



# Ressonância Magnética Nuclear - RMN

## Espectroscopia

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## **Acoplamento de $^1\text{H}$ e $^{13}\text{C}$ com Outros Núcleos**

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## Outros Núcleos

- núcleo de  $^{19}\text{F}$ 
  - $I = \frac{1}{2}$
  - abundância 100 %
- núcleo de  $^{31}\text{P}$ 
  - $I = \frac{1}{2}$
  - abundância 100 %
- núcleo de  $^{31}\text{P}$ 
  - $I = \frac{1}{2}$
  - abundância 0,37 %

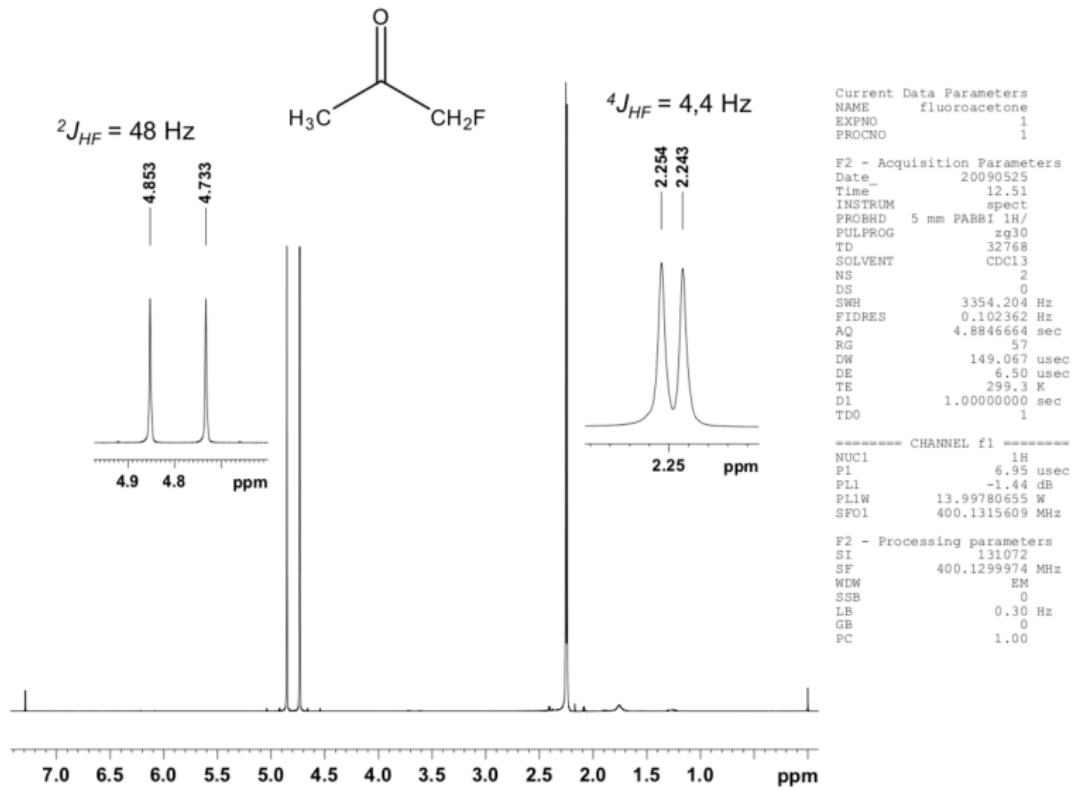
## **Espectros de $^1\text{H}$ e $^{13}\text{C}$ de moléculas com $^{19}\text{F}$**

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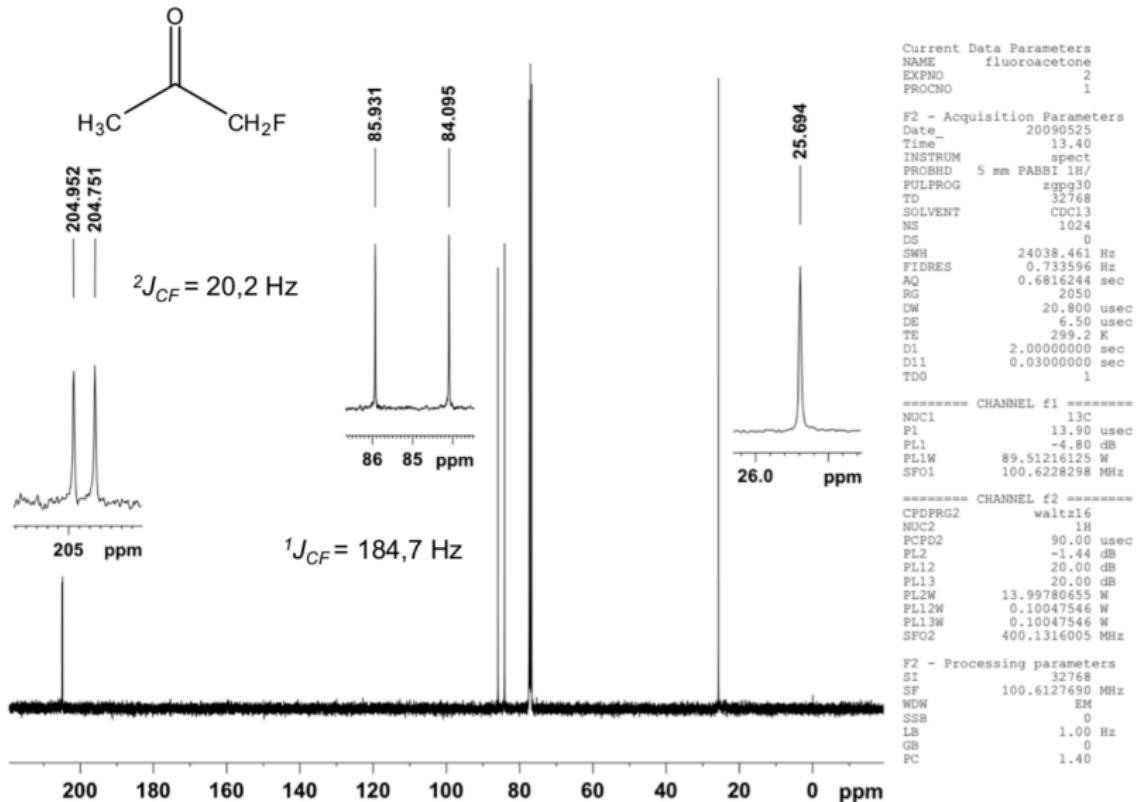
# Núcleo de $^{19}\text{F}$

- $I = \frac{1}{2}$
- Acoplamentos típicos com  $^1\text{H}$ 
  - ${}^1J_{\text{HF}} = 500 \text{ Hz}$
  - ${}^2J_{\text{HF}} = 40 - 60 \text{ Hz}$
  - ${}^3J_{\text{HF}} = 5 - 15 \text{ Hz}$
  - ${}^4J_{\text{HF}} = 1 - 5 \text{ Hz}$
- Acoplamentos típicos com  $^{13}\text{C}$ 
  - ${}^1J_{\text{CF}} = 150 - 300 \text{ Hz}$
  - ${}^2J_{\text{CF}} = 10 - 30 \text{ Hz}$
  - ${}^3J_{\text{CF}} = 3 - 15 \text{ Hz}$

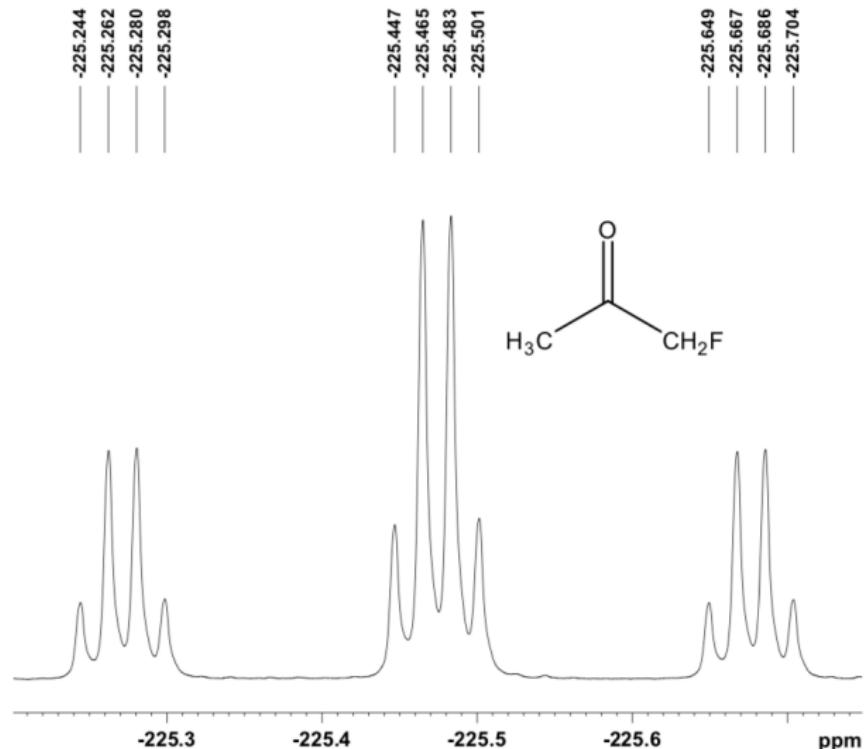
# Espectro de $^1\text{H}$ da Flúoracetona



# Espectro de $^{13}\text{C}$ da Flúoracetona



# Espectro de $^{19}\text{F}$ da Flúoracetona



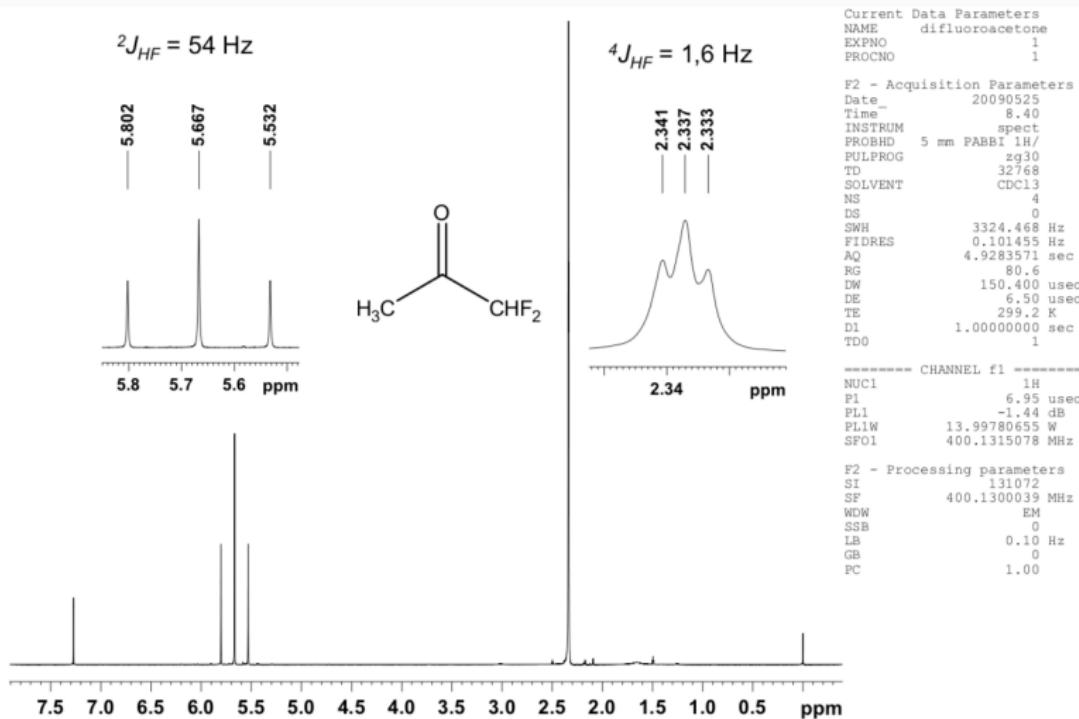
Current Data Parameters  
NAME 19F-fluoroacetone  
EXPNO 1  
PROCNO 1

F2 - Acquisition Parameters  
Date\_ 20090525  
Time 16.38  
INSTRUM spect  
PROBHD 5 mm QNP 1H/13  
PULPROG zgfgn  
TD 131072  
SOLVENT CDCl<sub>3</sub>  
NS 4  
DS 0  
SWH 1520.681 Hz  
FIDRES 0.011602 Hz  
AQ 43.0965233 sec  
RG 574.7  
DW 328.800 usec  
DE 6.00 usec  
TE 300.0 K  
D1 1.0000000 sec  
TDO 1

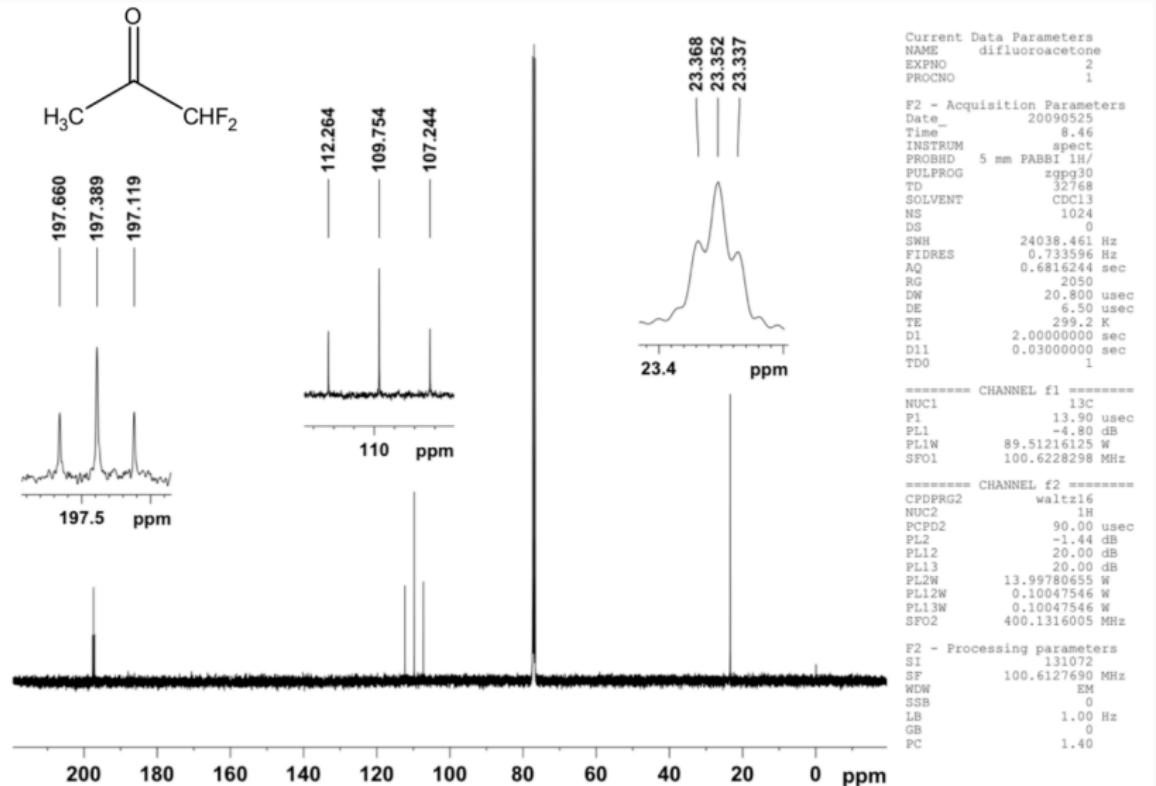
----- CHANNEL f1 -----  
NUC1 19F  
P1 13.60 usec  
PL1 -1.00 dB  
SF01 235.3043828 MHz

F2 - Processing parameters  
SI 131072  
SF 235.3573500 MHz  
WDW EM  
SSB 0  
LB 0.30 Hz  
GB 0  
PC 1.00

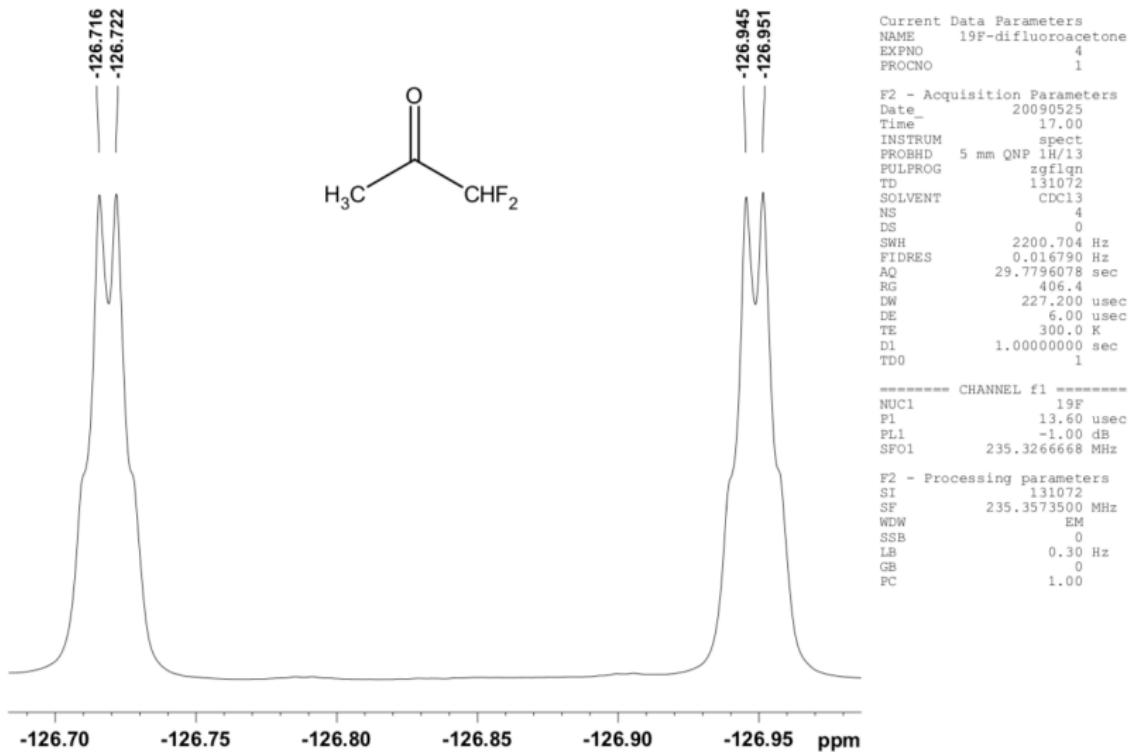
# Espectro de $^1\text{H}$ da Difluoracetona



# Espectro de $^{13}\text{C}$ da Difluoracetona



# Espectro de $^{19}\text{F}$ da Difluoracetona



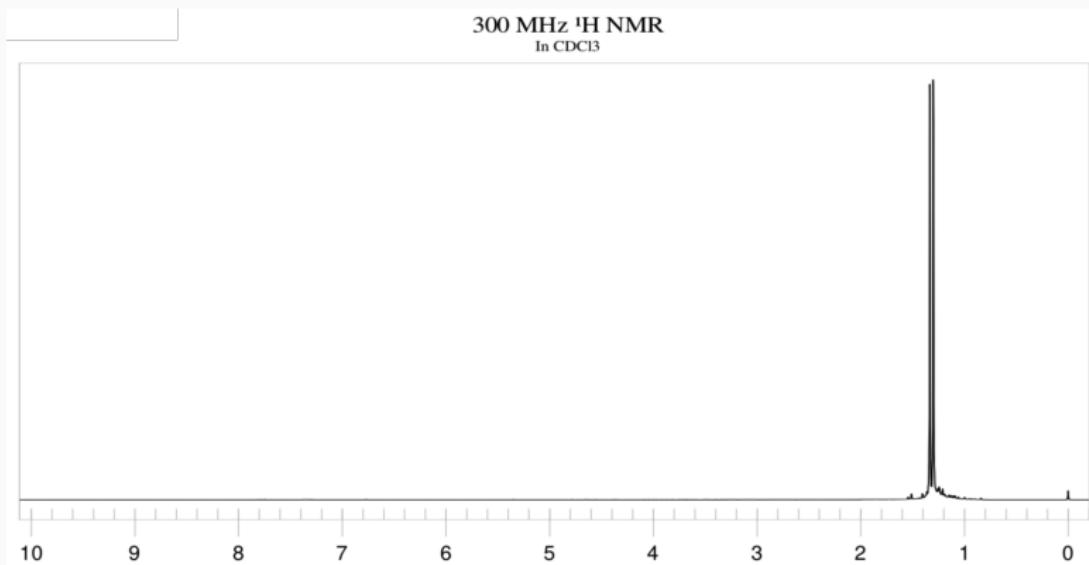
## **Espectros de $^1\text{H}$ e $^{13}\text{C}$ de moléculas $^{31}\text{P}$**

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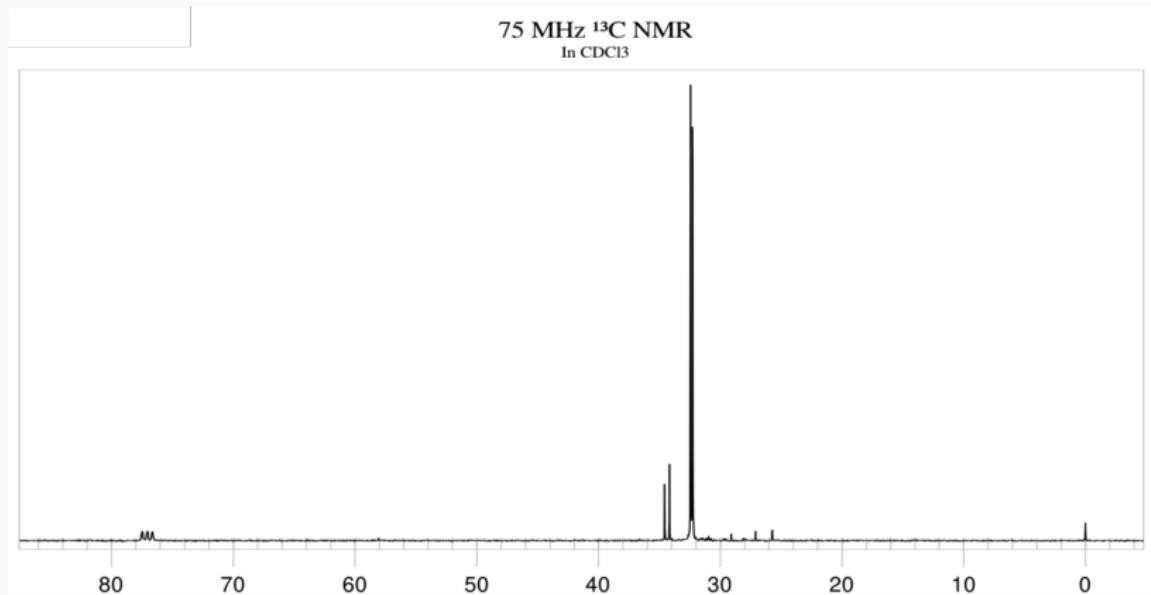
# Núcleo de $^{31}\text{P}$

- $I = \frac{1}{2}$
- Acoplamentos típicos com  $^1\text{H}$ 
  - ${}^1J_{\text{HP}} = 1000 - 180$  Hz
  - ${}^2J_{\text{HP}} = 30 - -10$  Hz
  - ${}^3J_{\text{HP}} = 30 - 10$  Hz
  - ${}^4J_{\text{HP}} = 1 - 5$  Hz
- Acoplamentos típicos com  $^{13}\text{C}$ 
  - ${}^1J_{\text{CP}} = 150 - -20$  Hz
  - ${}^2J_{\text{CP}} = 30 - 10$  Hz
  - ${}^3J_{\text{CP}} = 15 - 3$  Hz
  - ${}^4J_{\text{CP}} = 3 - 0$  Hz

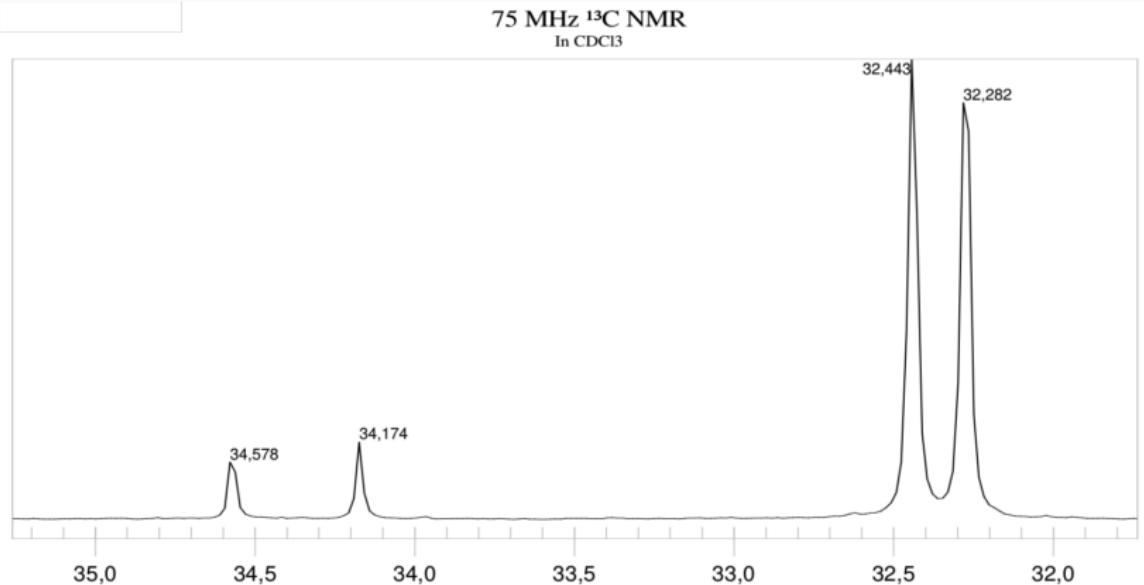
# Espectro de $^1\text{H}$ da tri-tercbutilfosfina



# Espectro de $^{13}\text{C}$ da tri-tercbutilfosfina



# Espectro de $^{13}\text{C}$ da tri-tercbutilfosfina



## **Espectros de $^1\text{H}$ e $^{13}\text{C}$ de moléculas com $^{15}\text{N}$**

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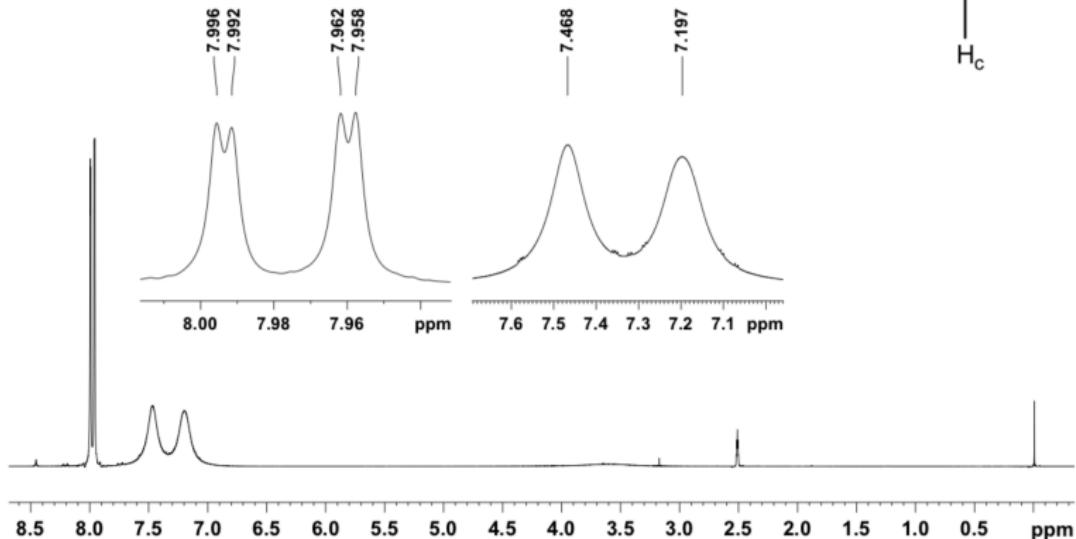
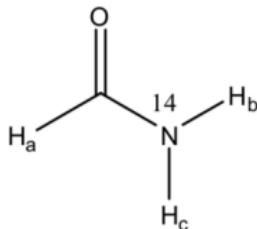
# Núcleo de N

- Núcleo de  $^{14}\text{N}$ 
  - $I = 1$
  - abundância de 99,63%
  - núcleo quadrupolar
  - $Q = 2,044 \times 10^{-30} \text{ m}^2$  ( $^2\text{D} \rightarrow Q = 0,286 \times 10^{-30} \text{ m}^2$ )
  - sinais de  $^1\text{H}$  são alargados
  - relação muito rápida - difícil observar acoplamento com  $^1\text{H}$
- Núcleo de  $^{15}\text{N}$ 
  - $I = \frac{1}{2}$
  - abundância 0,37 %
  - núcleo dipolar
  - sinais de  $^1\text{H}$  são finos
  - observação de acoplamento com  $^1\text{H}$

# Espectro de $^1\text{H}$ da Formamida

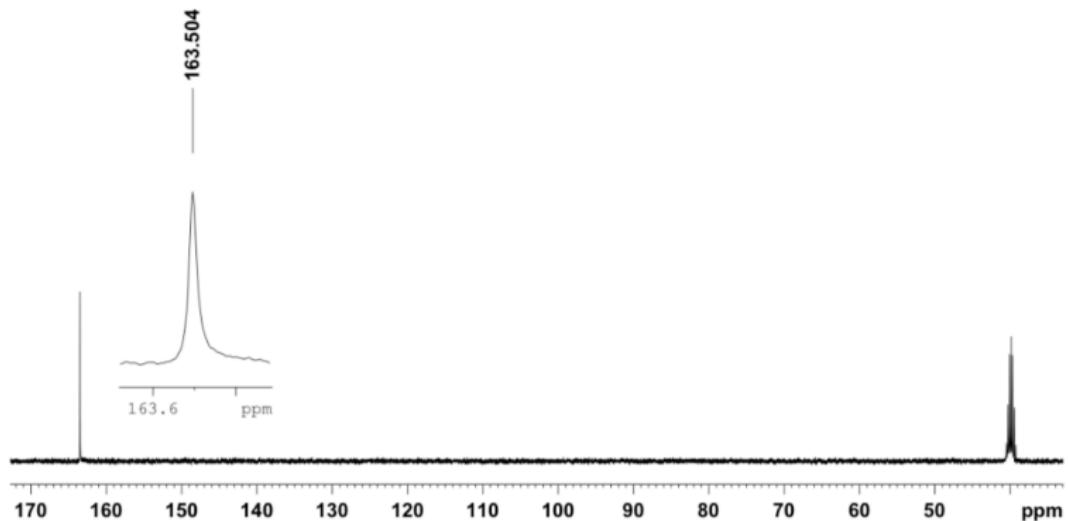
$$^3J_{\text{HaHc}} = 1,2 \text{ Hz}$$

$$^3J_{\text{HaHb}} = 13,5 \text{ Hz}$$



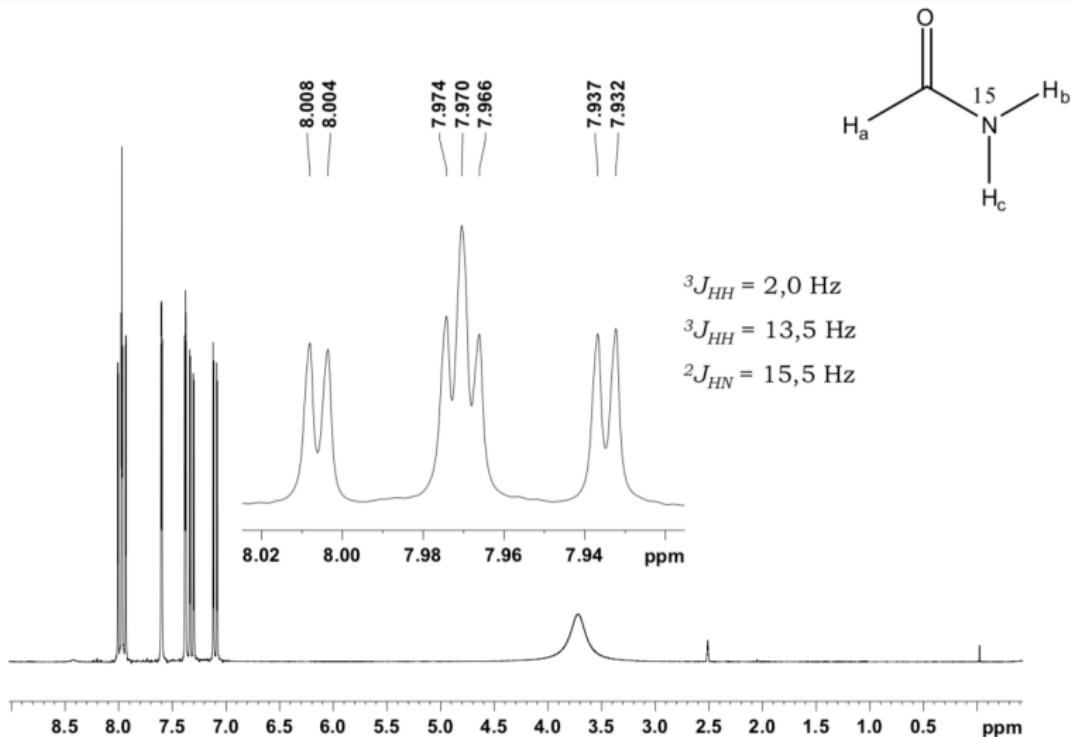
Espectro de RMN de  $^1\text{H}$  a 400 MHz em DMSO-d<sub>6</sub> para a formamida.

# Espectro de $^{13}\text{C}$ da Formamida



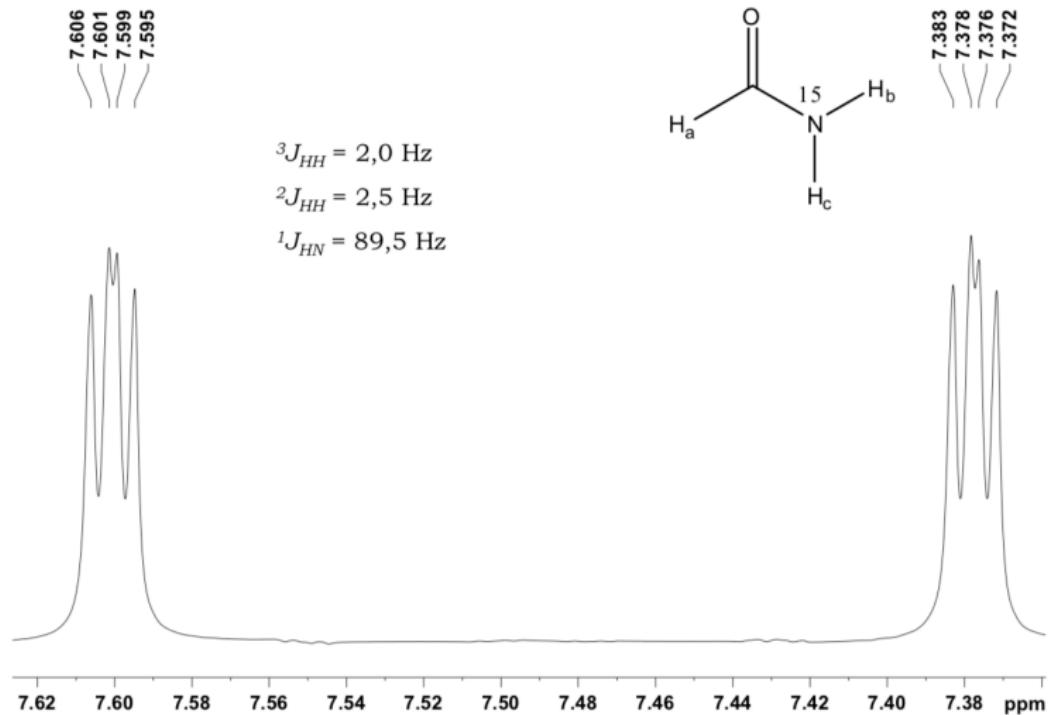
Espectro de RMN de  $^{13}\text{C}$  a 100 MHz em  $\text{DMSO-d}_6$  para a formamida.

# Espectro de $^1\text{H}$ da Formamida com 100 % de $^{15}\text{N}$



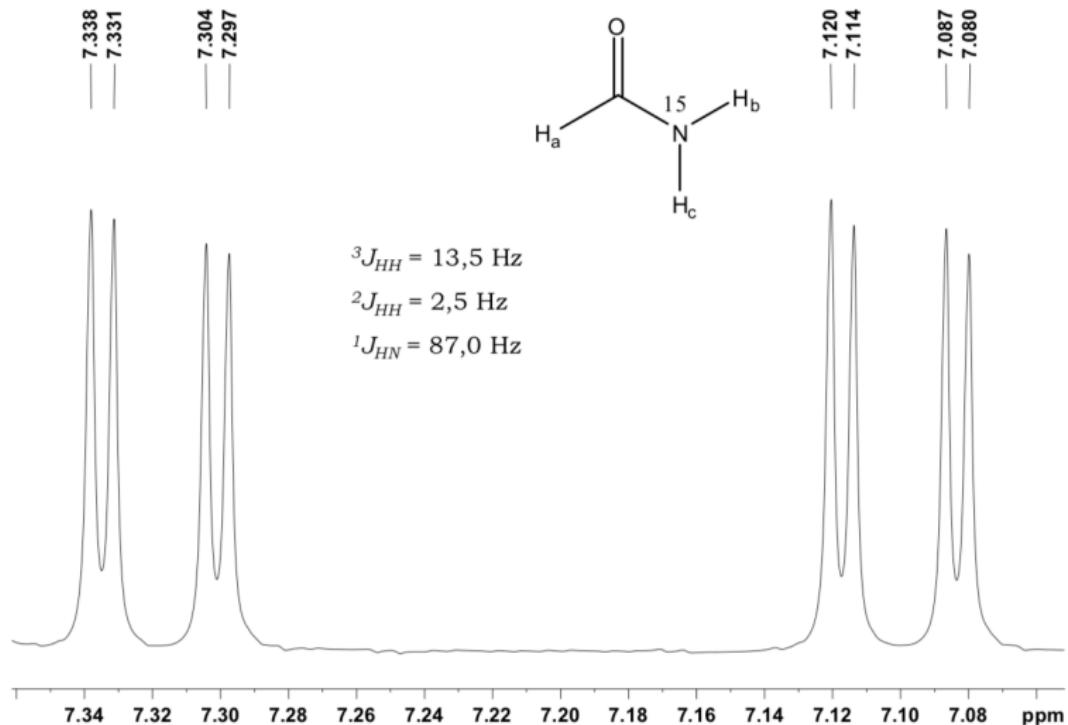
Espectro de RMN de  $^1\text{H}$  a 400 MHz em DMSO-d<sub>6</sub> para a formamida marcada.

# Espectro de $^1\text{H}$ da Formamida com 100 % de $^{15}\text{N}$



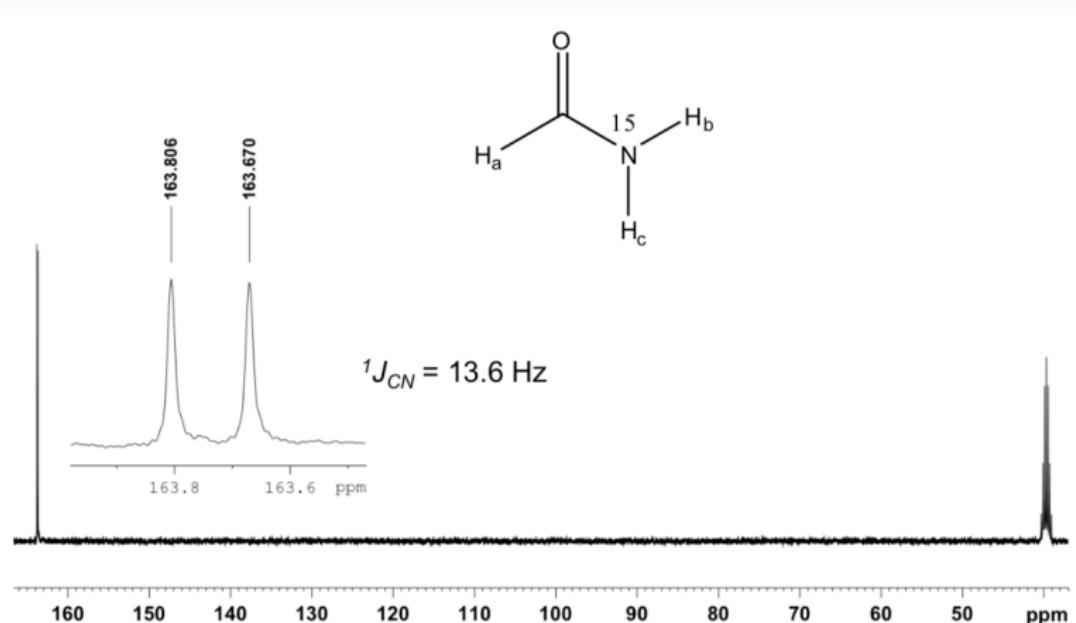
Espectro de RMN de  $^1\text{H}$  a 400 MHz em  $\text{DMSO-d}_6$  para a formamida marcada.

# Espectro de $^1\text{H}$ da Formamida com 100 % de $^{15}\text{N}$

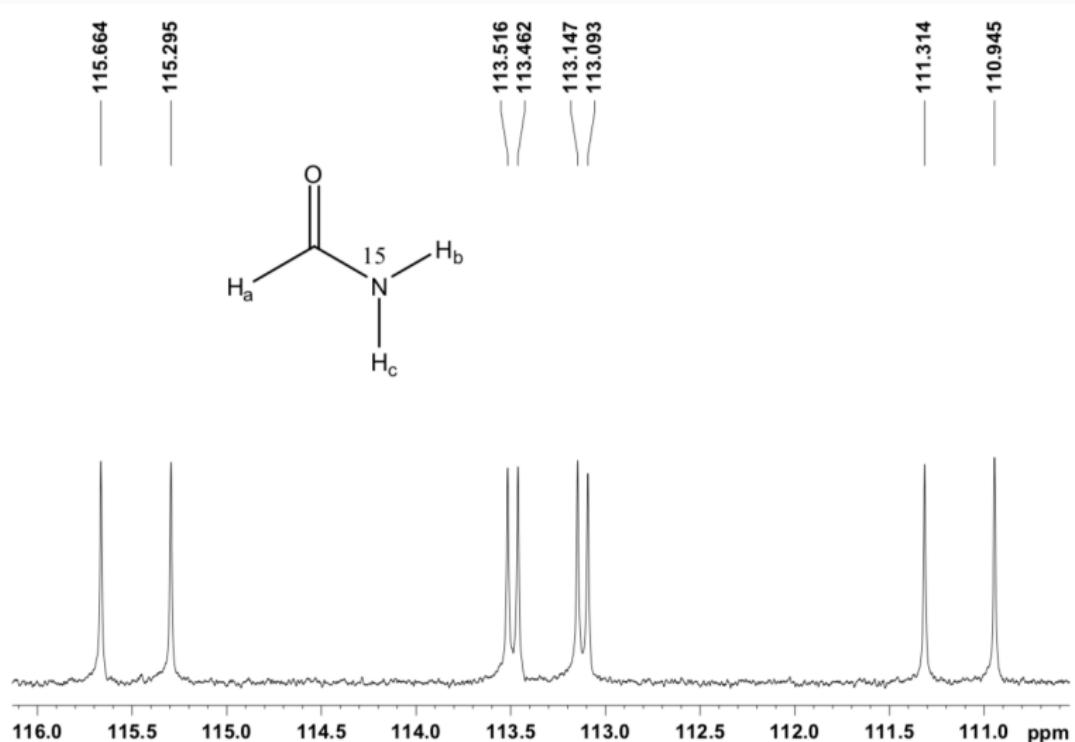


Espectro de RMN de  $^1\text{H}$  a 400 MHz em  $\text{DMSO-d}_6$  para a formamida marcada.

# Espectro de $^{13}\text{C}$ da Formamida com 100 % de $^{15}\text{N}$



# Espectro de $^{15}\text{N}$ da Formamida com 100 % de $^{15}\text{N}$



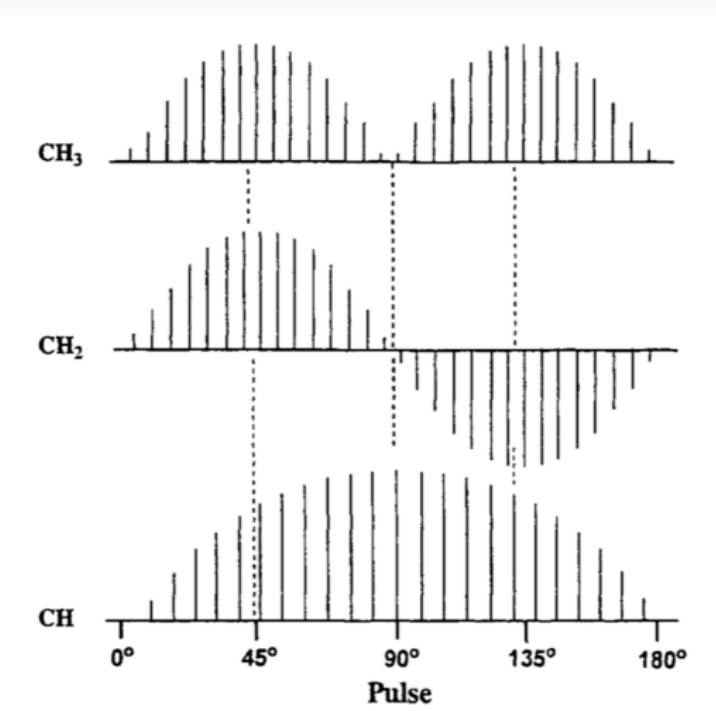
Espectro de RMN de  $^{15}\text{N}$  a 40.5 MHz em  $\text{DMSO-d}_6$  para a formamida marcada.

# **DEPT - Distortionless Enhancement by Polarization Transfer**

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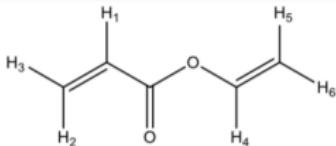
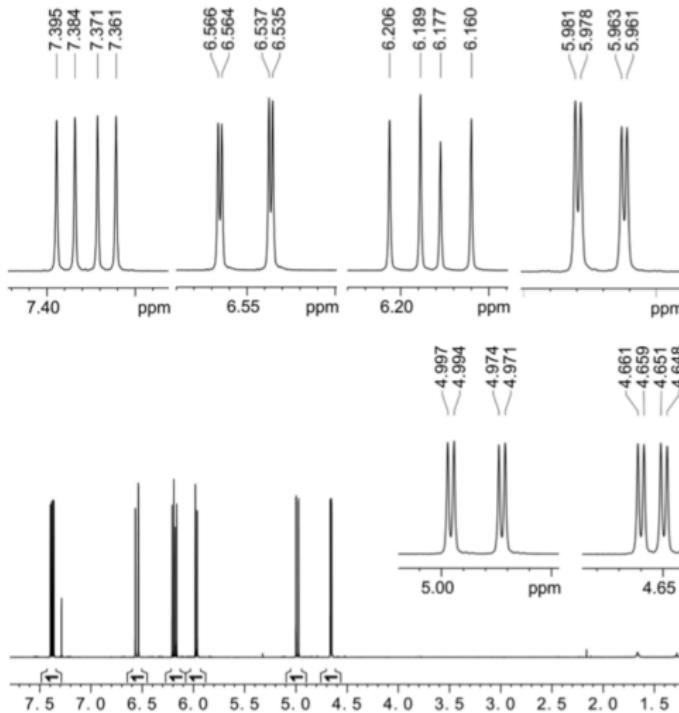
- Técnica de RMN 1D
- Determinar multiplicidade de  $^{13}\text{C}$
- DEPT45
  - intensidade positiva para CH,  $\text{CH}_2$  e  $\text{CH}_3$
  - intensidade nula para C
  - útil para subtrair do espectro de  $^{13}\text{C}$  e acharmos C
- DEPT90
  - intensidade positiva para CH
  - intensidade nula para C,  $\text{CH}_2$  e  $\text{CH}_3$
- DEPT135
  - intensidade negativa para CH,
  - intensidade positiva para  $\text{CH}_2$  e  $\text{CH}_3$
  - intensidade nula para C

# Distribuição da Intensidade de CH, CH<sub>2</sub> e CH<sub>3</sub> pela Largura do Pulso



# Espectro de $^1\text{H}$ do Acrilato de Vinila

## Exemplo



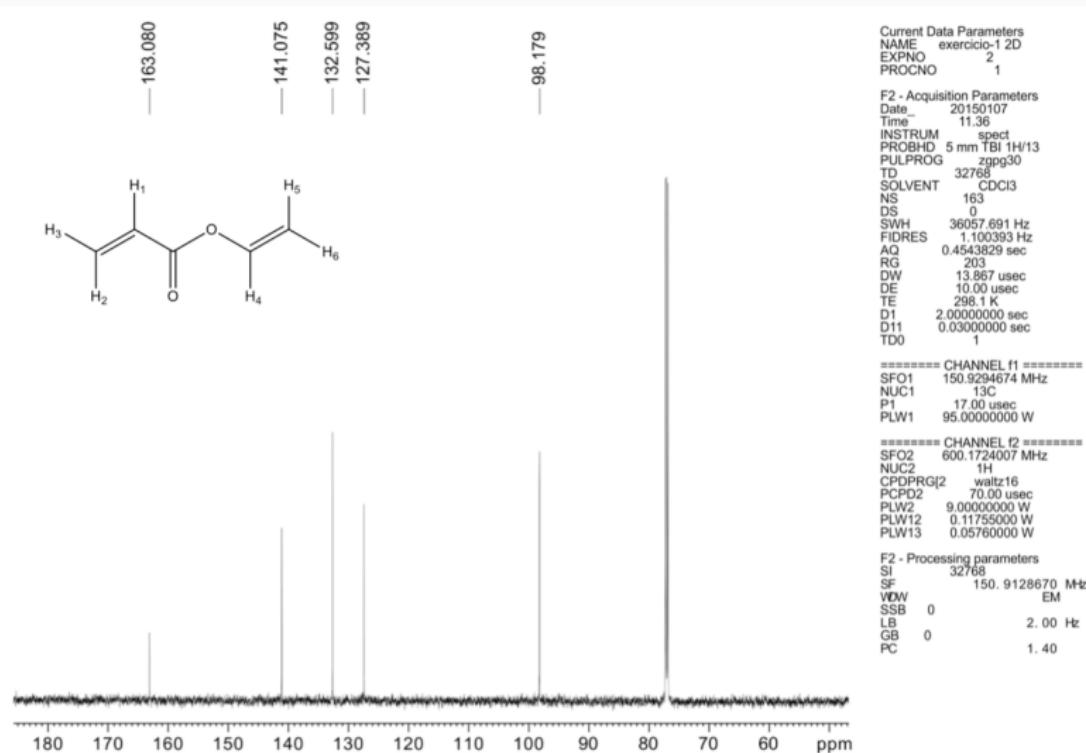
Current Data Parameters  
NAME Exercicio-1 2D  
EXPNO 1  
PROCNO 1

F2 - Acquisition Parameters  
Date 20150107  
Time 11:04  
INSTRUM spect  
PROBHD 5 mm TBI 1H/13C  
PULPROG zg30  
TD 65536  
SOLVENT CDCl<sub>3</sub>  
NS 4  
DS 0  
SWH 5933.544 Hz  
FIDRES 0.090539 Hz  
AQ 5.500000 sec  
RG 128  
DW 84.267 usec  
DE 6.50 usec  
TE 298.2 K  
D1 1.00000000 sec  
TD0 1

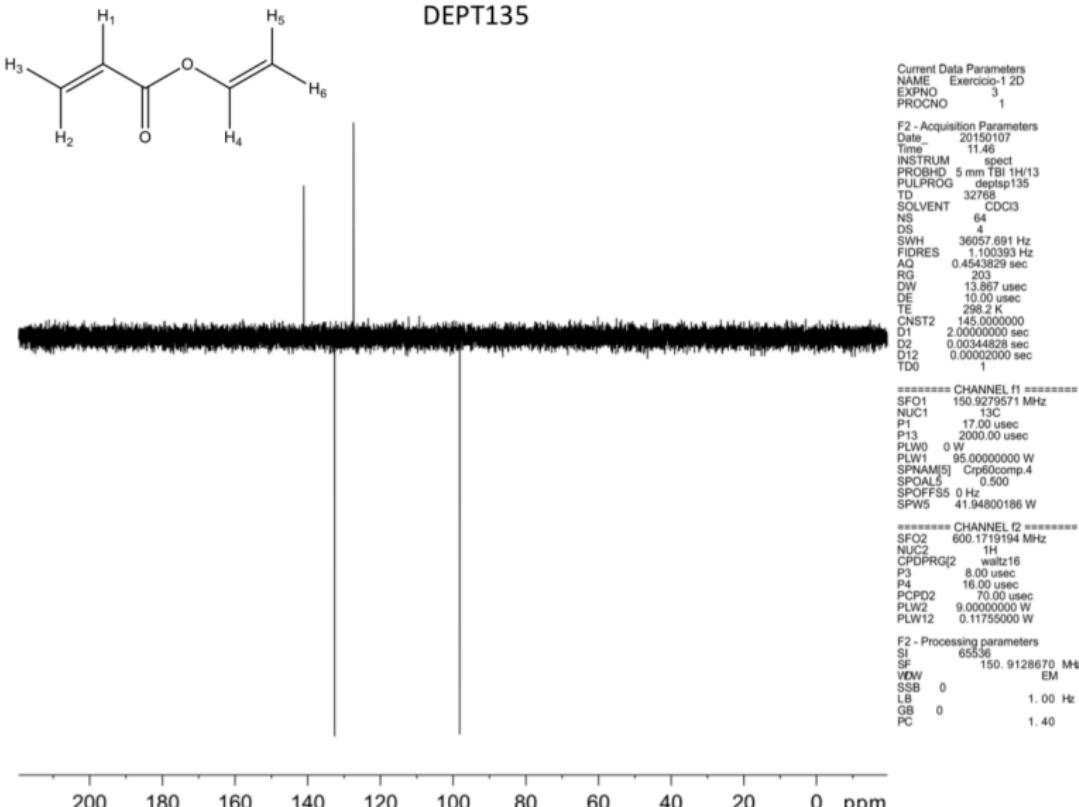
===== CHANNEL f1 ======  
SFO1 600.1723985 MHz  
NUC1 <sup>1</sup>H  
P1 7.15 usec  
PLW1 9.00000000 W

F2 - Processing parameters  
SI 131072  
SF 600.1700000 MHz  
WDW EM  
SSB 0  
LB 0 Hz  
GB 0  
PC 1.00

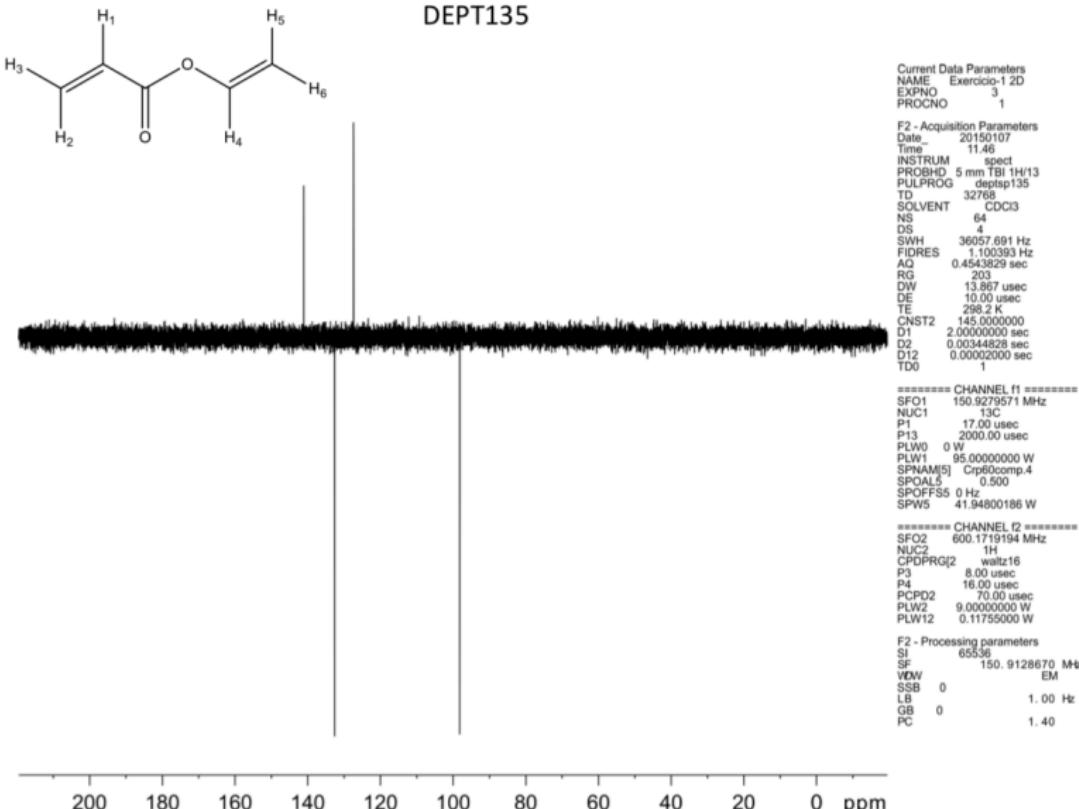
# Espectro de $^{13}\text{C}$ do Acrilato de Vinila



# Espectro de DEPT135 do Acrilato de Vinila



# Espectro de $^{13}\text{C}$ e DEPT135 do Acrilato de Vinila



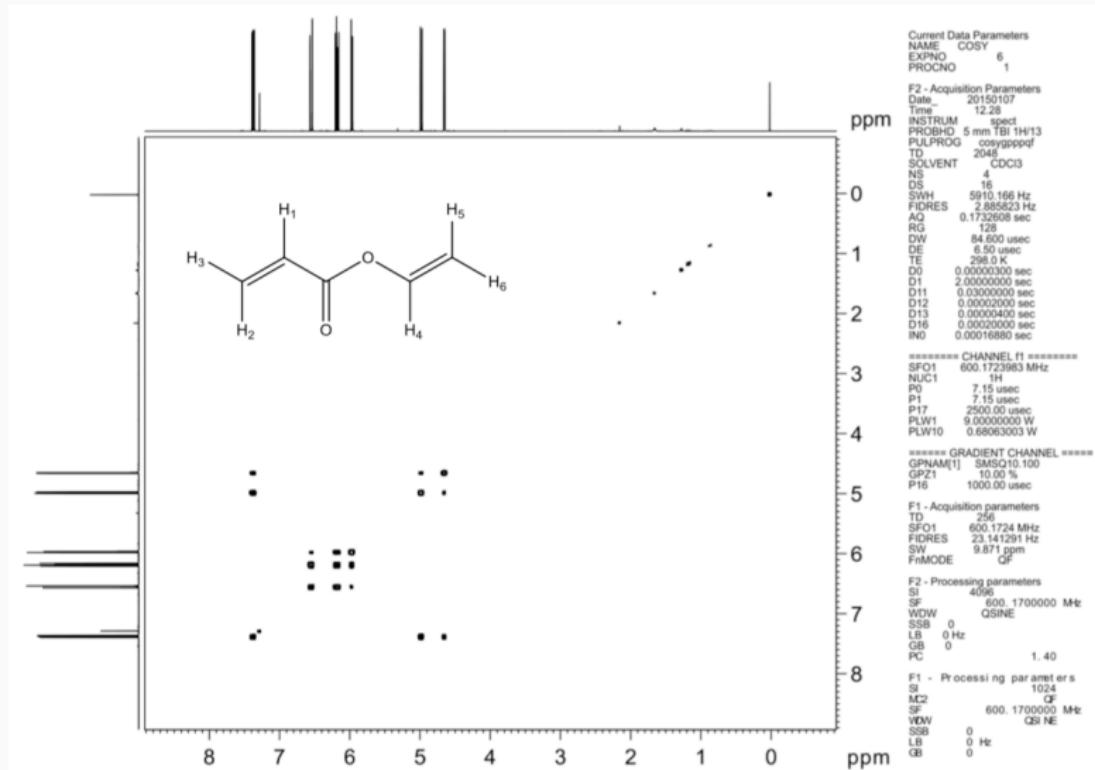
# **Técnicas Bidimensionais - RMN**

## **2D**

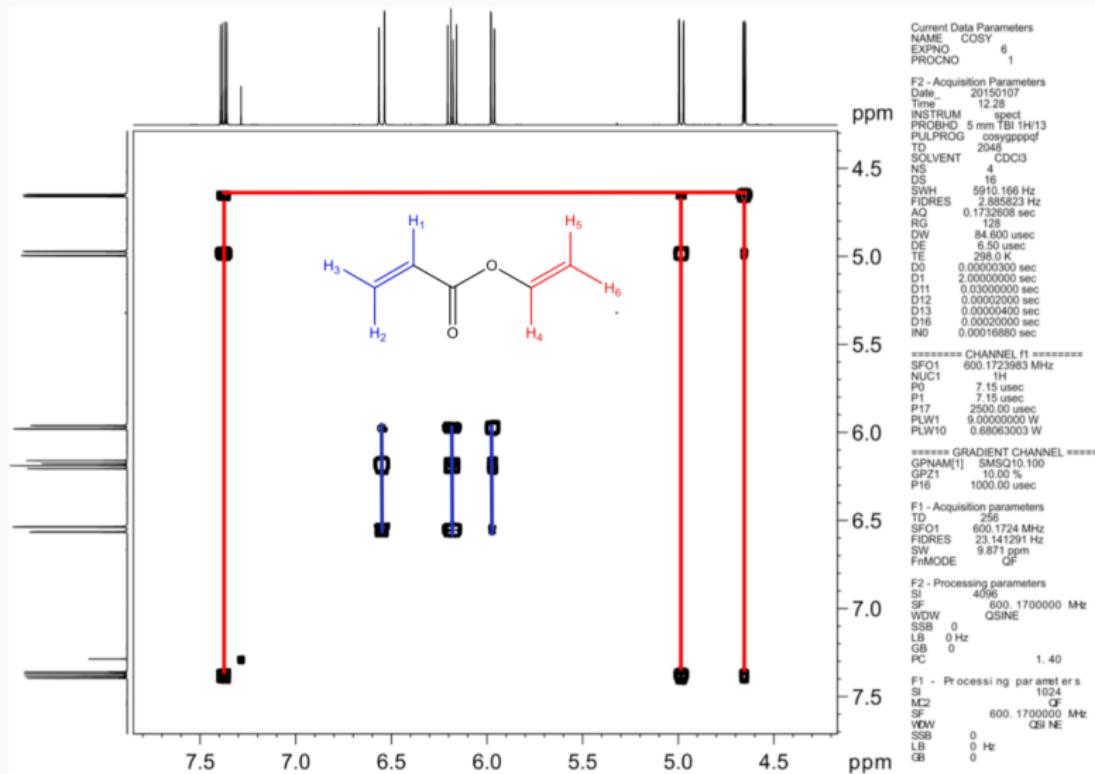
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- Correlações homonucleares
  - $^1\text{H}$ - $^1\text{H}$ ,  $^{19}\text{F}$ - $^{19}\text{F}$ ,  $^{31}\text{P}$ - $^{31}\text{P}$ , ...
- Correlações heteronucleares
  - $^1\text{H}$ - $^{13}\text{C}$ ,  $^1\text{H}$ - $^{15}\text{N}$ ,  $^1\text{H}$ - $^{19}\text{F}$ , ...
- Em **duas dimensões** temos um **mapa de contorno**, não um espectro
  - correlações entre os núcleos no mapa de contorno
  - correlações se devem aos  $J$  entre eles
- Experimentos mais comuns
  - COSY - Correlação  $^1\text{H}$ - $^1\text{H}$  via acoplamento escalar
  - HSQC - Correlação  $^1\text{H}$ - $^{13}\text{C}$  via acoplamento  $^1J_{\text{CH}}$
  - HMQC - Correlação  $^1\text{H}$ - $^{13}\text{C}$  via acoplamentos  $^nJ_{\text{CH}}$ , sendo  $n \geq 2$

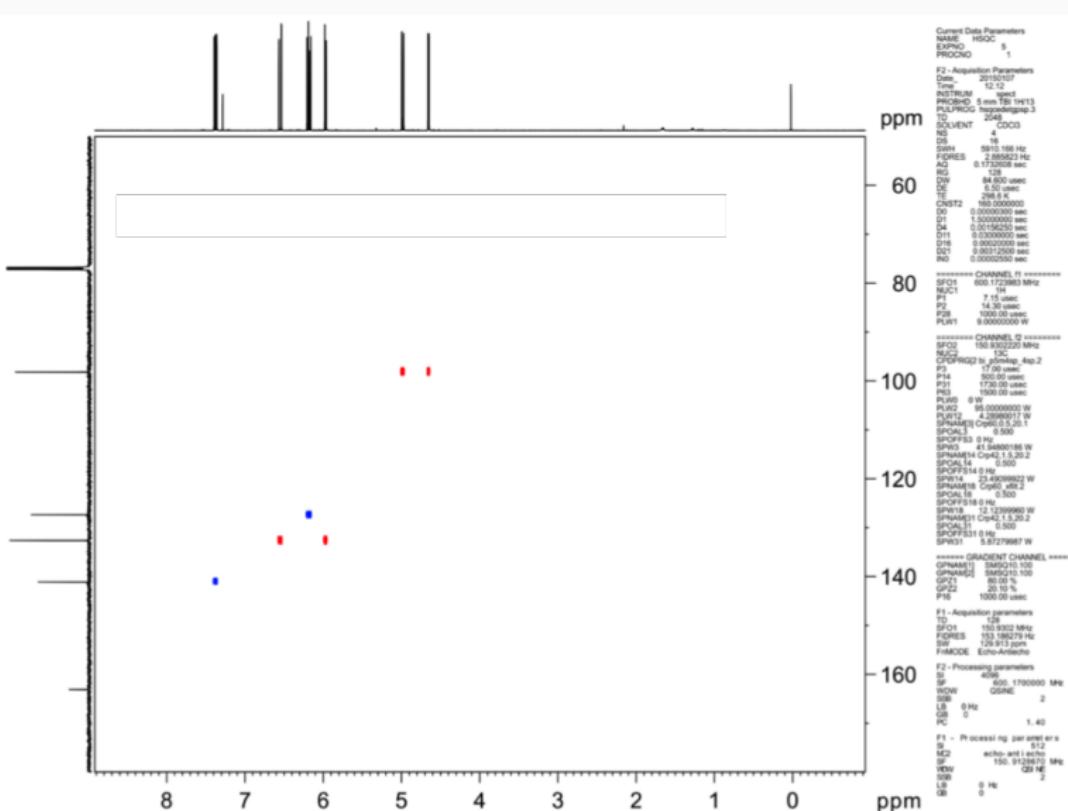
# COSY - Correlation Spectroscopy



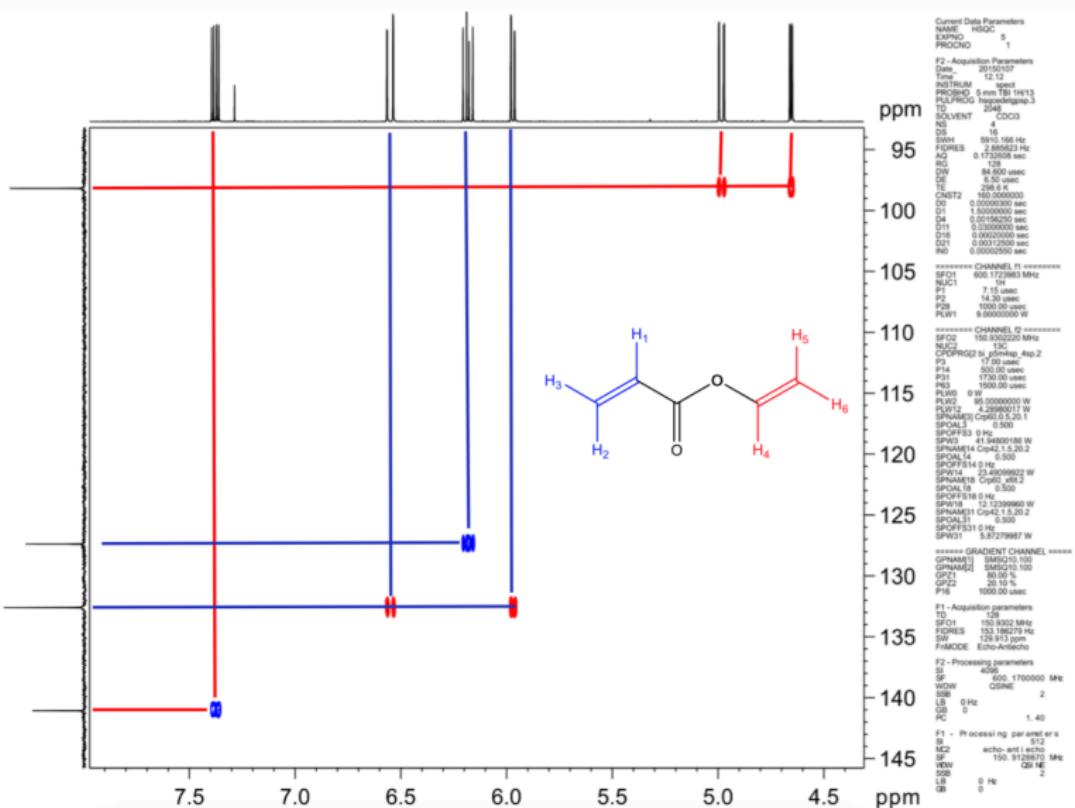
# COSY - Correlation Spectroscopy



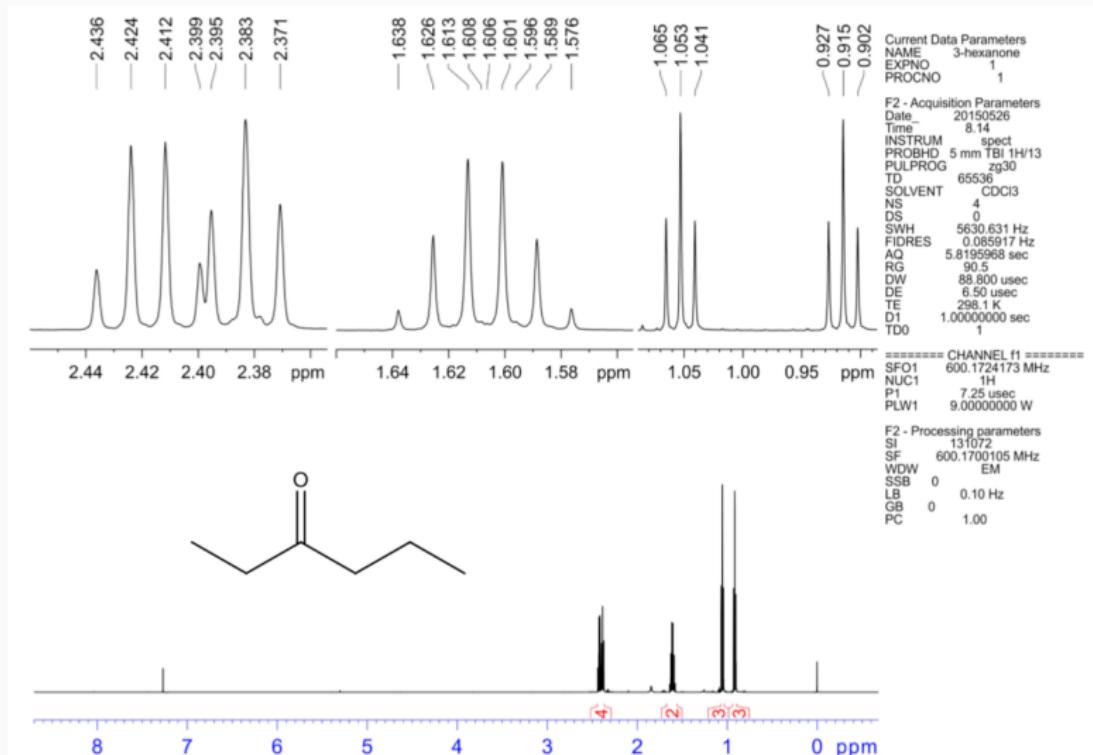
# HSQC - Heteronuclear Single Quantum Coherence



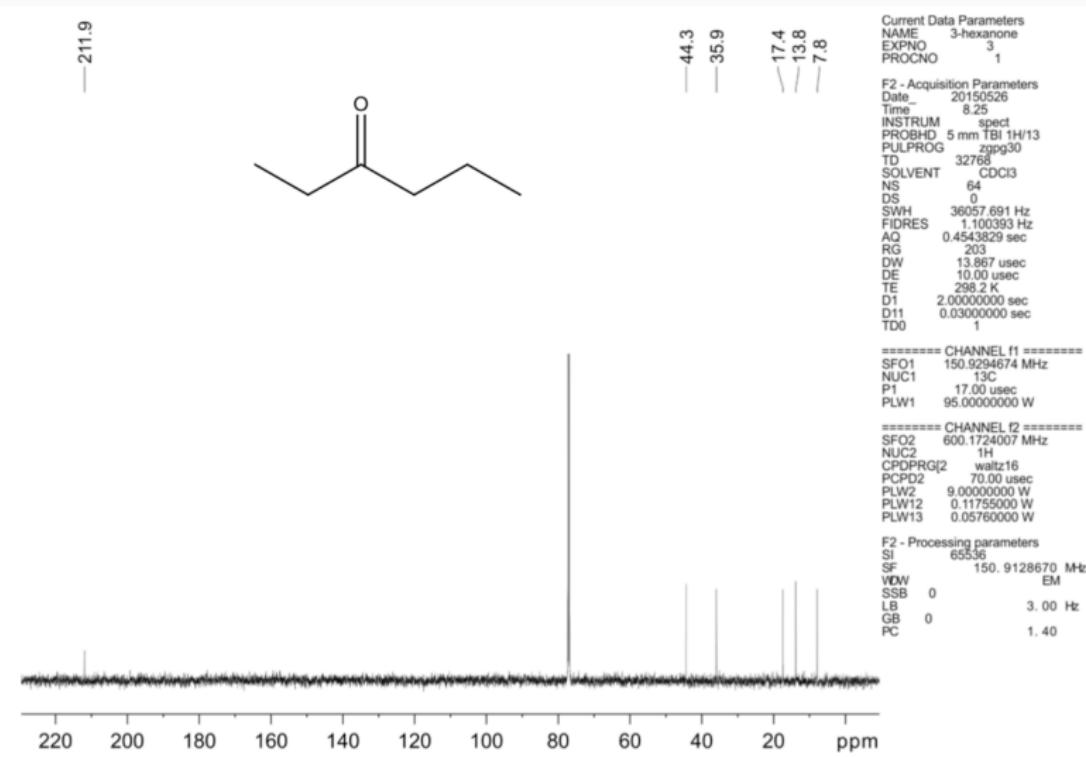
# HSQC - Heteronuclear Single Quantum Coherence



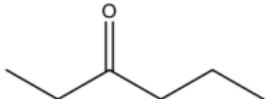
# Espectro de $^1\text{H}$ da 3-Hexanona



# Espectro de $^{13}\text{C}$ da 3-Hexanona



# Espectro de DEPT135 da 3-Hexanona



Current Data Parameters  
NAME 3-hexanone  
EXPNO 4  
PROCNO 1

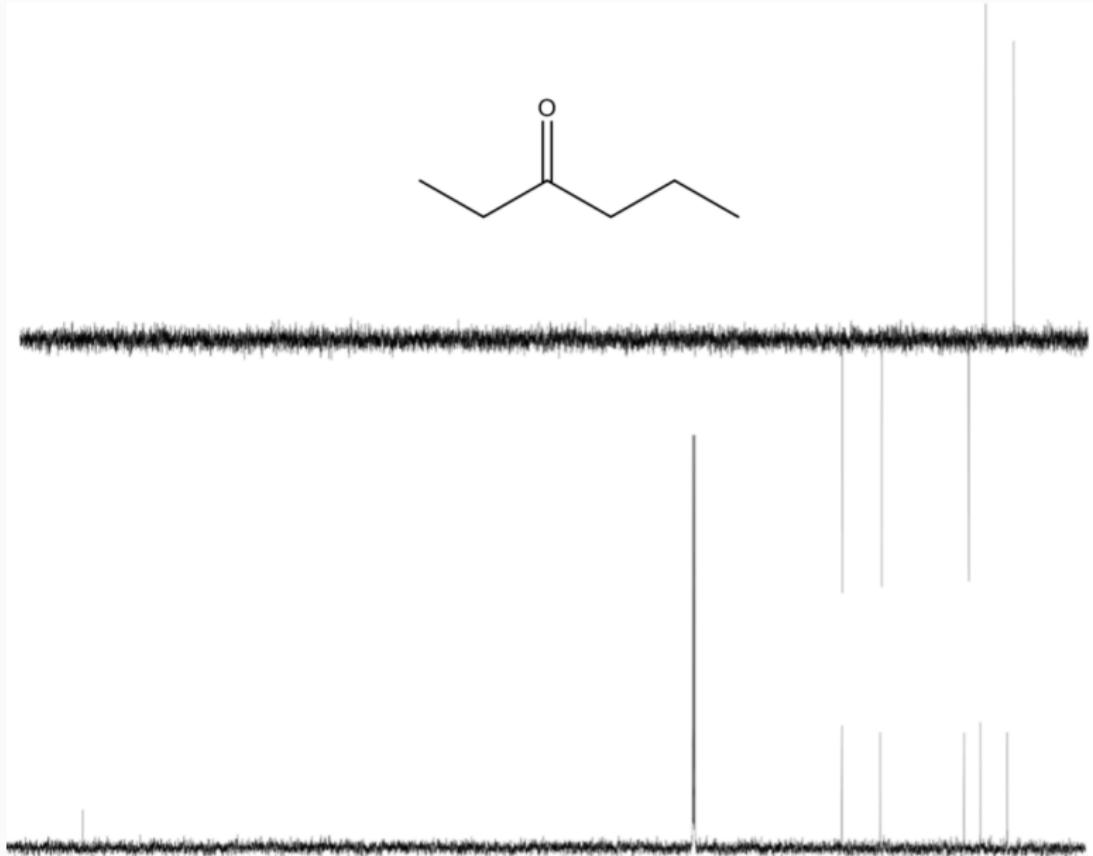
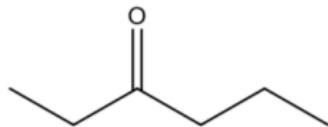
F2 - Acquisition Parameters  
Date\_ 20150526  
Time\_ 8:28  
INSTRUM spect  
PROBHD 5 mm TBI 1H/13C  
PULPROG depts135  
TD 32768  
SOLVENT CDCl3  
NS 8  
DS 4  
SWH 36057.691 Hz  
FIDRES 1.100393 Hz  
AQ 0.4543329 sec  
RG 100  
DW 13.867 usec  
DE 10.00 usec  
TE 298.2 K  
CNST2 130.0000000  
D1 2.0000000 sec  
D2 0.00384615 sec  
D12 0.00002000 sec  
TD0 1

===== CHANNEL f1 ======  
SF01 150.9279571 MHz  
NUC1 13C  
P1 17.00 usec  
P13 2000.00 usec  
PLW0 0 W  
PLW1 95.00000000 W  
SCAM[5] Cpm60comp.4  
SPOAL5 0.500  
SPOFF55 0 Hz  
SPW5 41.94800186 W

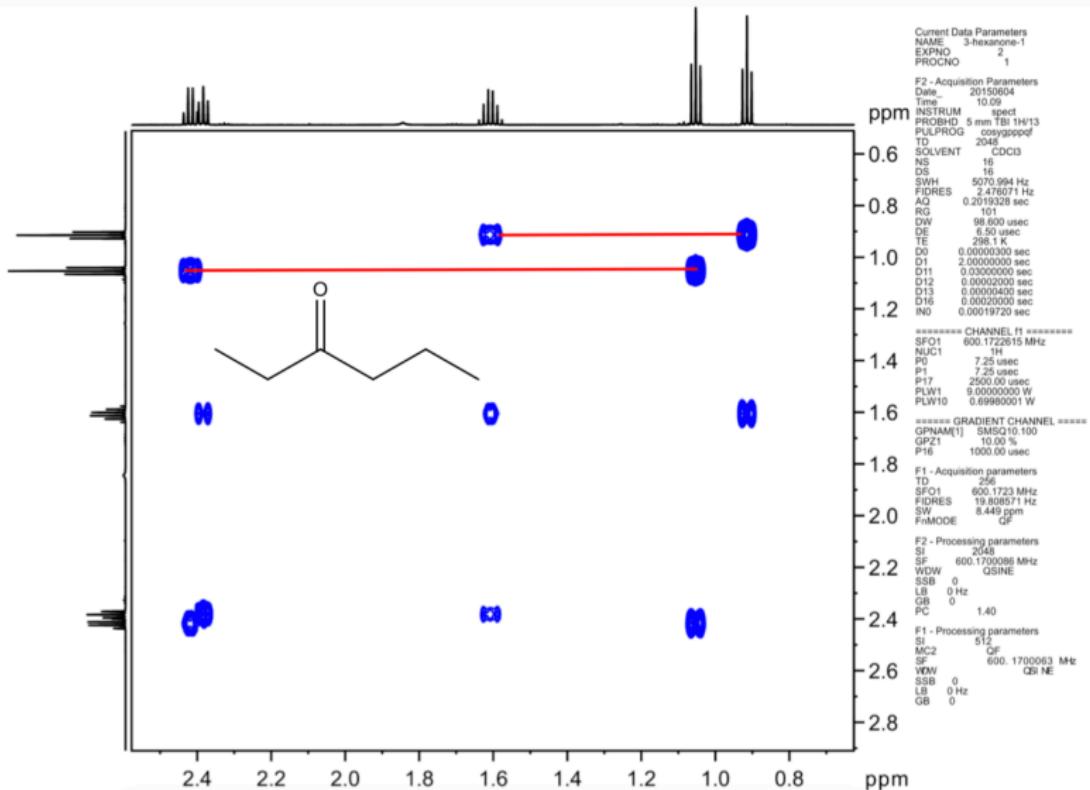
===== CHANNEL f2 ======  
SF02 600.1719194 MHz  
NUC2 1H  
CPDPGRG[2] waltz16  
P3 8.00 usec  
P4 16.00 usec  
PCPD2 70.00 usec  
PLW2 9.00000000 W  
PLW12 0.11755000 W

F2 - Processing parameters  
SI 65536  
SF 150.9128670 MHz  
WDW EM  
SSB 0  
LB 2.00 Hz  
GB 0  
PC 1.40

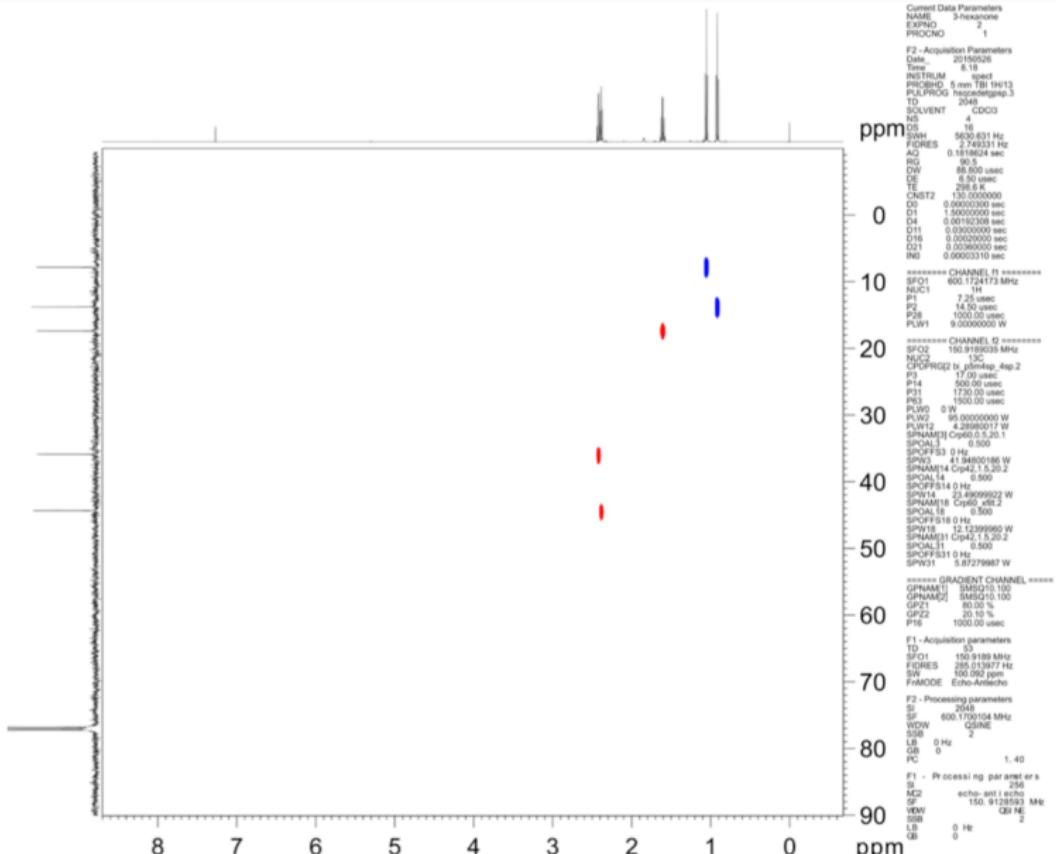
## Espectro de $^{13}\text{C}$ e DEPT135 da 3-Hexanona



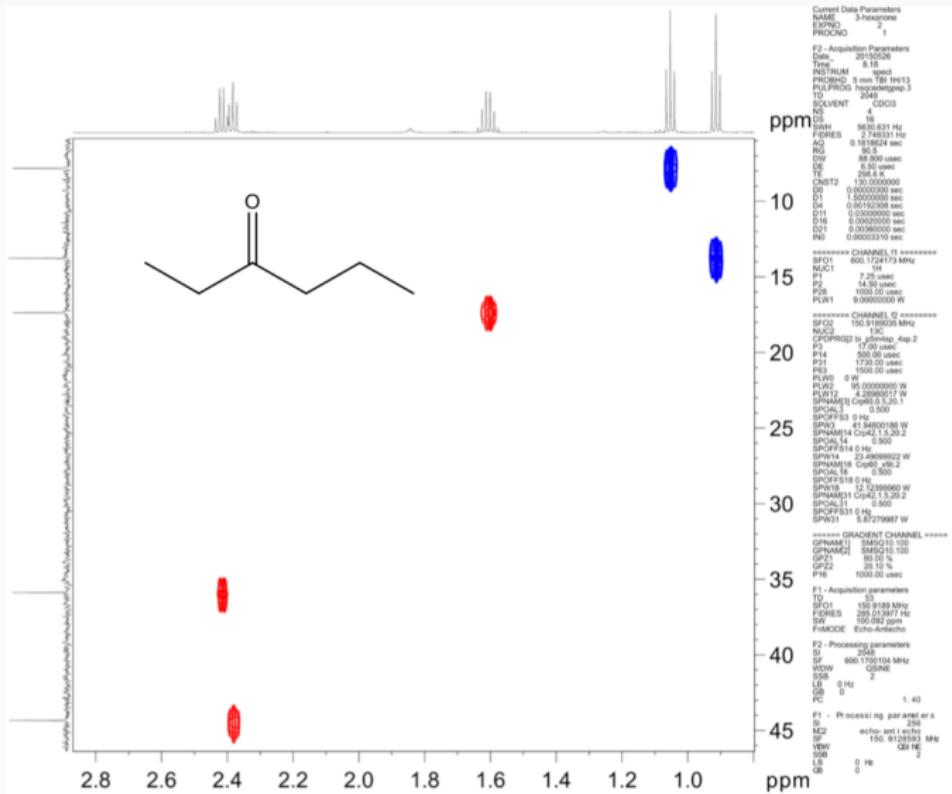
# COSY da 3-Hexanona



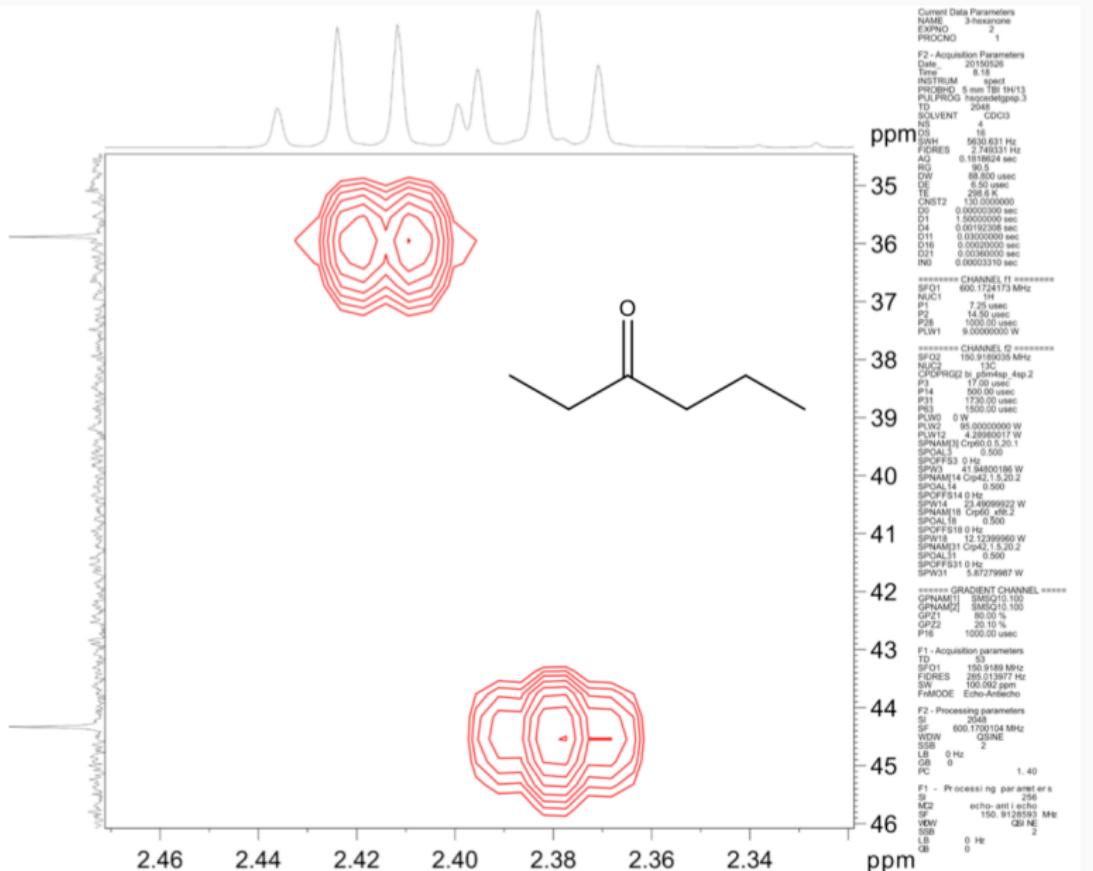
# HSQC da 3-Hexanona



# HSQC da 3-Hexanona



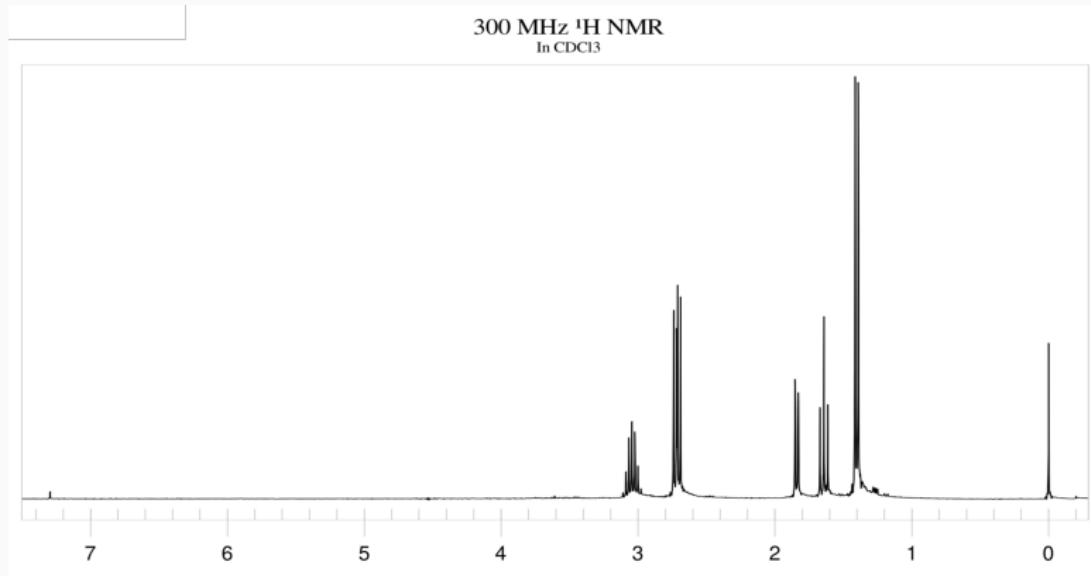
# HSQC da 3-Hexanona



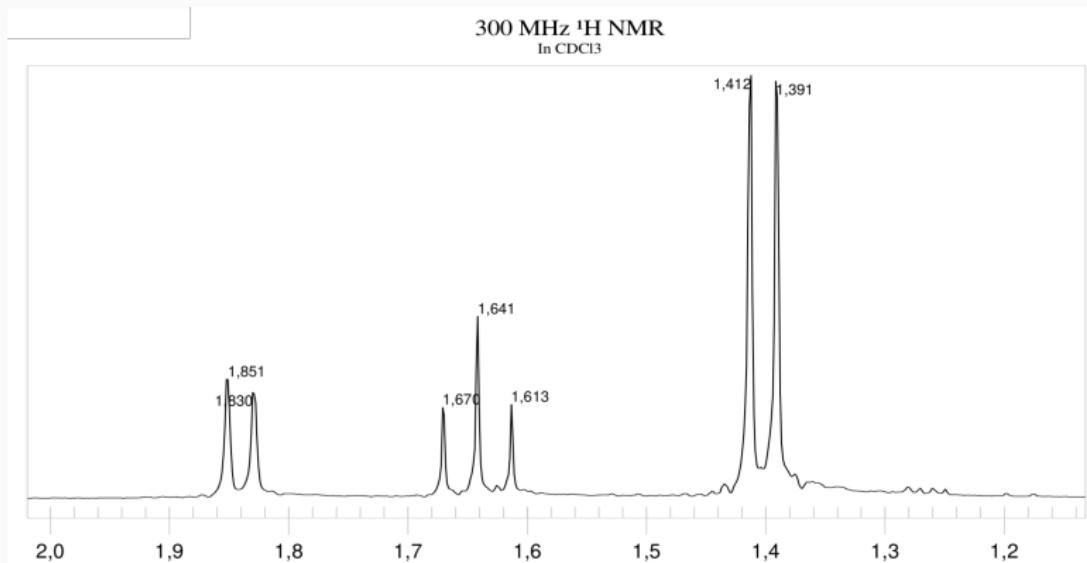
## Exercícios

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## Ex1: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}_2$

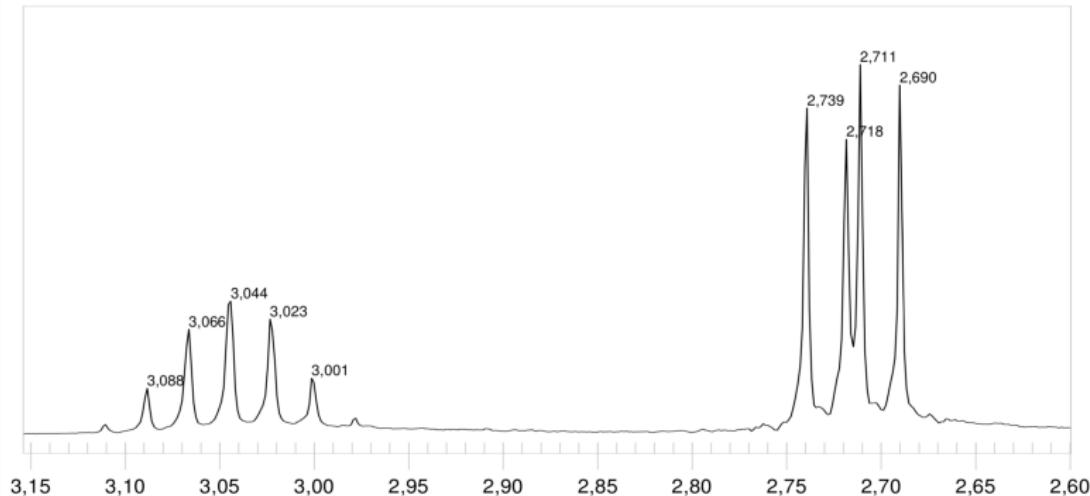


# Ex1: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}_2$

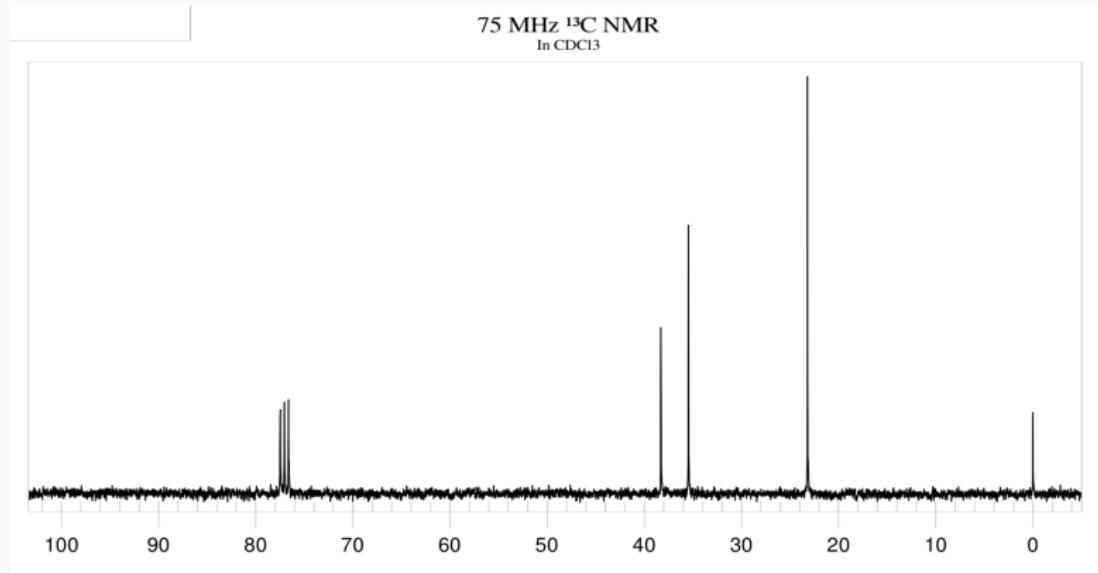


# Ex1: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}_2$

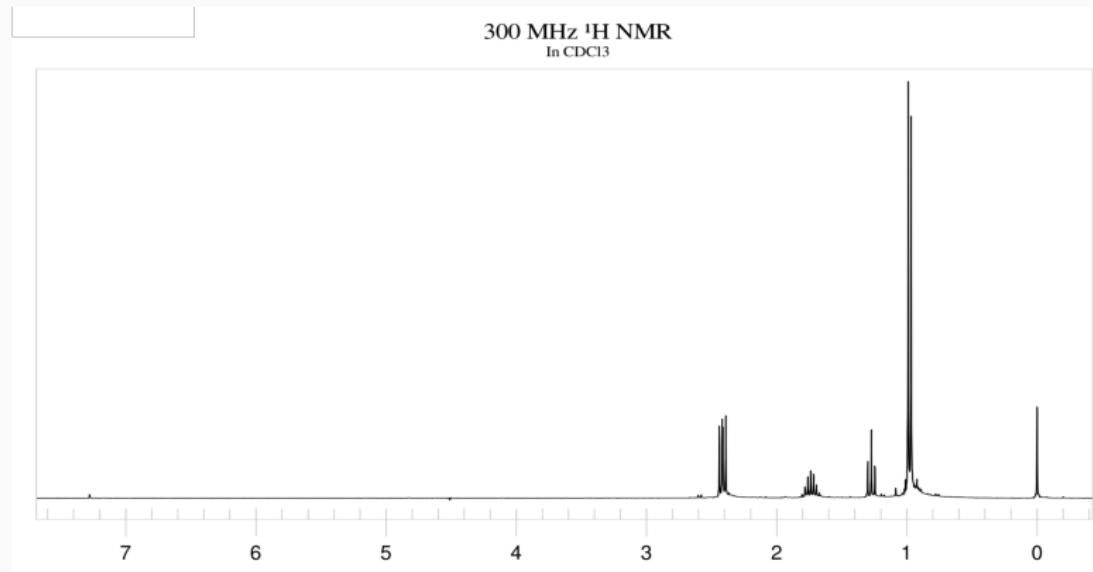
300 MHz  $^1\text{H}$  NMR  
In  $\text{CDCl}_3$



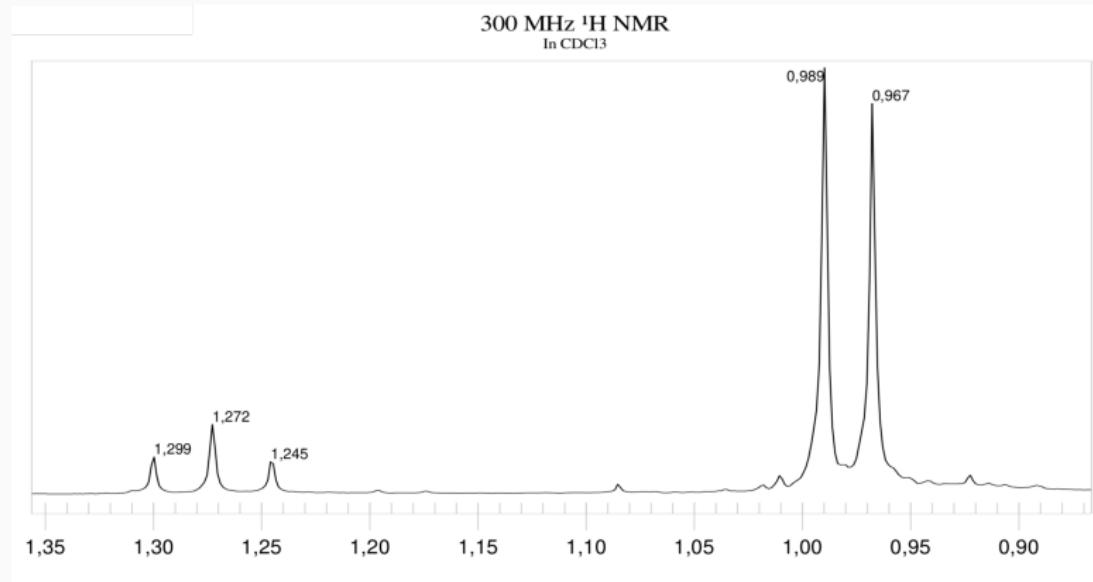
# Ex1: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_8\text{S}_2$



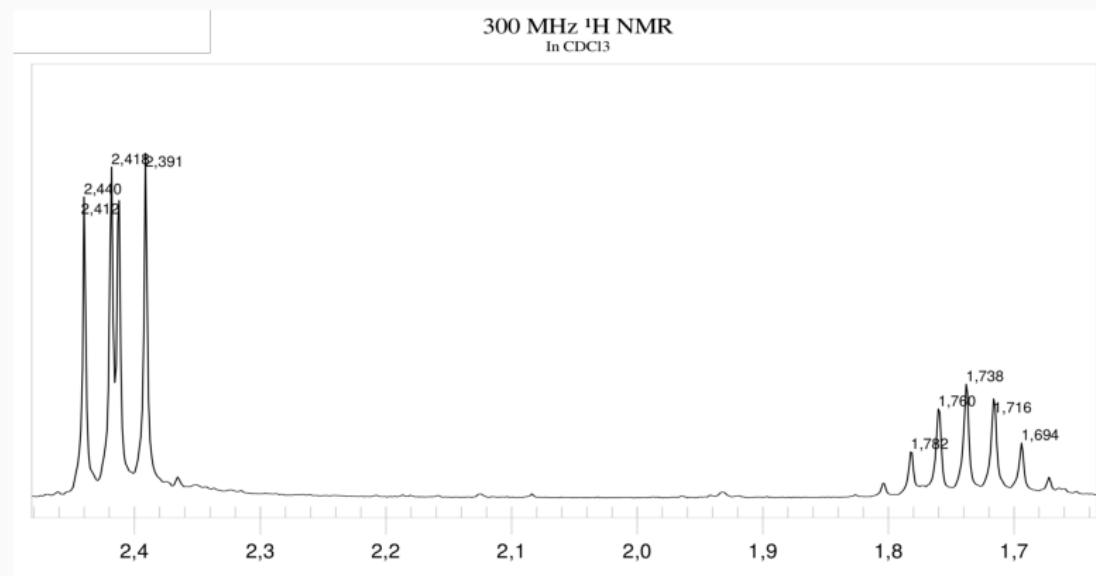
## Ex2: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{S}$



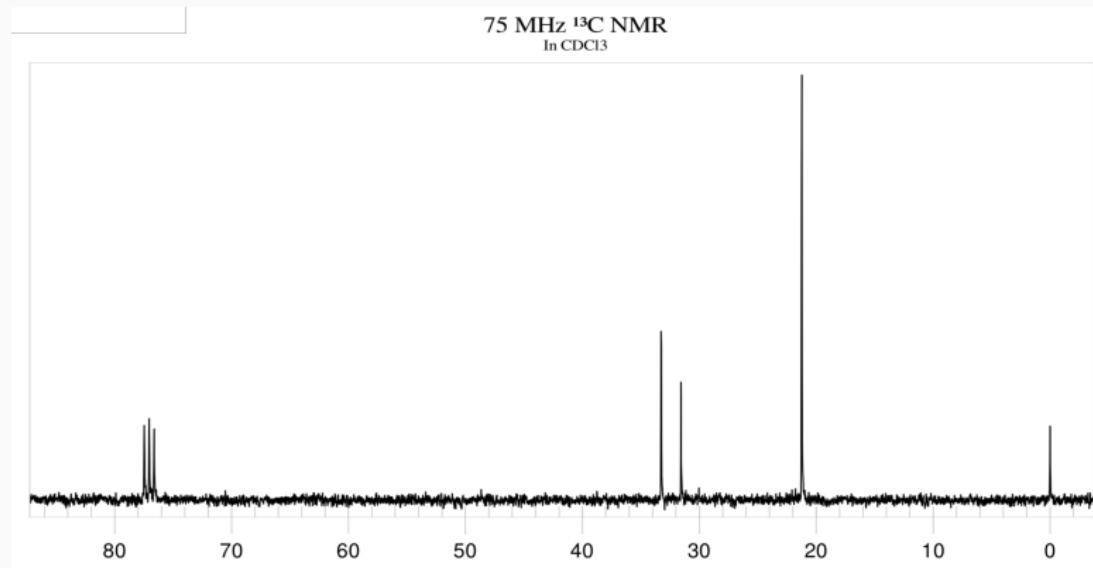
## Ex2: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{S}$



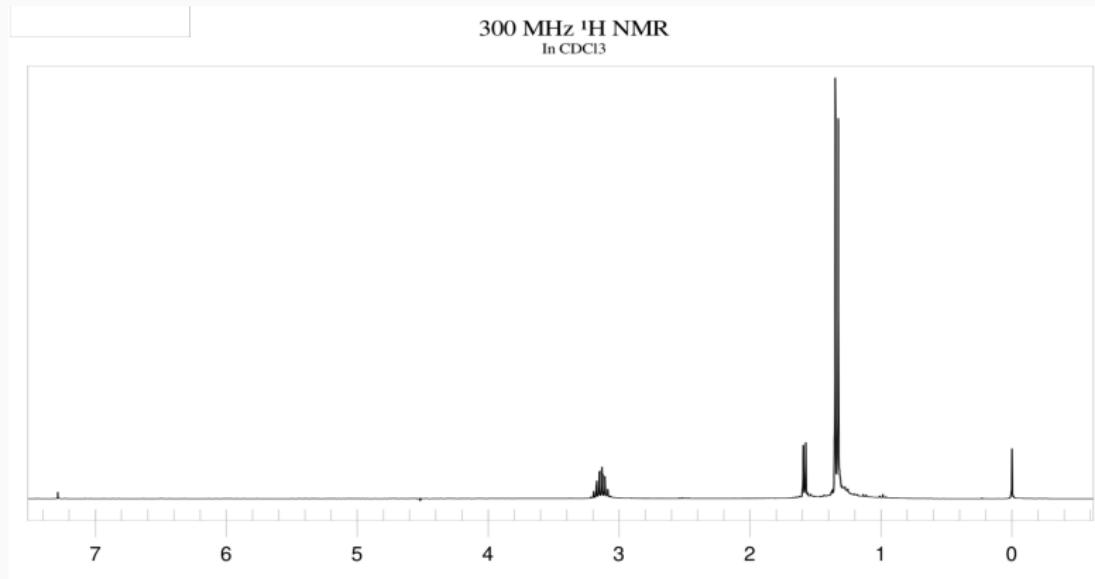
## Ex2: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{S}$



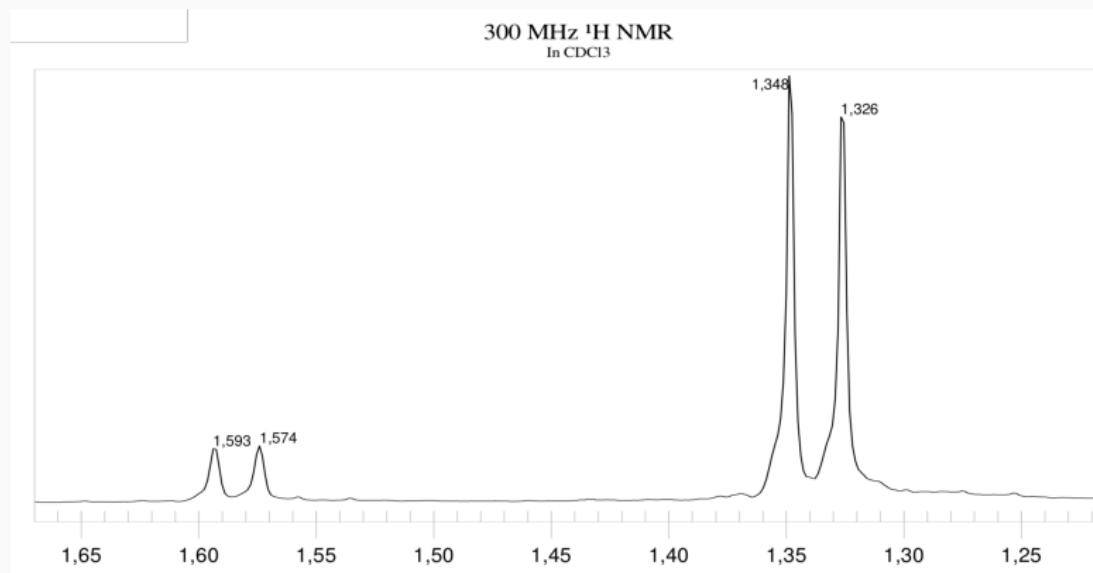
## Ex2: Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_{10}\text{S}$



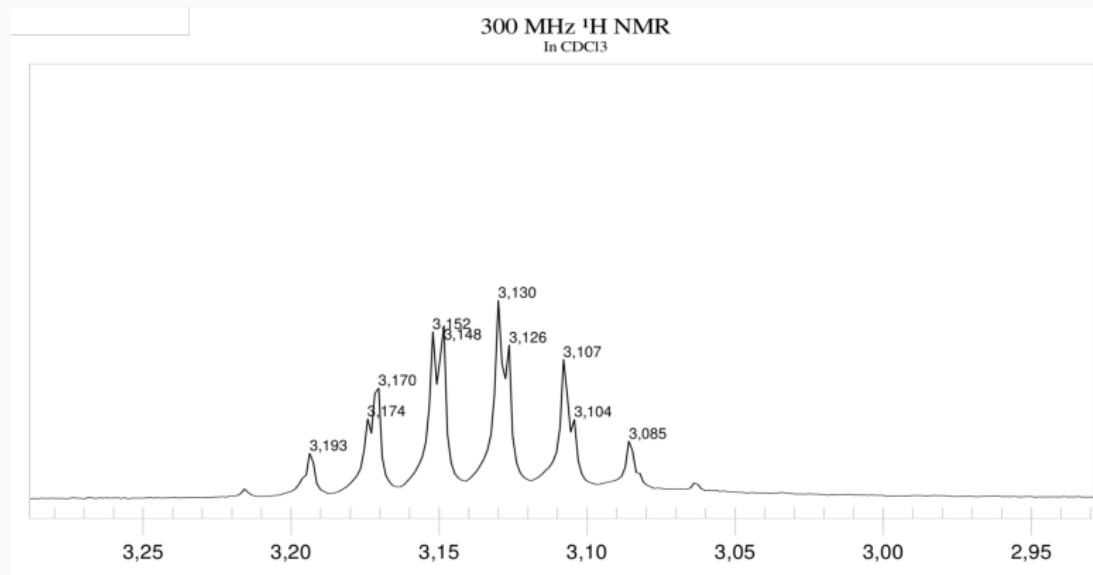
## Ex3: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}$



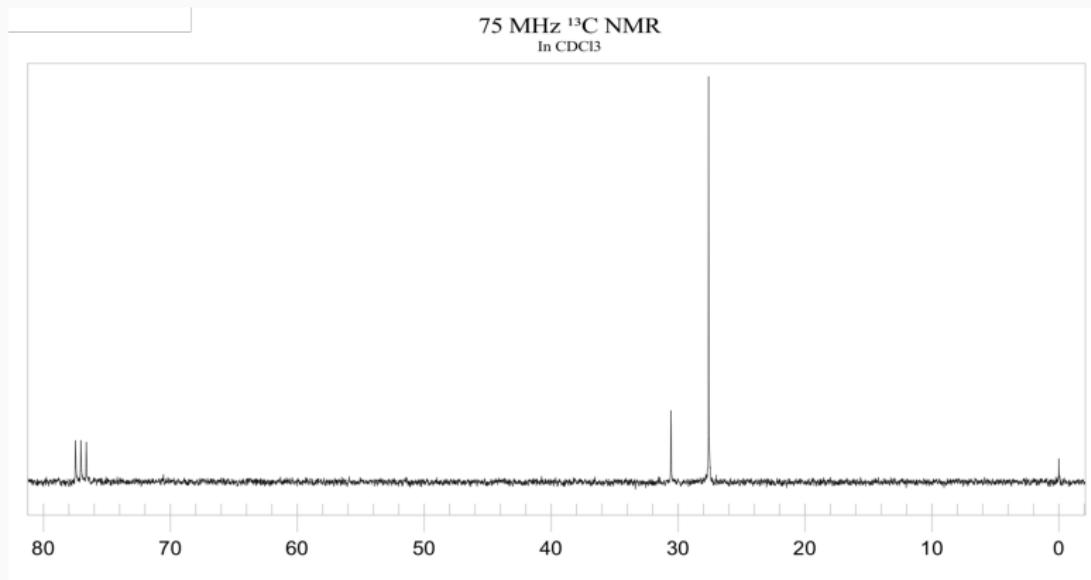
## Ex3: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}$



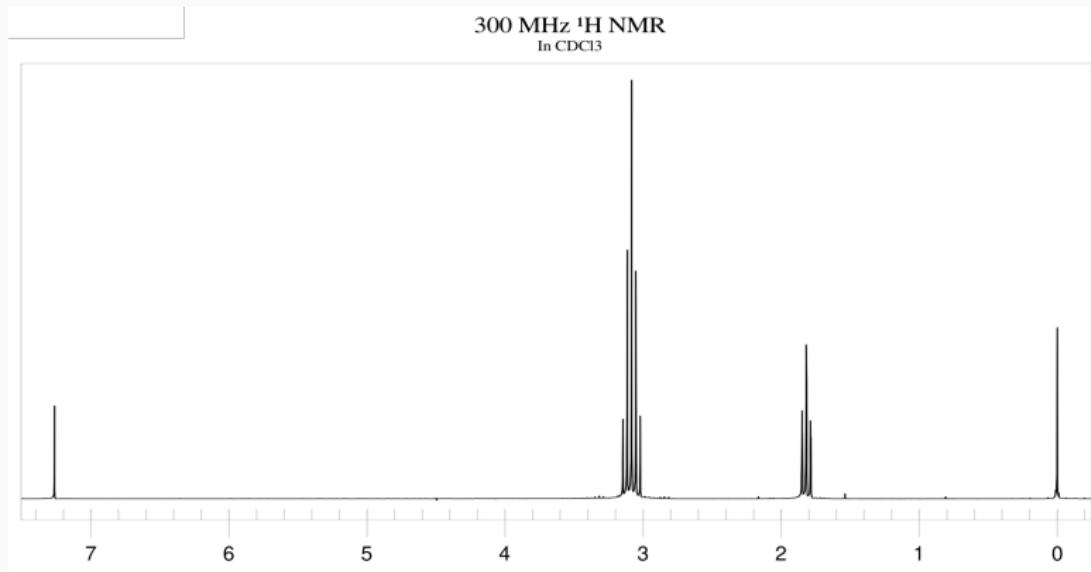
## Ex3: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_8\text{S}$



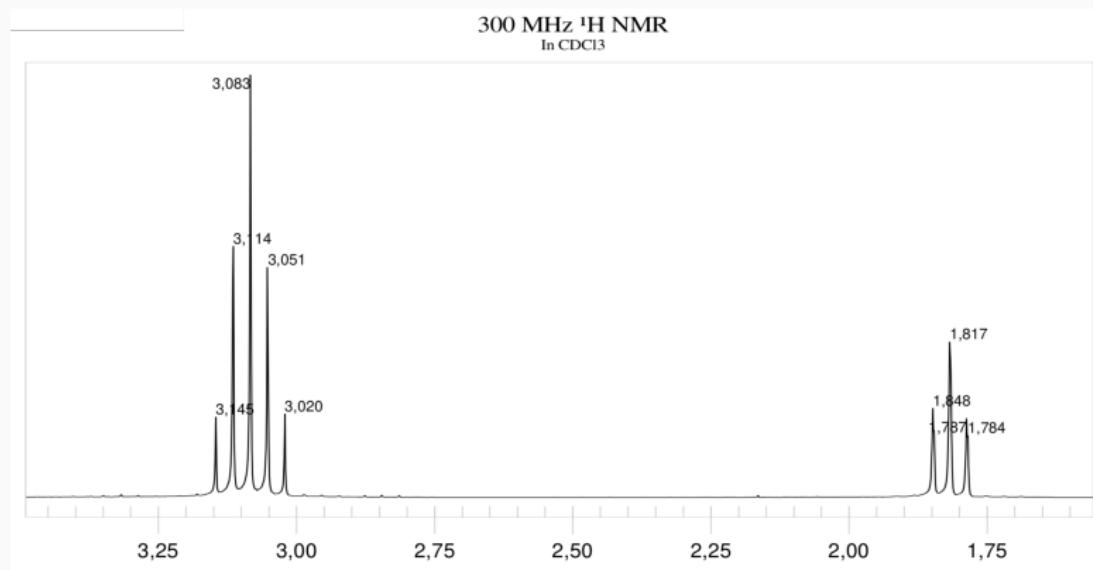
## Ex3: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_8\text{S}$



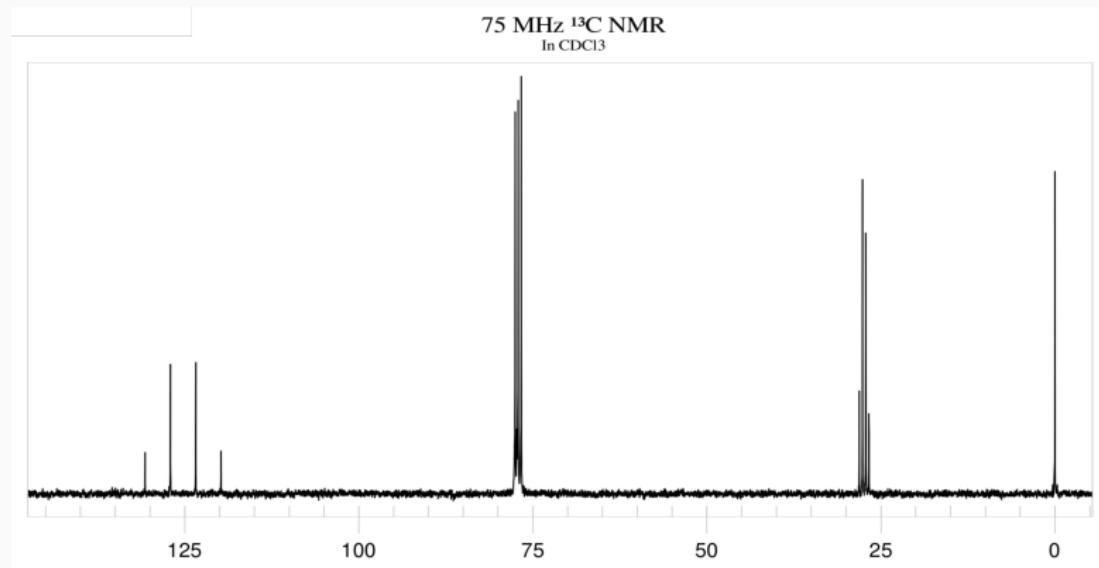
## Ex4: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_3\text{F}_3\text{S}$



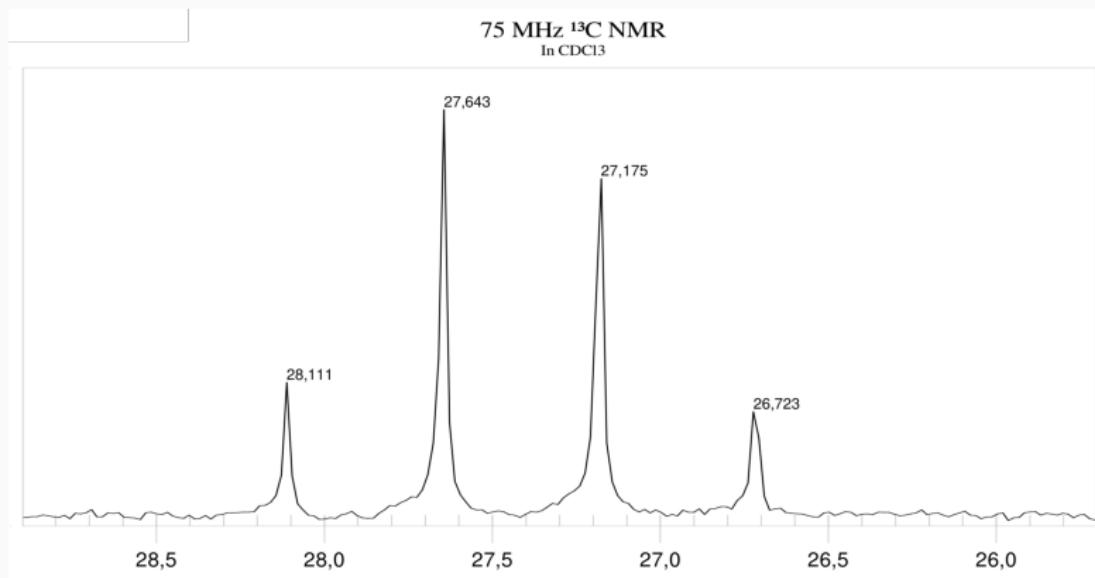
## Ex4: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_3\text{F}_3\text{S}$



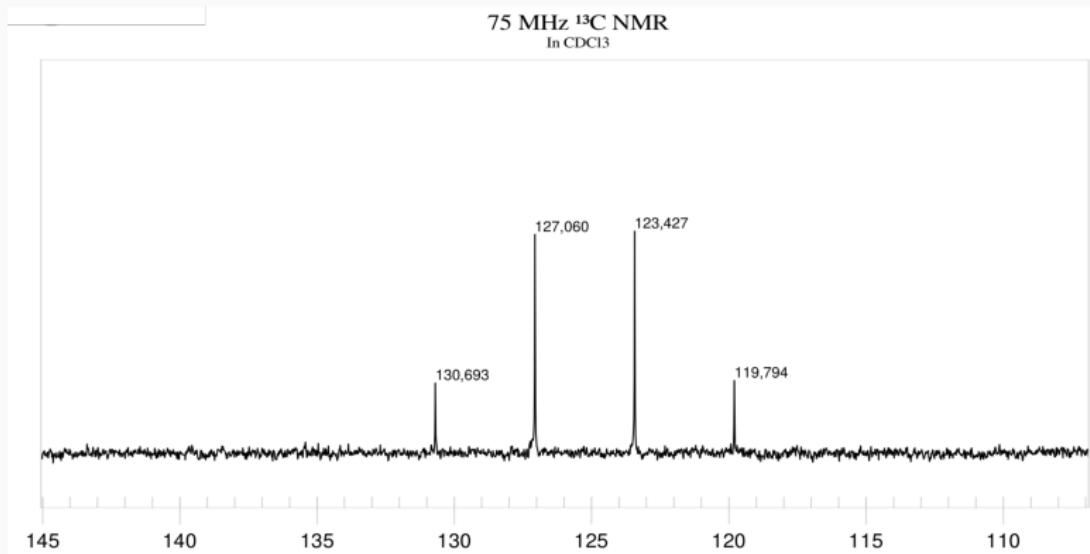
## Ex4: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_3\text{F}_3\text{S}$



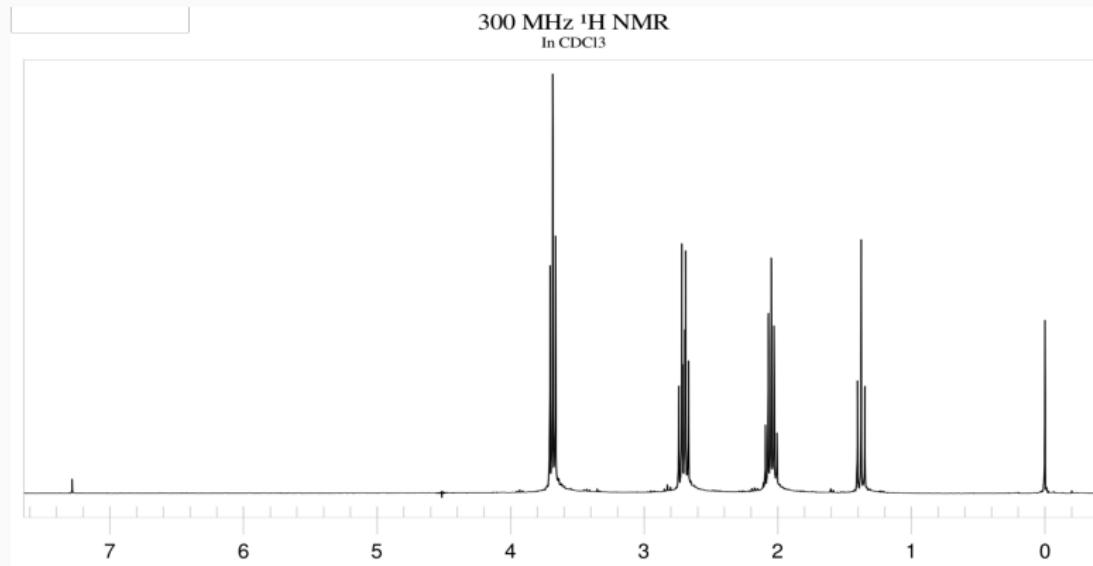
## Ex4: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_3\text{F}_3\text{S}$



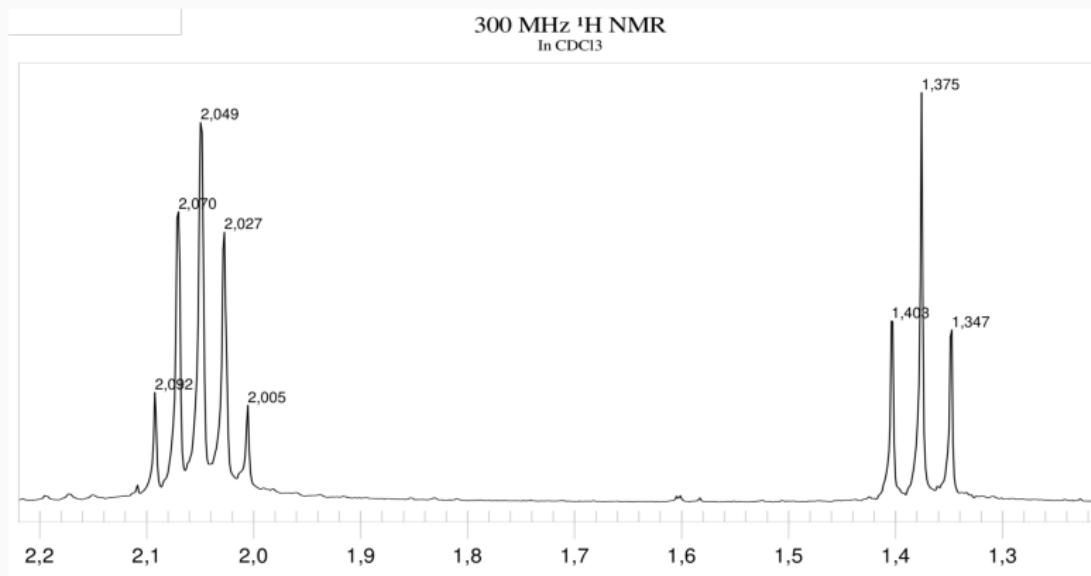
## Ex4: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_3\text{F}_3\text{S}$



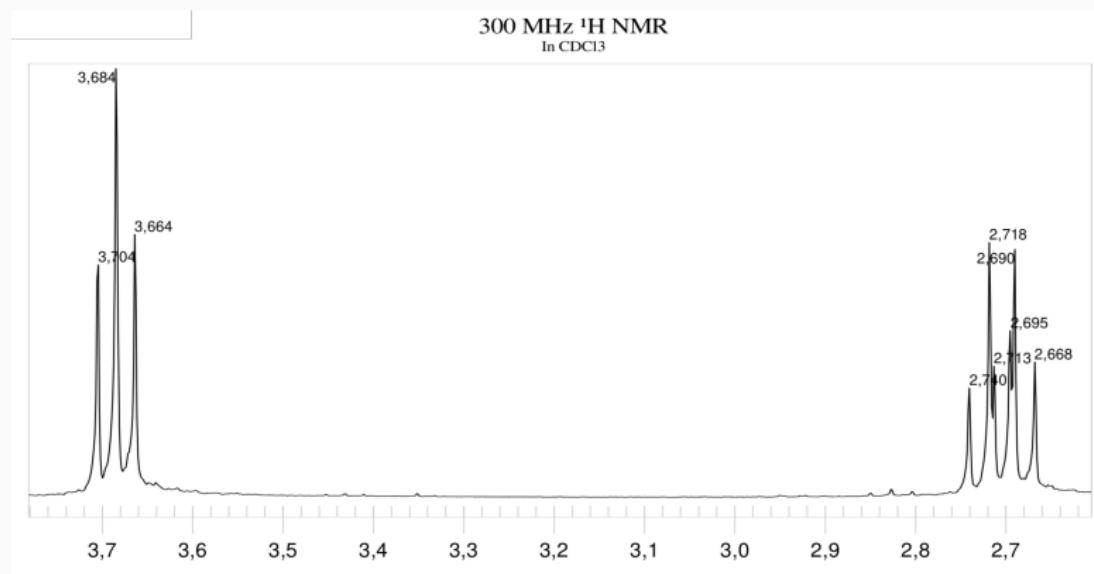
## Ex5: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{CIS}$



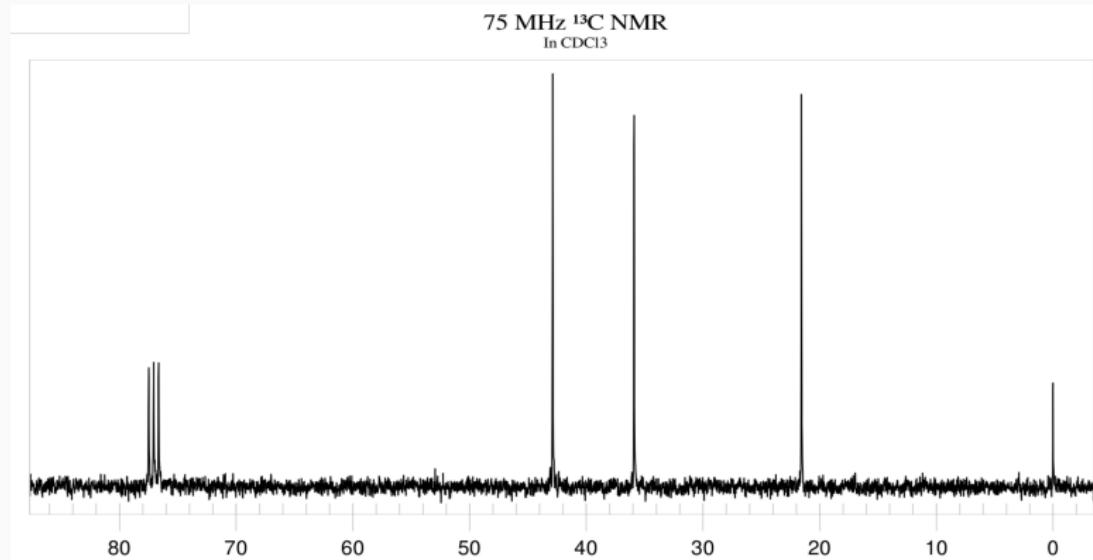
## Ex5: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{CIS}$



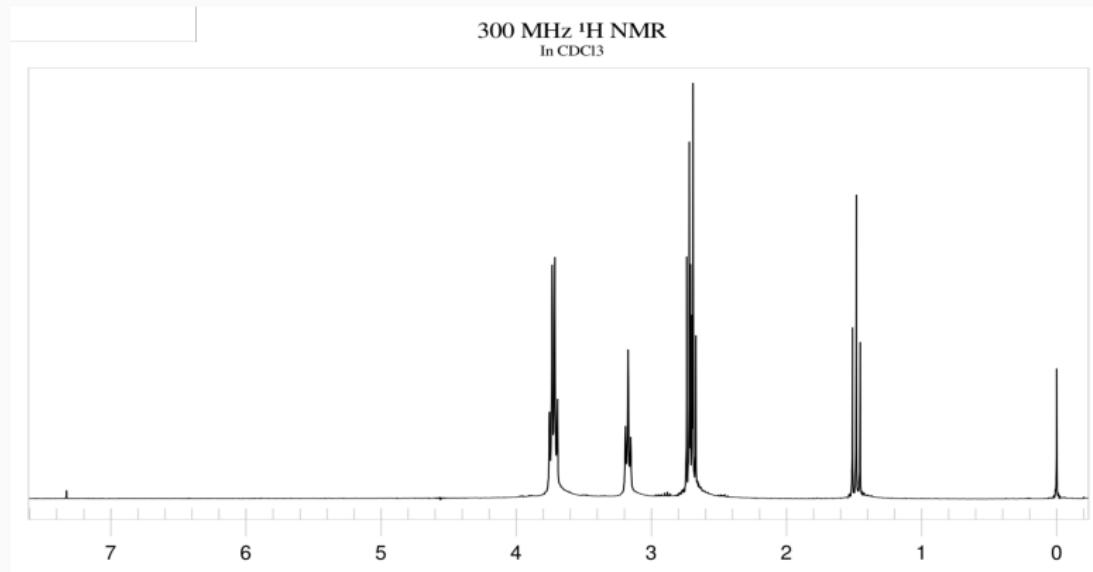
## Ex5: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{CIS}$



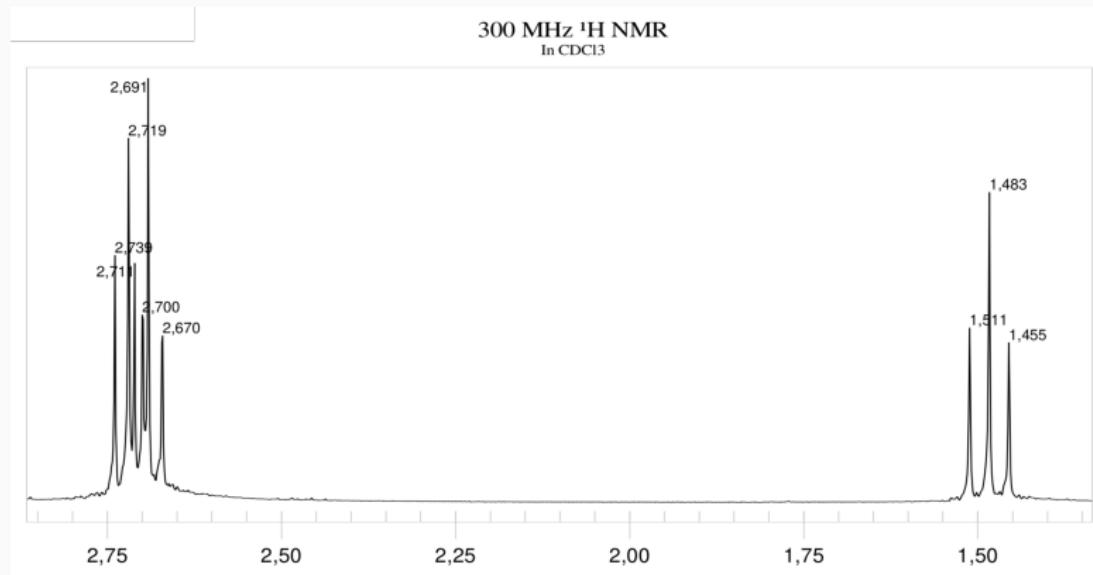
## Ex5: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_7\text{CIS}$



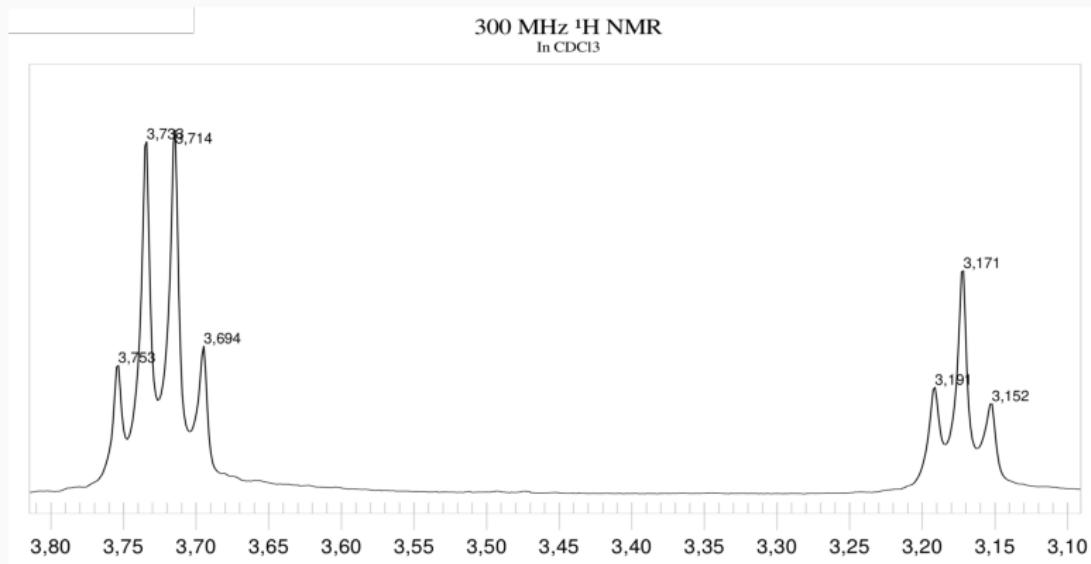
## Ex6: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_6\text{OS}$



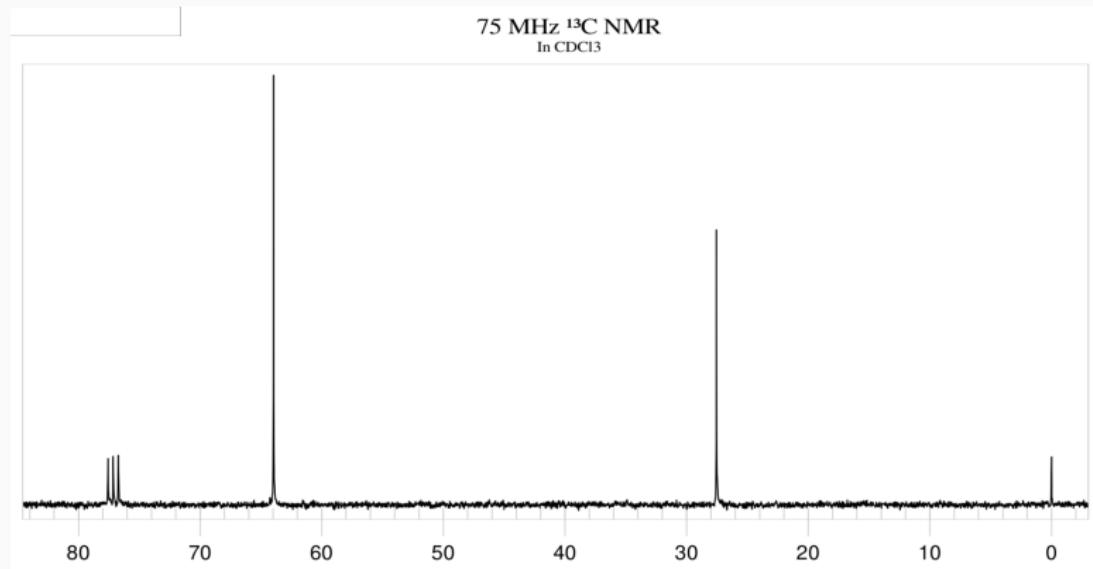
## Ex6: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_6\text{OS}$



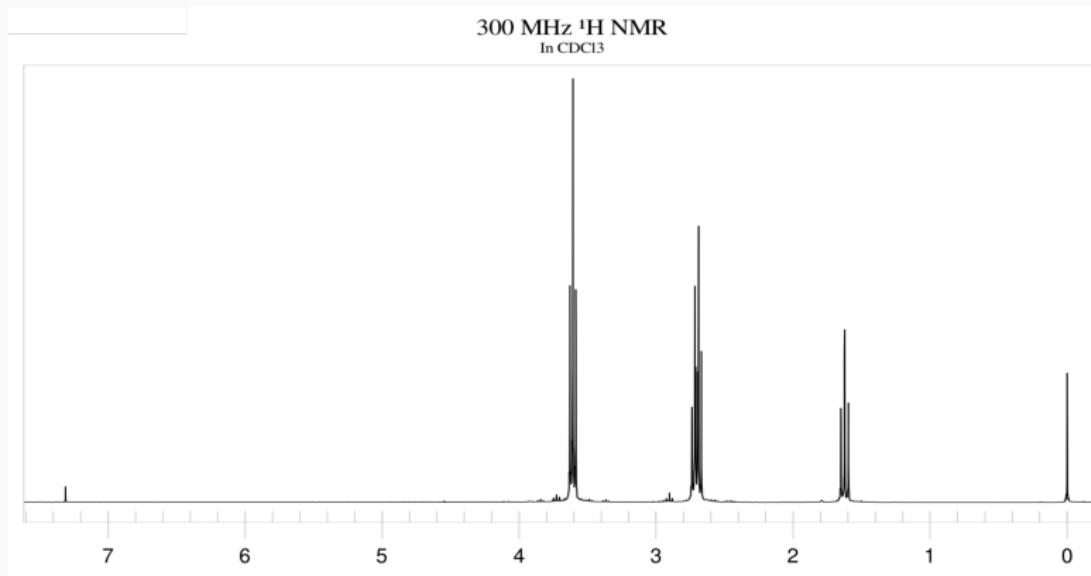
## Ex6: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_6\text{OS}$



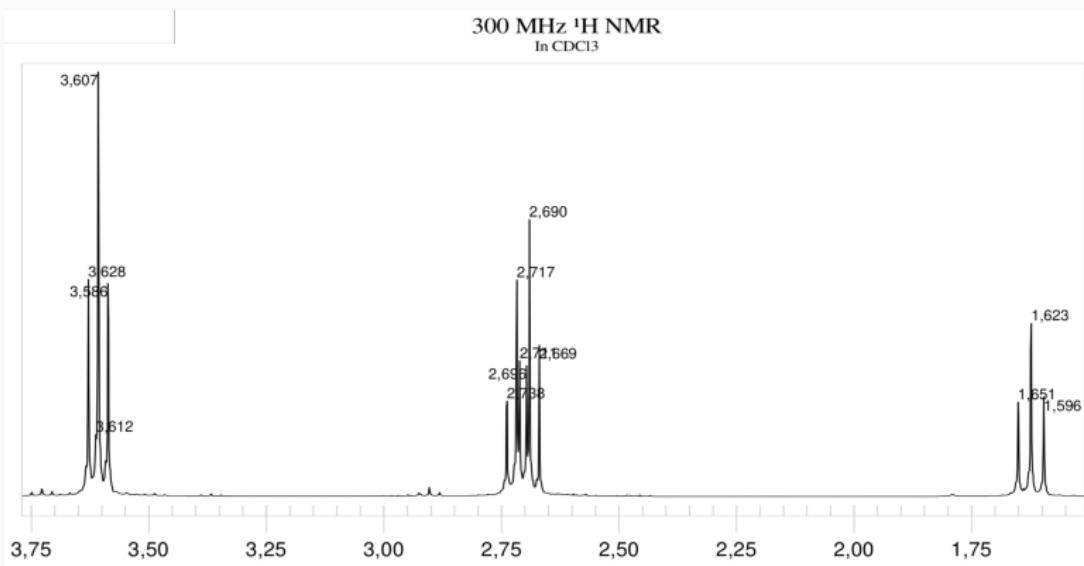
## Ex6: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_6\text{OS}$



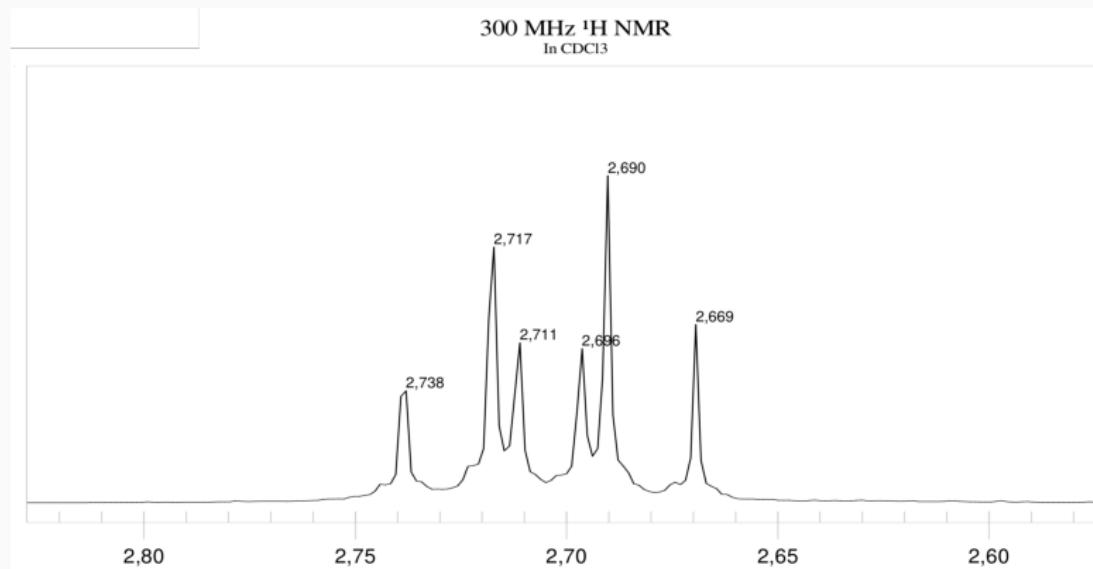
## Ex7: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{OS}_2$



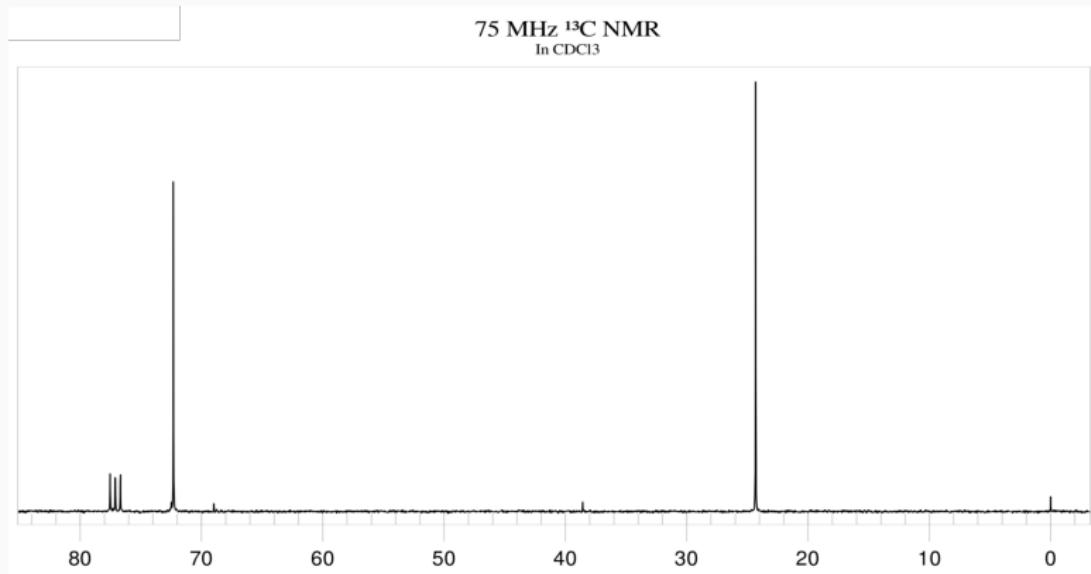
## Ex7: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{OS}_2$



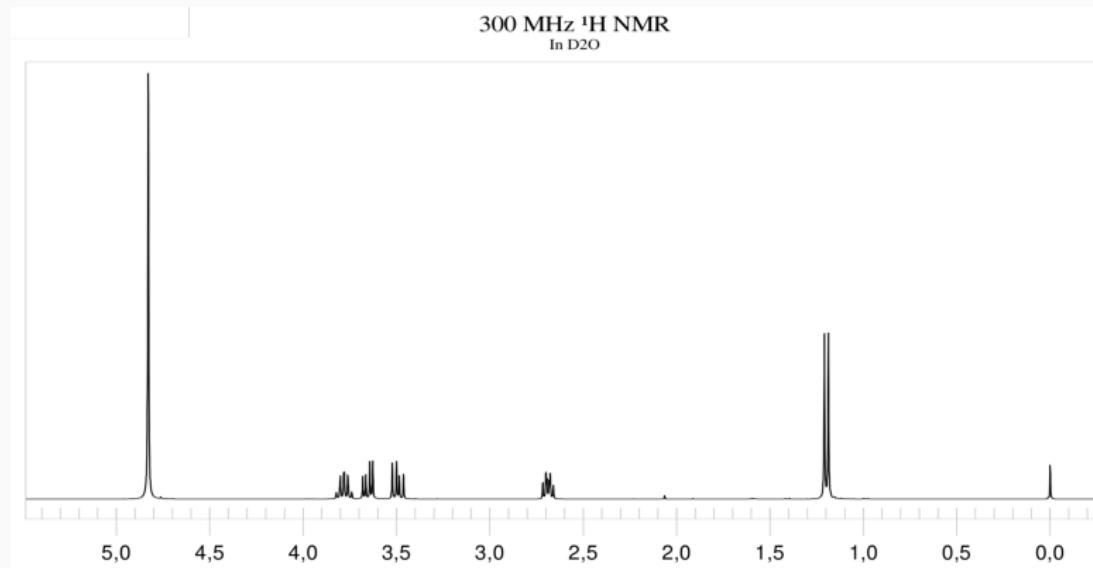
## Ex7: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{10}\text{OS}_2$



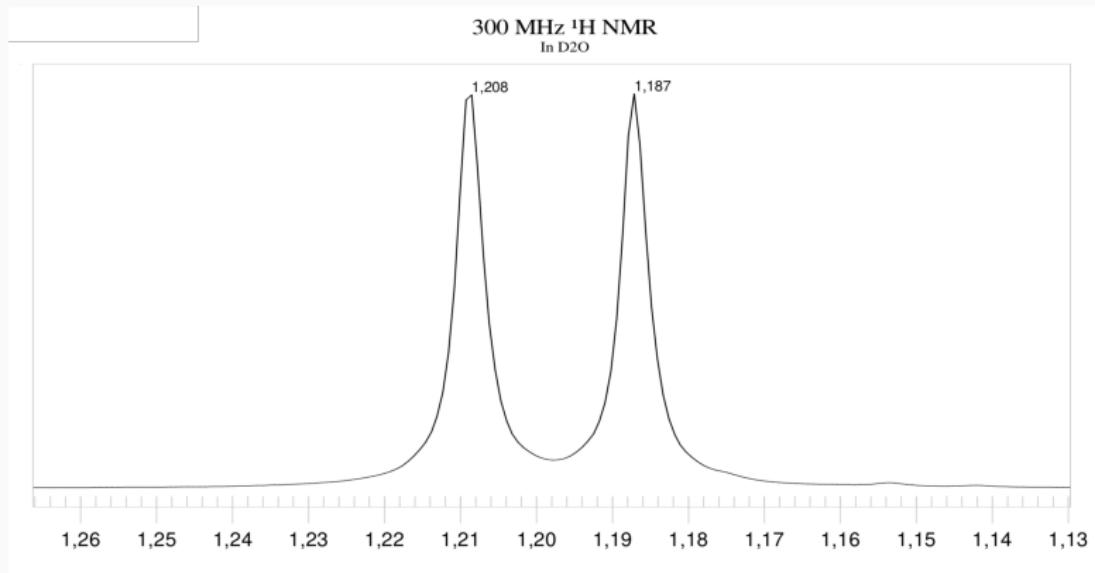
## Ex7: Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_{10}\text{OS}_2$



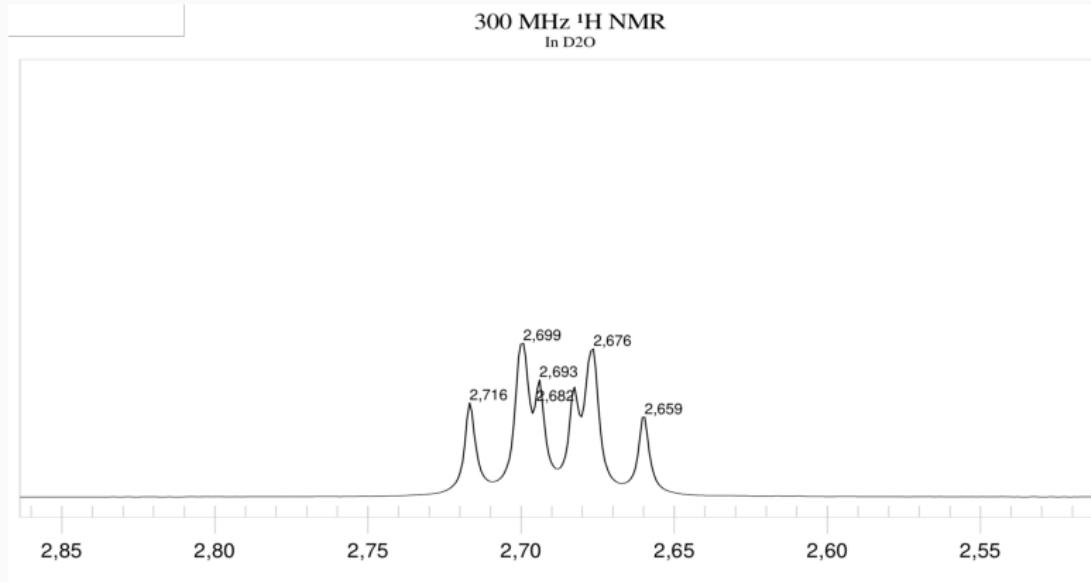
## Ex8: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{11}\text{NO}_2$



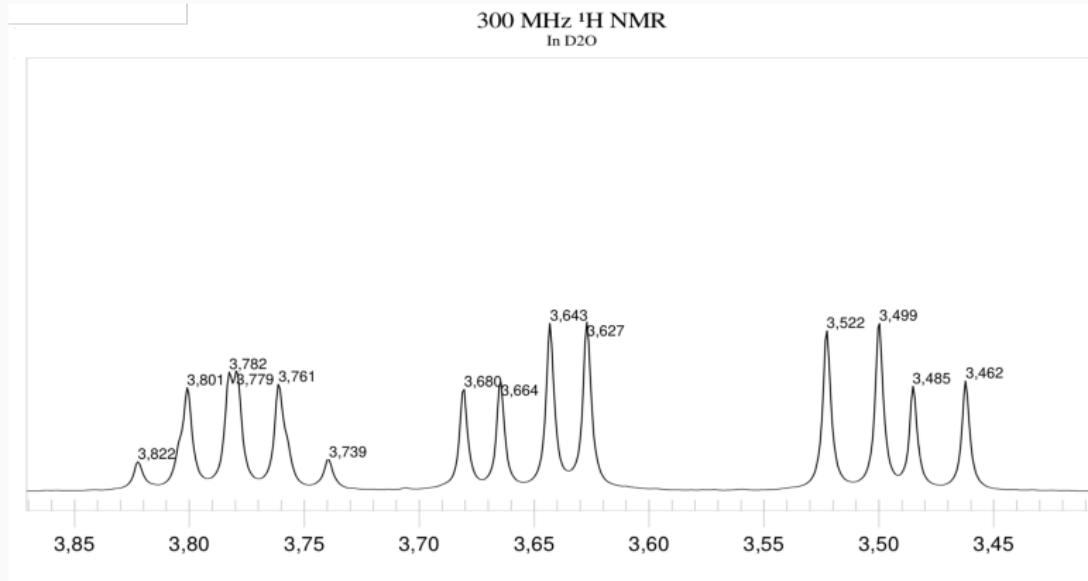
## Ex8: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{11}\text{NO}_2$



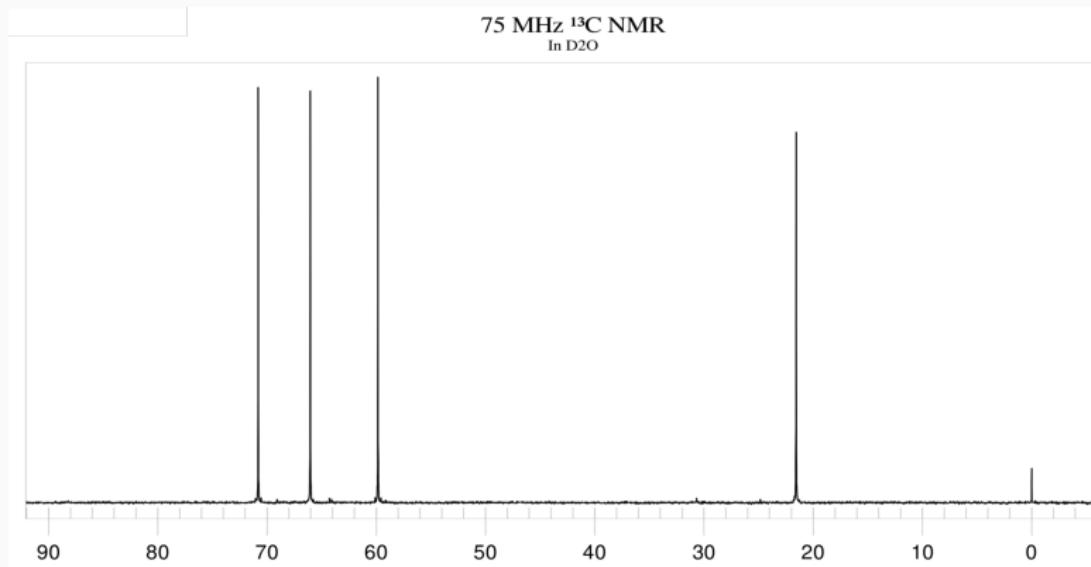
## Ex8: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{11}\text{NO}_2$



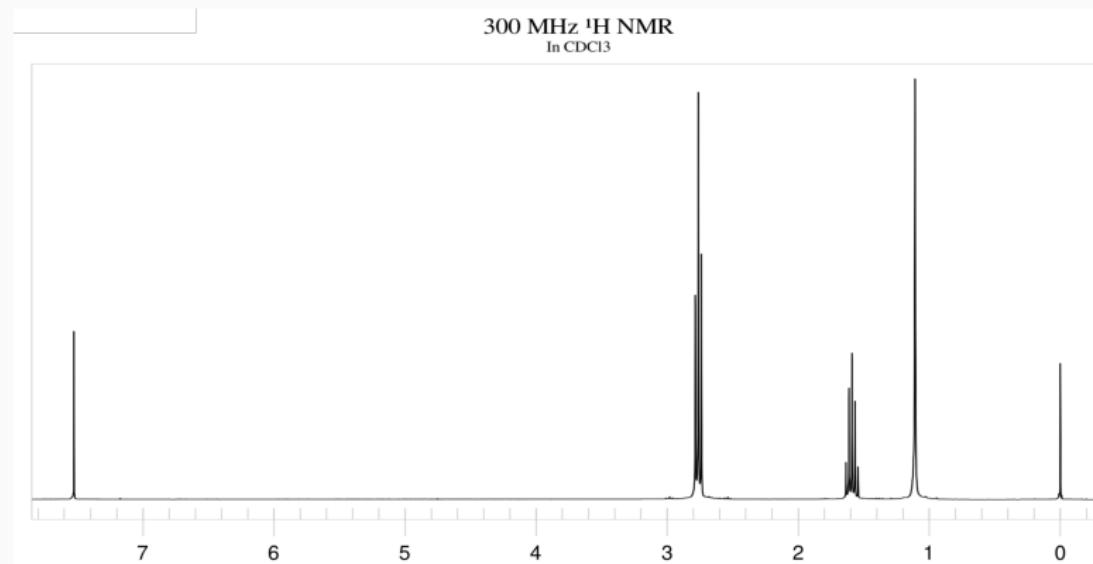
## Ex8: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_{11}\text{NO}_2$



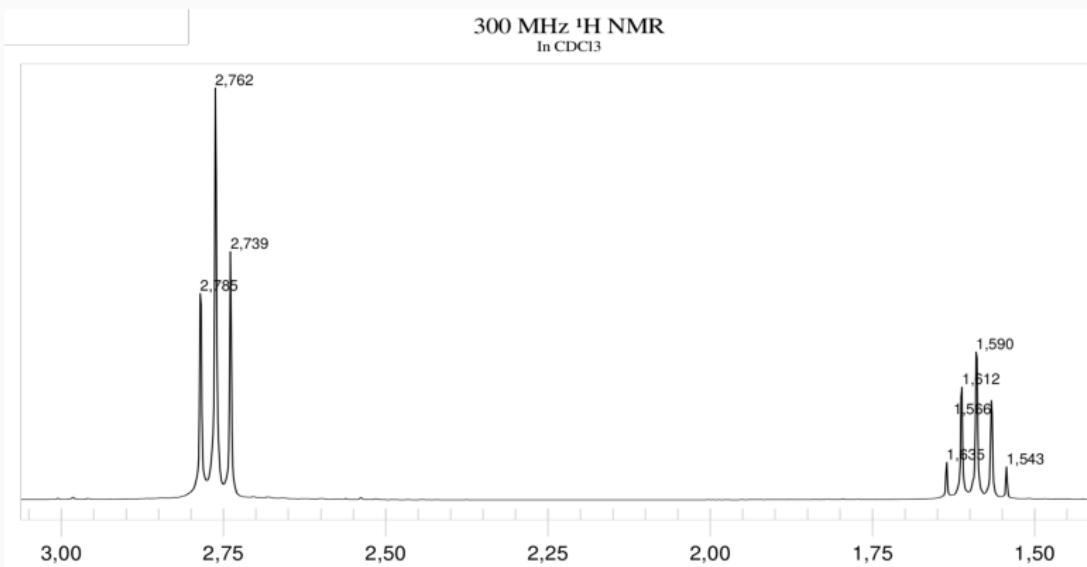
## Ex8: Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_{11}\text{NO}_2$



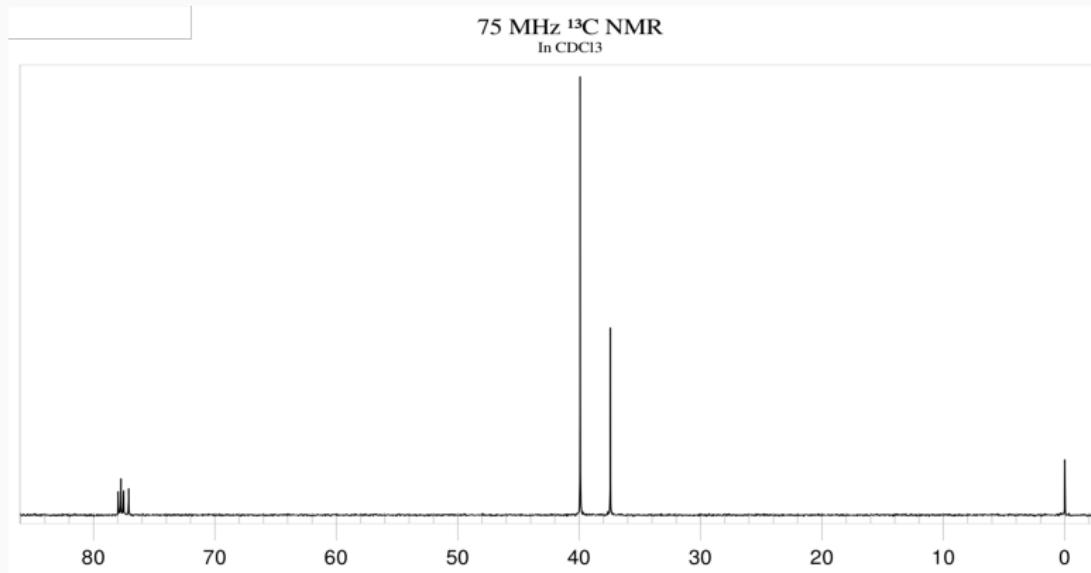
## Ex9: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_{10}\text{N}_2$



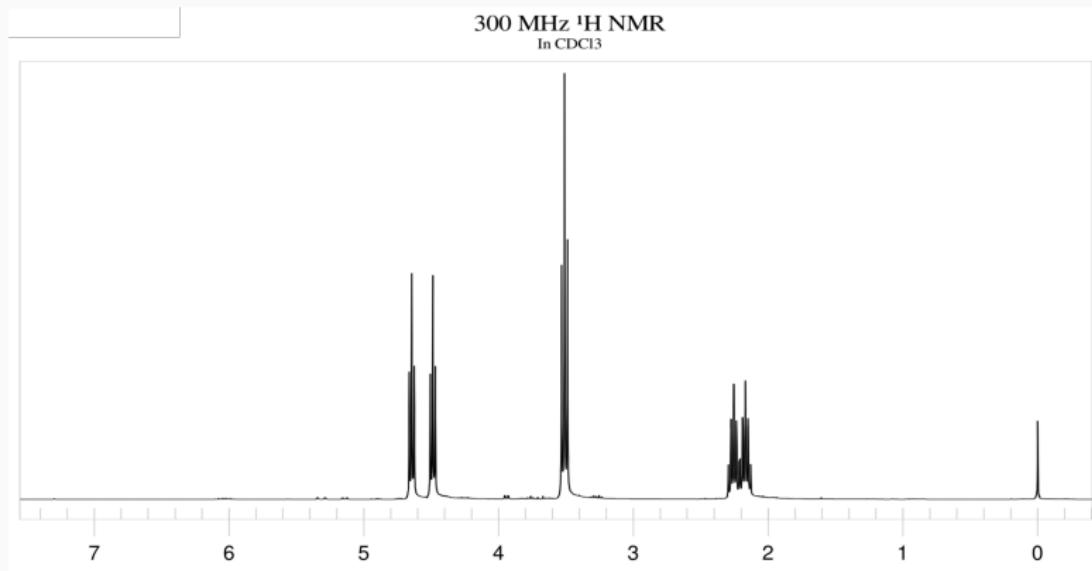
## Ex9: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_{10}\text{N}_2$



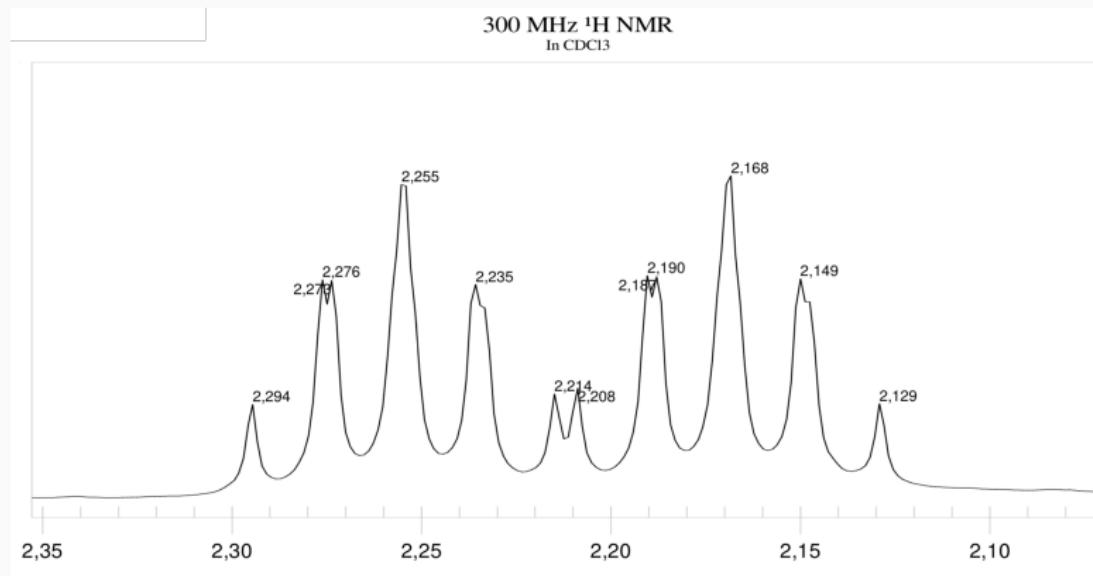
## Ex9: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_{10}\text{N}_2$



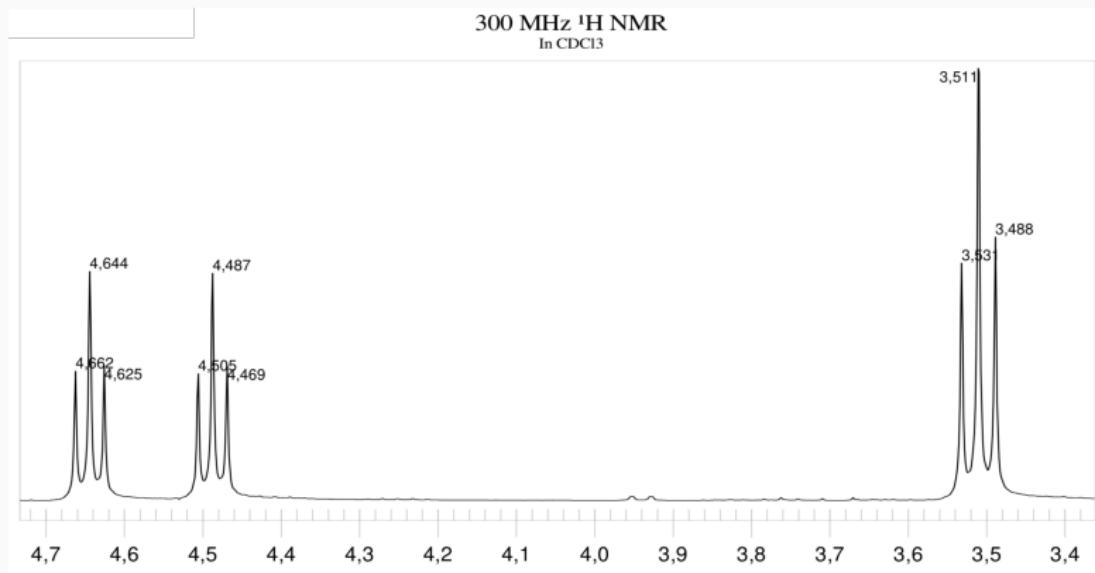
## Ex10: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_6\text{BrF}$



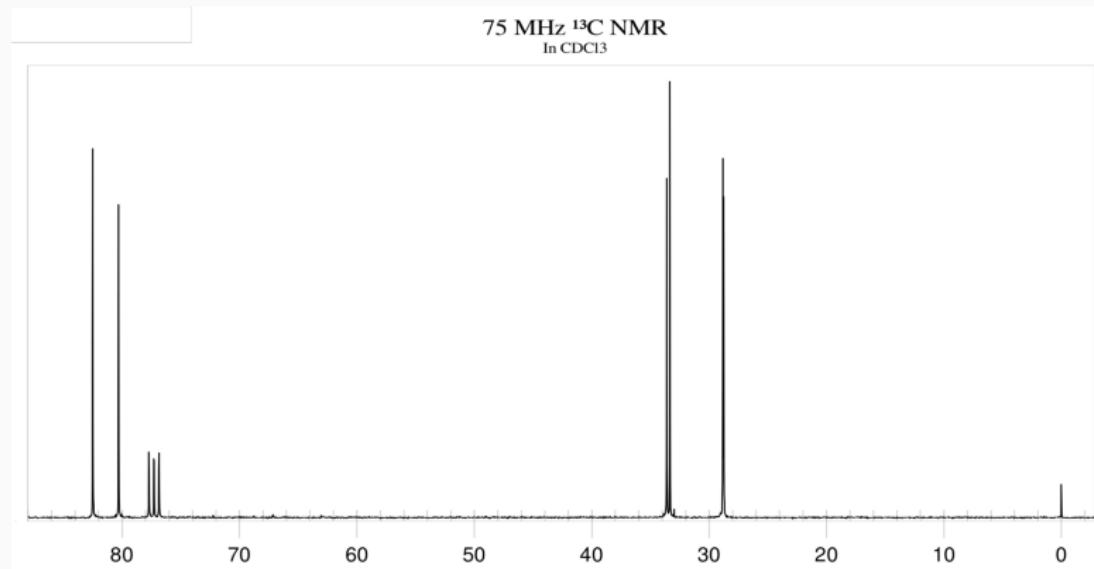
## Ex10: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_6\text{BrF}$



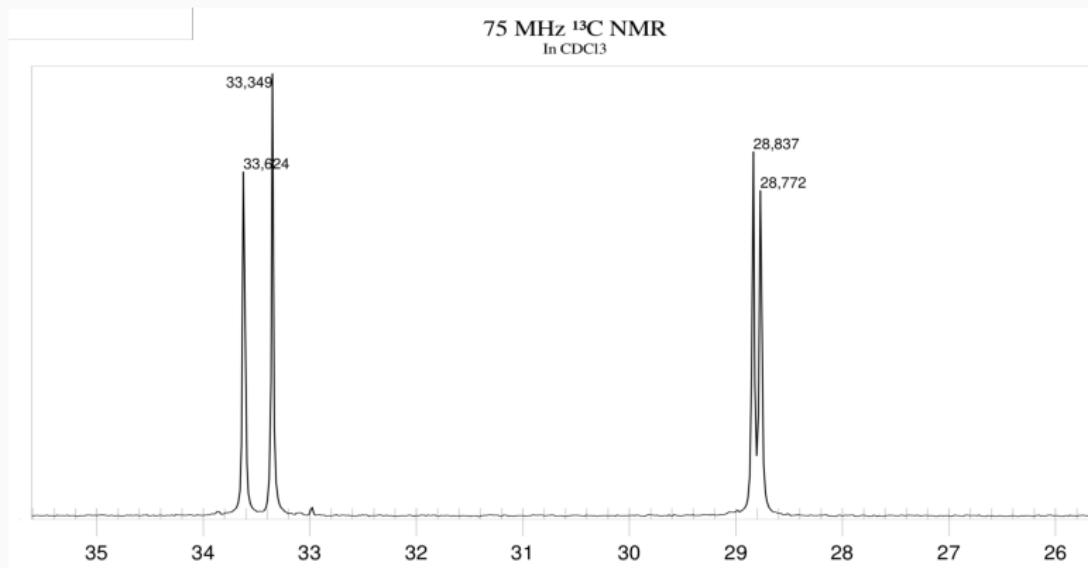
## Ex10: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_6\text{BrF}$



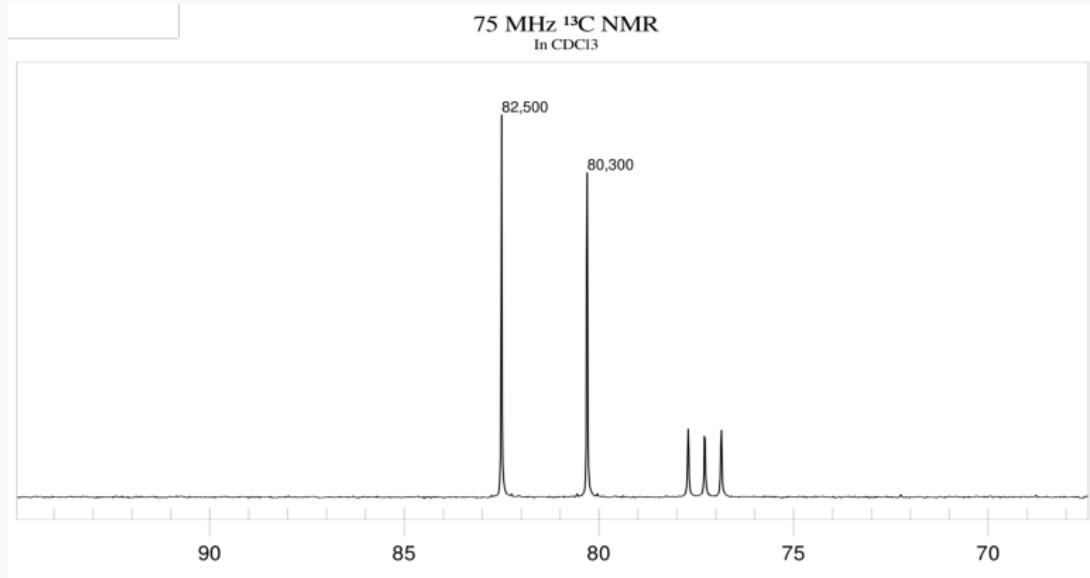
## Ex10: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_6\text{BrF}$



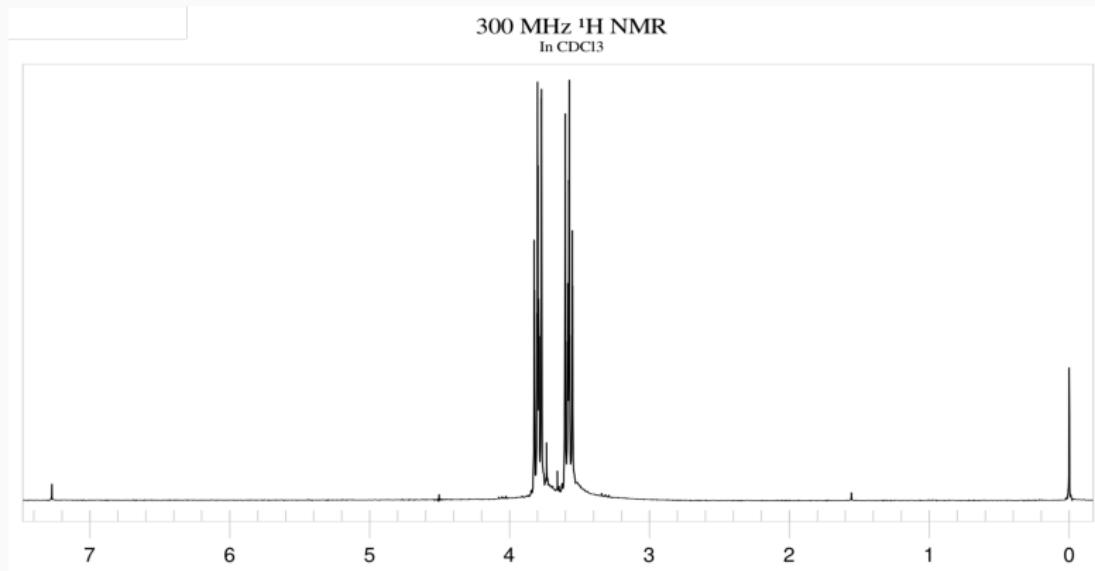
## Ex10: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_6\text{BrF}$



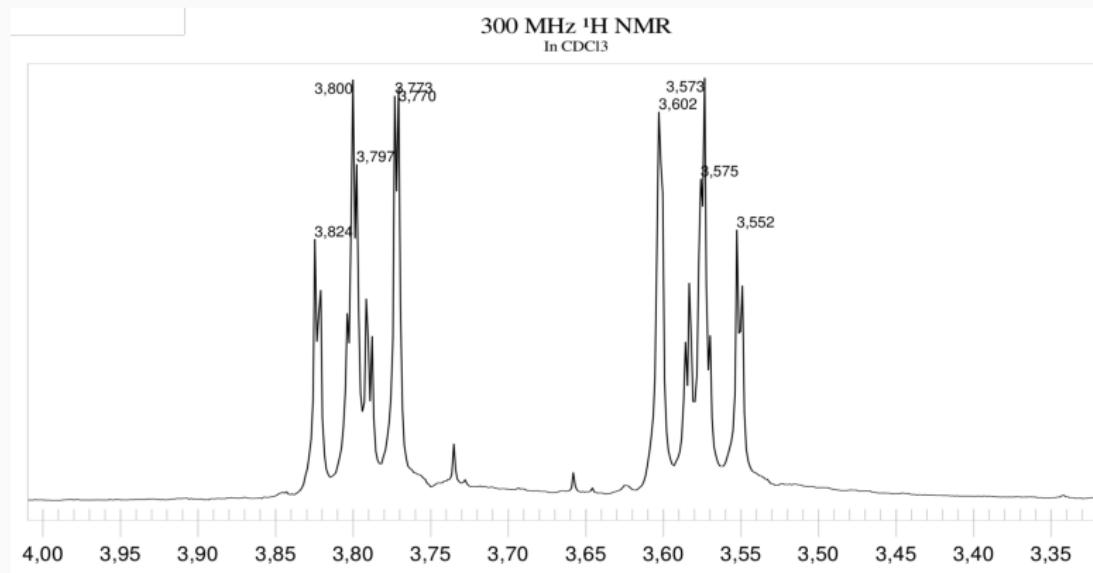
## Ex10: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_6\text{BrF}$



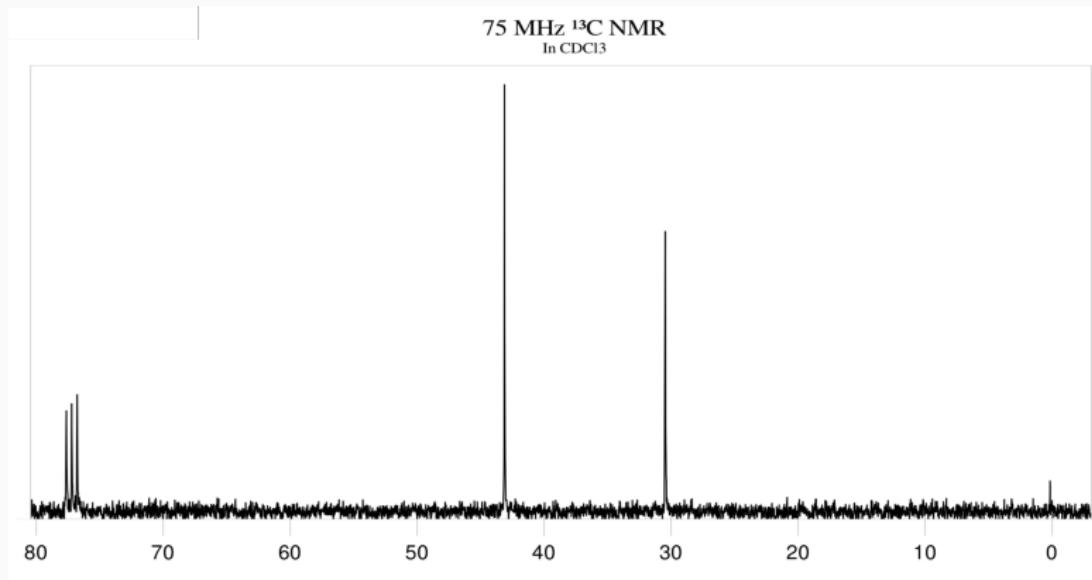
## Ex11: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_4\text{ClBr}$



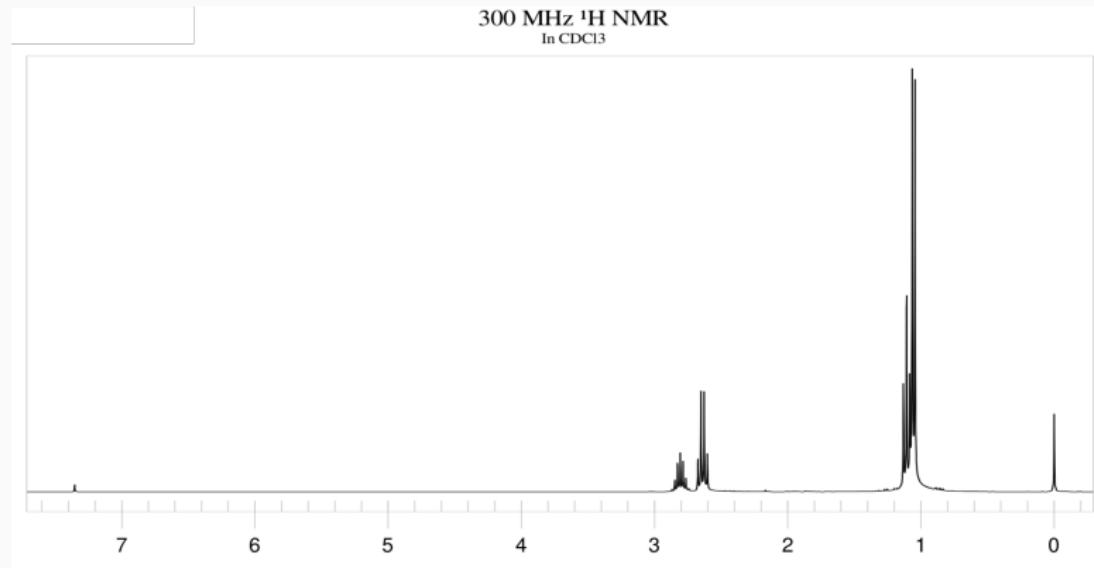
## Ex11: Espectro de $^1\text{H}$ do $\text{C}_2\text{H}_4\text{ClBr}$



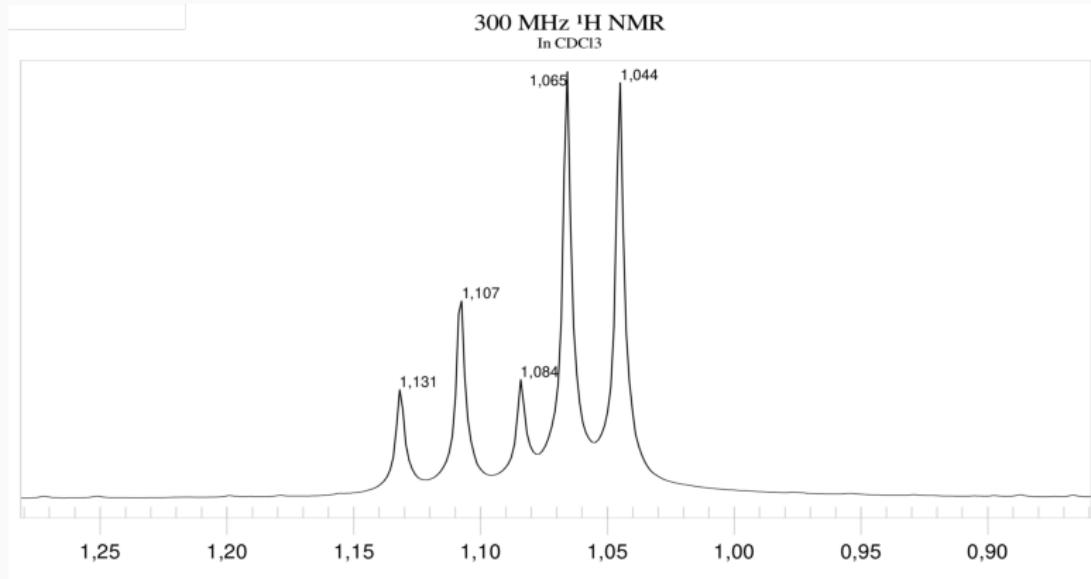
## Ex11: Espectro de $^{13}\text{C}$ do $\text{C}_2\text{H}_4\text{ClBr}$



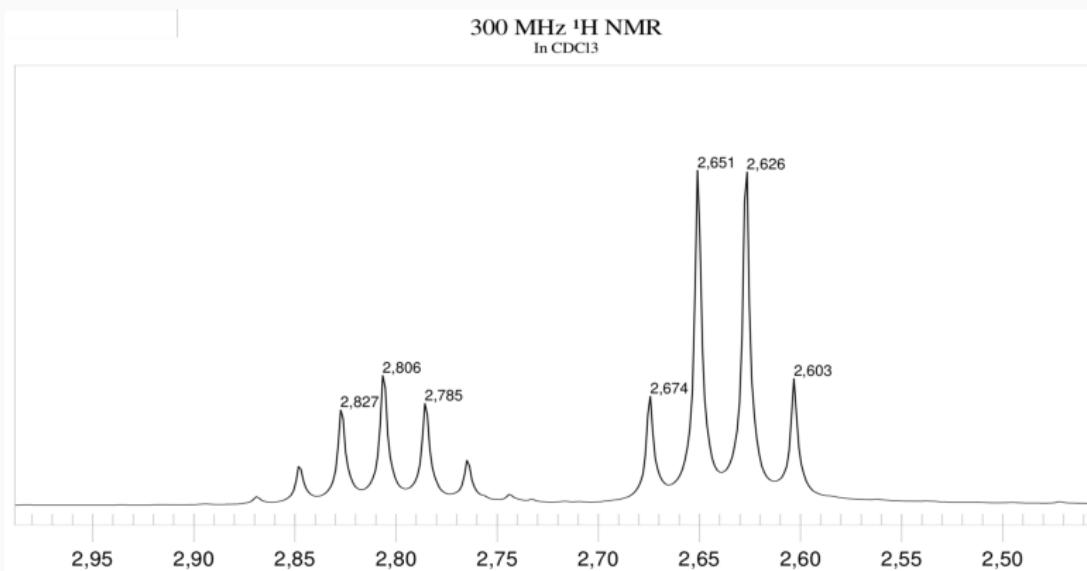
## Ex12: Espectro de $^1\text{H}$ do $\text{C}_5\text{H}_{13}\text{N}$



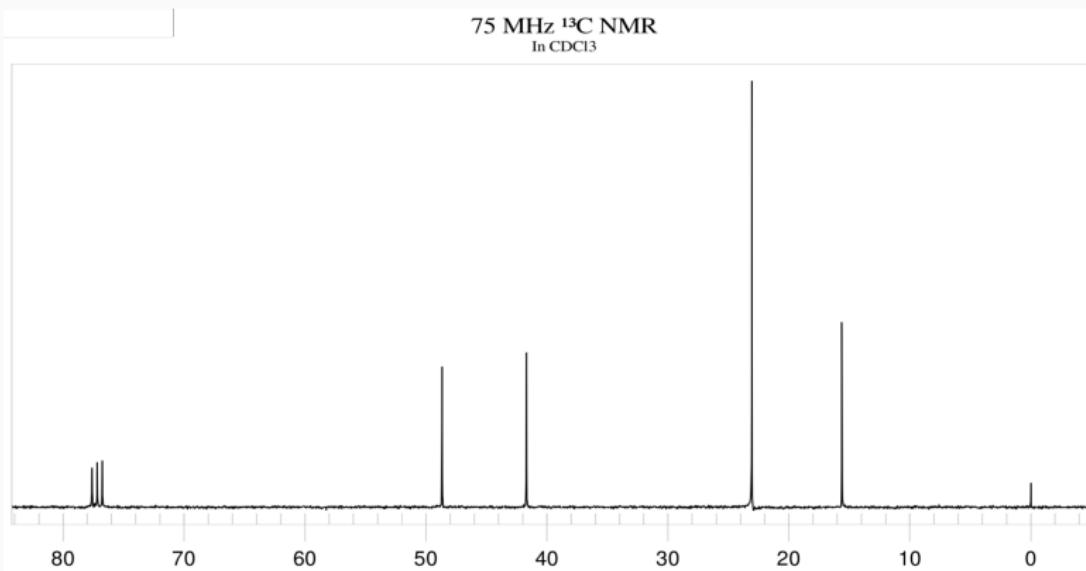
## Ex12: Espectro de $^1\text{H}$ do $\text{C}_5\text{H}_{13}\text{N}$



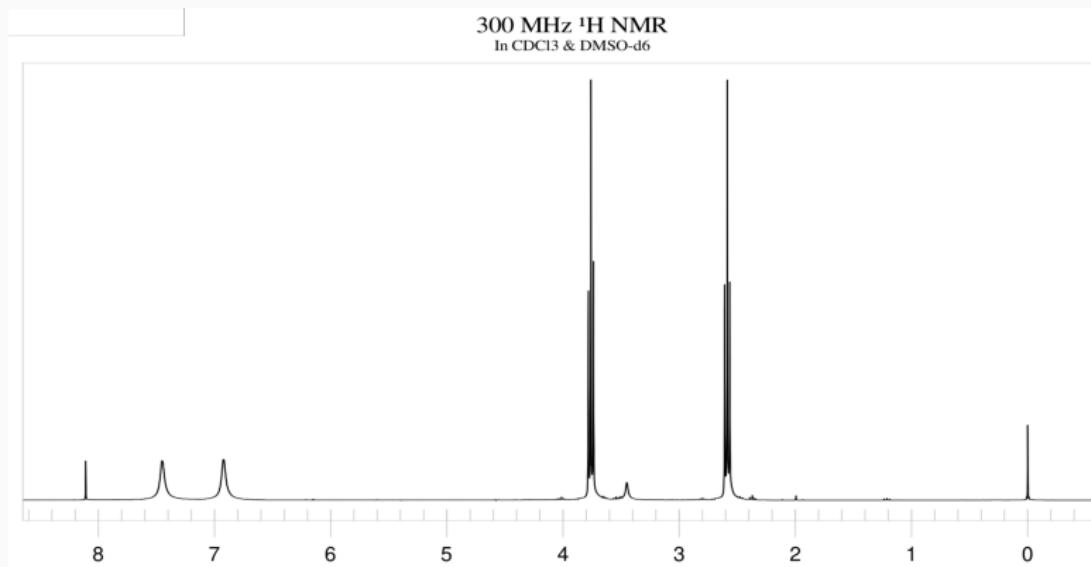
## Ex12: Espectro de $^1\text{H}$ do $\text{C}_5\text{H}_{13}\text{N}$



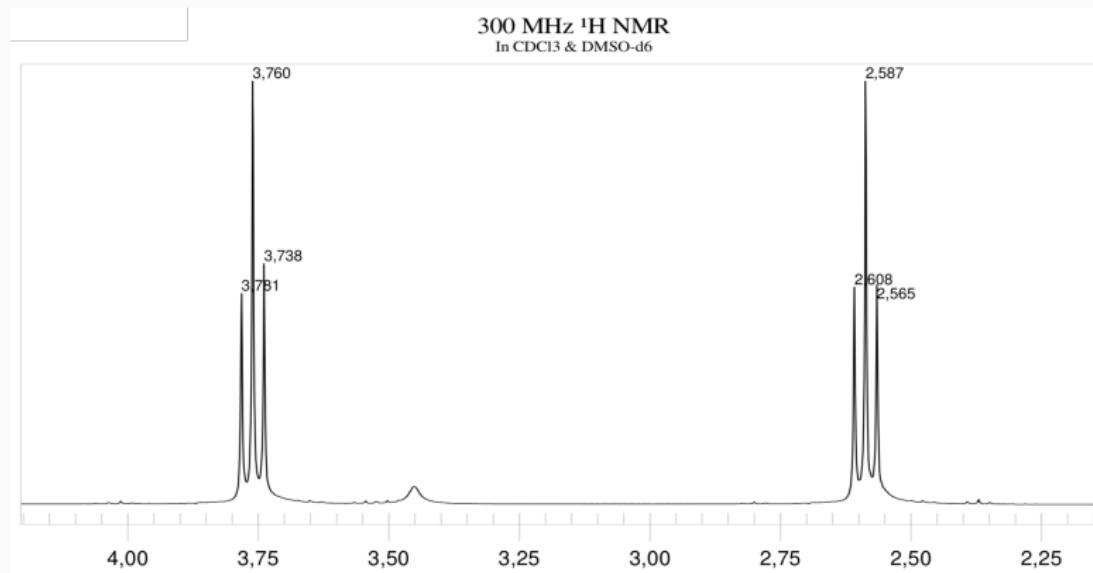
## Ex12: Espectro de $^{13}\text{C}$ do $\text{C}_5\text{H}_{13}\text{N}$



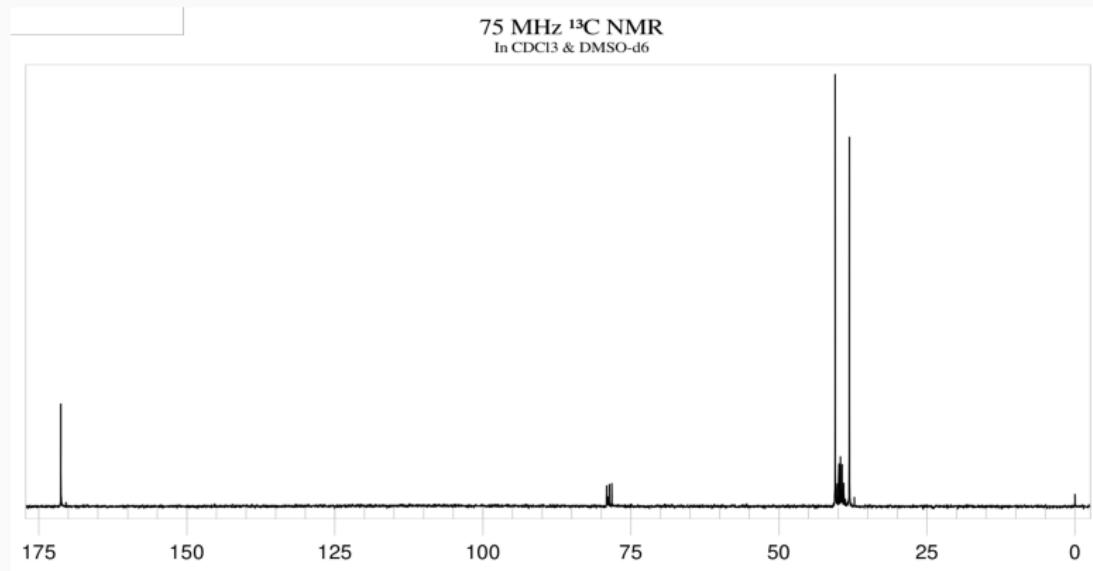
## Ex13: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_6\text{ClNO}$



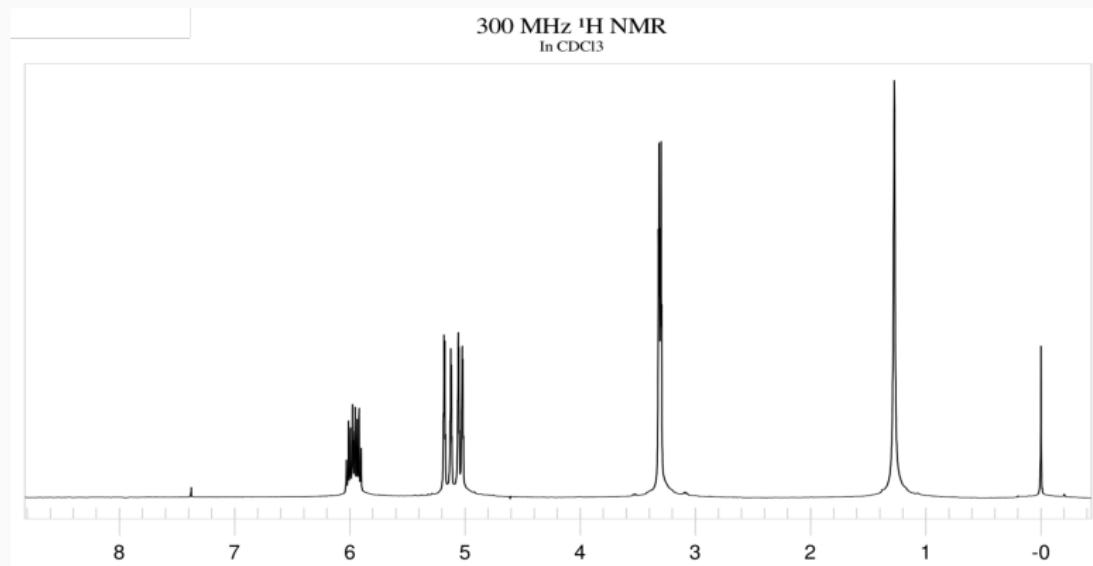
## Ex13: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_6\text{ClNO}$



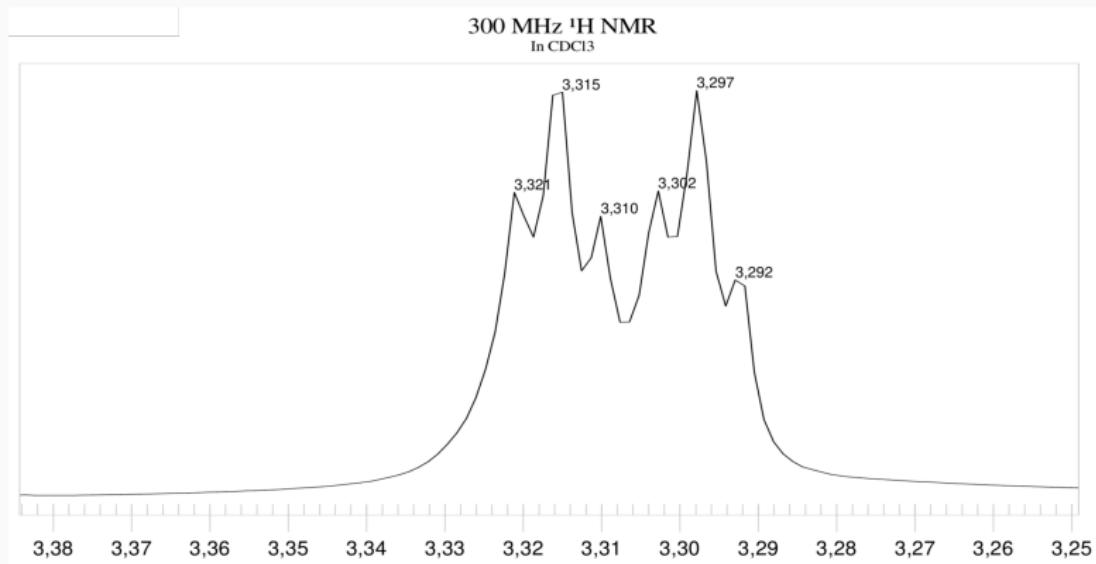
## Ex13: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_6\text{ClNO}$



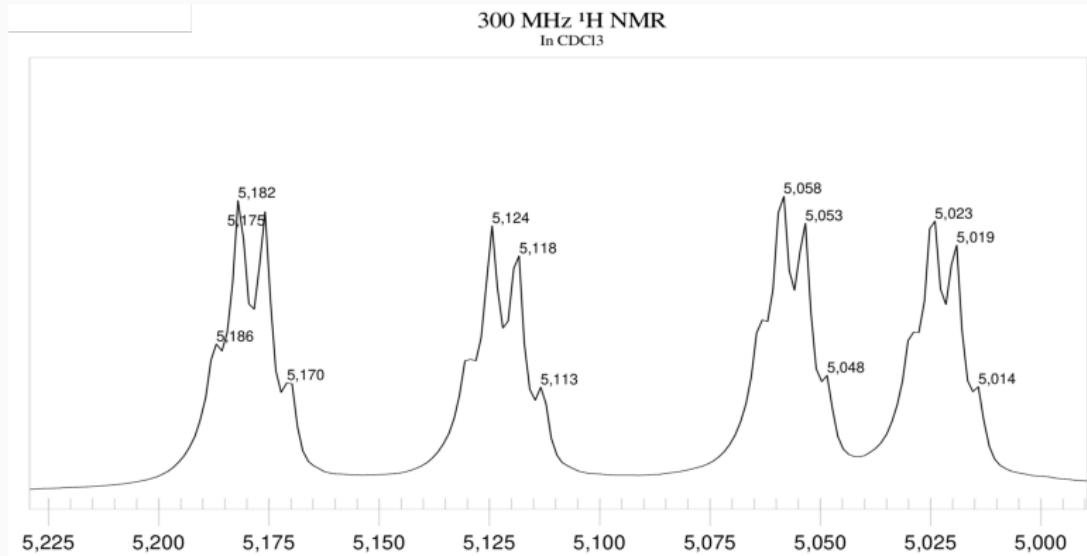
## Ex14: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{N}$



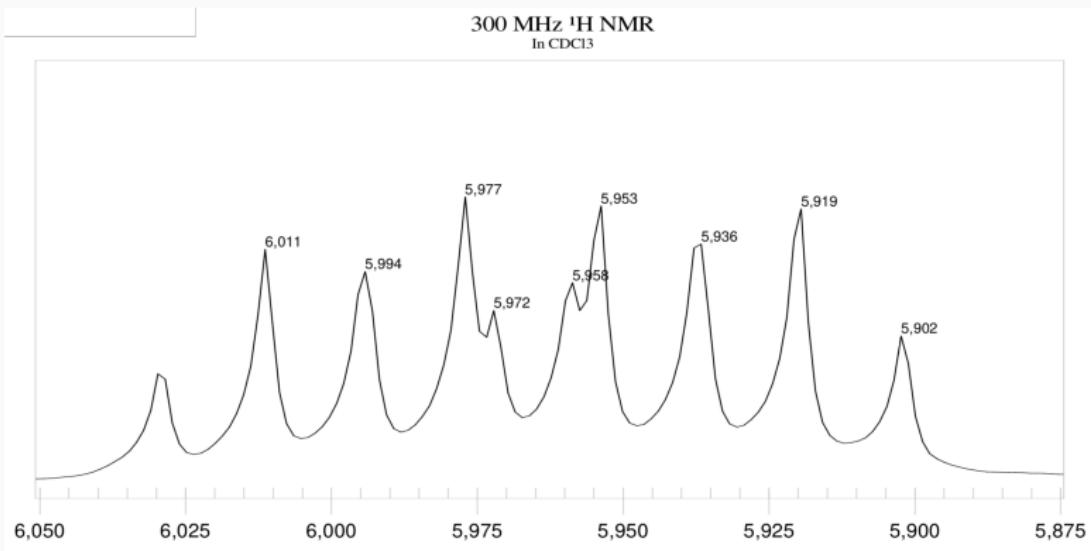
## Ex14: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{N}$



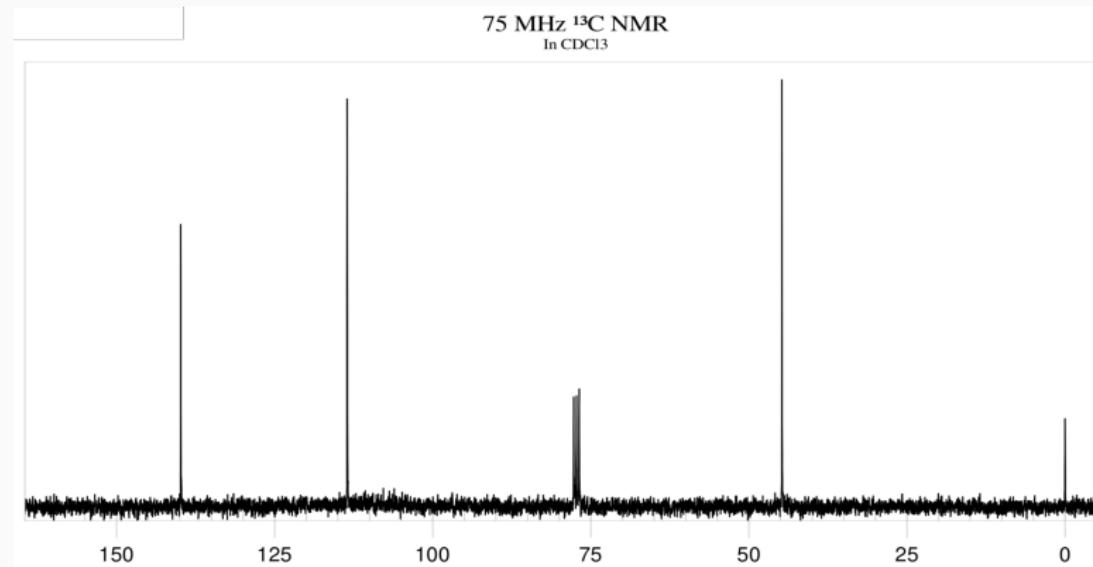
## Ex14: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{N}$



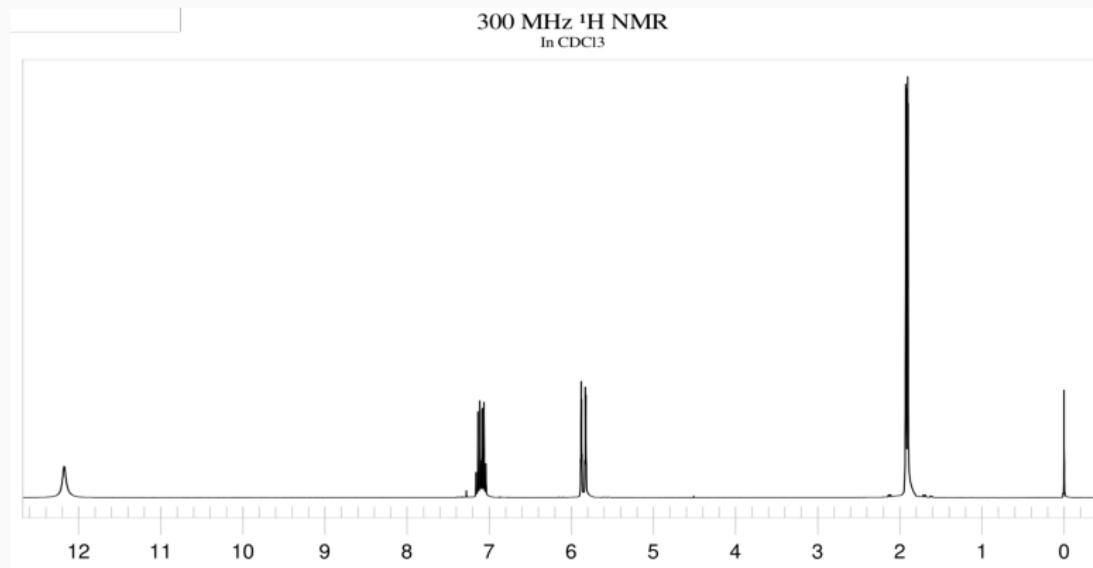
## Ex14: Espectro de $^1\text{H}$ do $\text{C}_3\text{H}_7\text{N}$



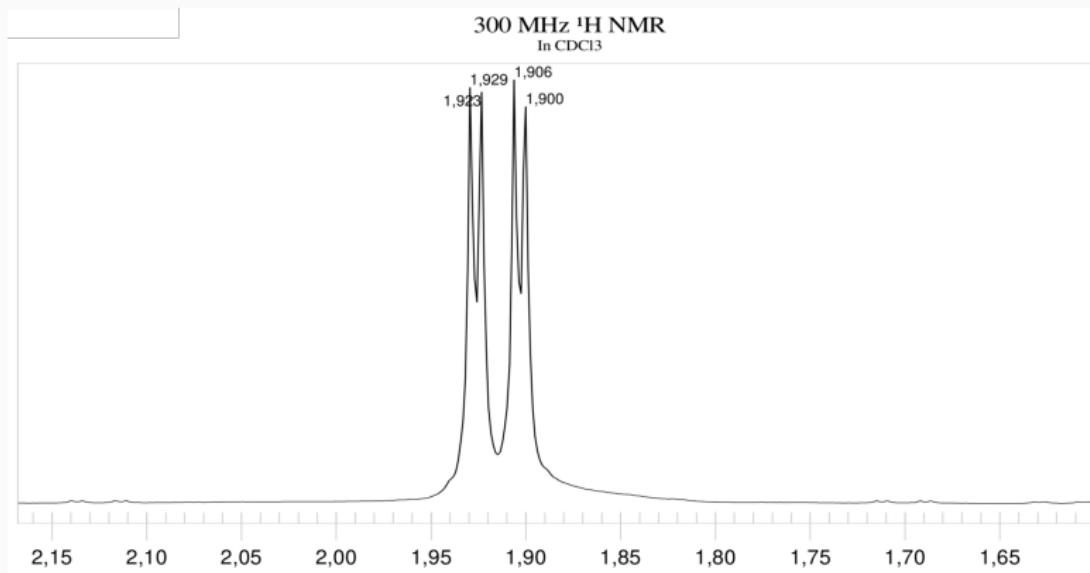
## Ex14: Espectro de $^{13}\text{C}$ do $\text{C}_3\text{H}_7\text{N}$



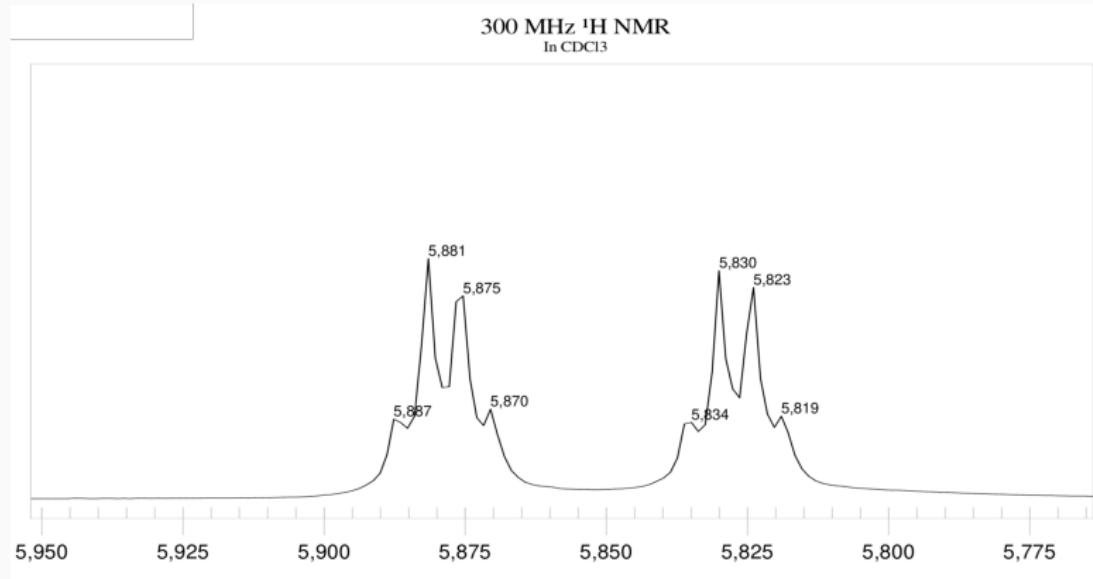
## Ex15: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_6\text{O}_2$



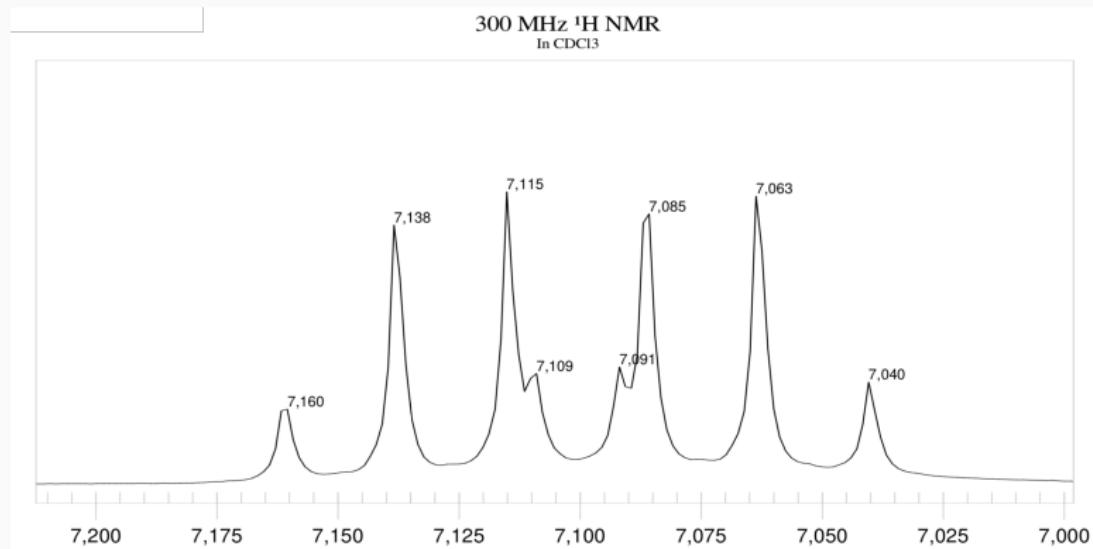
## Ex15: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_6\text{O}_2$



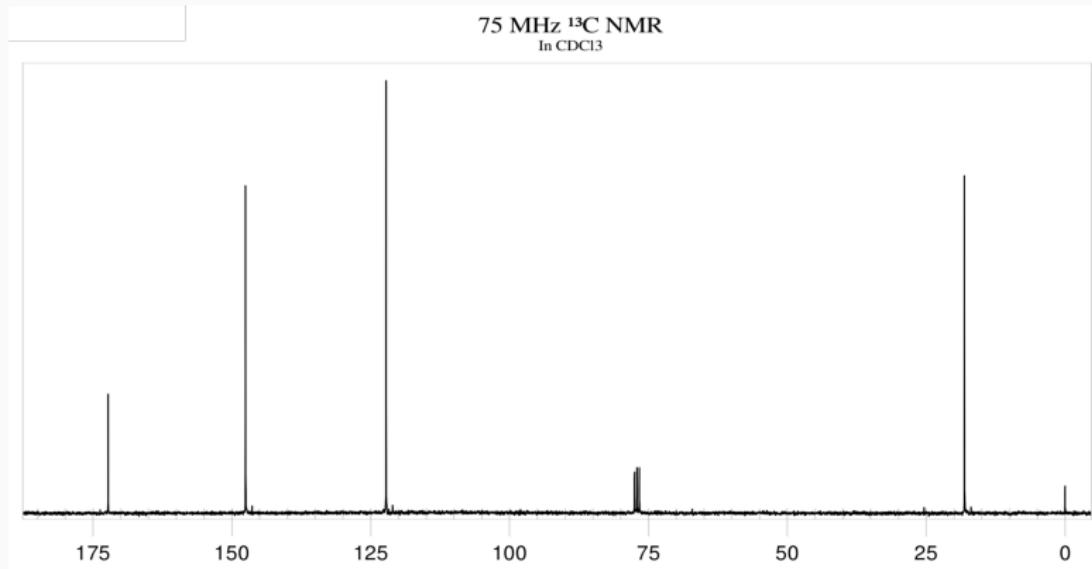
## Ex15: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_6\text{O}_2$



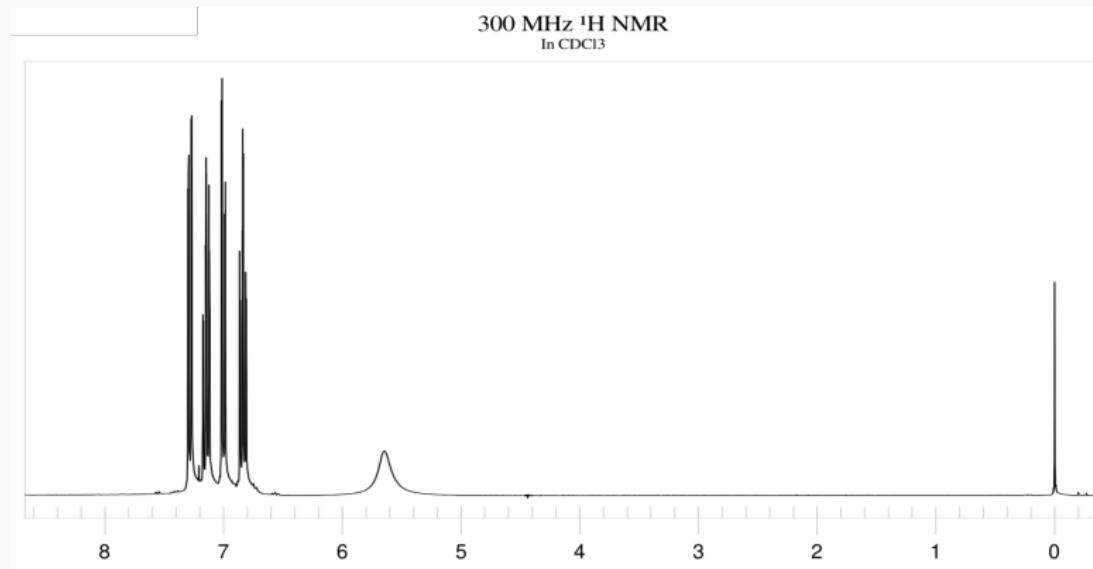
## Ex15: Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_6\text{O}_2$



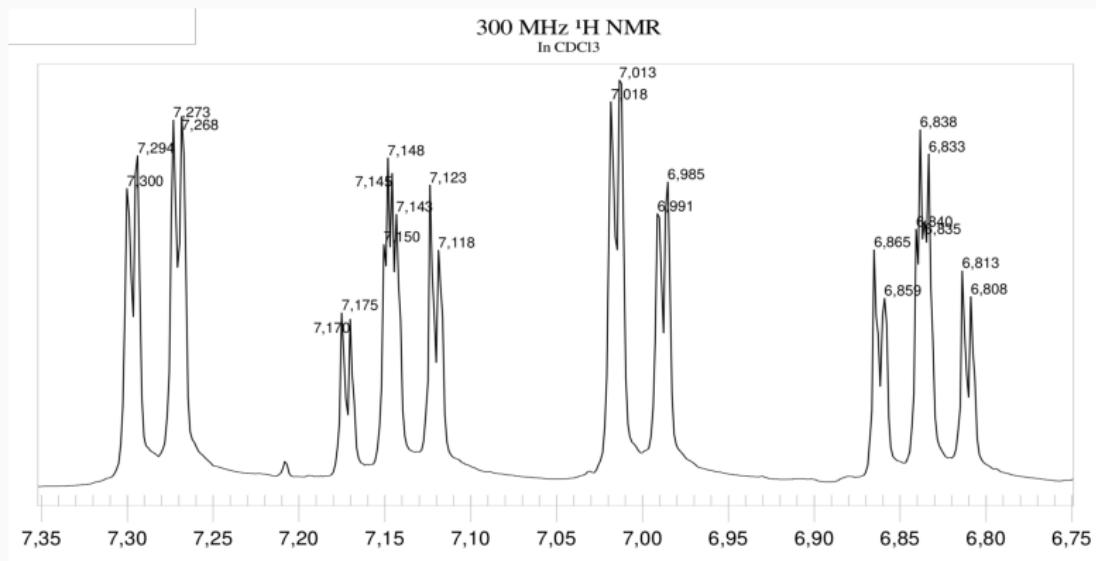
## Ex15: Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_6\text{O}_2$



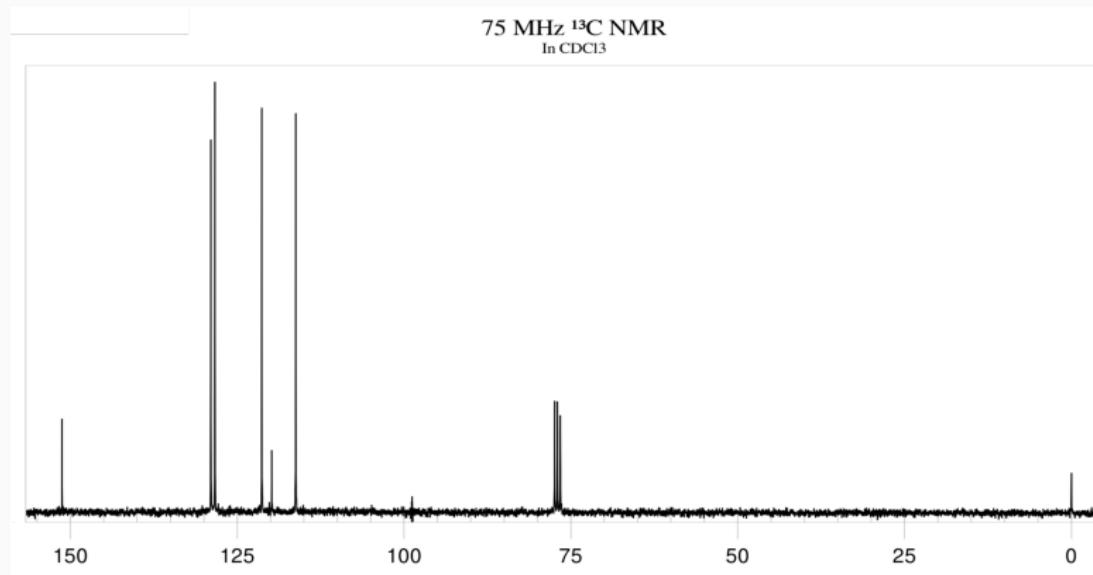
## Ex16: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}$



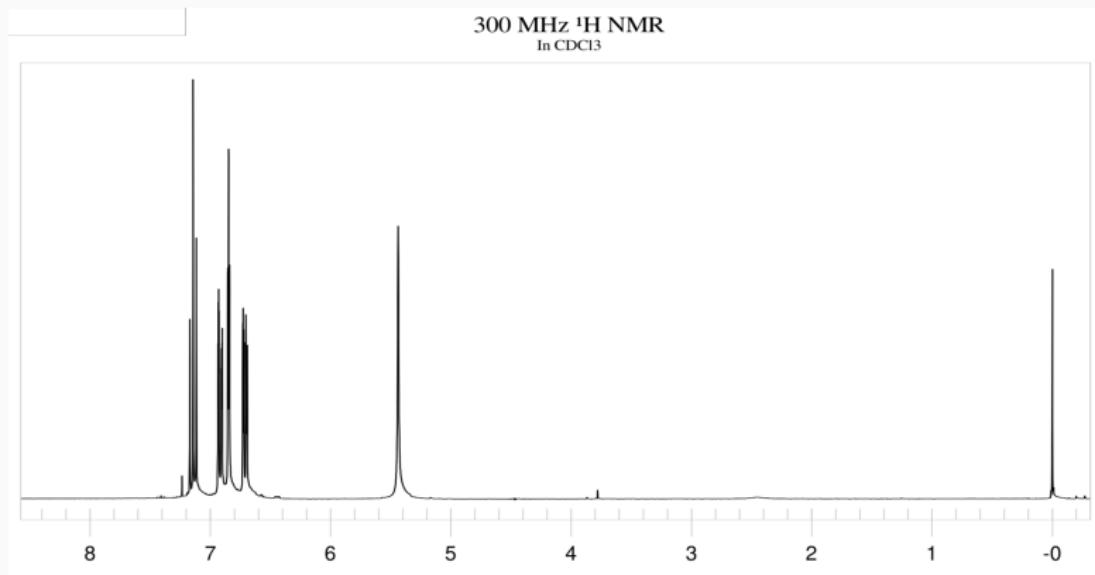
## Ex16: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}$



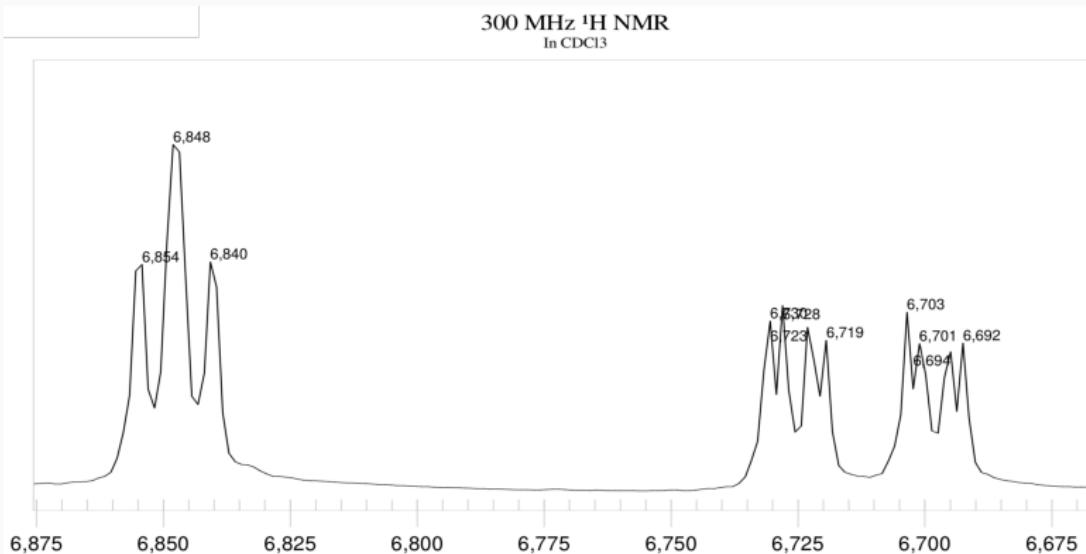
## Ex16: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClO}$



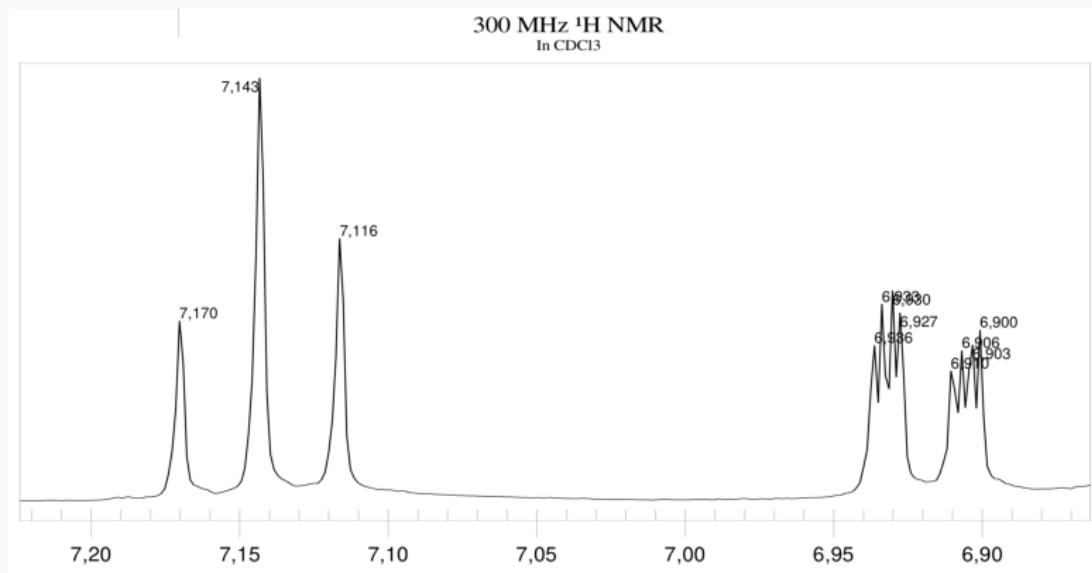
## Ex17: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}$



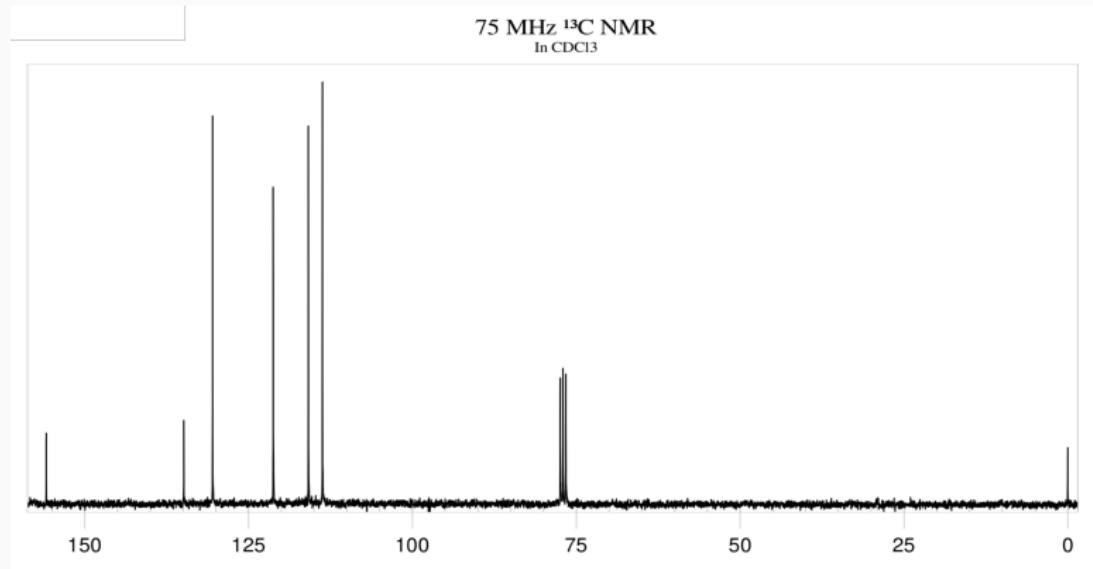
## Ex17: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}$



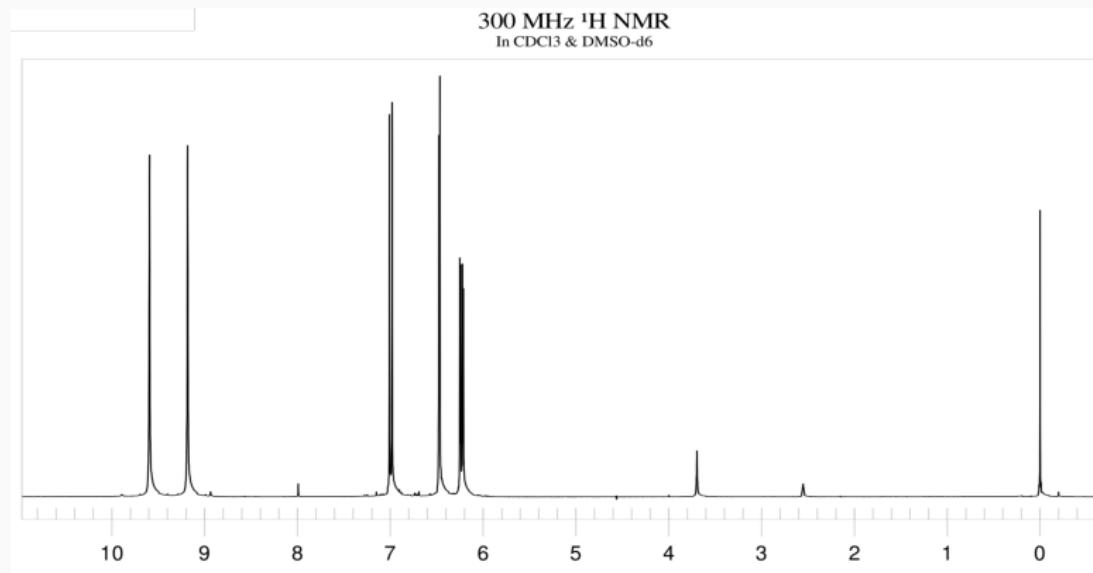
## Ex17: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}$



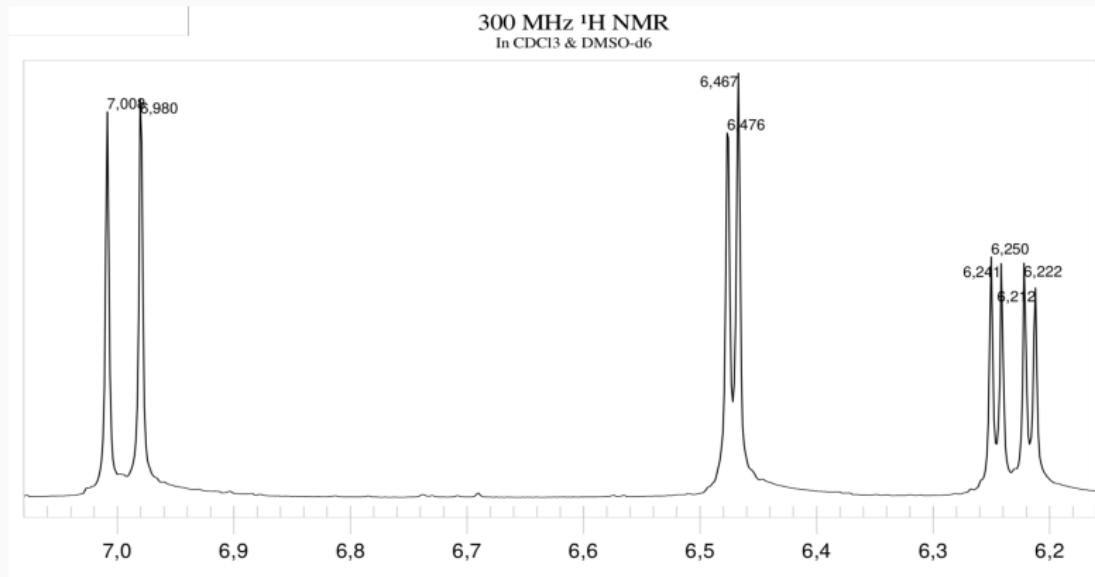
## Ex17: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClO}$



## Ex18: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}_2$

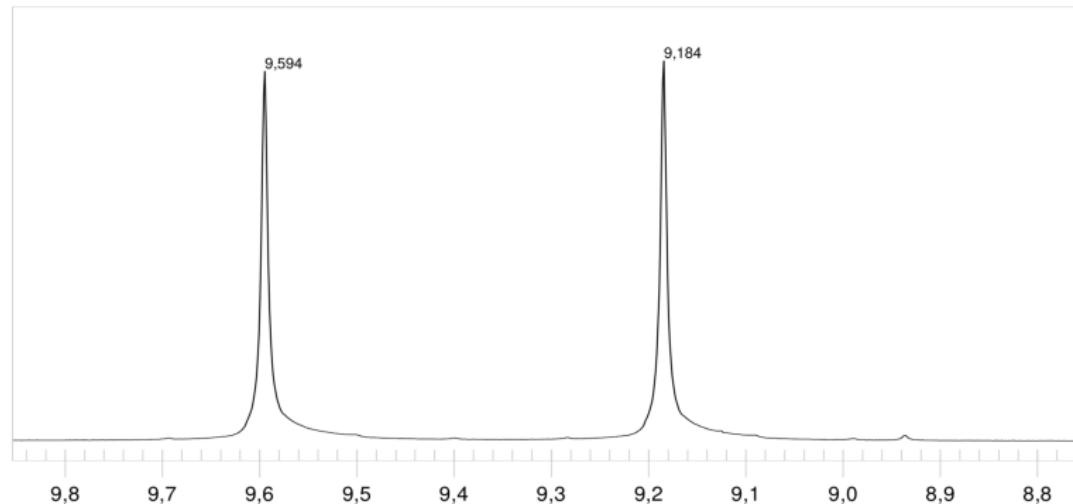


## Ex18: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}_2$

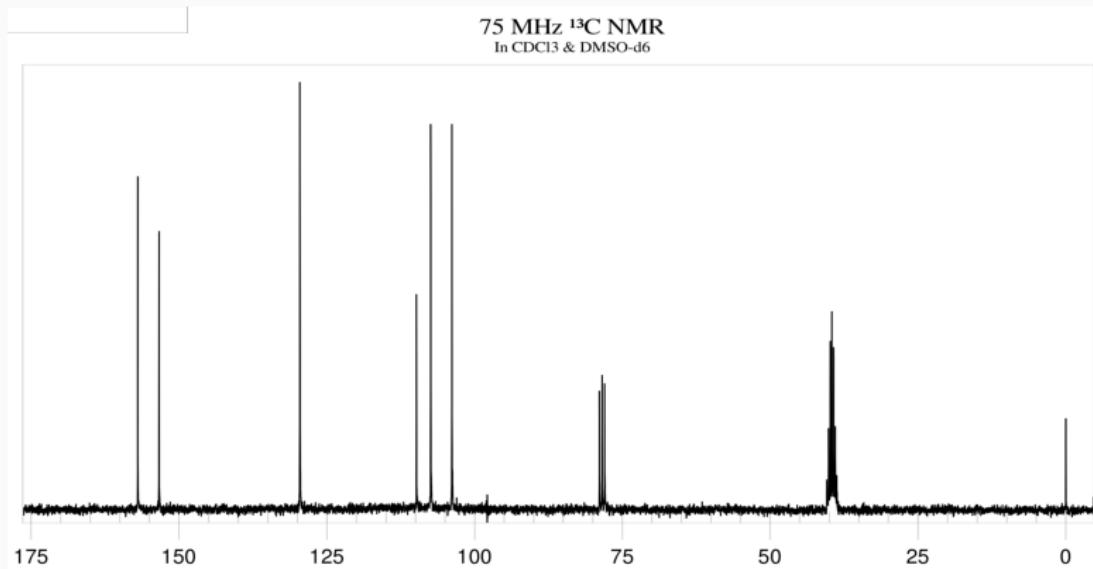


## Ex18: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClO}_2$

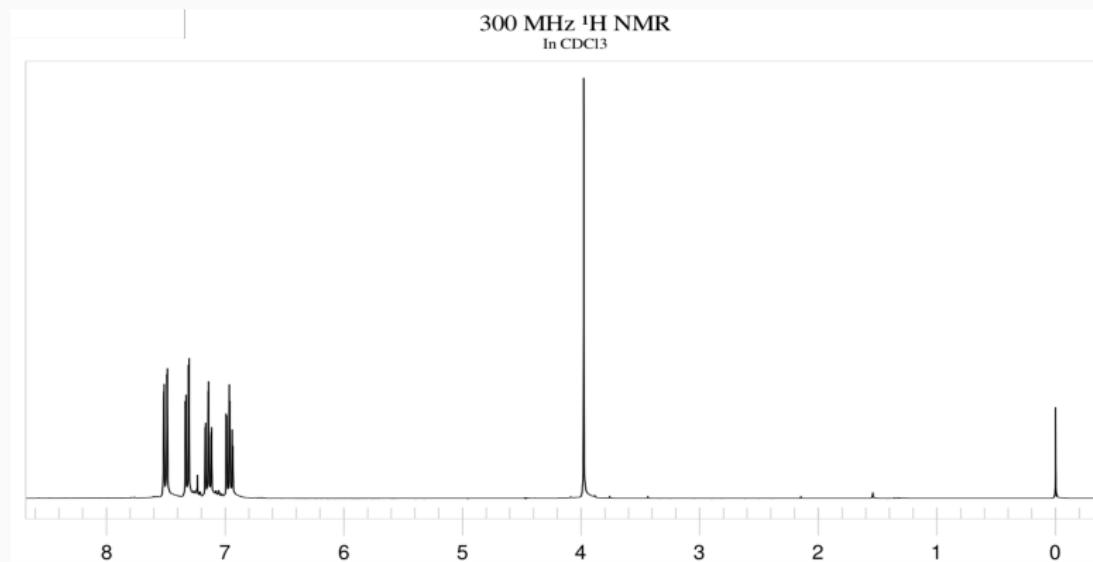
300 MHz  $^1\text{H}$  NMR  
In  $\text{CDCl}_3$  &  $\text{DMSO-d}_6$



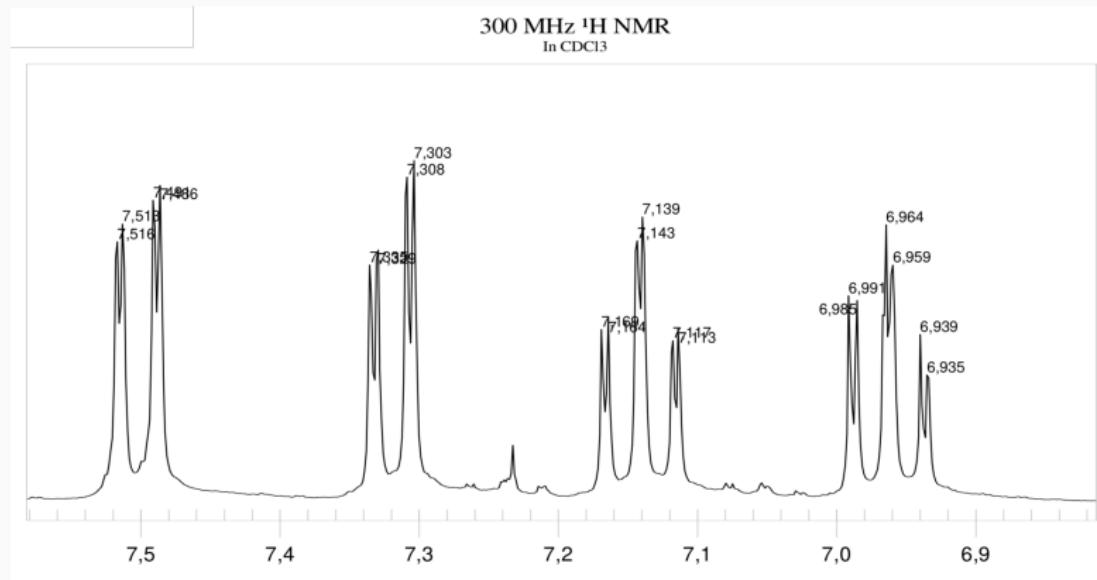
## Ex18: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClO}_2$



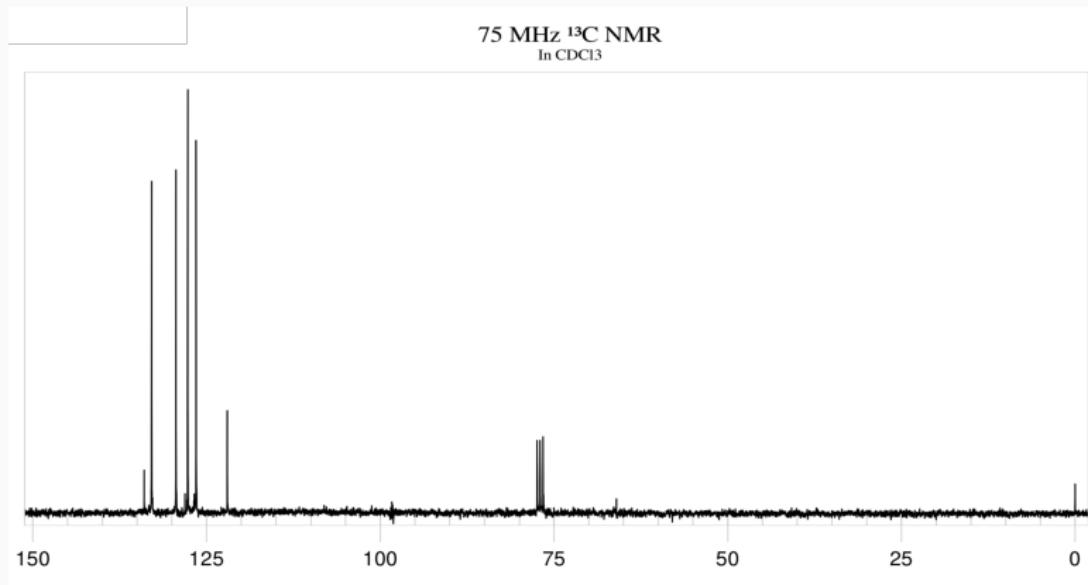
## Ex19: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{BrS}$



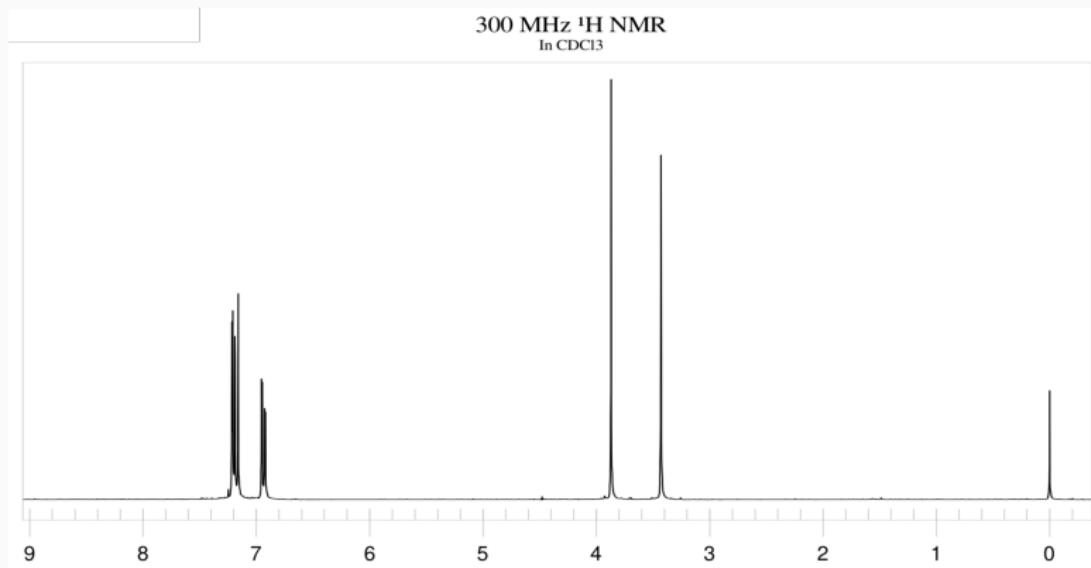
## Ex19: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{BrS}$



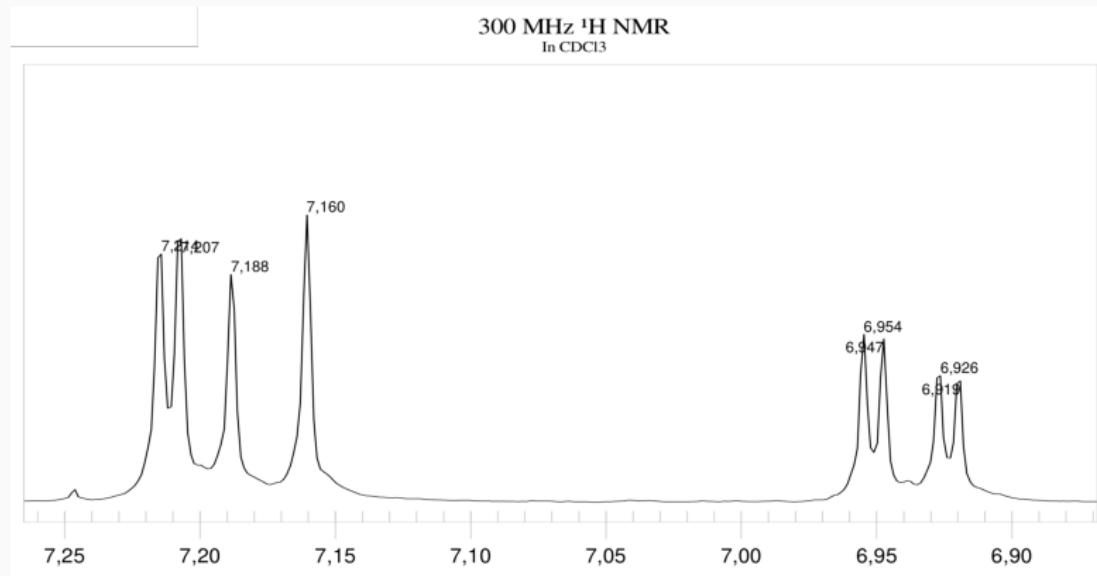
## Ex19: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{BrS}$



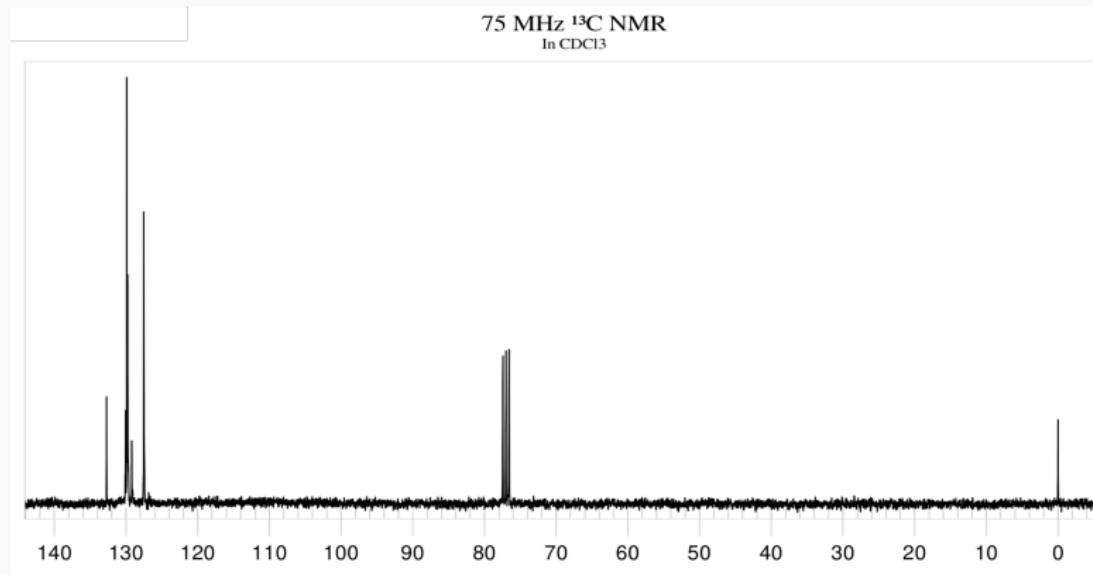
## Ex20: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClS}_2$



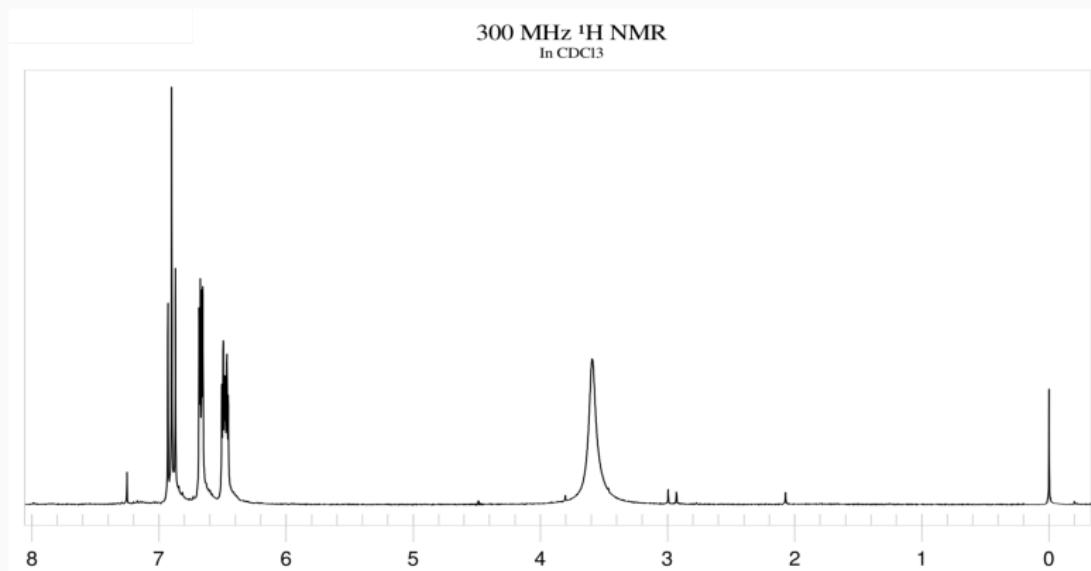
## Ex20: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClS}_2$



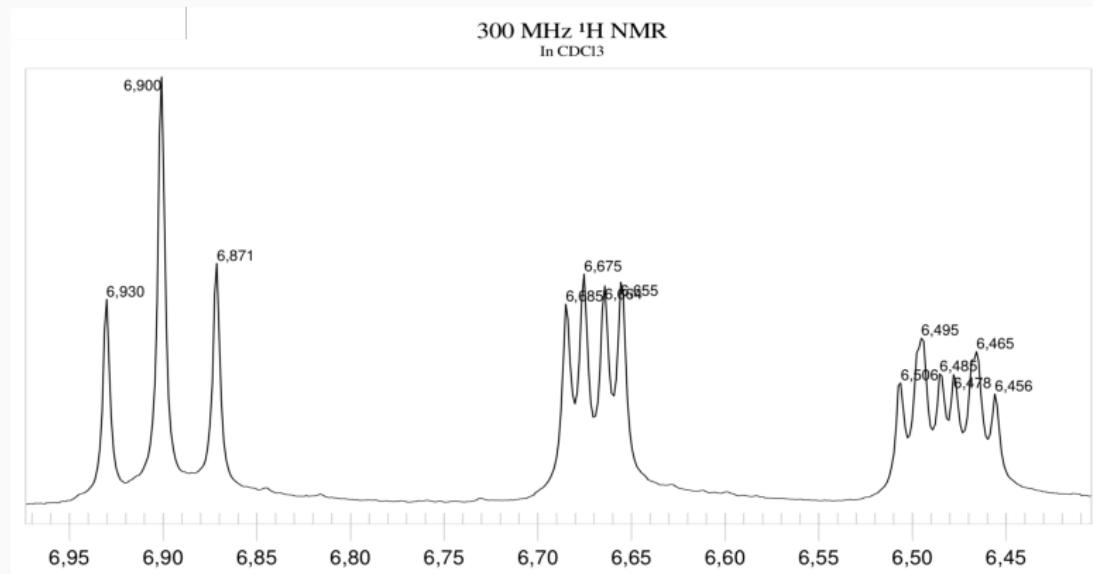
## Ex20: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClS}_2$



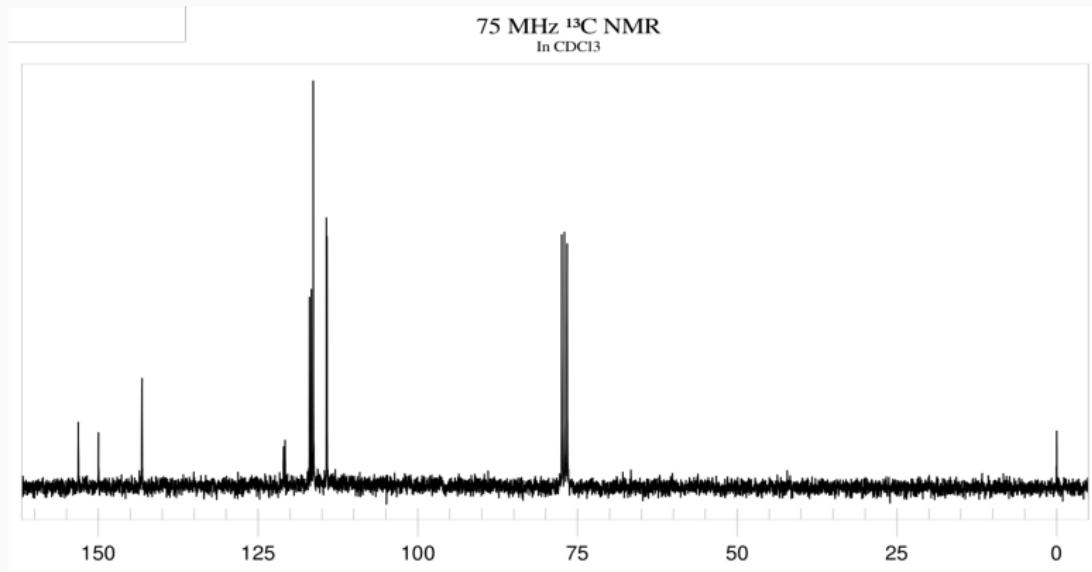
## Ex21: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClFN}$



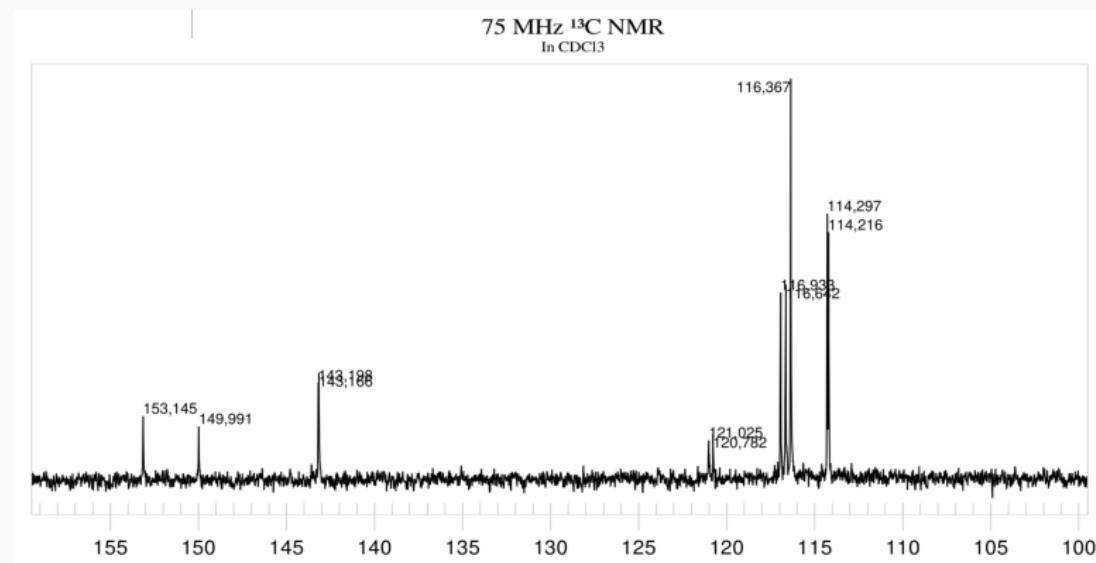
## Ex21: Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_5\text{ClFN}$



## Ex21: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClFN}$



## Ex21: Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_5\text{ClFN}$

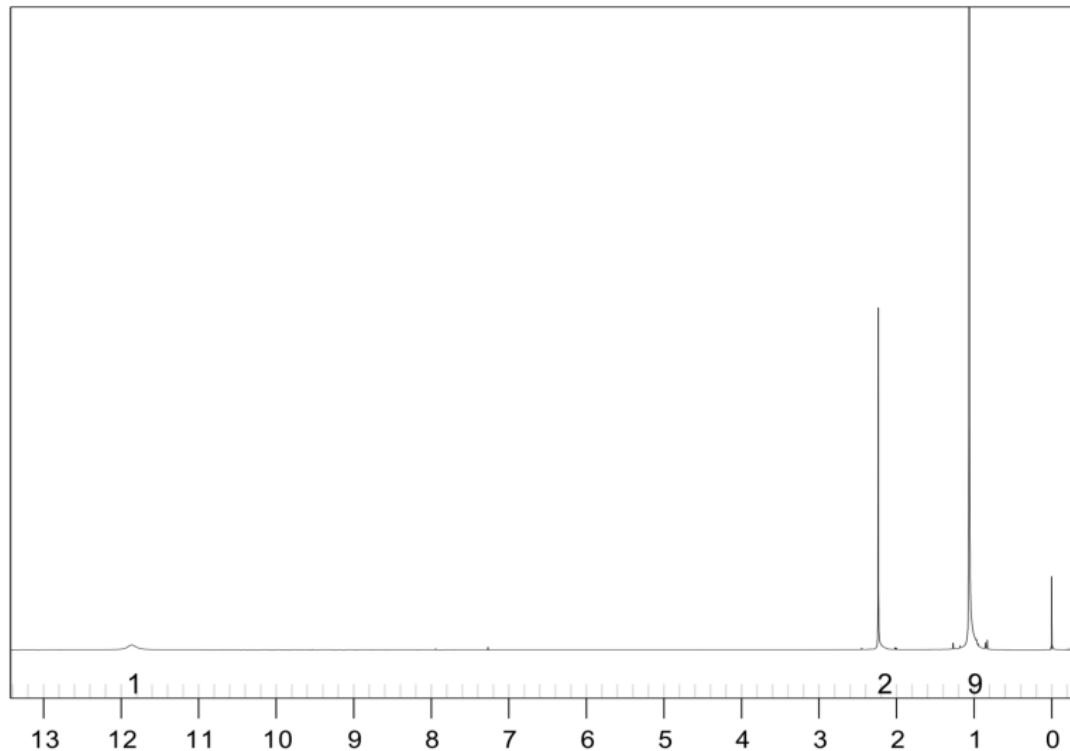


## Exercícios Integrados

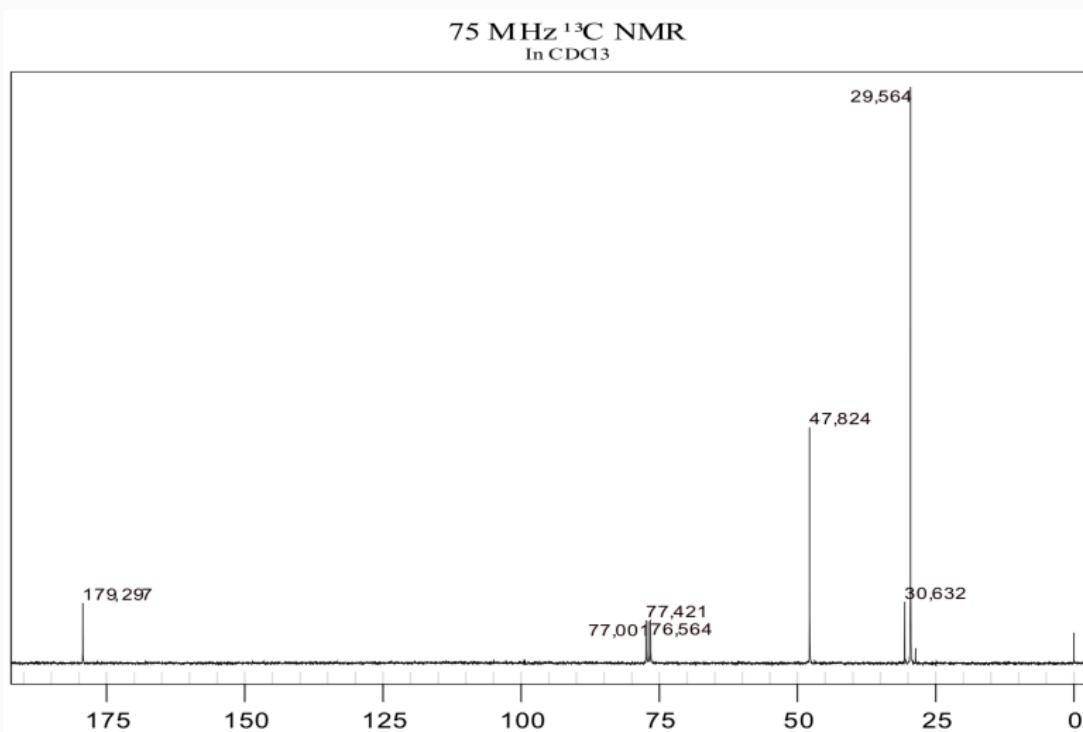
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# Atribua os Sinais do Espectro de $^1\text{H}$ do $\text{C}_6\text{H}_{12}\text{O}_2$

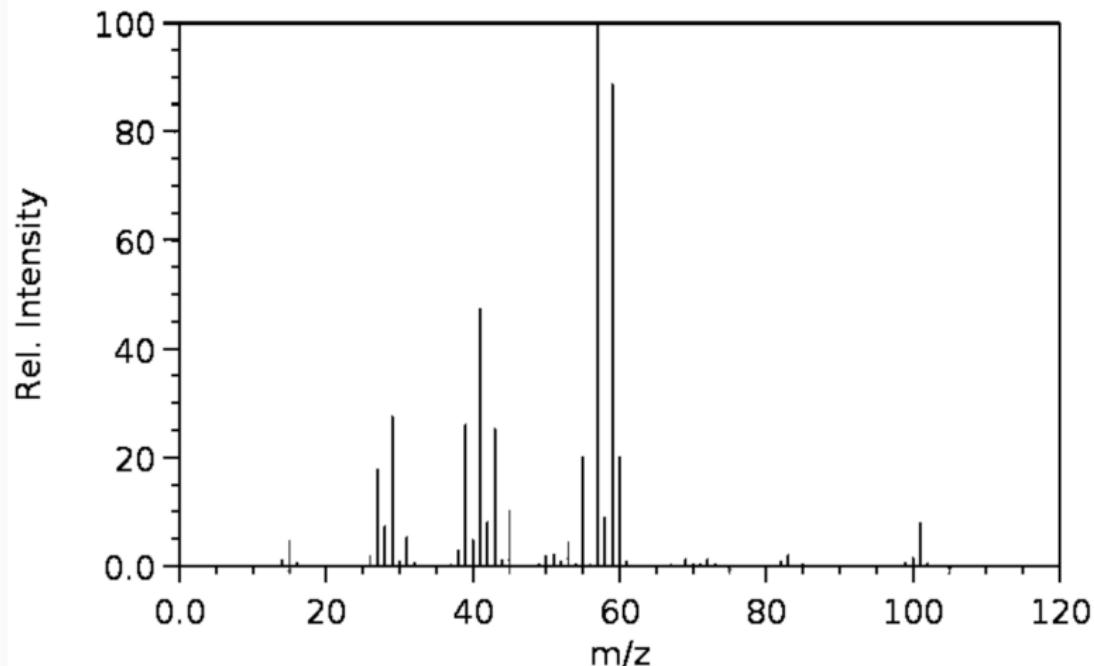
300 MHz  $^1\text{H}$  NMR  
In  $\text{CDCl}_3$



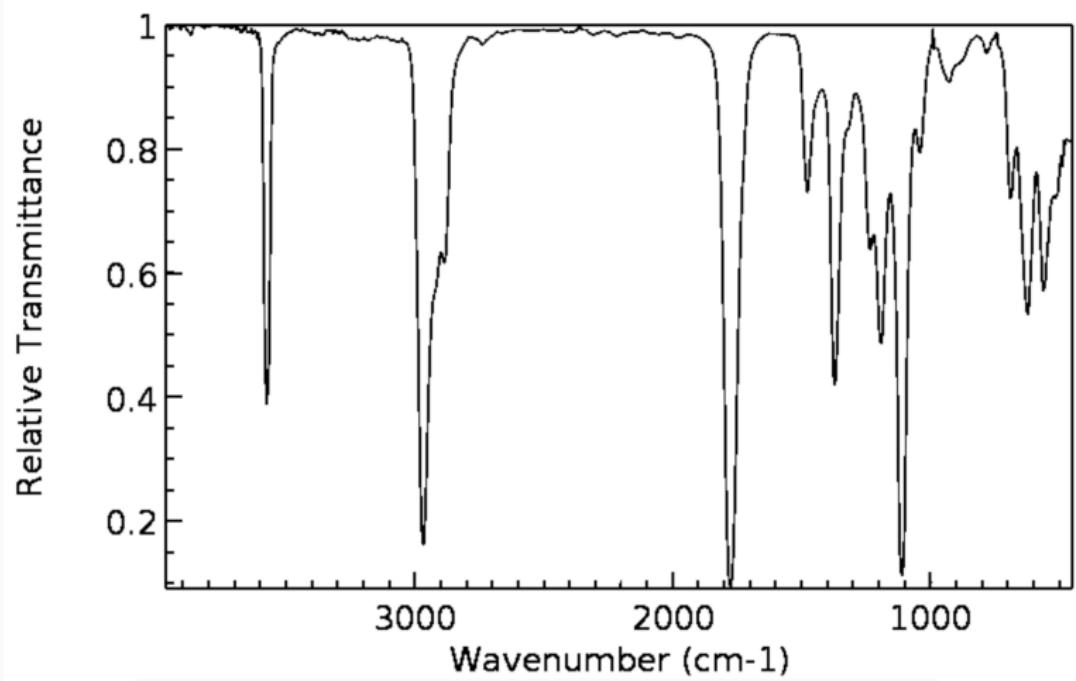
# Atribua os Sinais do Espectro de $^{13}\text{C}$ do $\text{C}_6\text{H}_{12}\text{O}_2$



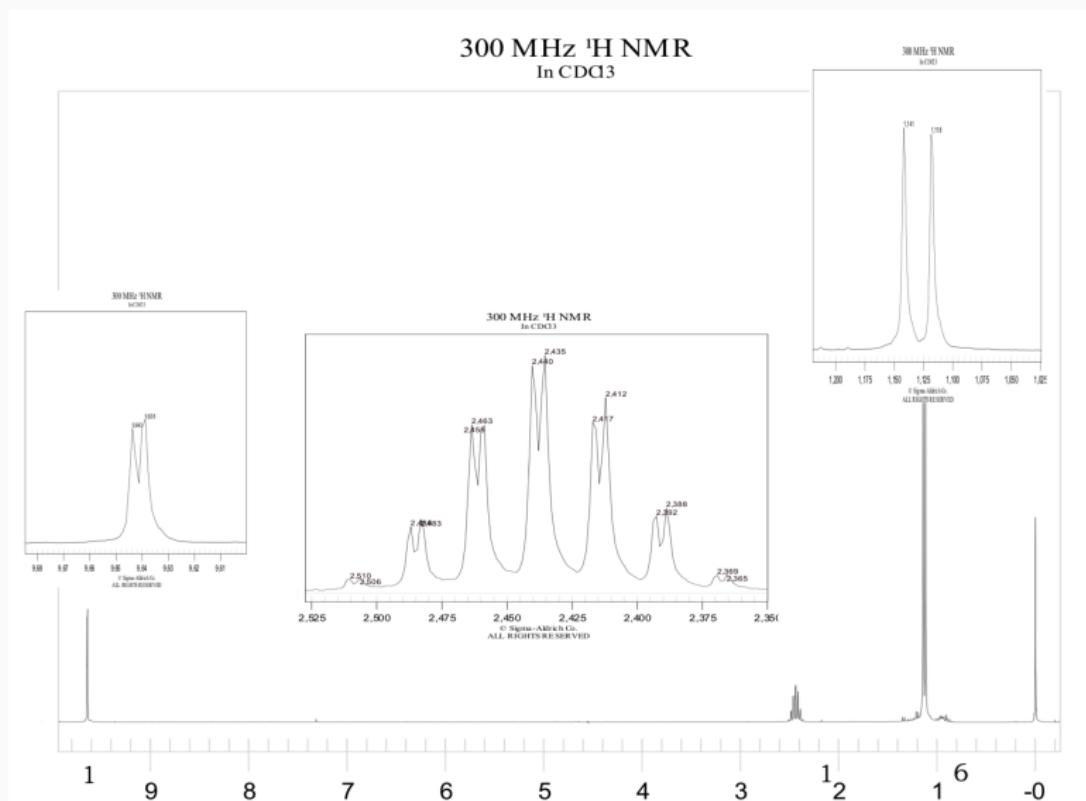
# Atribua os Sinais Mais Intensos do Espectro de Massas do C<sub>6</sub>H<sub>12</sub>O<sub>2</sub>. Mostre o Mecanismo de Fragmentação



# Atribua as Bandas Mais Intensas do Espectro de Infravermelho do C<sub>6</sub>H<sub>12</sub>O<sub>2</sub>

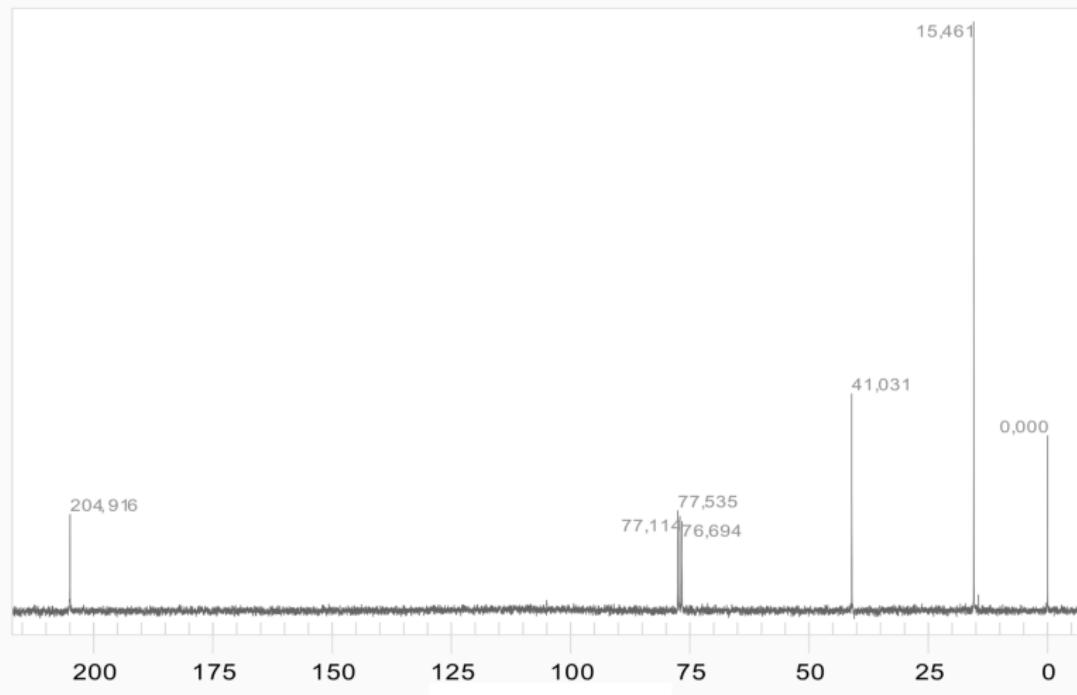


# Atribua os Sinais do Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_8\text{O}$

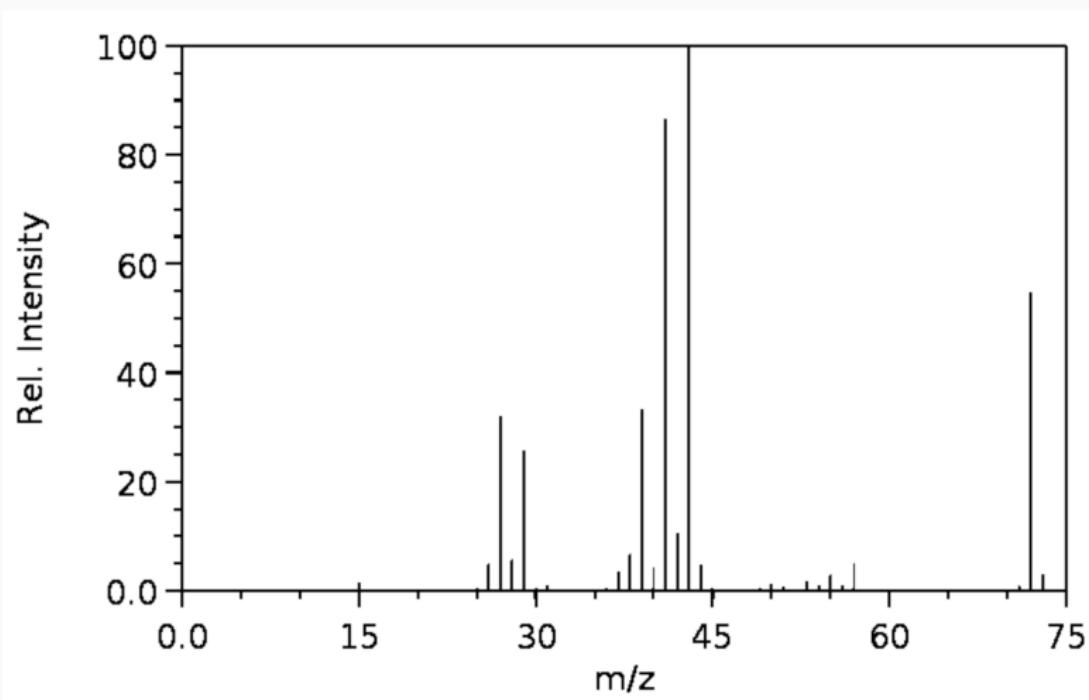


# Atribua os Sinais do Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_8\text{O}$

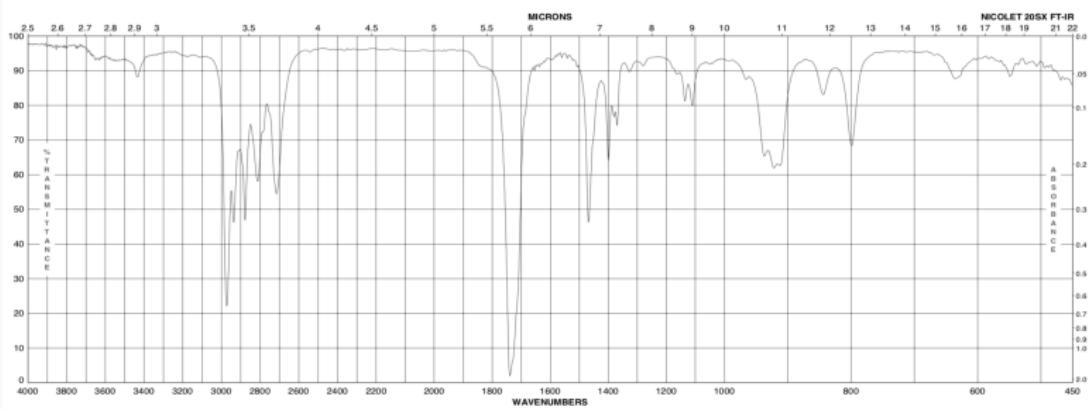
75 MHz  $^{13}\text{C}$  NMR  
In  $\text{CDCl}_3$



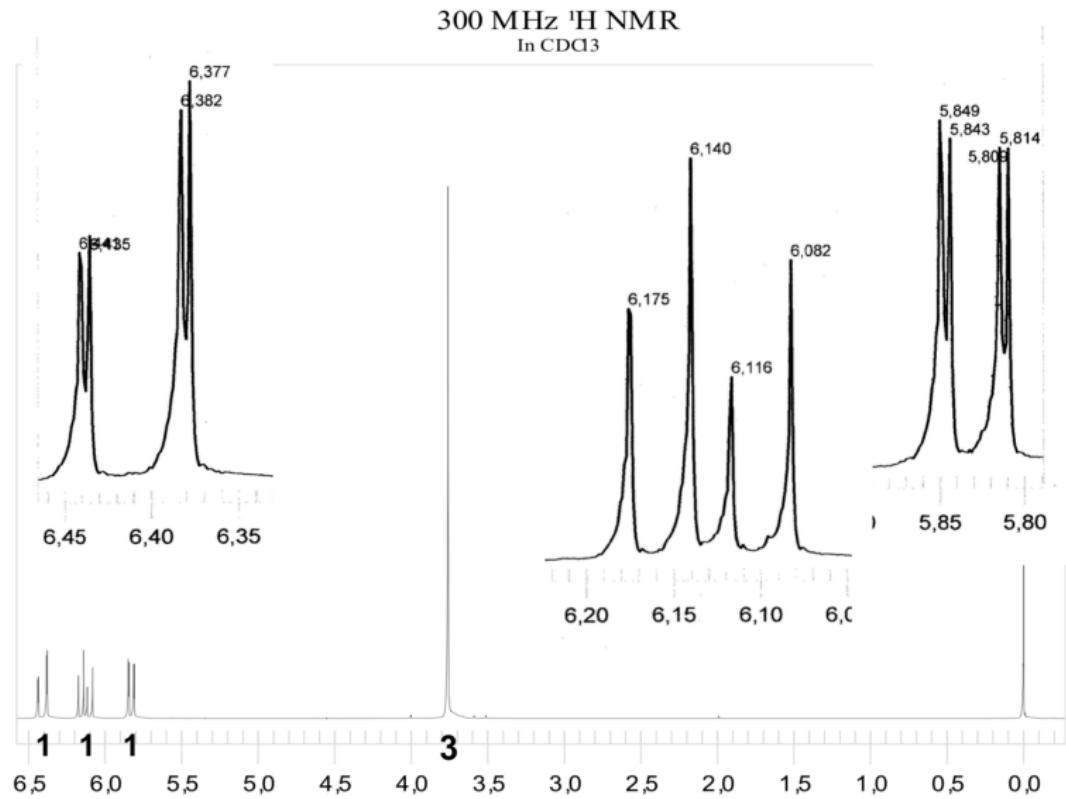
# Atribua os Sinais Mais Intensos do Espectro de Massas do C<sub>4</sub>H<sub>8</sub>O. Mostre o Mecanismo de Fragmentação



# Atribua as Bandas Mais Intensas do Espectro de Infravermelho do C<sub>4</sub>H<sub>8</sub>O

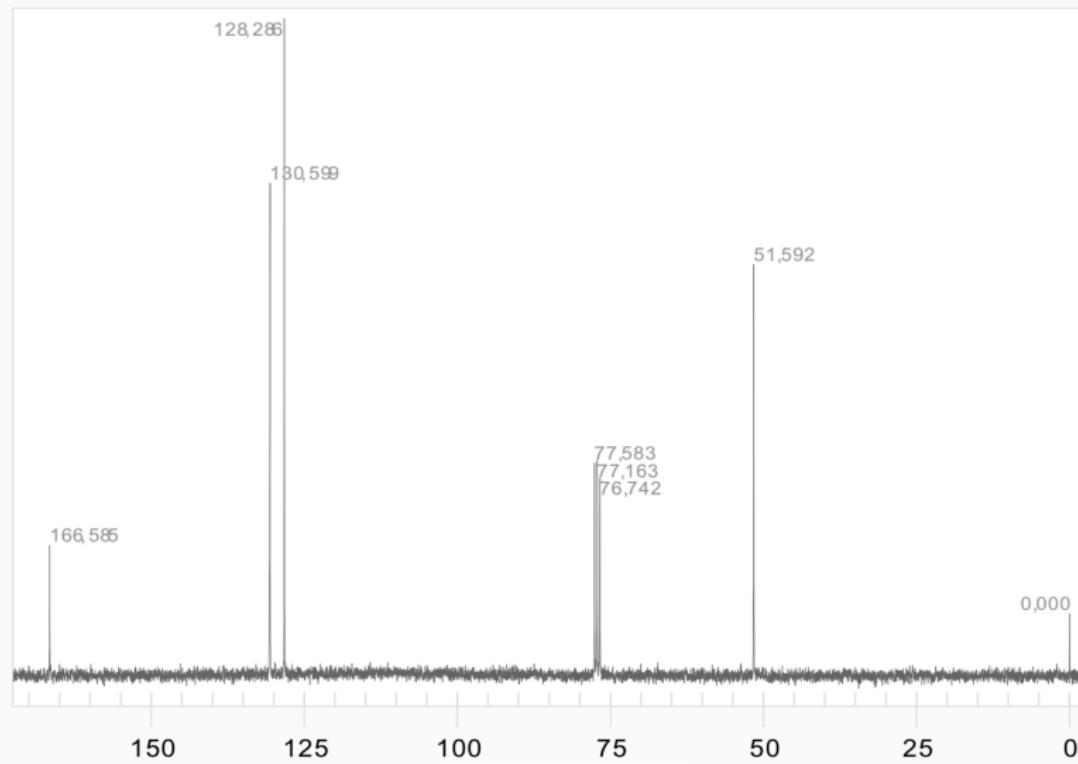


# Atribua os Sinais do Espectro de $^1\text{H}$ do $\text{C}_4\text{H}_6\text{O}_2$

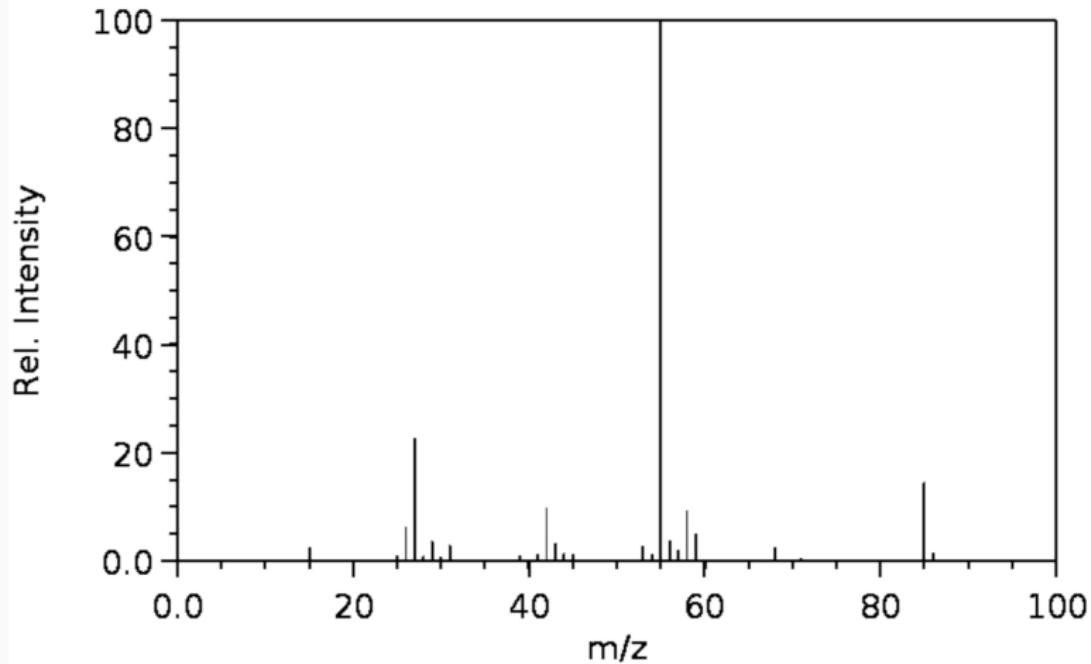


# Atribua os Sinais do Espectro de $^{13}\text{C}$ do $\text{C}_4\text{H}_6\text{O}_2$

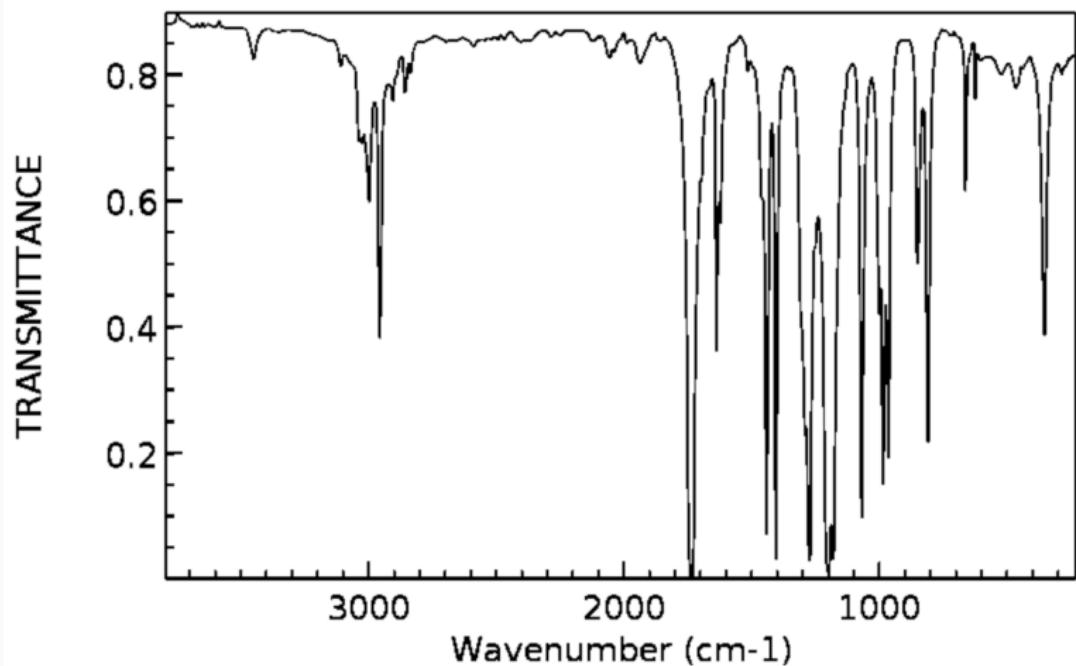
75 MHz  $^{13}\text{C}$  NMR  
In  $\text{CDCl}_3$



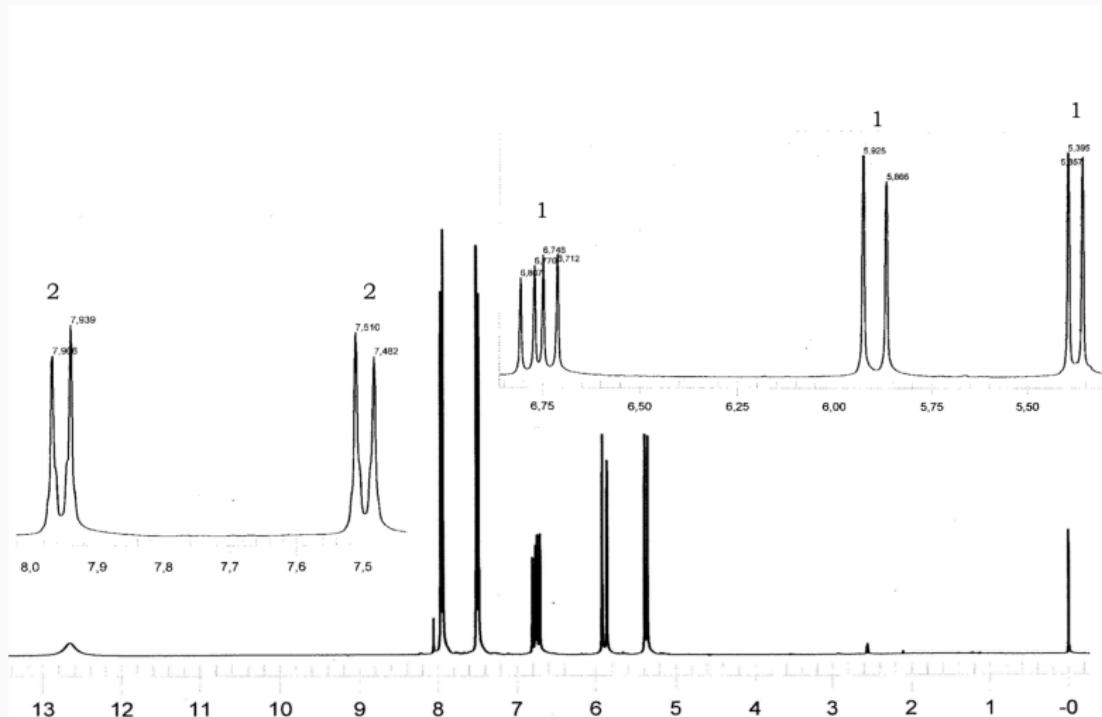
# Atribua os Sinais Mais Intensos do Espectro de Massas do $C_4H_6O_2$ . Mostre o Mecanismo de Fragmentação



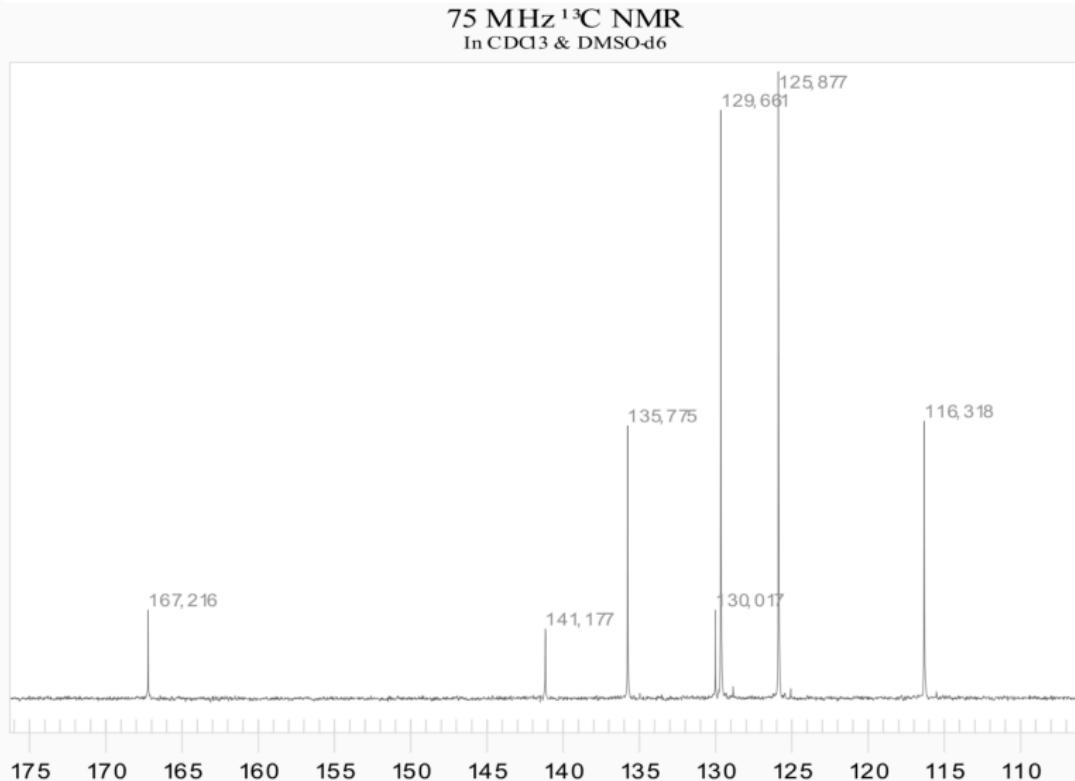
# Atribua as Bandas Mais Intensas do Espectro de Infravermelho do C<sub>4</sub>H<sub>6</sub>O<sub>2</sub>



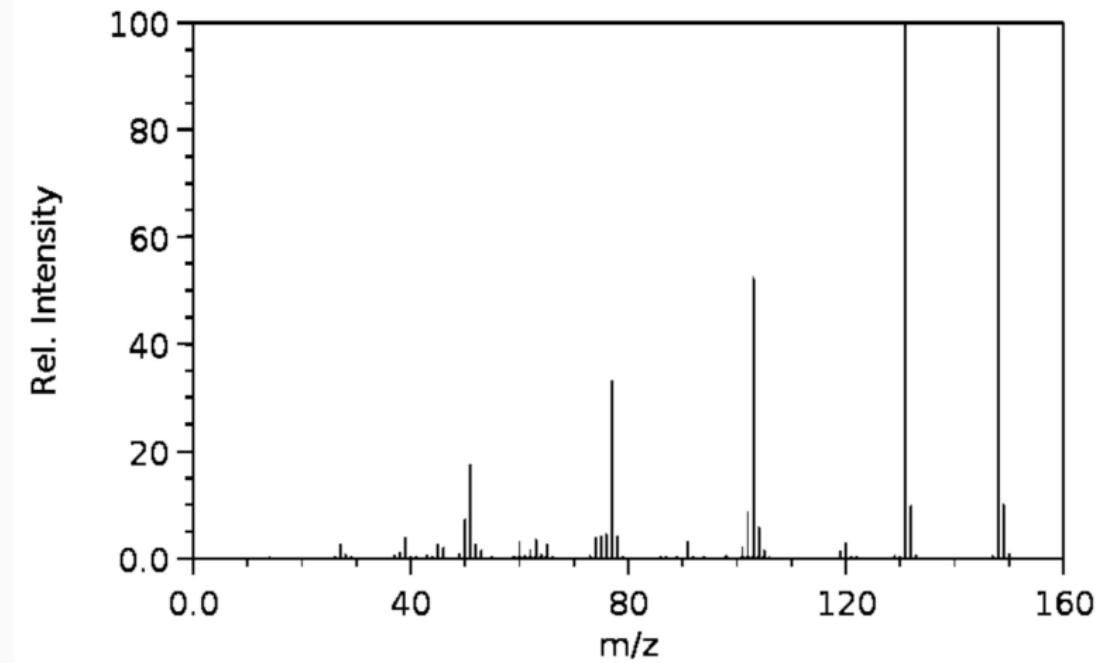
# Atribua os Sinais do Espectro de $^1\text{H}$ do $\text{C}_9\text{H}_8\text{O}_2$



# Atribua os Sinais do Espectro de $^{13}\text{C}$ do $\text{C}_9\text{H}_8\text{O}_2$



# Atribua os Sinais Mais Intensos do Espectro de Massas do C<sub>9</sub>H<sub>8</sub>O<sub>2</sub>. Mostre o Mecanismo de Fragmentação



## Atribua as Bandas Mais Intensas do Espectro de Infravermelho do C<sub>9</sub>H<sub>8</sub>O<sub>2</sub>

