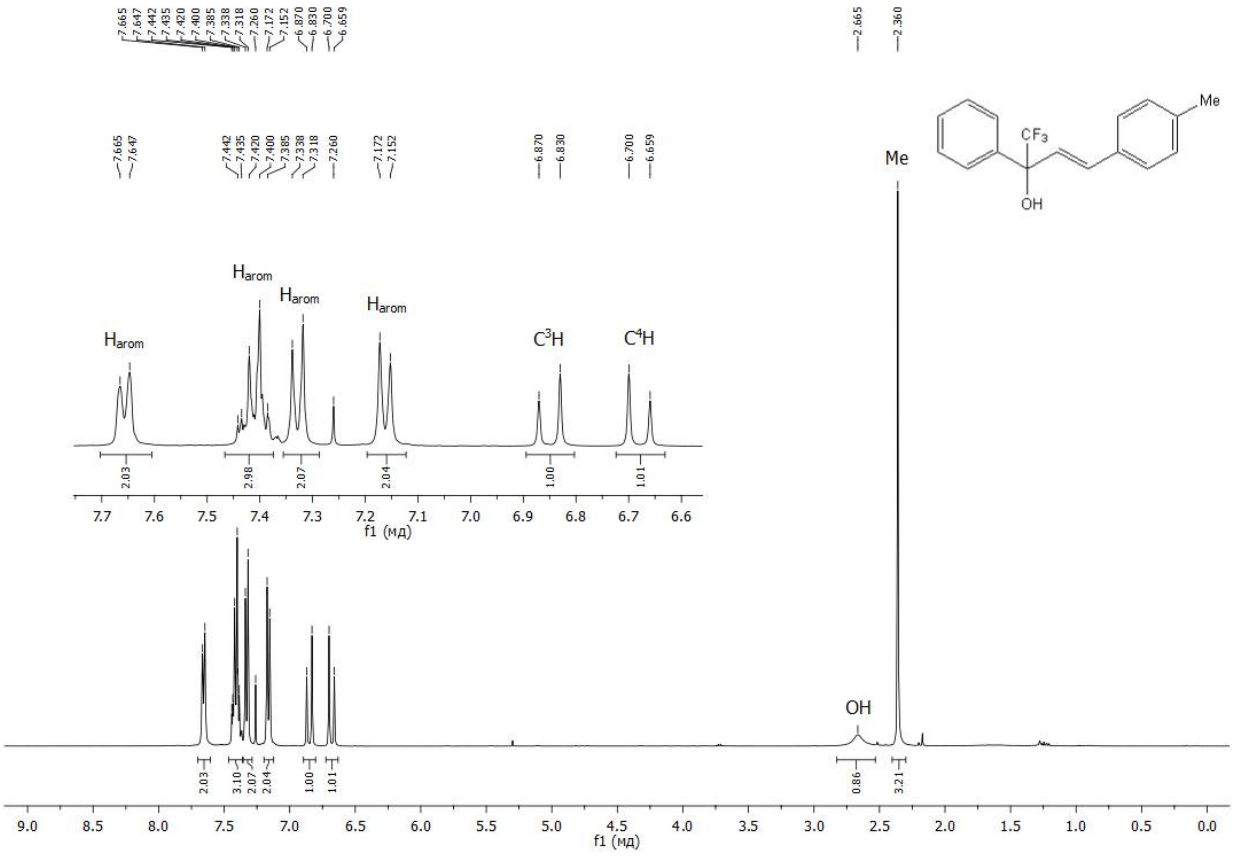


Fig. S56. ^{1}H NMR spectrum of the compound **2c** ($CDCl_3$, 400 MHz).

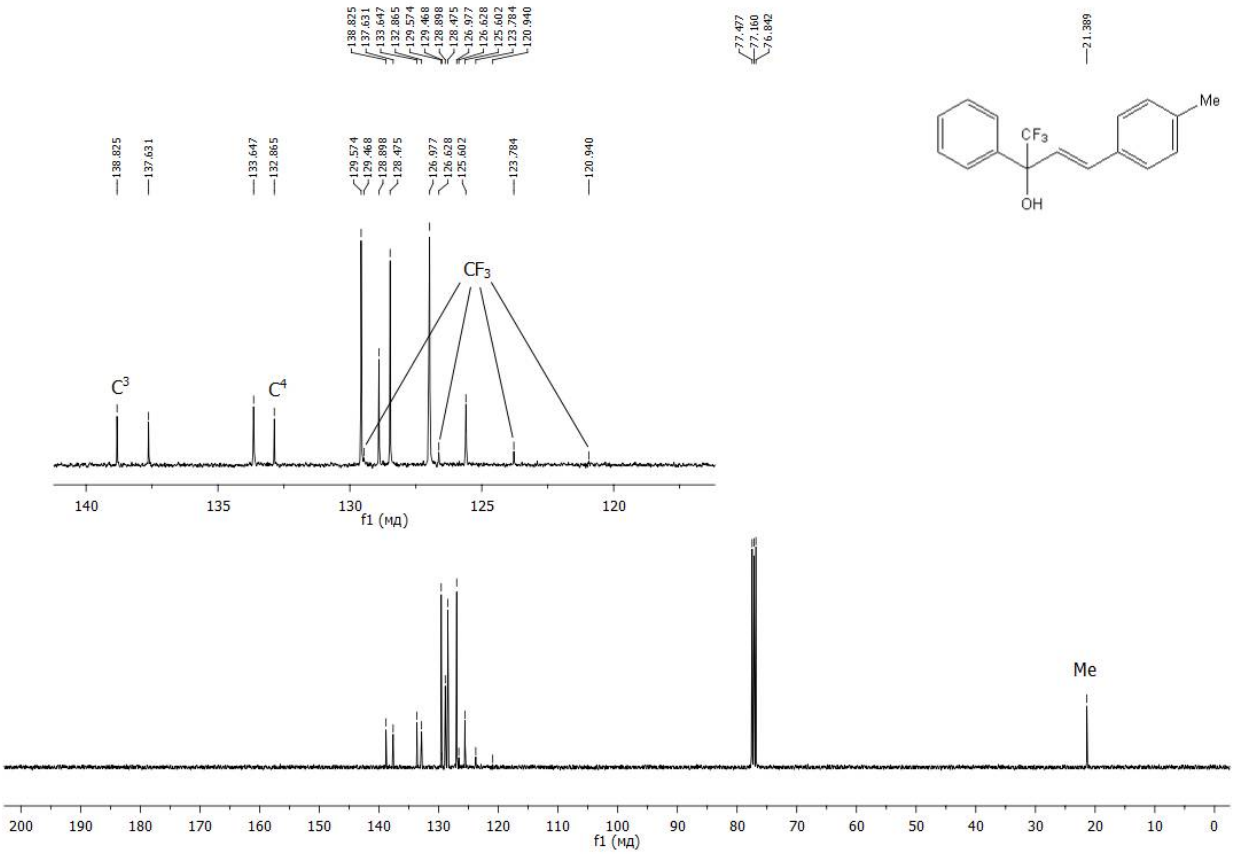


Fig. S57. ^{13}C NMR spectrum of the compound **2c** ($CDCl_3$, 100 MHz).

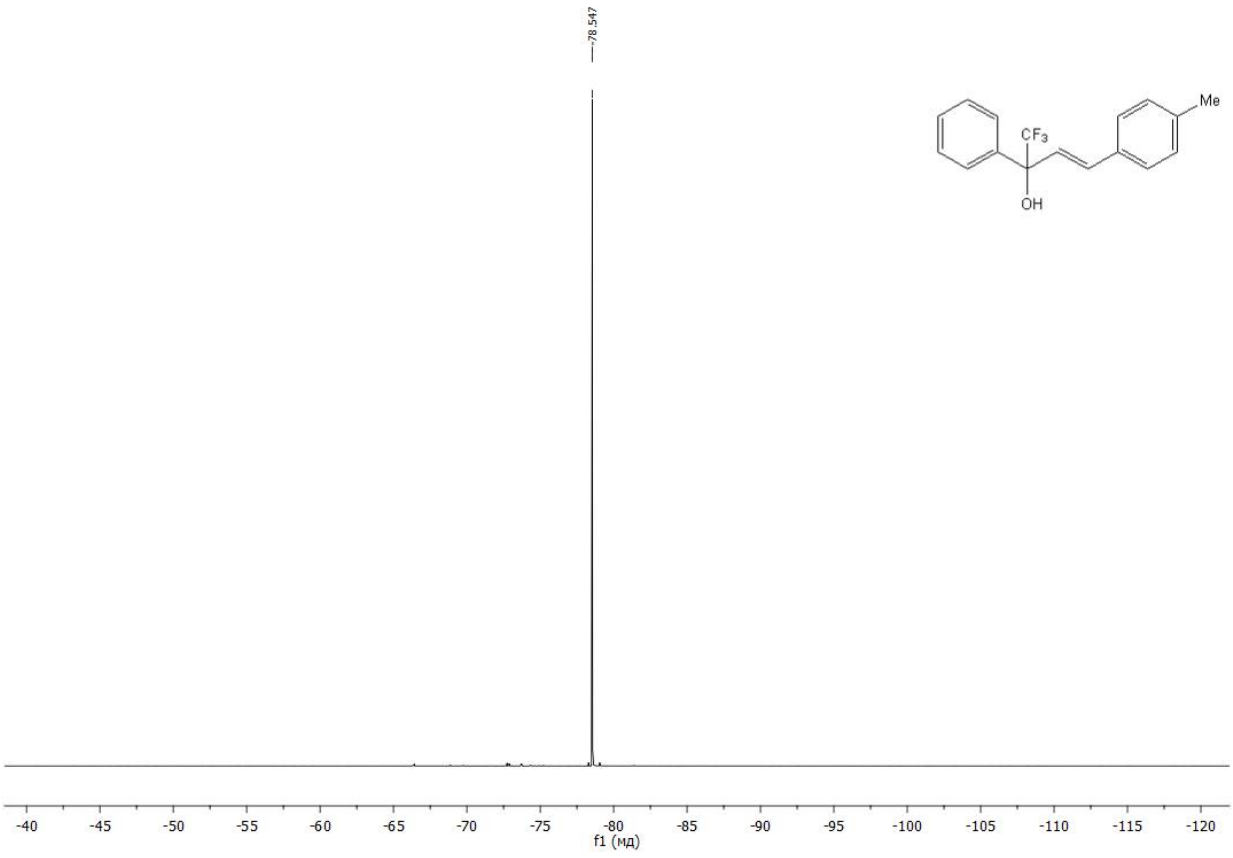


Fig. S58. ^{19}F NMR spectrum of the compound **2c** ($CDCl_3$, 376 MHz).

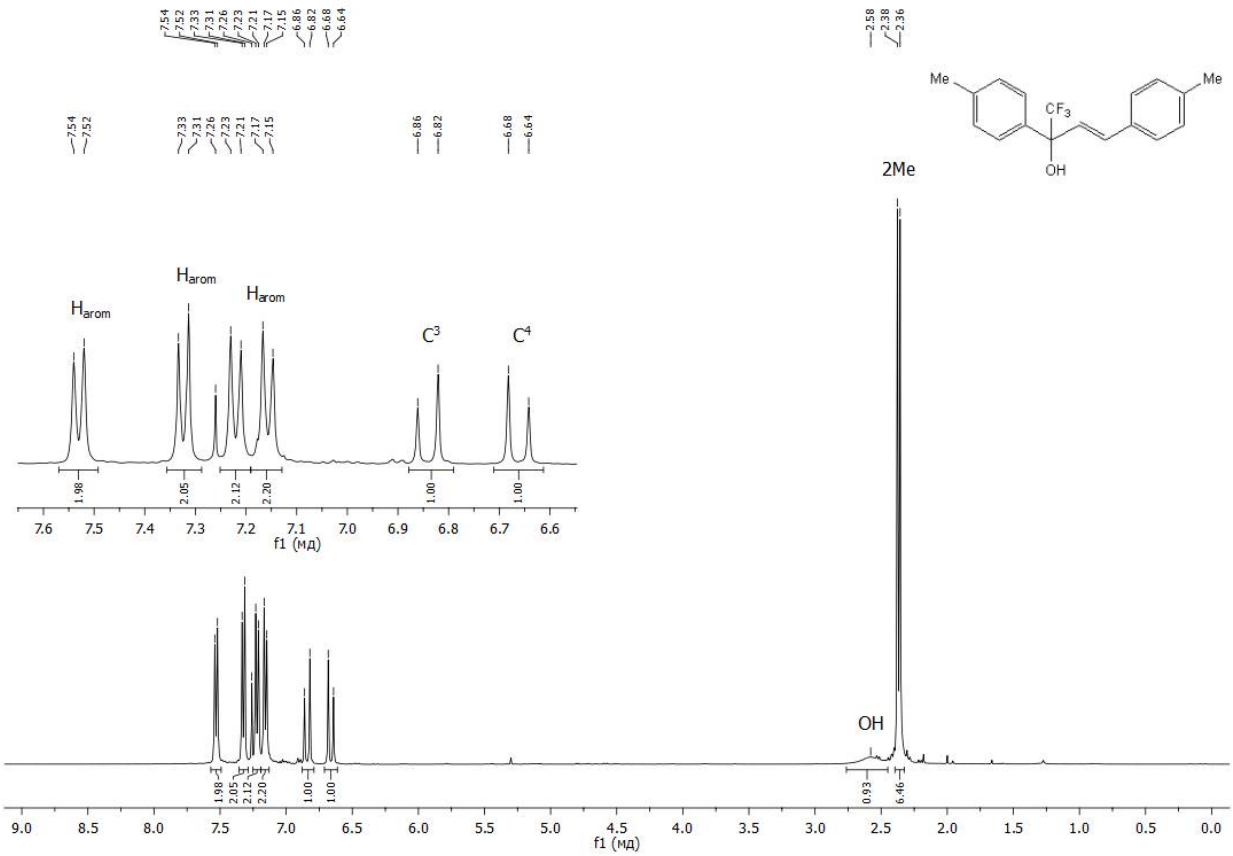


Fig. S59. ^{1}H NMR spectrum of the compound **2d** ($CDCl_3$, 400 MHz).

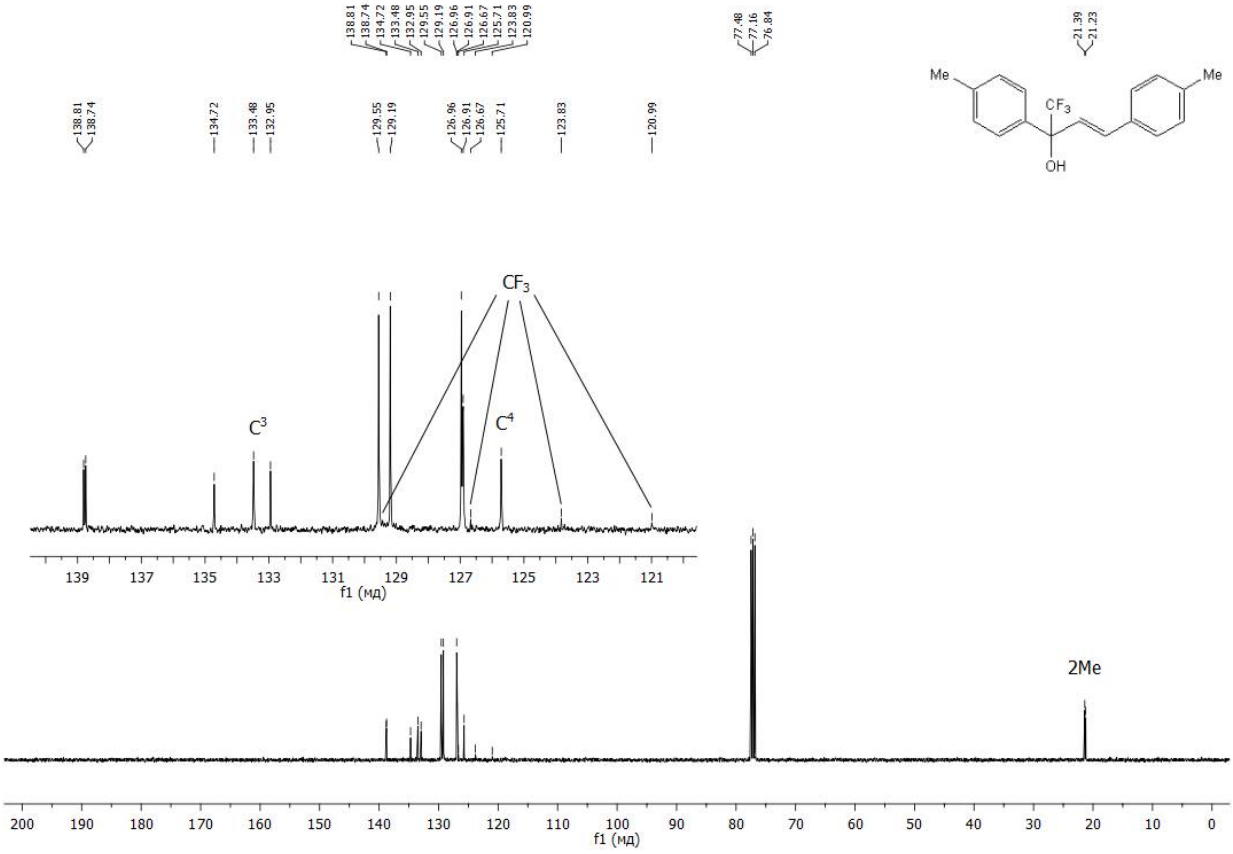


Fig. S60. ^{13}C NMR spectrum of the compound **2d** ($CDCl_3$, 100 MHz).

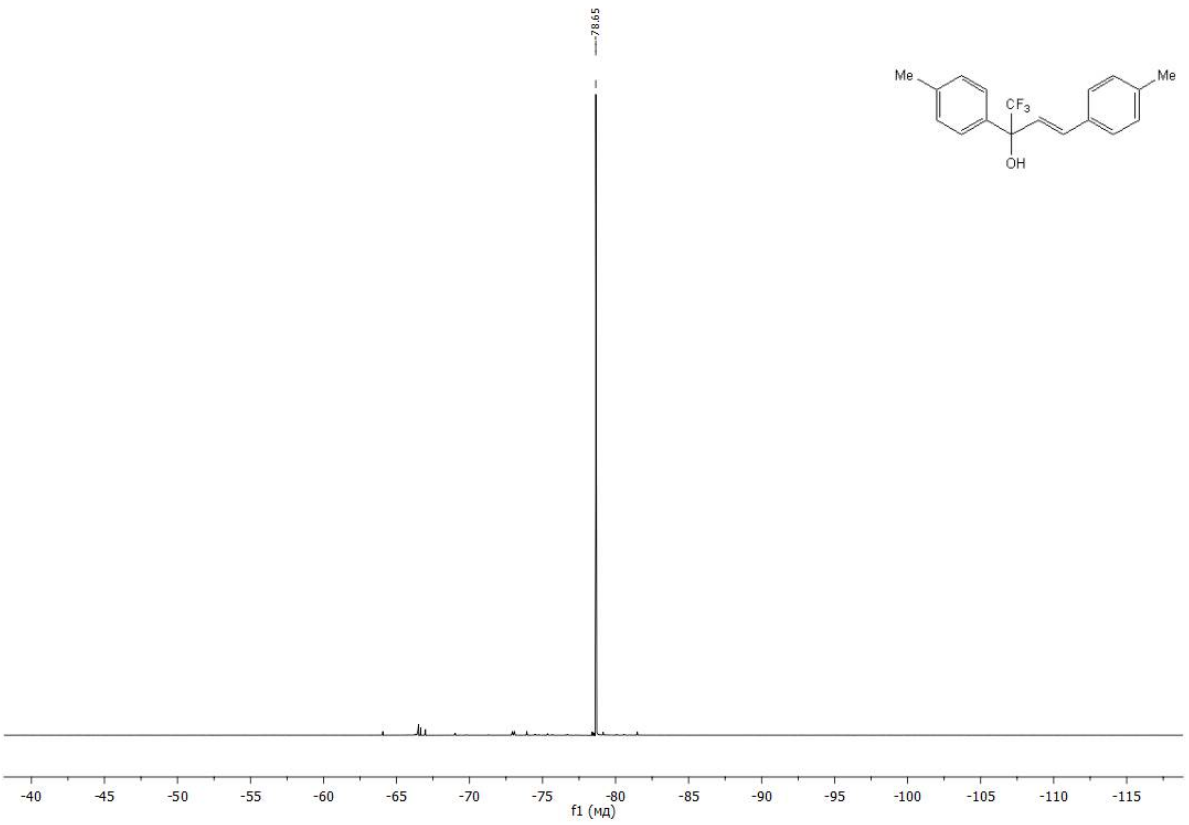


Fig. S61. ^{19}F NMR spectrum of the compound **2d** ($CDCl_3$, 376 MHz).

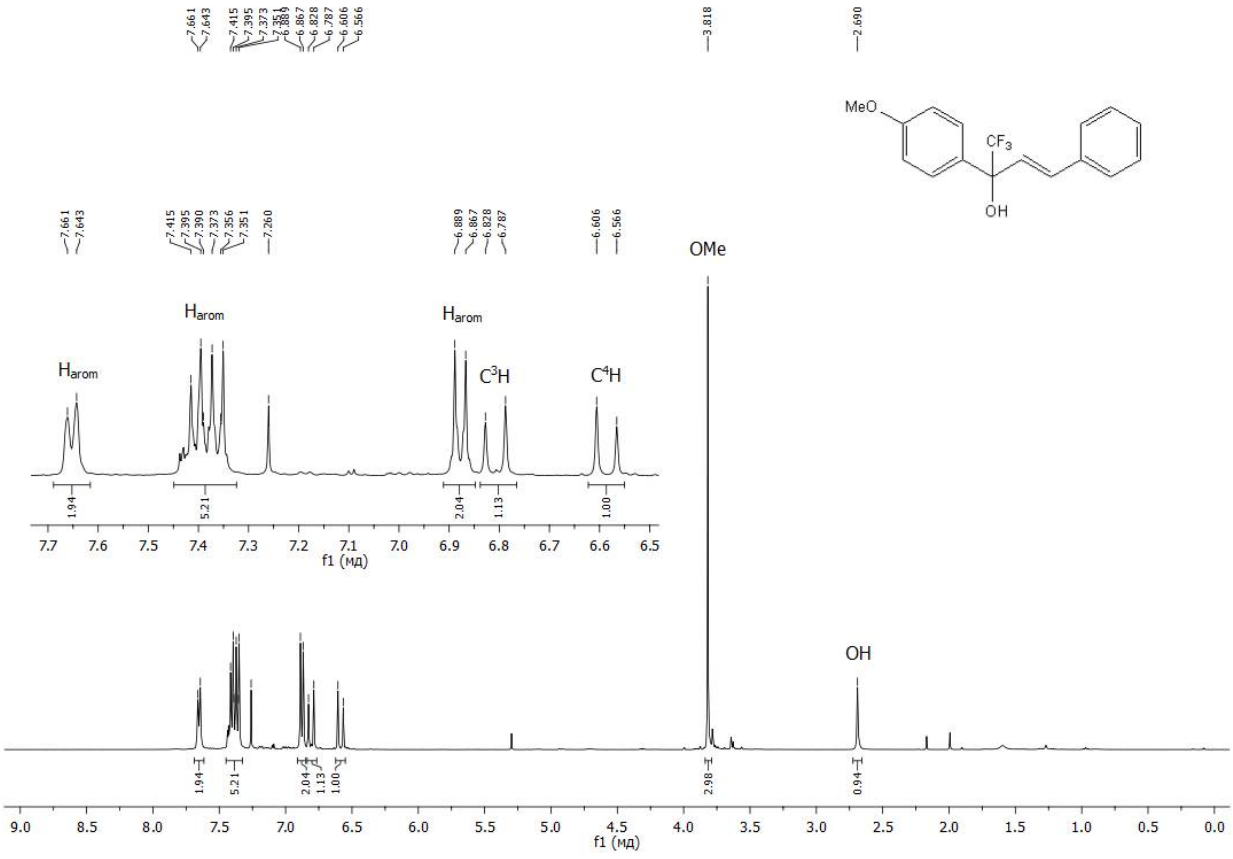


Fig. S62. ^{1}H NMR spectrum of the compound **2e** ($CDCl_3$, 400 MHz).

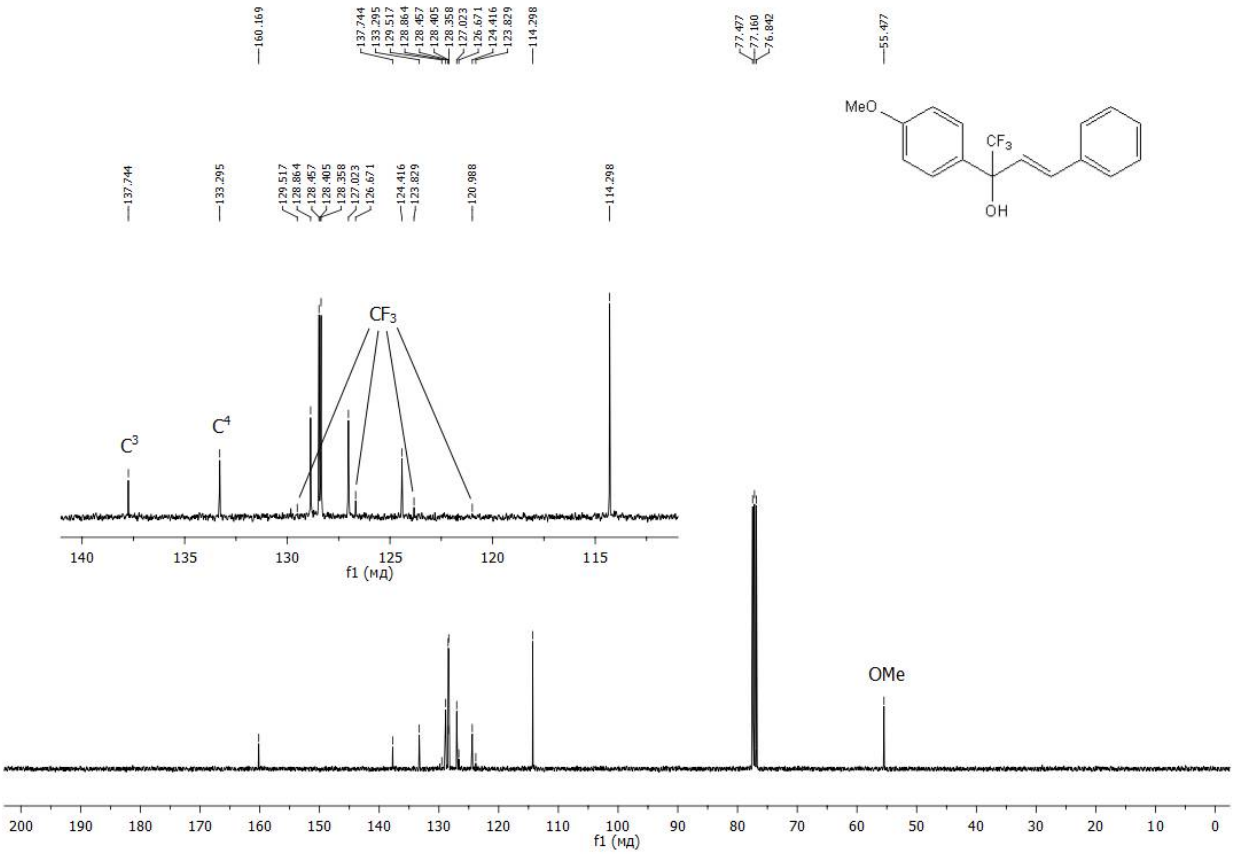


Fig. S63. ^{13}C NMR spectrum of the compound **2e** ($CDCl_3$, 100 MHz).

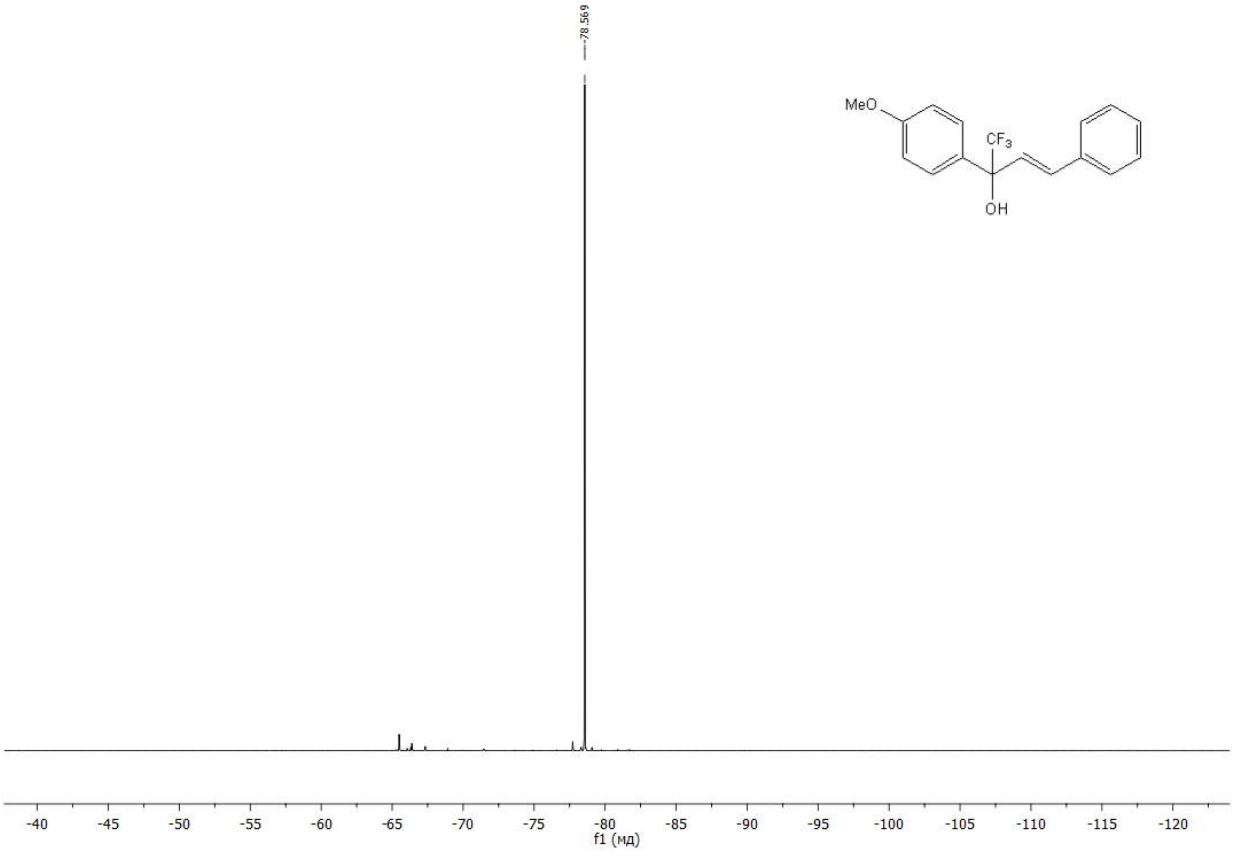


Fig. S64. ^{19}F NMR spectrum of the compound **2e** ($CDCl_3$, 376 MHz).

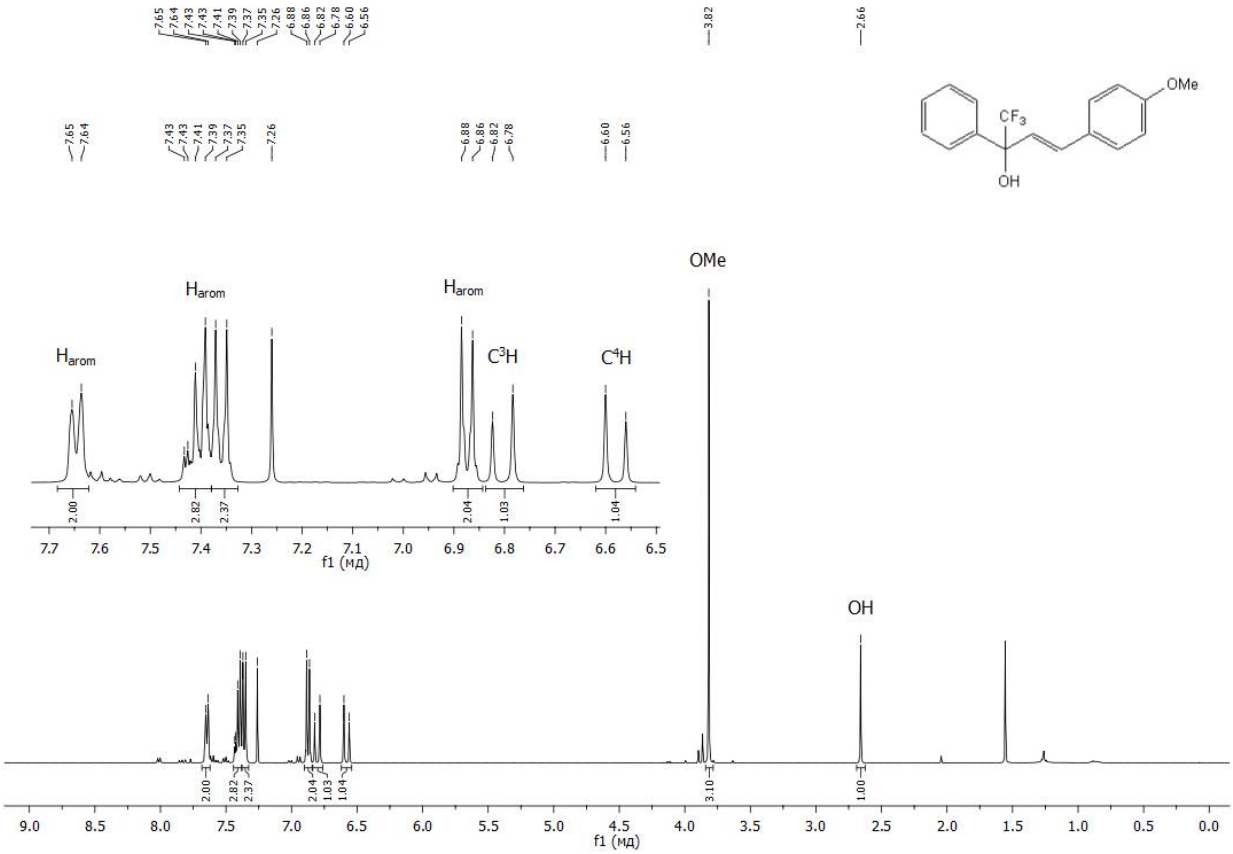


Fig. S65. ^{1}H NMR spectrum of the compound **2f** ($CDCl_3$, 400 MHz).

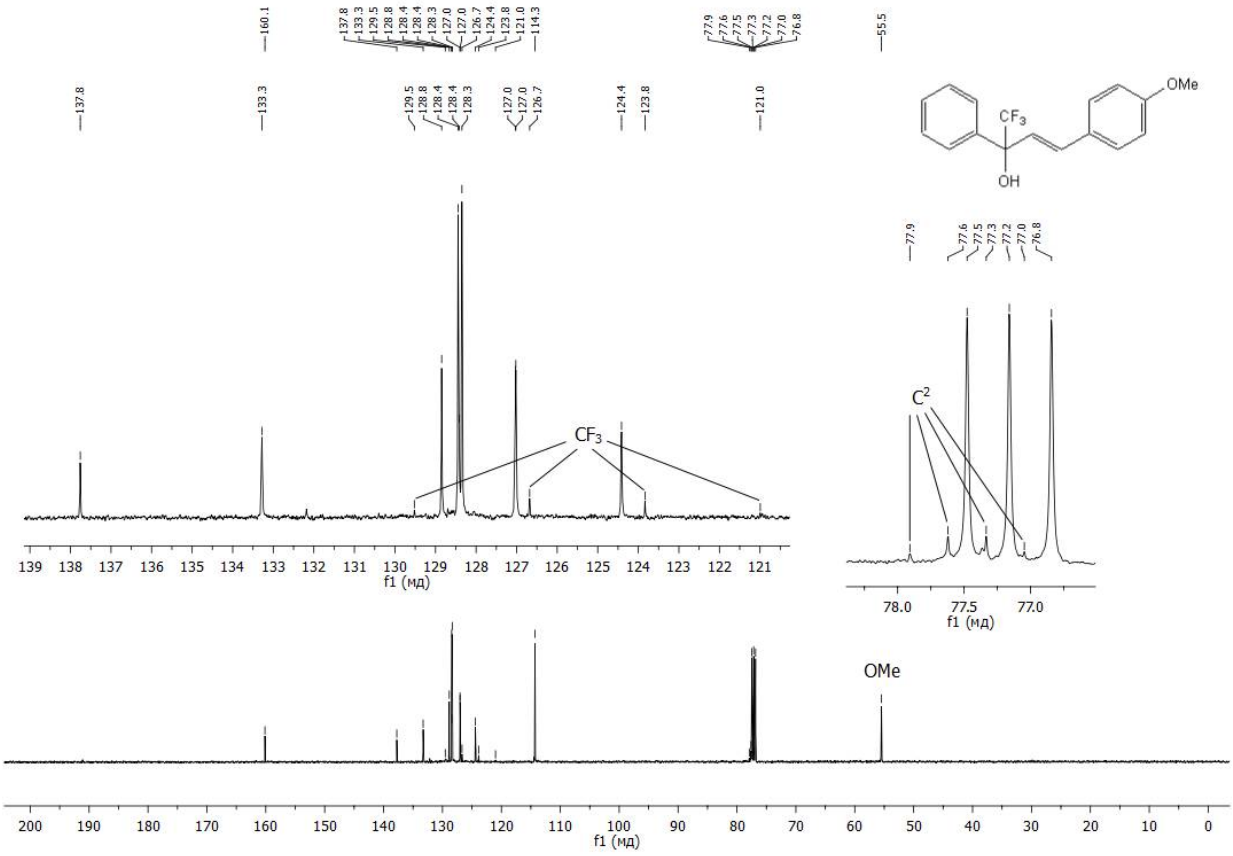


Fig. S66. ^{13}C NMR spectrum of the compound **2f** ($CDCl_3$, 100 MHz).

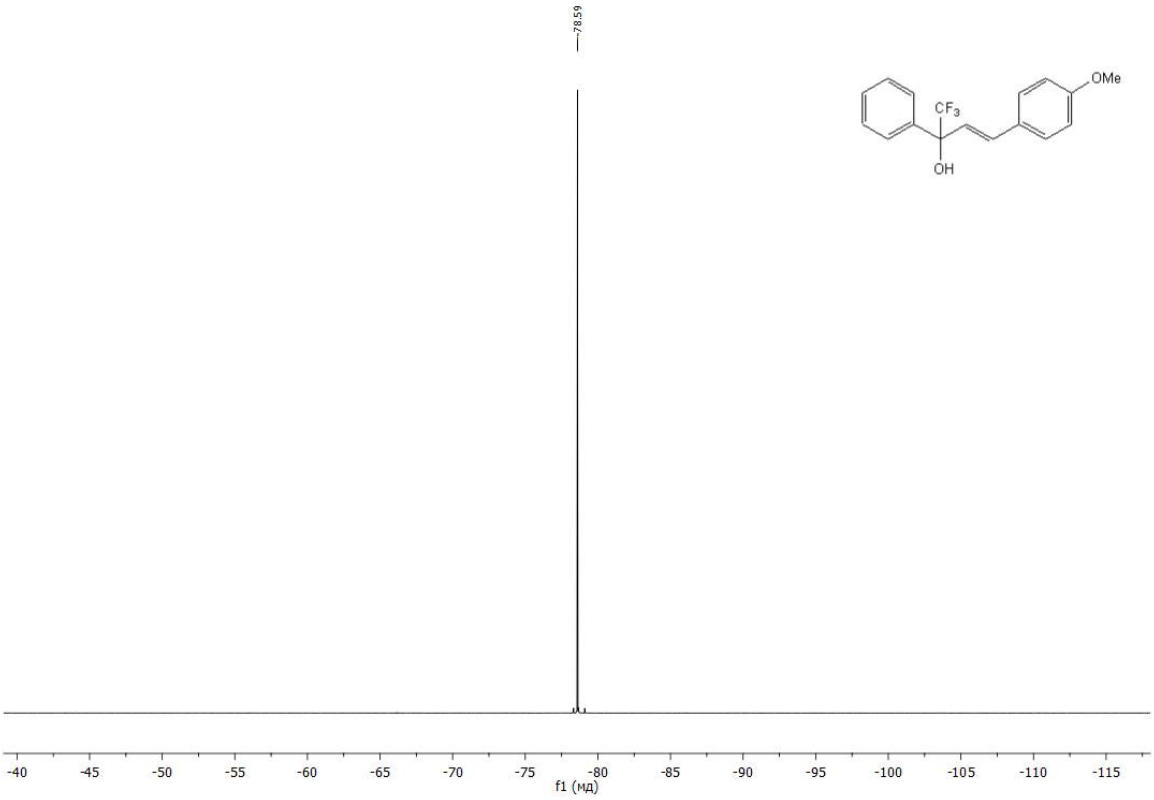


Fig. S67. ^{19}F NMR spectrum of the compound **2f** ($CDCl_3$, 376 MHz).

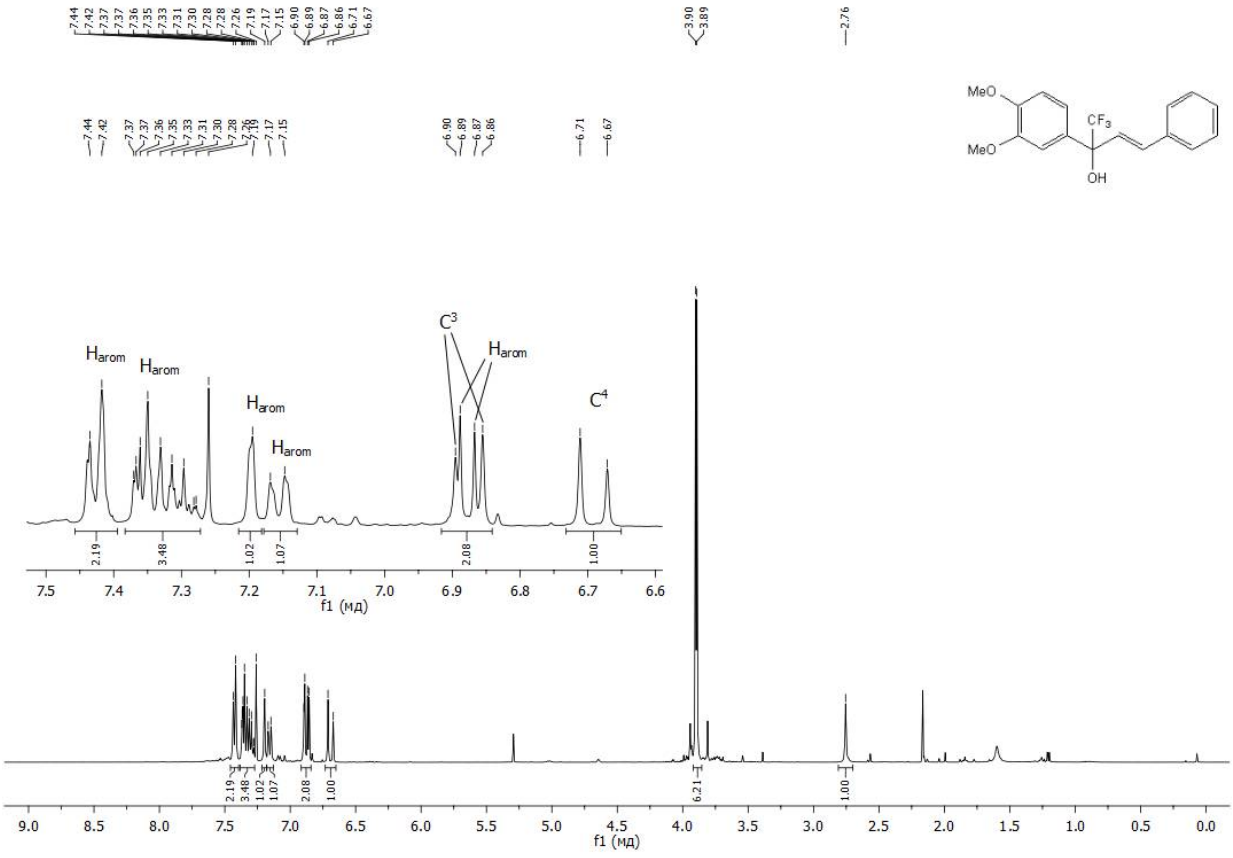


Fig. S68. ^{1}H NMR spectrum of the compound **2g** ($CDCl_3$, 400 MHz).

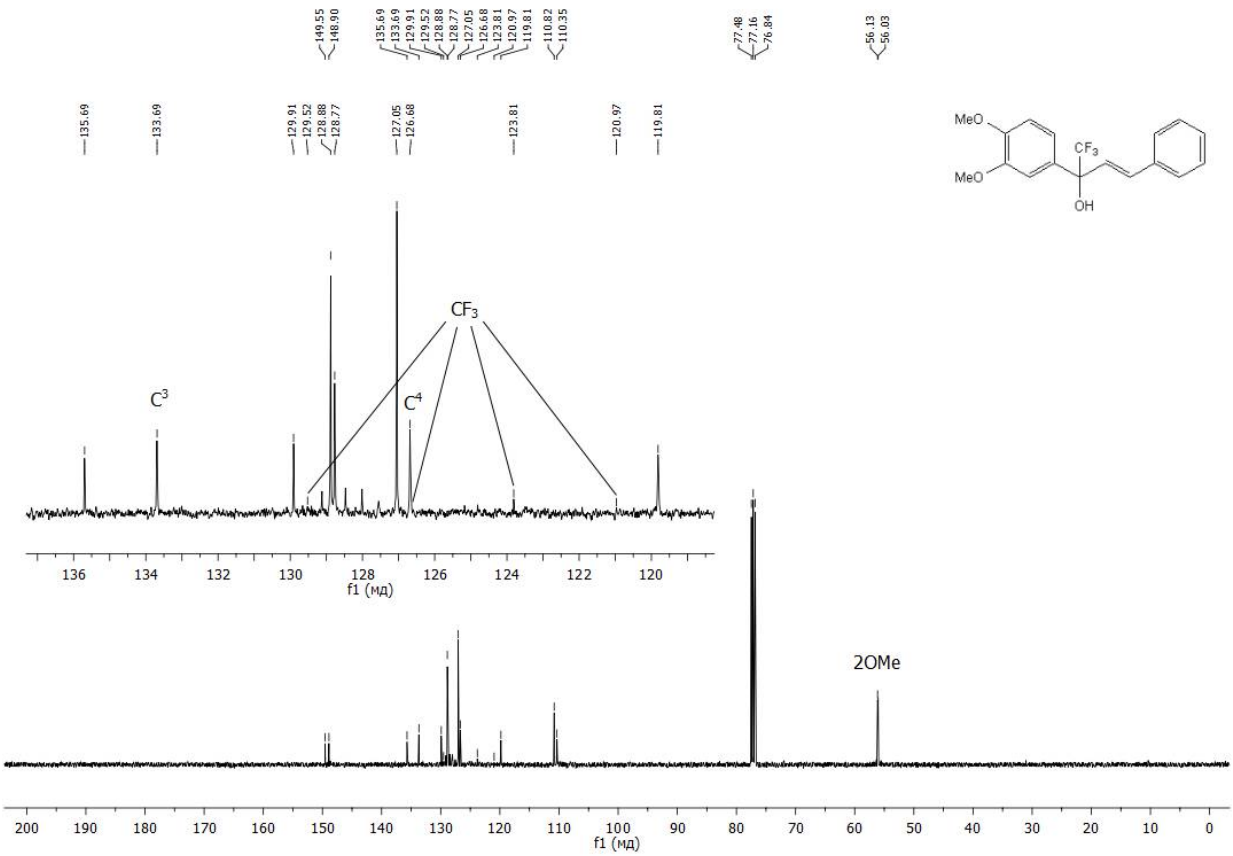


Fig. S69. ^{13}C NMR spectrum of the compound **2g** ($CDCl_3$, 100 MHz).

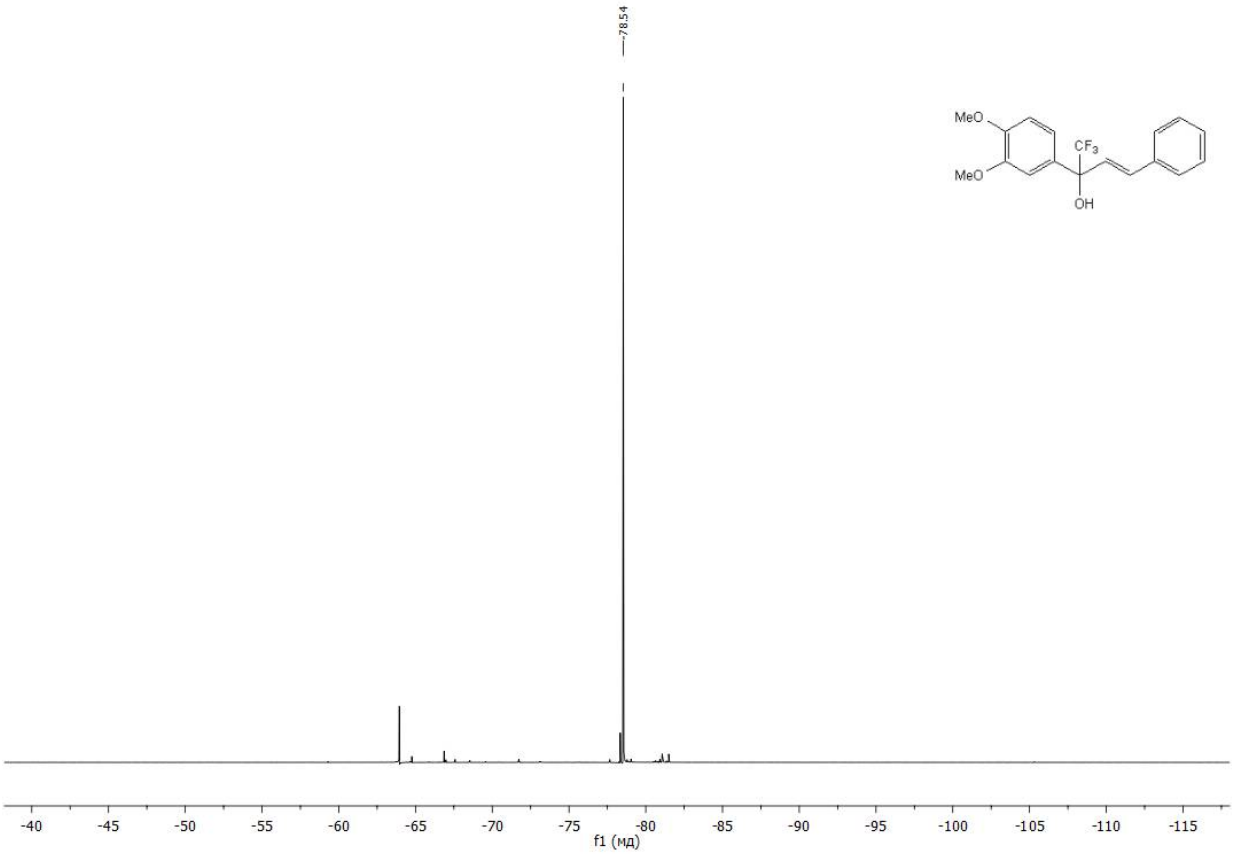


Fig. S70. ^{19}F NMR spectrum of the compound **2g** ($CDCl_3$, 376 MHz).

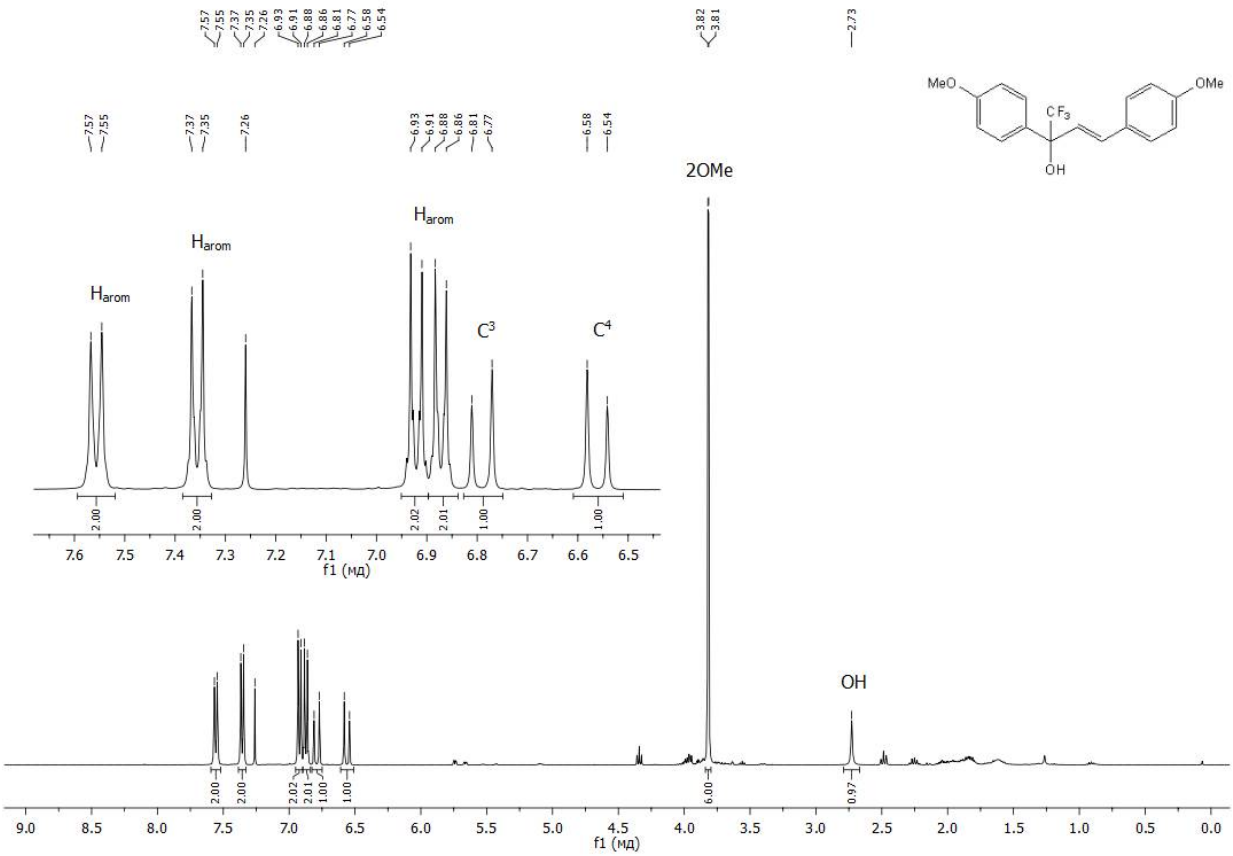


Fig. S71. ^{1}H NMR spectrum of the compound **2h** ($CDCl_3$, 400 MHz).

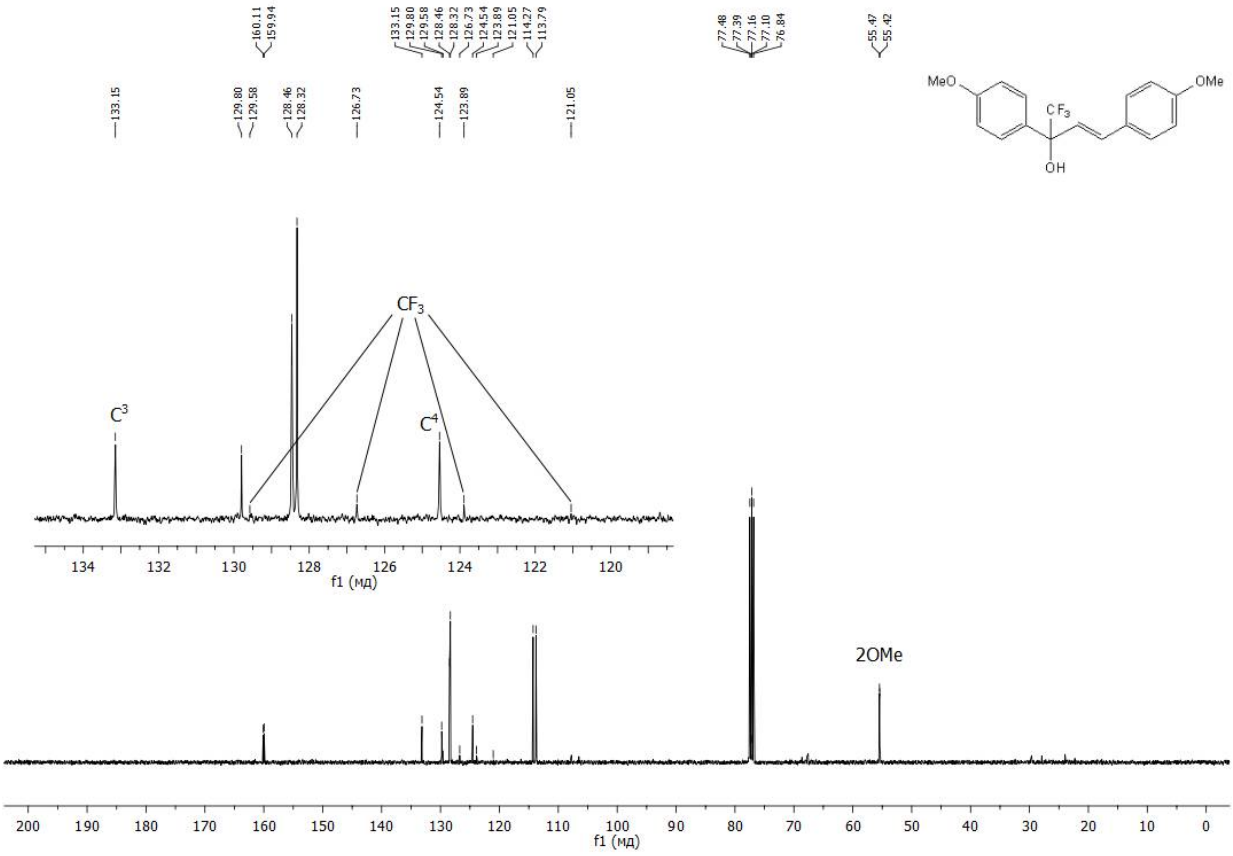


Fig. S72. ^{13}C NMR spectrum of the compound **2h** ($CDCl_3$, 100 MHz).

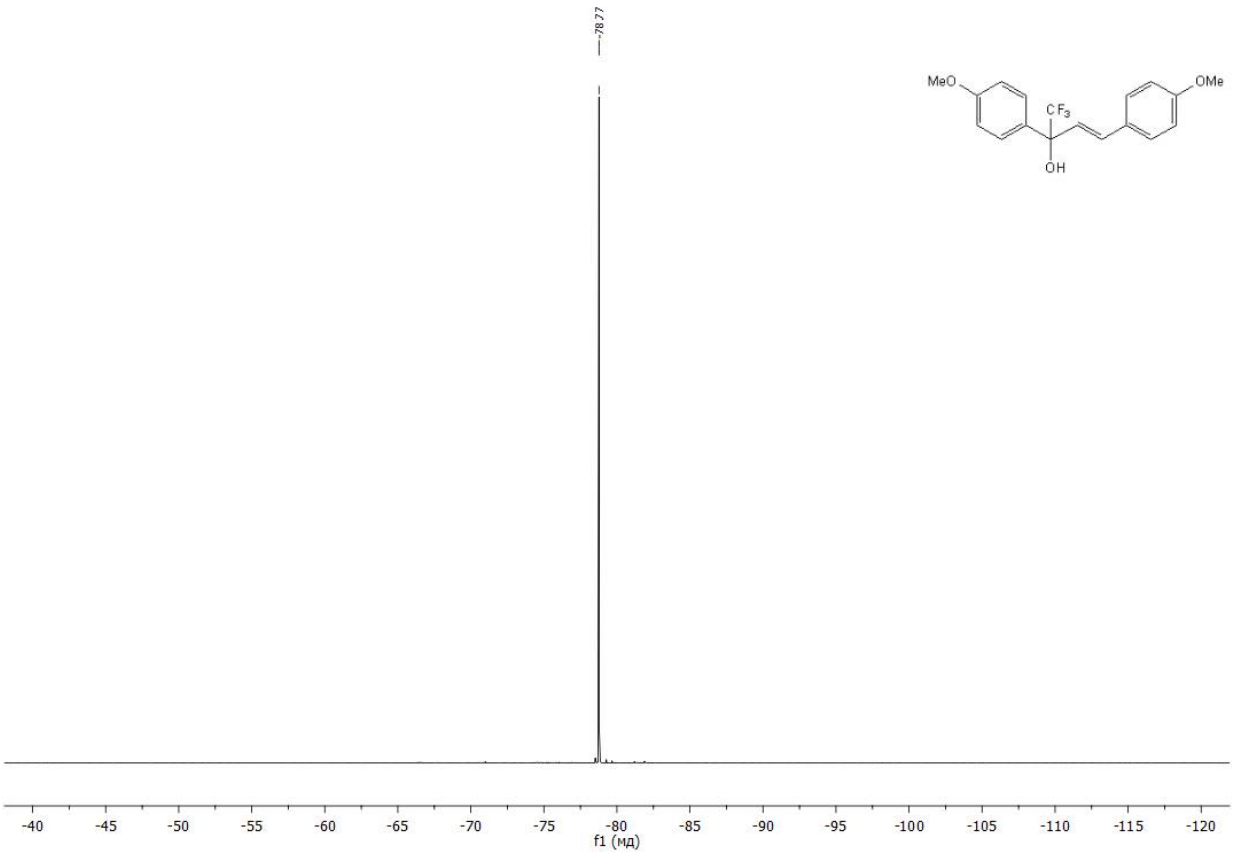


Fig. S73. ^{19}F NMR spectrum of the compound **2h** ($CDCl_3$, 376 MHz).

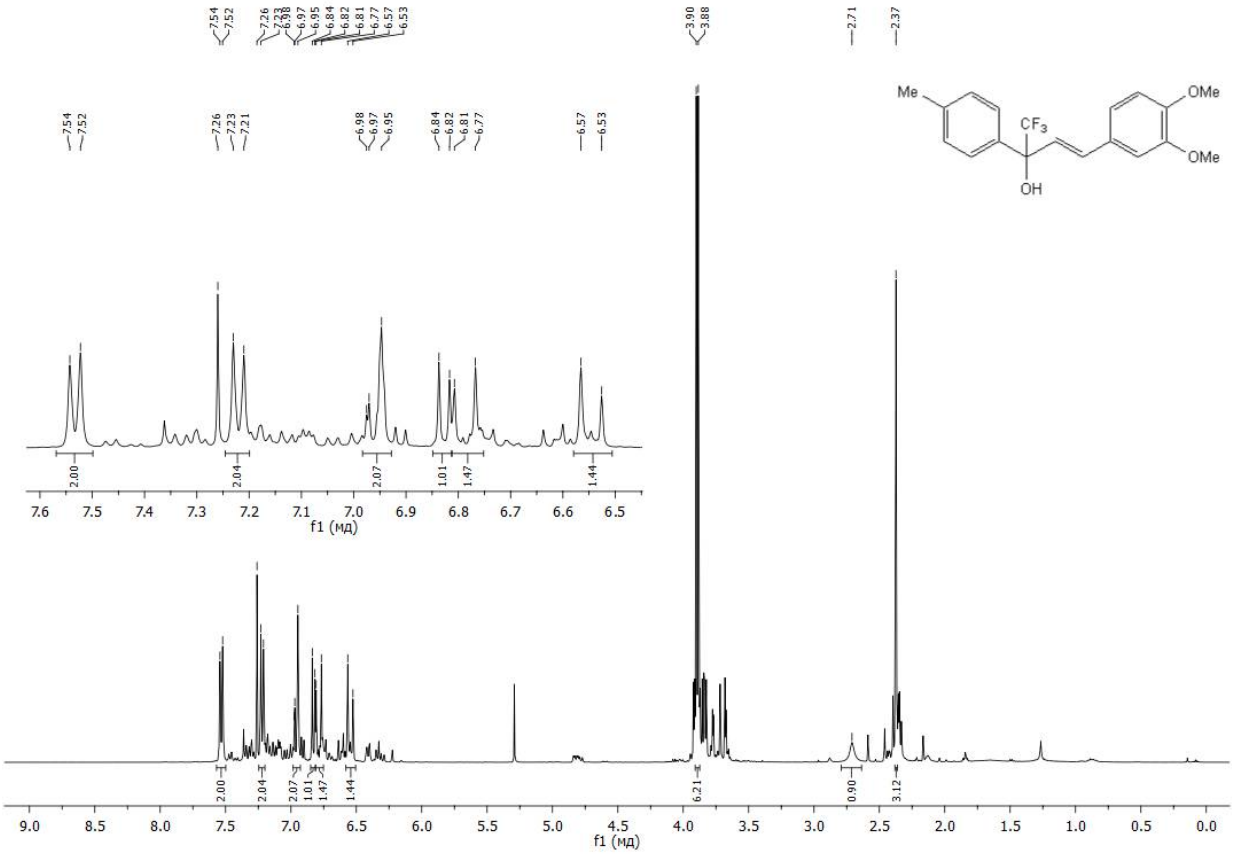


Fig. S74. ^{1}H NMR spectrum of the compound **2i** ($CDCl_3$, 400 MHz).

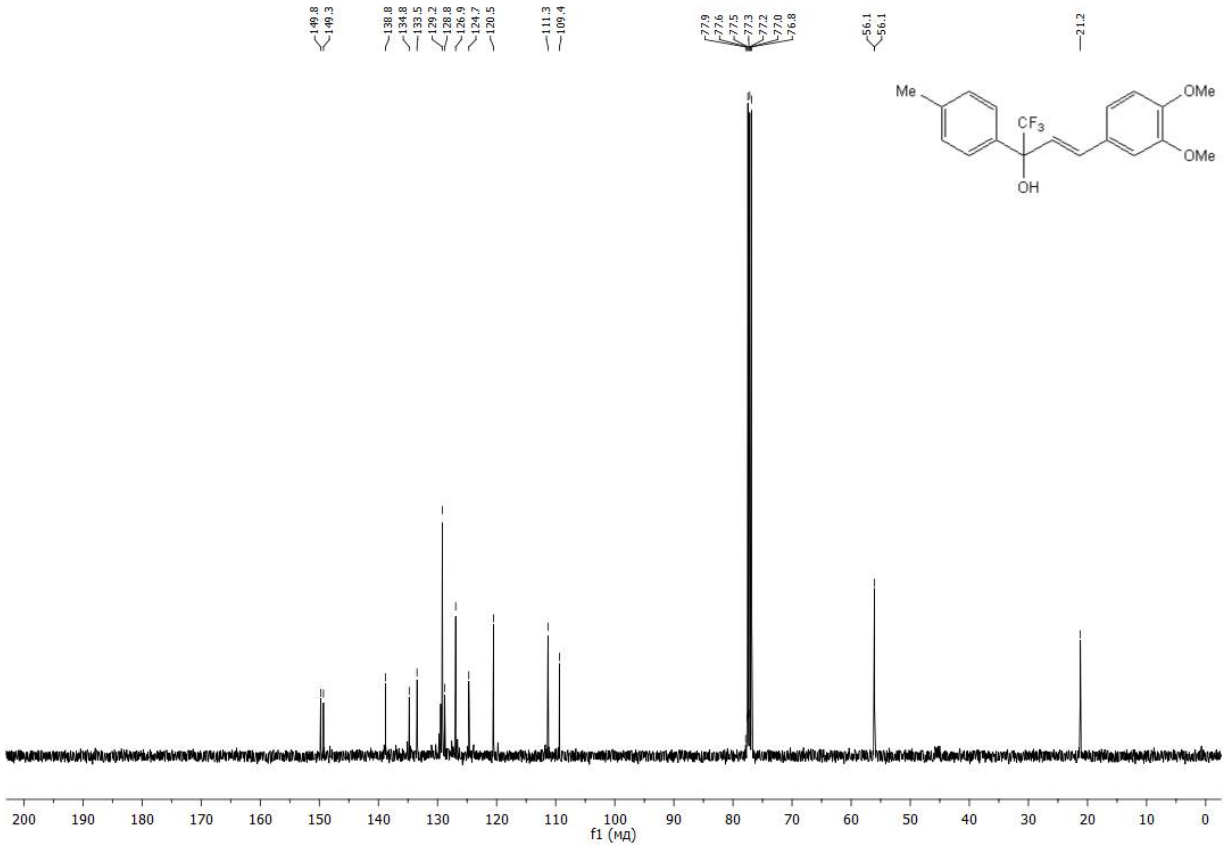


Fig. S75. ^{13}C NMR spectrum of the compound **2i** ($CDCl_3$, 100 MHz).

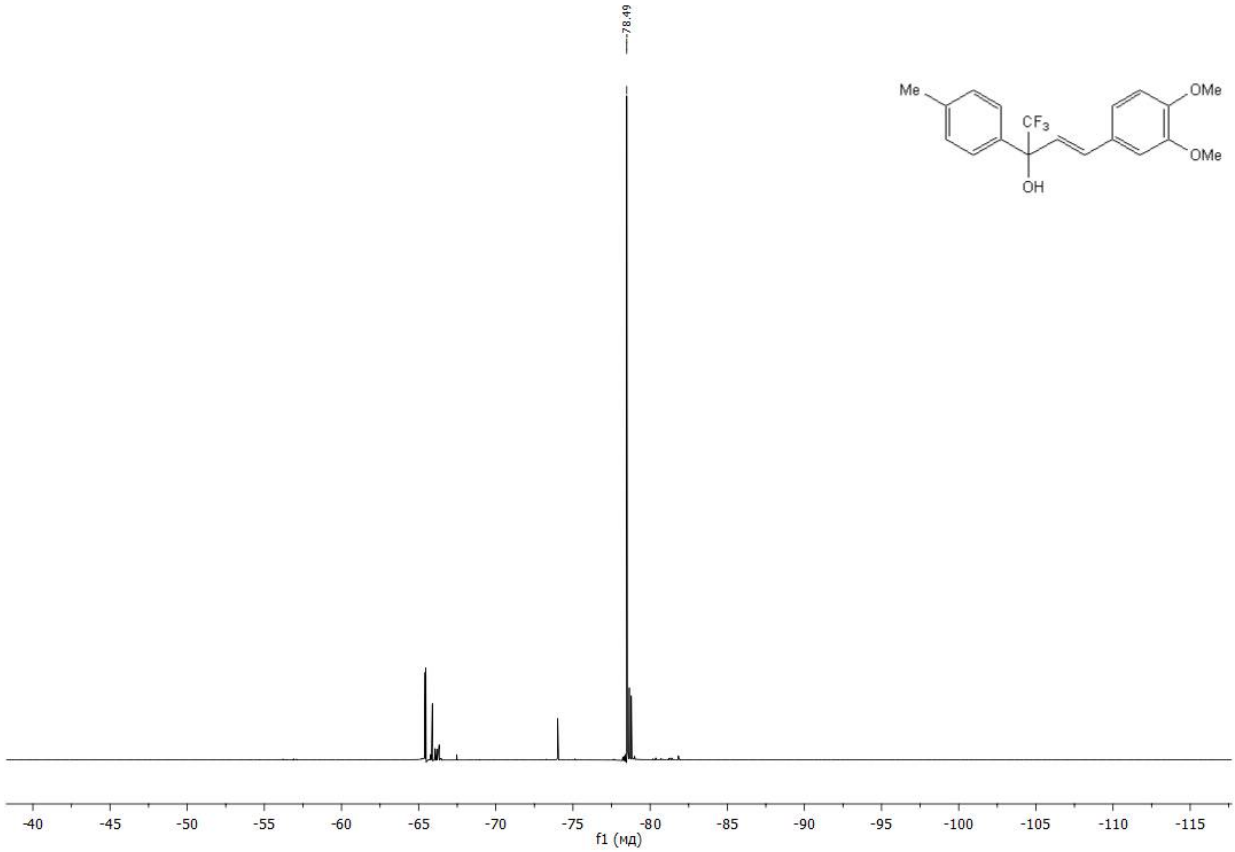


Fig. S76. ^{19}F NMR spectrum of the compound **2i** ($CDCl_3$, 376 MHz).

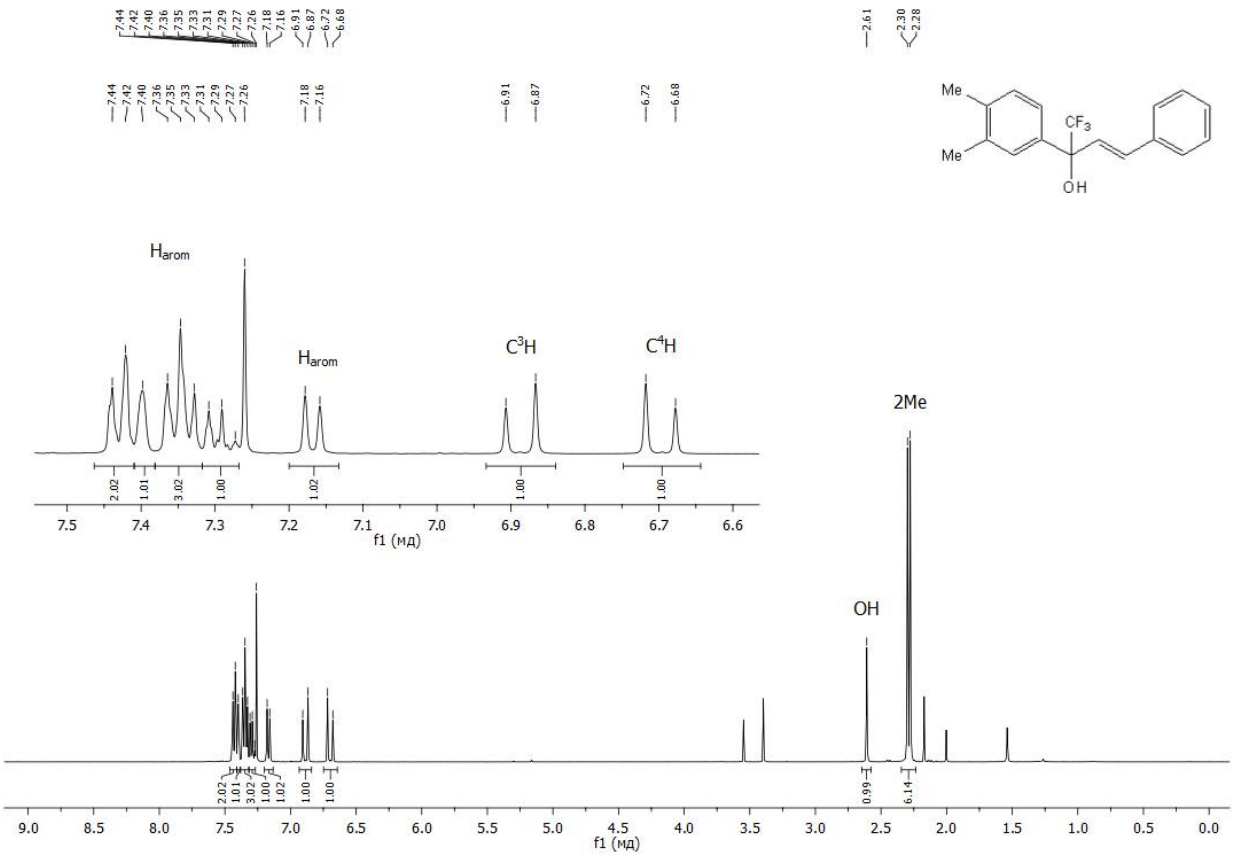


Fig. S77. ^{1}H NMR spectrum of the compound **2j** ($CDCl_3$, 400 MHz).

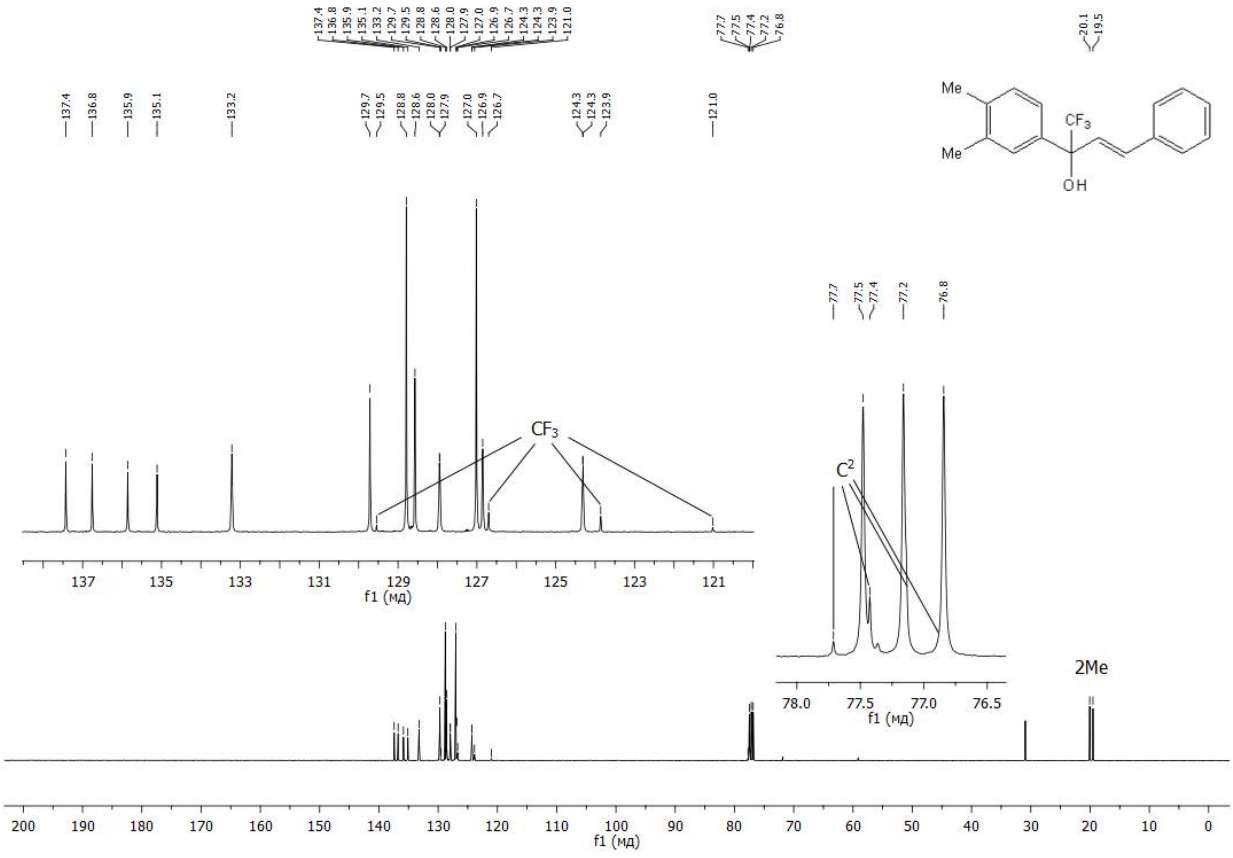


Fig. S78. ^{13}C NMR spectrum of the compound **2j** ($CDCl_3$, 100 MHz).

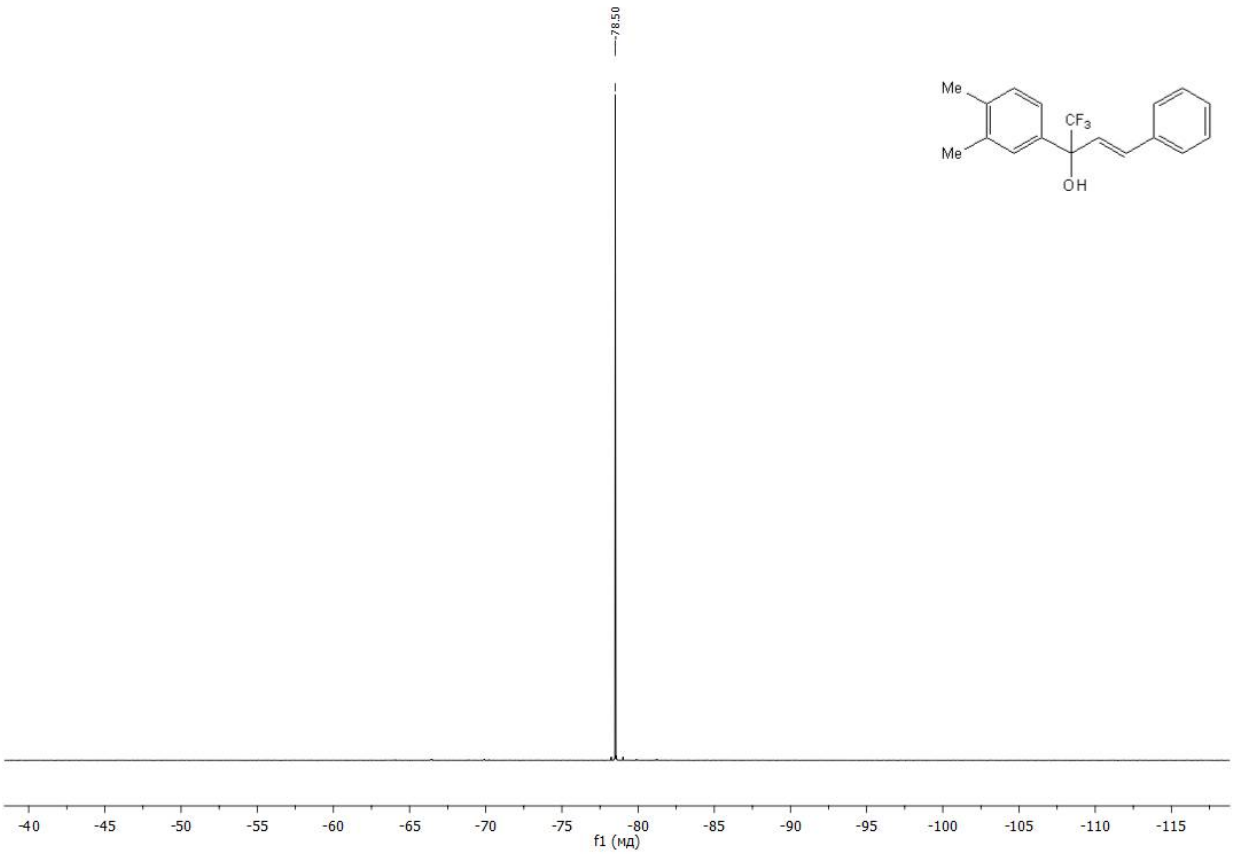


Fig. S79. ^{19}F NMR spectrum of the compound **2j** ($CDCl_3$, 376 MHz).

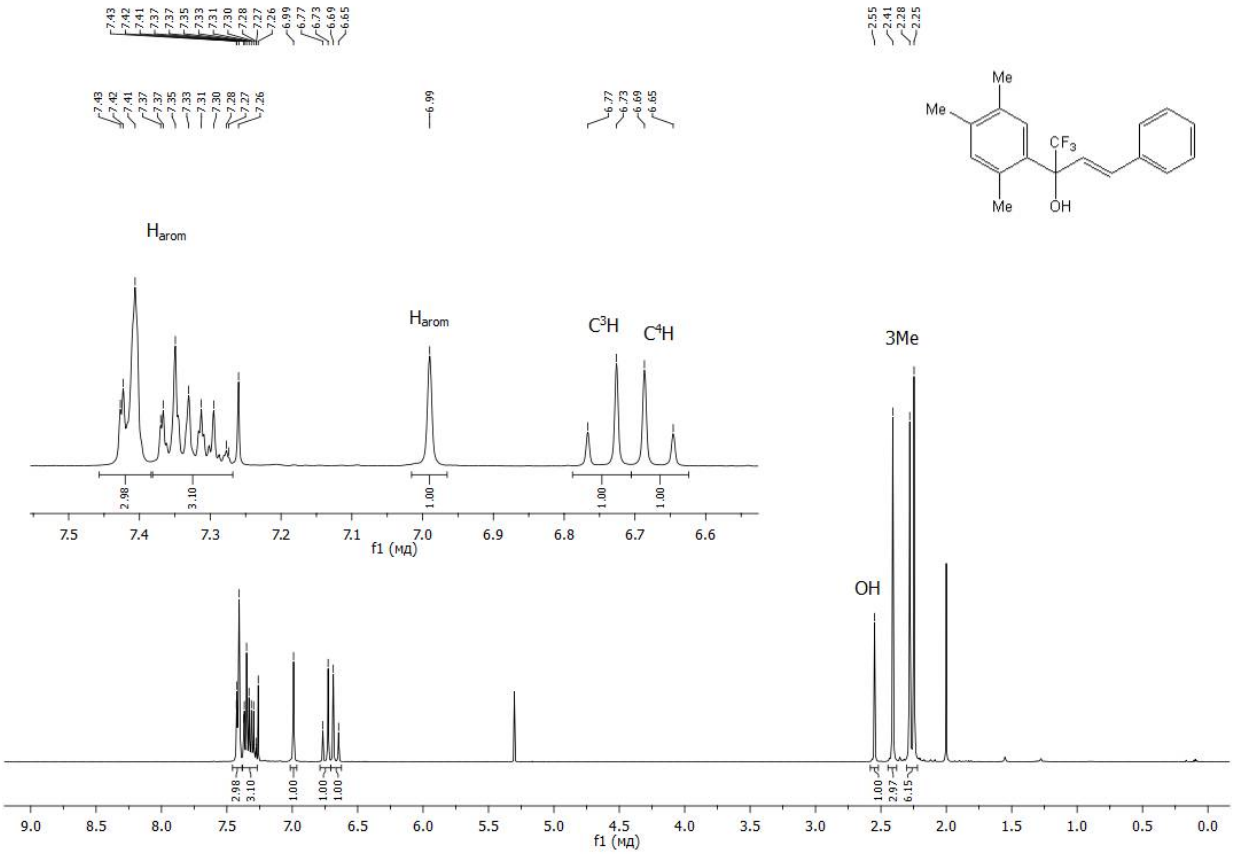


Fig. S80. ^{1}H NMR spectrum of the compound **2m** ($CDCl_3$, 400 MHz).

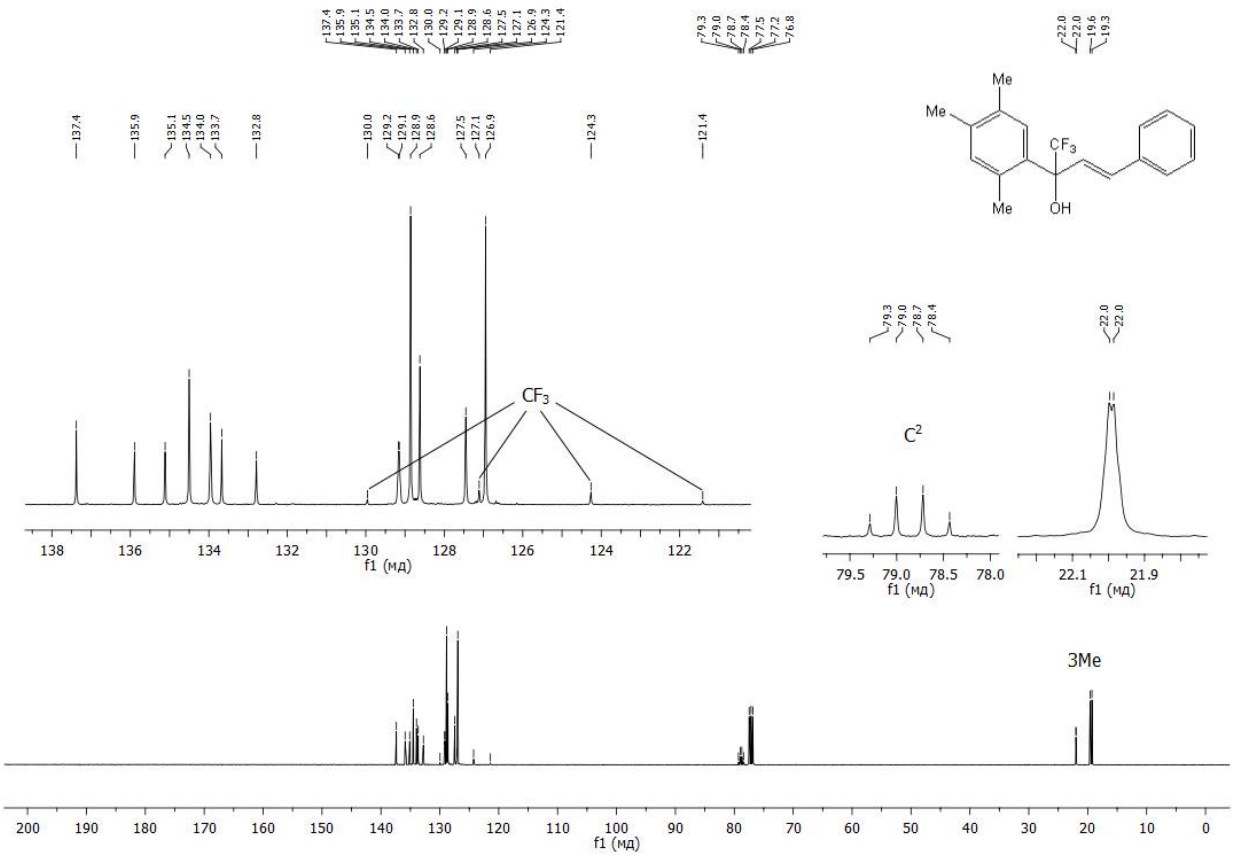


Fig. S81. ^{13}C NMR spectrum of the compound **2m** ($CDCl_3$, 100 MHz).

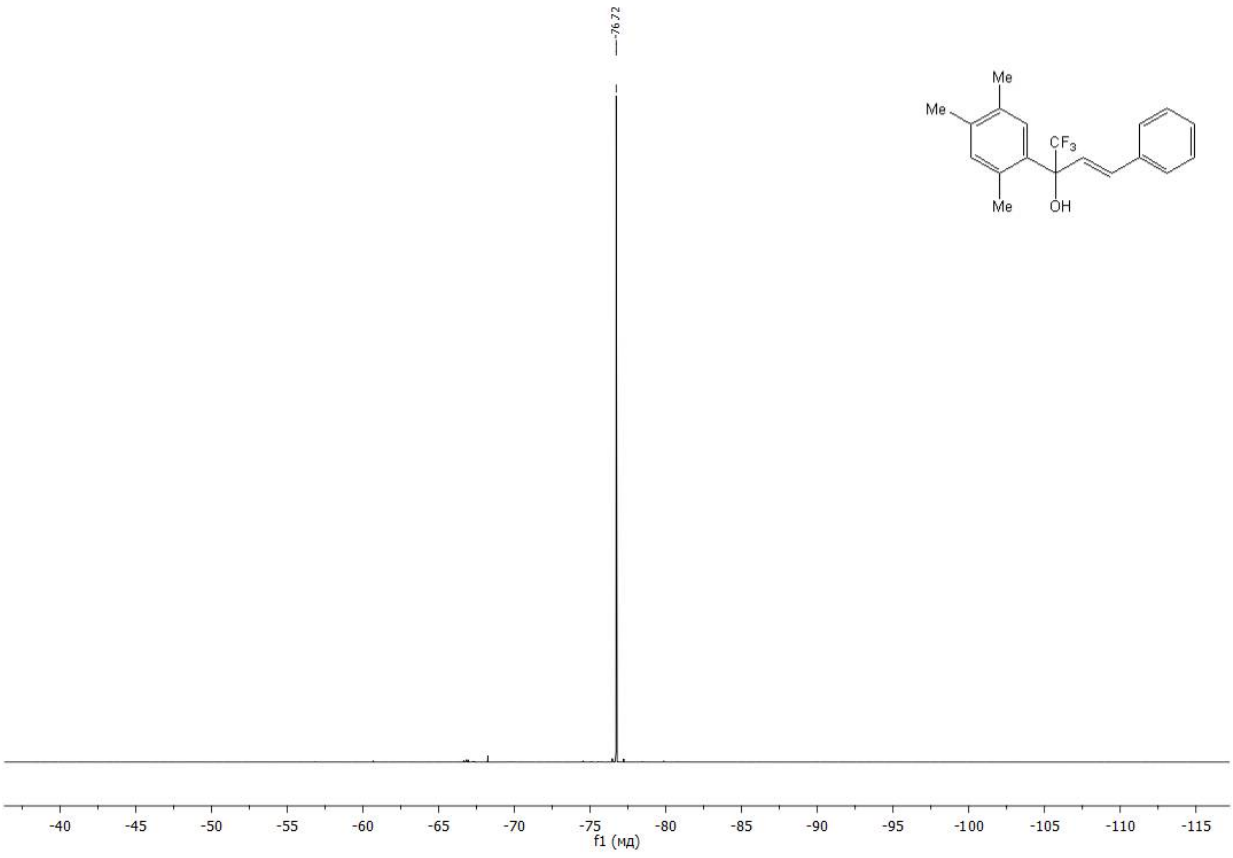


Fig. S82. ^{19}F NMR spectrum of the compound **2m** ($CDCl_3$, 376 MHz).

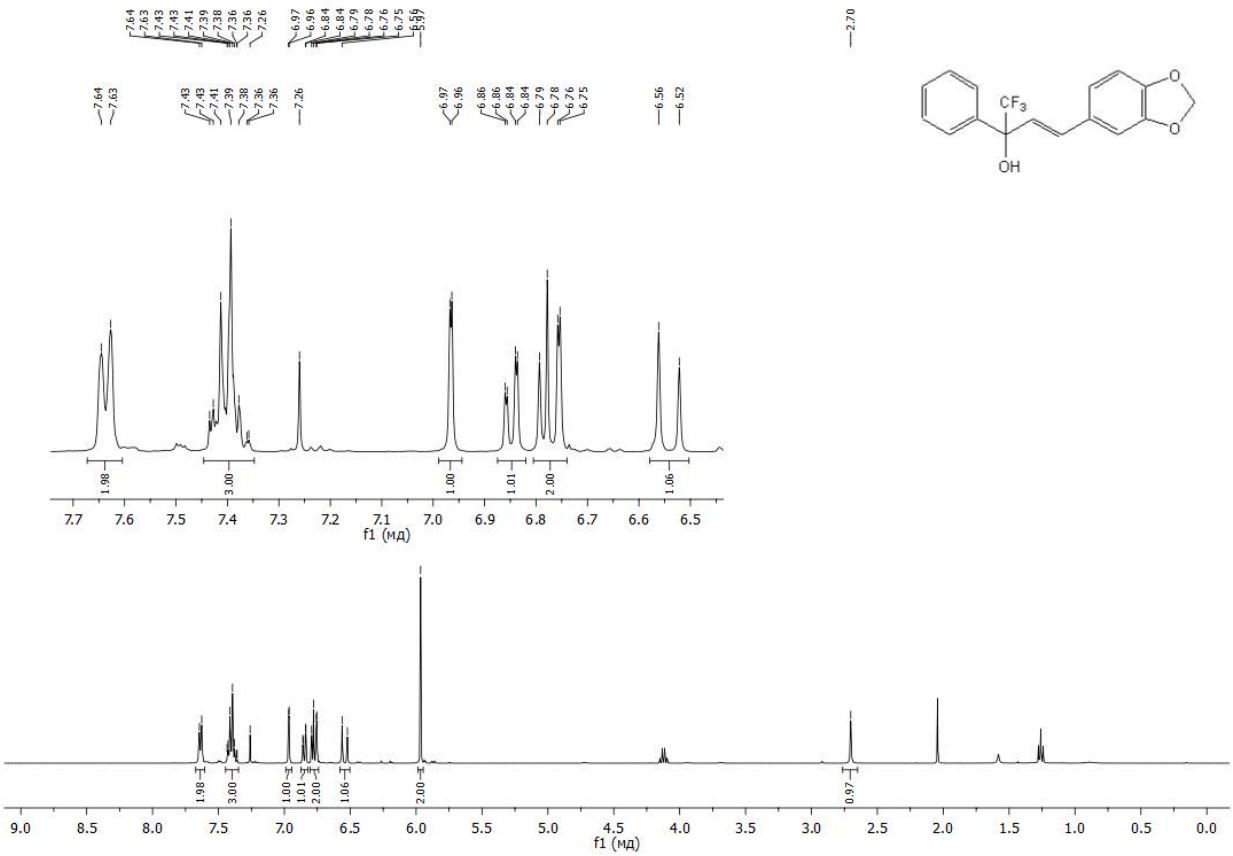


Fig. S83. ^{1}H NMR spectrum of the compound **2n** ($CDCl_3$, 400 MHz).

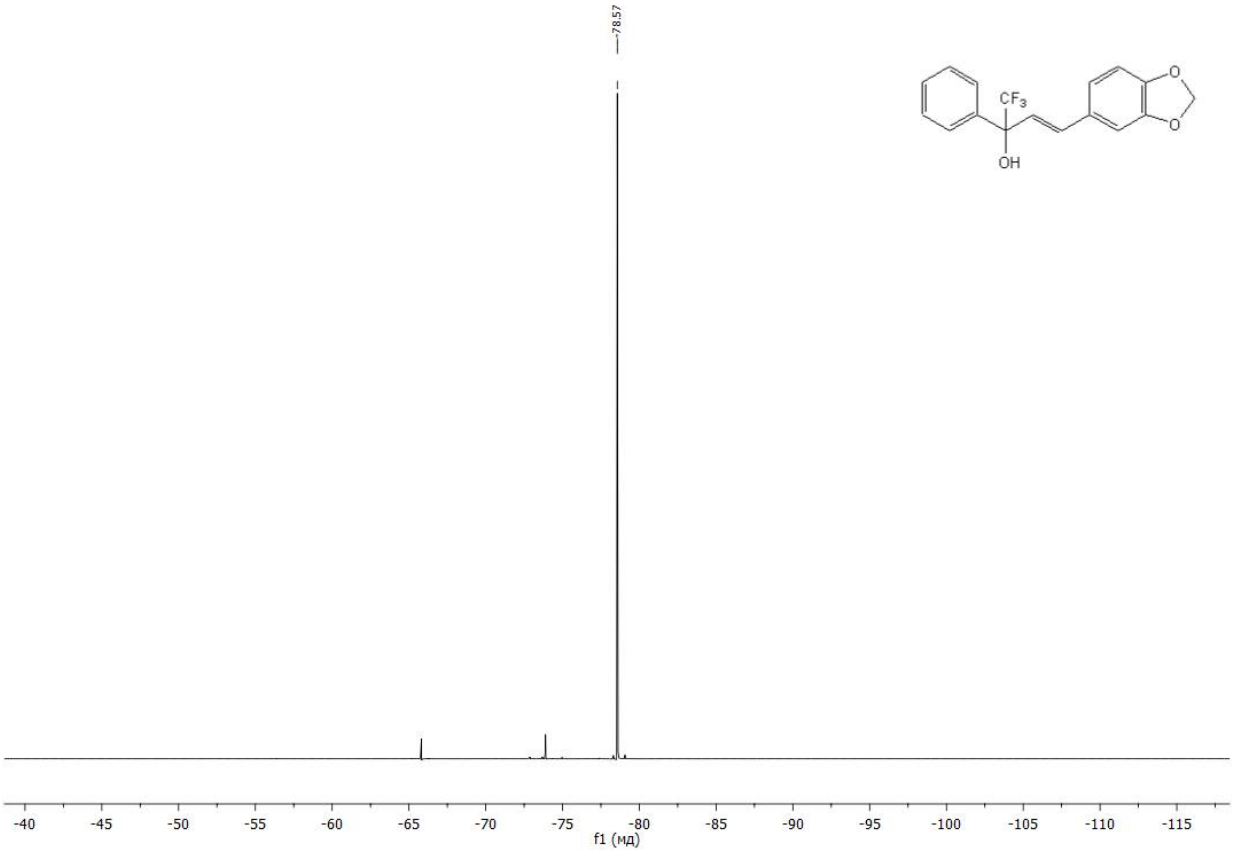


Fig. S84. ^{19}F NMR spectrum of the compound **2n** ($CDCl_3$, 376 MHz).

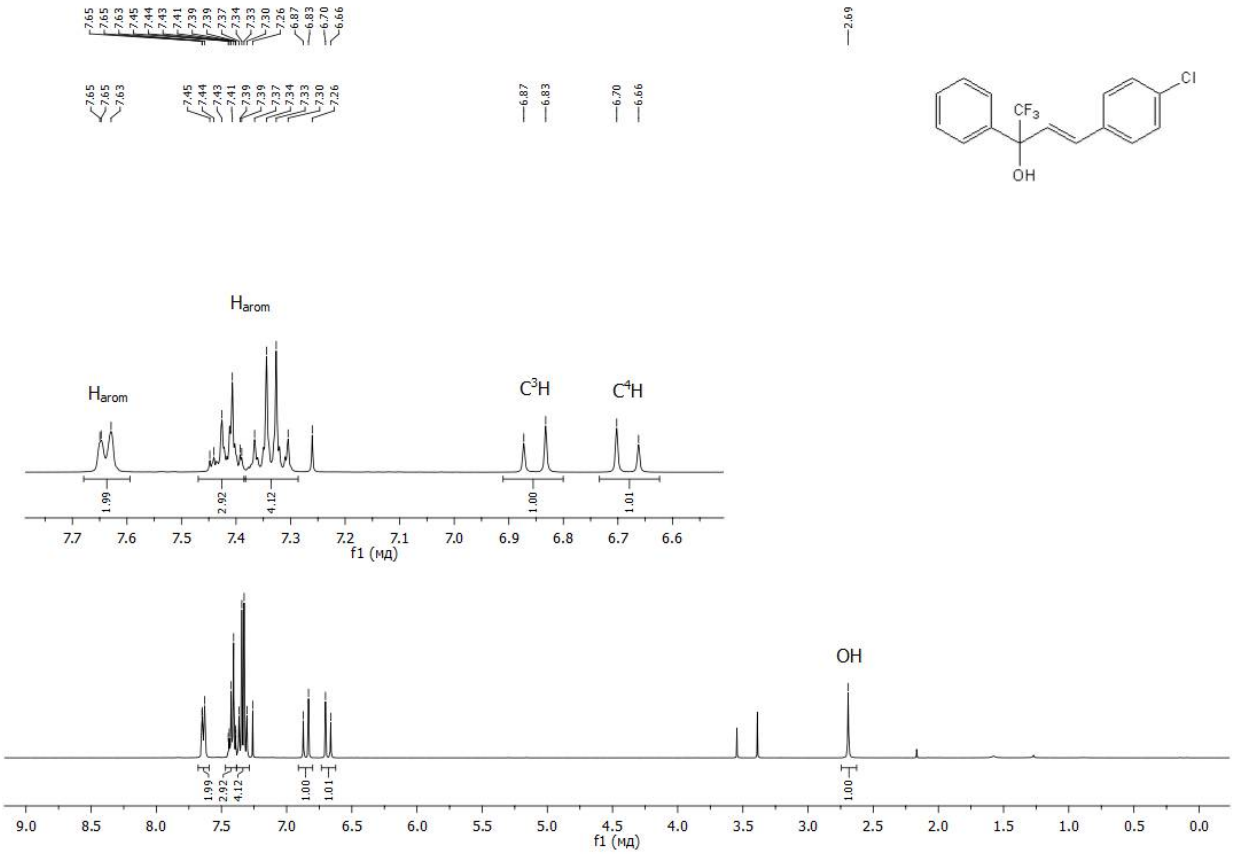


Fig. S85. ^{1}H NMR spectrum of the compound **2o** ($CDCl_3$, 400 MHz).

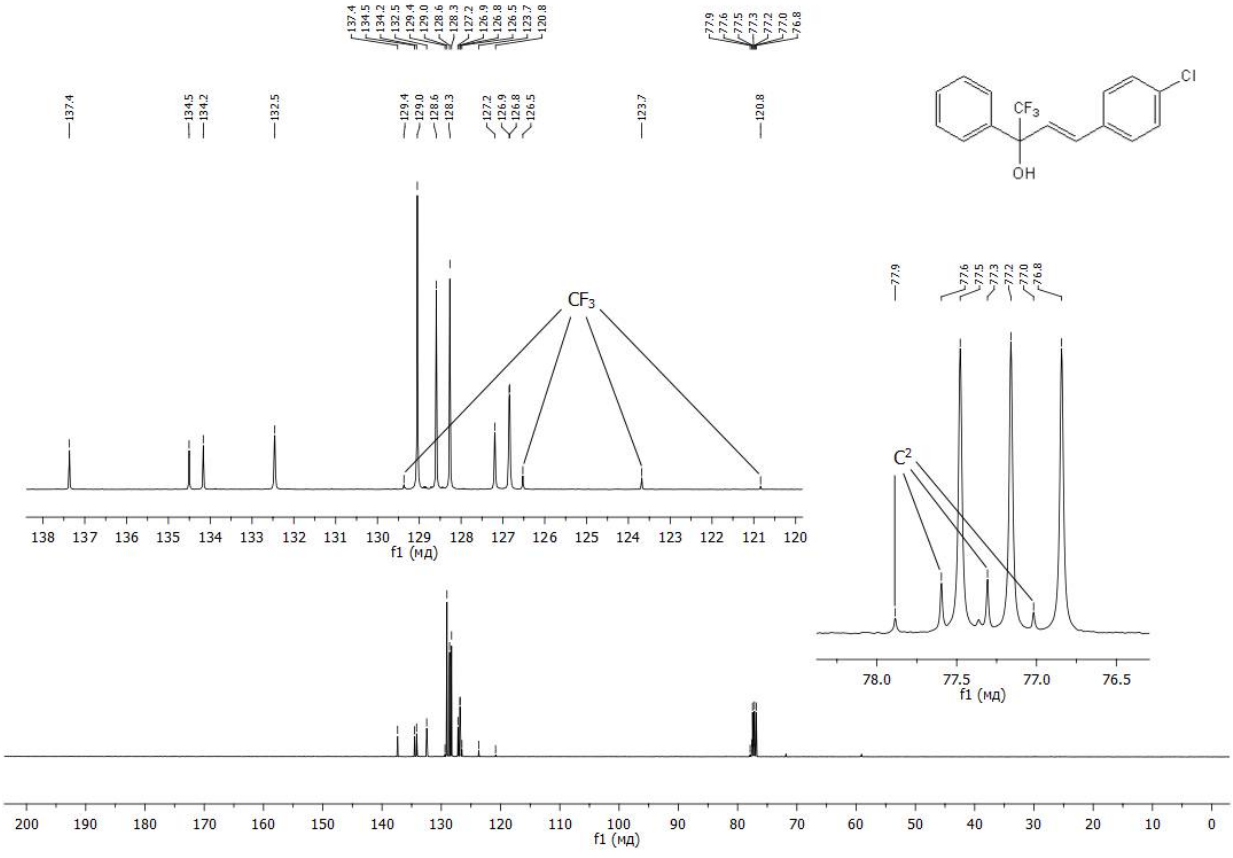


Fig. S86. ^{13}C NMR spectrum of the compound **2o** ($CDCl_3$, 100 MHz).

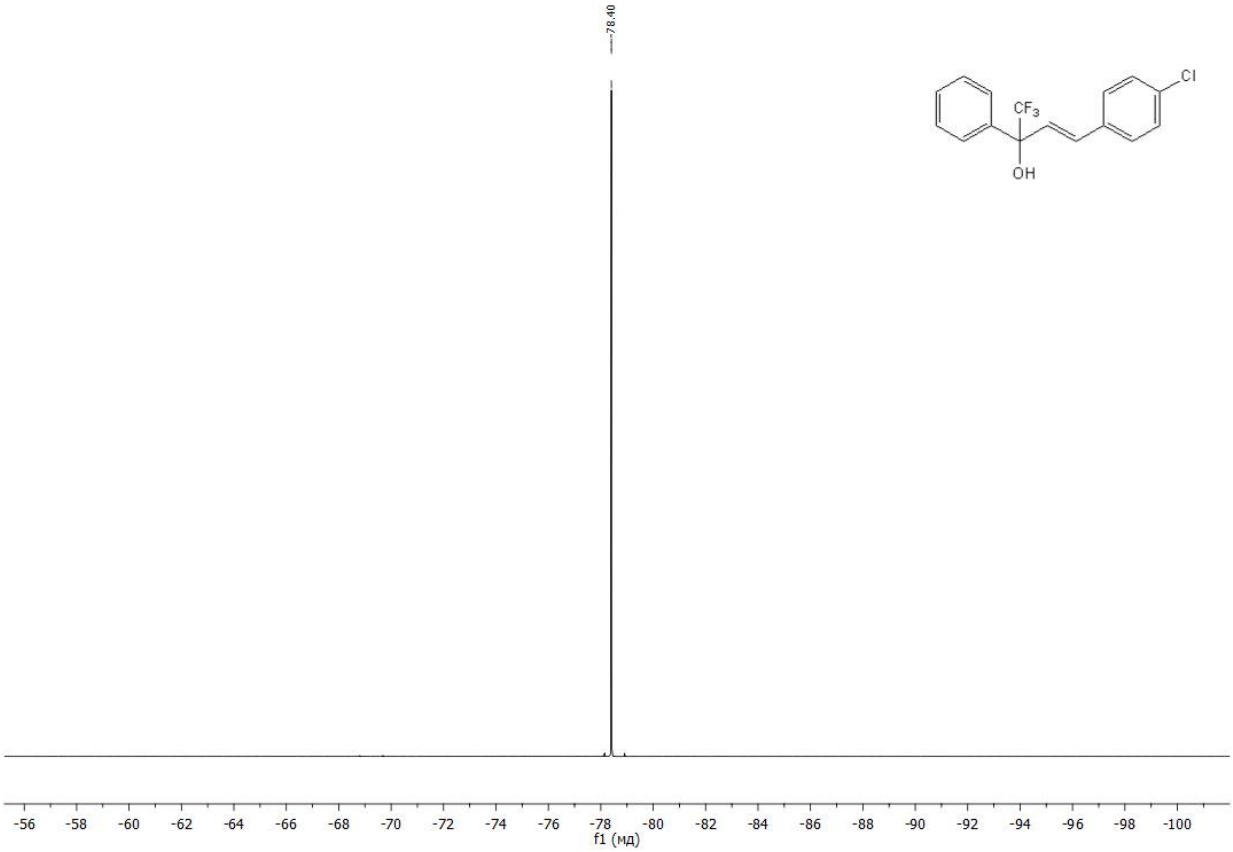


Fig. S87. ^{19}F NMR spectrum of the compound **2o** ($CDCl_3$, 376 MHz).

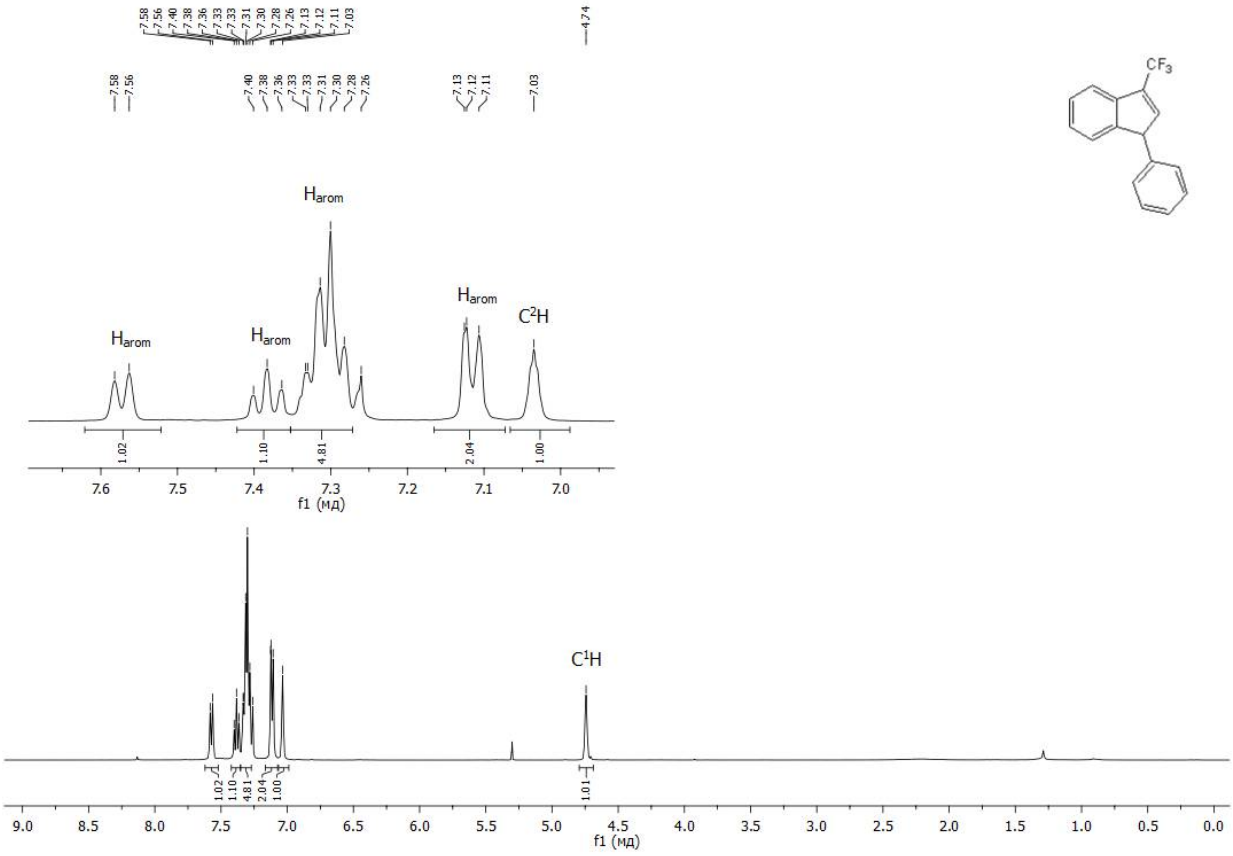


Fig. S88. ^{1}H NMR spectrum of the compound **3a** ($CDCl_3$, 400 MHz).

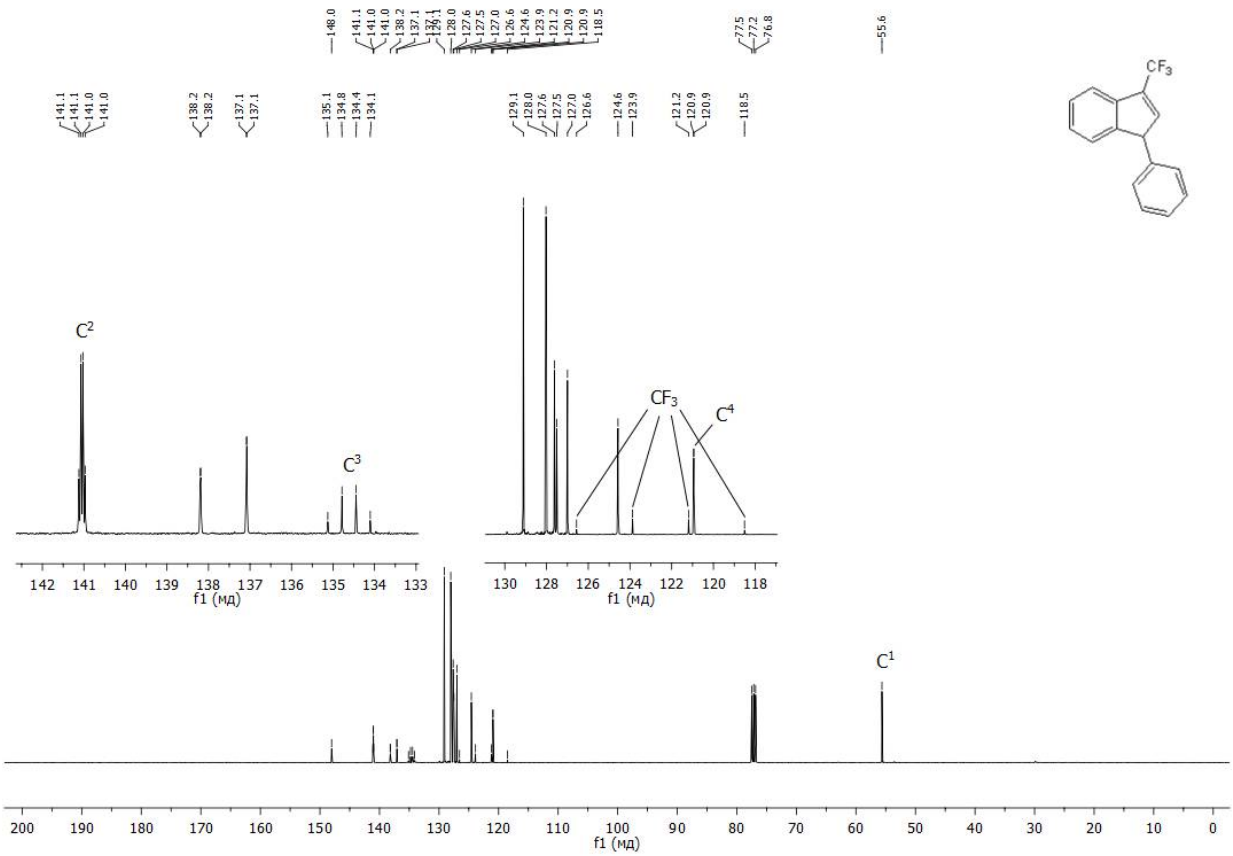


Fig. S89. ^{13}C NMR spectrum of the compound **3a** ($CDCl_3$, 100 MHz).

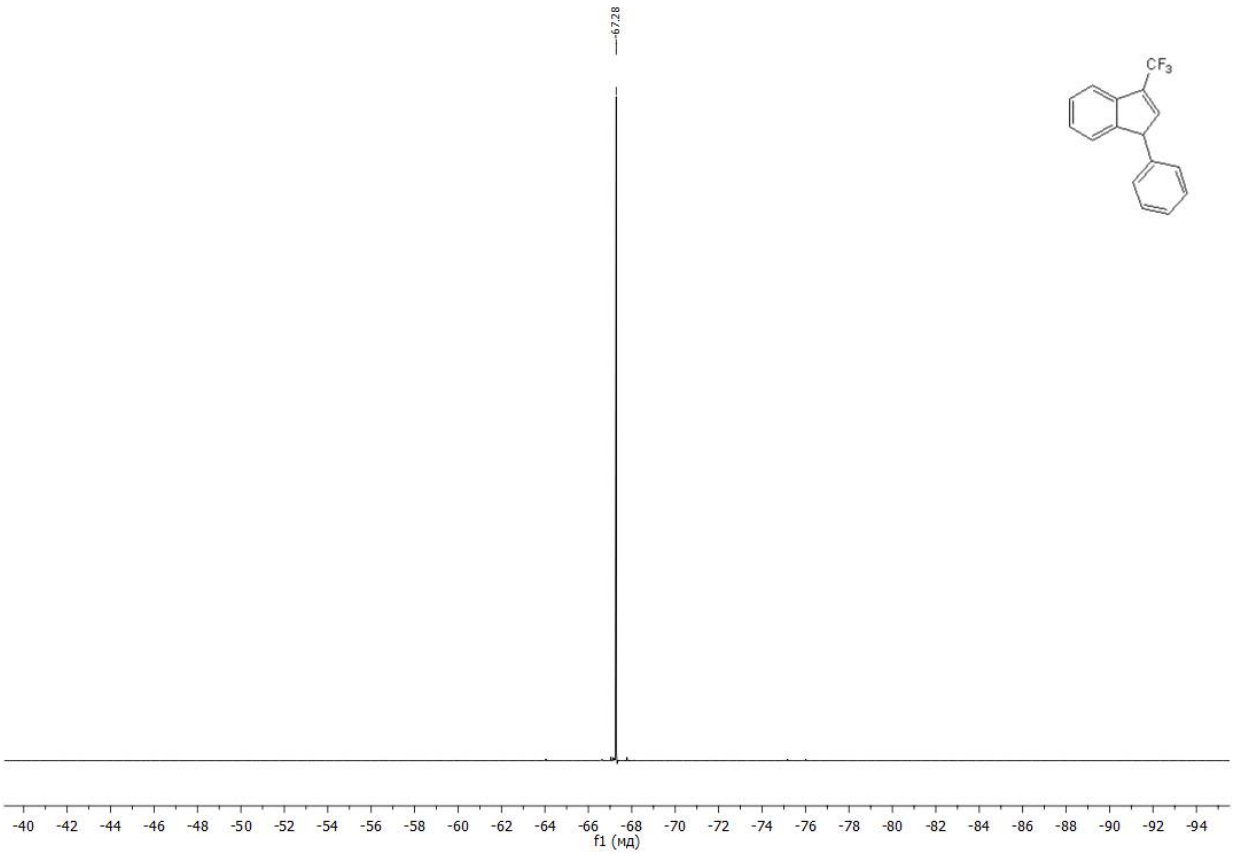


Fig. S90. ^{19}F {^{1}H} NMR spectrum of the compound **3a** ($CDCl_3$, 376 MHz).

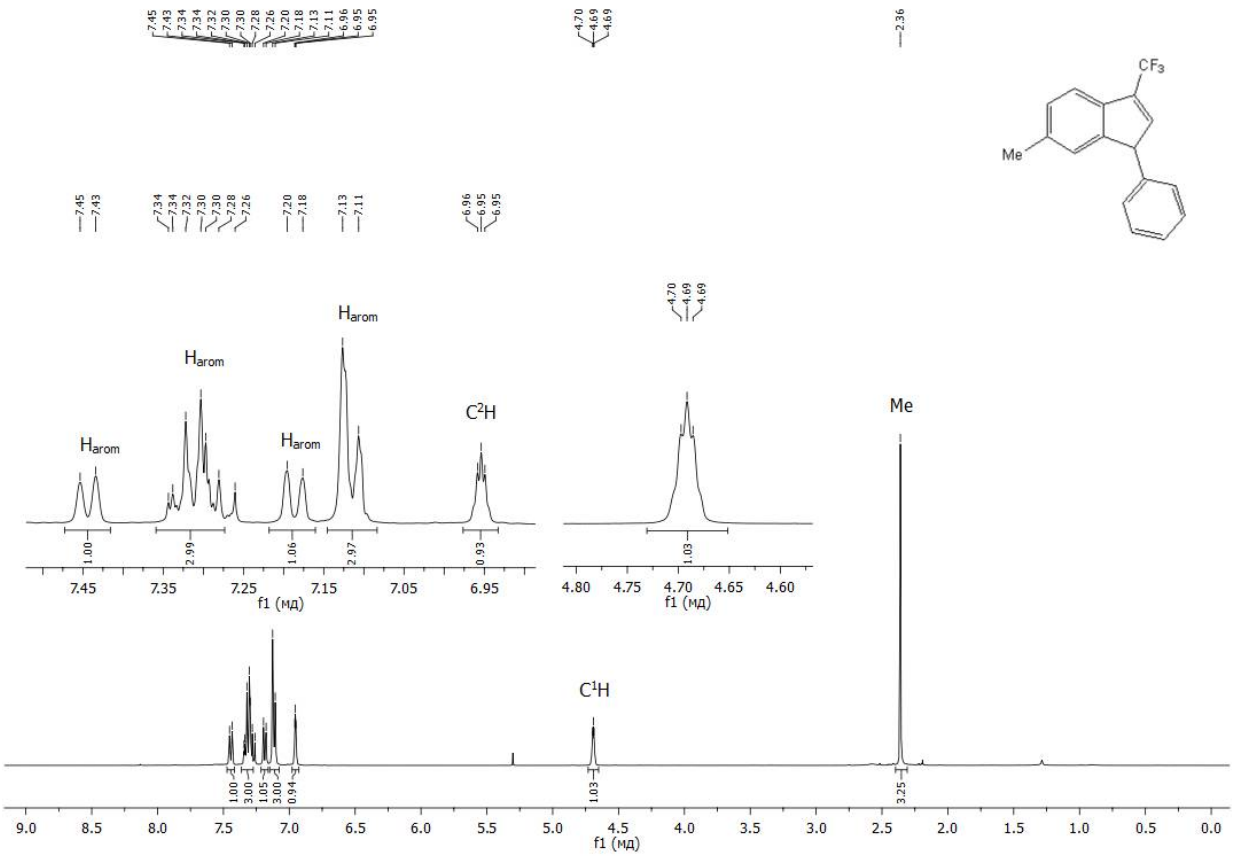


Fig. S91. ^{1}H NMR spectrum of the compound **3b** ($CDCl_3$, 400 MHz).

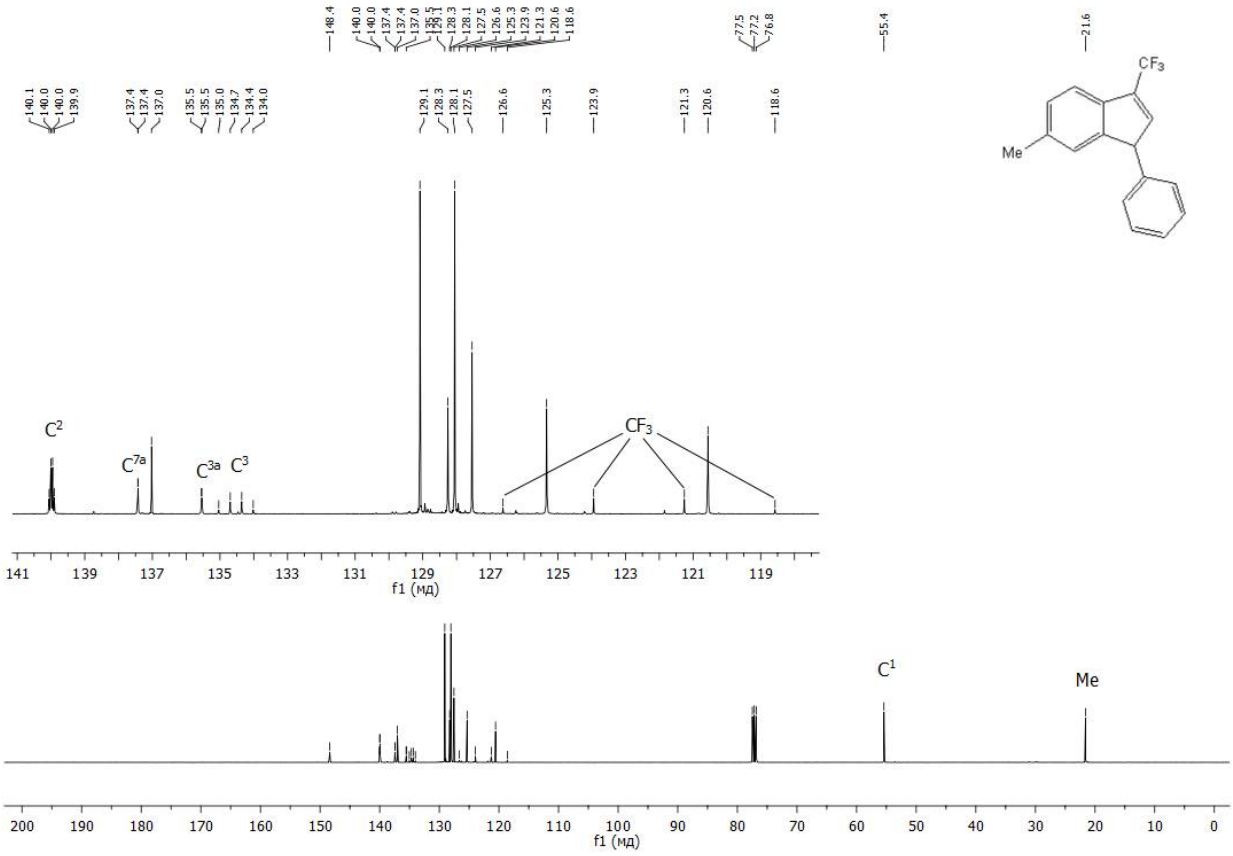


Fig. S92. ^{13}C NMR spectrum of the compound **3b** ($CDCl_3$, 100 MHz).

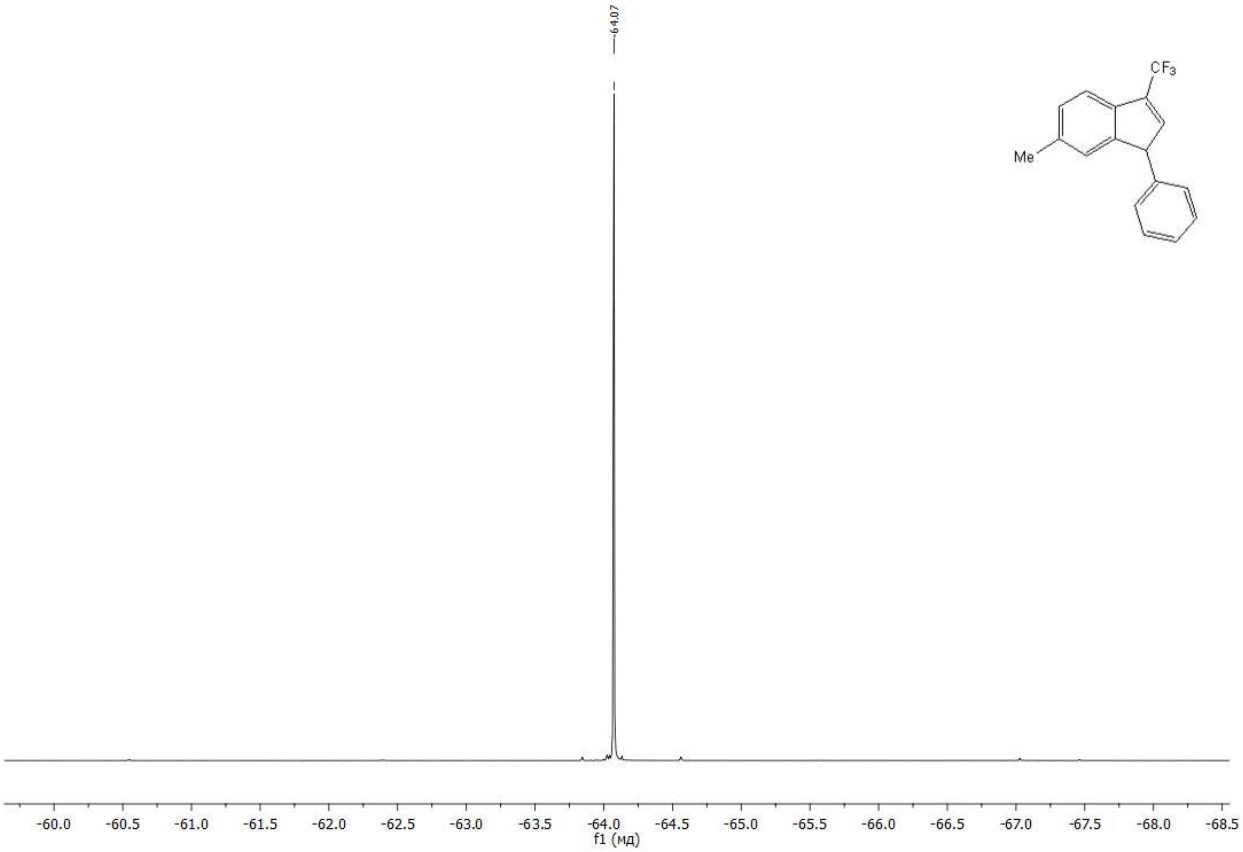


Fig. S93. $^{19}F\{^{1}H\}$ NMR spectrum of the compound **3b** ($CDCl_3$, 376 MHz).

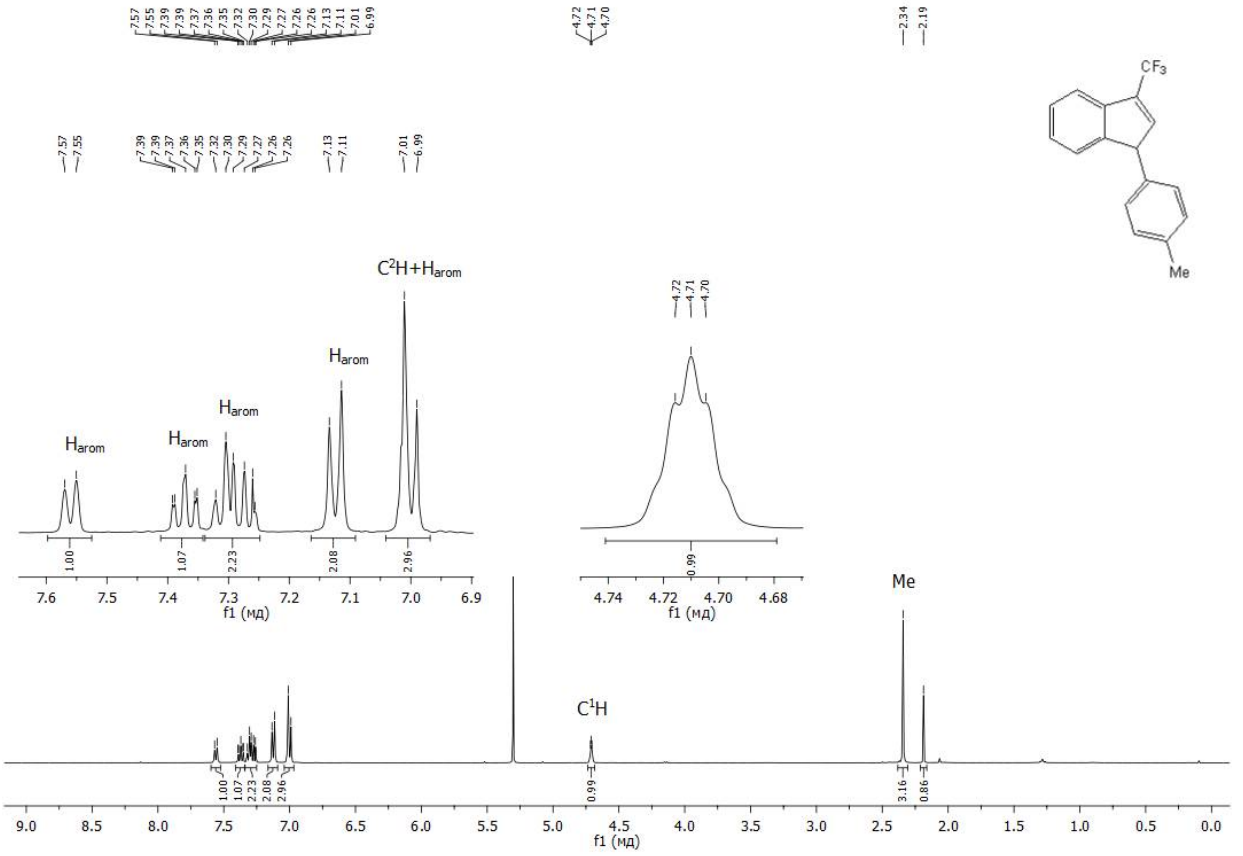


Fig. S94. ^{1}H NMR spectrum of the compound **3c** ($CDCl_3$, 400 MHz).

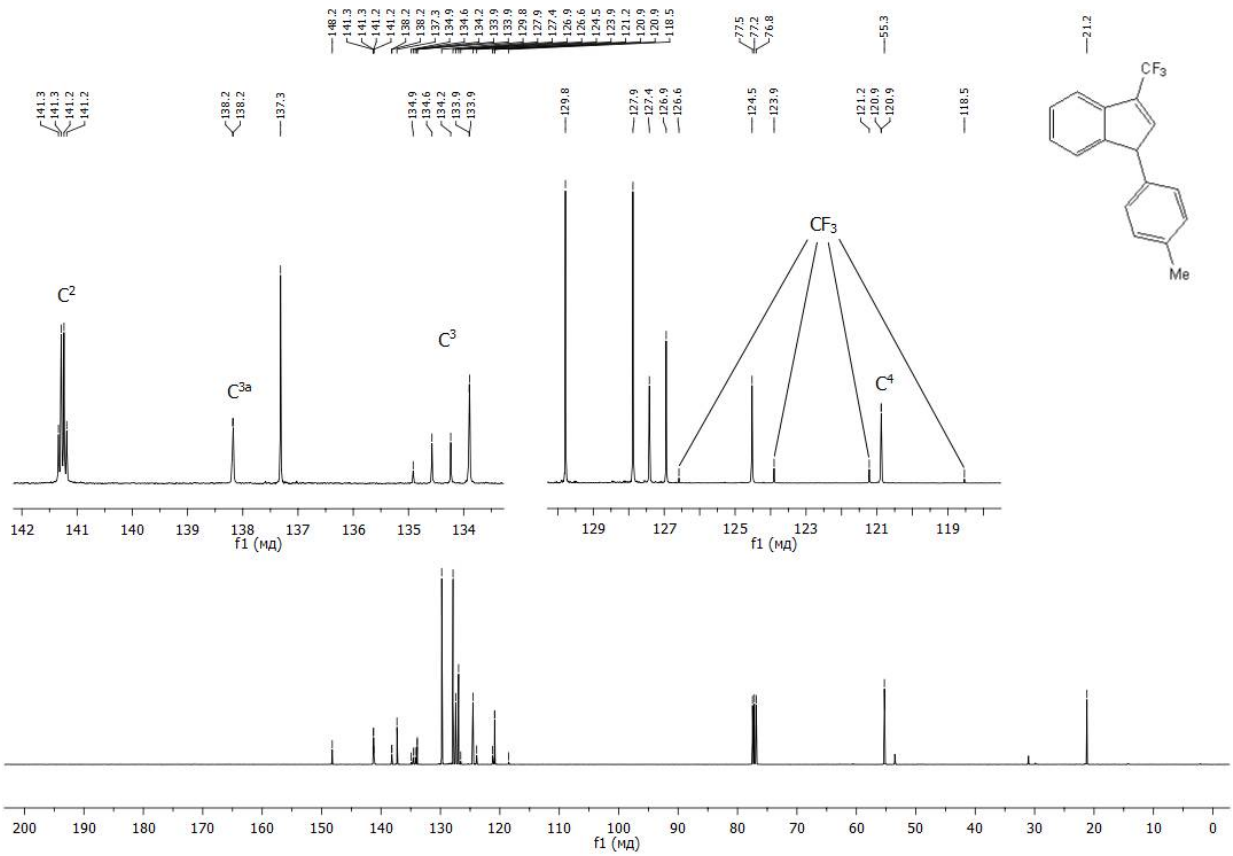


Fig. S95. ^{13}C NMR spectrum of the compound **3c** ($CDCl_3$, 100 MHz).

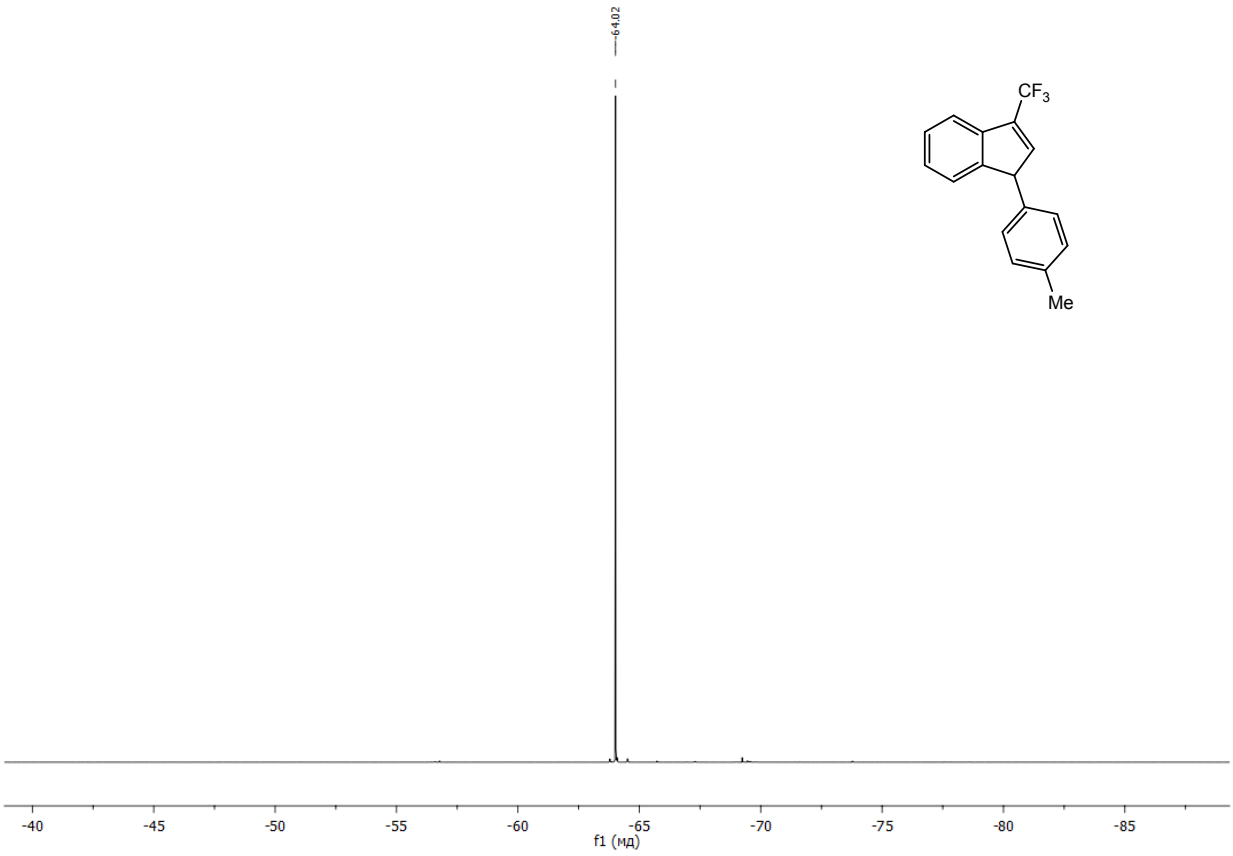


Fig. S96. ^{19}F $\{^1H\}$ NMR spectrum of the compound **3c** ($CDCl_3$, 376 MHz).

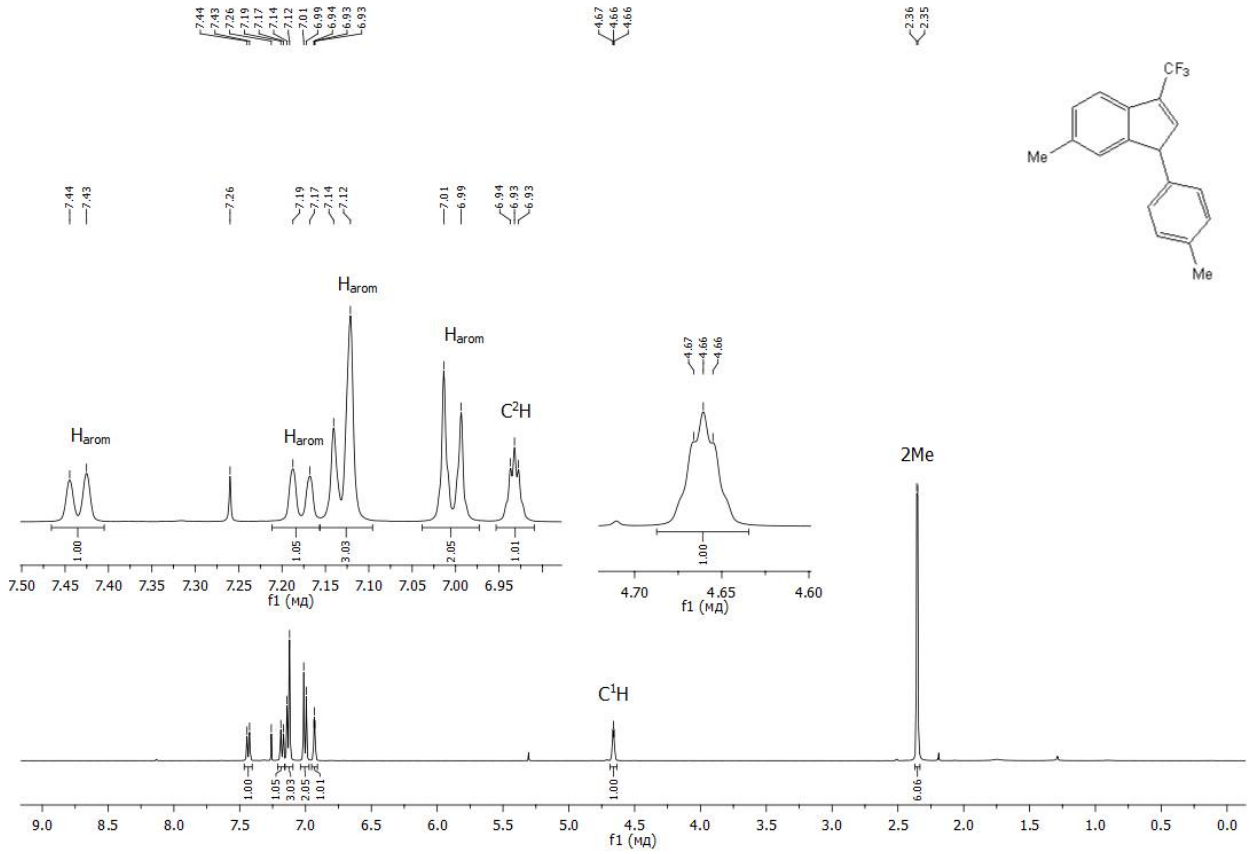


Fig. S97. ^{1}H NMR spectrum of the compound **3d** ($CDCl_3$, 400 MHz).

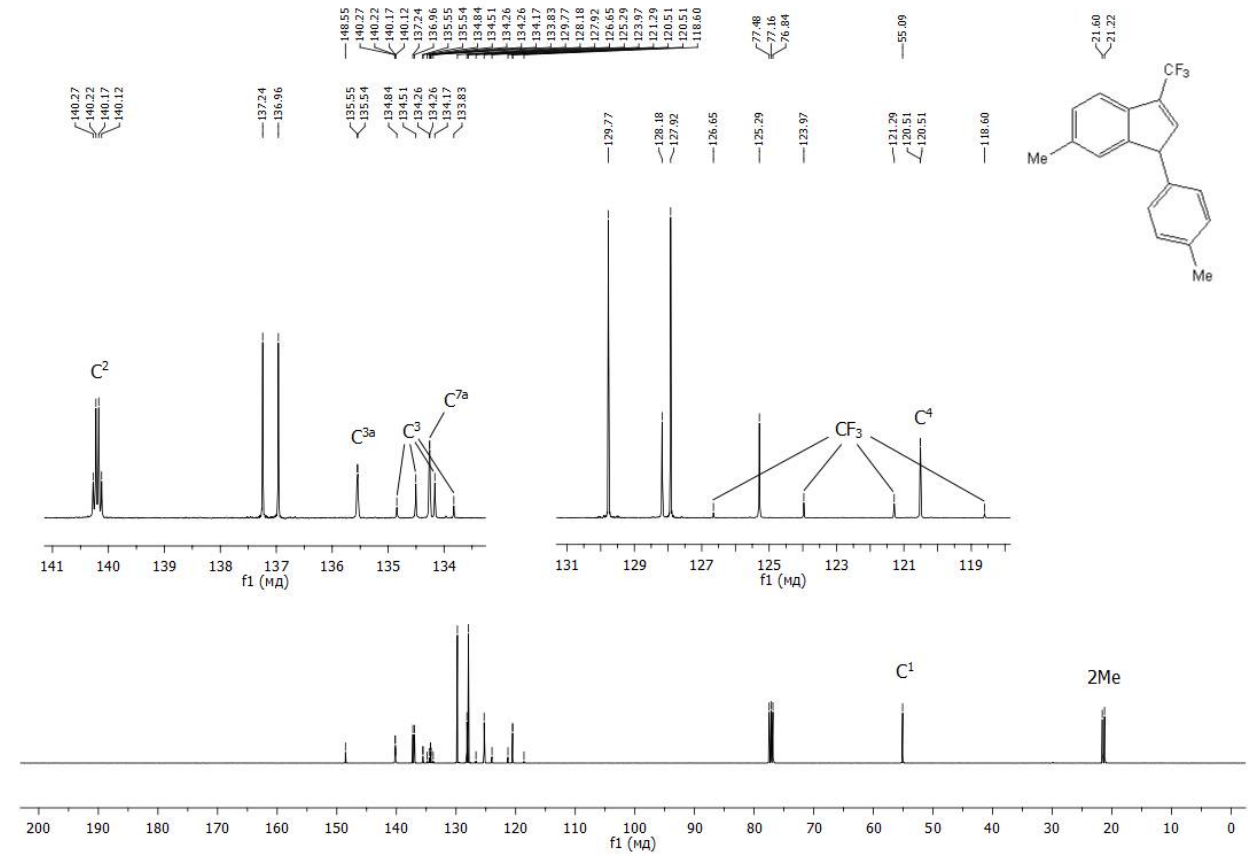


Fig. S98. ^{13}C NMR spectrum of the compound **3d** ($CDCl_3$, 100 MHz).

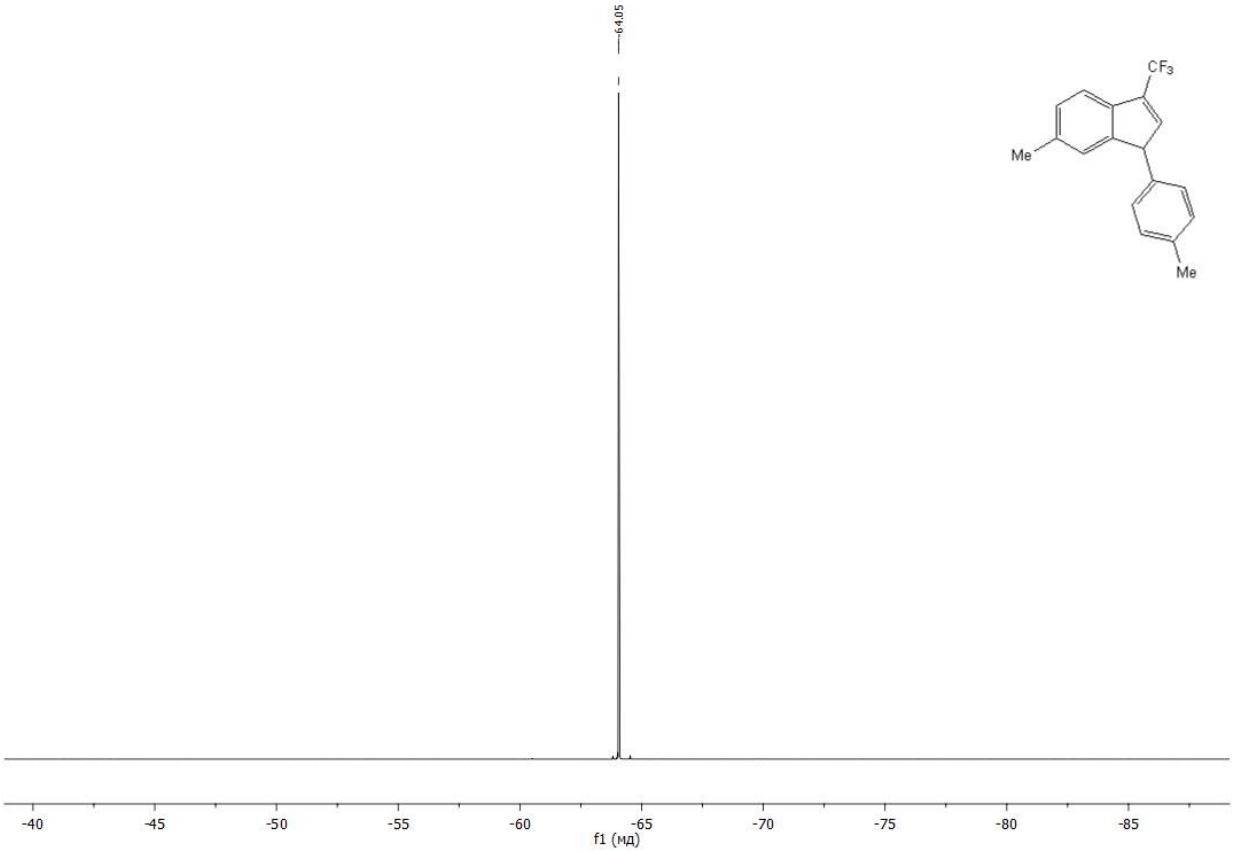


Fig. S99. ^{19}F {^{1}H} NMR spectrum of the compound **3d** ($CDCl_3$, 376 MHz).

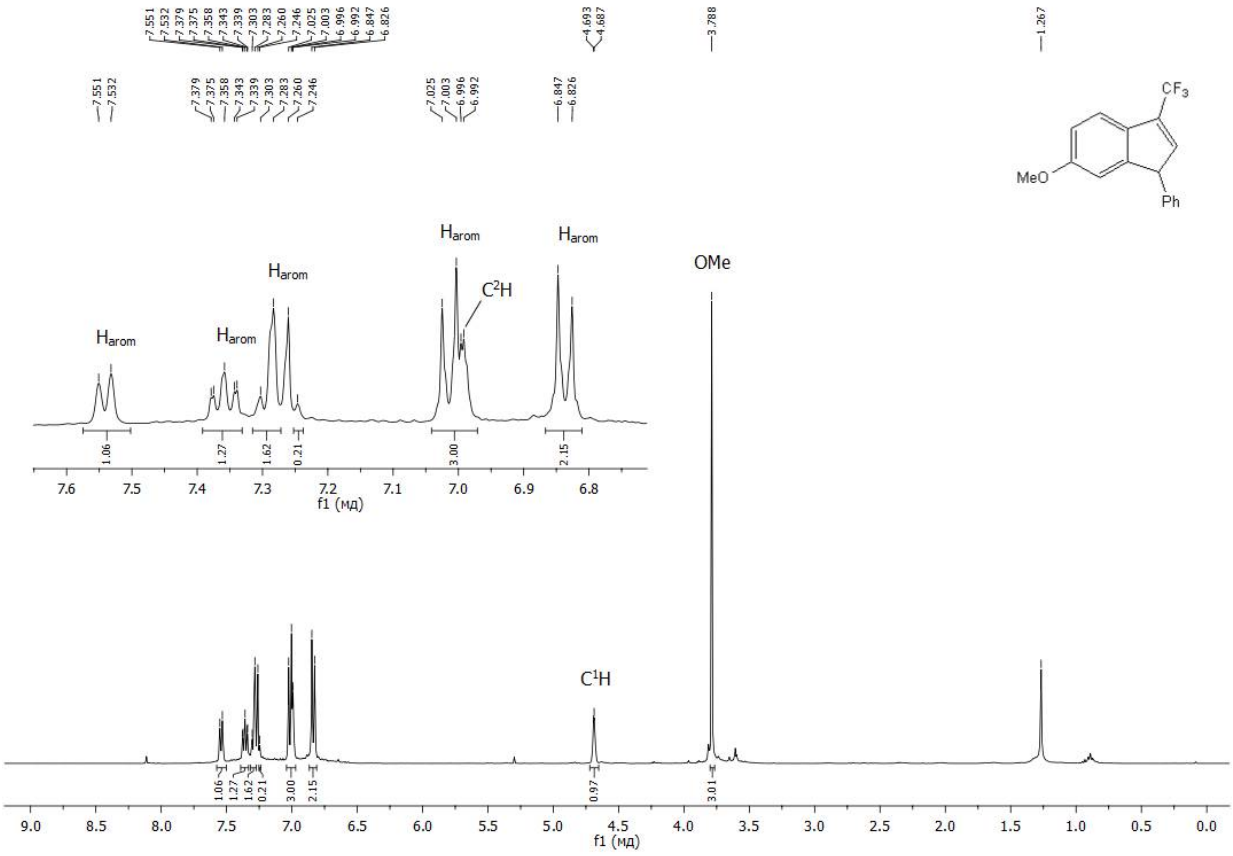


Fig. S100. ^{1}H NMR spectrum of the compound **3e** ($CDCl_3$, 400 MHz).

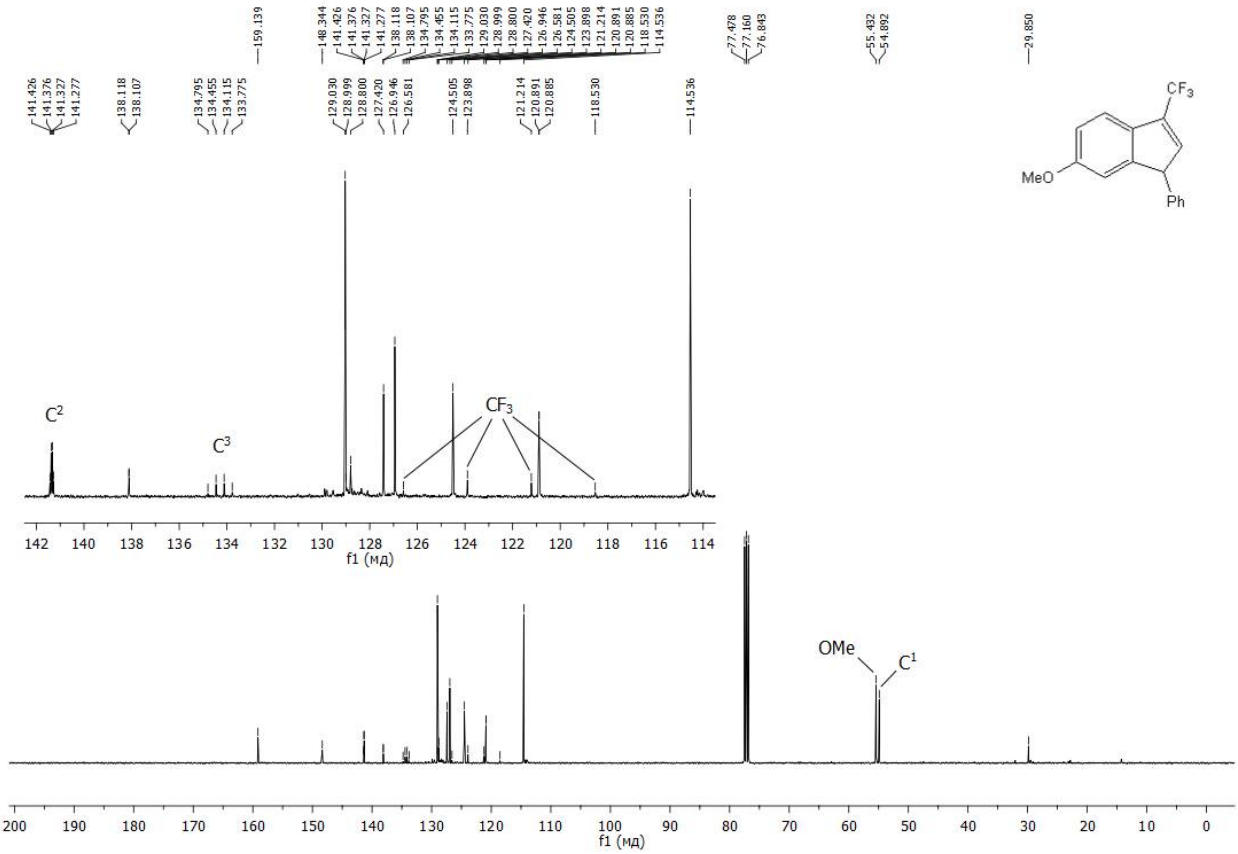


Fig. S101. ^{13}C NMR spectrum of the compound **3e** ($CDCl_3$, 100 MHz).

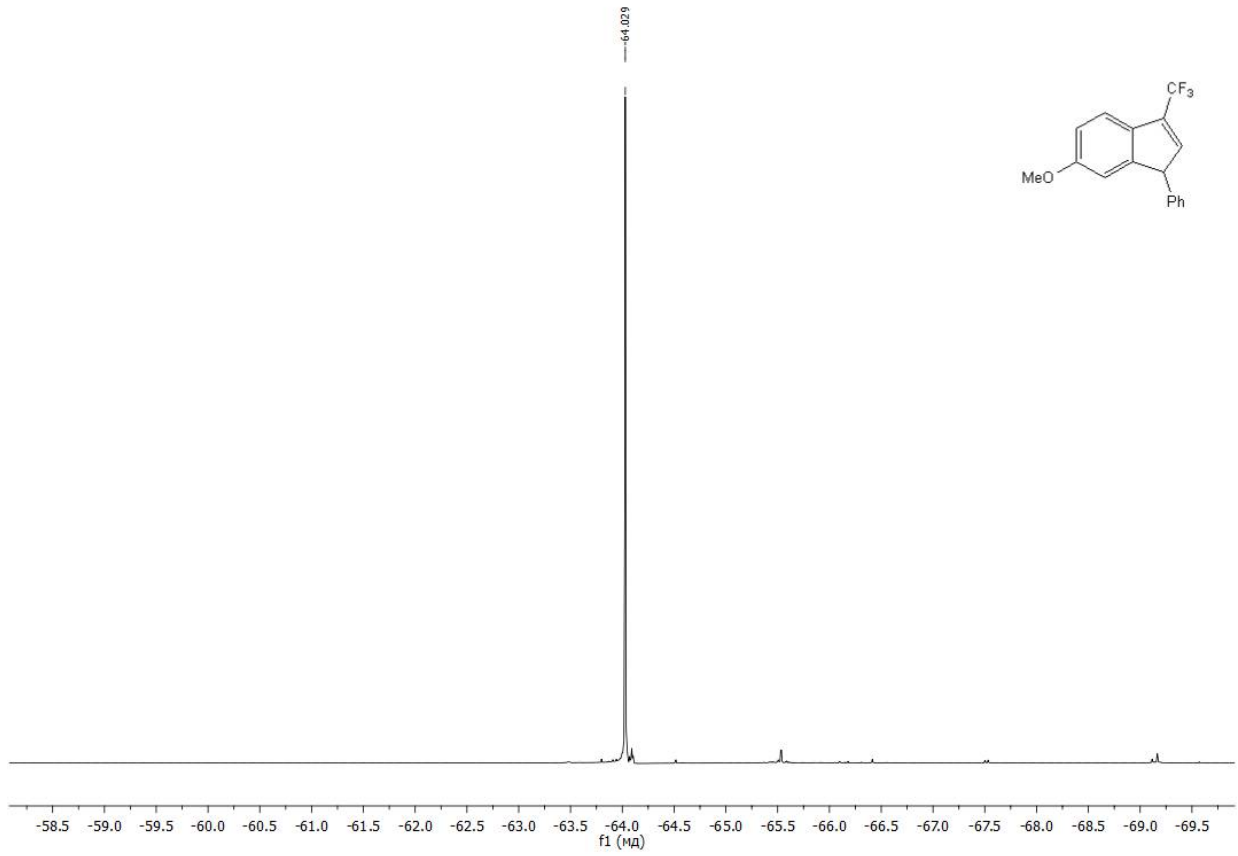


Fig. S102. ^{19}F $\{^1H\}$ NMR spectrum of the compound **3e** ($CDCl_3$, 376 MHz).

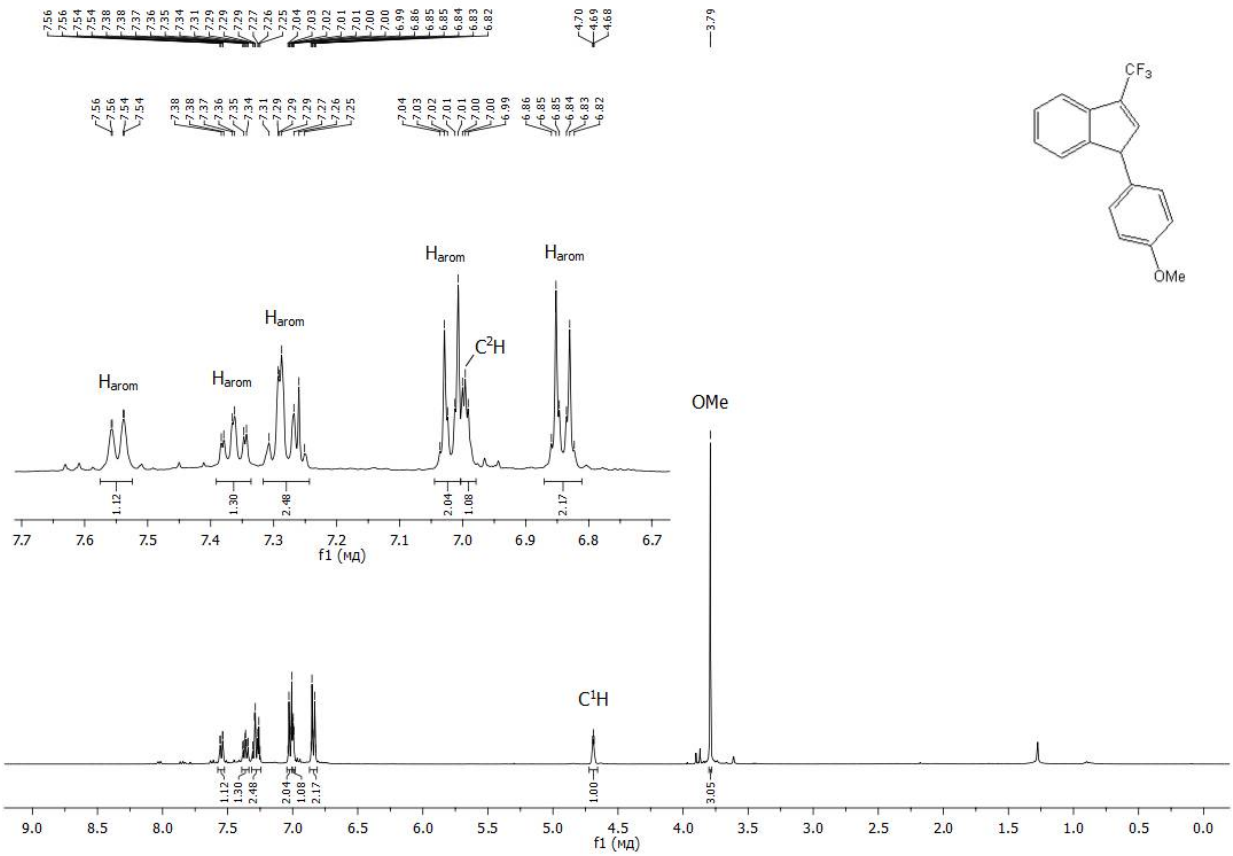


Fig. S103. ^{1}H NMR spectrum of the compound **3f** ($CDCl_3$, 400 MHz).

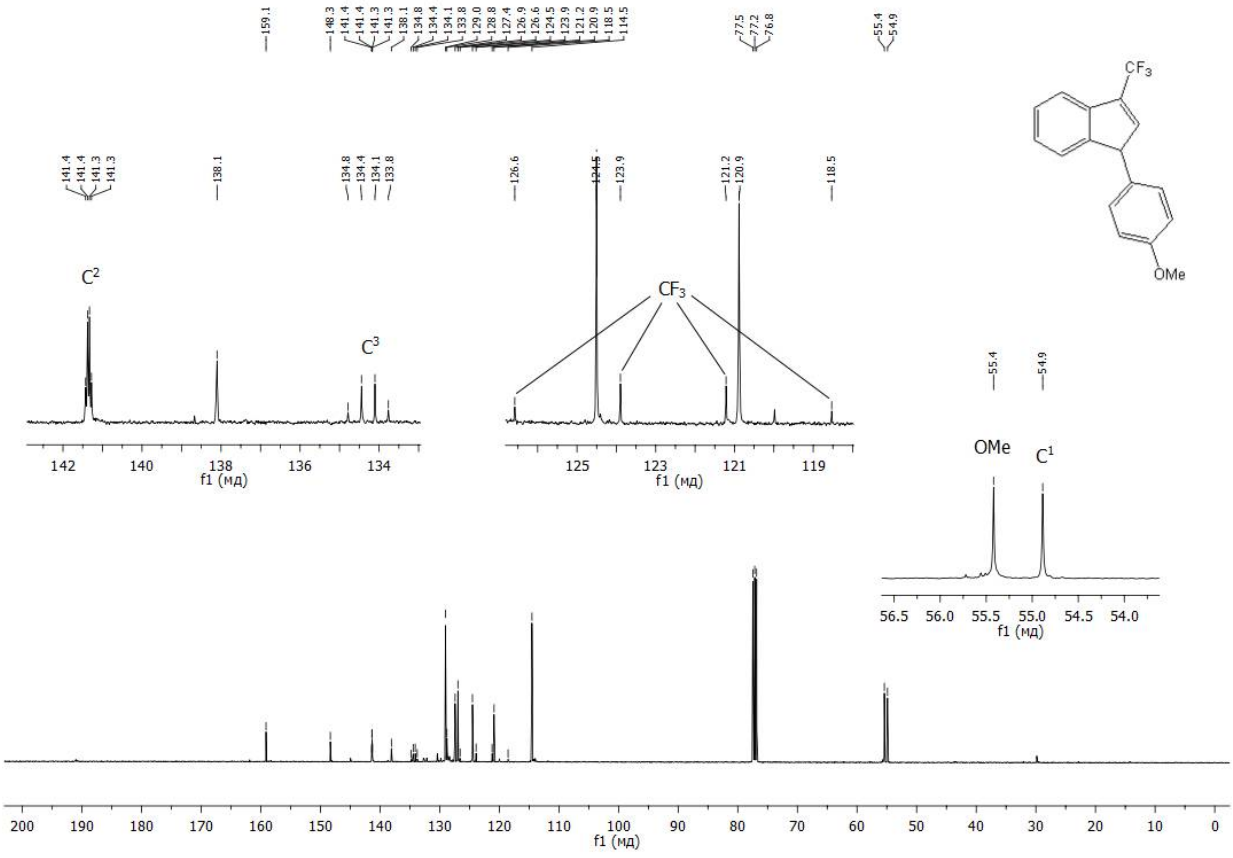


Fig. S104. ^{13}C NMR spectrum of the compound **3f** ($CDCl_3$, 100 MHz).

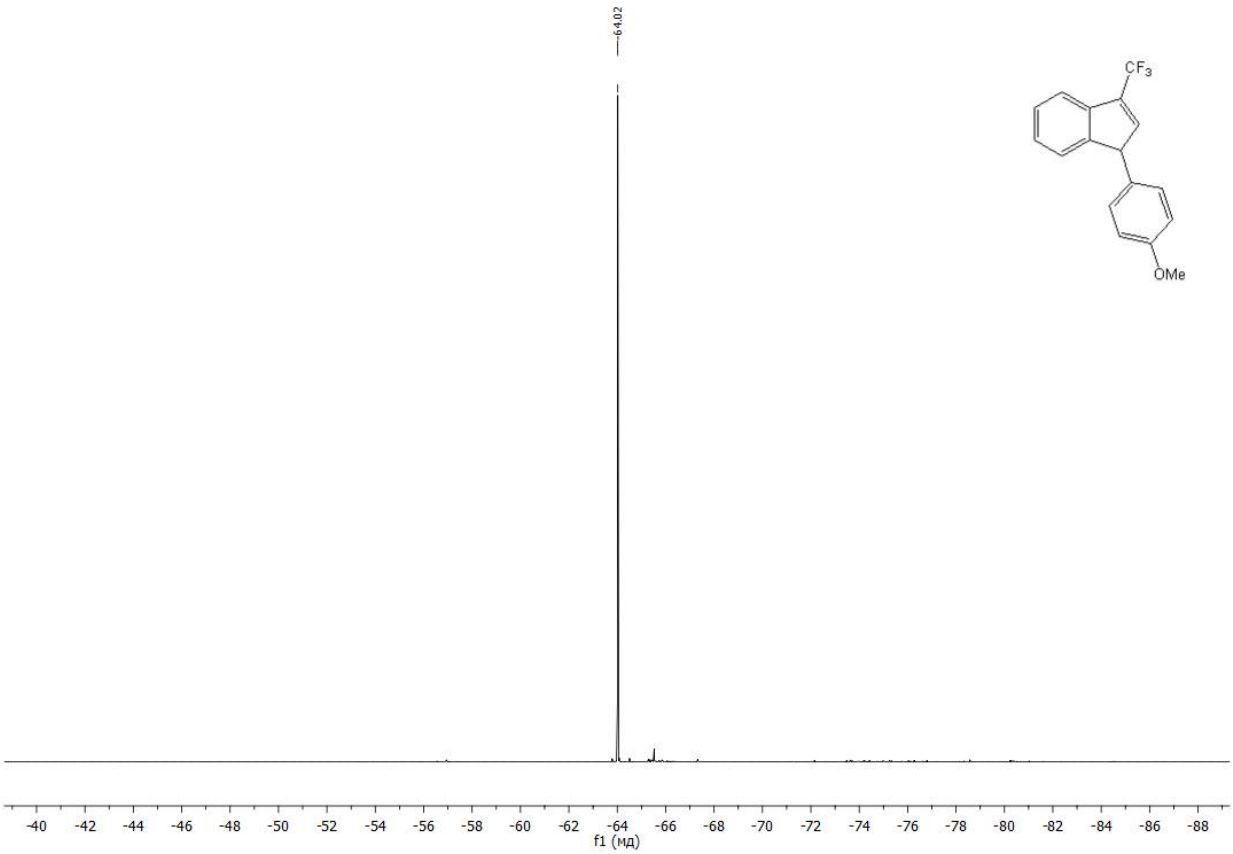


Fig. S105. ^{19}F {^{1}H} NMR spectrum of the compound **3f** ($CDCl_3$, 376 MHz).

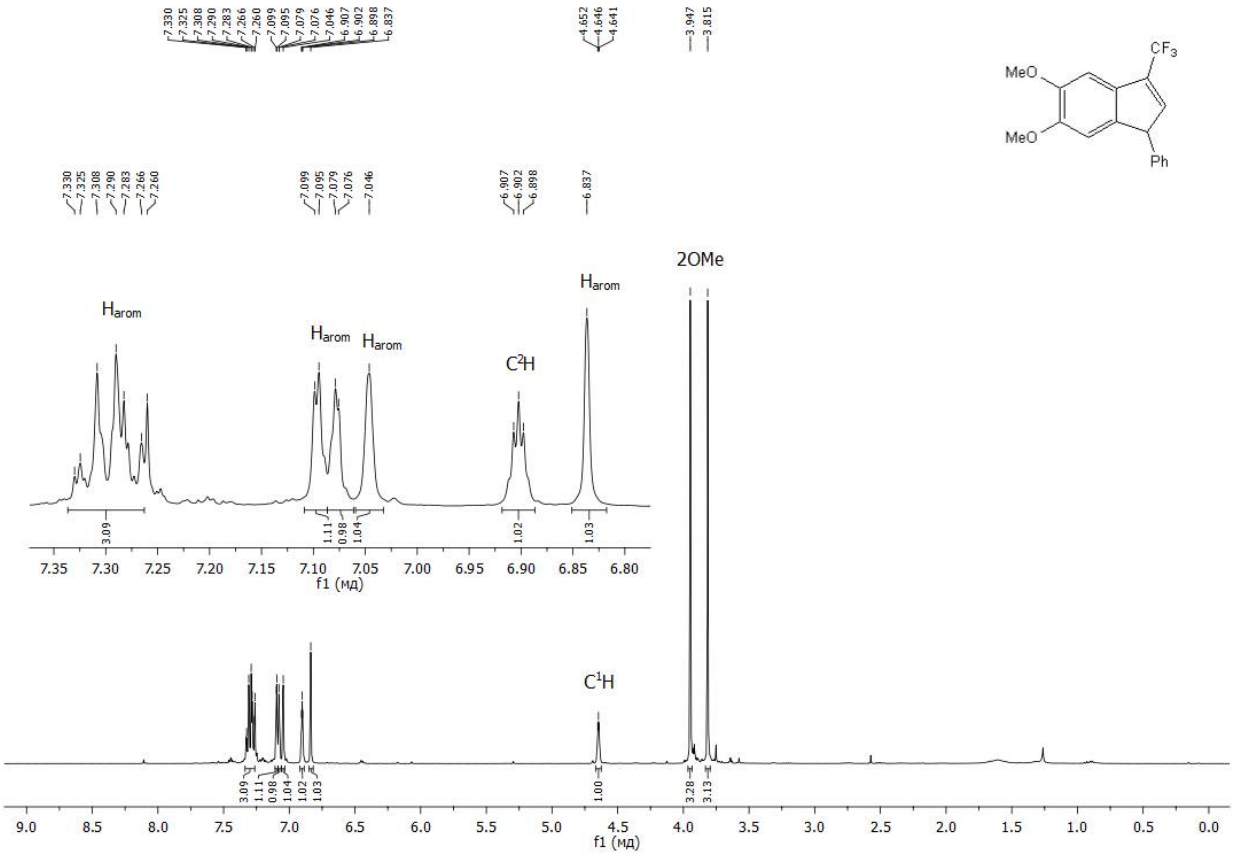


Fig. S106. ^{1}H NMR spectrum of the compound **3g** ($CDCl_3$, 400 MHz).

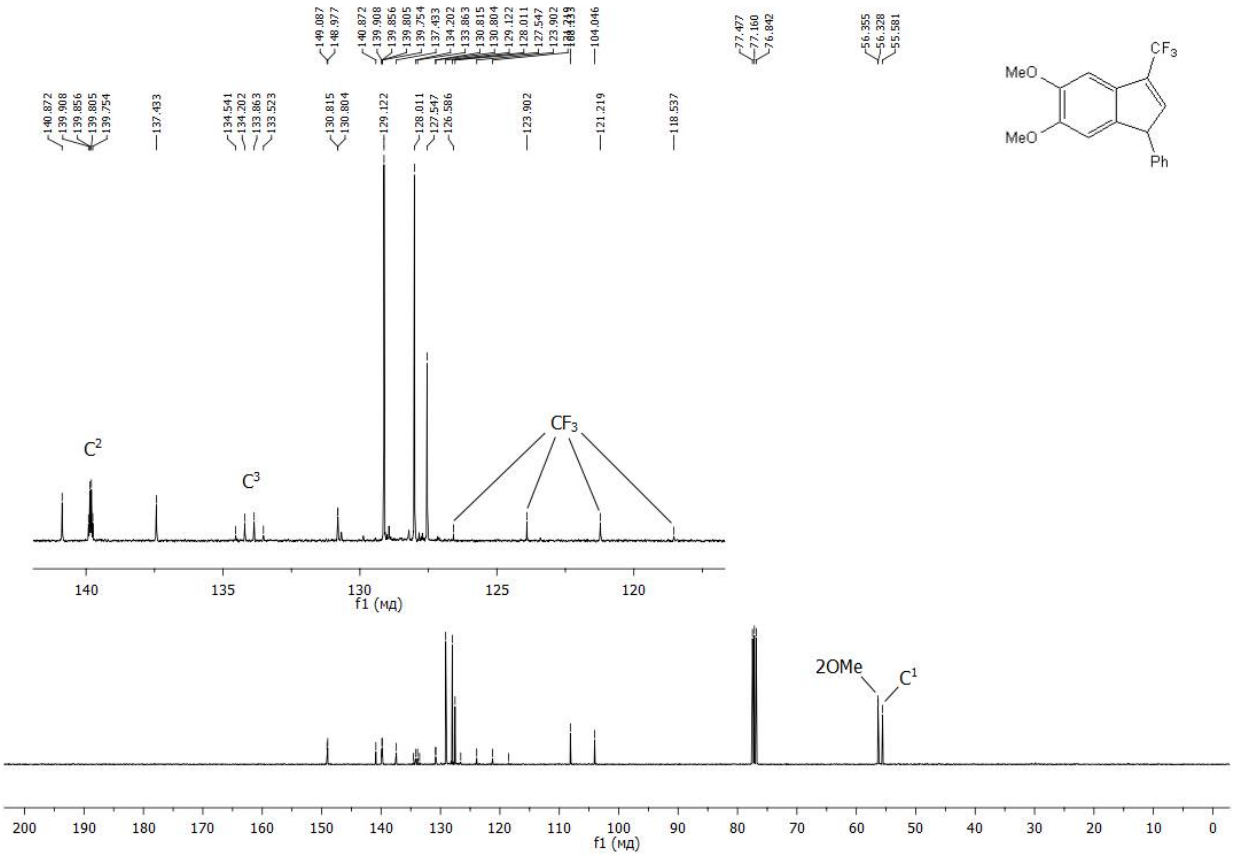


Fig. S107. ^{13}C NMR spectrum of the compound **3g** ($CDCl_3$, 100 MHz).

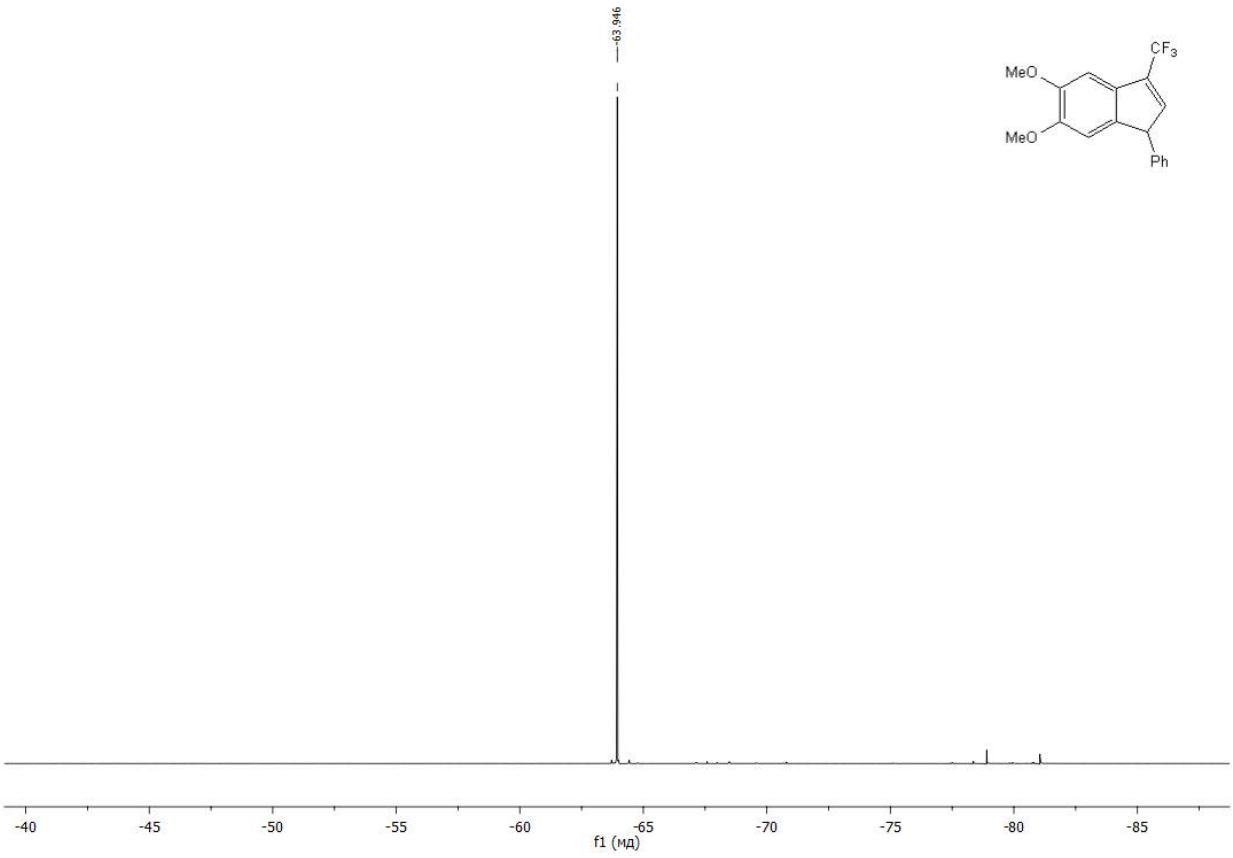


Fig. S108. ^{19}F {^{1}H} NMR spectrum of the compound **3g** ($CDCl_3$, 376 MHz).

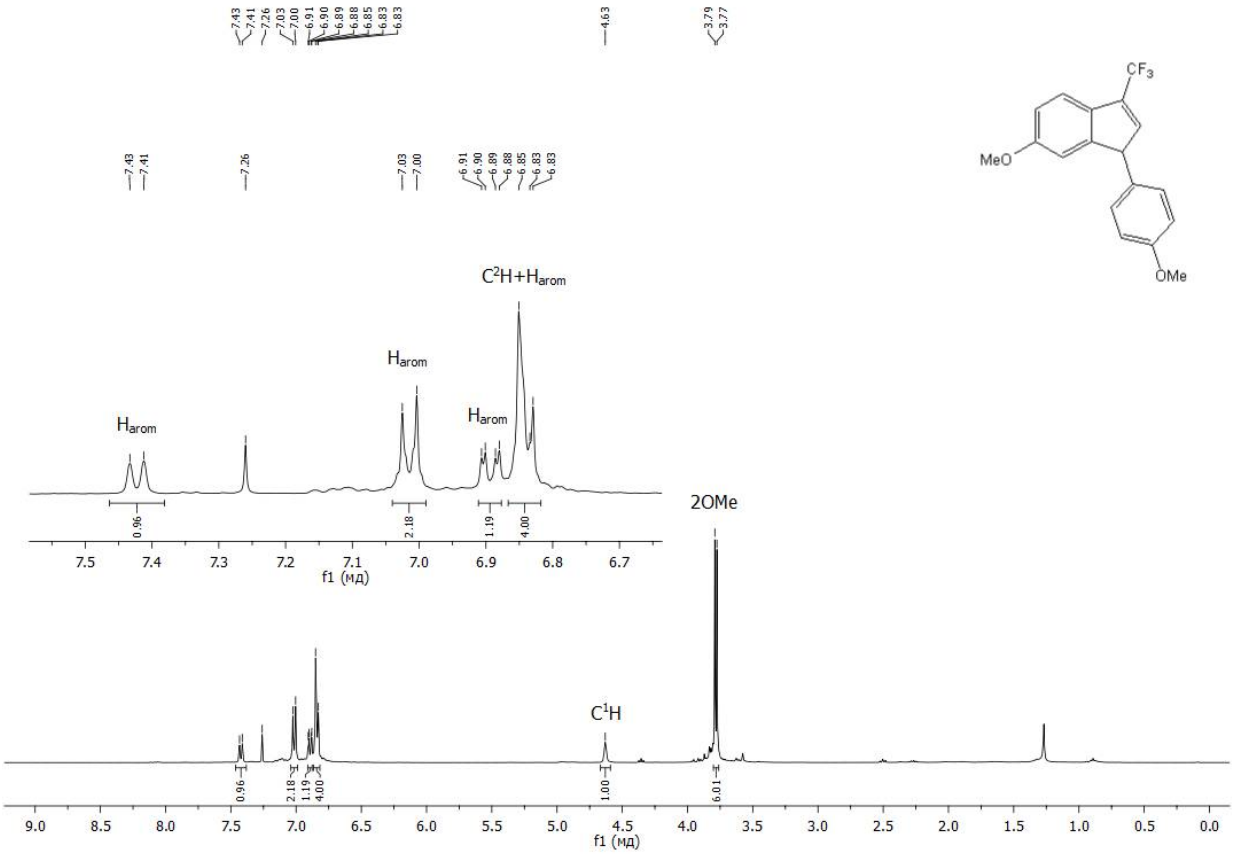


Fig. S109. ^{1}H NMR spectrum of the compound **3h** ($CDCl_3$, 400 MHz).

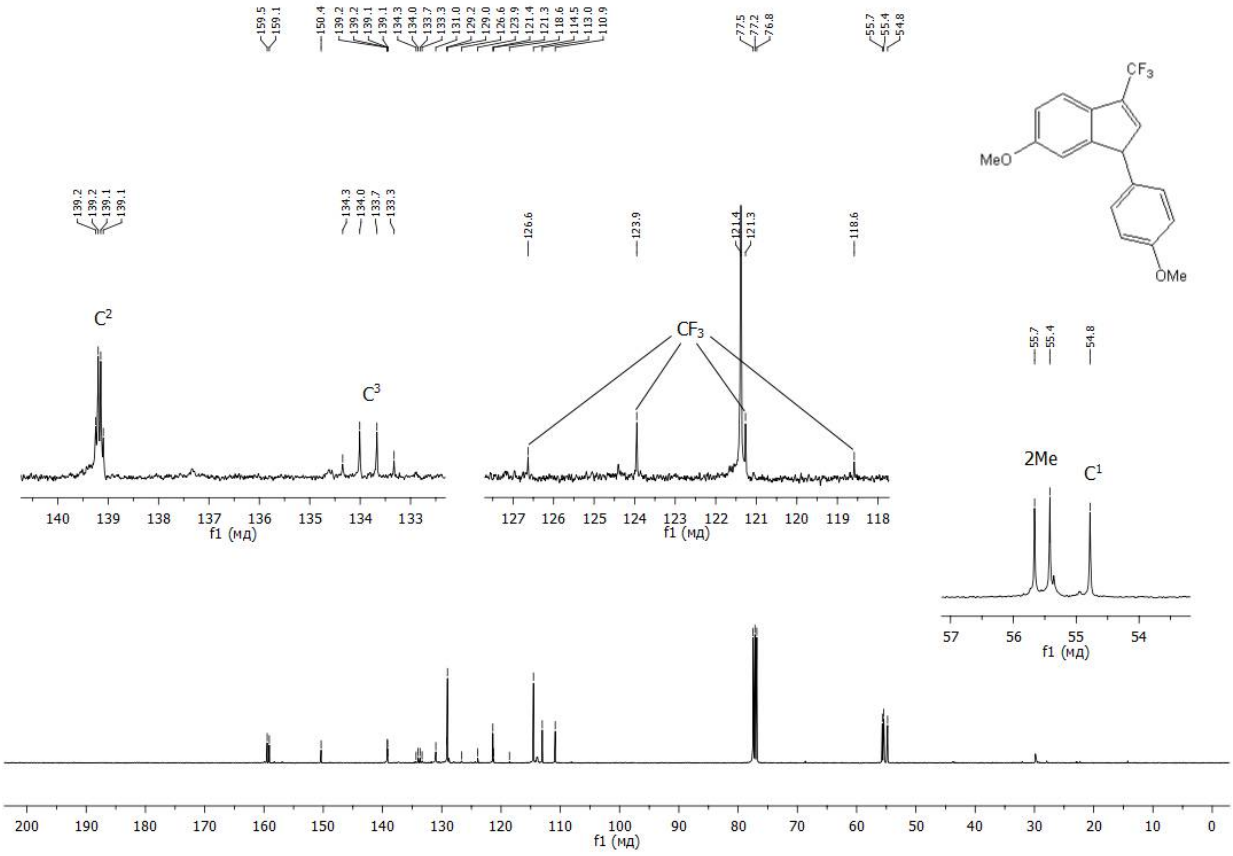


Fig. S110. ^{13}C NMR spectrum of the compound **3h** ($CDCl_3$, 100 MHz).

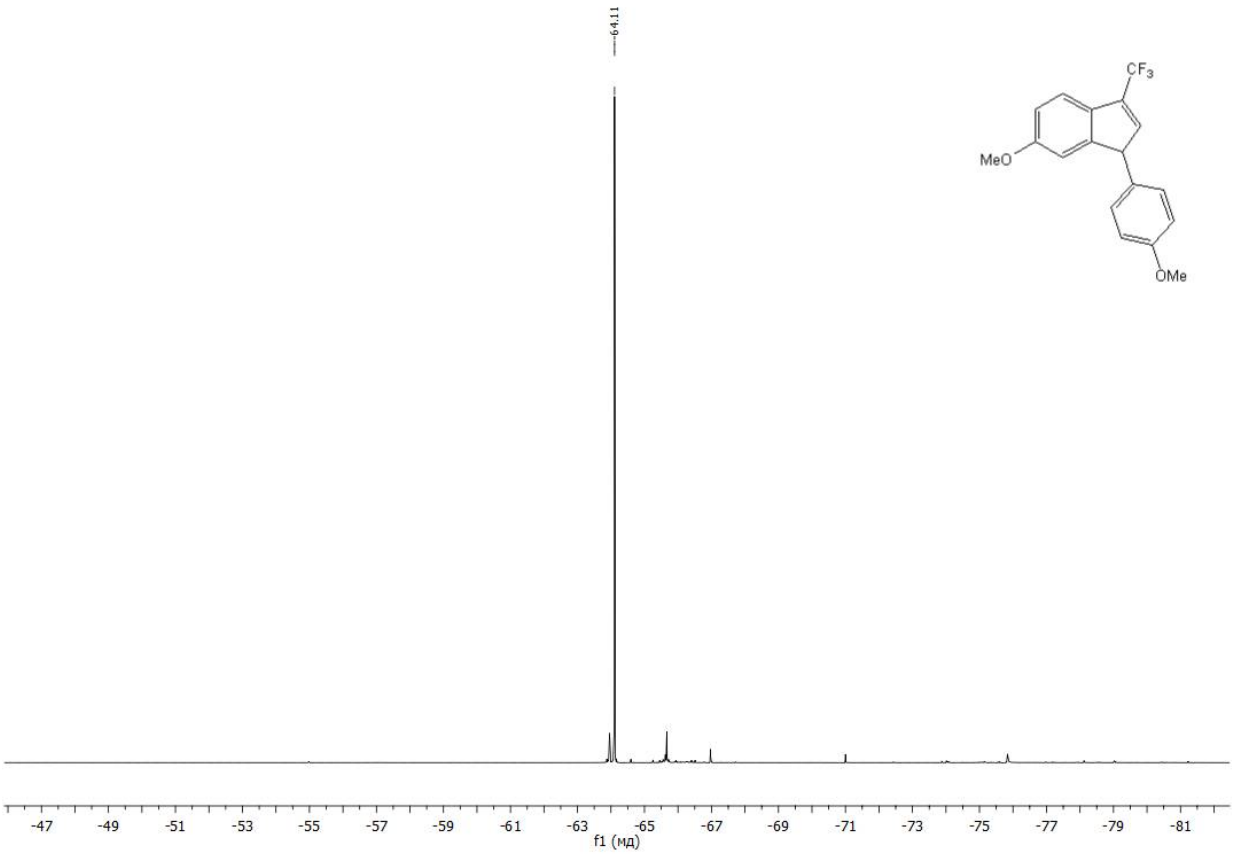


Fig. S111. ^{19}F {^{1}H} NMR spectrum of the compound **3h** ($CDCl_3$, 376 MHz).

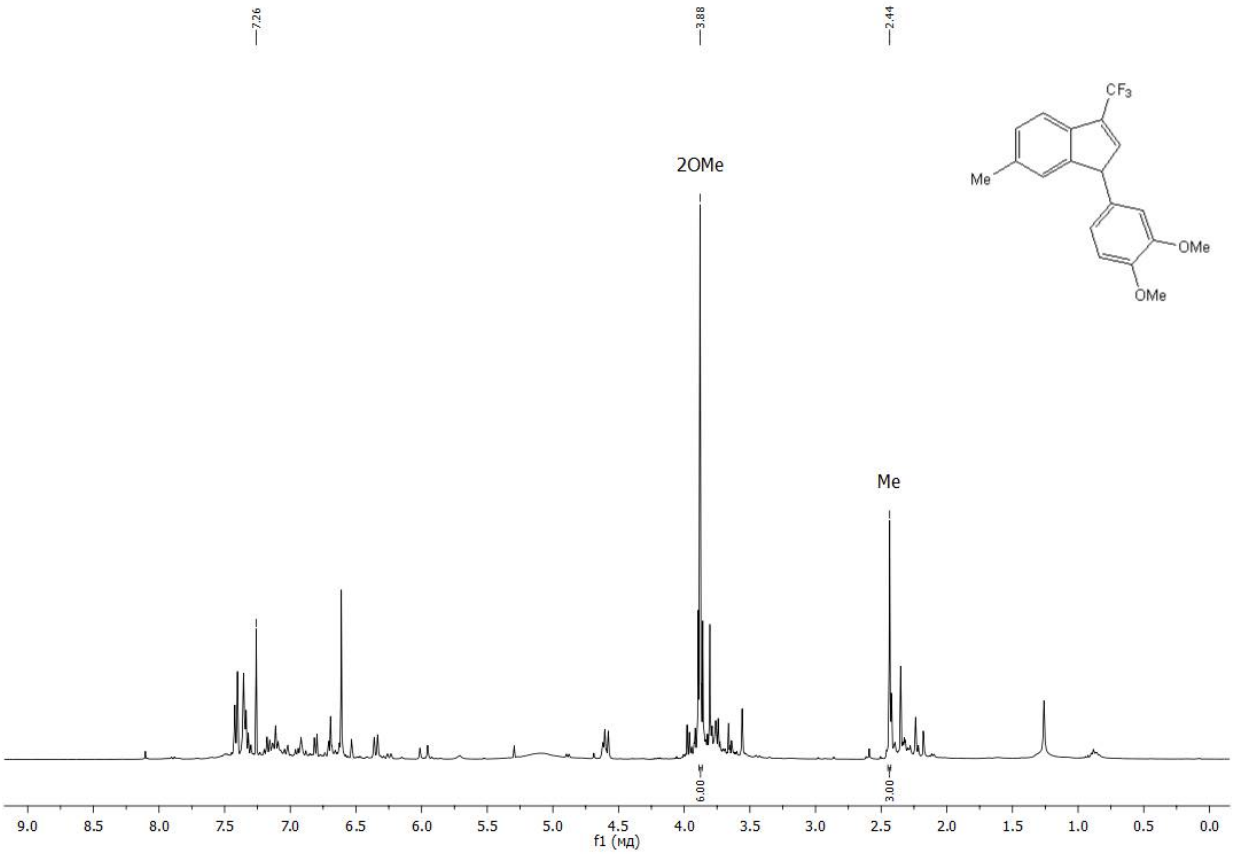


Fig. S112. ^{1}H NMR spectrum of the compound **3i** ($CDCl_3$, 400 MHz).

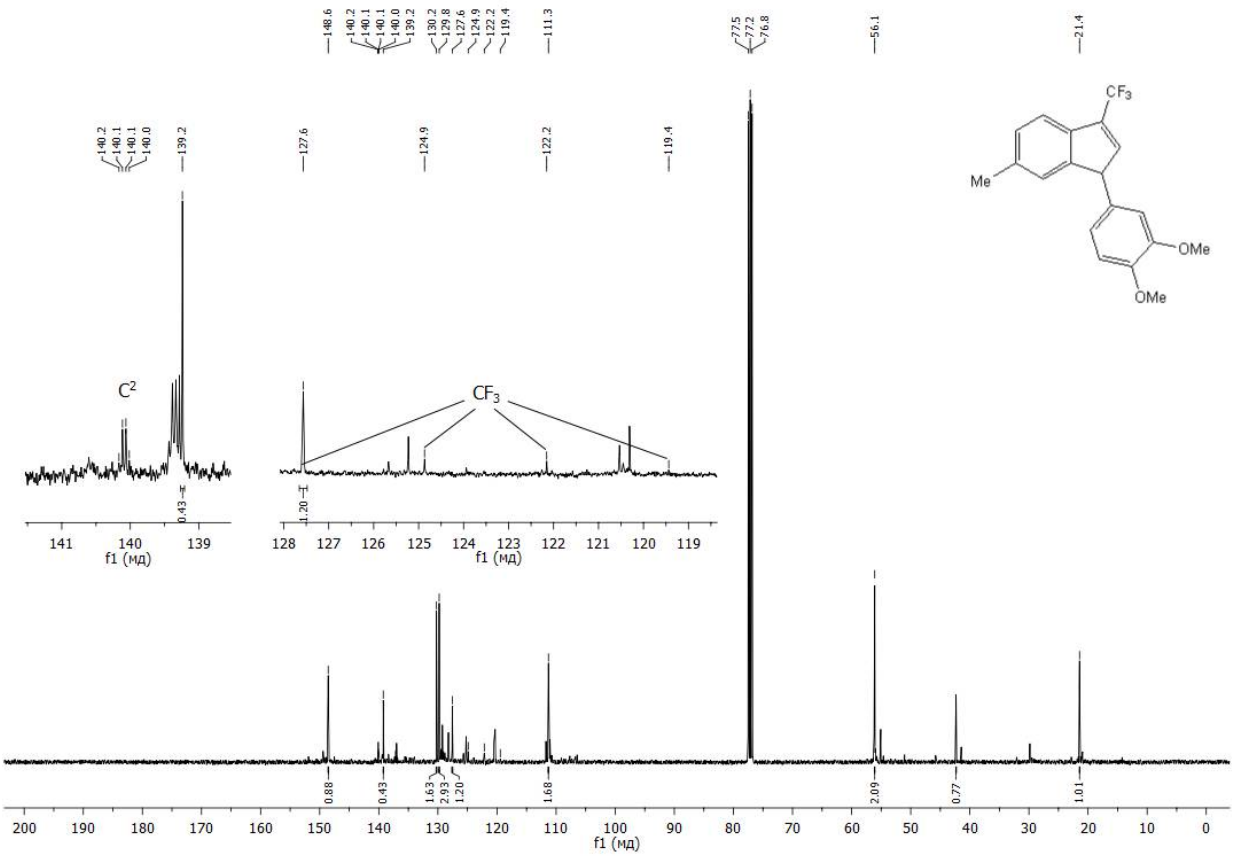


Fig. S113. ^{13}C NMR spectrum of the compound **3i** ($CDCl_3$, 100 MHz).

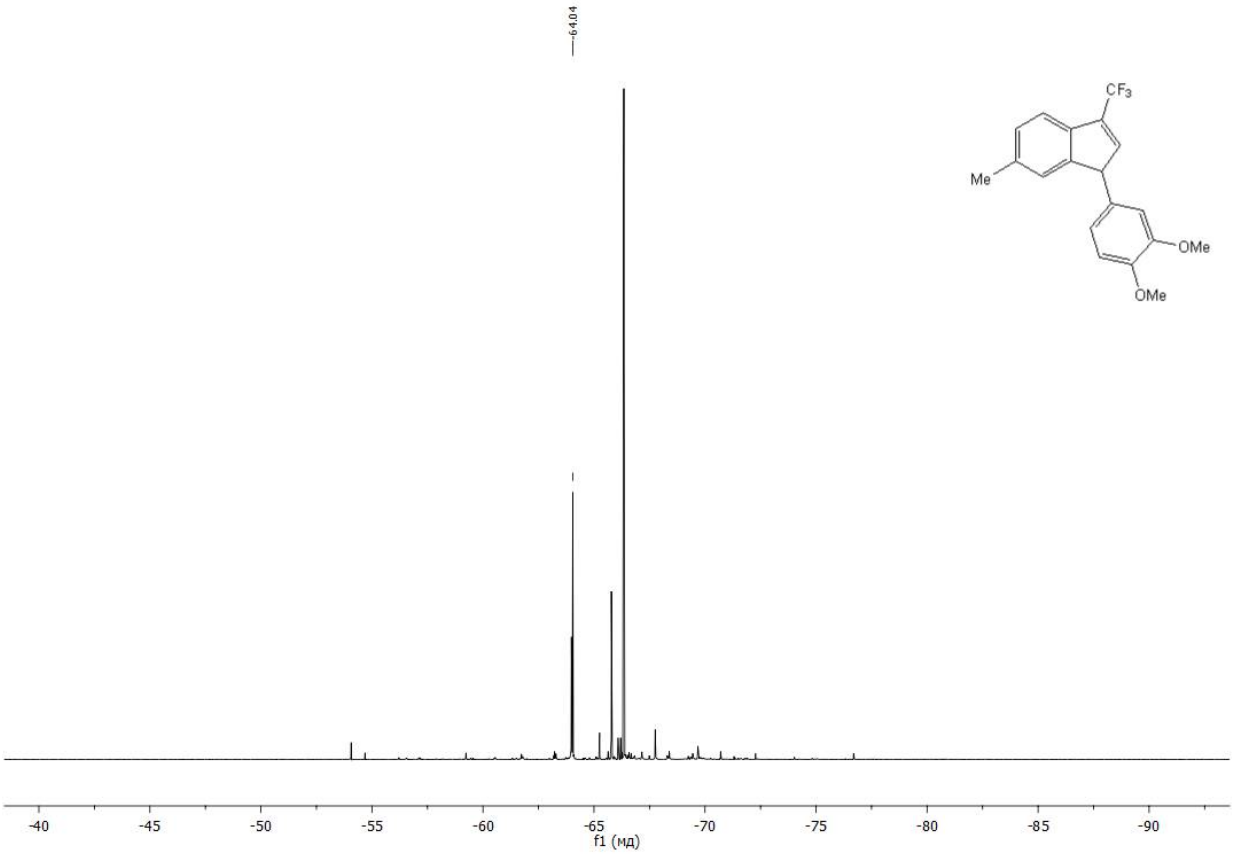


Fig. S114. $^{19}F\{^1H\}$ NMR spectrum of the compound **3i** ($CDCl_3$, 376 MHz).

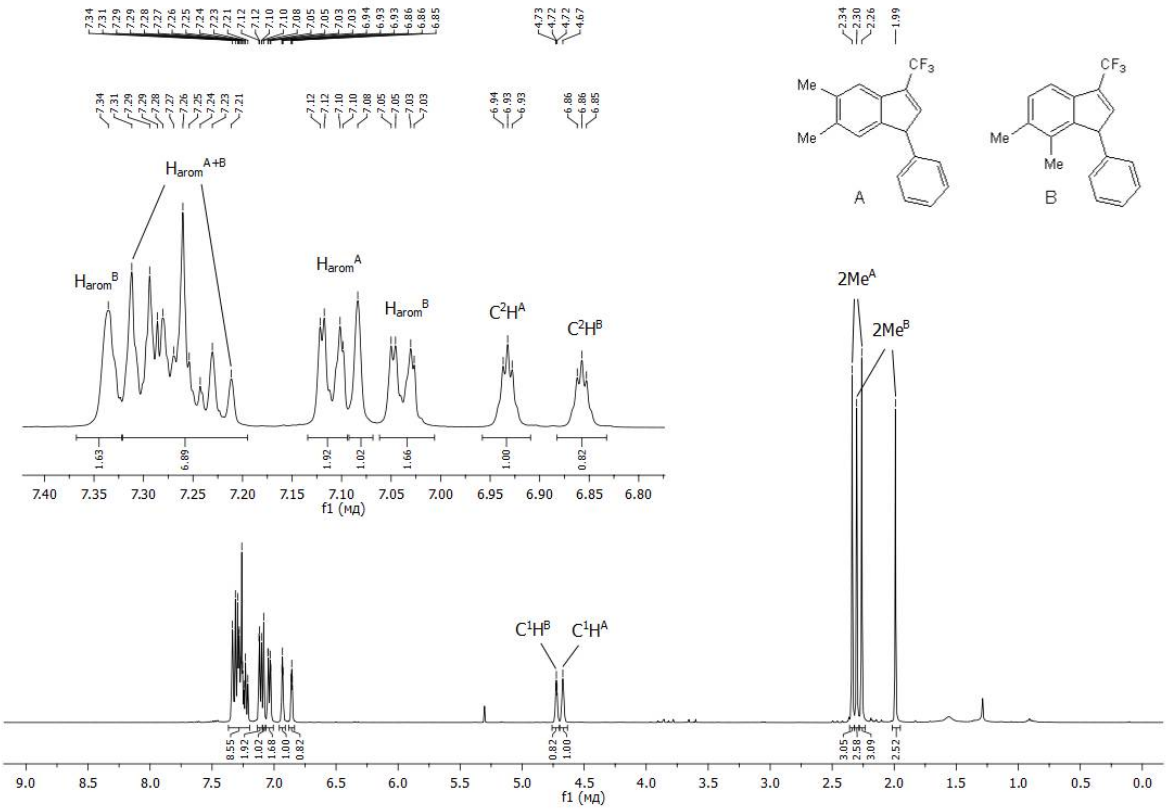


Fig. S115. ^{1}H NMR spectrum of mixture of the compounds **3j1** (A) and **3j2** (B) ($CDCl_3$, 400 MHz).

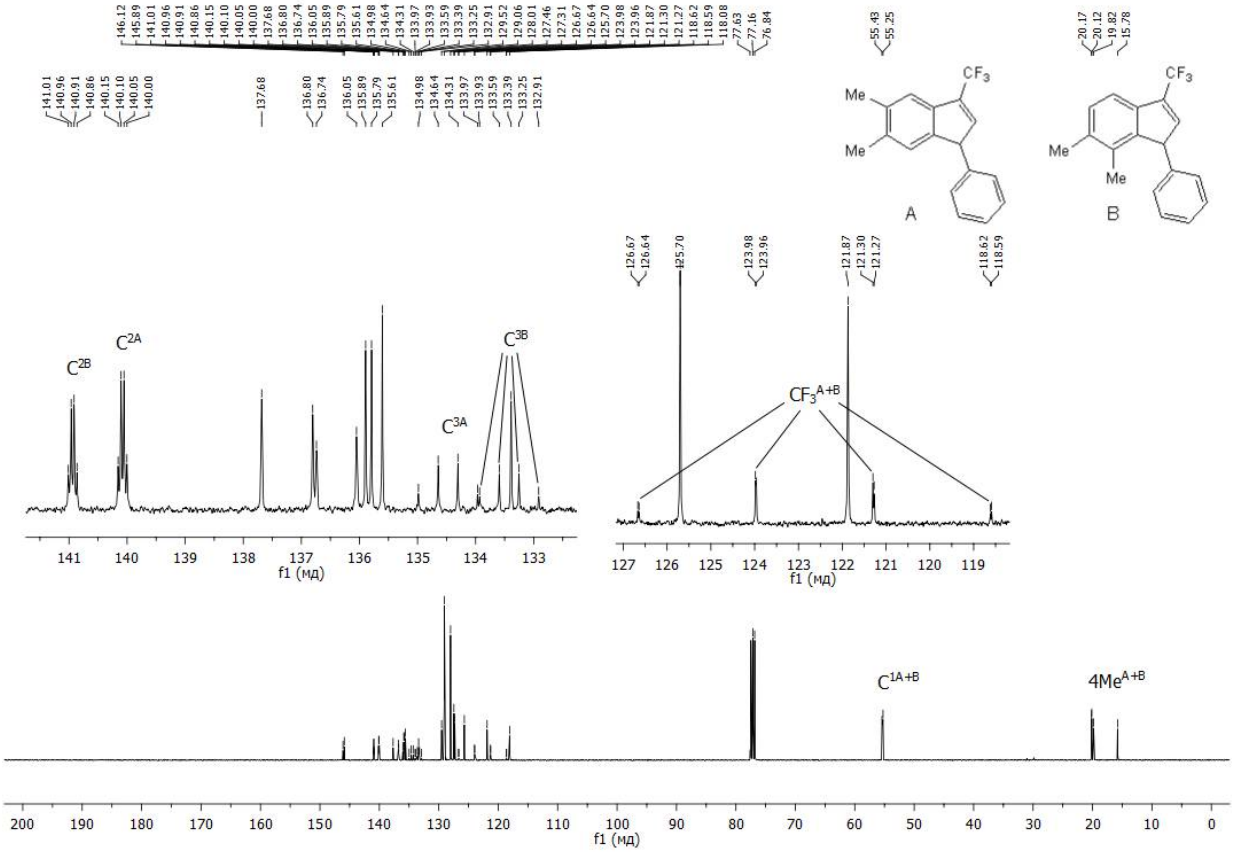


Fig. S116. ^{13}C NMR spectrum of mixture of the compounds **3j1** (A) and **3j2** (B) ($CDCl_3$, 100 MHz).

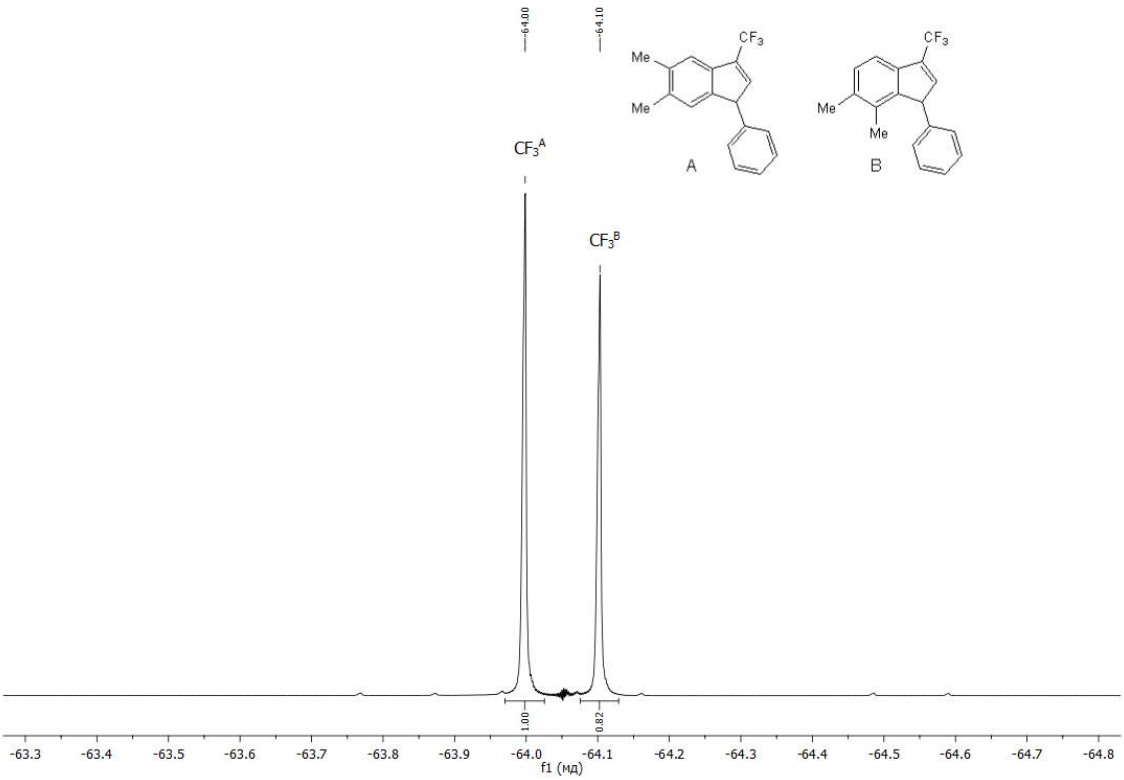


Fig. S117. ^{19}F {^{1}H} NMR spectrum of mixture of the compounds **3j1** (A) and **3j2** (B) ($CDCl_3$, 376 MHz).

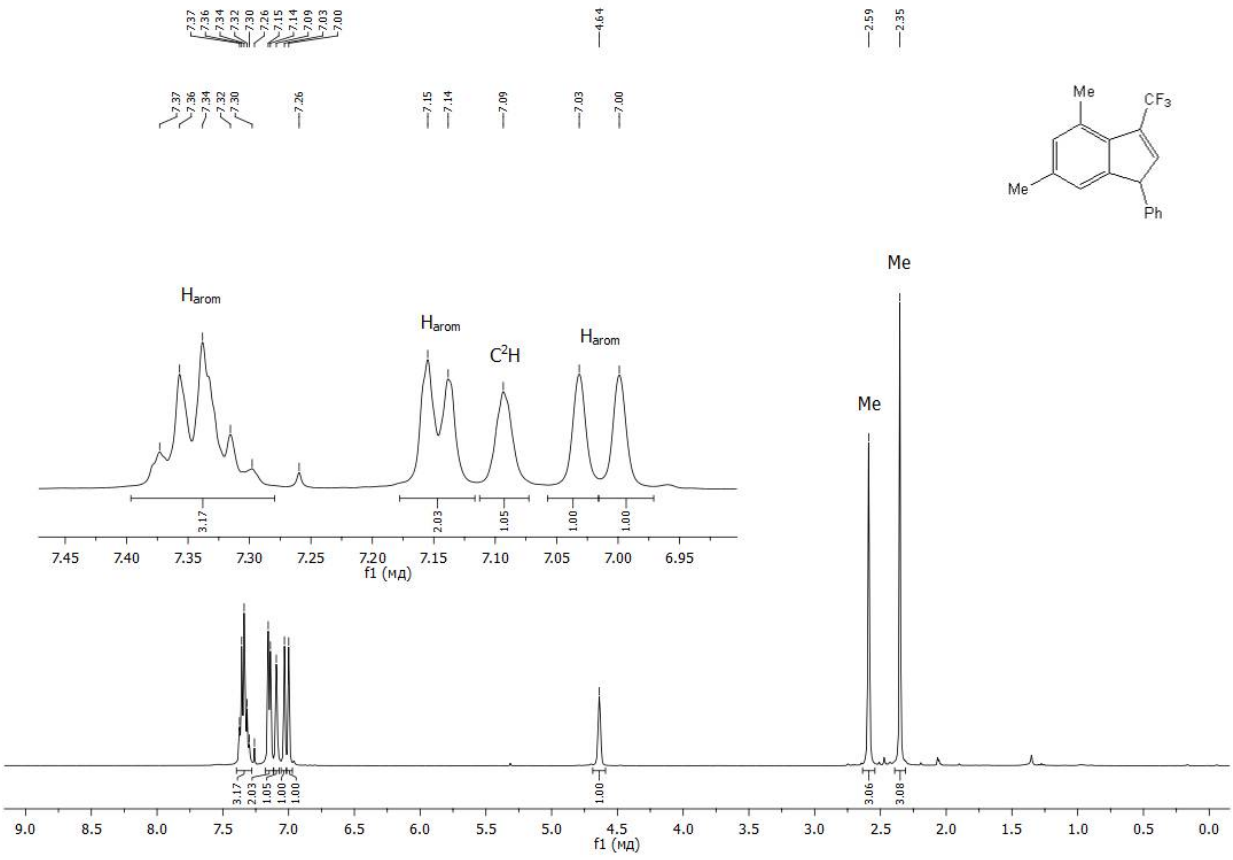


Fig. S118. ^{1}H NMR spectrum of the compound **3k** ($CDCl_3$, 400 MHz).

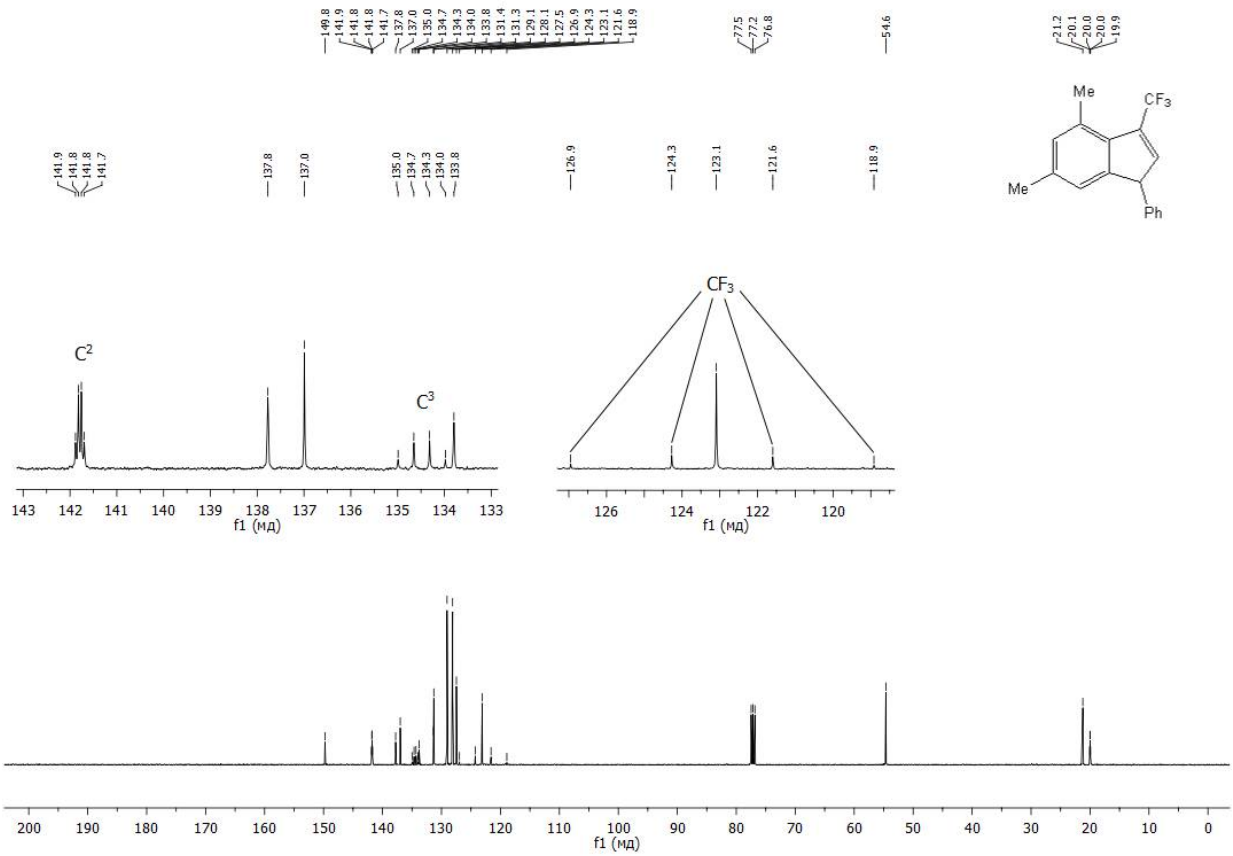


Fig. S119. ^{13}C NMR spectrum of the compound **3k** ($CDCl_3$, 100 MHz).

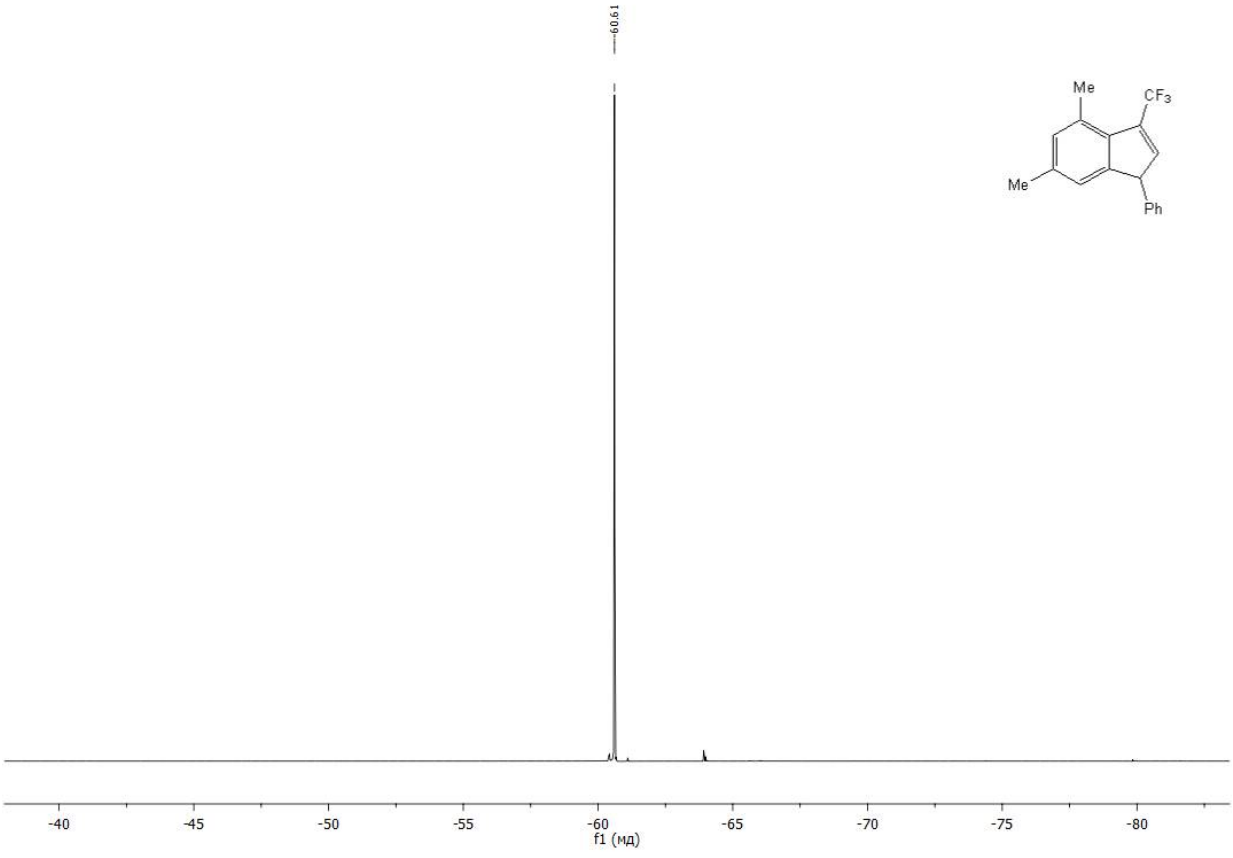


Fig. S120. $^{19}F\{^1H\}$ NMR spectrum of the compound **3k** ($CDCl_3$, 376 MHz).

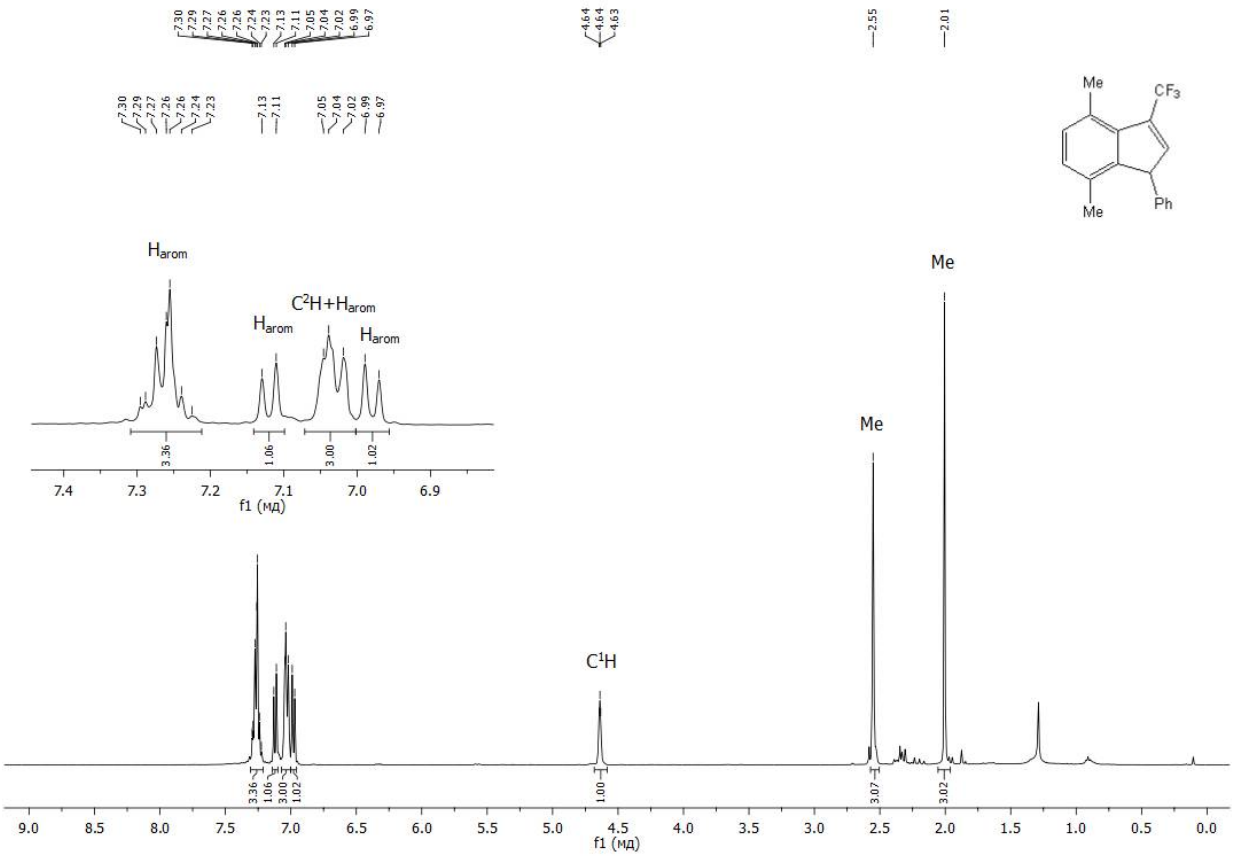


Fig. S121. ^{1}H NMR spectrum of the compound **3l** ($CDCl_3$, 400 MHz).

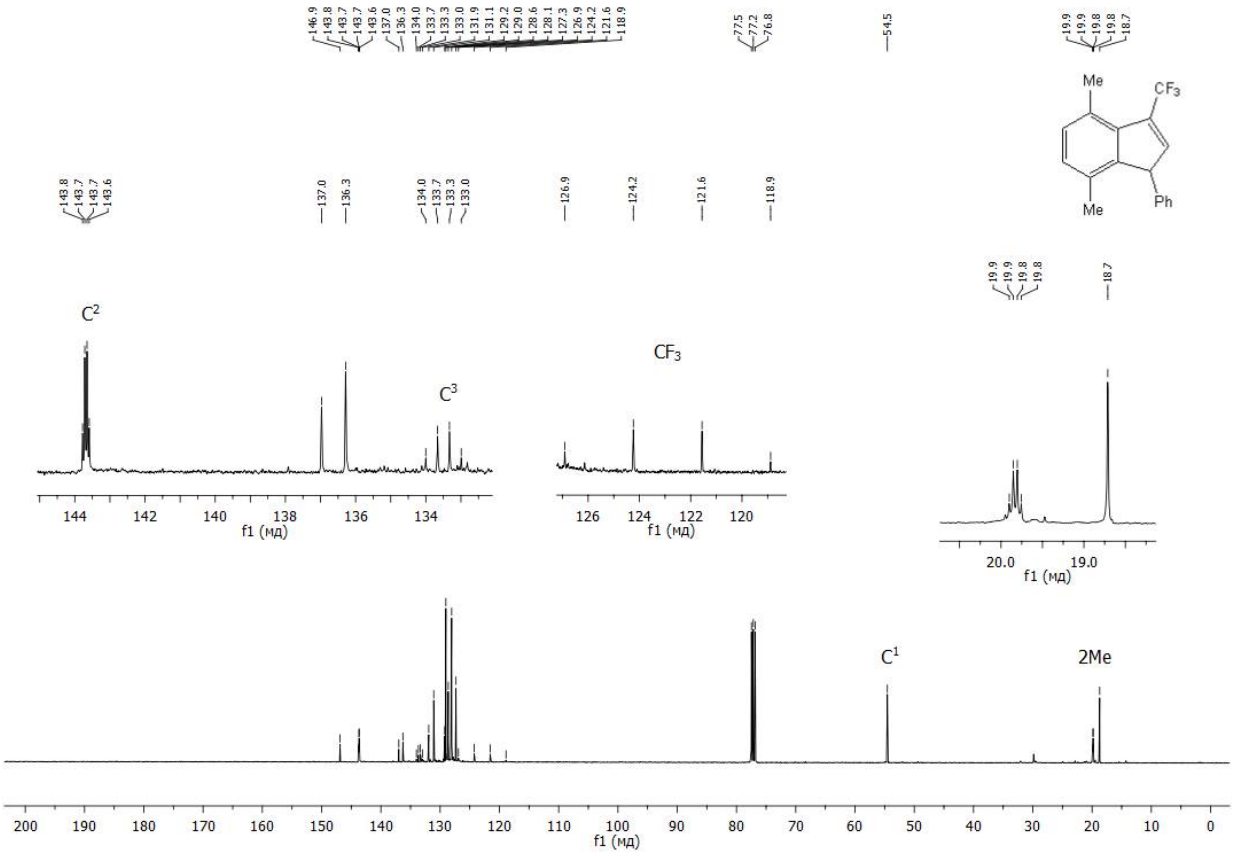


Fig. S122. ^{13}C NMR spectrum of the compound **3l** ($CDCl_3$, 100 MHz).

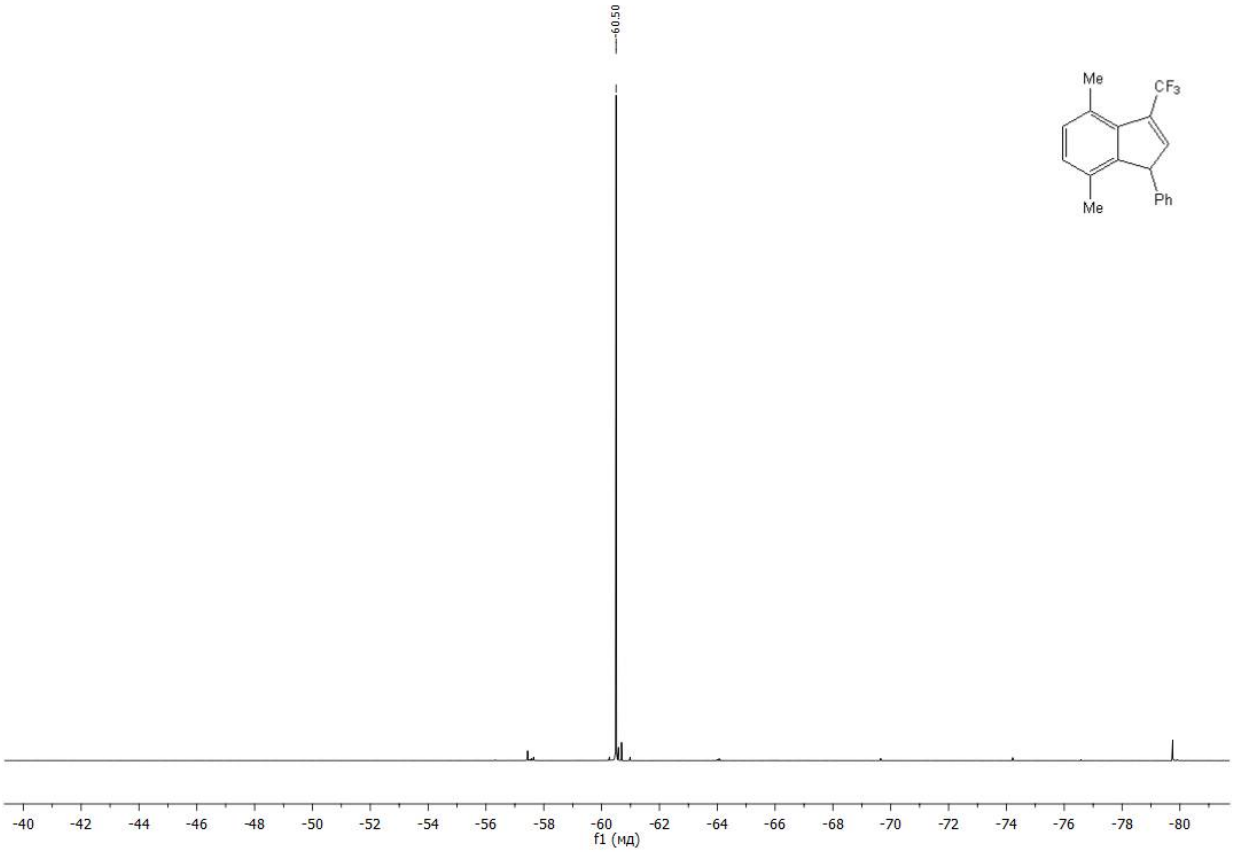


Fig. S123. ^{19}F {^{1}H} NMR spectrum of the compound **3l** ($CDCl_3$, 376 MHz).

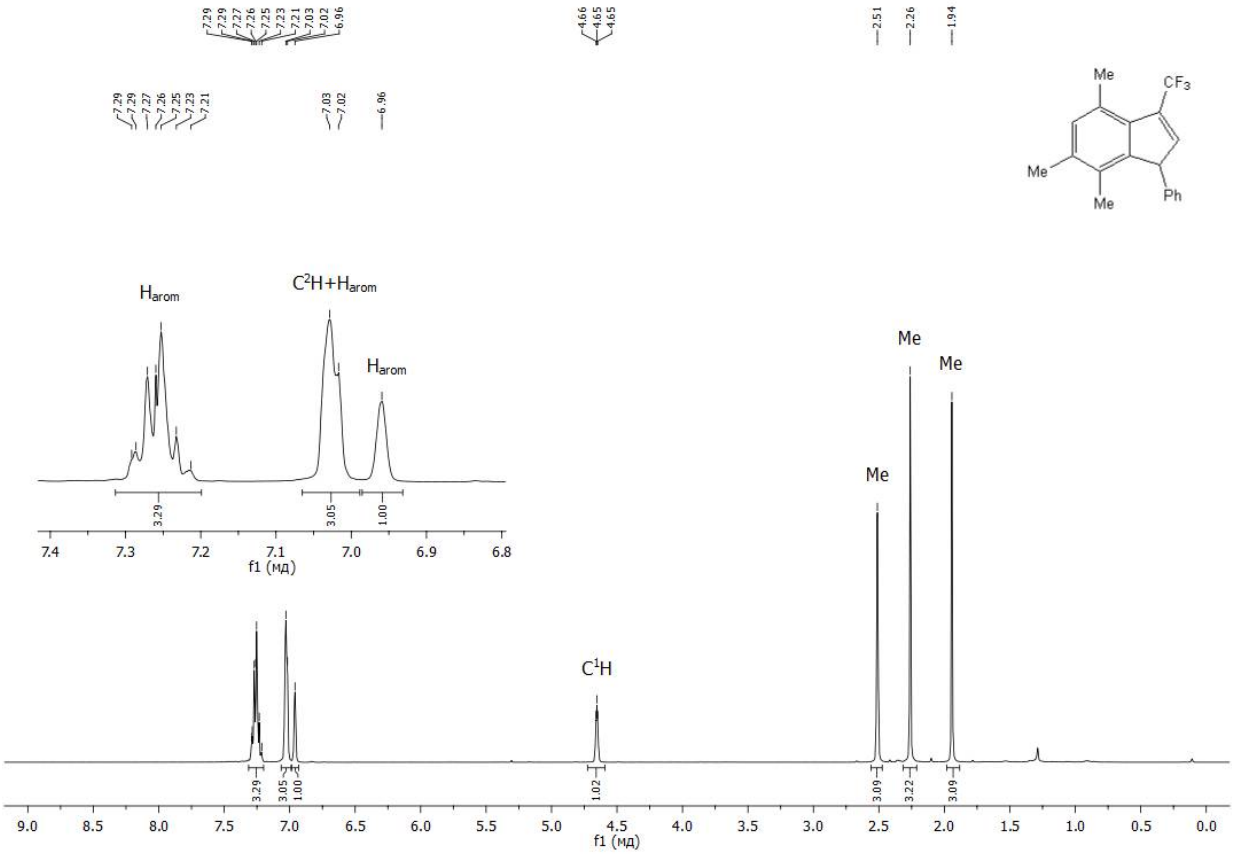


Fig. S124. ^{1}H NMR spectrum of the compound **3m** ($CDCl_3$, 400 MHz).

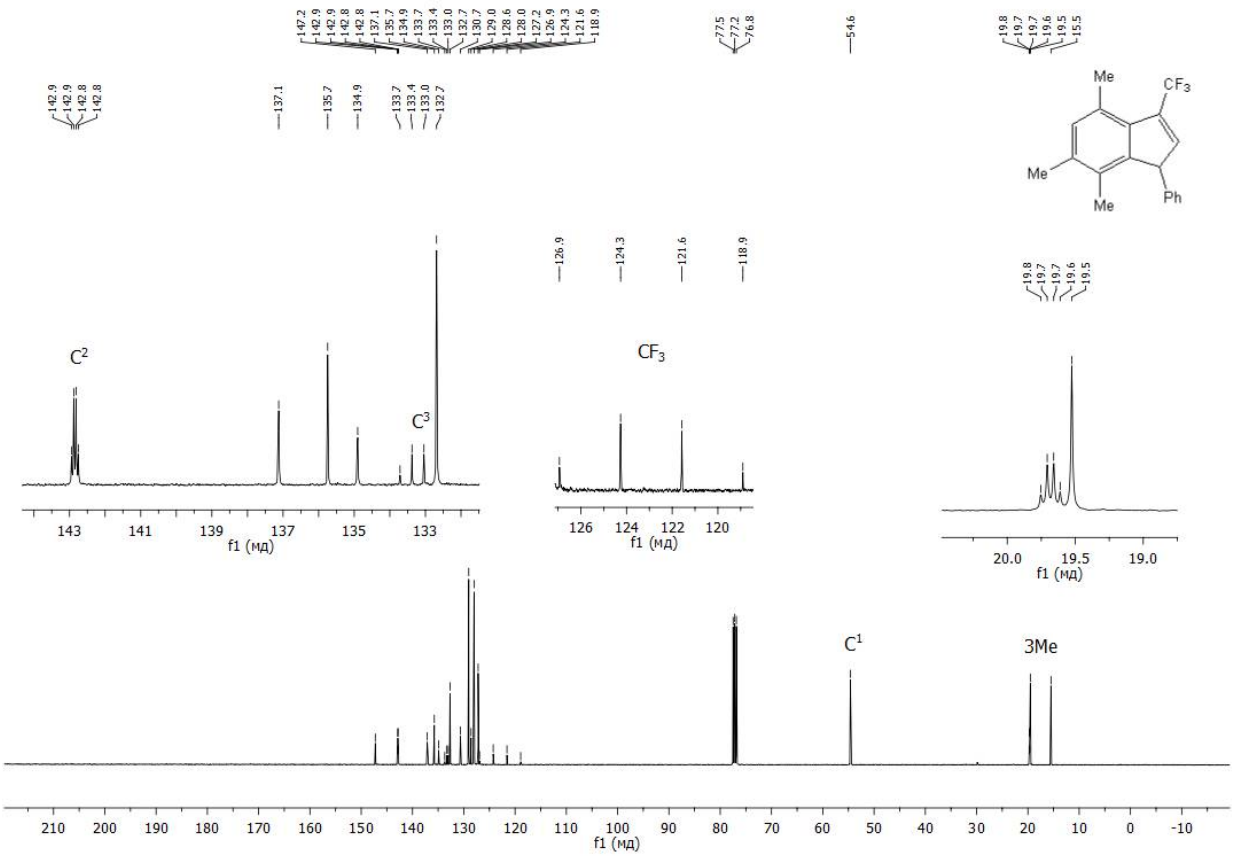


Fig. S125. ^{13}C NMR spectrum of the compound **3m** ($CDCl_3$, 100 MHz).

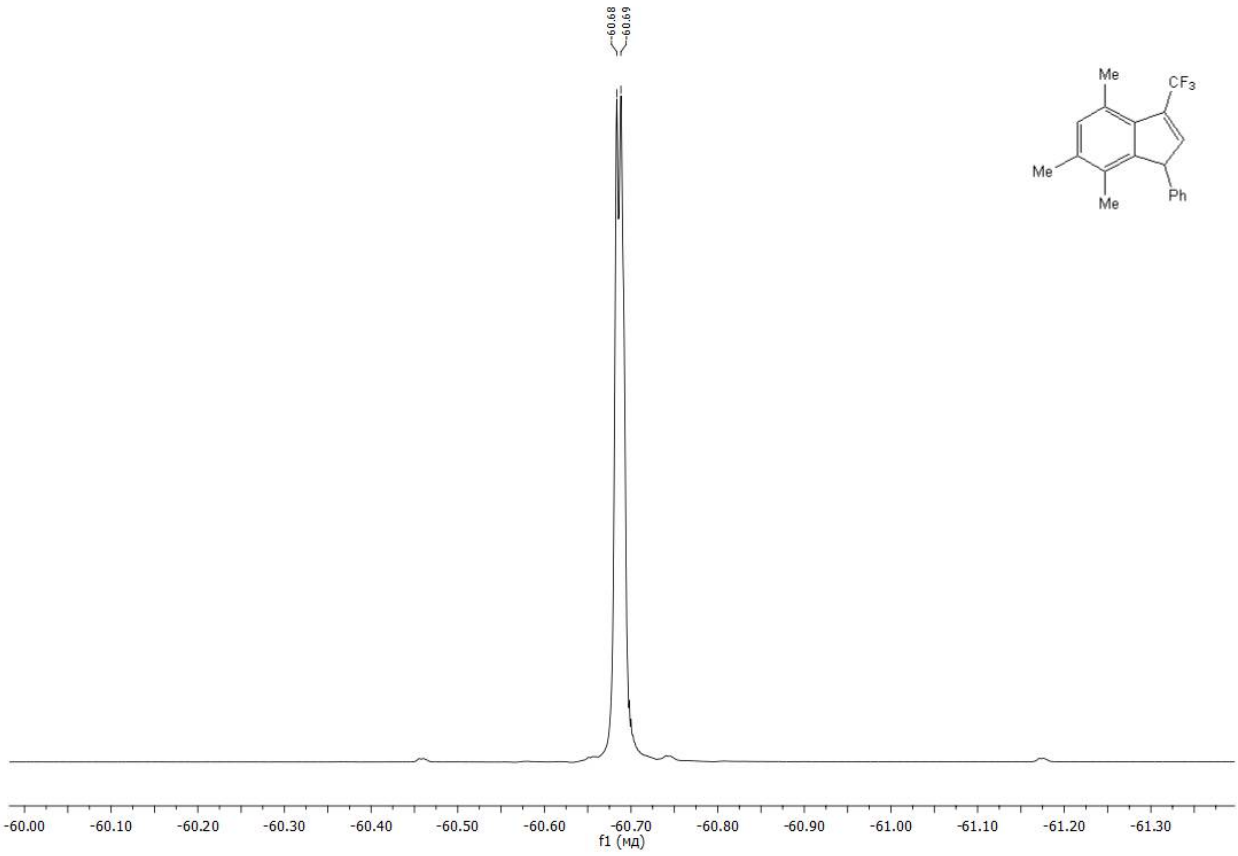


Fig. S126. ^{19}F NMR spectrum of the compound **3m** ($CDCl_3$, 376 MHz).

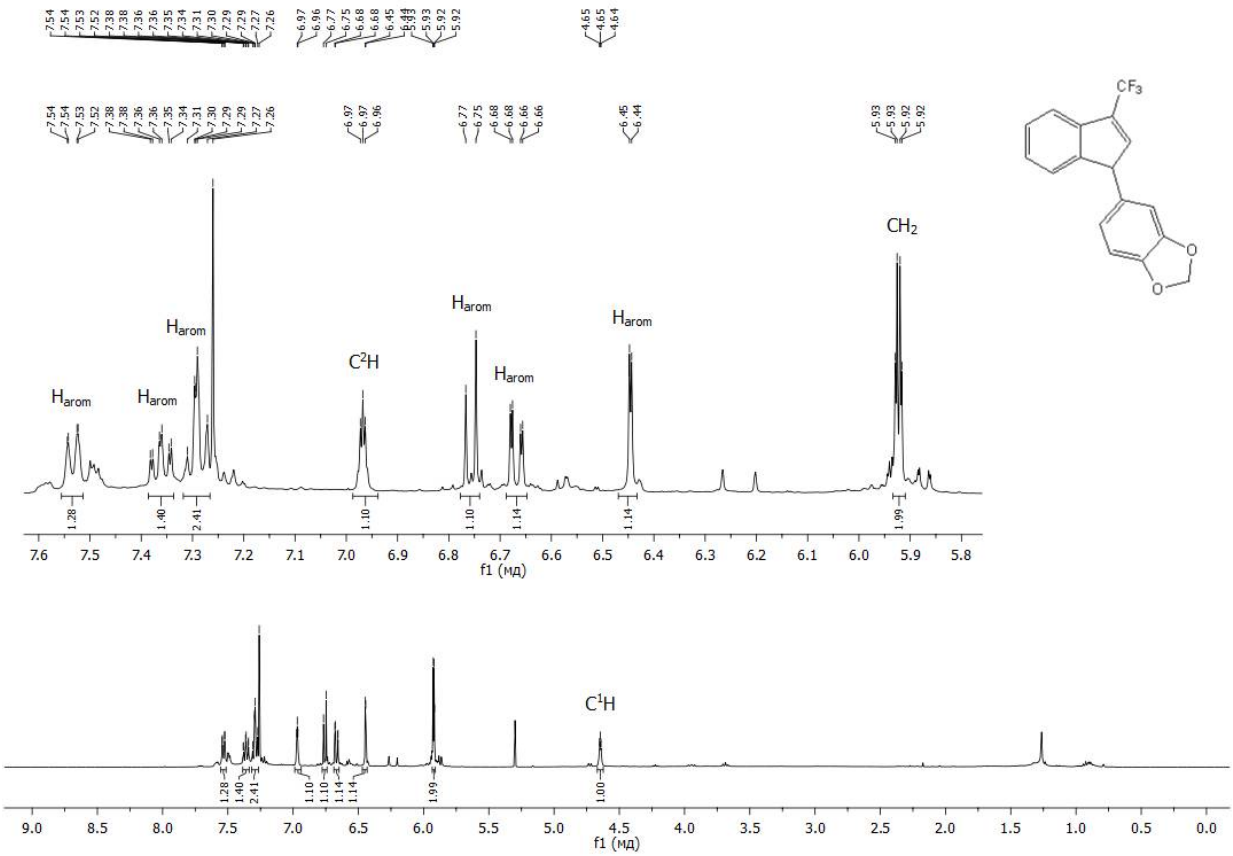


Fig. S127. ^{1}H NMR spectrum of the compound **3n** ($CDCl_3$, 400 MHz).

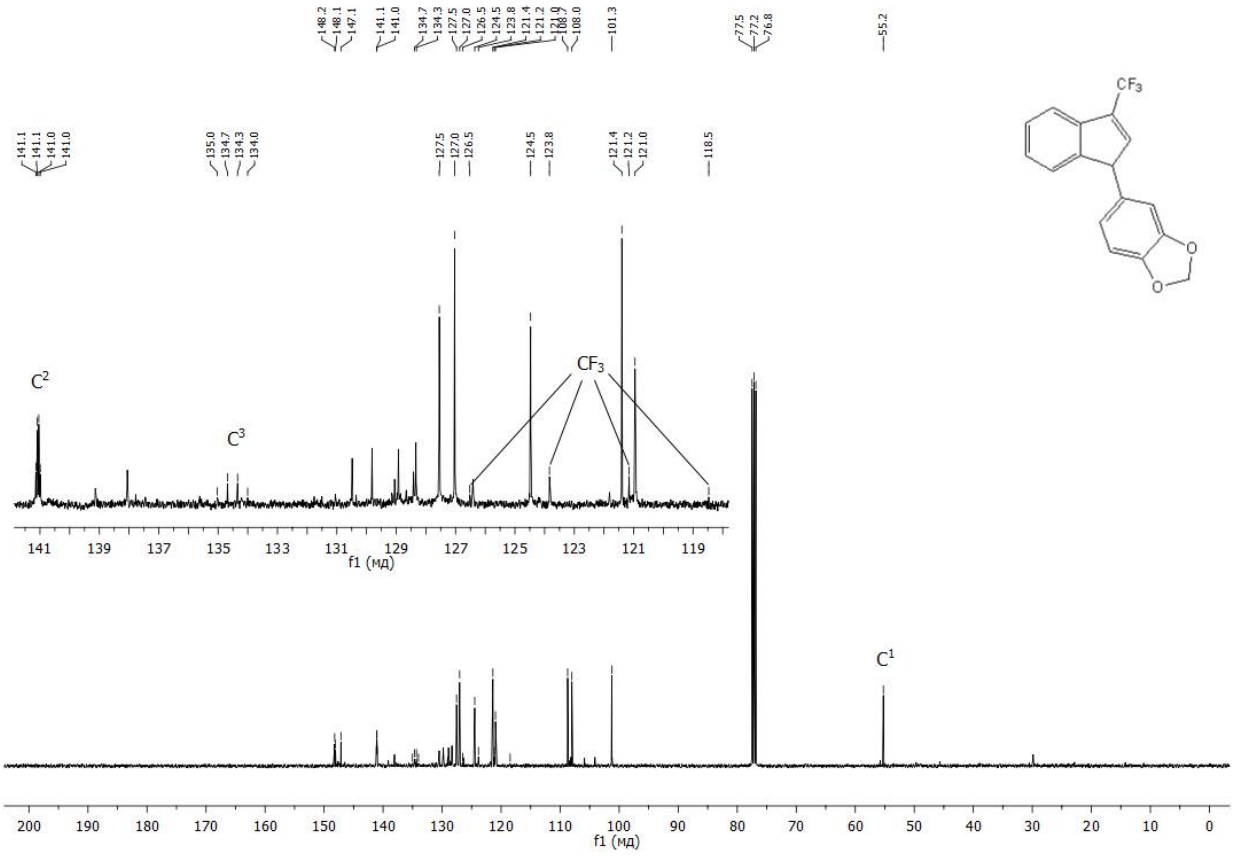


Fig. S128. ^{13}C NMR spectrum of the compound **3n** ($CDCl_3$, 100 MHz).

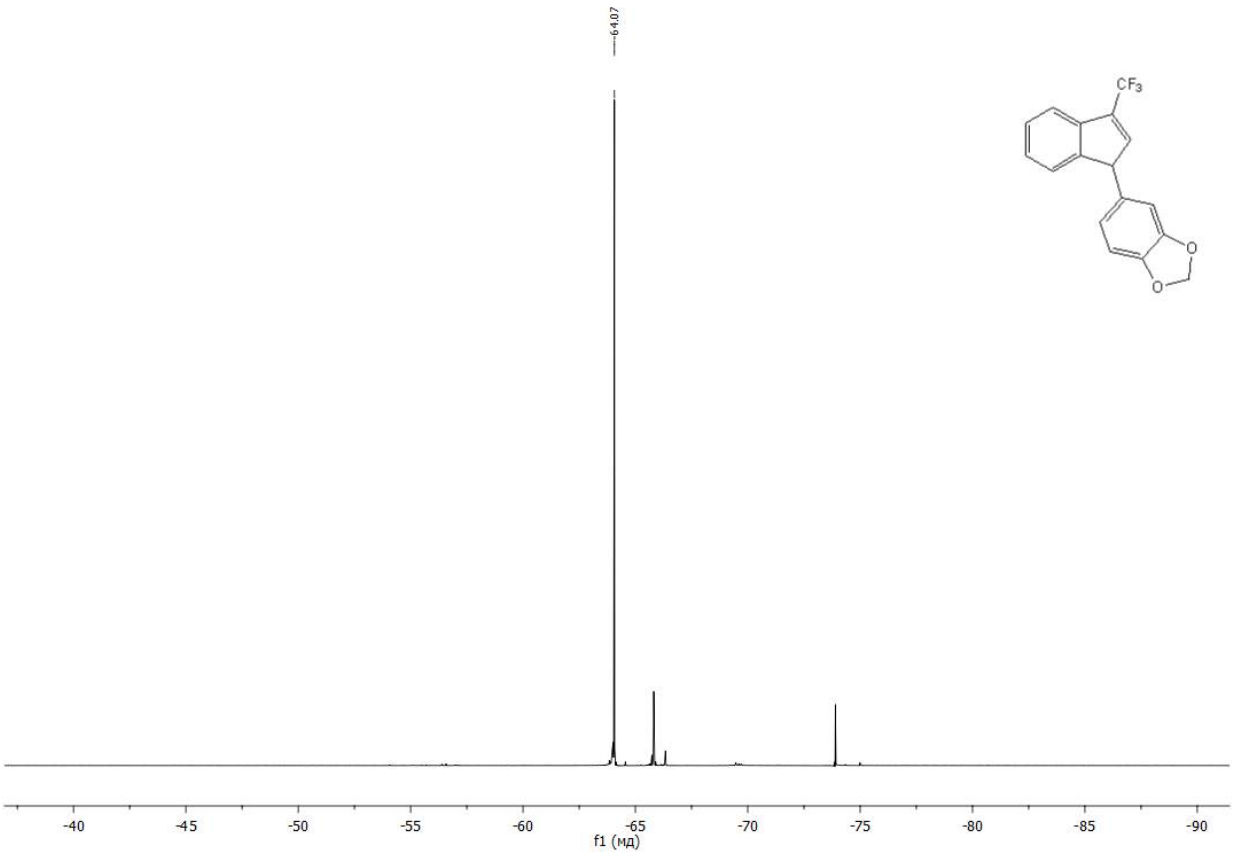


Fig. S129. ^{19}F {^{1}H} NMR spectrum of the compound **3n** ($CDCl_3$, 376 MHz).

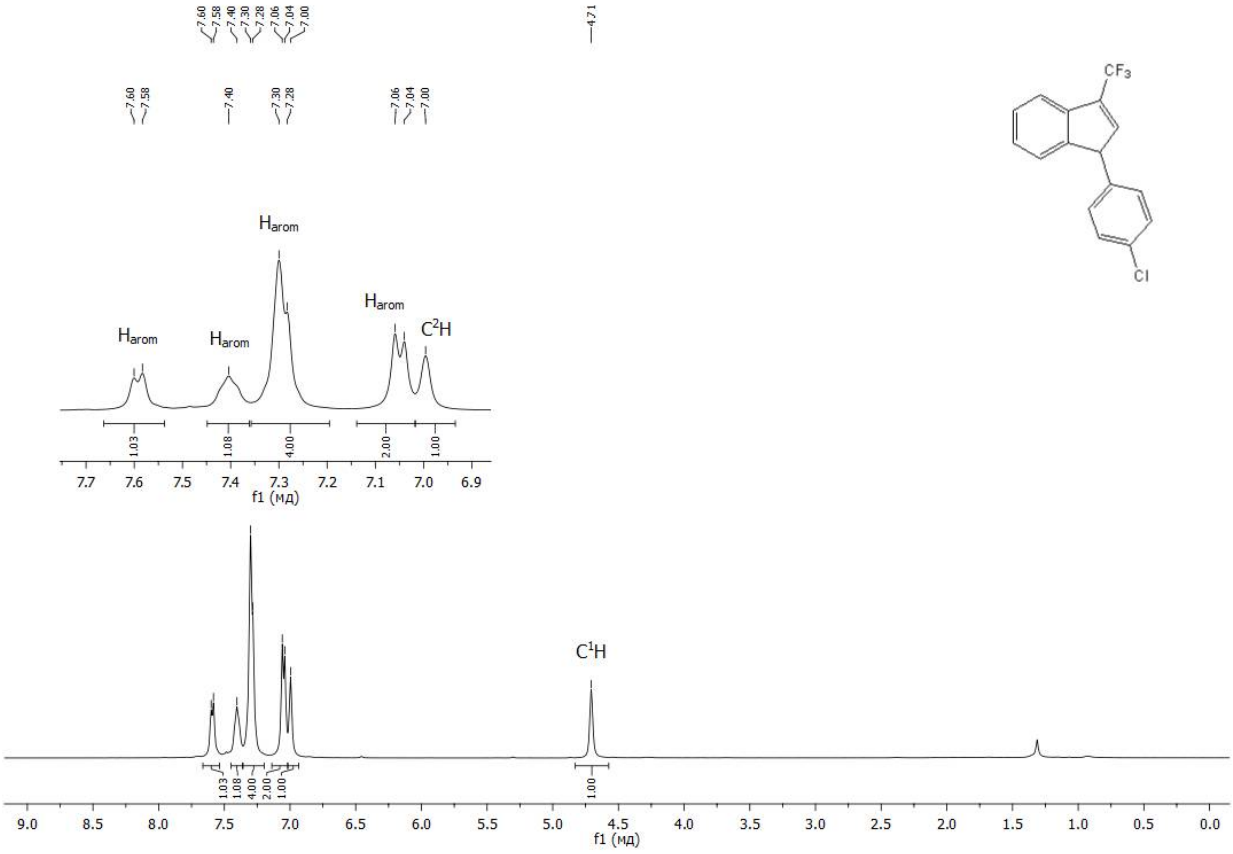


Fig. S130. ^{1}H NMR spectrum of the compound **3o** ($CDCl_3$, 400 MHz).

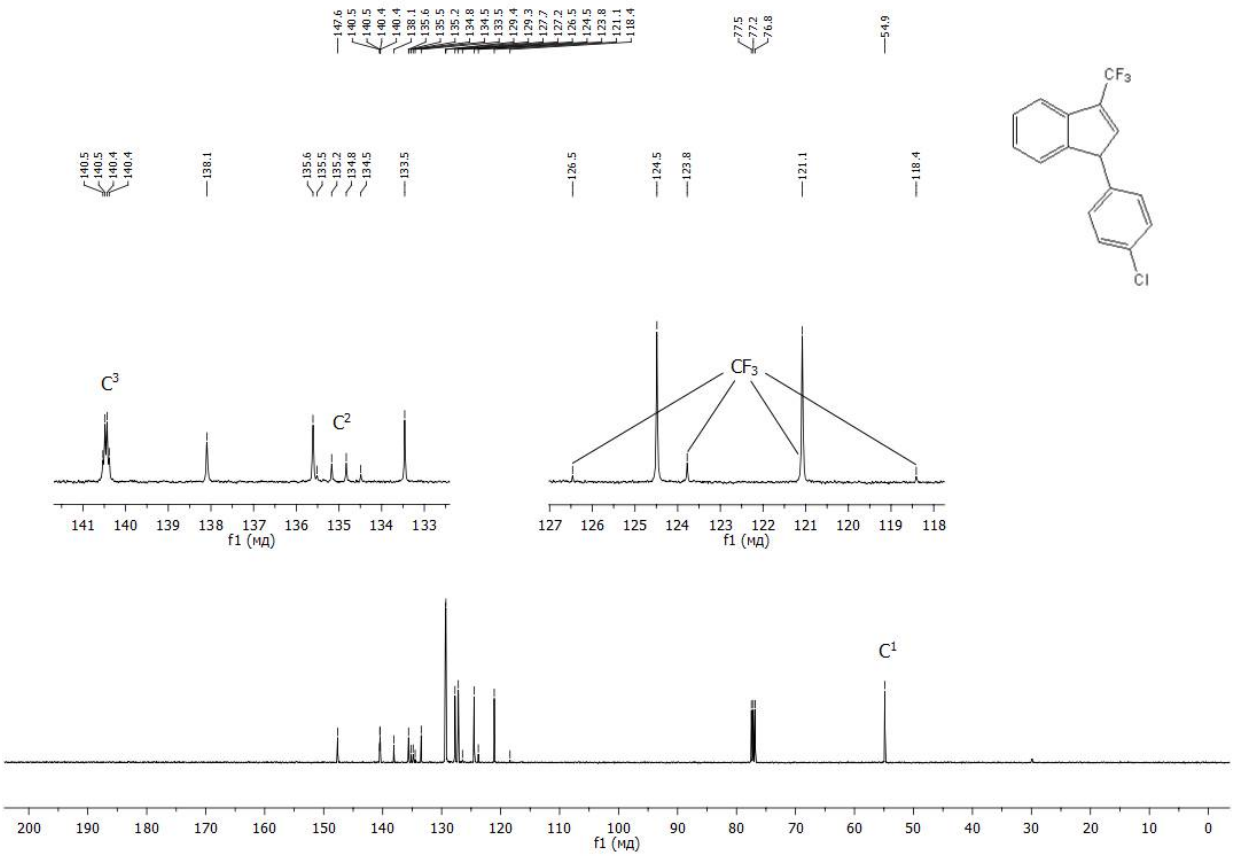


Fig. S131. ^{13}C NMR spectrum of the compound **3o** ($CDCl_3$, 100 MHz).

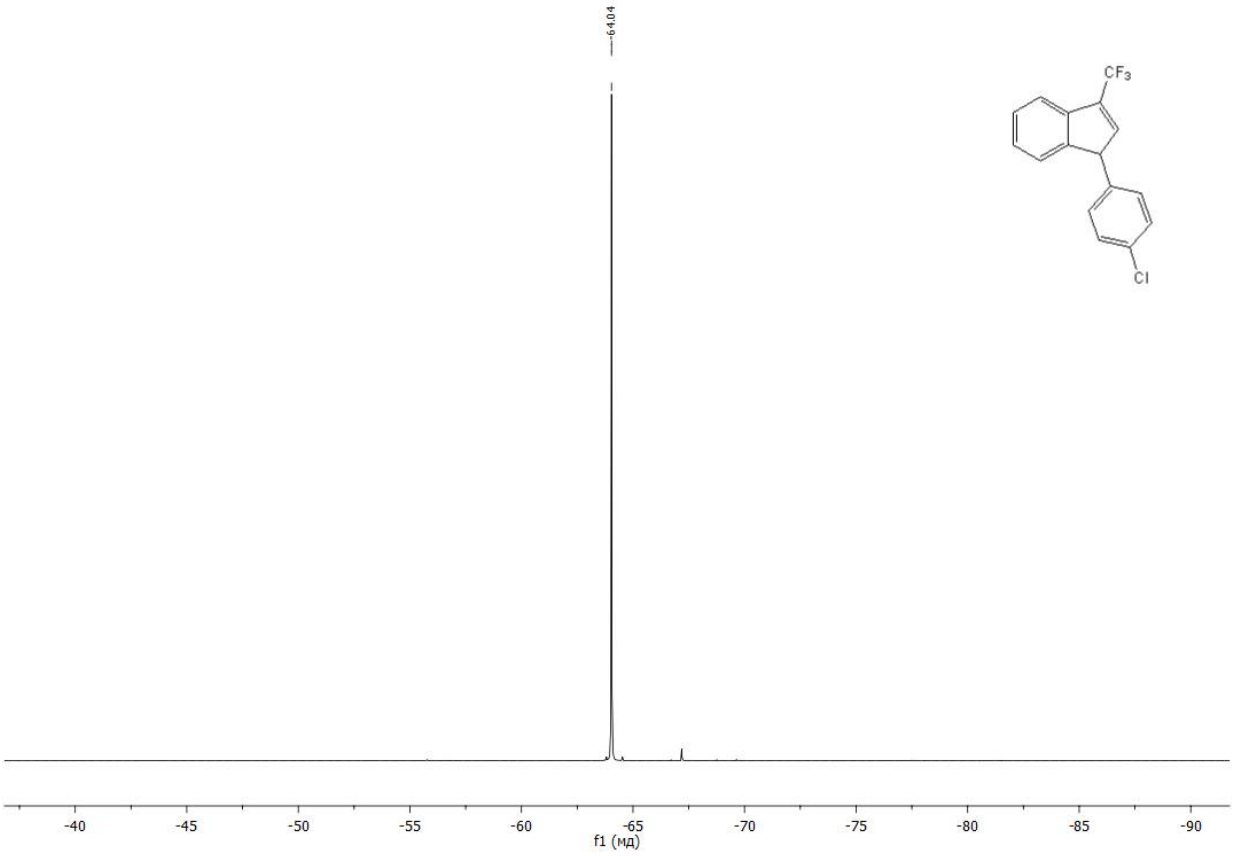


Fig. S132. ^{19}F $\{^1H\}$ NMR spectrum of the compound **3o** ($CDCl_3$, 376 MHz).

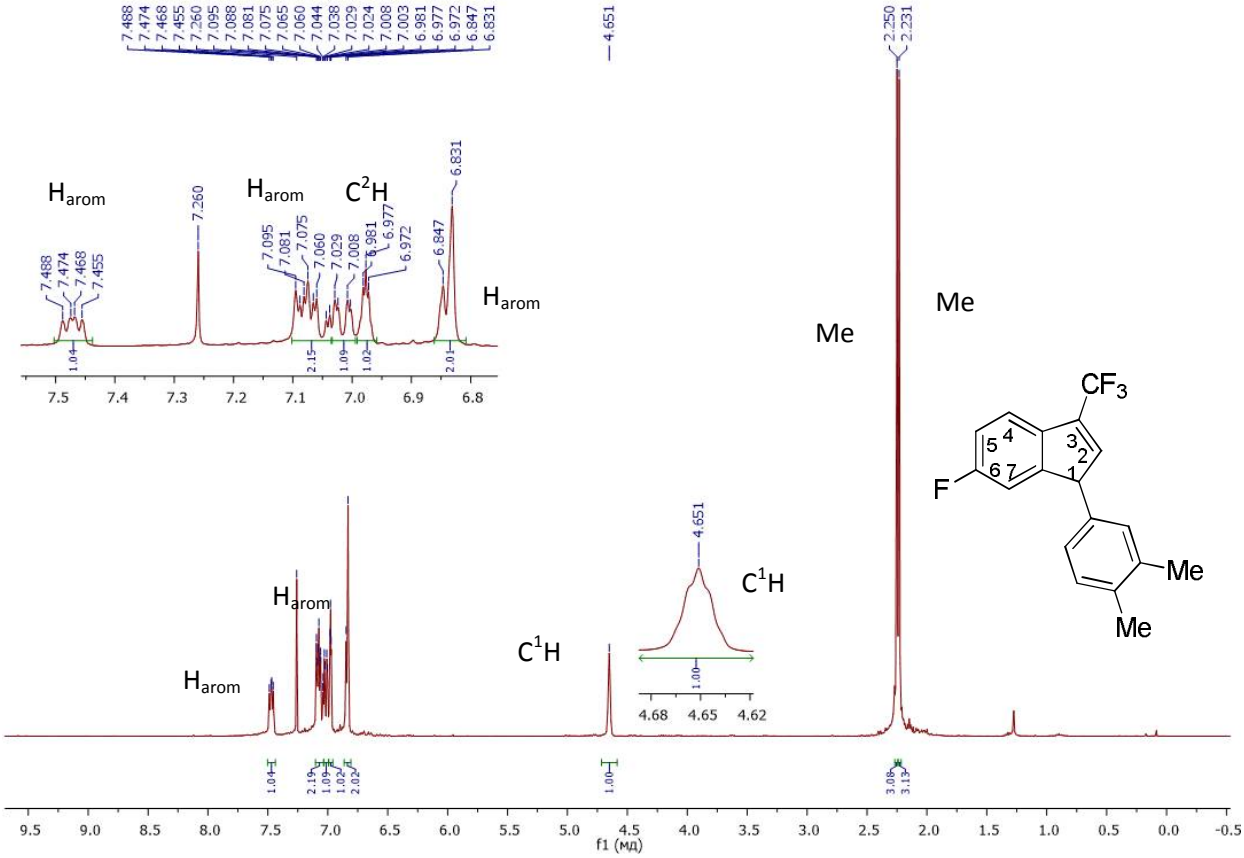


Fig. S133. ^{1}H NMR spectrum of the compound **3p** ($CDCl_3$, 400 MHz).

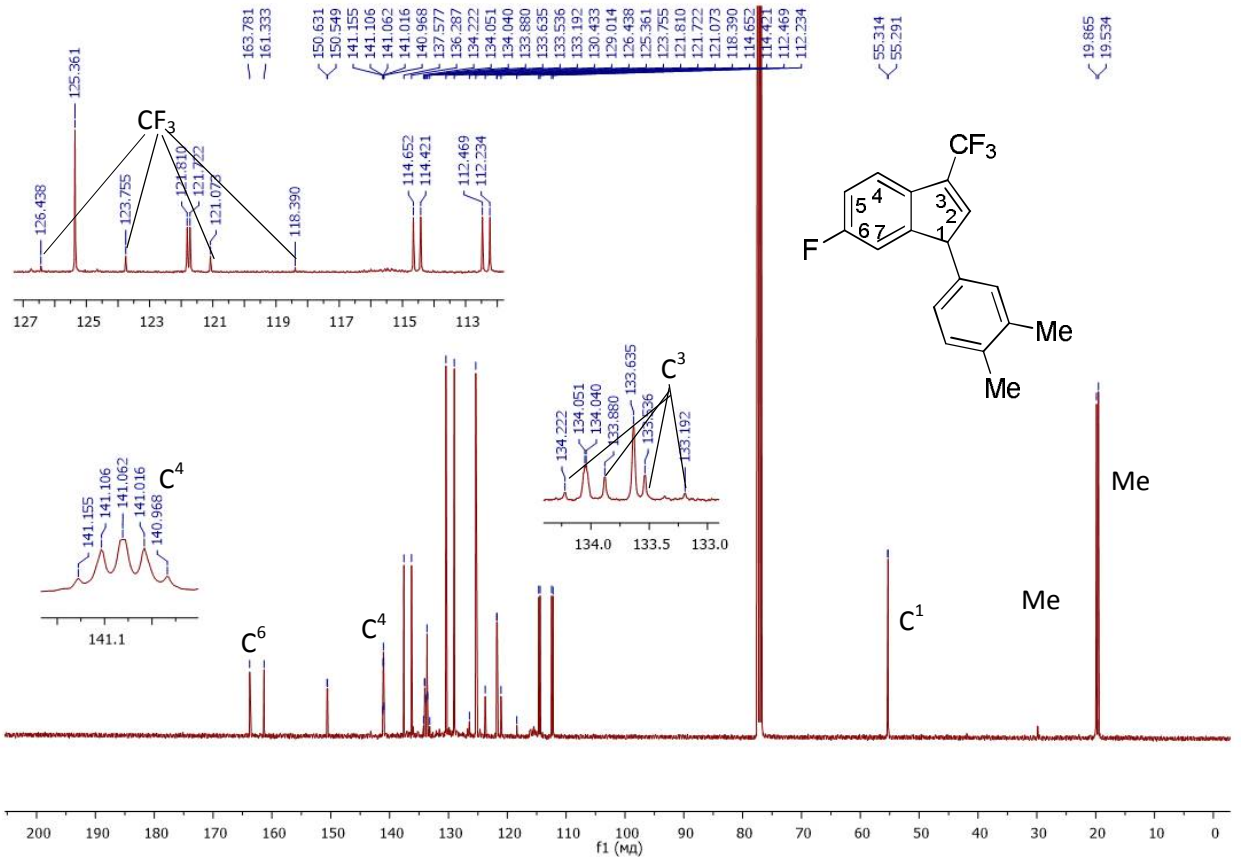


Fig. S134. ^{13}C NMR spectrum of the compound **3p** ($CDCl_3$, 100 MHz).

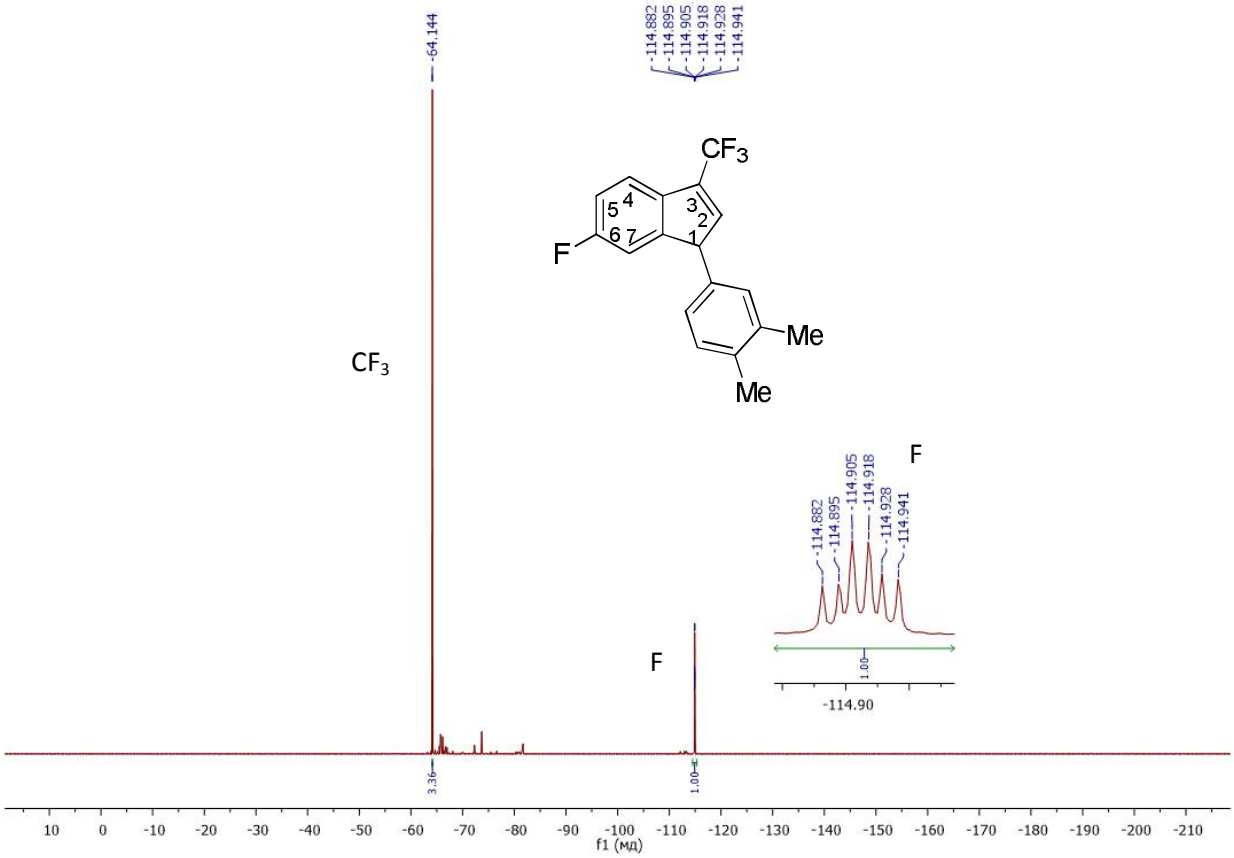


Fig. S135. ^{19}F NMR spectrum of the compound **3p** ($CDCl_3$, 376 MHz).

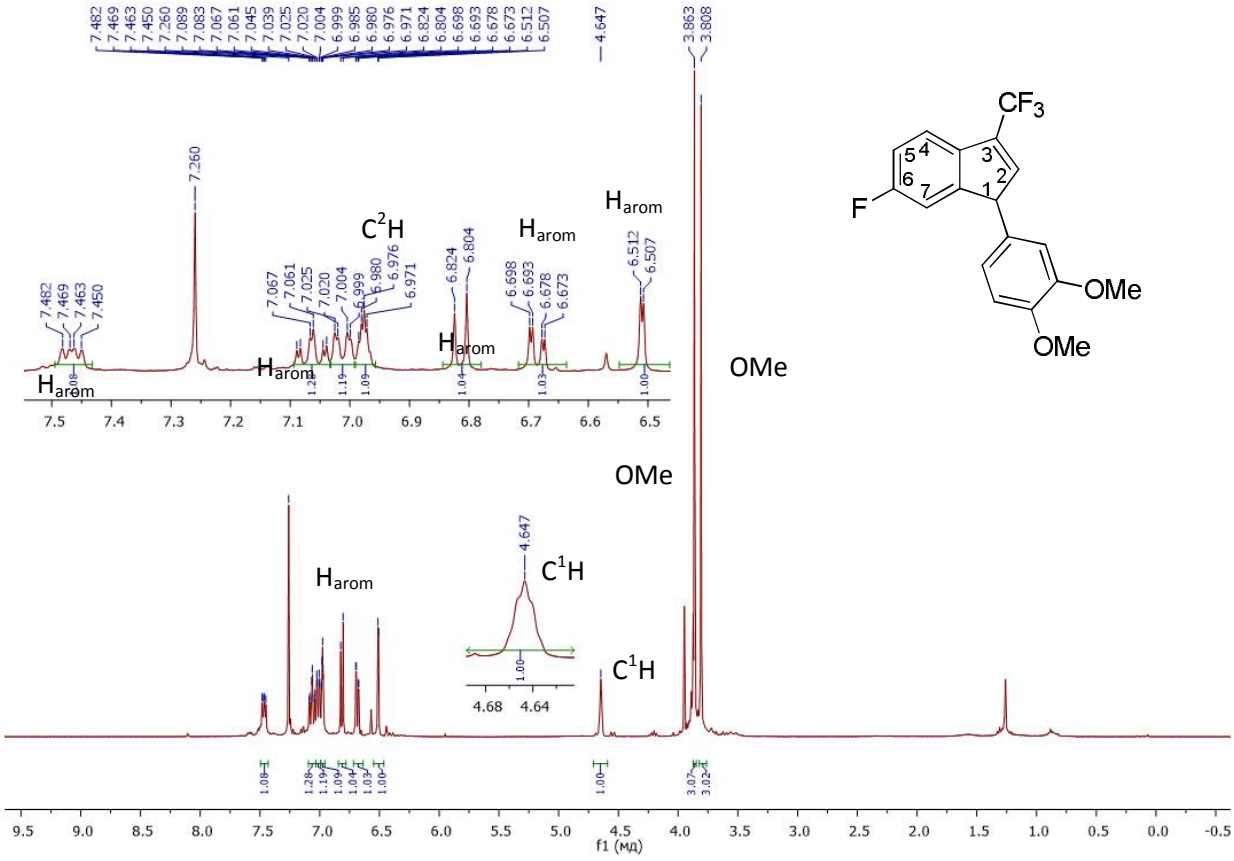


Fig. S136. ^{1}H NMR spectrum of the compound **3q** ($CDCl_3$, 400 MHz).

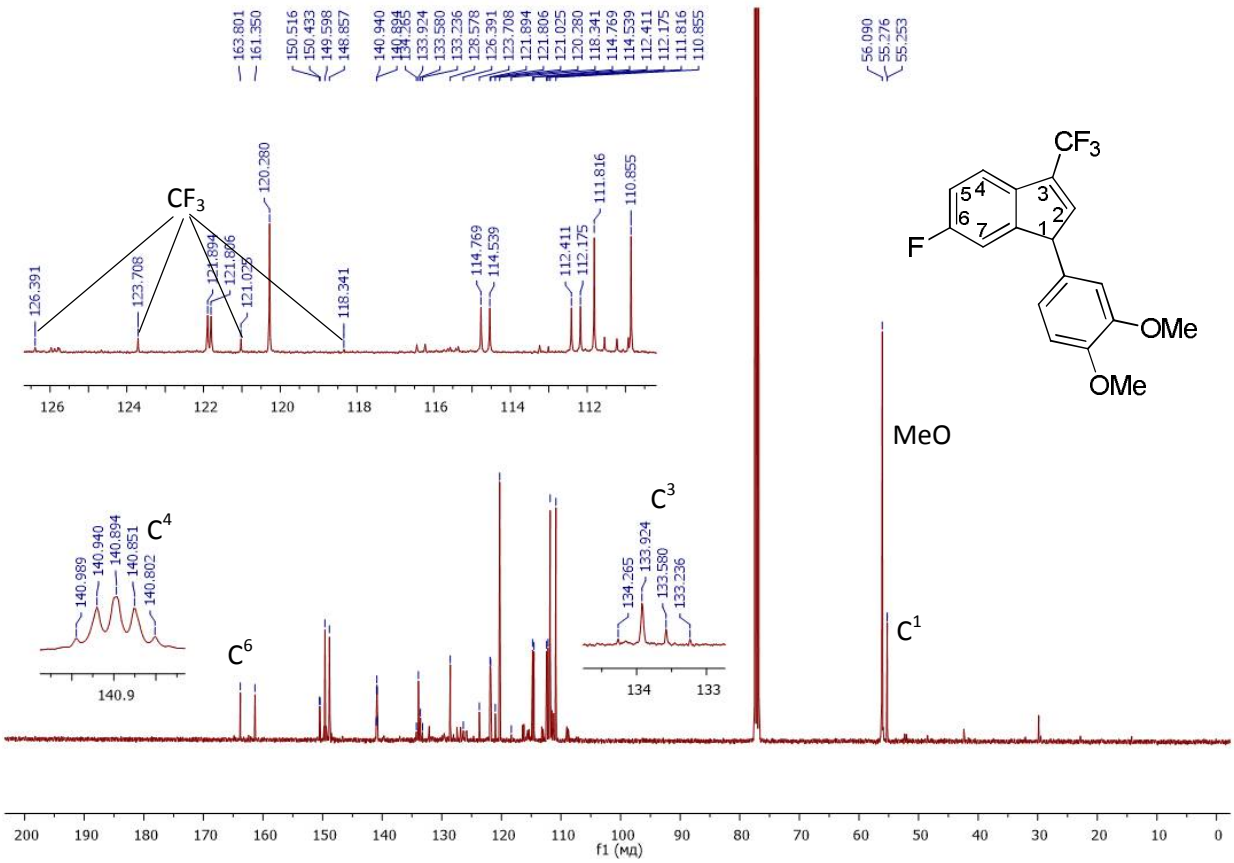


Fig. S137. ^{13}C NMR spectrum of the compound **3q** ($CDCl_3$, 100 MHz).

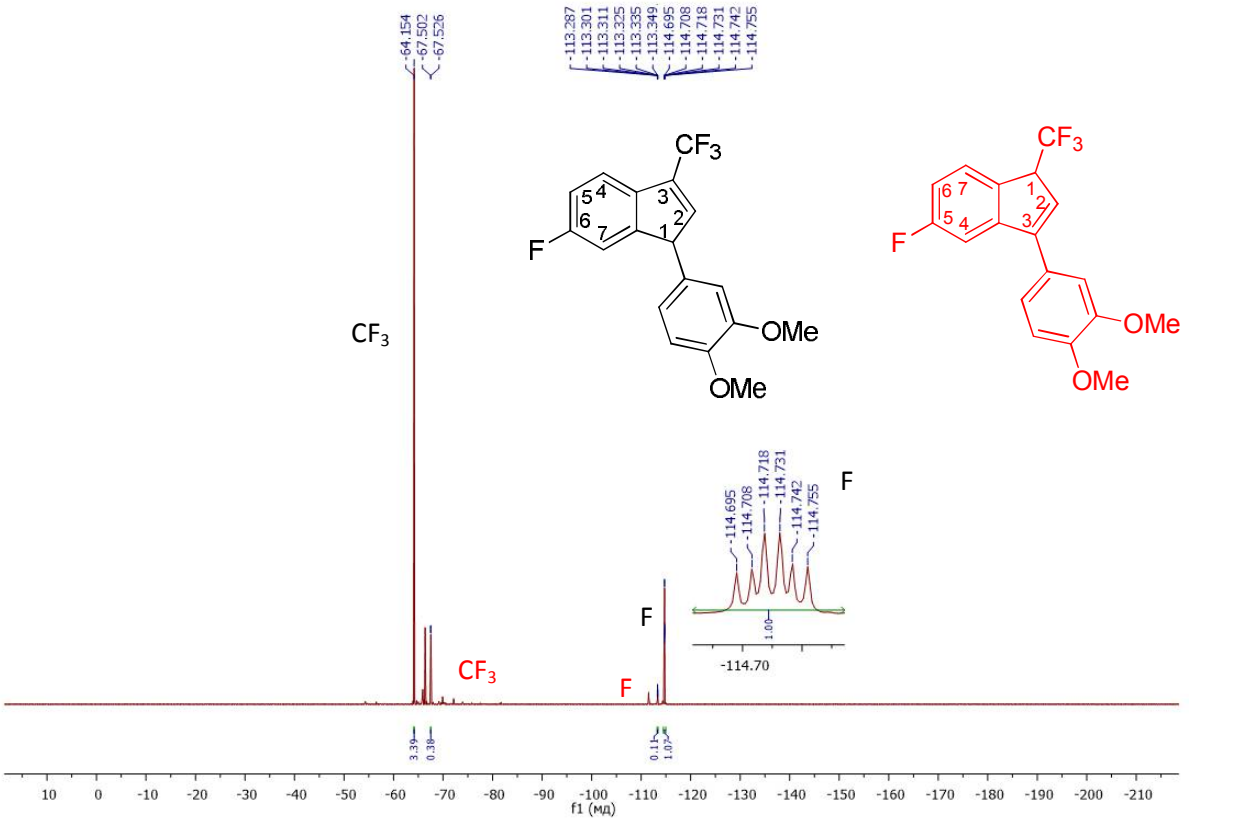


Fig. S138. ^{19}F NMR spectrum of the compound **3q** (admixture of isomer **4q** in red) ($CDCl_3$, 376 MHz).

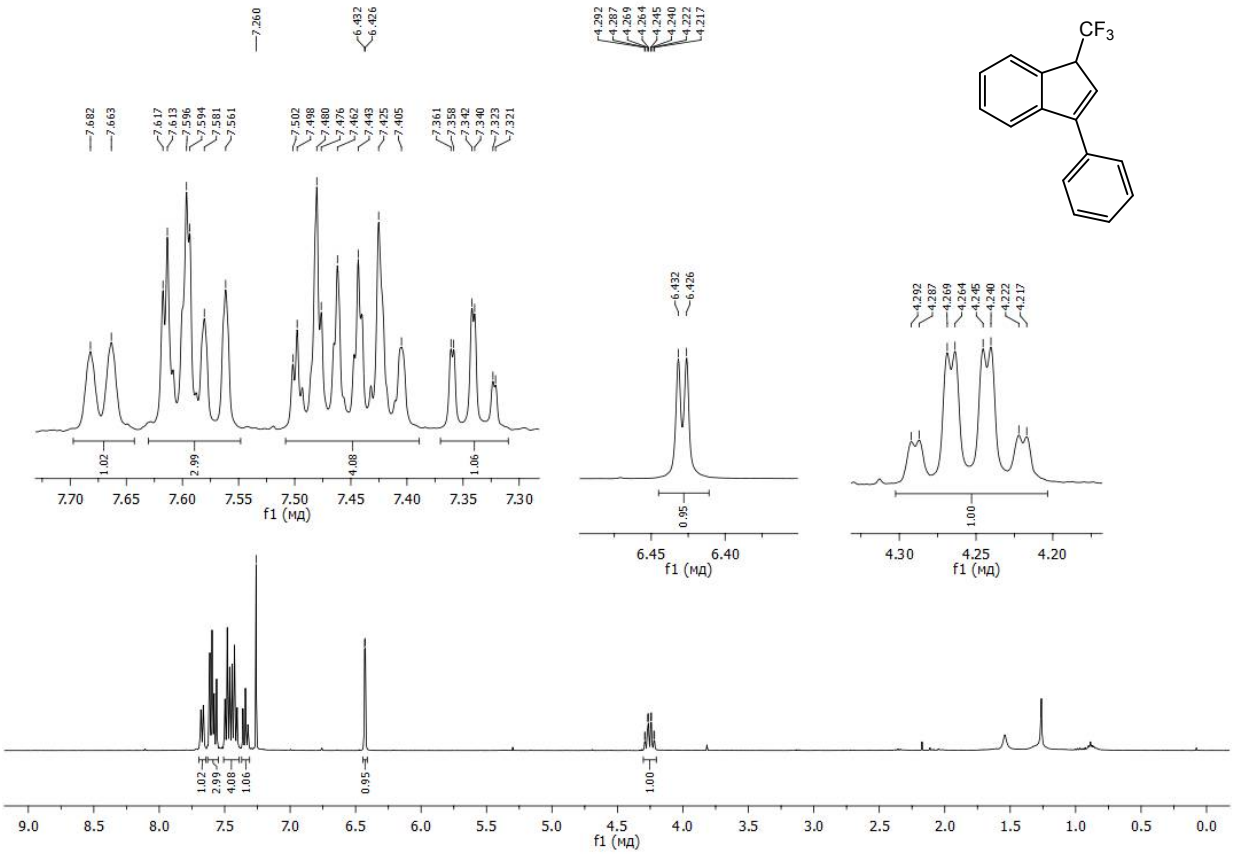


Fig. S139. ^{1}H NMR spectrum of the compound **4a** ($CDCl_3$, 400 MHz).

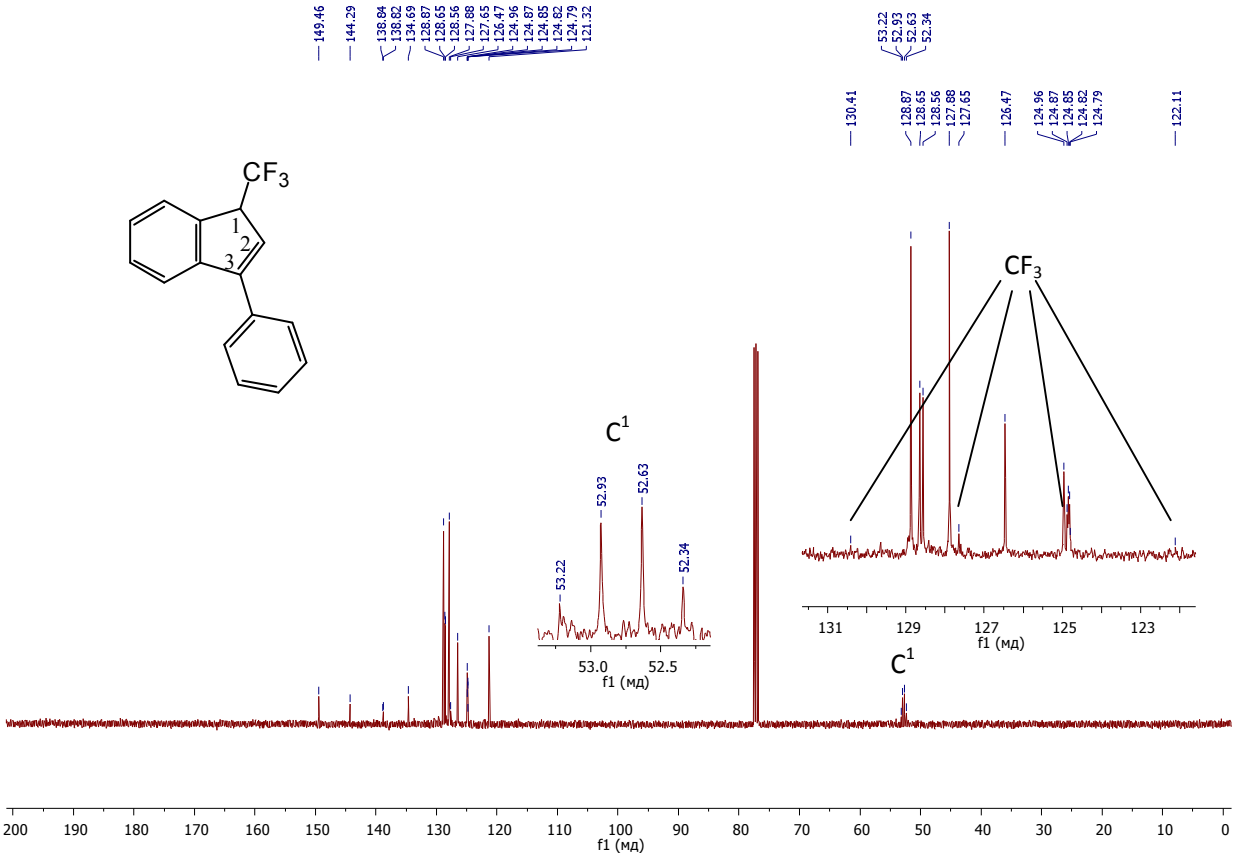


Fig. S140. ^{13}C NMR spectrum of the compound **4a** ($CDCl_3$, 100 MHz).

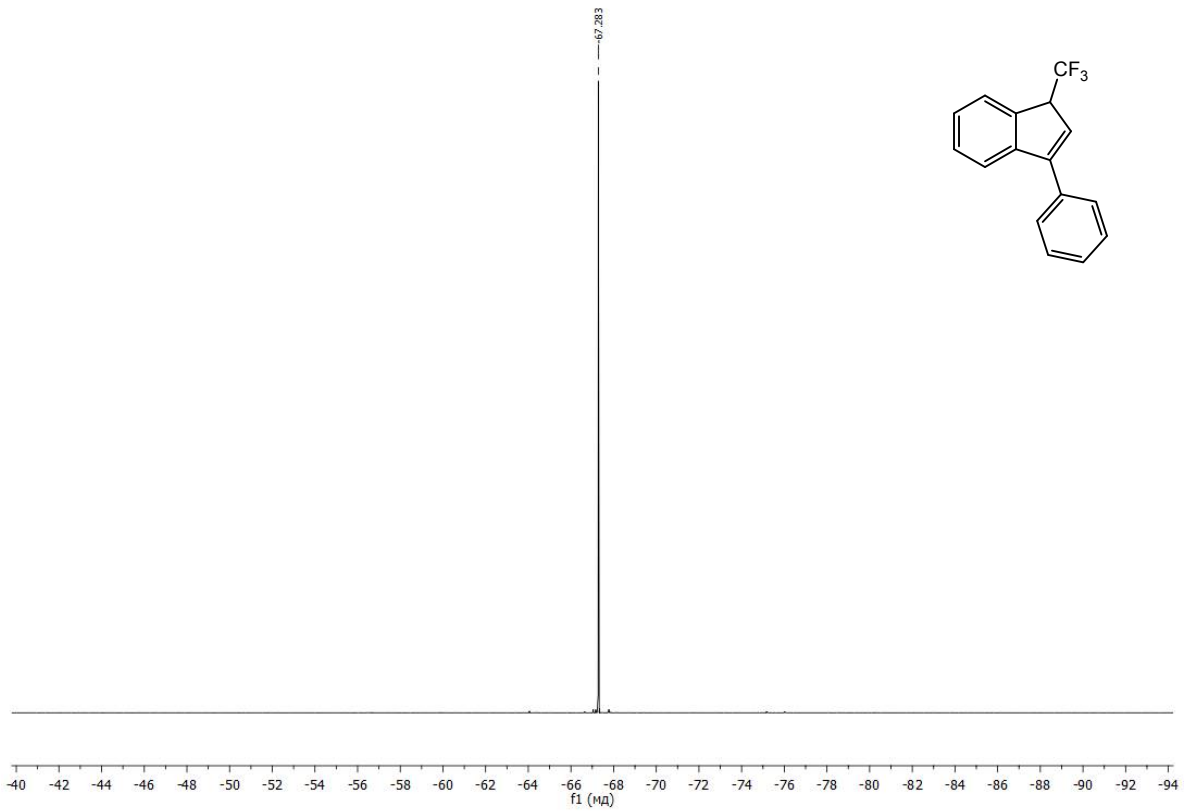


Fig. S141. ^{19}F {^{1}H} NMR spectrum of the compound **4a** ($CDCl_3$, 376 MHz).

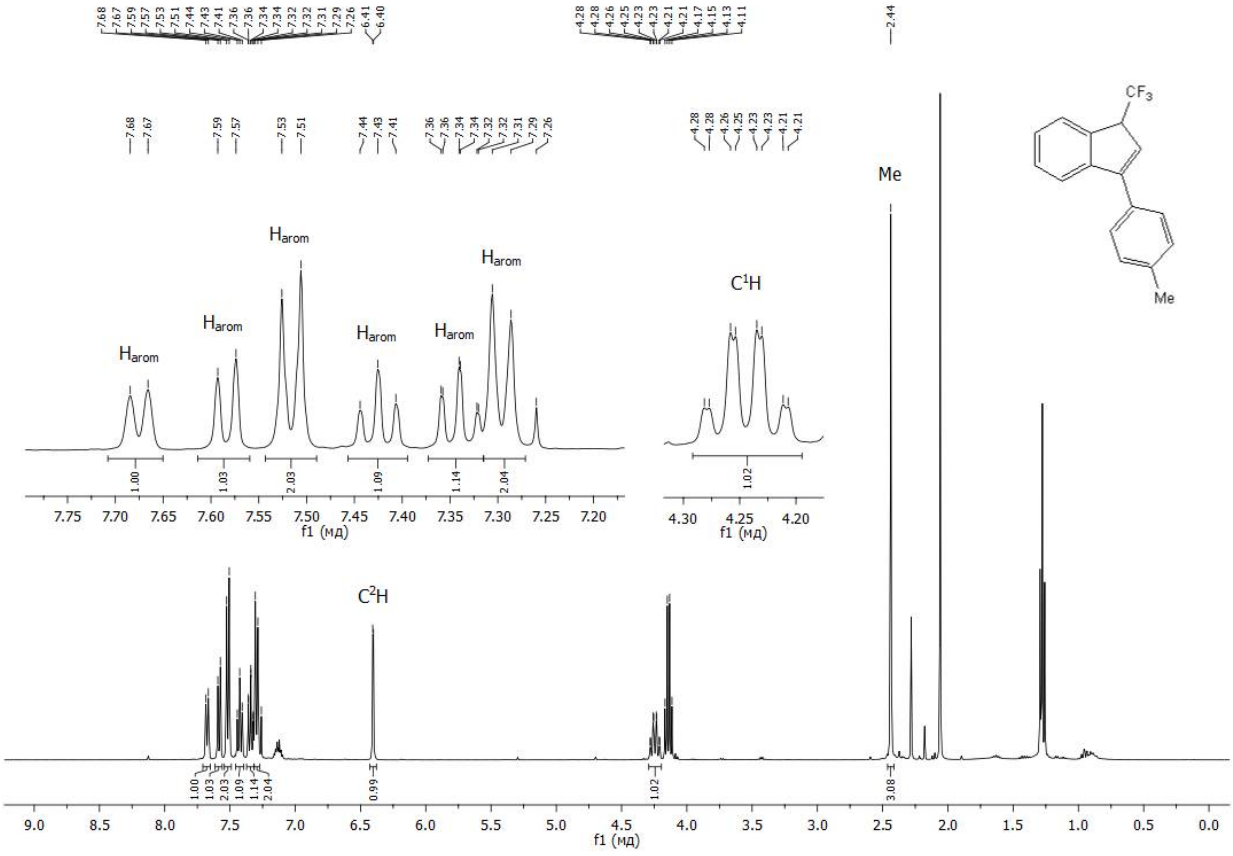


Fig. S142. ^{1}H NMR spectrum of the compound **4c** ($CDCl_3$, 400 MHz).

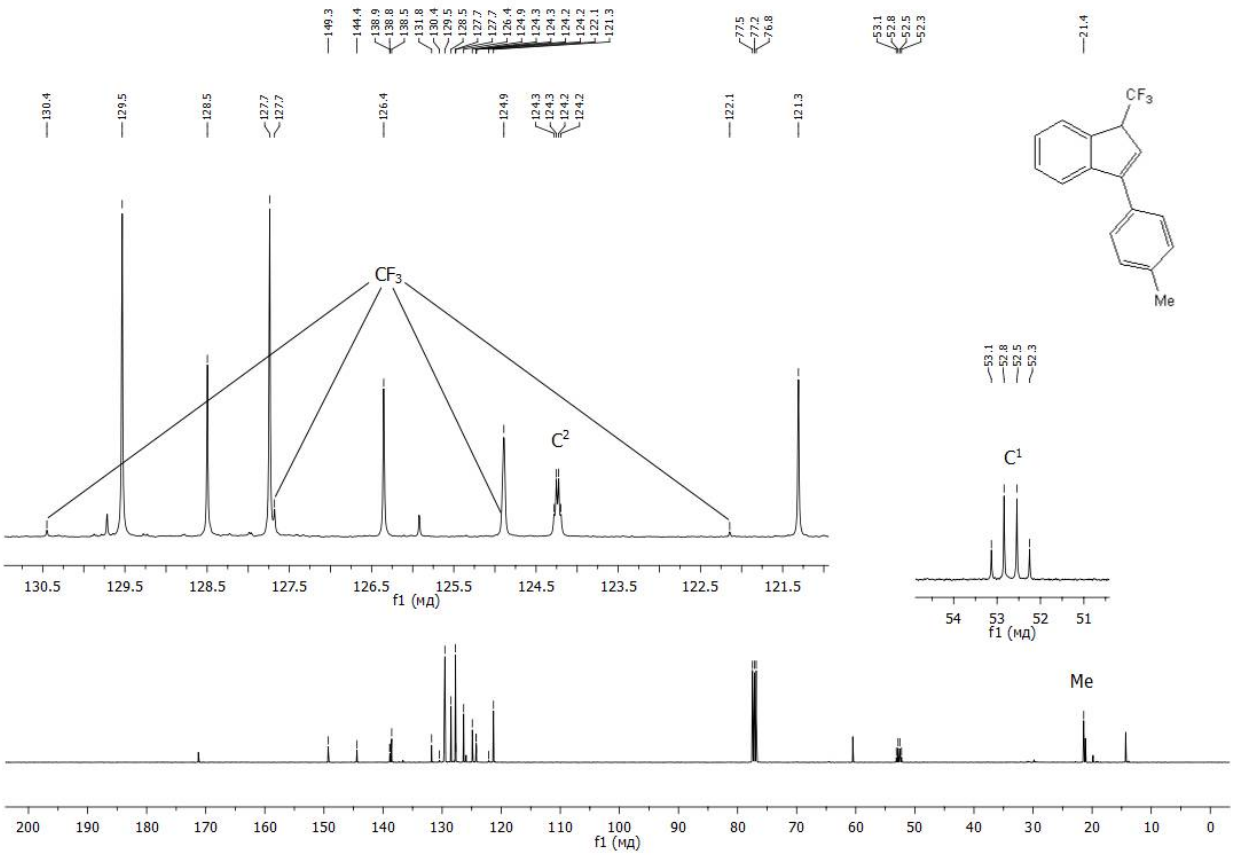


Fig. S143. ^{13}C NMR spectrum of the compound **4c** ($CDCl_3$, 100 MHz).

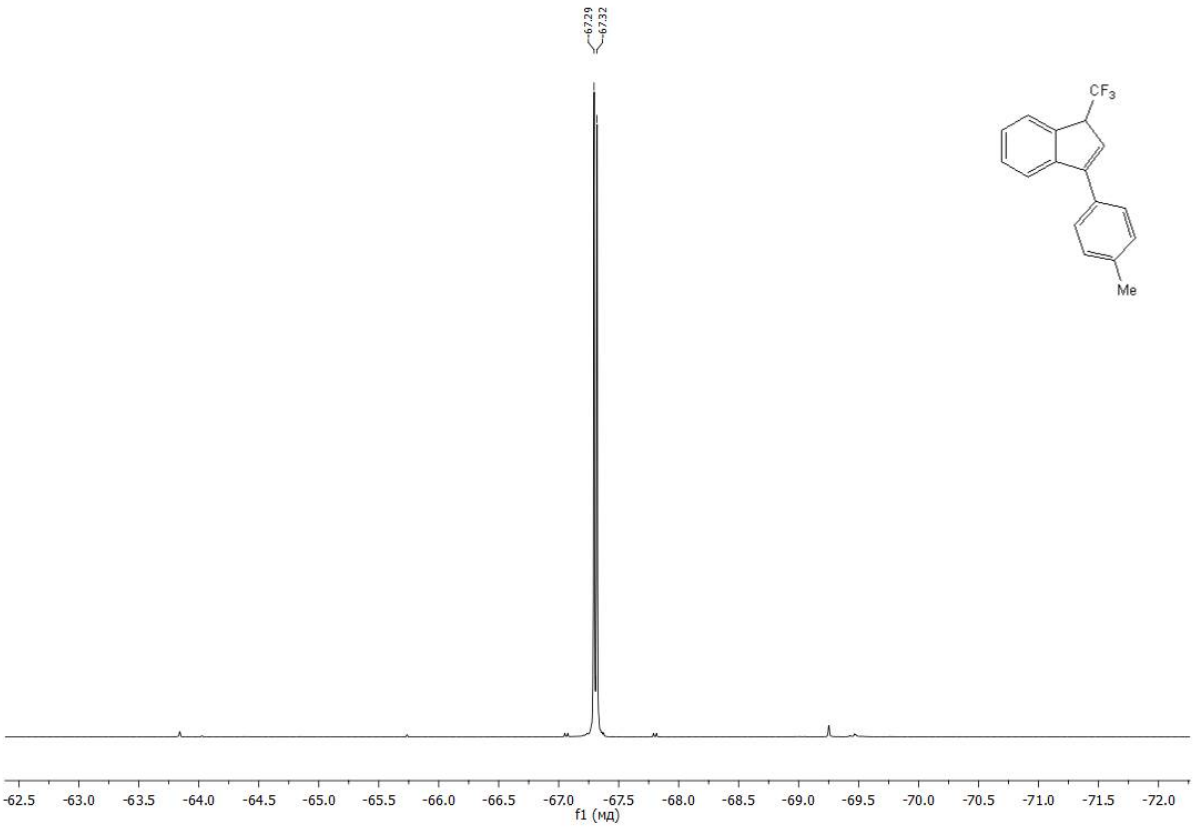


Fig. S144. ^{19}F NMR spectrum of the compound **4c** ($CDCl_3$, 376 MHz).

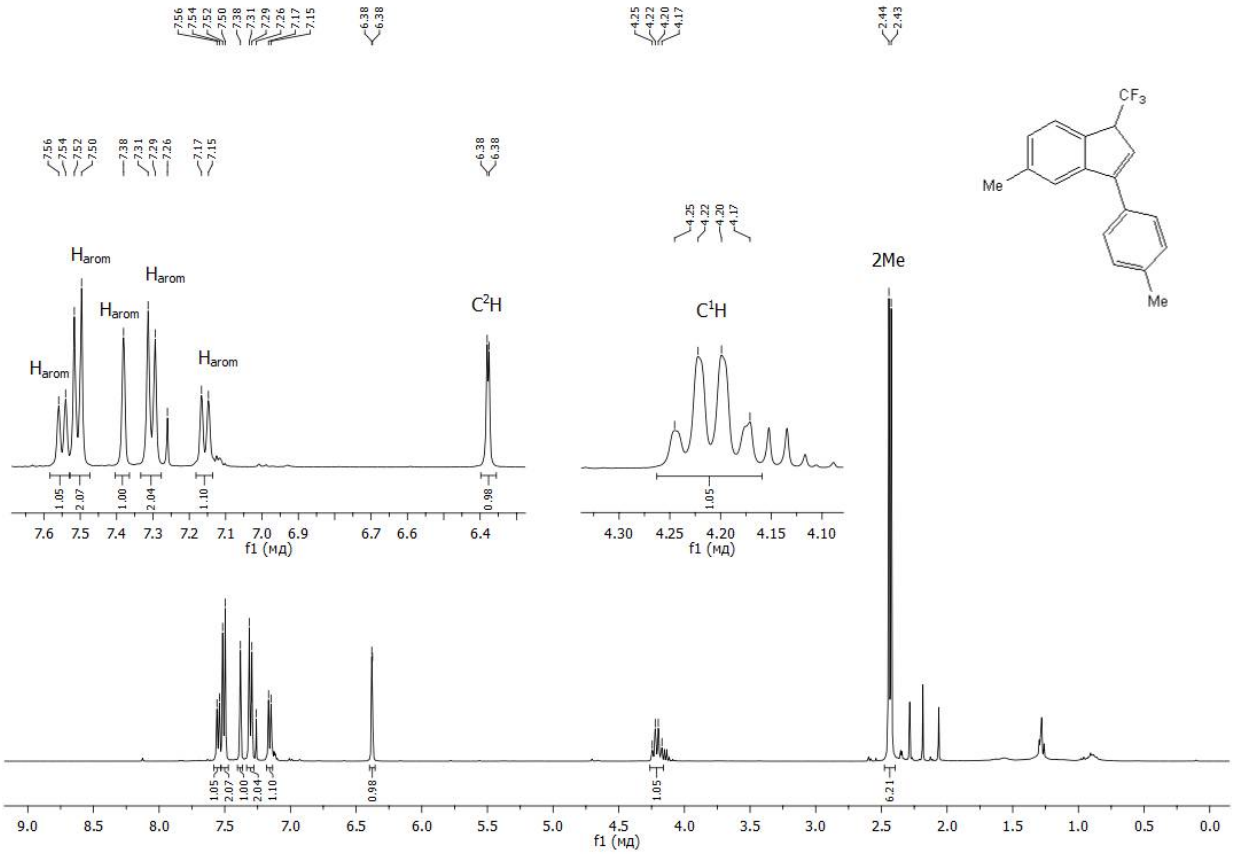


Fig. S145. ^{1}H NMR spectrum of the compound **4d** ($CDCl_3$, 400 MHz).

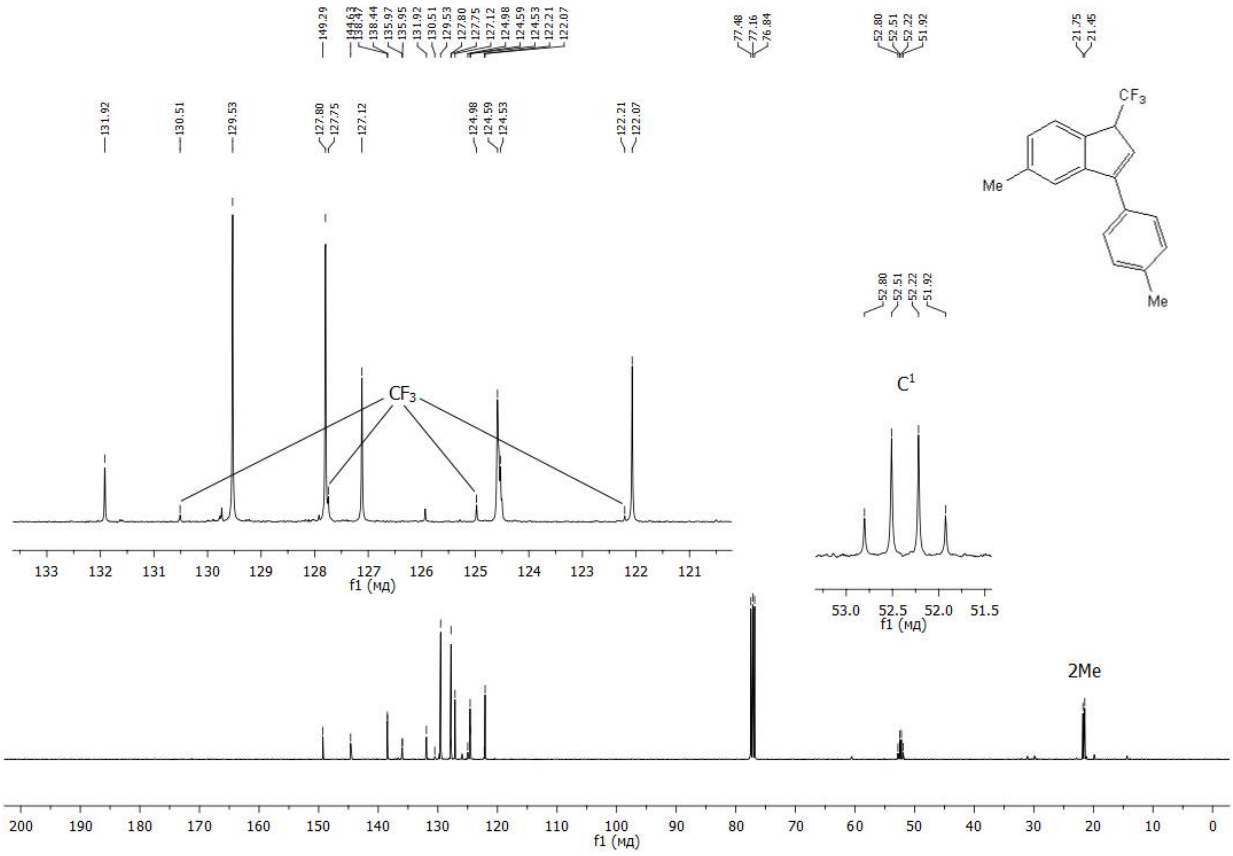


Fig. S146. ^{13}C NMR spectrum of the compound **4d** ($CDCl_3$, 100 MHz).

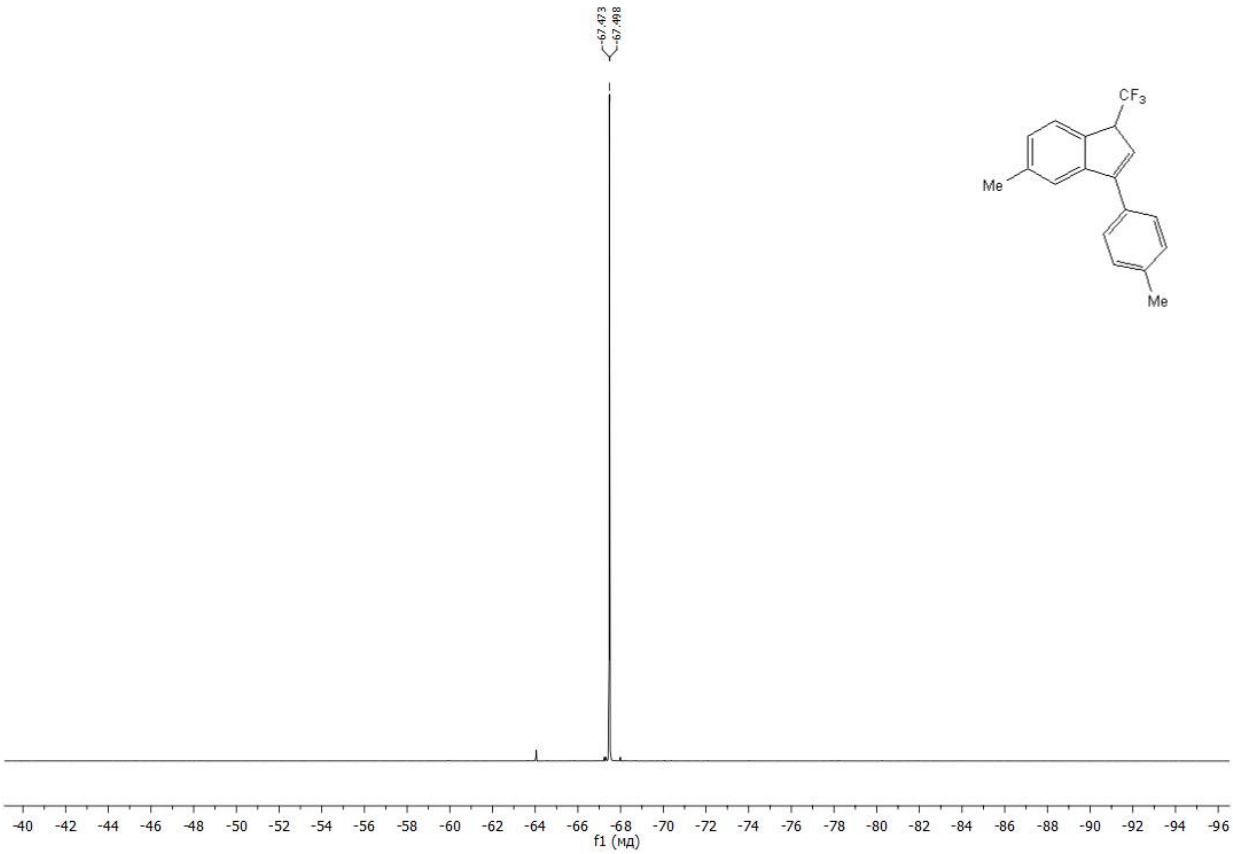


Fig. S147. ^{19}F NMR spectrum of the compound **4d** ($CDCl_3$, 376 MHz).

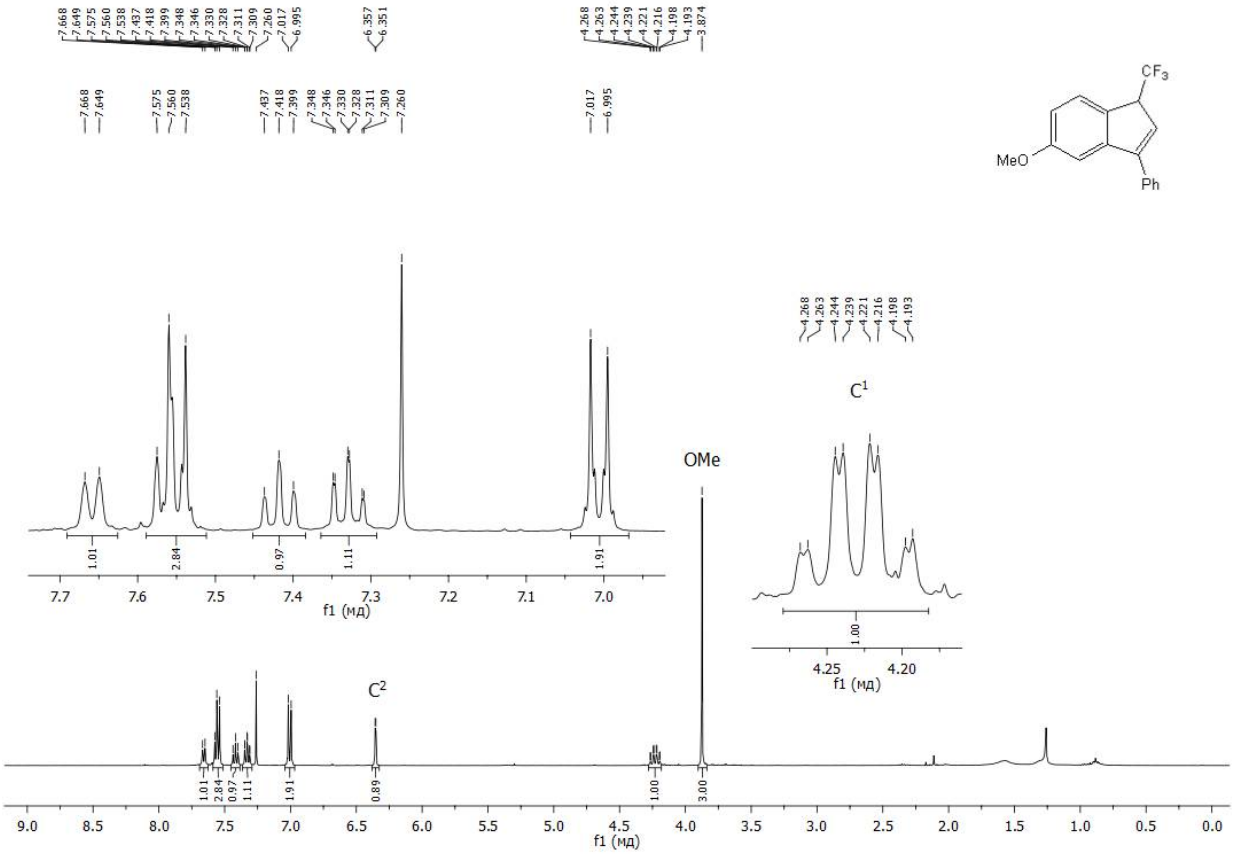


Fig. S148. ^{1}H NMR spectrum of the compound **4e** ($CDCl_3$, 400 MHz).

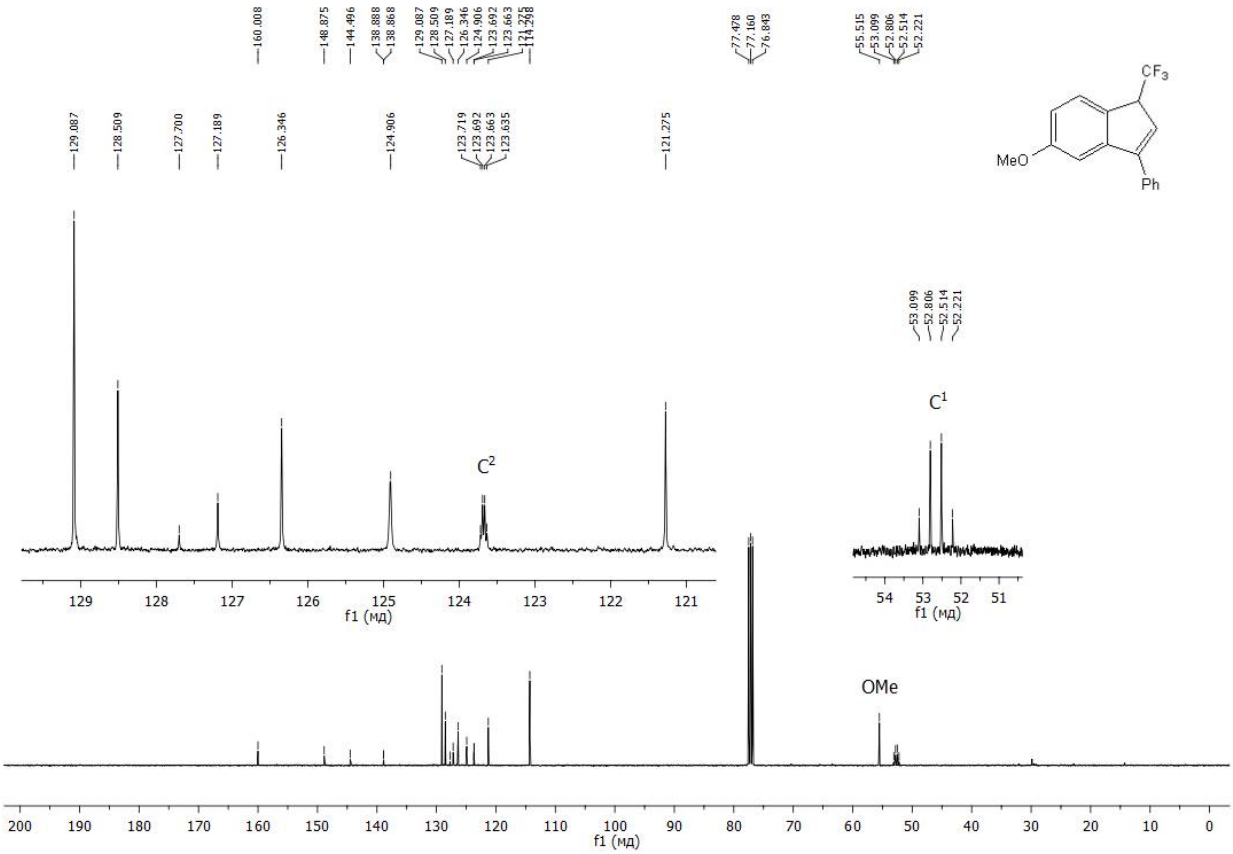


Fig. S149. ^{13}C NMR spectrum of the compound **4e** ($CDCl_3$, 100 MHz).

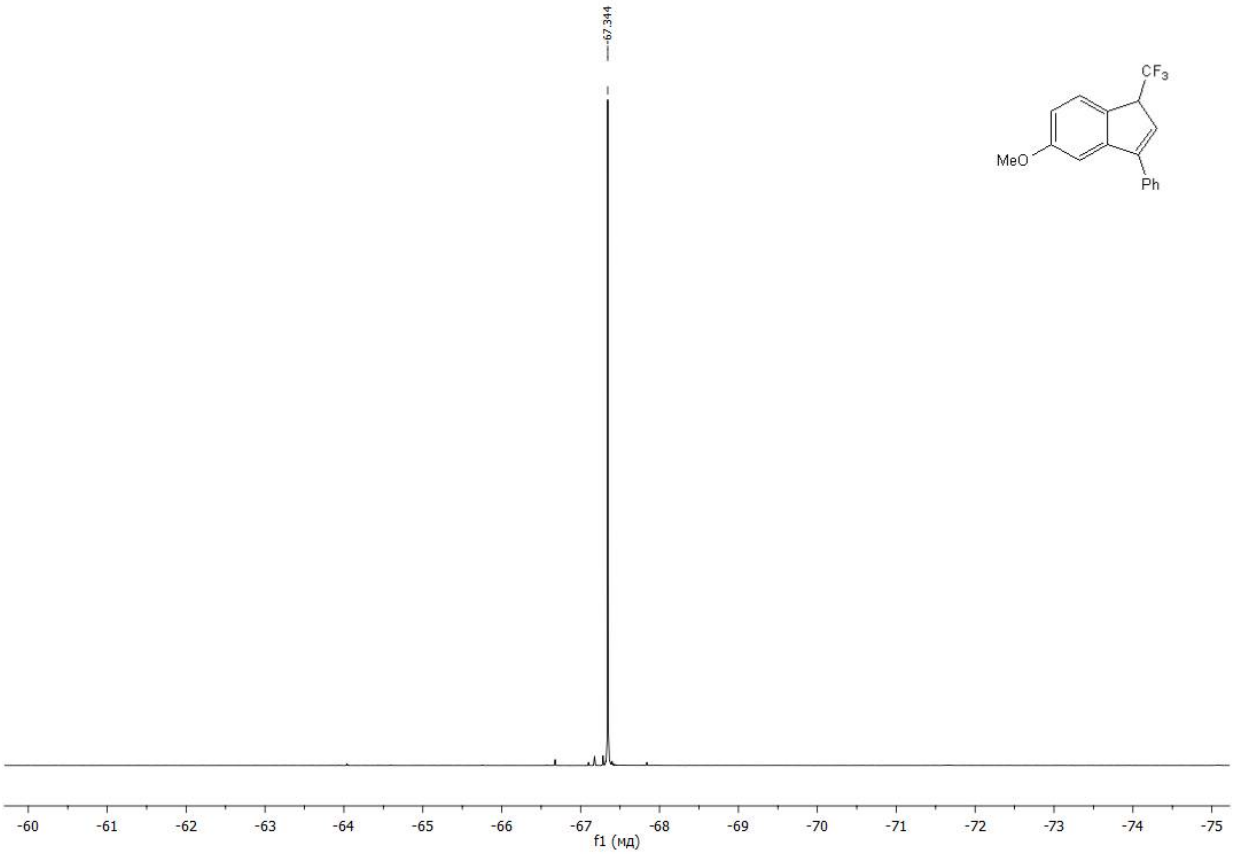


Fig. S150. ^{19}F $\{^1H\}$ NMR spectrum of the compound **4e** ($CDCl_3$, 376 MHz).

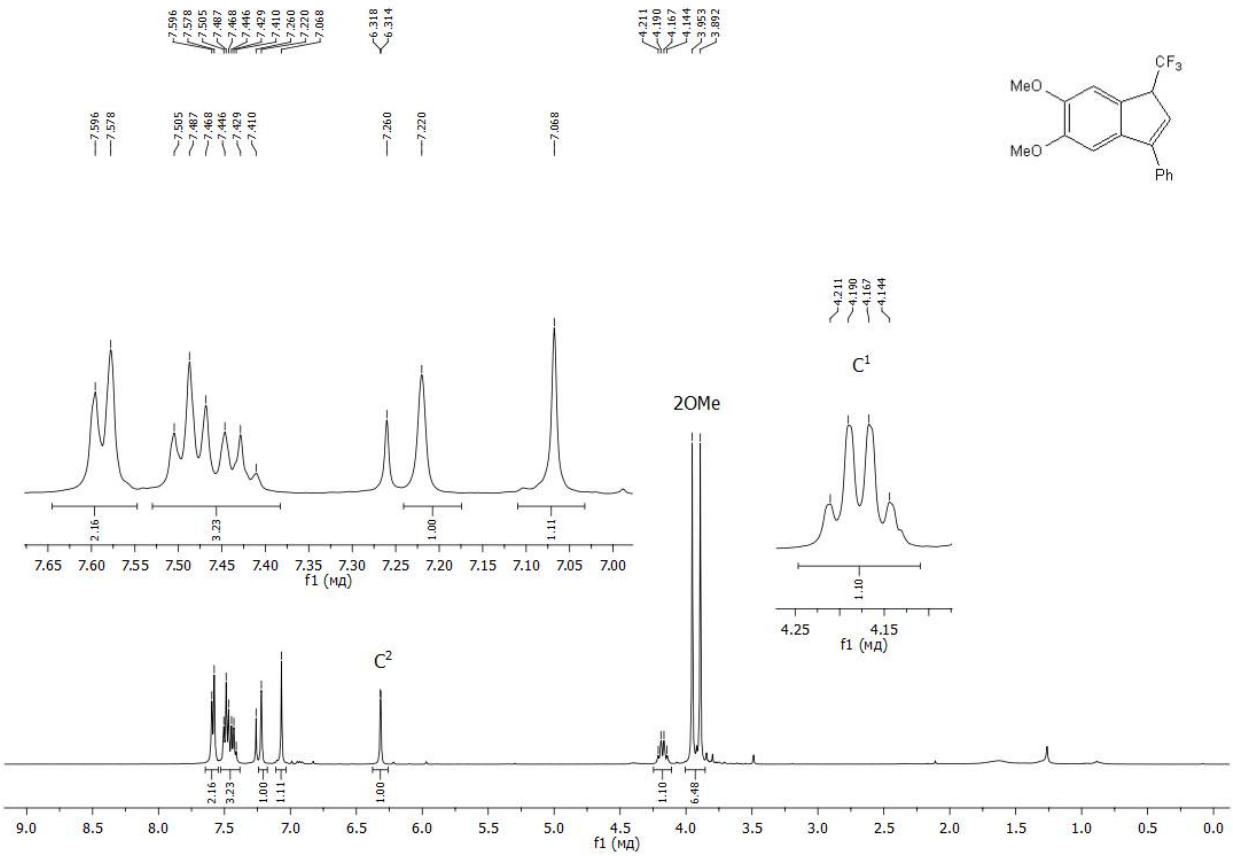


Fig. S151. ^{1}H NMR spectrum of the compound **4g** ($CDCl_3$, 400 MHz).

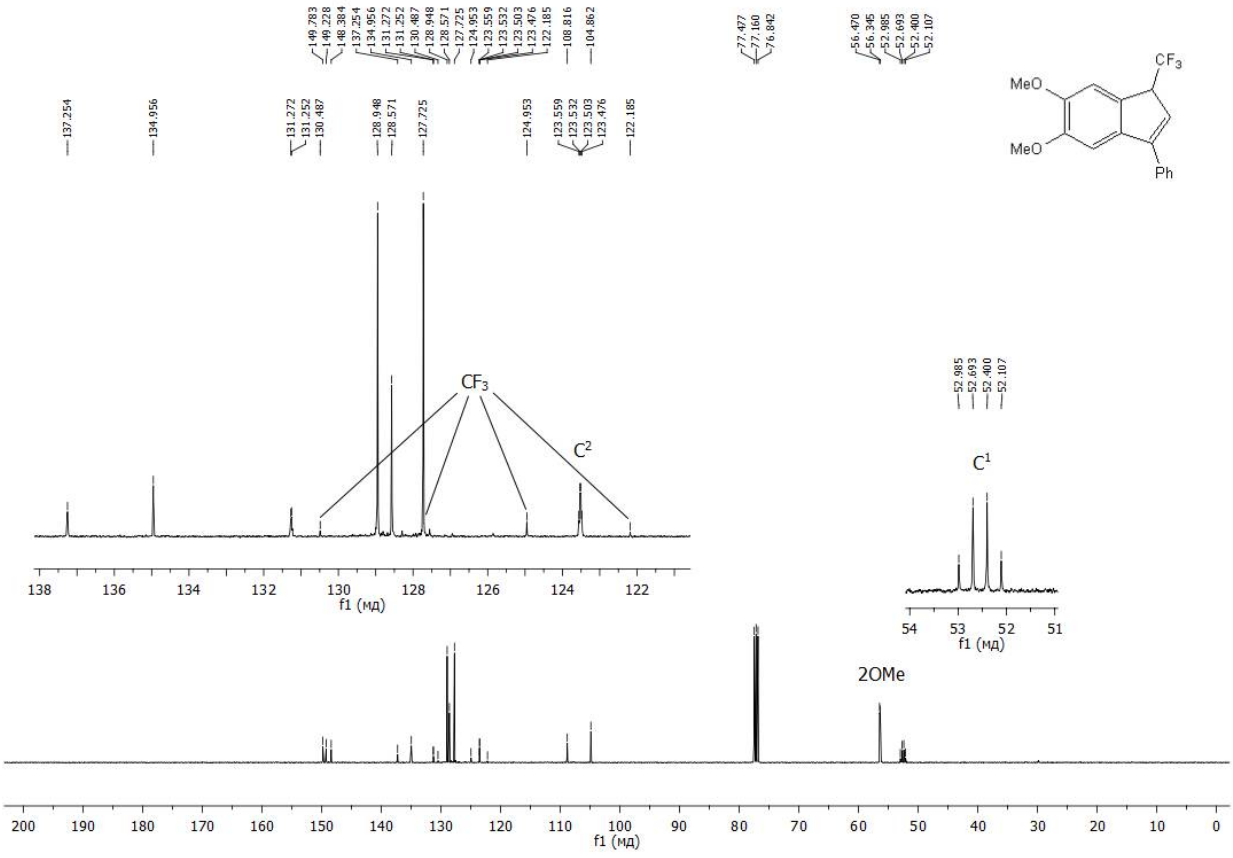


Fig. S152. ^{13}C NMR spectrum of the compound **4g** ($CDCl_3$, 100 MHz).

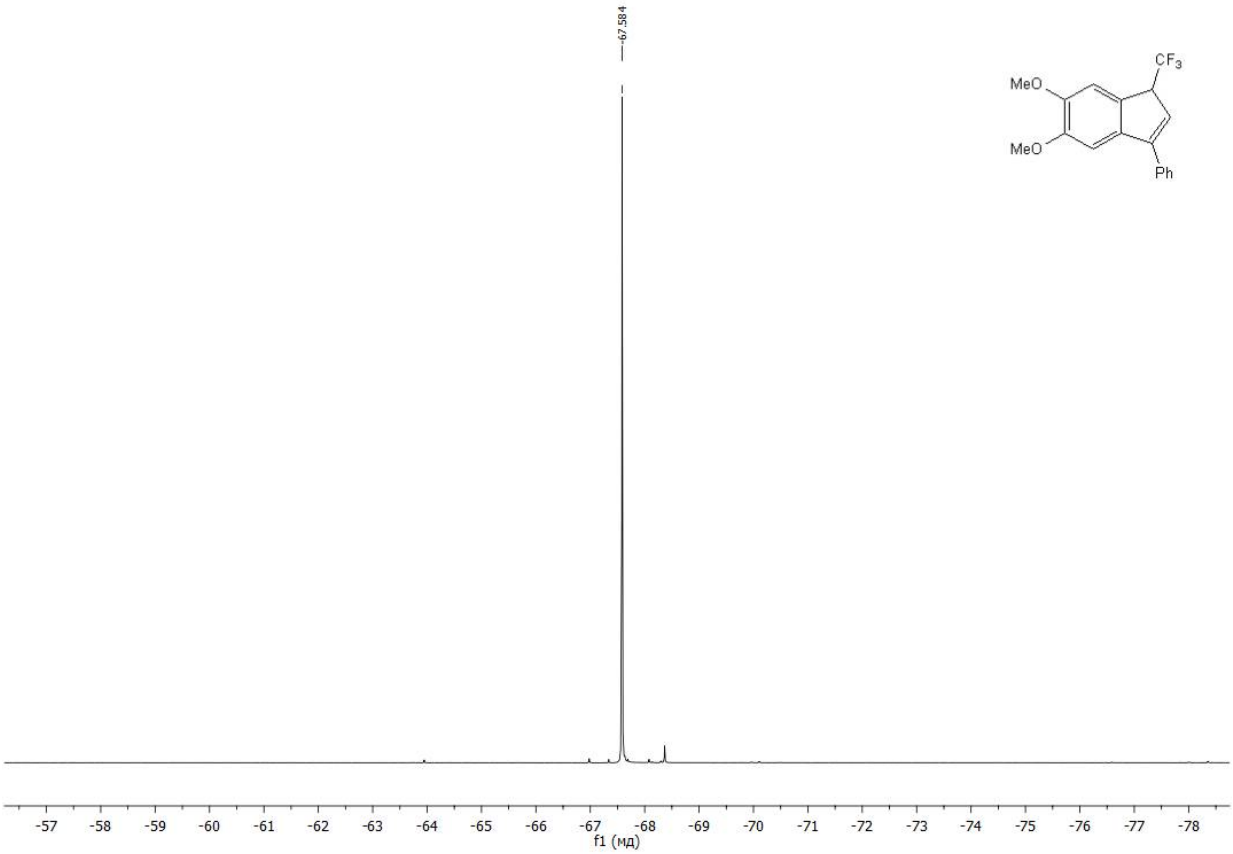


Fig. S153. ^{19}F {^{1}H} NMR spectrum of the compound **4g** ($CDCl_3$, 376 MHz).

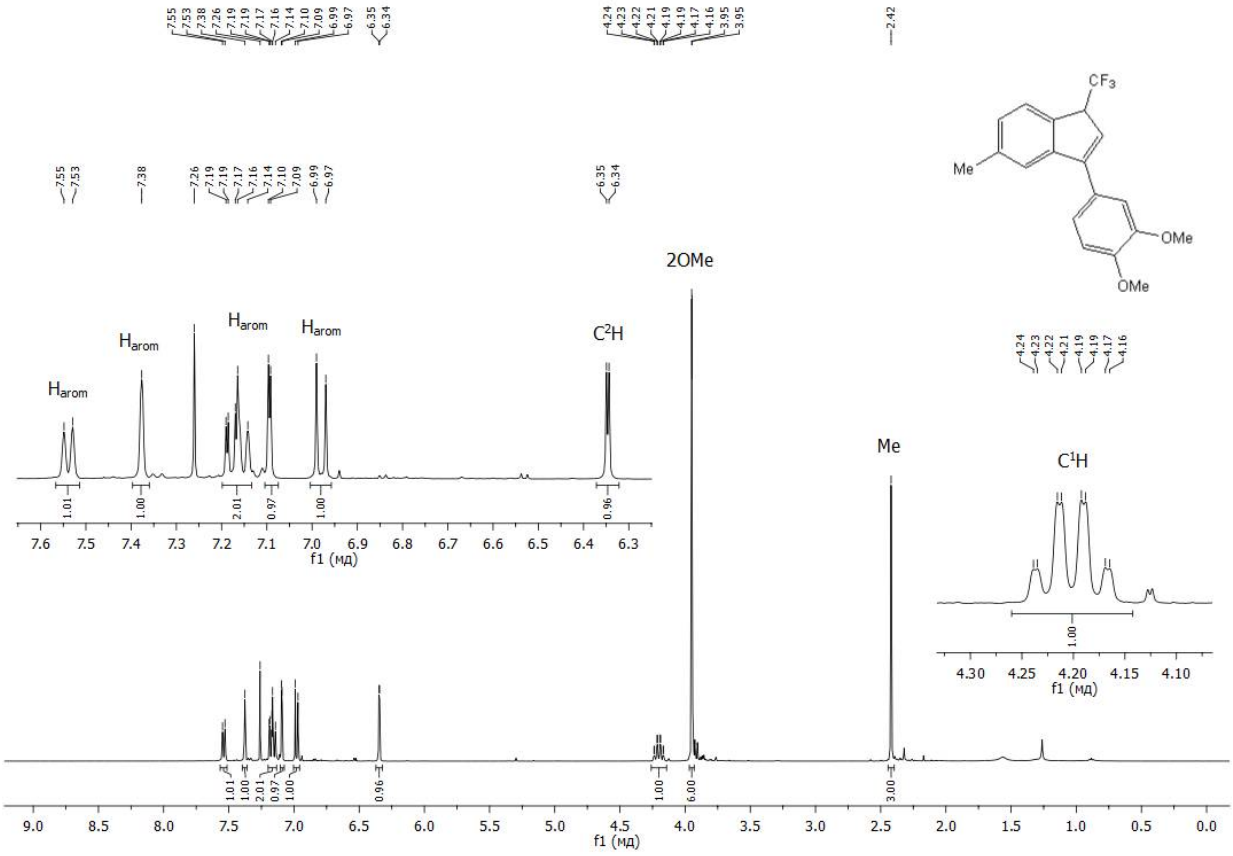


Fig. S154. ^{1}H NMR spectrum of the compound **4i** ($CDCl_3$, 400 MHz).

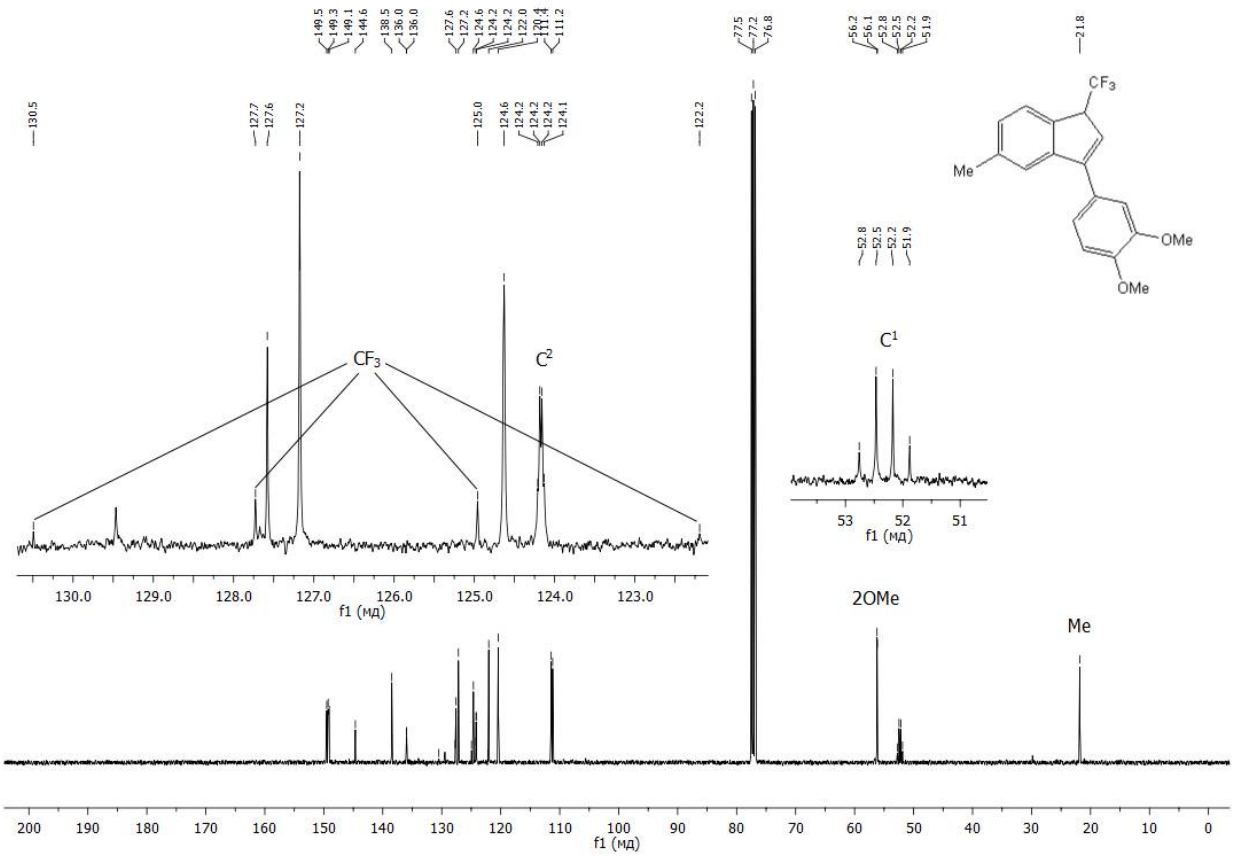


Fig. S155. ^{13}C NMR spectrum of the compound **4i** ($CDCl_3$, 100 MHz).

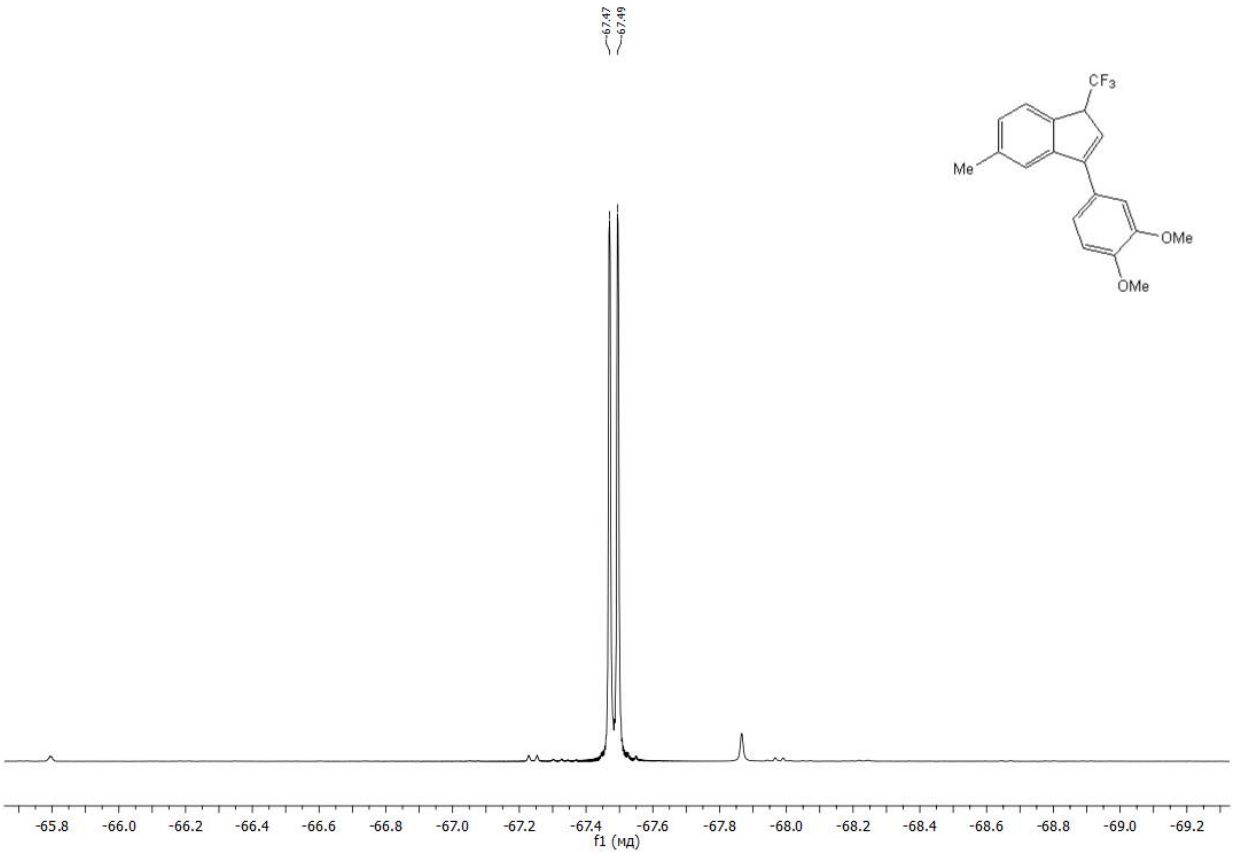


Fig. S156. ^{19}F NMR spectrum of the compound **4i** ($CDCl_3$, 376 MHz).

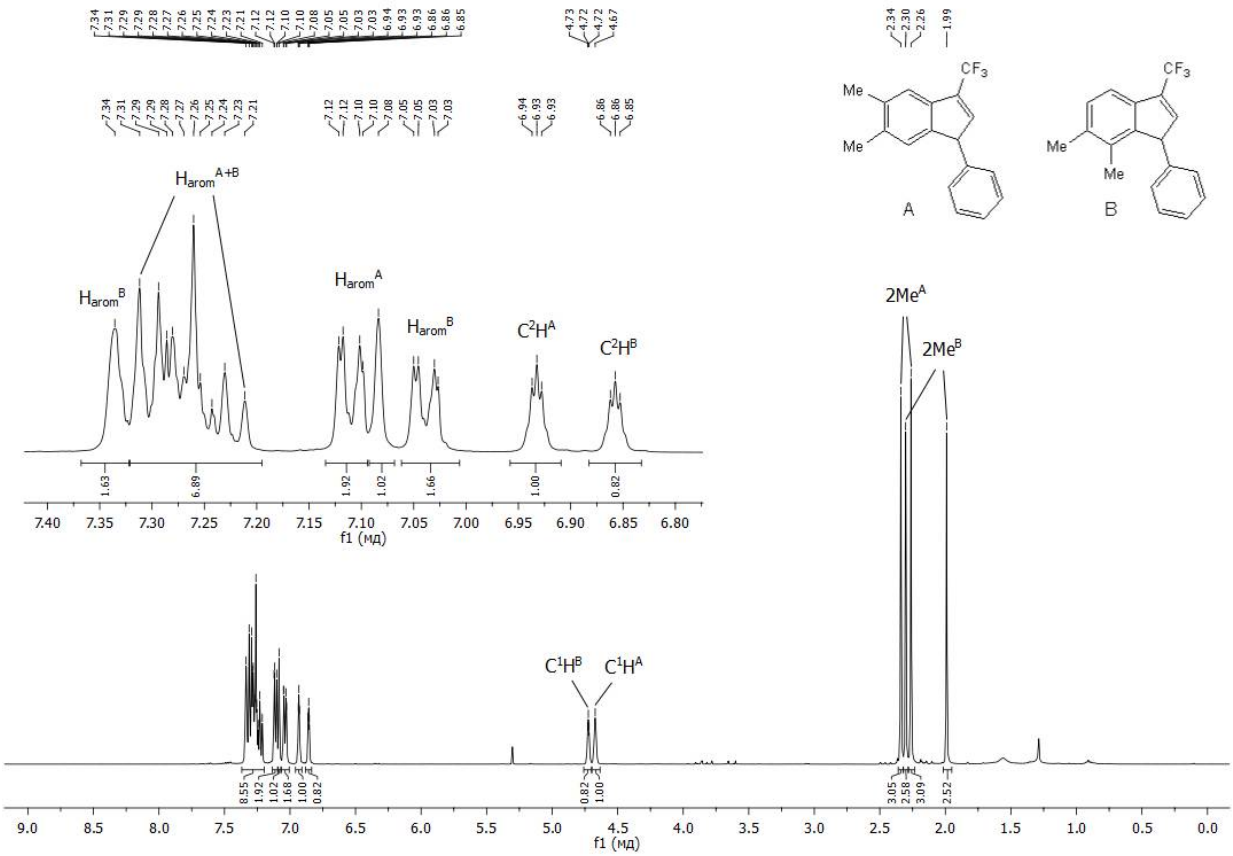


Fig. S157. ^{1}H NMR spectrum of mixture of the compounds **4j1** (A) and **3j2** (B) ($CDCl_3$, 400 MHz).

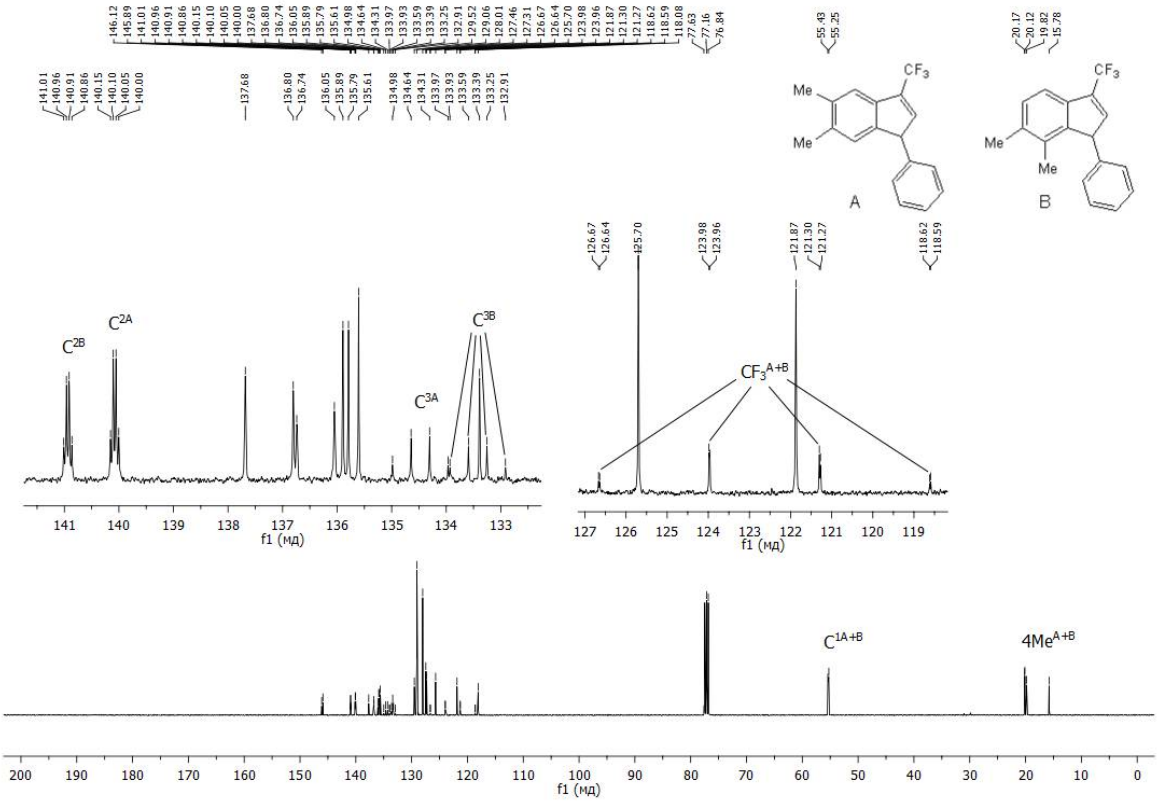


Fig. S158. ^{13}C NMR spectrum of mixture of the compounds **4j1** (A) and **3j2** (B) ($CDCl_3$, 100 MHz).

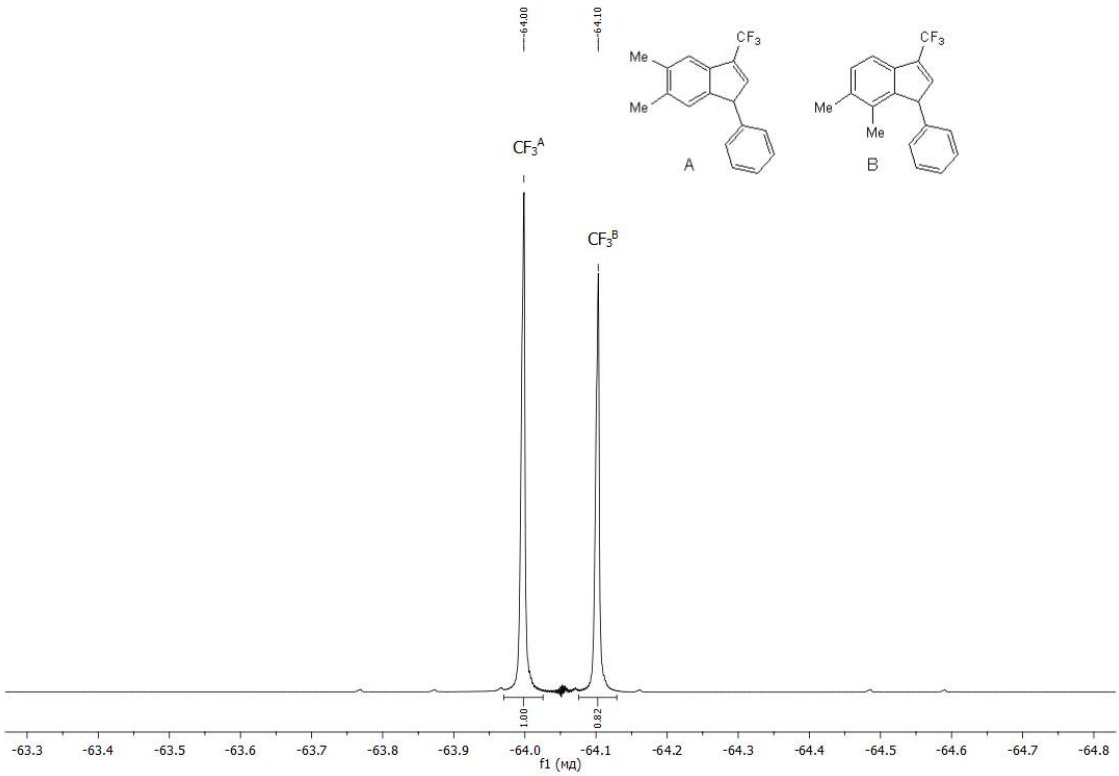


Fig. S159. ^{19}F $\{^{1}H\}$NMR spectrum of mixture of the compounds **4j1** (A) and **3j2** (B) ($CDCl_3$, 376 MHz).

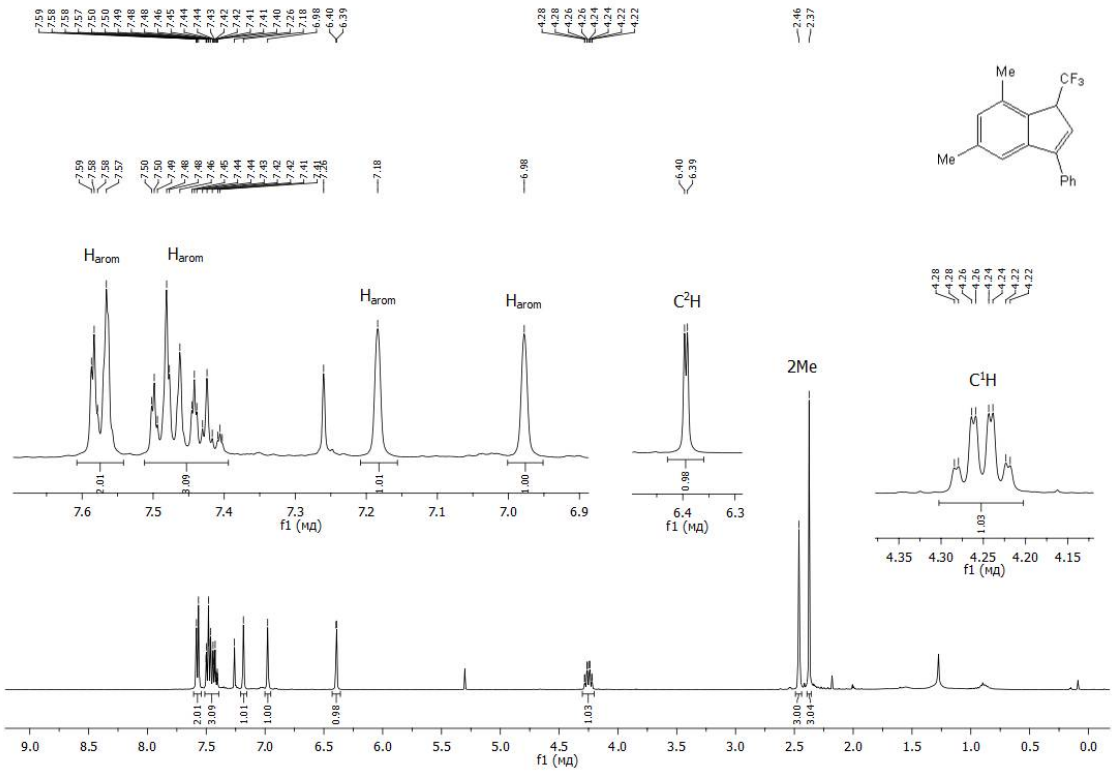


Fig. S160. ^{1}H NMR spectrum of the compound **4k** ($CDCl_3$, 400 MHz).

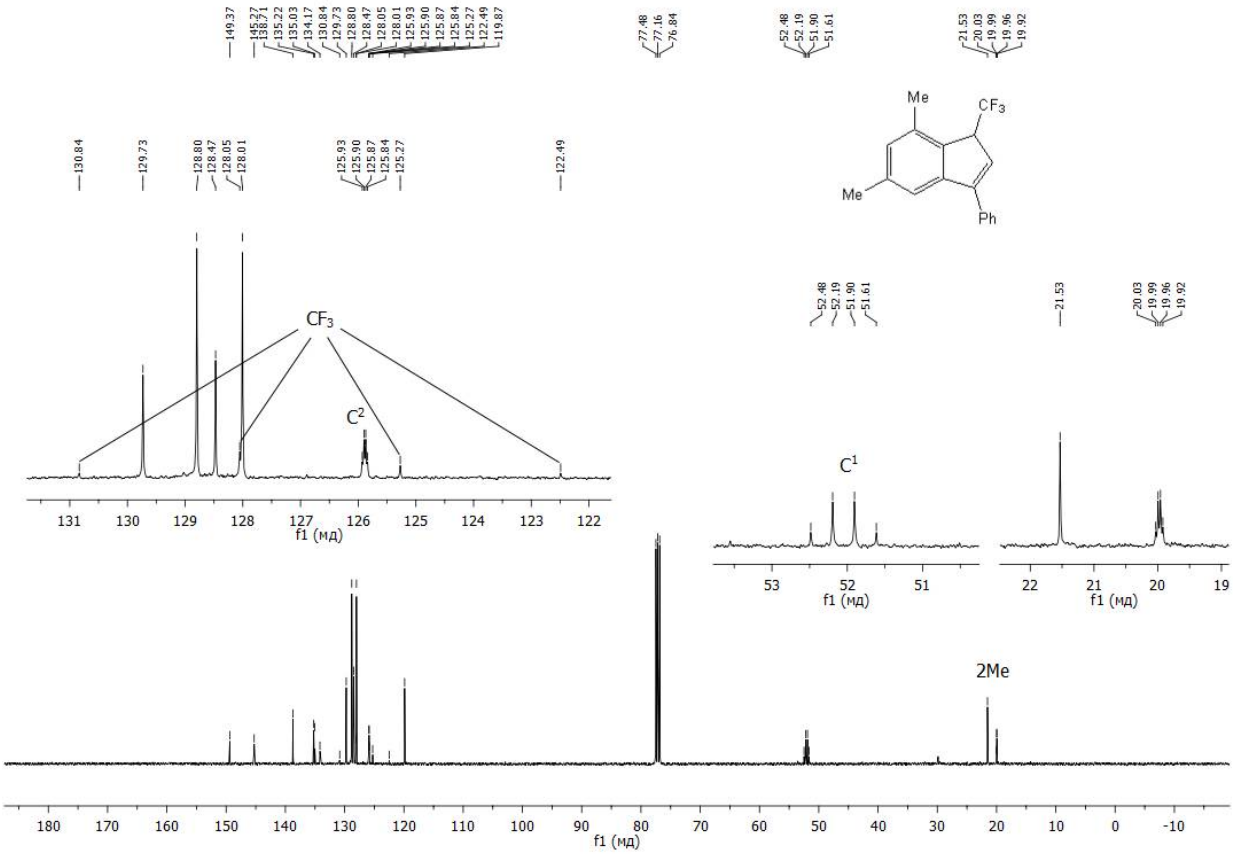


Fig. S161. ^{13}C NMR spectrum of the compound **4k** ($CDCl_3$, 100 MHz).

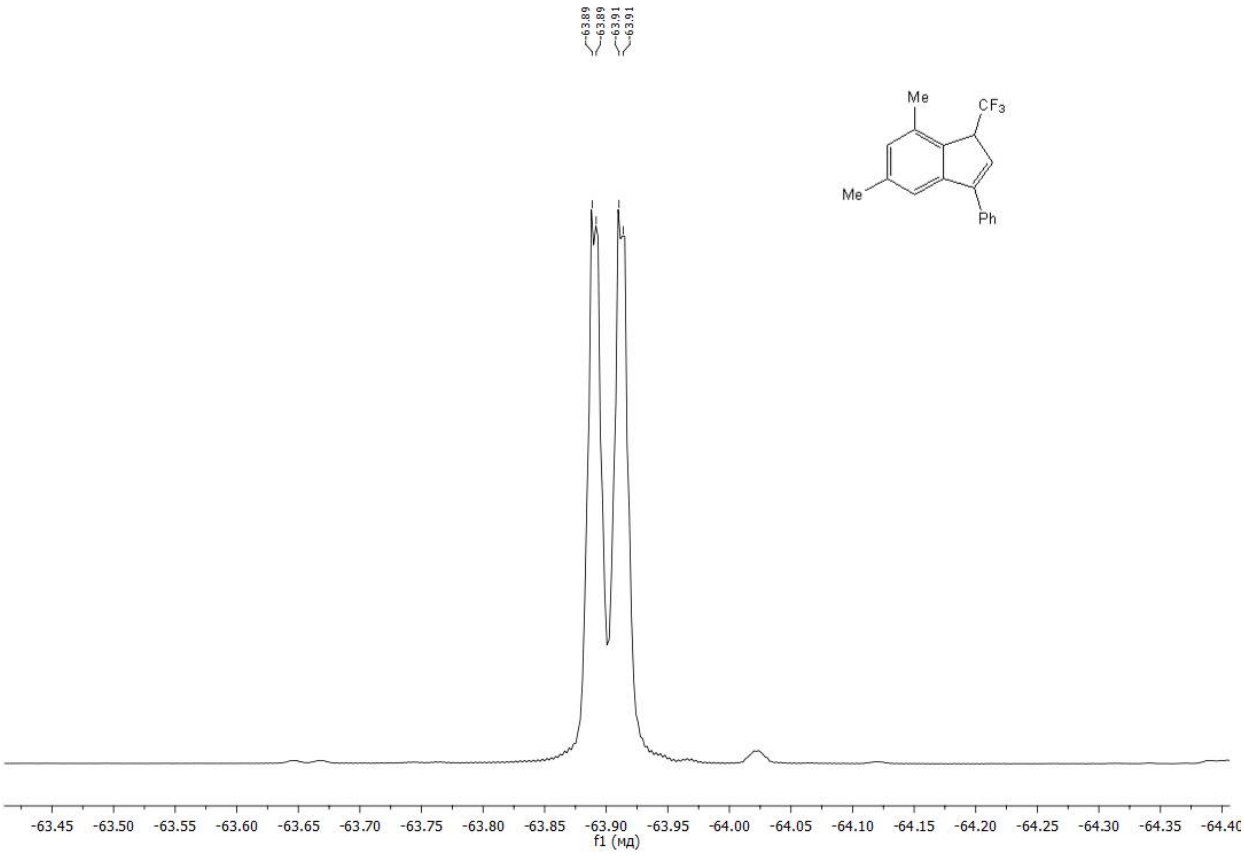


Fig. S162. ^{19}F NMR spectrum of the compound **4k** ($CDCl_3$, 376 MHz).

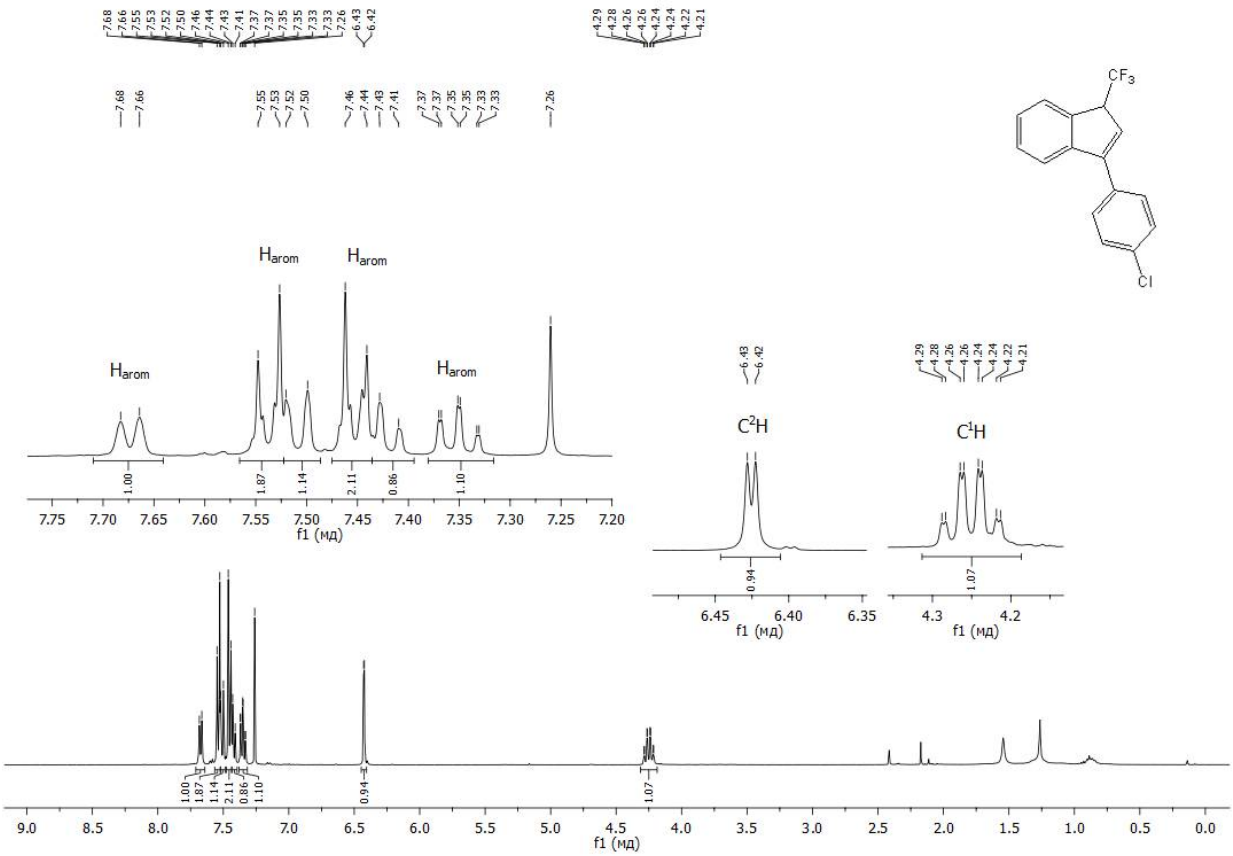


Fig. S163. ^{1}H NMR spectrum of the compound **4o** ($CDCl_3$, 400 MHz).

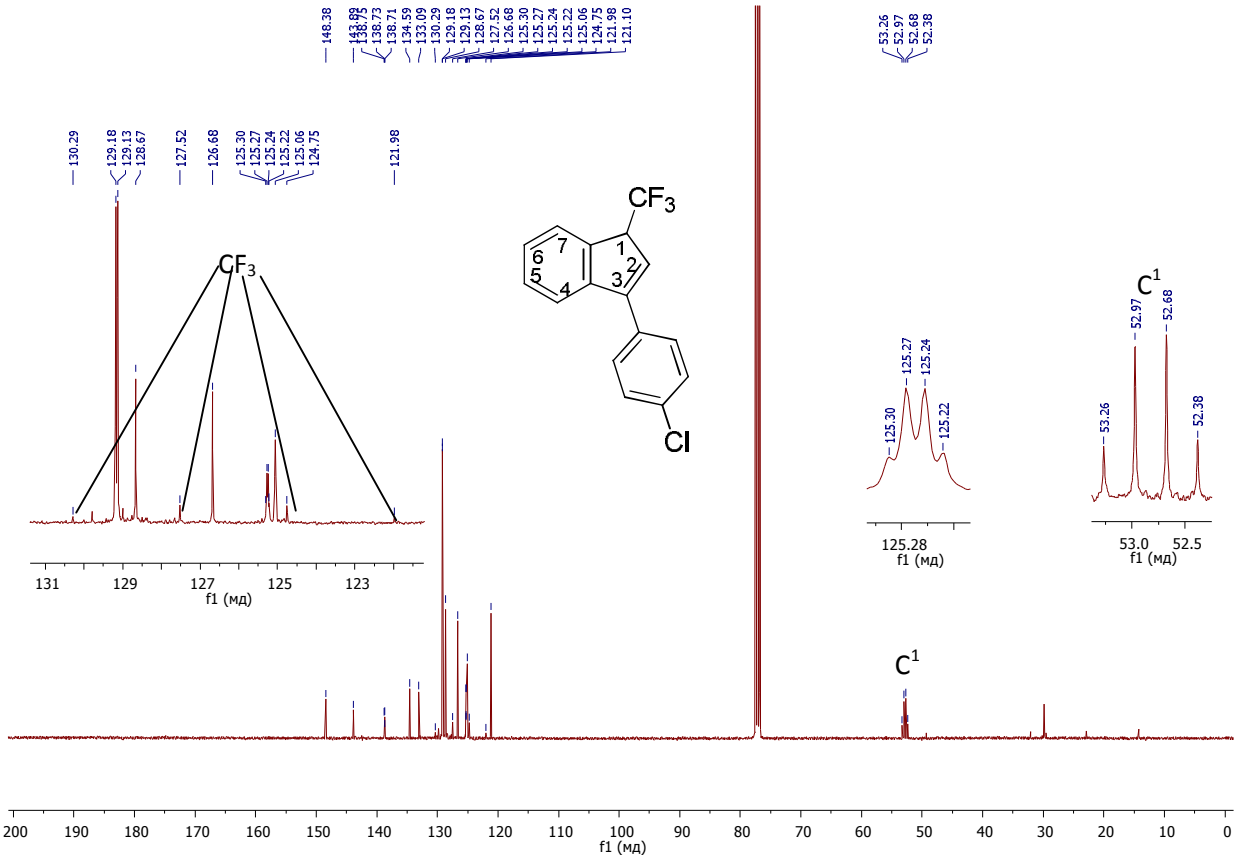


Fig. S164. ^{13}C NMR spectrum of the compound **4o** ($CDCl_3$, 100 MHz).

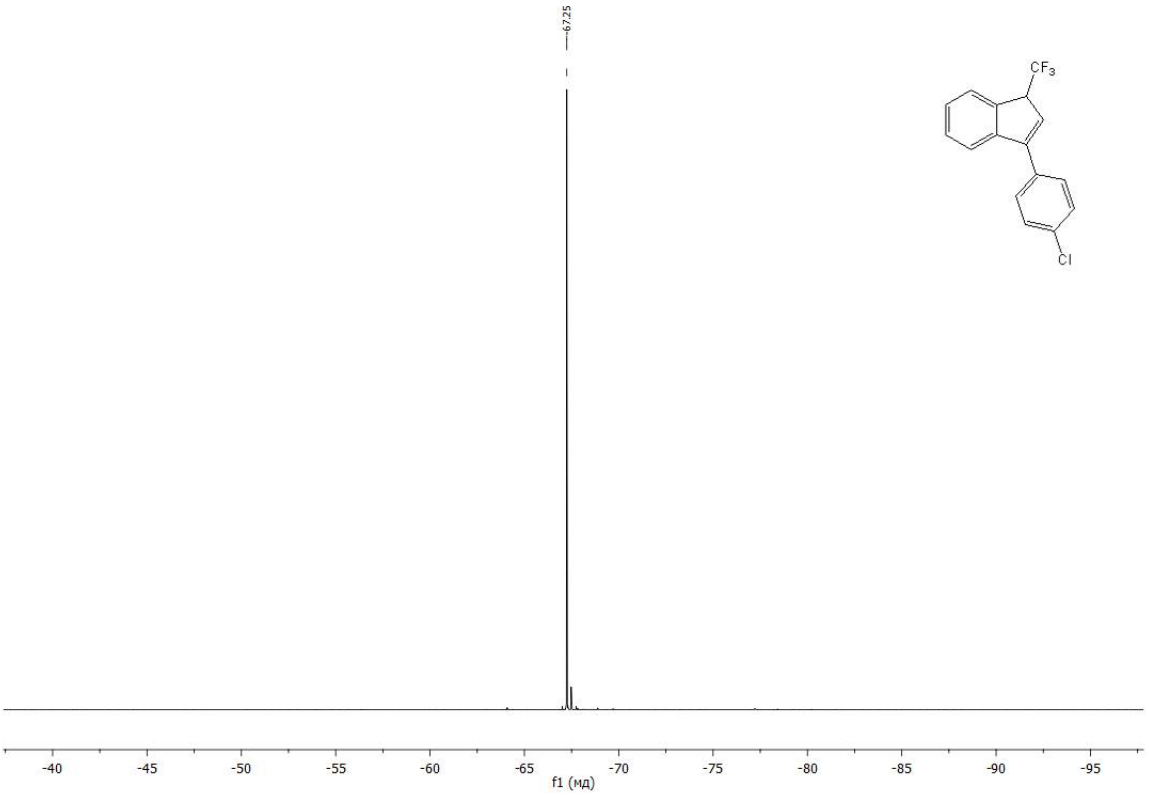


Fig. S165. ^{19}F NMR spectrum of the compound **4o** ($CDCl_3$, 376 MHz).

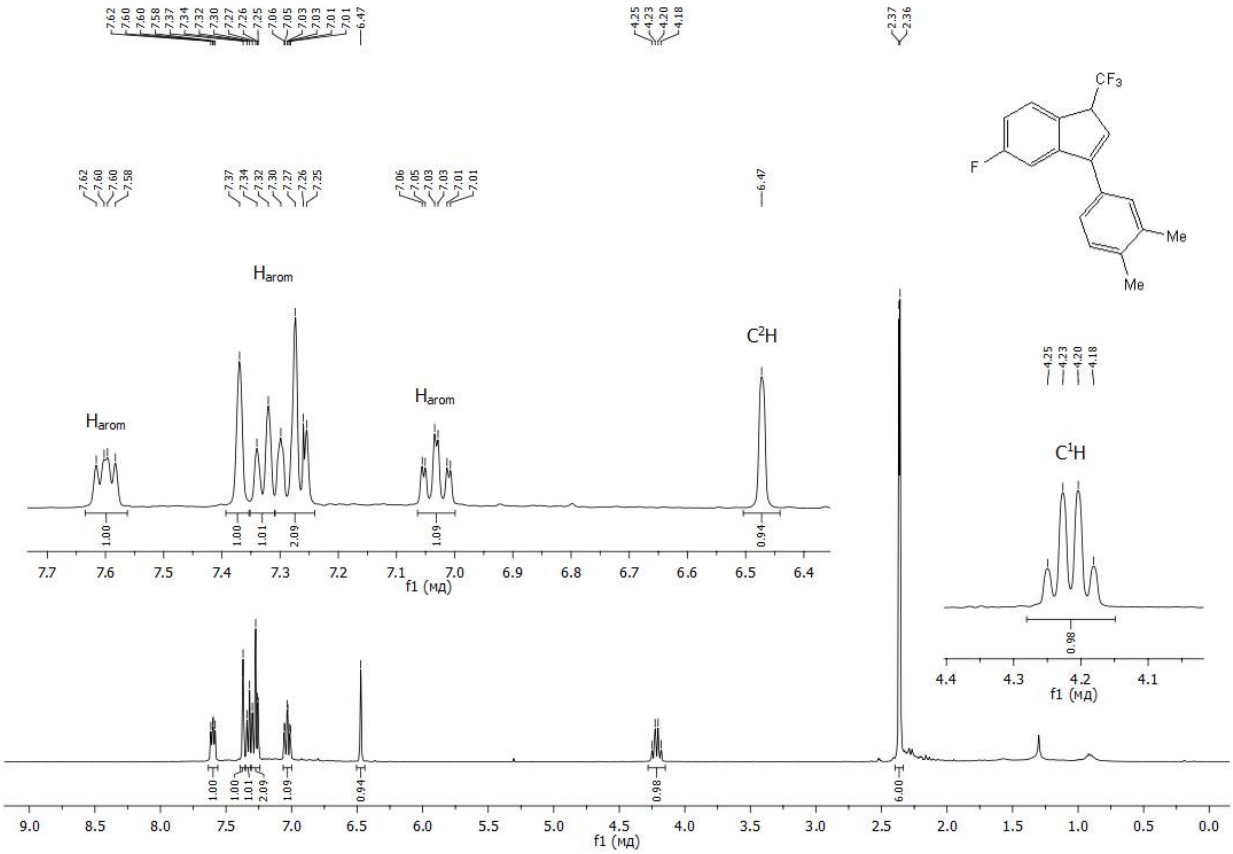


Fig. S166. ^{1}H NMR spectrum of the compound **4p** ($CDCl_3$, 400 MHz).

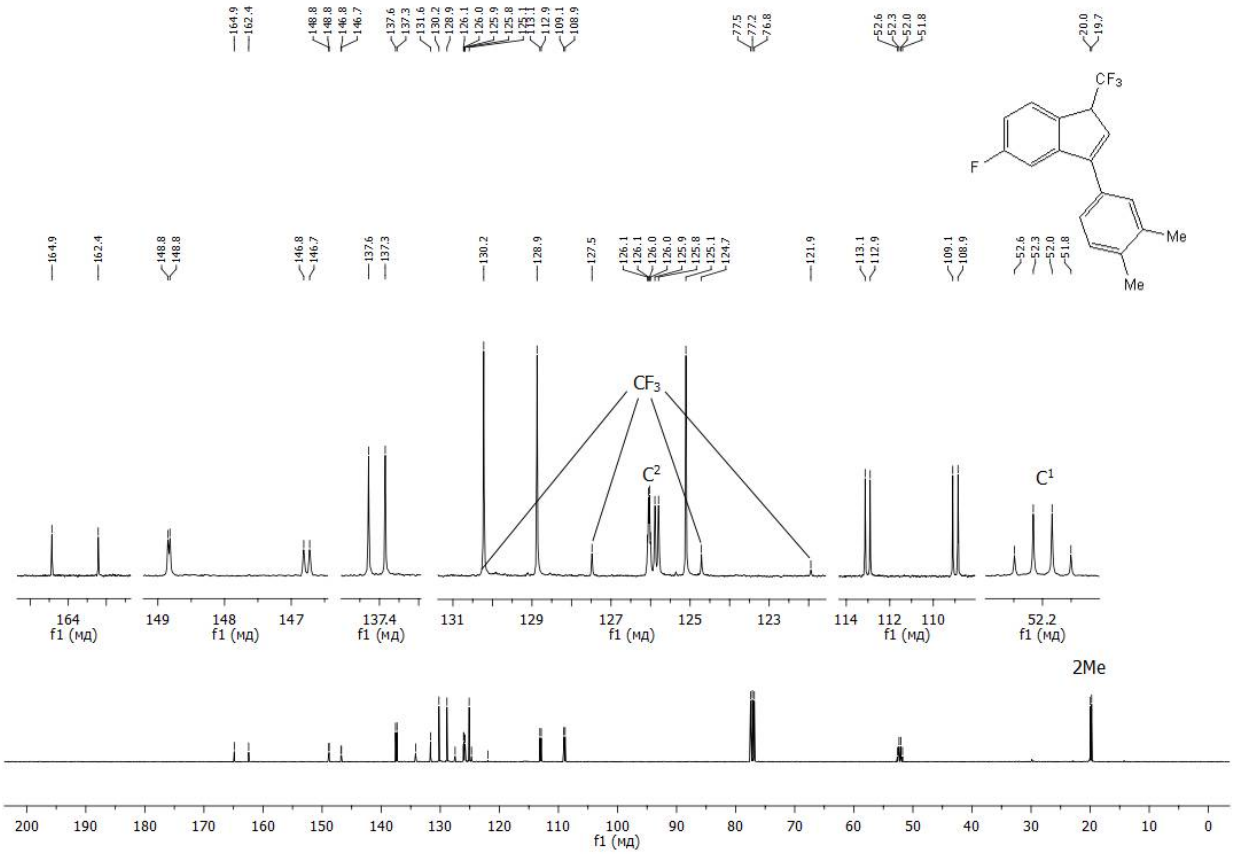


Fig. S167. ^{13}C NMR spectrum of the compound **4p** ($CDCl_3$, 100 MHz).

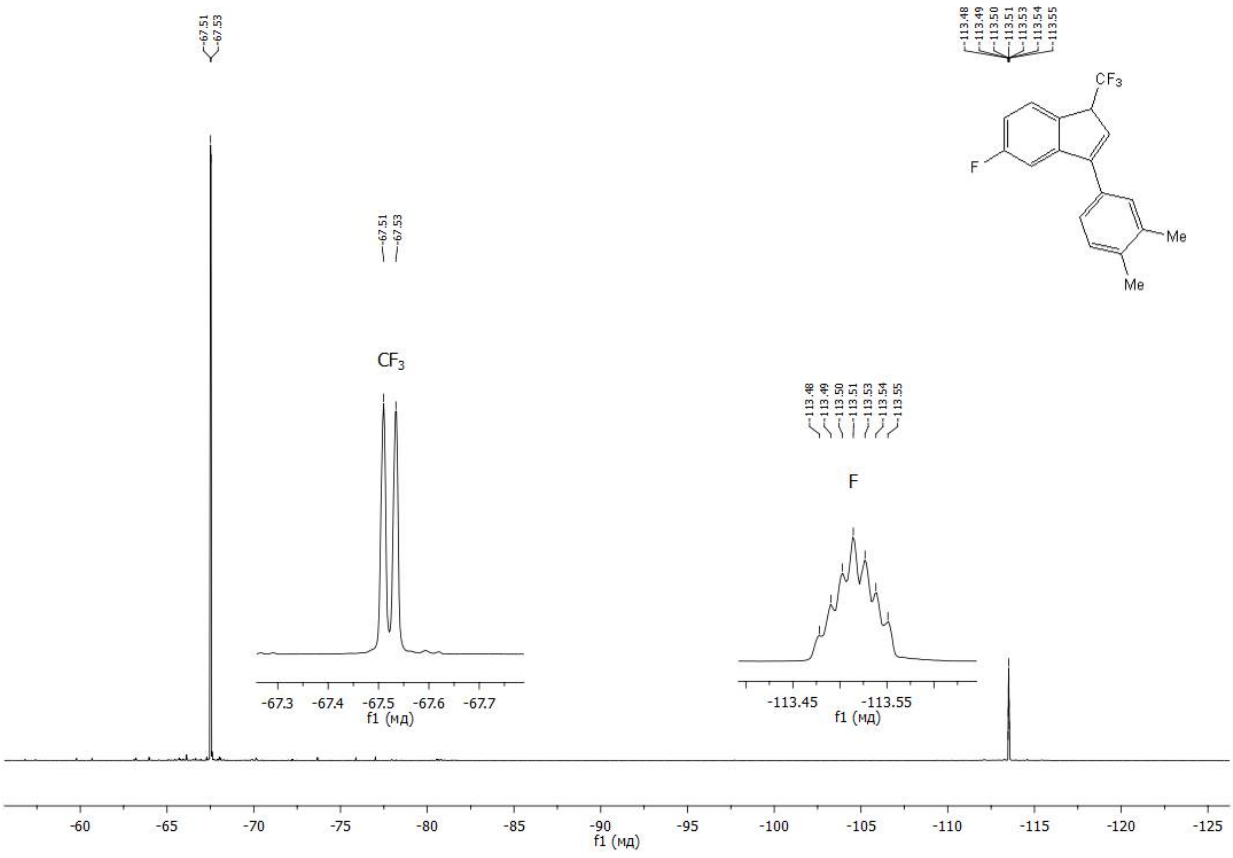


Fig. S168. ^{19}F NMR spectrum of the compound **4p** ($CDCl_3$, 376 MHz).

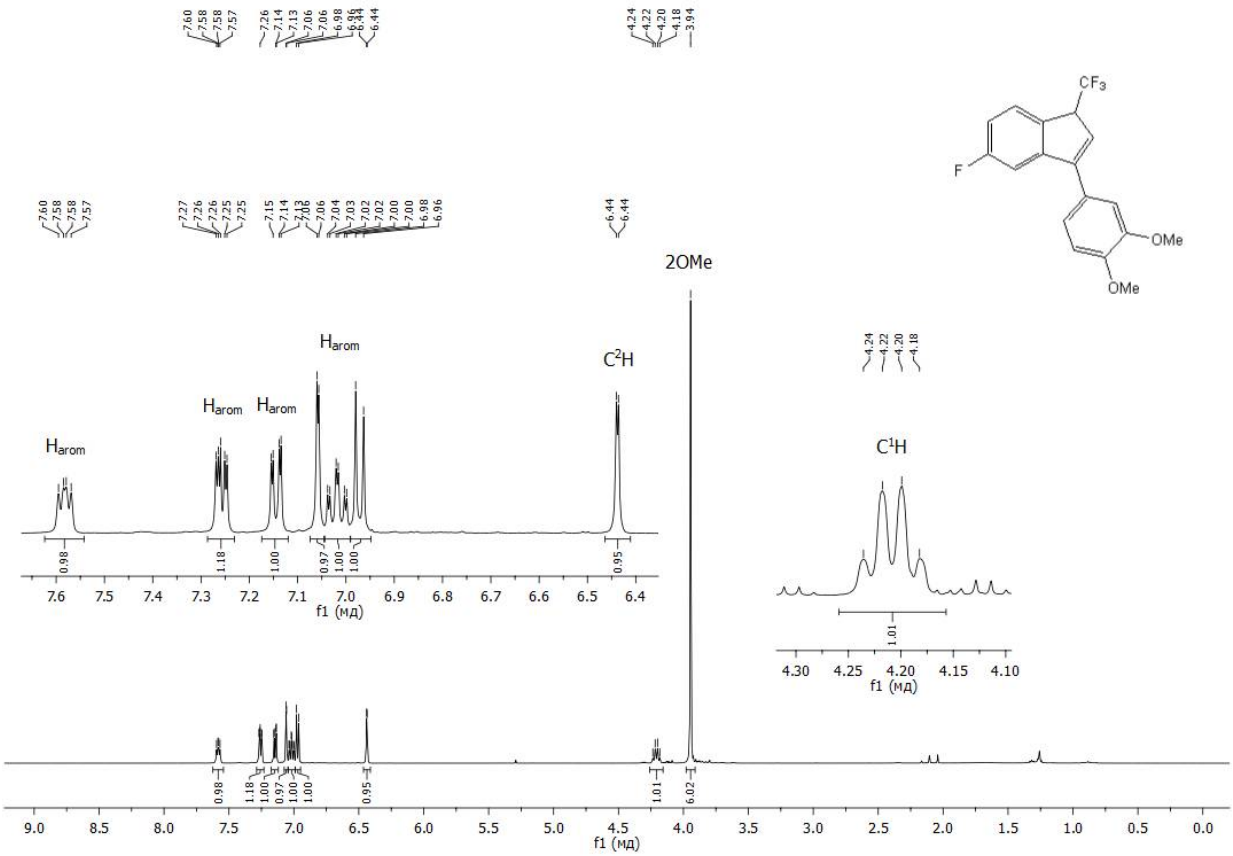


Fig. S169. ^{1}H NMR spectrum of the compound **4q** ($CDCl_3$, 400 MHz).

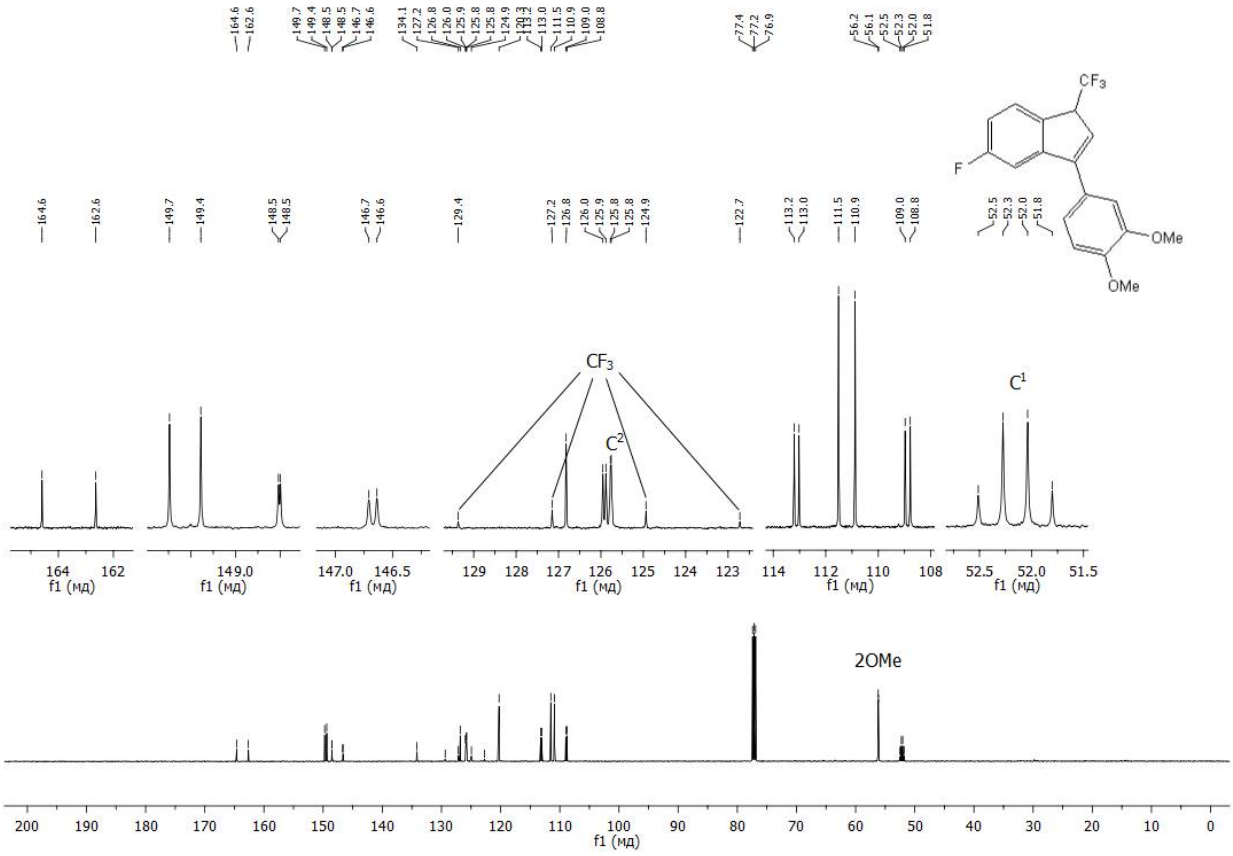


Fig. S170. ^{13}C NMR spectrum of the compound **4q** ($CDCl_3$, 100 MHz)

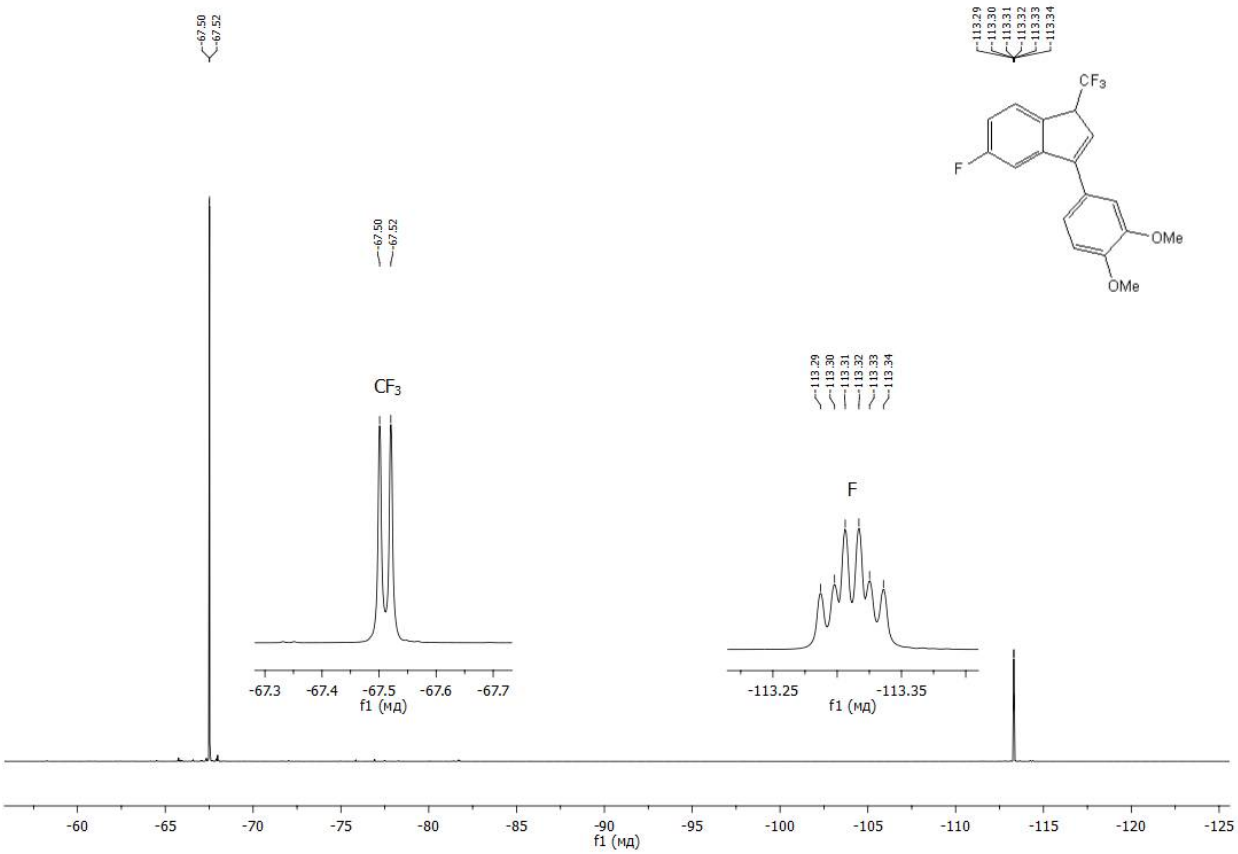


Fig. S171. ^{19}F NMR spectrum of the compound **4q** ($CDCl_3$, 376 MHz).