

Supporting Information

Highly selective halogenation of unactivated C(sp³)-H with NaX under co-catalysis of visible light and Ag@AgX

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Table of Contents	Pages
Experimental procedures	S2
General experimental	S2
Preparation and of nano Ag/AgBr and Ag/AgCl	S2
Nano Ag/AgBr and Ag/AgCl characterization	S2-S4
¹ H NMR and ¹³ C NMR spectra, GS-MS of photocatalyzed reaction solution	S4-S41

Experimental

General experimental

The morphology of the Ag/AgBr or Ag/AgCl composite was characterized using a scanning electron microscope (SEM; Hitachi S4800 SEM) with an accelerating voltage of 30.0 kV. The crystallinity was determined by X-ray diffraction (XRD) using a diffractometer with Cu-K α radiation (Shimadzu Lab-X XRD-6000). The accelerating voltage and applied current were 40 kV and 30 mA. The composition was verified by energy dispersive X-ray analysis (EDX, equipped with SEM JSM-6360LV). The light absorption properties were measured using UV-vis diffuse reflectance spectrophotometer (DRS, JASCO, UV-550) with a wavelength range of 200–900 nm . A 300W xenon lamp ($\lambda > 290\text{nm}$, PLS-SXE300CUV, perfectlight Instruments Co. Ltd., Beijing) was used as light source, and the average light intensity was 78.5mw/cm^{-2} (UV-A radiation meter). GC were recorded on SHIMADZU 2014C . GC-MS data were measured with Thermo Scientific ISQ QD. ^1H NMR were recorded on a Bruker Avance II 500 spectrometer in CDCl_3 unless stated otherwise, using tetramethylsilane as an internal reference, operated at 500.13 for ^1H , and J values are given in Hz.

Preparation and of nano Ag/AgBr and Ag/AgCl

The Ag/AgBr or Ag/AgCl composite was prepared by a one-step chemical bath method at low temperature. In a typical case, 0.51g AgNO_3 and 0.625g polyvinyl pyrrolidone (PVP, K30) were dissolved in 50 mL of 1.4 M nitric acid solution under magnetic stirring at room temperature. Then 50 mL of 0.06M NaBr or KCl aqueous solution was added to the mixture by dropwise for 30 min. The reaction system was stirred for another 30 min and then heated in water bath at 80°C for 3 h. The precipitate was collected by centrifugation. The solid was dispersed to the solution of 50 mL deionized water and 0.10g AgNO_3 . The suspension solution was irradiated with UV irradiation for 20 min in the presence of sodium formate (1m L 0.02 M). The resulting product was collected and washed thoroughly with deionized water and absolute ethanol, and then dried at 70°C in air for 12 h.

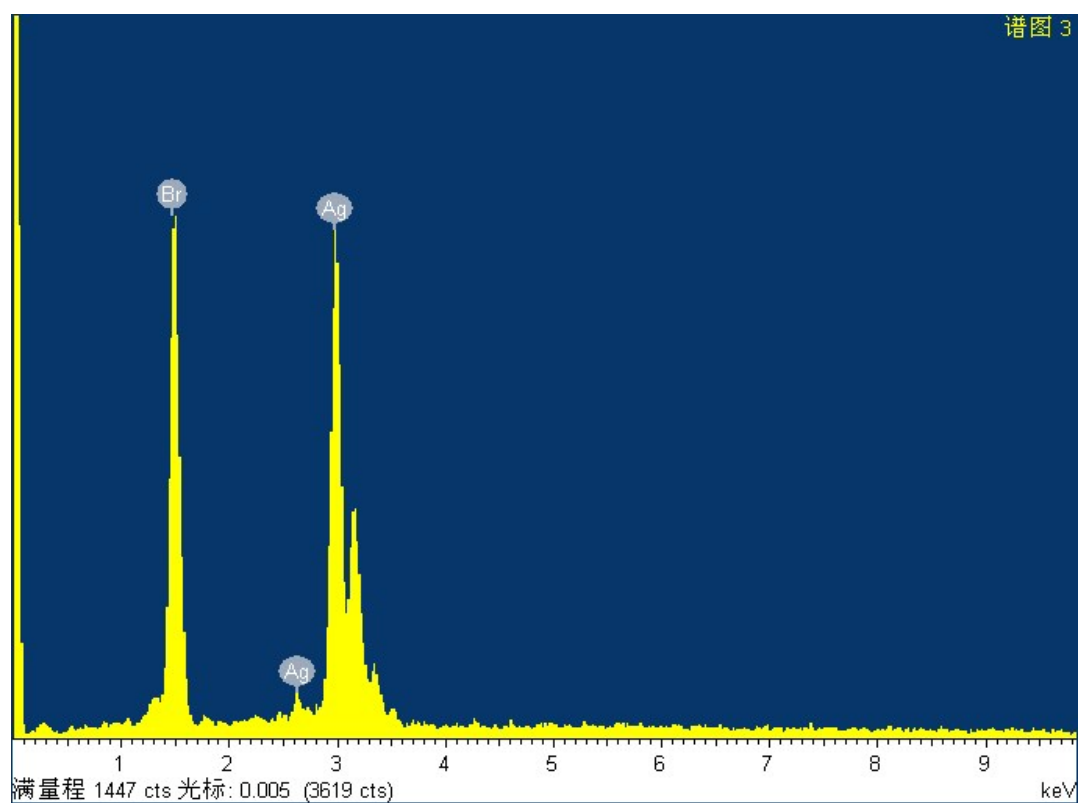
Nano Ag/AgBr characterization

Ag /AgBr, EDX, nano Ag 4.5% mol sample:

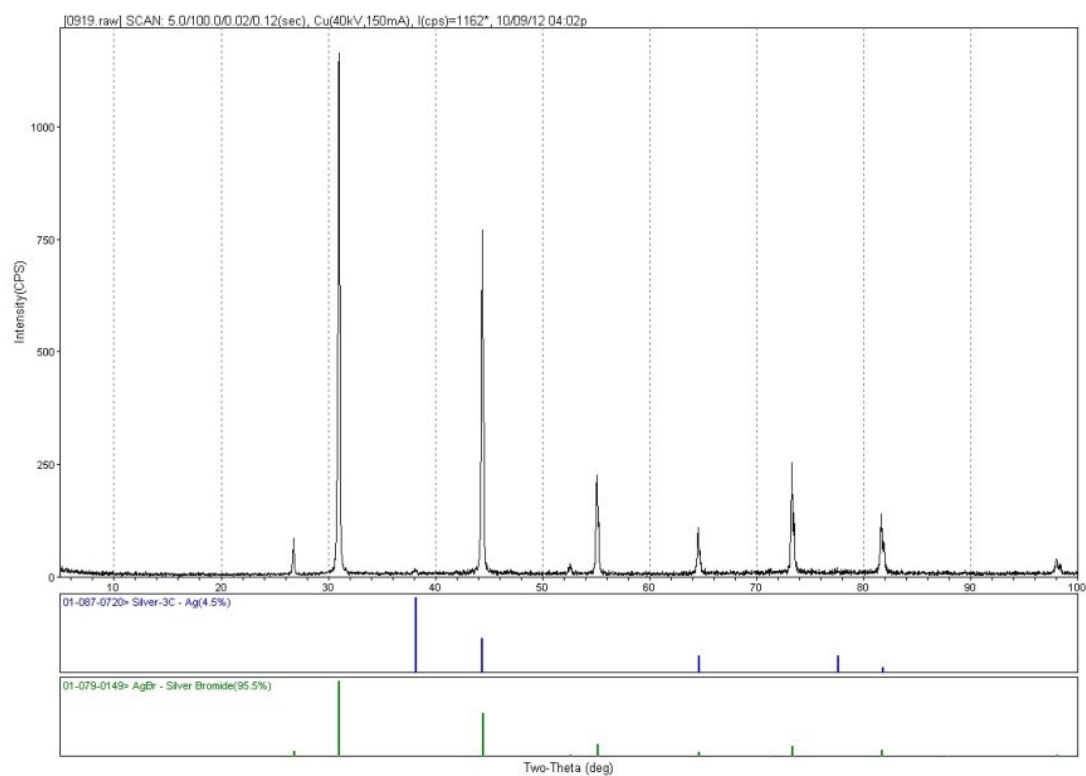
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Ag Ag 1-Jun-1999 12:00 AM

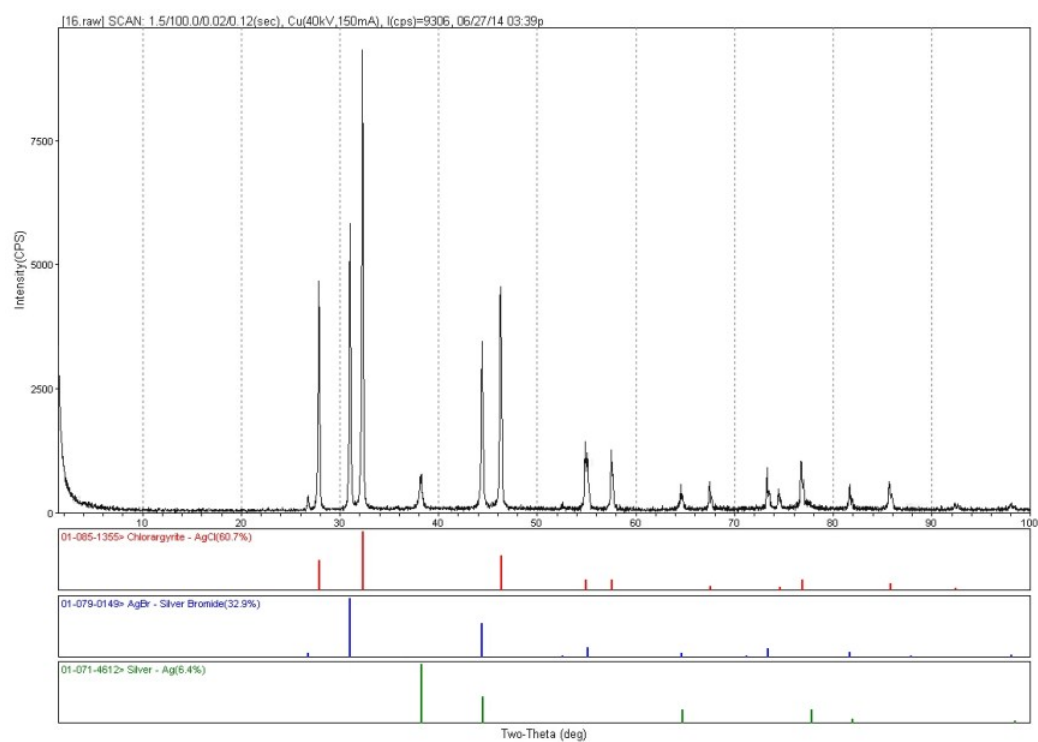
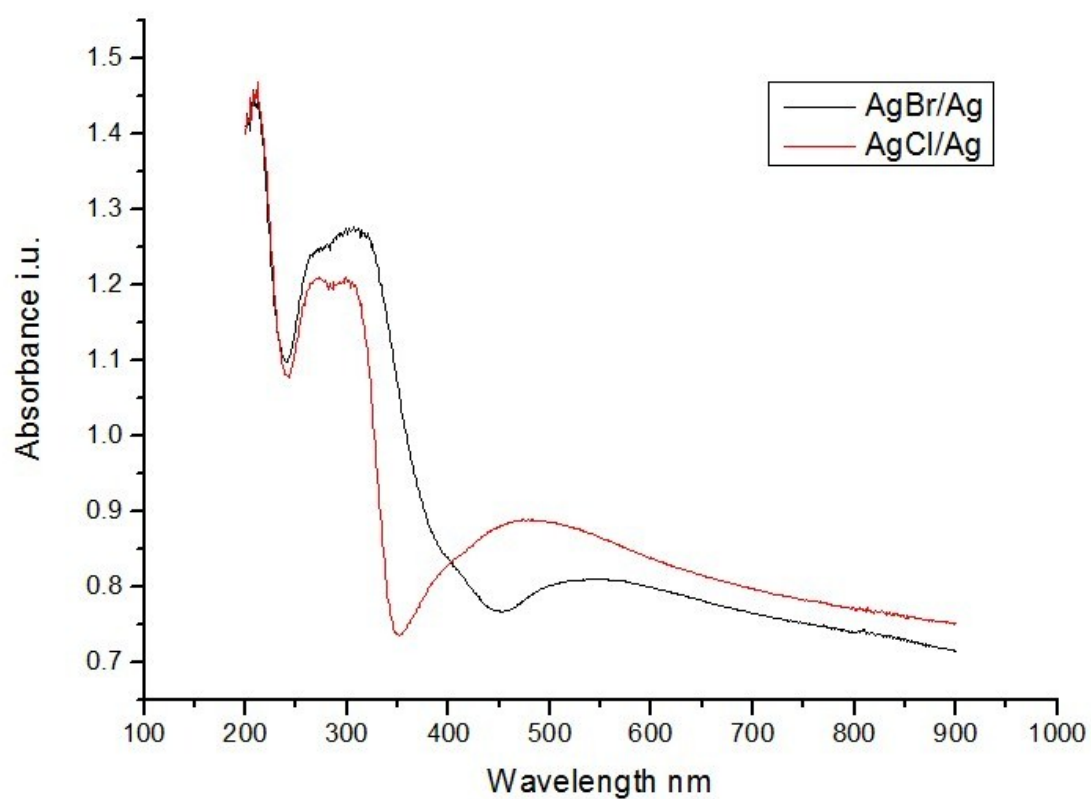
Elem.	Weight	Atom
	%	%
Br L	40.43	47.81
Ag L	59.57	52.19
Total	100.00	



Ag/AgBr, XRD, nano Ag 4.5 %mol



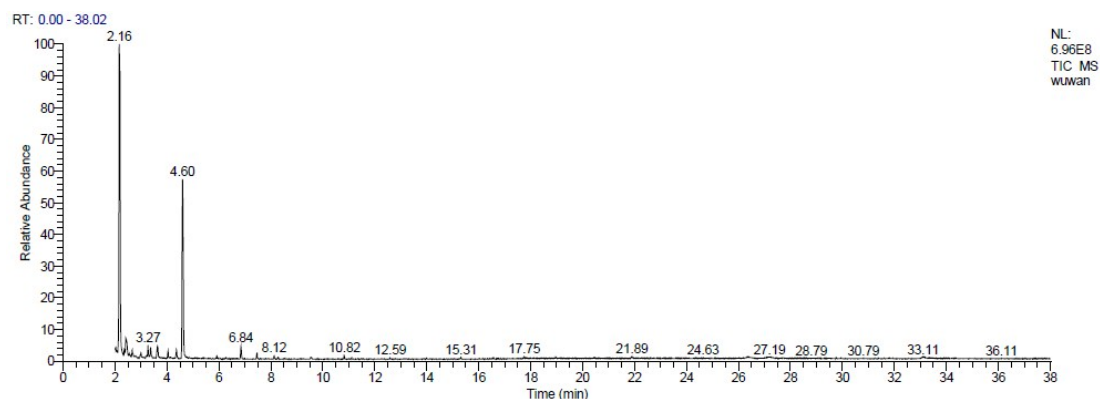
Ag/AgBr and Ag/AgCl, UV-Vis diffuse reflectance spectra



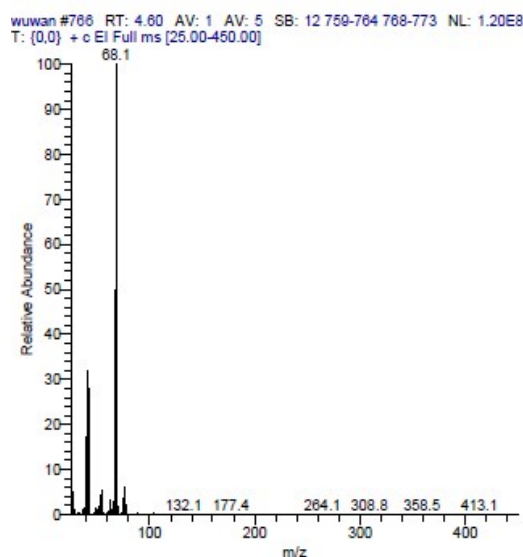
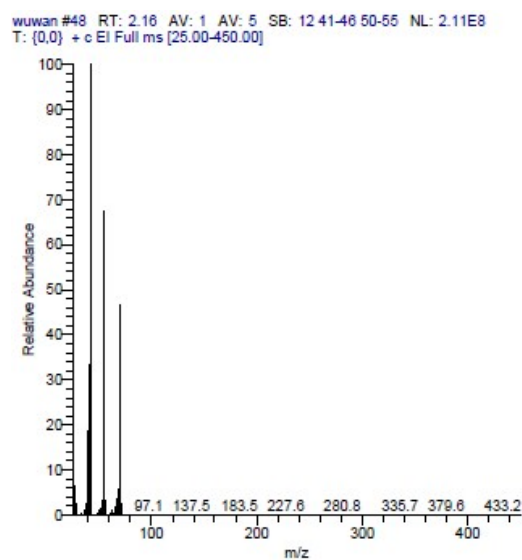
X-ray diffraction of catalyst Ag@AgCl after the reaction

The photocatalytic halogenation of alicyclic hydrocarbon

The reaction solution of cyclopentane chlorination

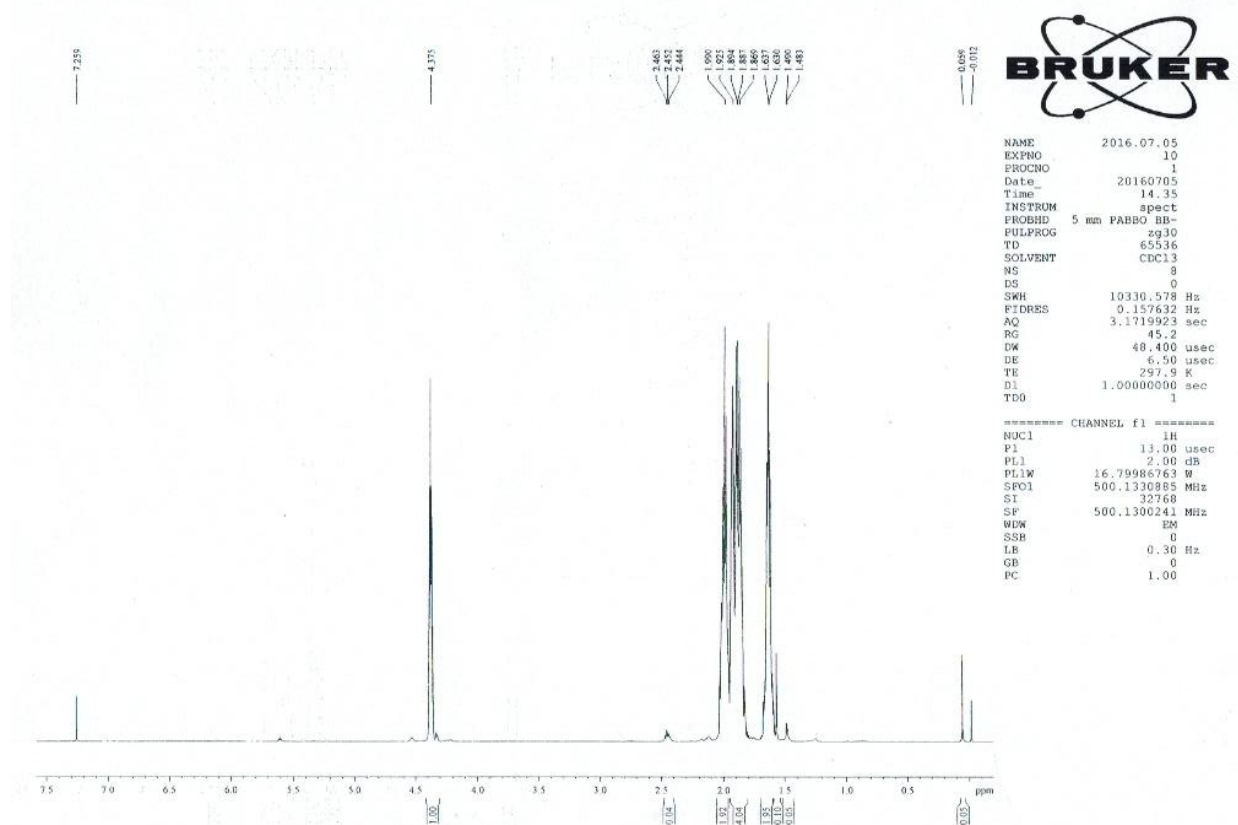


GC of the cyclopentane chlorination reaction mixture

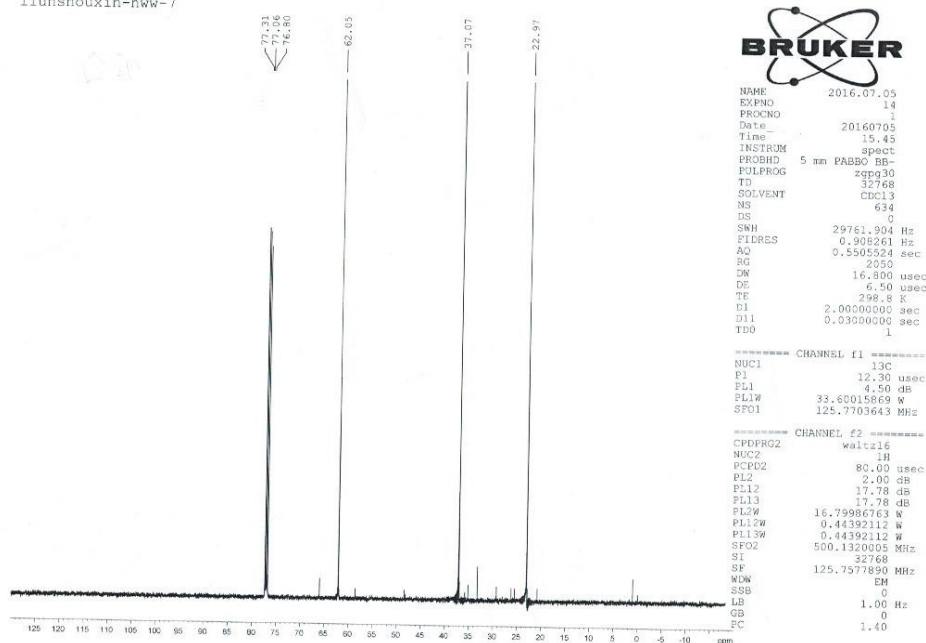


GC-MS of the cyclopentane chlorination reaction solution

liuhshouxin-hww-7

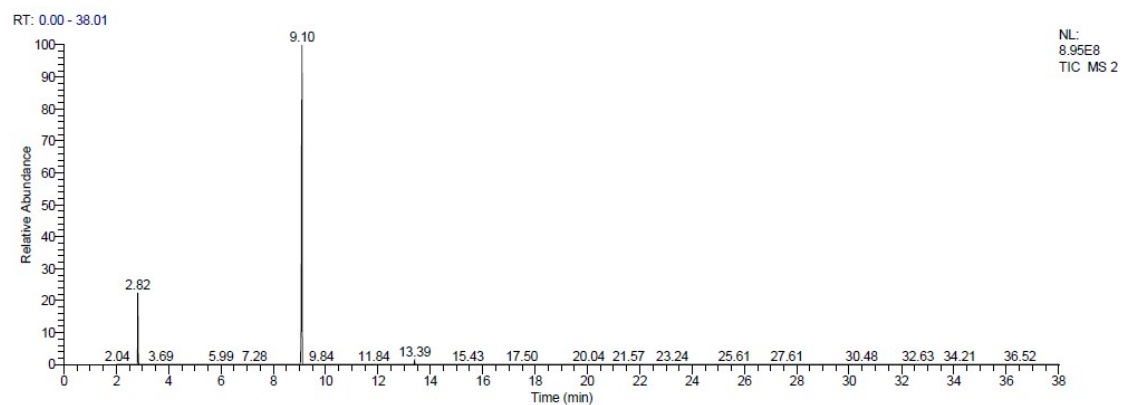


liuhshouxin-hww-7

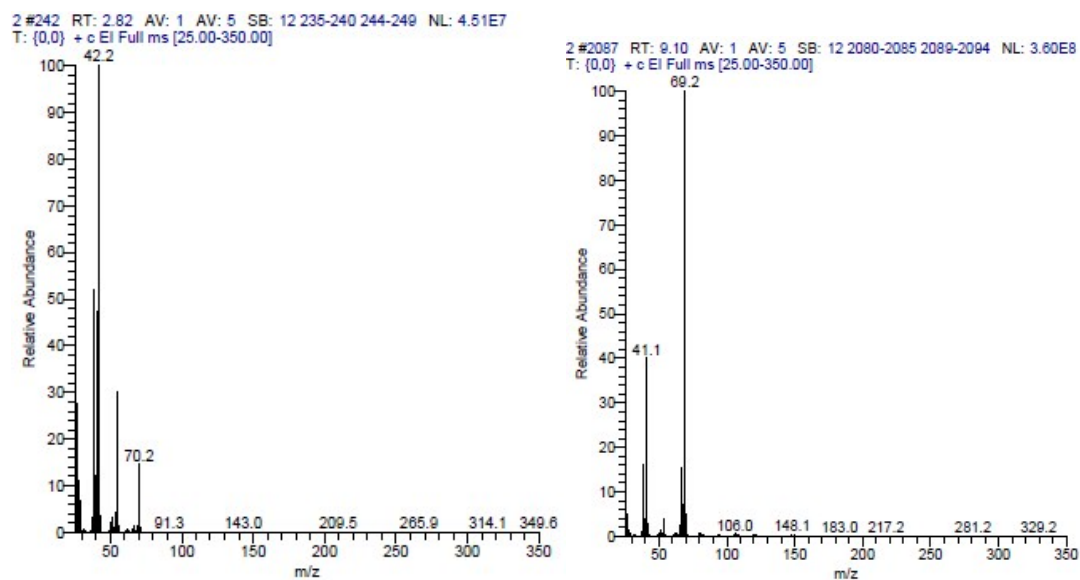


NMR of the cyclopentane chlorination reaction mixture

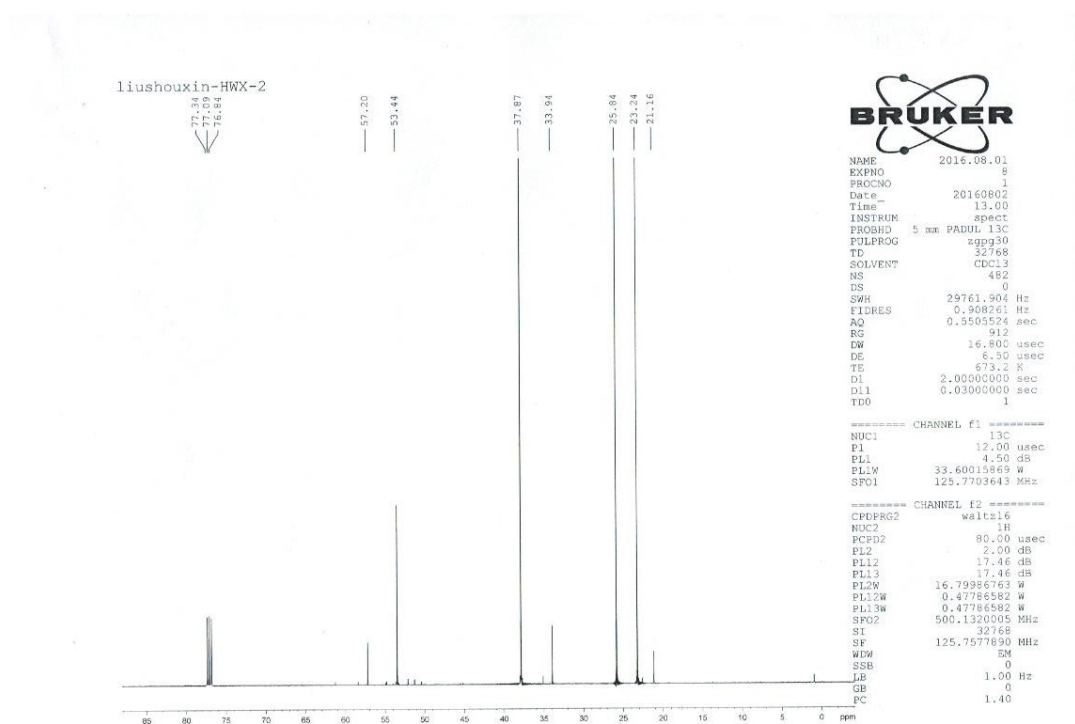
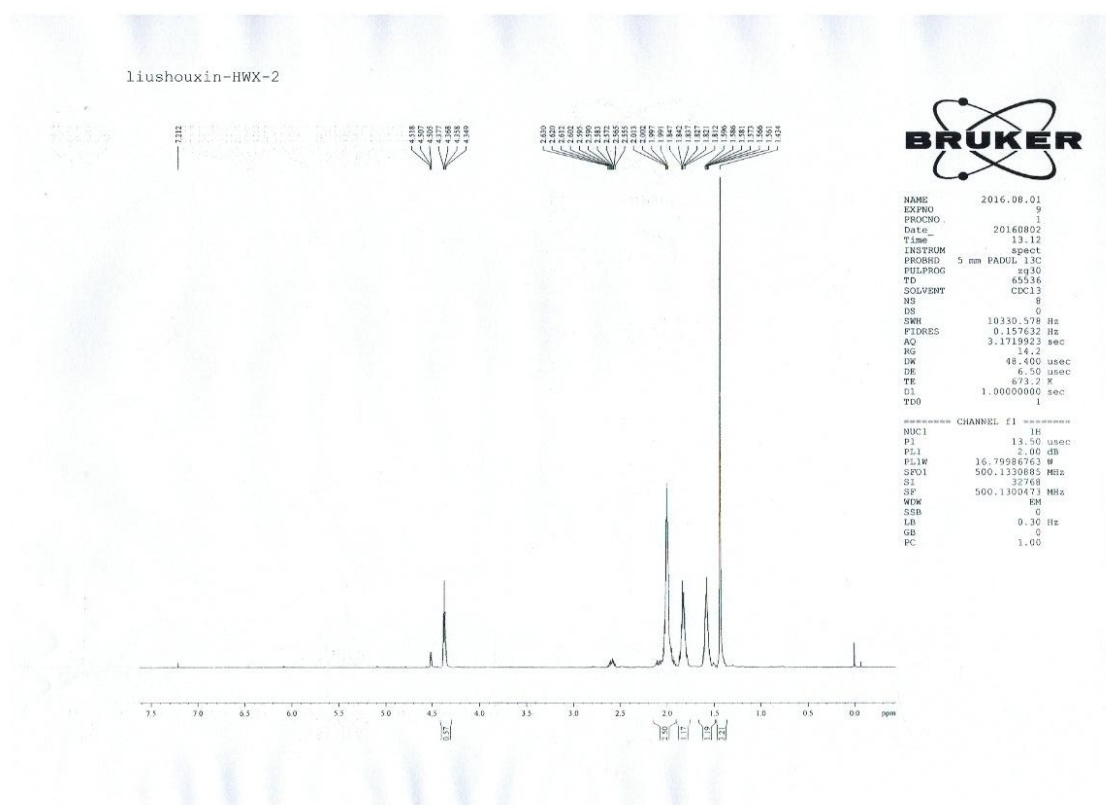
The reaction solution of cyclopentane bromination



GC of the cyclopentane bromination reaction mixture

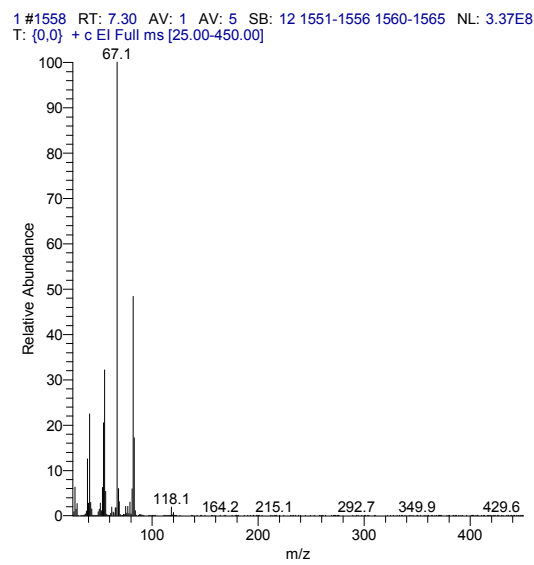
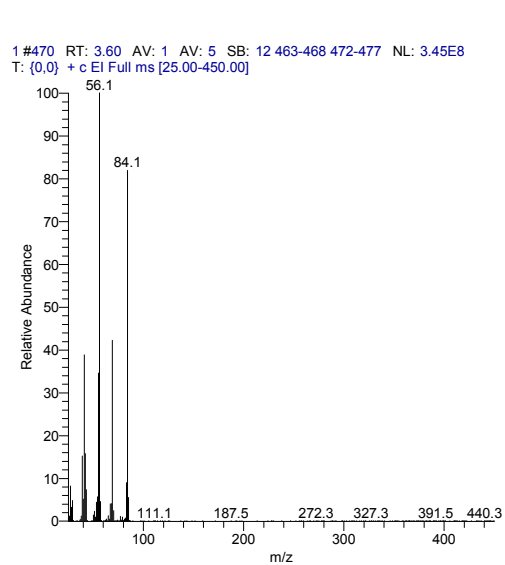
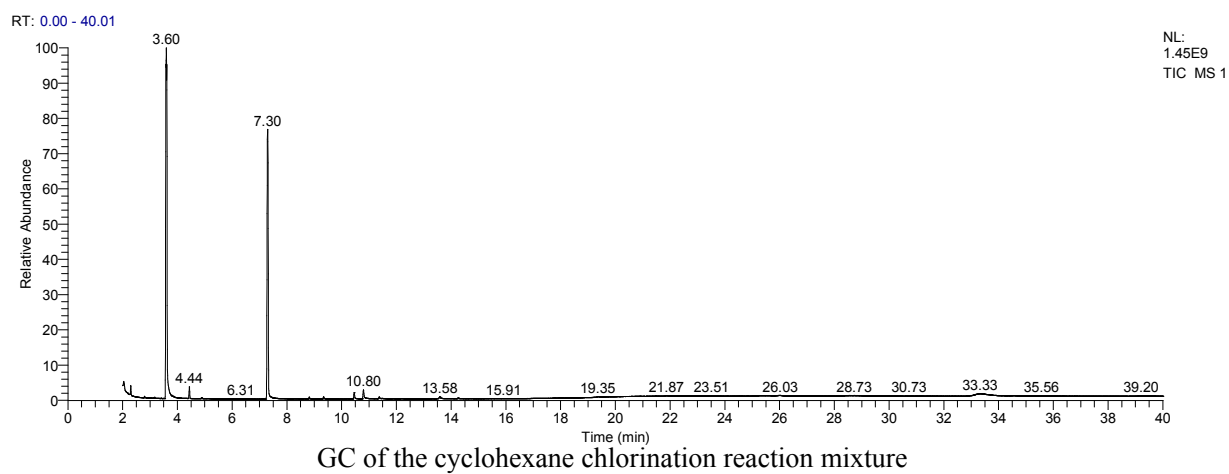


GC-MS of the cyclopentane bromination reaction solution



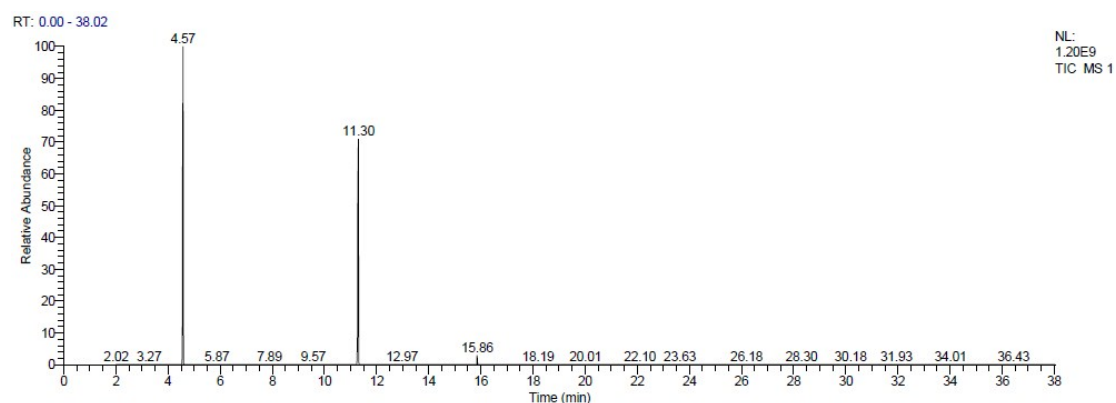
NMR of the cyclopentane bromination reaction mixture from Ag/AgCl catalysis

The reaction solution of cyclohexane chlorination

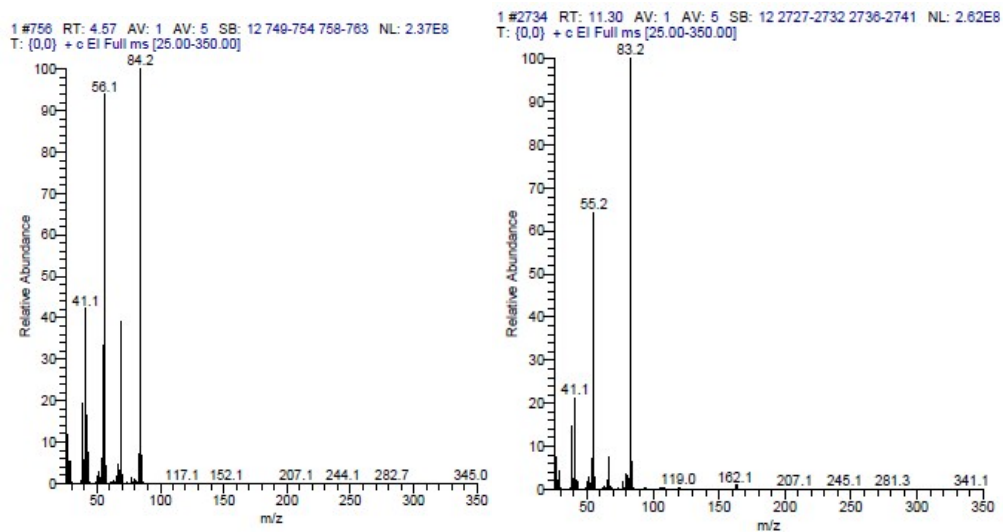


GC-MS of the cyclohexane chlorination reaction solution

The reaction solution of cyclohexane bromination



GC of the cyclohexane bromination reaction mixture



GC-MS of the cyclohexane bromination reaction solution

[illegible]

```
NAME 2016.08.01
EXPNO 10
PROCNO 1
Date_ 20160802
Time 13.36
INSTRUM spect
PROBHD 5 mm PABUL 13C
PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 8
DS 6
SWH 10330.578 Hz
FIDRES 0.157632 Hz
AQ 3.1719923 sec
RG 14.2
DW 48.400 usec
DE 6.50 usec
TE 673.2 K
D1 1.00000000 sec
TD0
```

```

***** CHANNEL f1 *****
NUC1                IH
P1                  13.50 usec
PL1                 2.00 dB
PL1W                16.79986763 W
SPO1               500.13300885 MHz
SI                   32768
SF                 500.1300185 MHz
WDW                  EM
SSB                  0
LB                   0.30 Hz
GB                   0
PC                   1.00

```

1H NMR spectrum of compound 10 in CDCl₃. The x-axis represents chemical shift in ppm, ranging from 0 to 8. The spectrum shows several peaks: a multiplet at ~7.8 ppm (labeled 7.8, 7.7, 7.6), a multiplet at ~5.5 ppm (labeled 5.9, 5.1), a sharp singlet at ~3.8 ppm (labeled 3.759), and a complex multiplet between 2.5 and 2.8 ppm (labeled 2.8, 2.6, 2.4, 2.3, 2.1, 1.8). A list of peak assignments is provided on the right side of the spectrum.

Chemical Shift (ppm)	Assignment
7.8	NU
7.7	EX
7.6	PR
5.9	Da
5.1	FL
3.759	IN
2.8	PR
2.6	FO
2.4	TD
2.3	NS
2.1	CS
1.8	SW
1.6	FI
1.4	AC
1.2	RG
1.0	DW
0.8	DE
0.6	TE
0.4	D1
0.2	D1
0.1	TD
0.0	==
0.0	NU
0.0	FL
0.0	FL
0.0	FL
0.0	SF
0.0	==
0.0	CP
0.0	NU
0.0	PC
0.0	FL
0.0	FL
0.0	FL
0.0	FL
0.0	FL
0.0	SF
0.0	S1
0.0	SF
0.0	ND
0.0	SS
0.0	LB
0.0	GB
0.0	PC



NAME	2016.08.01	
EXPNO	11	
PROCNO	1	
Date_	20160802	
Time_	13.48	
INSTRUM	aspect	
PROBHD	5 mm	PADUL 13C
PULPROG	zgpg30	
TD	32768	
SOLVENT	CDCl3	
NS	388	
DS	0	
SWH	29761.904	Hz
FIDRES	0.908261	Hz
ACQ	0.5505524	sec
RG	2050	
DW	16.800	usec
DE	6.50	usec
TE	673.2	K
D1	2.0300000	sec
D11	0.0300000	sec
TD0	1	

```
===== CHANNEL F1 =====
NUC1          13C
P1            12.00 usec
PL1           4.50 dB
PL1W          33.60015869 W
SFO1          125.7703643 MHz
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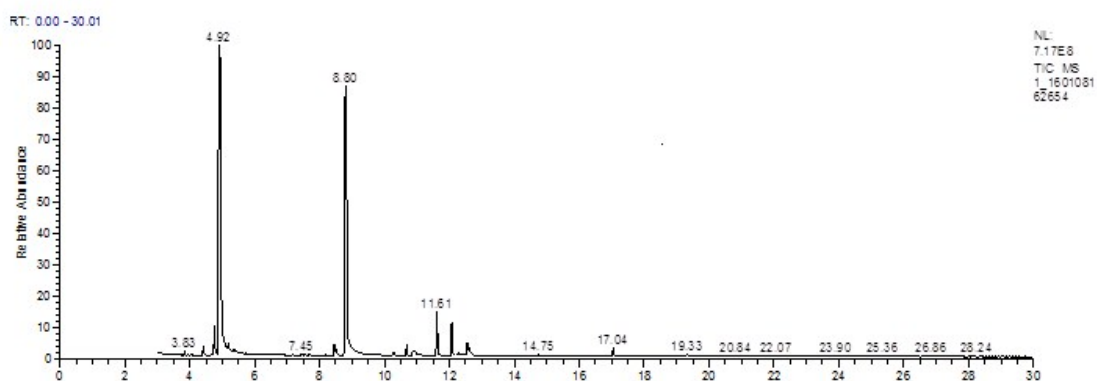
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CHANNEL f2
waitz16
CPDRG2
NUC2      1H
PCPD2     80.00 usec
PL2       2.00 dB
PL12      17.46 dB
PL13      17.46 dB
PL12M     16.79986763
PL12M     0.47786582 W
PL13M     0.47786582 W
SFO2      500.1320005 MHz
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NDW        RM
SSB        RM
LP         1.00 Hz
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PC         1.40

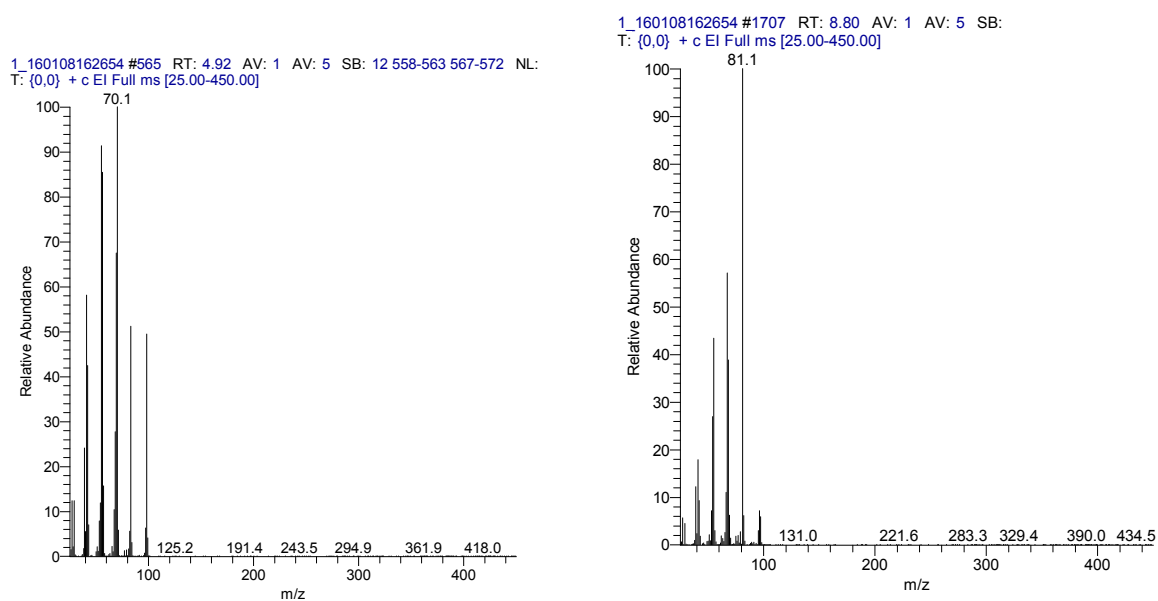
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NMR of the cyclohexane bromination reaction mixture from Ag/AgCl catalysis

The reaction solution of cycloheptane chlorination

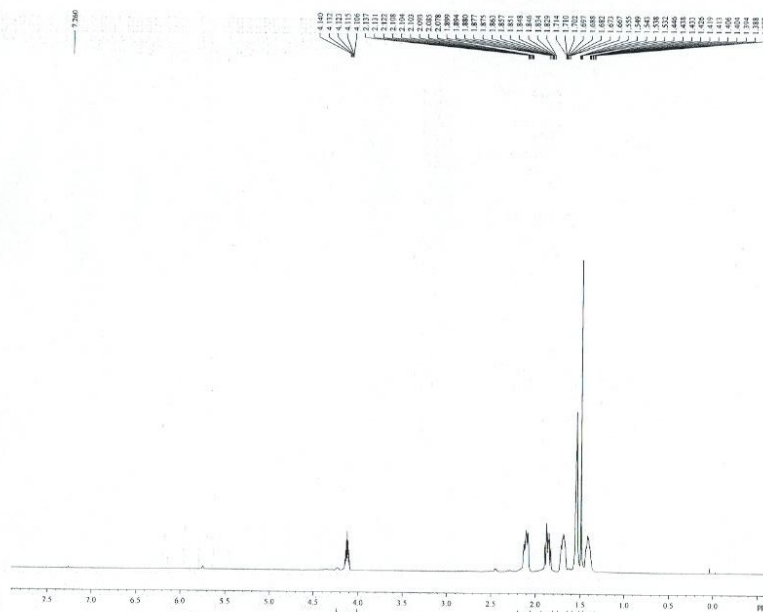


GC of the cycloheptane chlorination reaction mixture



GC-MS of the cycloheptane chlorination reaction solution

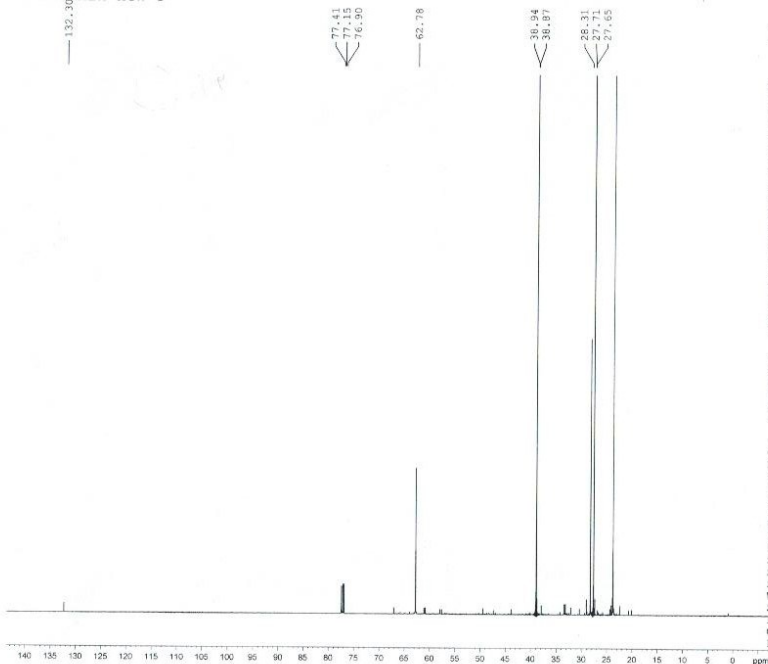
liushouxin-HGW-3



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PROCNO 1
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PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 2
DS 0
SWH 10330.578 Hz
FIDRES 0.157632 Hz
AQ 3.1719923 sec
RG 9
DW 48.400 usec
DE 6.50 usec
TE 297.8 K
D1 1.0000000 sec
TDO 1

===== CHANNEL f1 =====
NUC1 1H
P1 13.00 usec
PL1 2.00 dB
PL1W 16.79986763 W
SFO1 500.1330885 MHz
SI 32768
SF 500.1300233 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

liushouxin-HGW-3



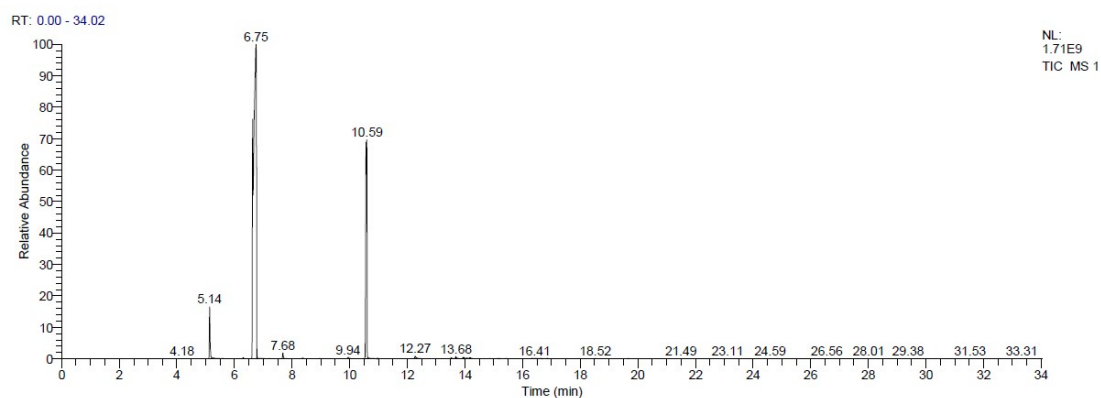
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PROCNO 1
Date_ 20160628
Time_ 19.45
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TD 32768
SOLVENT CDCl3
NS 205
DS 0
SWH 29761.904 Hz
FIDRES 0.908261 Hz
AQ 0.5505524 sec
RG 2050
DW 16.800 usec
DE 6.50 usec
TE 299.4 K
D1 2.0000000 sec
D11 0.0300000 sec
TDO 1

===== CHANNEL f1 =====
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PL1 4.50 dB
PL1W 33.6005869 W
SFO1 125.7703643 MHz

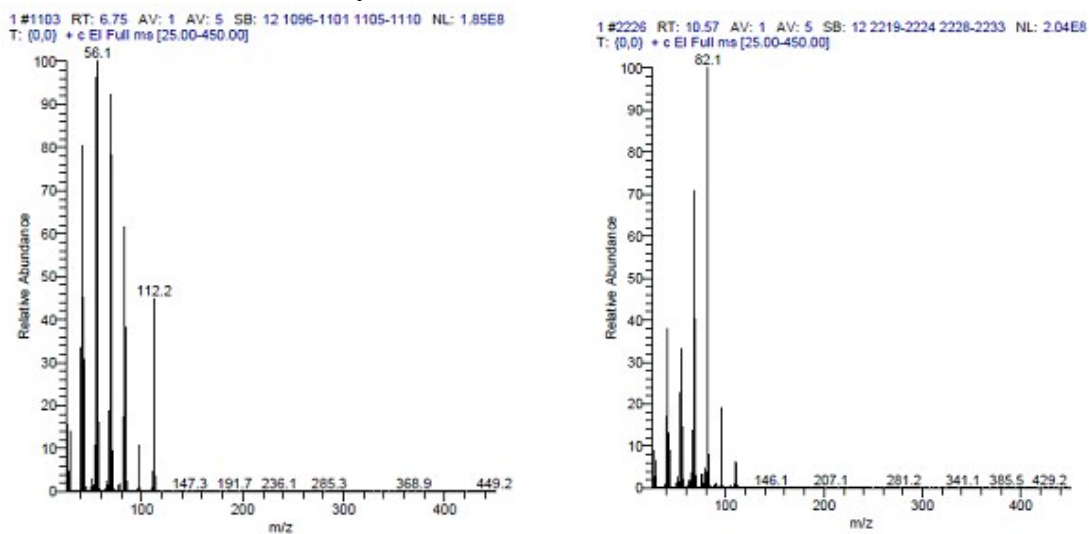
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CPDPRG2 waltz16
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PCPD2 80.00 usec
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PL12 17.78 dB
PL13 17.78 dB
PL2W 16.79986763 W
PL12W 0.44392112 W
PL13W 0.44392112 W
SFO2 500.1320005 MHz
SI 32768
SF 125.7577907 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

NMR of the cycloheptane chlorination reaction solution

The reaction solution of cyclooctane chlorination

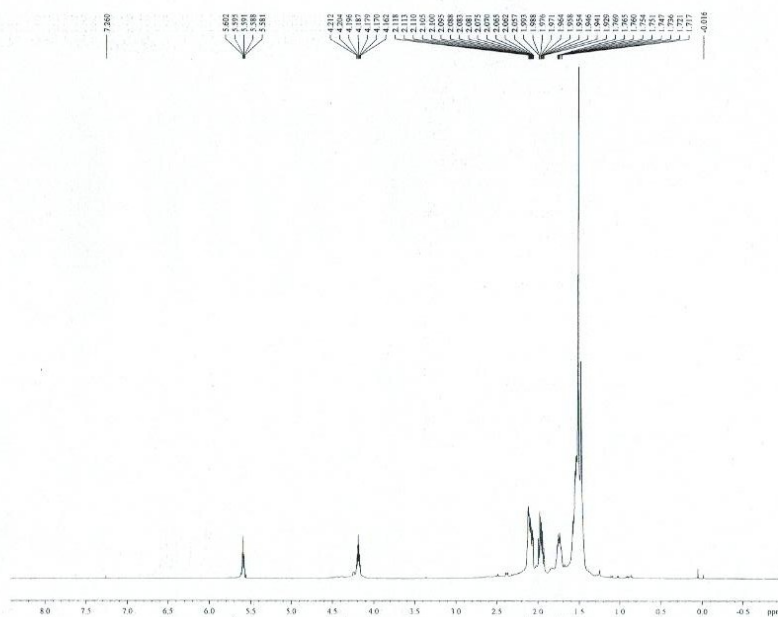


GC of the cyclooctane chlorination reaction mixture



GC-MS of the cyclooctane chlorination reaction mixture

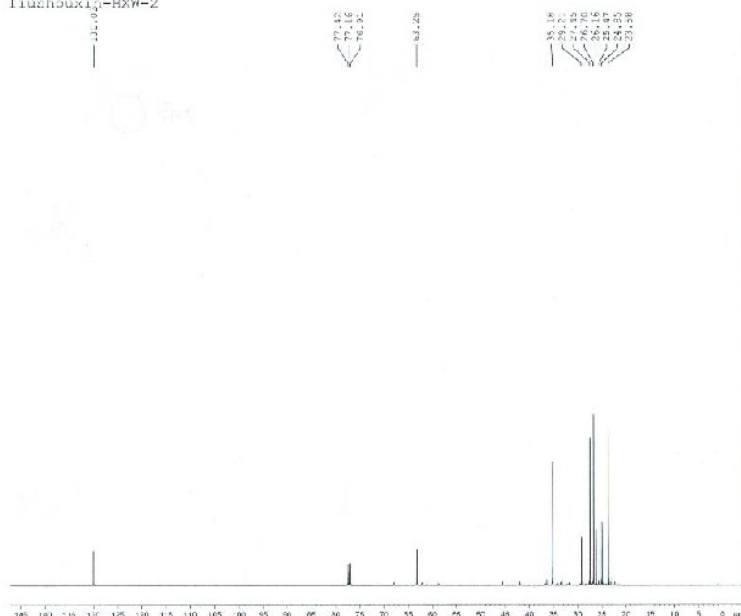
liushouxin-HXW-2



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PROCNO 1
Date_ 20160628
Time_ 19.22
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PULPROG zg30
TD 65536
SOLVENT CDCl3
NS 2
DS 0
SWH 10330.578 Hz
FIDRES 0.157632 Hz
AQ 3.1719923 sec
RG 0
DN 48.400 usec
DE 6.50 usec
TE 297.7 K
D1 1.00000000 sec
TDO 1

===== CHANNEL f1 =====
NUC1 1H
P1 13.00 usec
PL1 2.00 dB
PL1W 16.79986763 W
SFO1 500.1330885 MHz
SL 32768
SF 500.1330885 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

liushouxin-HXW-2



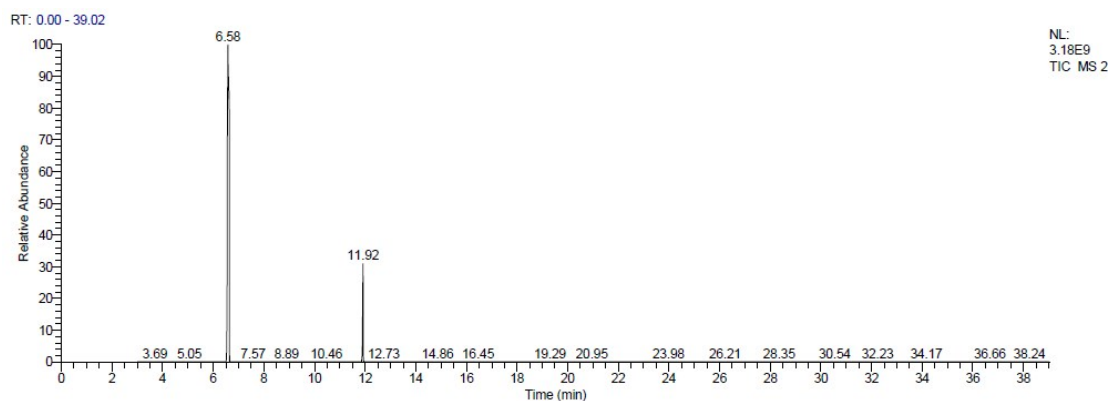
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PROCNO 1
Date_ 20160628
Time_ 19.20
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PULPROG zgpg30
TD 32768
SOLVENT CDCl3
NS 115
DS 0
SWH 25761.964 Hz
FIDRES 0.004261 Hz
AQ 0.5505524 sec
RG 287.0
DN 16.800 usec
DE 5.50 usec
TE 299.2 K
D1 2.03000000 sec
D11 0.03000000 sec
TDO 1

===== CHANNEL f1 =====
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PL1 0.00 dB
PL1W 33.63015889 W
SFO1 125.7705644 MHz

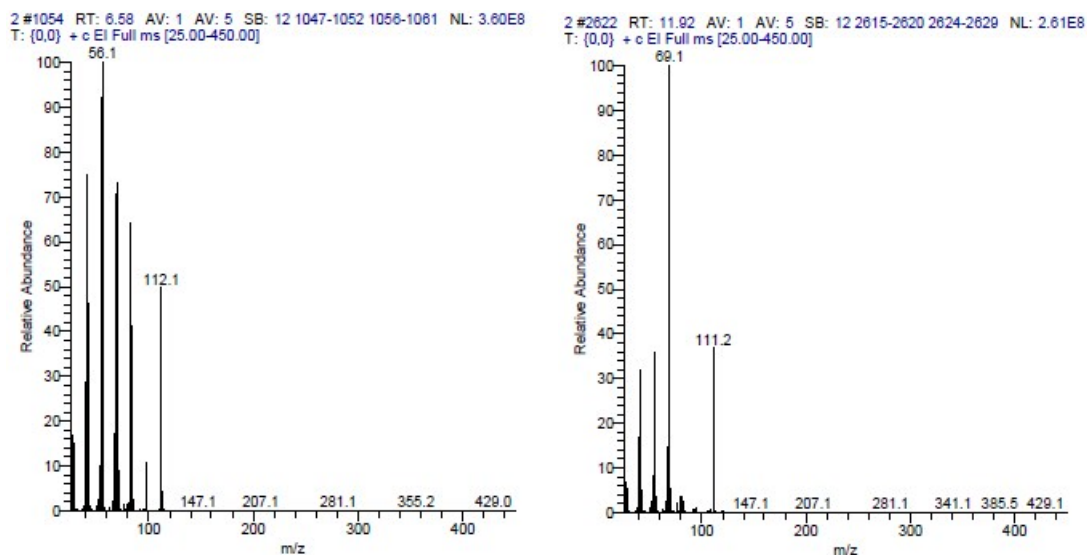
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PL12 17.70 dB
PL13 17.70 dB
PL2W 16.79986763 W
SFO2 500.1330885 MHz
SFO3 500.1330885 MHz
SL 32768
SF 125.7705644 MHz
WDW RM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

NMR of the cyclooctane chlorination reaction mixture

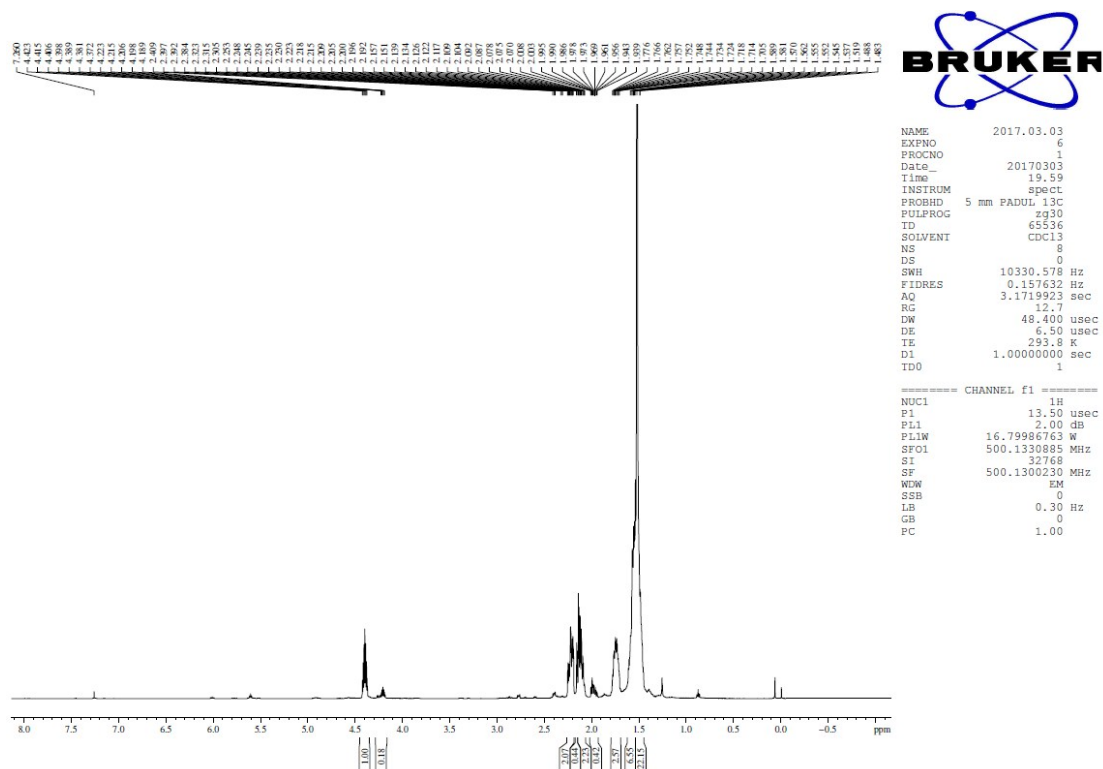
The reaction solution of cyclooctane bromination



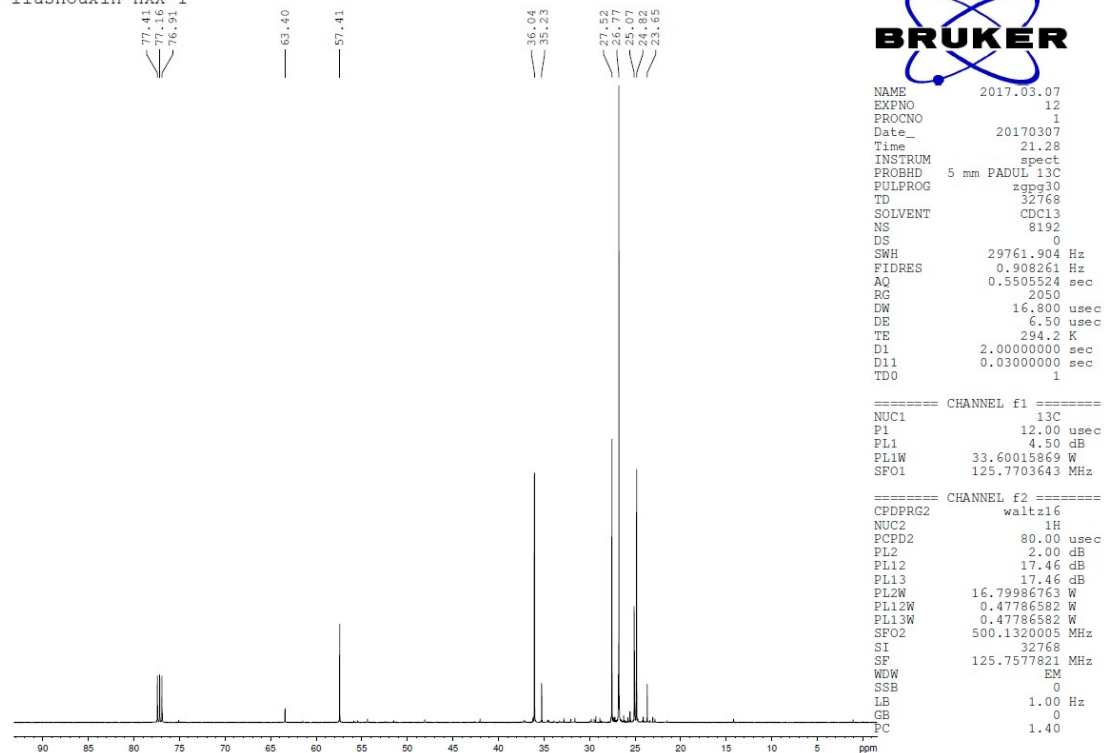
GC of the cyclooctane bromination reaction mixture



GC-MS of the cyclooctane bromination reaction mixture

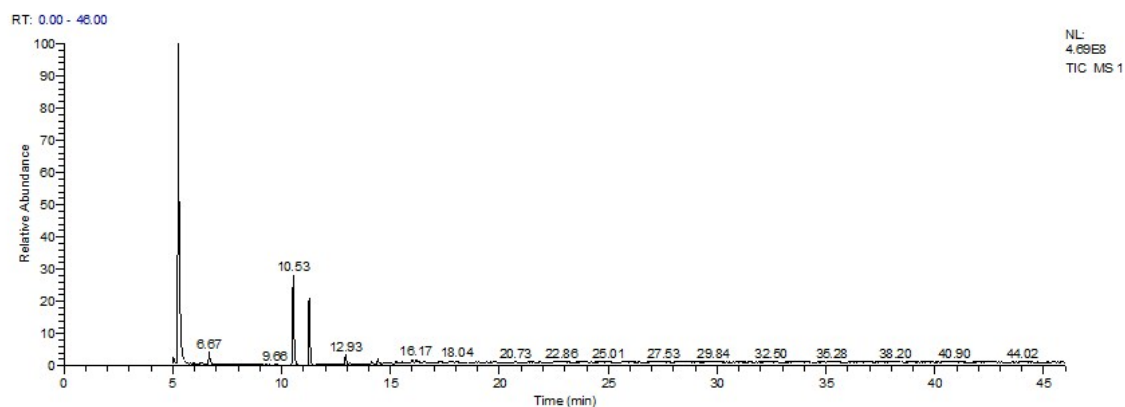


liushouxin-HXX-1

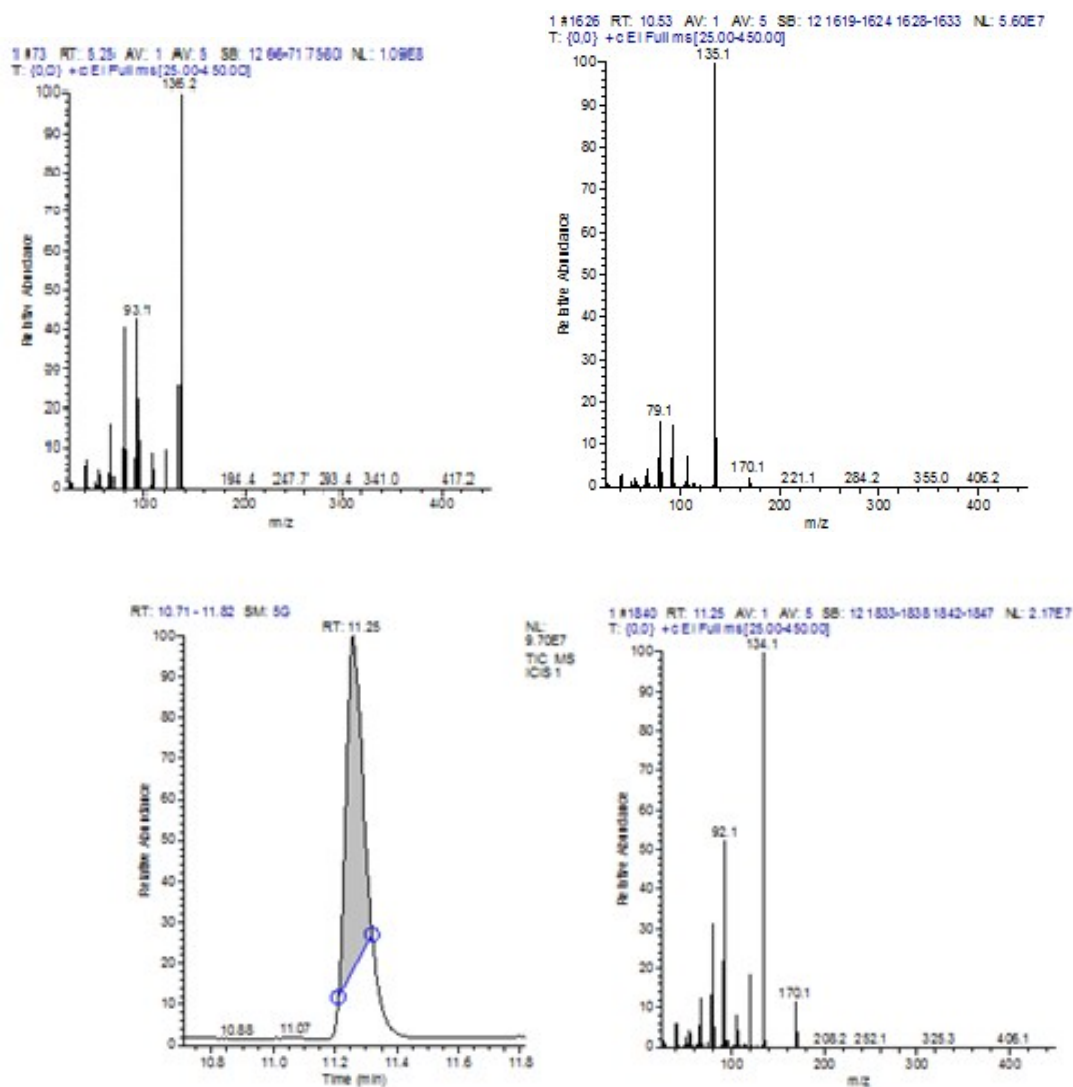


NMR of the cyclooctane bromination reaction mixture

The halogenation of adamantane

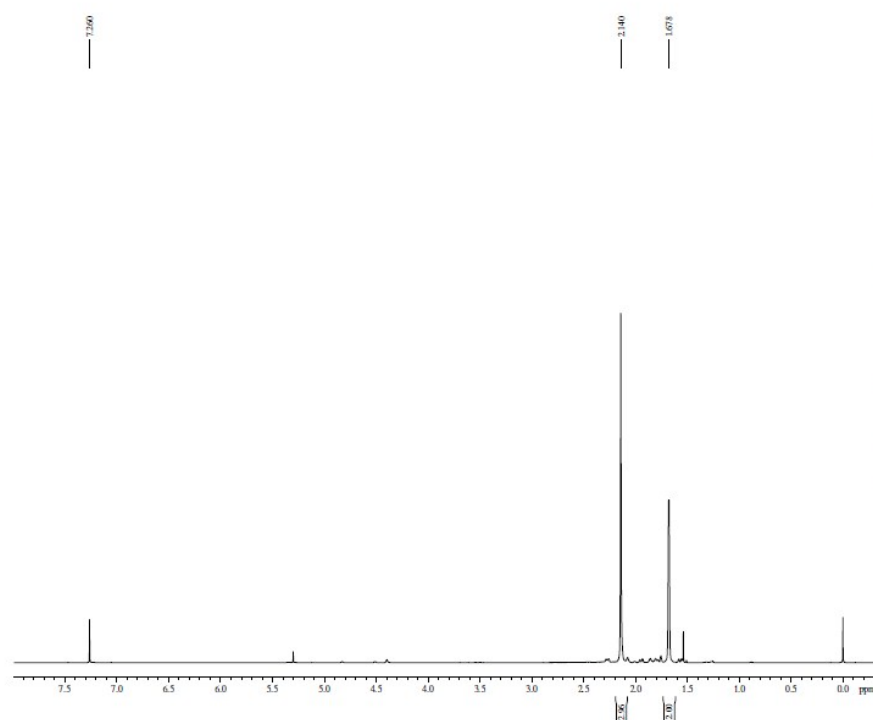


GC of the adamantane chlorination reaction mixture



GC-MS of the adamantane chlorination reaction mixture

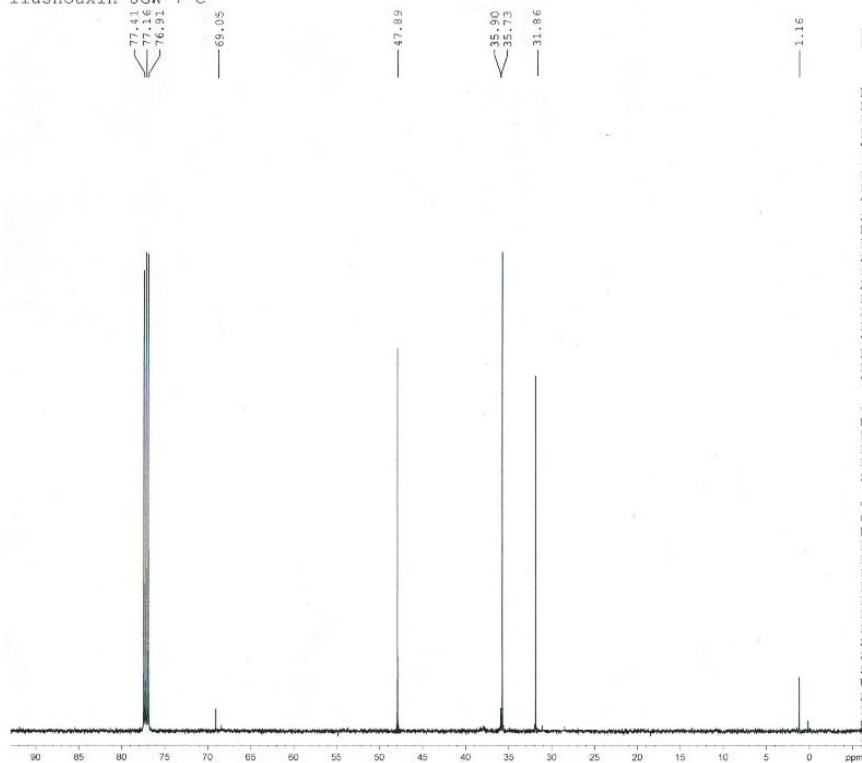
TZQ-12-CDCl₃



NAME 2015.02.04
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PROCNO 1
Date_ 20150204
Time 15.33
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PULPROG zg30
TD 32768
SOLVENT CDCl₃
NS 32
DS 0
SWH 10000.000 Hz
FIDRES 0.305176 Hz
AQ 1.6384500 sec
RG 287
DW 50.000 usec
DE 6.50 usec
TE 298.0 K
D1 1.00000000 sec
TD0 1

===== CHANNEL f1 =====
NUC1 1H
P1 13.00 usec
PL1 2.00 dB
PL1W 16.79986763 W
SFO1 500.1323506 MHz
SI 65536
SF 500.1300234 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

liushouxin-JGW-7-C



NAME 2016.10.23
EXPNO 4
PROCNO 1
Date_ 20161023
Time 12.48
INSTRUM spect
PROBHD 5 mm F4BBO BB-
PULPROG zgpg30
TD 32768
SOLVENT CDCl₃
NS 530
DS 0
SWH 29761.904 Hz
FIDRES 0.908261 Hz
AQ 0.5505524 sec
RG 2050
DW 16.800 usec
DE 6.50 usec
TE 297.2 K
D1 2.00000000 sec
D11 0.03000000 sec
TD0 1

===== CHANNEL f1 =====
NUC1 13C
P1 12.00 usec
PL1 4.50 dB
PL1W 33.60015869 W
SFO1 125.7703643 MHz

===== CHANNEL f2 =====
CPDPRG2 waltz16
NUC2 1H
PCPD2 80.00 usec
PL2 2.00 dB
PL12 17.46 dB
PL13 17.46 dB
PL12W 16.79986763 W
PL12W 0.47786582 W
PL13W 0.47786582 W
SFO2 500.1320005 MHz
SI 32768
SF 125.7577740 MHz
WDW EM
SSB 0
LB 1.00 Hz
GB 0
PC 1.40

NMR of the adamantane chlorination reaction mixture (1-Cl-adamantine)

liushouxin-JGW-5

liushouxin-JGW-5-C

77.41
77.16
76.91
68.39
47.89
38.25
37.90
37.60
36.80
35.90
35.73
31.87
31.07
28.49
27.54
26.95

BRUKER

```

NAME                2016.10.22
EXPNO                4
PROCNO              1
Date_               20161022
Time                16.38
INSTRUM             spect
PROBHD              5 mm PABUL 13C
PULPROG             zgpg30
TD                  32768
SOLVENT             CDCl3
NS                   4270
DS                   0
SWH                 29761.904 Hz
FIDRES              0.908261 Hz
AQ                  0.5503524 sec
RG                   1820
DW                  16.800 usec
DE                   6.50 usec
TE                  298.1 K
D1                   2.00000000 sec
D11                  0.03000000 sec
TD0                  1
  
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===== CHANNEL f1 =====

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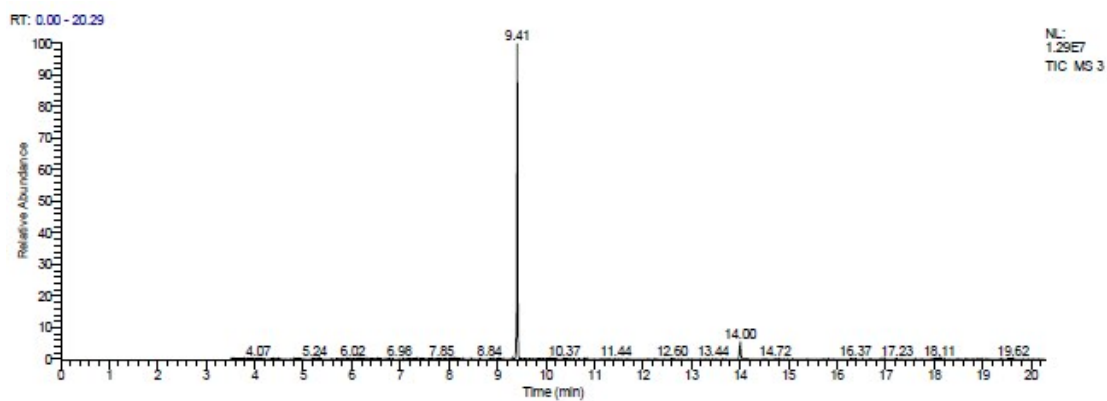
NUC1                13C
P1                   12.00 usec
PL1                  4.50 dB
PL1W                 33.60015869 W
SFO1                 125.7703643 MHz
  
```

===== CHANNEL f2 =====

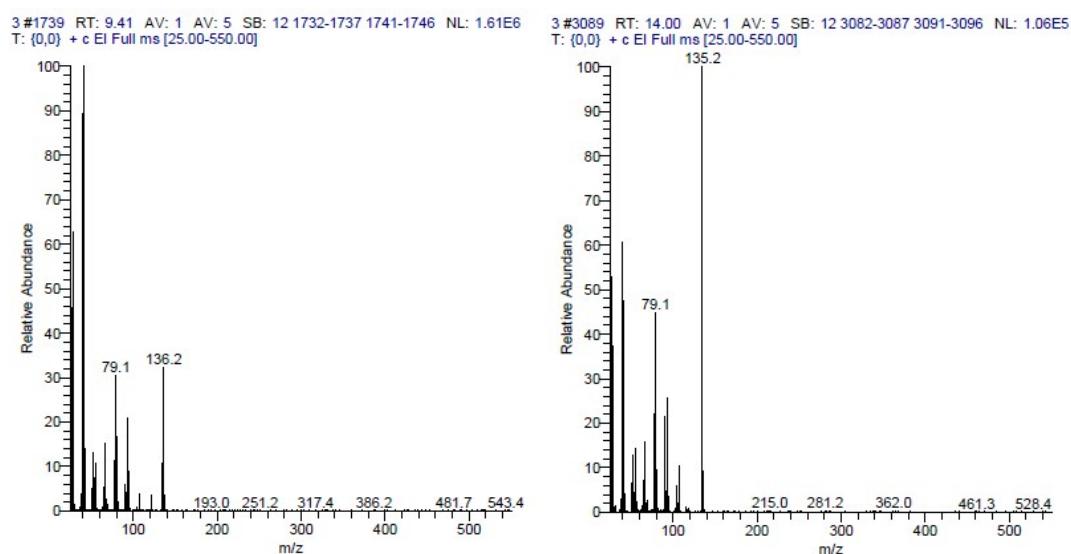
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CPDPRG2             waltz16
NUC2                 1H
PCPD2                80.00 usec
PL2                   2.00 dB
PL12                 17.46 dB
PL13                 17.46 dB
PL2W                 16.79986763 W
PL12W                0.47786582 W
PL13W                0.47786582 W
SFO2                 500.1320005 MHz
SI                   32768
SF                   125.7577739 MHz
WDW                  EM
SGB                   0
LB                   1.00 Hz
GB                   0
PC                   1.40
  
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NMR of the adamantane chlorination reaction mixture (adamantane and 2-Cl-adamantane)



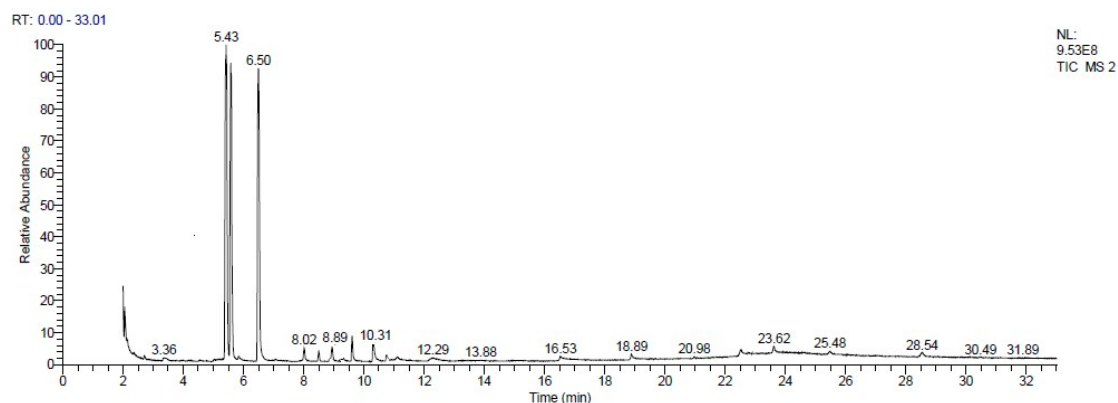
GC of the adamantane bromination reaction mixture



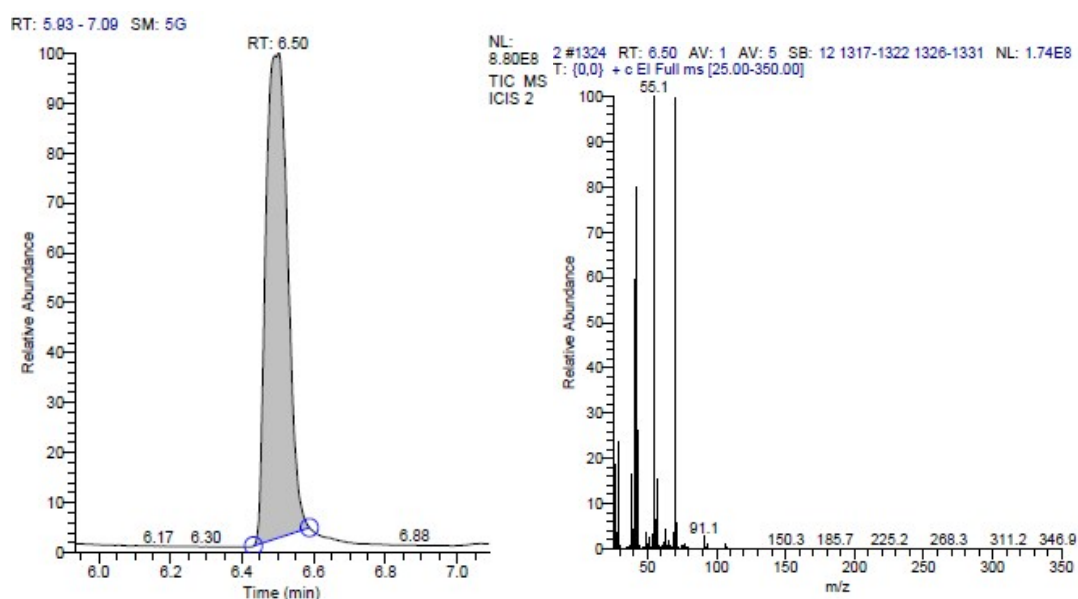
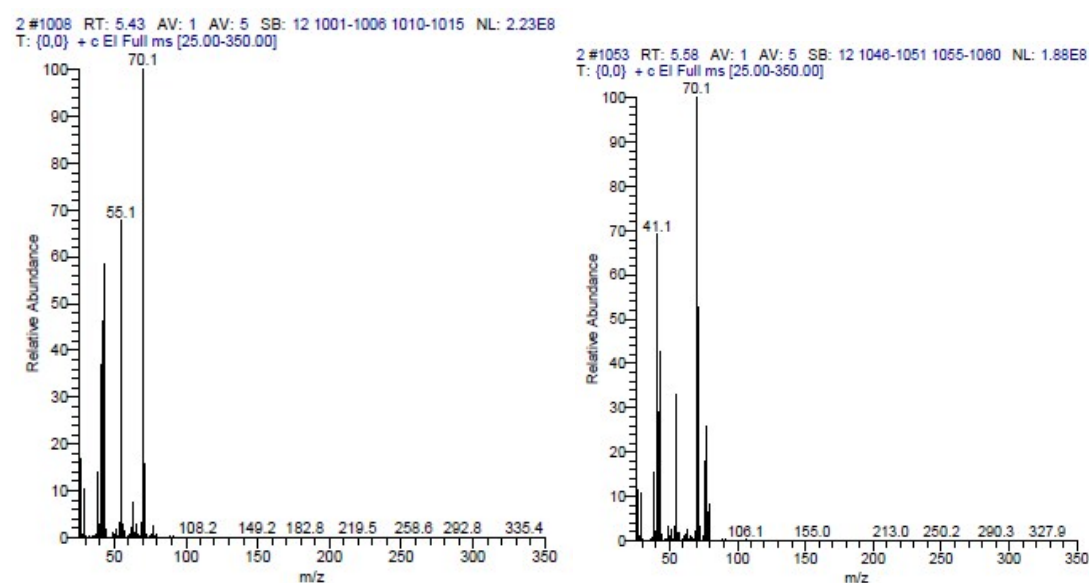
GC-MS of the adamantane bromination reaction mixture

The chlorinations of chain alkanes

Chlorination of *n*-pentane

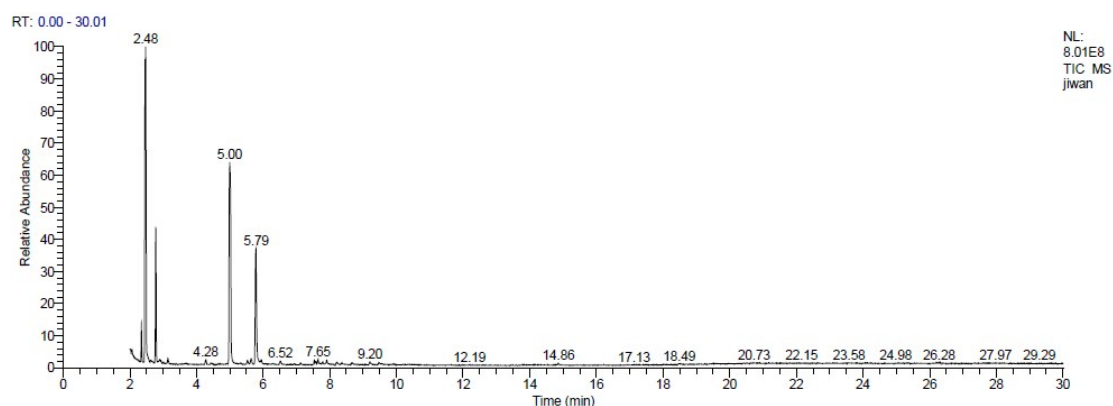


GC of the chlorination reaction mixture of *n*-pentane

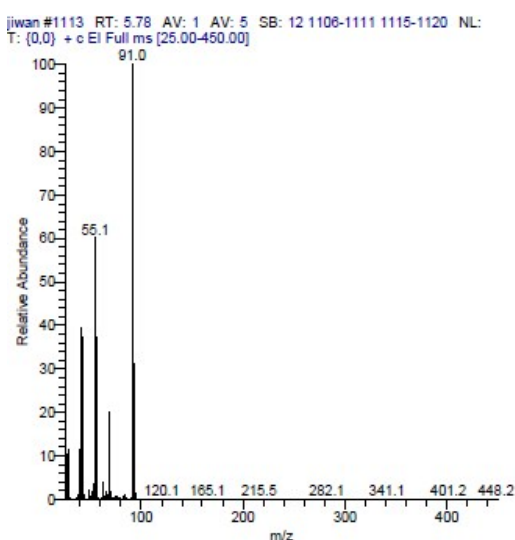
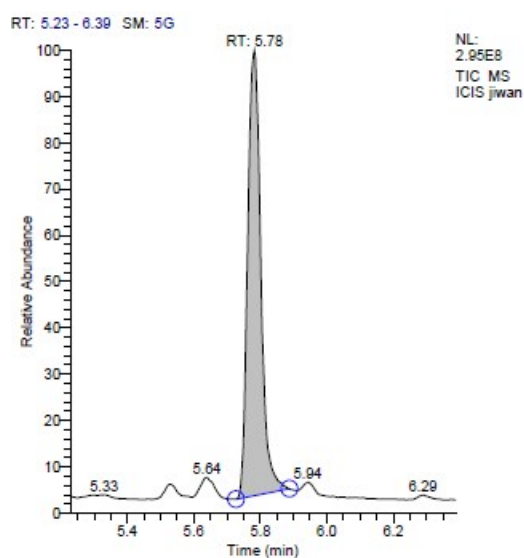
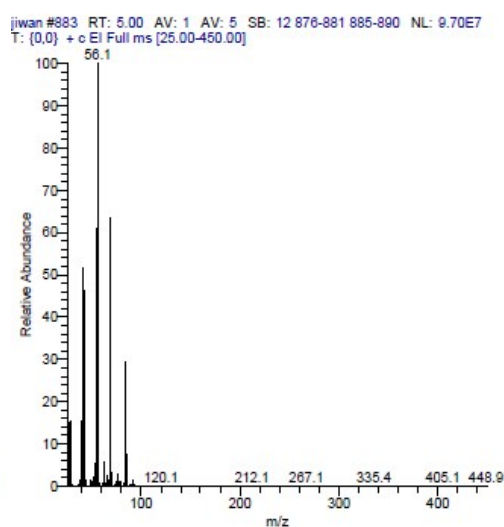
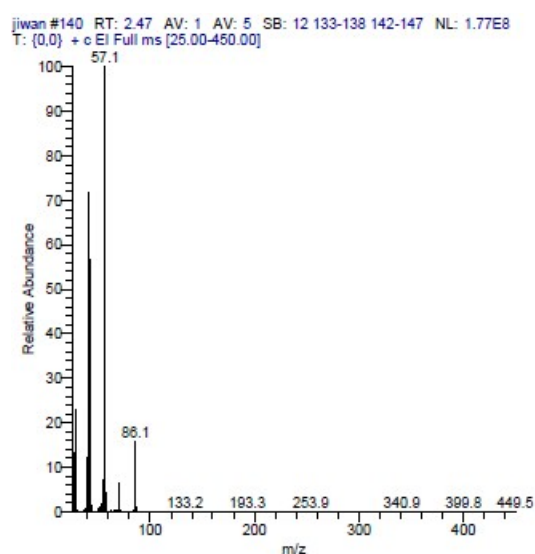


GC-MS of the chlorination reaction mixture of *n*-pentane

Chlorination of *n*-hexane

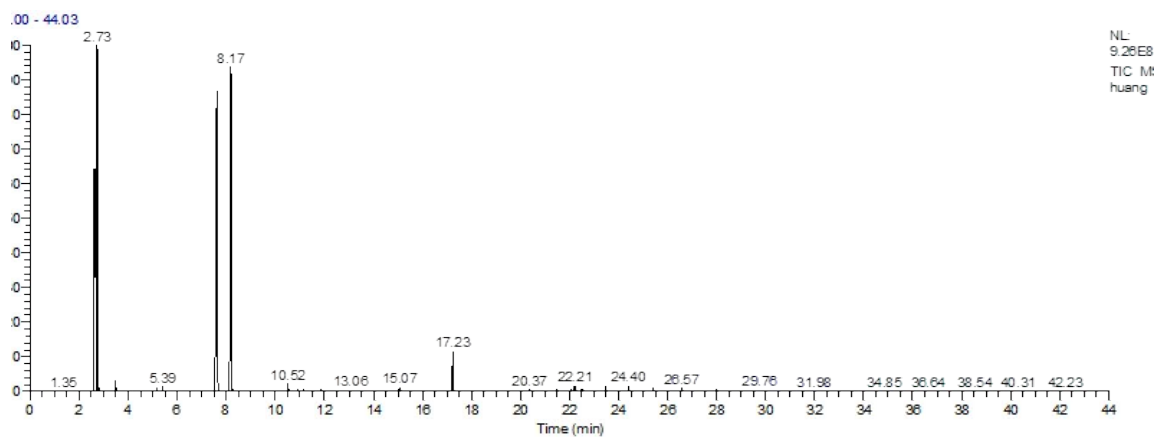


GC of the chlorination reaction mixture of *n*-hexane

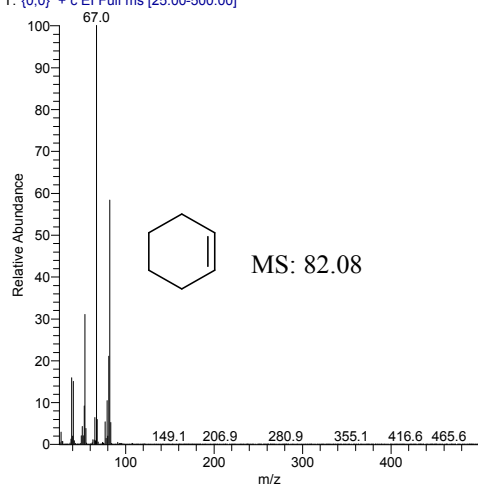


GC-MS of the chlorination reaction mixture of *n*-hexane

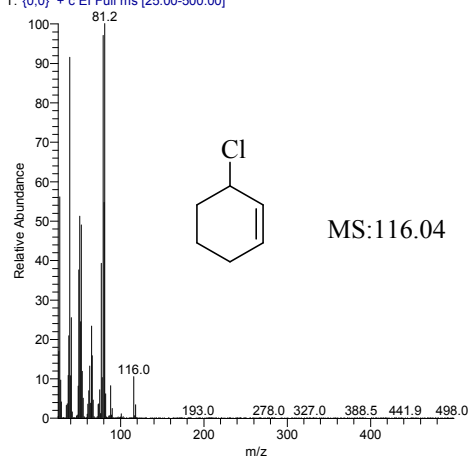
The chlorination products of cyclohexene



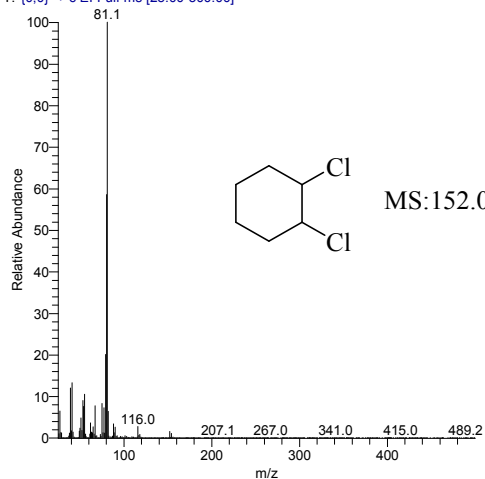
huang #795 RT: 2.73 AV: 1 AV: 5 SB: 12 788-793 797-802 NL: 2.82E8
T: {0,0} + c EI Full ms [25.00-500.00]



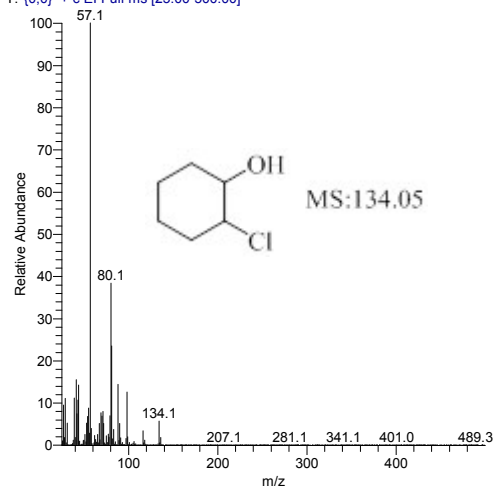
huang #1577 RT: 5.39 AV: 1 AV: 5 SB: 12 1570-1575 1579-1584 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



huang #2394 RT: 8.17 AV: 1 AV: 5 SB: 12 2387-2392 2396-2401 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



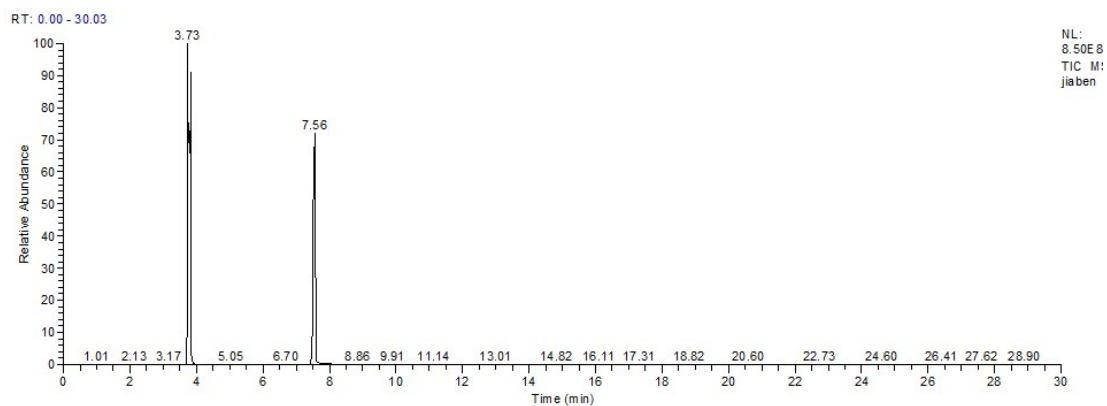
huang #2233 RT: 7.62 AV: 1 AV: 5 SB: 12 2226-2231 2235-2240 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



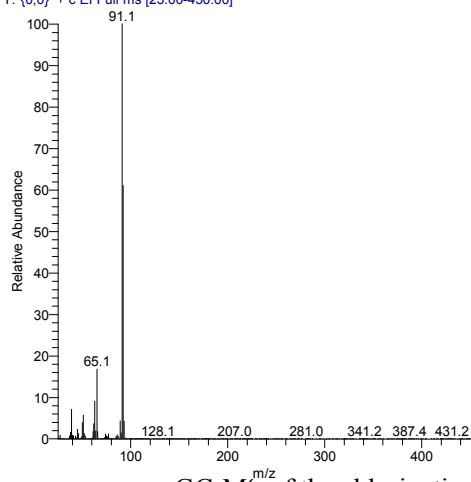
GC-MS of the chlorination reaction mixture of cyclohexene

The halogenation of α -H at alkylbenzene

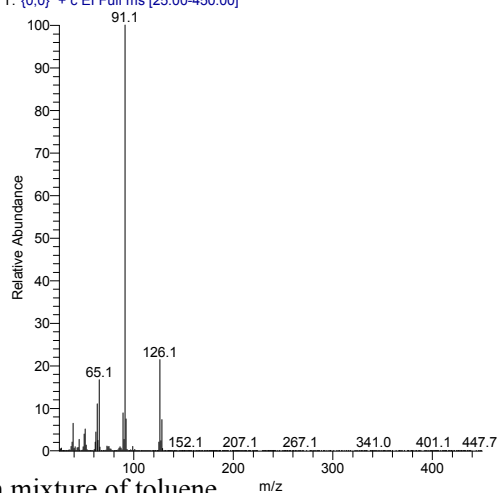
Chlorination of toluene by Ag/AgCl catalyztion



jiaben #1089 RT: 3.73 AV: 1 AV: 5 SB: 12 1082-1087 1091-1096 NL:
T: {0,0} + c EI Full ms [25.00-450.00]

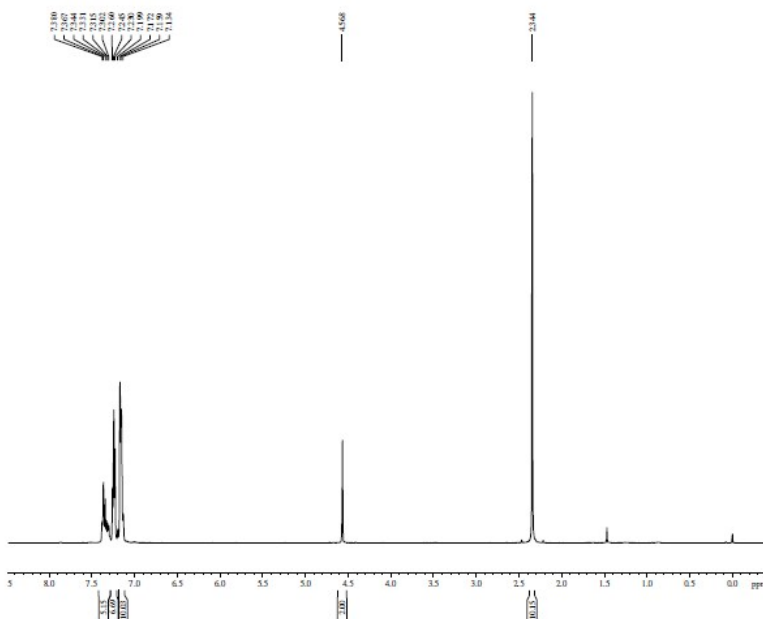


jiaben #2214 RT: 7.56 AV: 1 AV: 5 SB: 12 2207-2212 2216-2221 NL:
T: {0,0} + c EI Full ms [25.00-450.00]



GC-MS of the chlorination reaction mixture of toluene

liushouxin---benzyl chloride---zqlhb



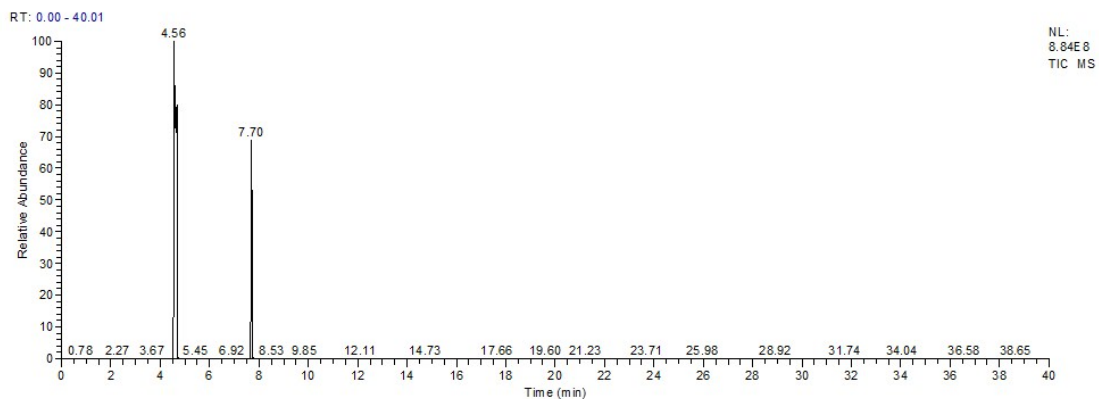
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NAME      2012.09.11
EXPNO     2
PROCNO    1
Date_     20120911
Time      14.27
INSTRUM   spect
PROBHD    5 mm PABBO BB-
PULPROG   zg30
TD        32768
SOLVENT   CDCl3
NS         1
DS         2
SWH        10330.578 Hz
FIDRES     0.315264 Hz
AQ         1.5860212 sec
RG         90.5
FW         48.400 usec
DE         6.50 usec
TE         297.5 K
D1         1.00000000 sec
TD0        1
  
```

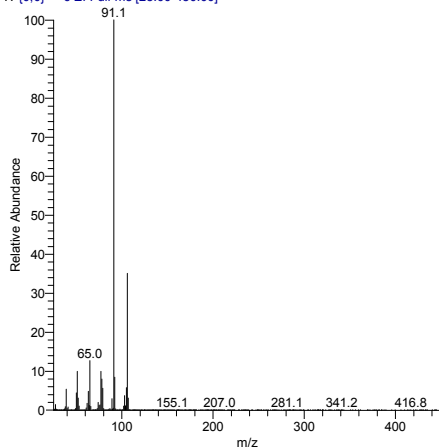
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===== CHANNEL f1 =====
NUC1      1H
P1        13.00 usec
PL1       2.00 dB
PL1W      16.79986763 W
SFO1      500.1330885 MHz
SI        32768
SF        500.1300442 MHz
WDW        EM
SSB        0
LB         0.30 Hz
GB         0
PC         1.00
  
```

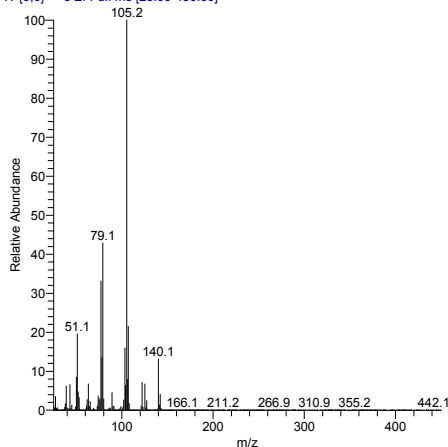
¹H NMR of the the chlorination reaction mixture of toluene



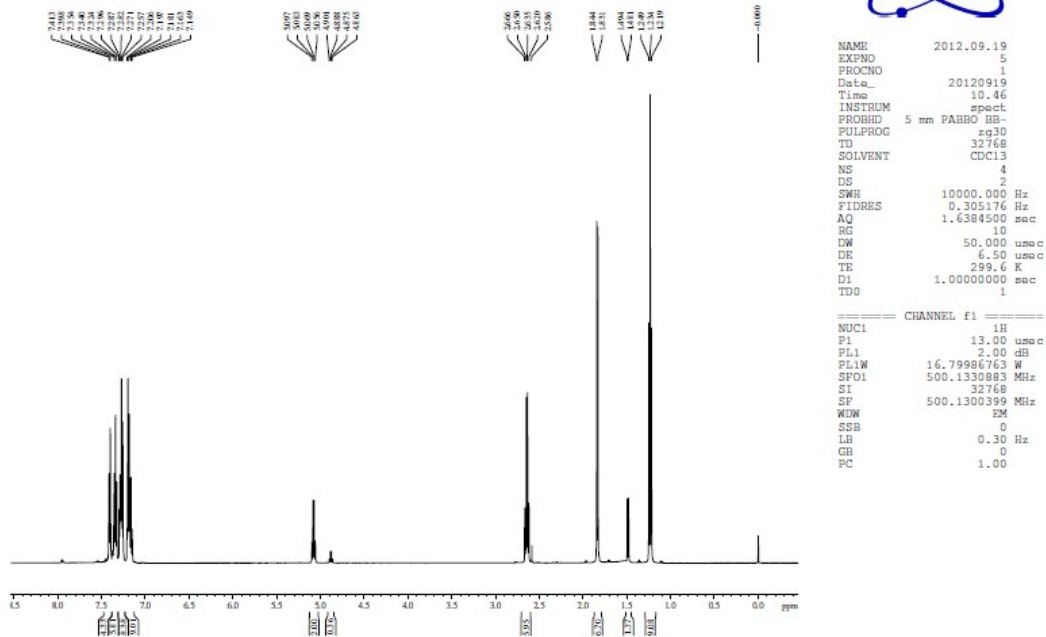
1#1331 RT: 4.56 AV: 1 AV: 5 SB: 12 1324-1329 1333-1338 NL: 3.07E8
T: (0,0) + c EI Full ms [25.00-450.00]



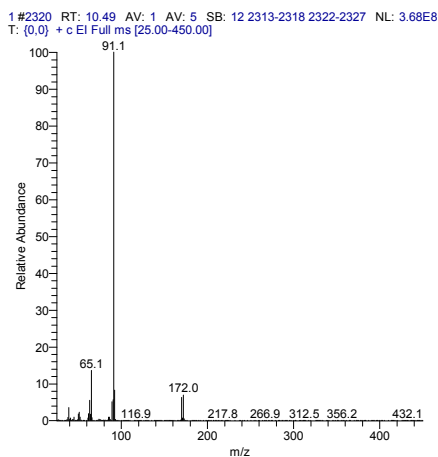
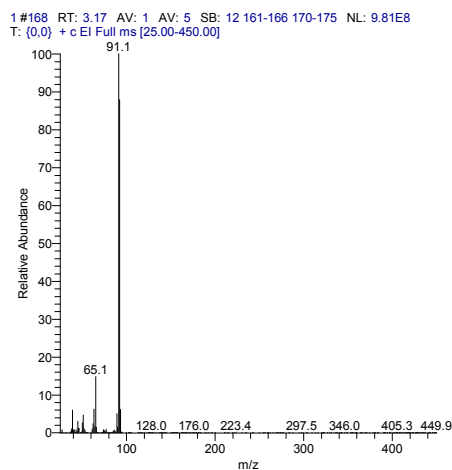
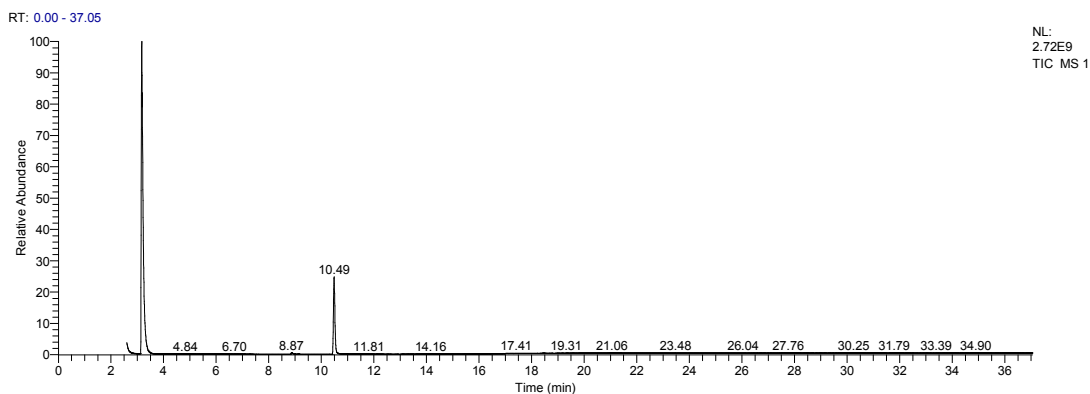
1#2256 RT: 7.70 AV: 1 AV: 5 SB: 12 2249-2254 2258-2263 NL: 1.52E8
T: (0,0) + c EI Full ms [25.00-450.00]



GC-MS of the chlorination reaction mixture of ethylbenzene

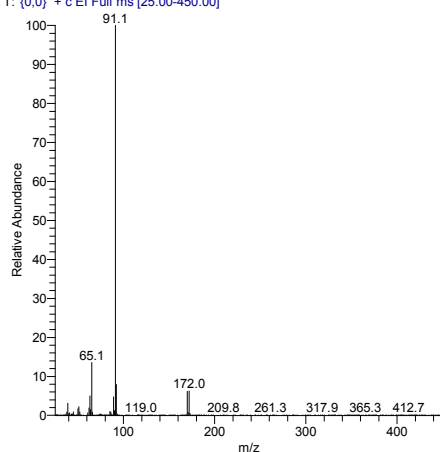


Bromination of toluene by the Ag/AgBr catalyzation

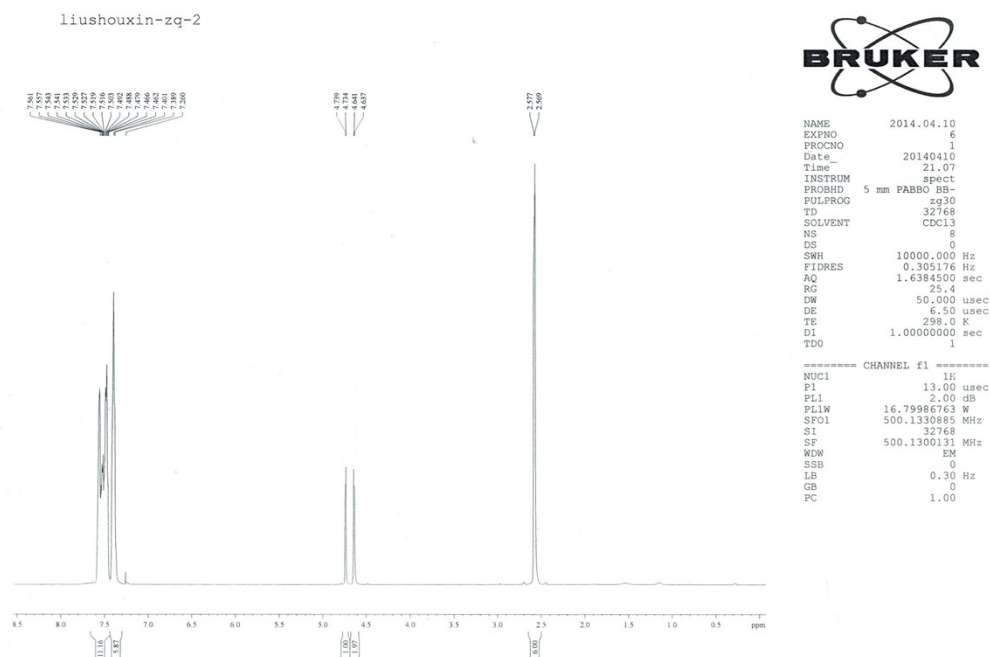


GC-MS of the bromination reaction mixture of toluene

2 #2319 RT: 10.48 AV: 1 AV: 5 SB: 12 2312-2317 2321-2326 NL: 6.23E8
T: {0,0} + c EI Full ms [25.00-450.00]

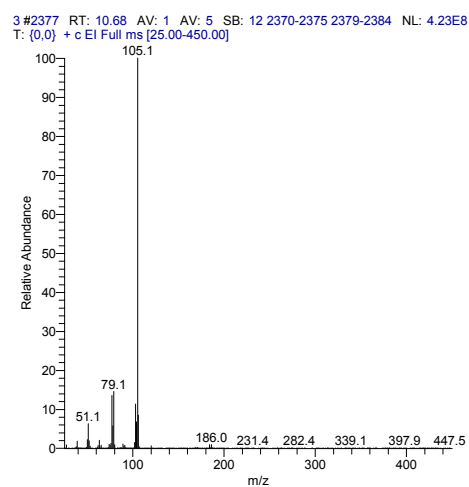
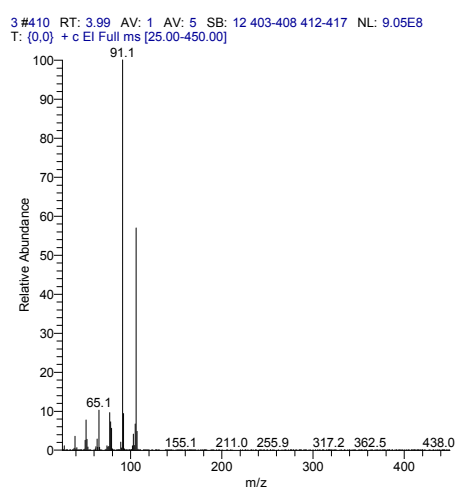
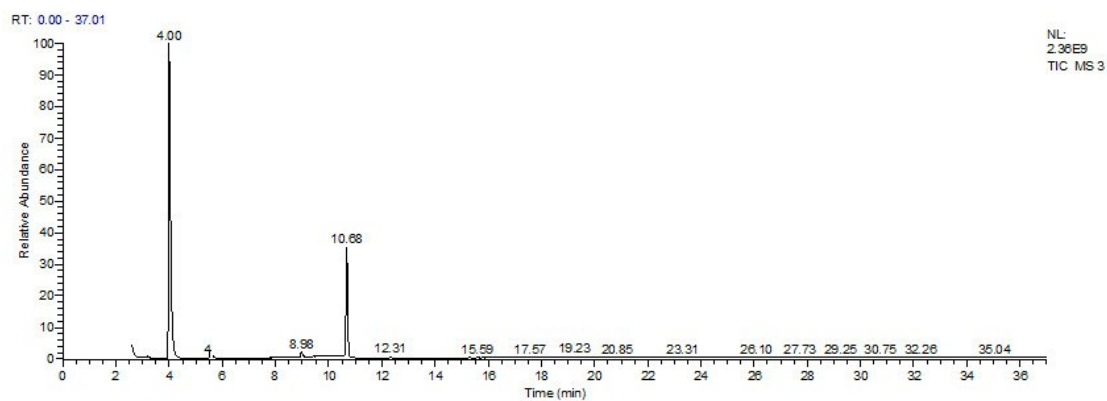


GC-MS of the bromination reaction mixture of toluene

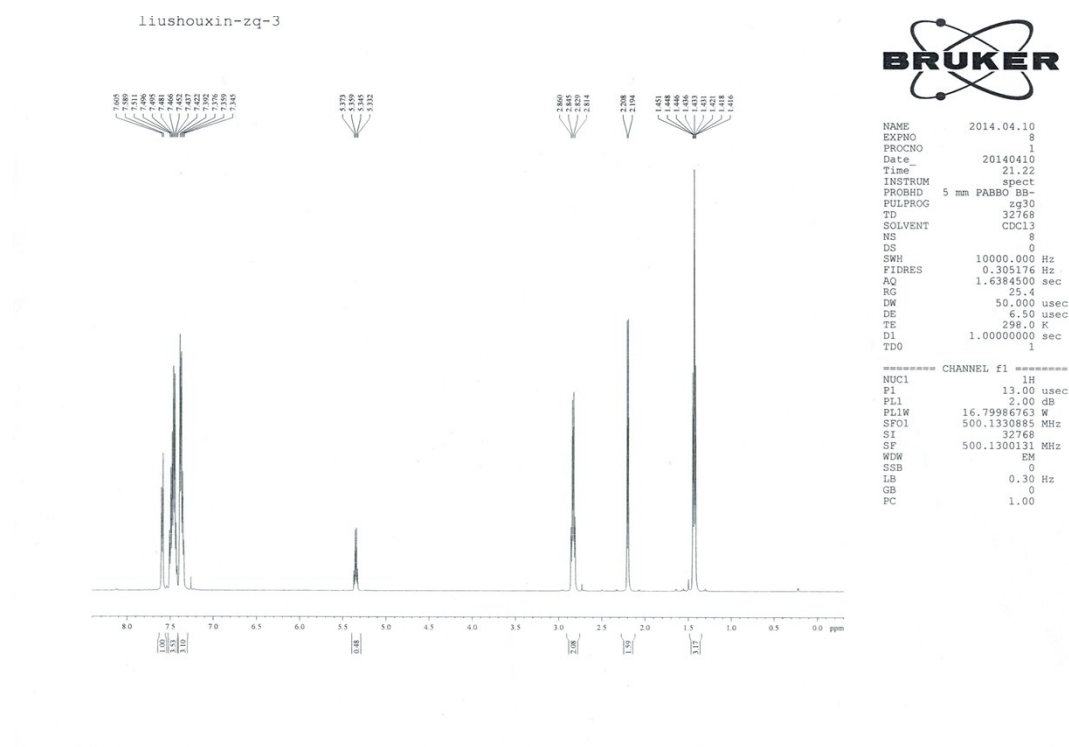


NMR of the bromination reaction mixture of toluene

Bromination of ethylbenzene by Ag/AgBr catalyzaion

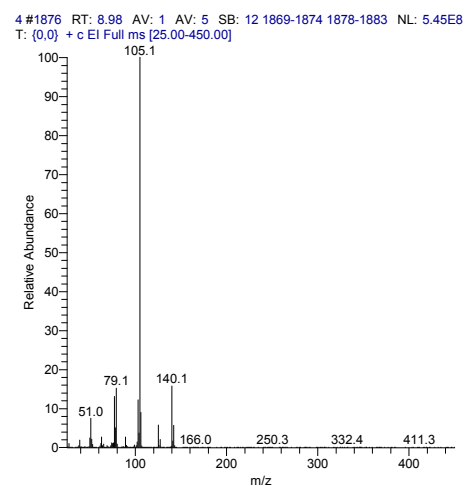
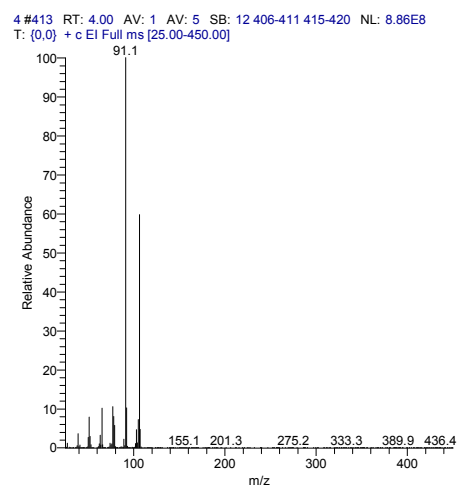
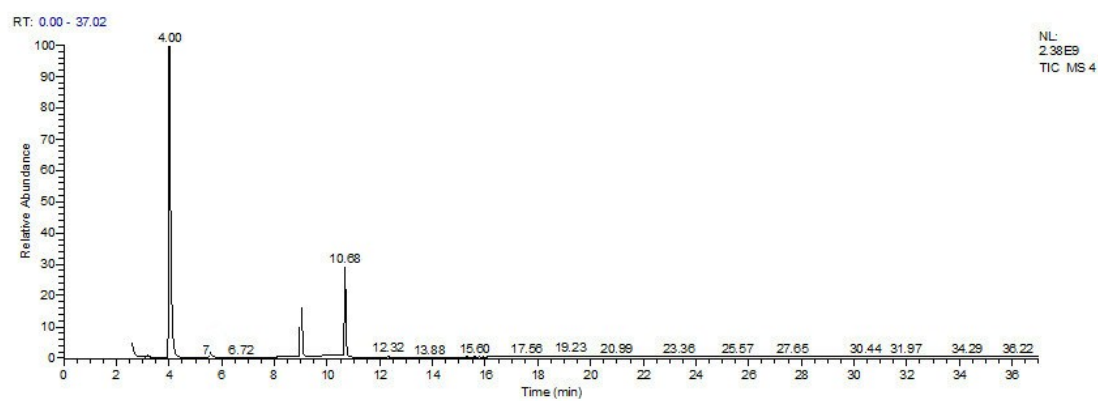


GC-MS of the bromination reaction mixture of ethylbenzene

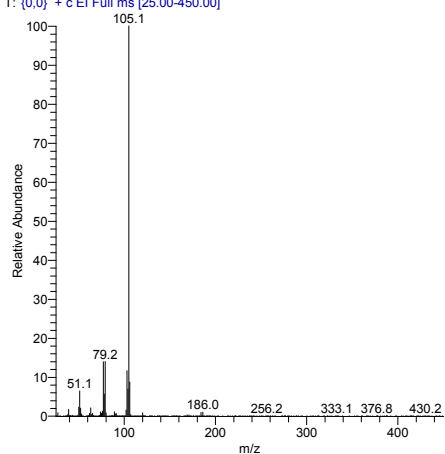


NMR of the bromination reactionmixture of ethylbenzene

Bromination of ethylbenzene by Ag/AgCl catalyzation

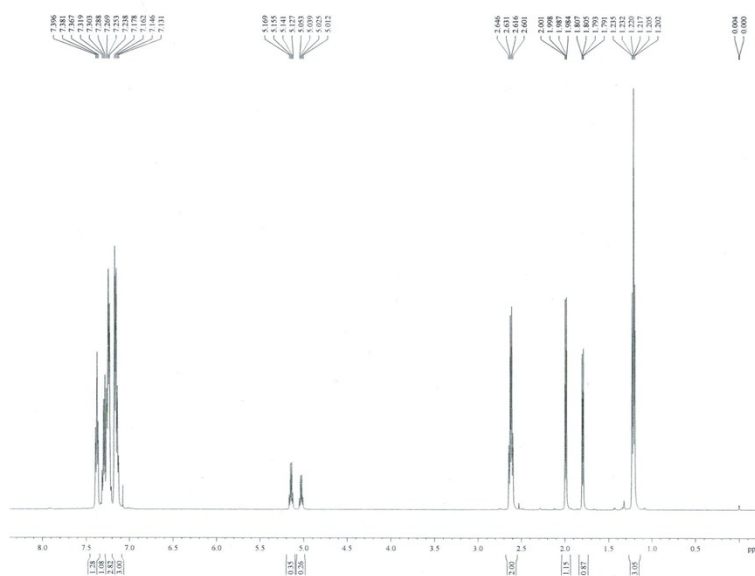


4 #2376 RT: 10.68 AV: 1 AV: 5 SB: 12 2369-2374 2378-2383 NL: 3.38E8
T: {0,0} + c EI Full ms [25.00-450.00]



GC-MS of the bromination reaction mixture of ethylbenzene

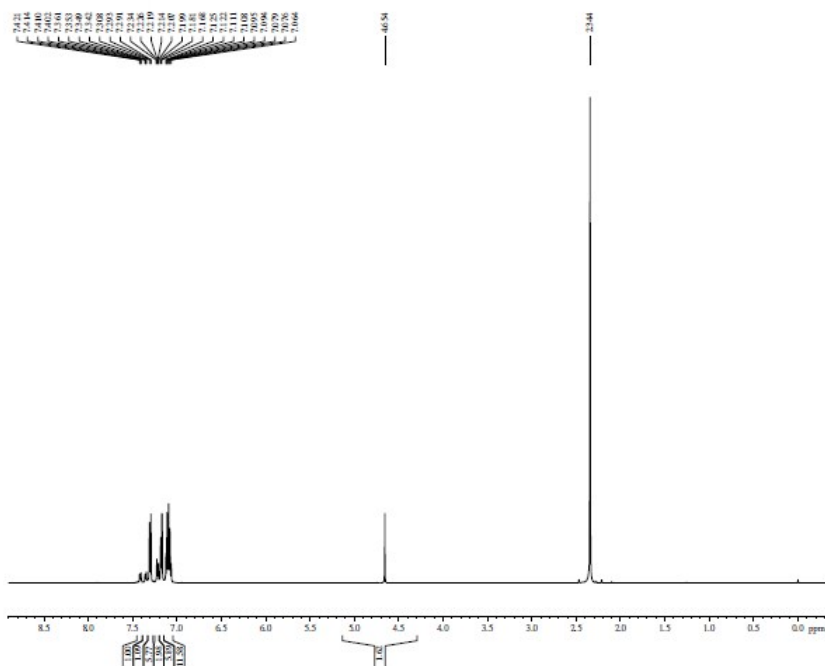
liushouxin-zq-4



NAME 2014.04.10
EXPNO 5
PROCNO 1
Date 20140410
Time 20.59
INSTRUM spect
PROBHD 5 mm PABBO BB-
FULPROG zg30
TD 32768
SOLVENT CDCl3
NS 8
DS 0
SWH 10000.000 Hz
FIDRES 0.305176 Hz
AQ 1.6384500 sec
RG 25.4
DW 50.000 usec
DE 6.50 usec
TE 298.0 K
D1 1.00000000 sec
TD0 1

===== CHANNEL f1 =====
NUC1 1H
P1 13.00 usec
PL1 2.00 dB
PL1W 16.79986763 W
SF01 500.1330885 MHz
SI 32768
SF 500.1301034 MHz
WDW EM
SSB 0
LB 0.30 Hz
GB 0
PC 1.00

NMR of the bromination reaction mixture of ethylbenzene



RT: 0.00 - 29.00

Relative Abundance

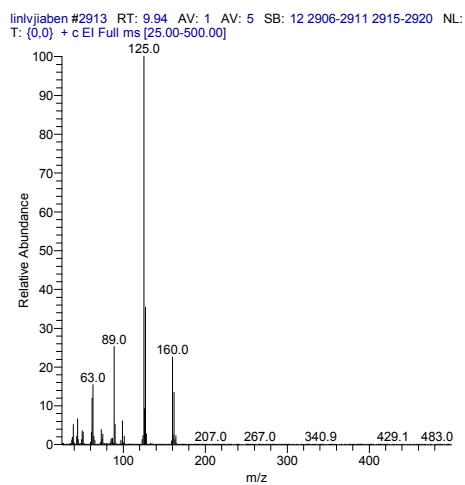
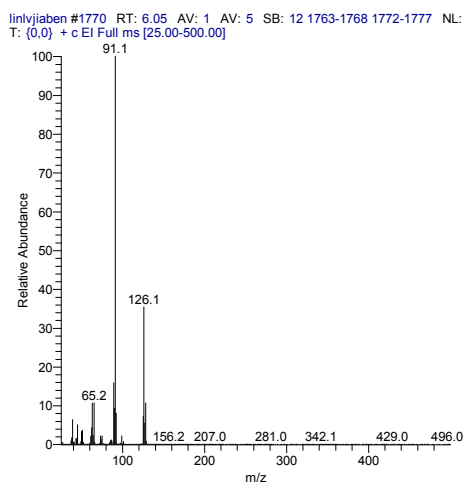
Time (min)

6.05

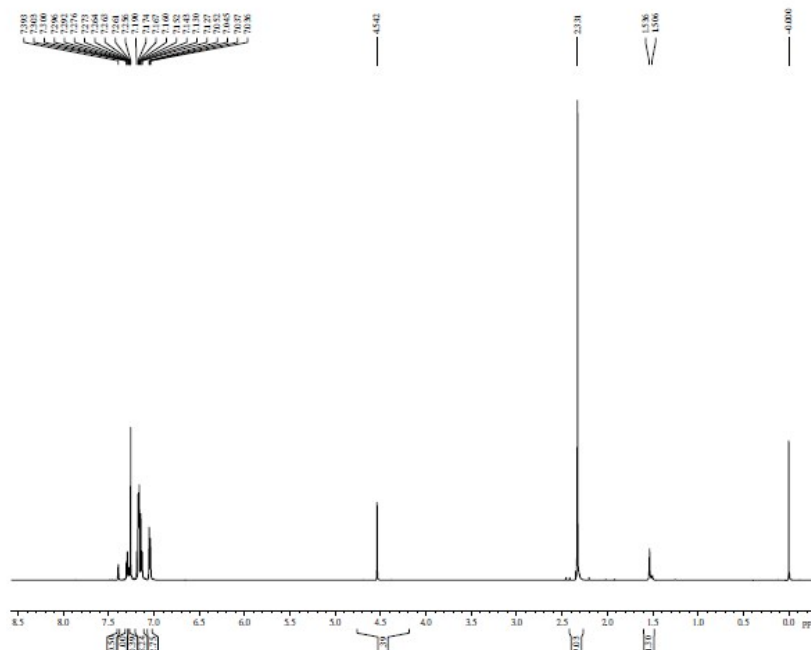
9.94

0.60 1.95 3.46 4.47 5.44 7.53 8.96 11.17 12.37 13.55 14.71 16.20 17.40 18.85 20.38 22.32 23.93 25.31 26.58 28.01

NL: 7.89E8
TIC: MS
Inkylaben



GC-MS of the chlorination reaction mixture of 2-chlorotoluene



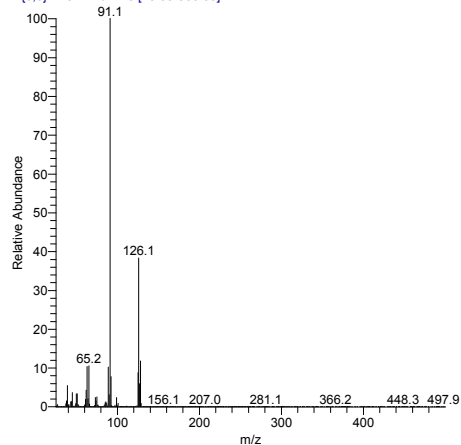
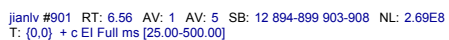
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NAME                2012.12.13
EXPNO                8
PROCNO              1
Date_                20121213
Time                18.35
INSTRUM              spect
PROBHD               5 mm PABBO BB-
PULPROG              zg30
TD                  32768
SOLVENT              CDCl3
NS                   16
DS                   0
SWH                 10330.578 Hz
FIDRES              0.315264 Hz
AQ                 1.5860212 sec
RG                 181
DQ                  48.400 usec
DE                  6.50 usec
TE                  298.0 K
D1                  1.00000000 sec
TDO                  1
===== CHANNEL f1 =====
NUC1                 1H
P1                   13.00 usec
PL1                  2.00 dB
PL1W                 16.79986763 W
SFO1                 500.1330885 MHz
PC                   32768
SF                   500.1330154 MHz
WDW                  EM
SSB                  0
LB                   0.30 Hz
GB                   0
EC                   1.00

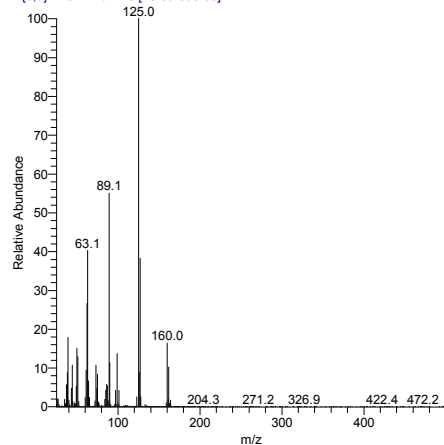
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Chromatogram showing relative abundance versus time (min). The x-axis ranges from 0 to 36 minutes. The y-axis ranges from 0 to 100 relative abundance. A major peak is labeled at 6.56 minutes. Other labeled peaks include 4.11, 5.54, 7.61, 9.39, 10.79, 12.46, 14.96, 16.44, 18.64, 20.19, 21.64, 24.26, 25.77, 27.50, 29.41, 31.34, 33.50, and 35.02 minutes.

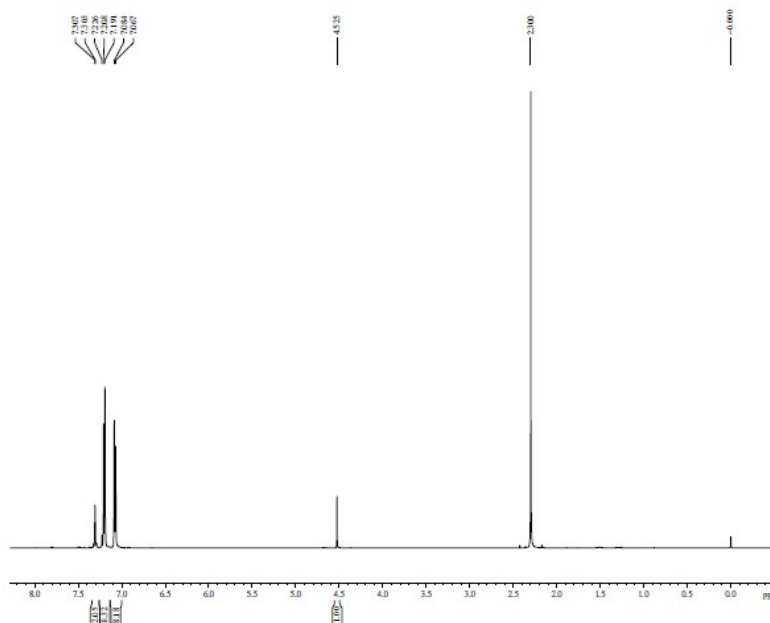
NL:
7.14E8
TIC MS
jianlv



jianlv #2144 RT: 10.79 AV: 1 AV: 5 SB: 12 2137-2142 2146-2151 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



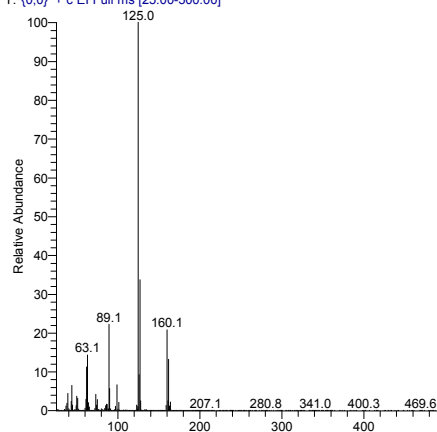
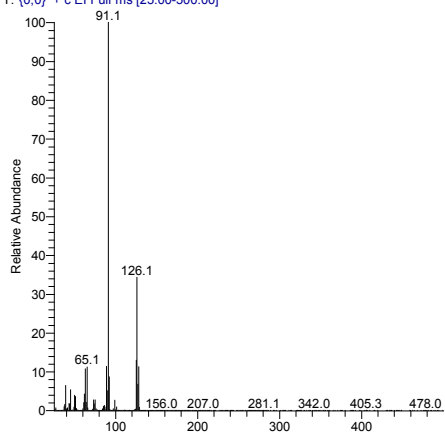
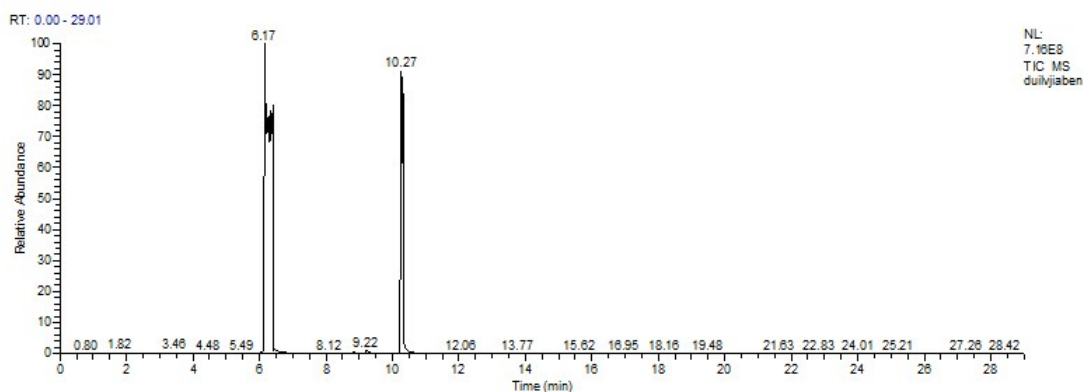
GC-MS of the chlorination reaction mixture of 3-chlorotoluene



```

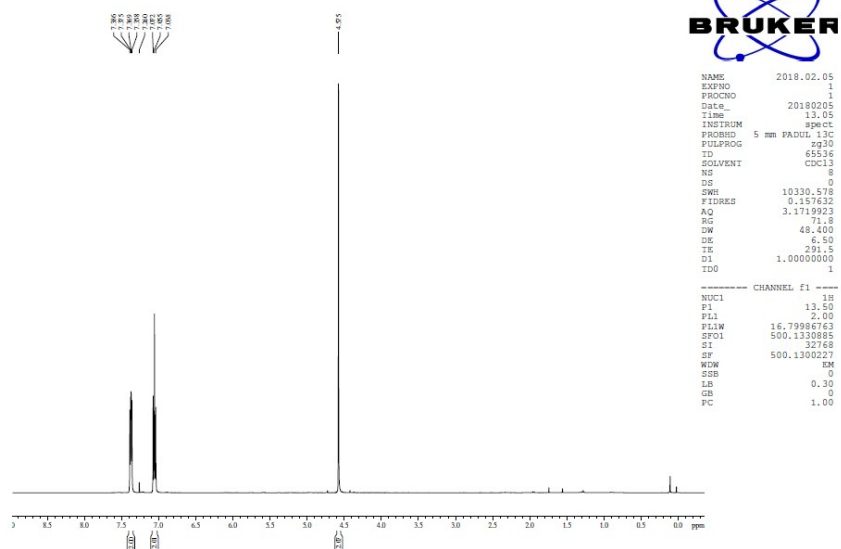
NAME                2012.12.01
EXPNO                8
PROCNO              1
Date_              20121201
Time              12.39
INSTRUM             spect
PROBHD              5 mm PABBO HB
PULPROG             zgpg
TD                 32768
SOLVENT             CDCl3
NS                  578
DS                  0
SWH                10330.578 Hz
FIDRES             0.315264 Hz
AQ                 1.5866202 sec
RG                 80.6
DE                 48.400 usec
DW                 6.50 usec
TE                 299.0 K
D1                 1.0000000 sec
TD0                1
===== CHANNEL f1 =====
NUC1                1H
P1                 13.00 usec
PL1                -2.00 dB
F1                 16.79987653 MHz
SFO1               500.1330895 MHz
SF                 32768
SSB                500.1330303 MHz
WDW                EM
SSB                0
GB                 0.50 Hz
PC                 0
LG                 1.00

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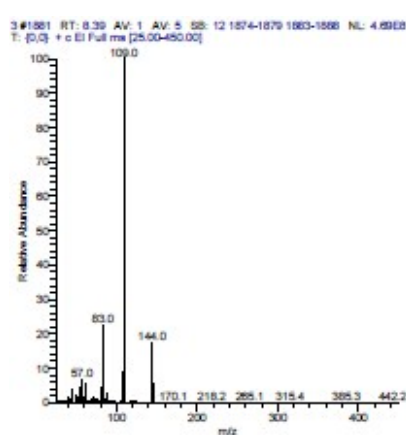
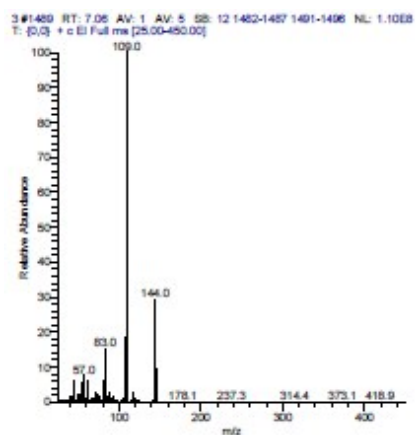
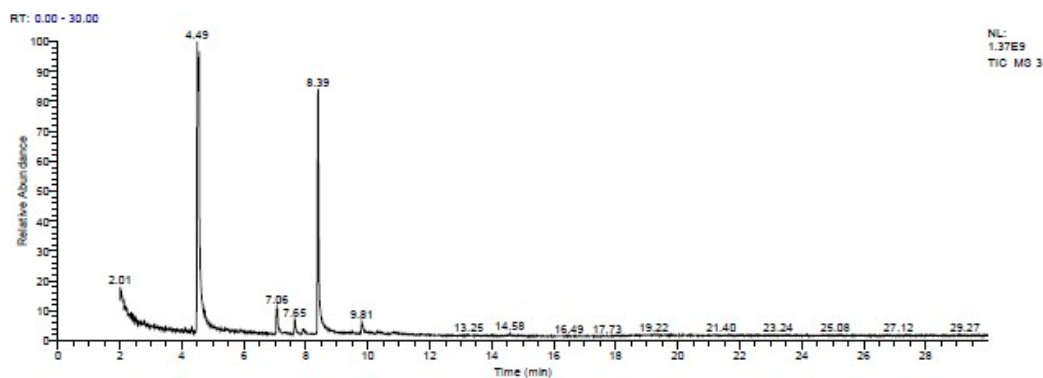


GC-MS of the chlorination reaction mixture of 4-chlorotoluene

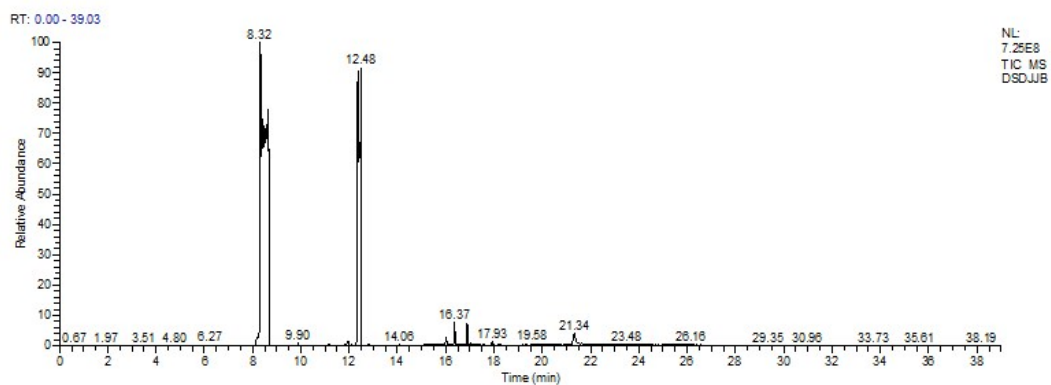
liushouxin-TZQ-4



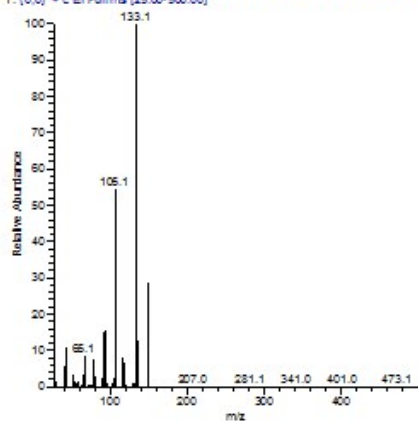
¹H NMR of the chlorination reaction mixture of 4-fluorotoluene



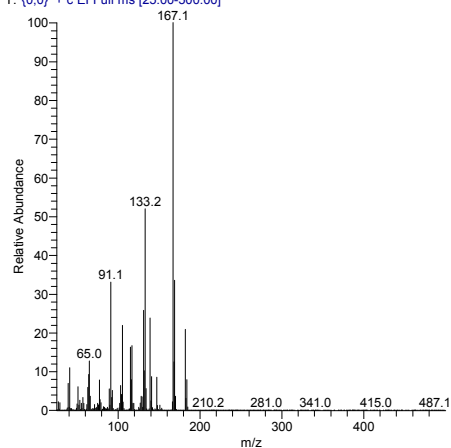
GC-MS of the chlorination reactionmixture of 4-fluorotoluene



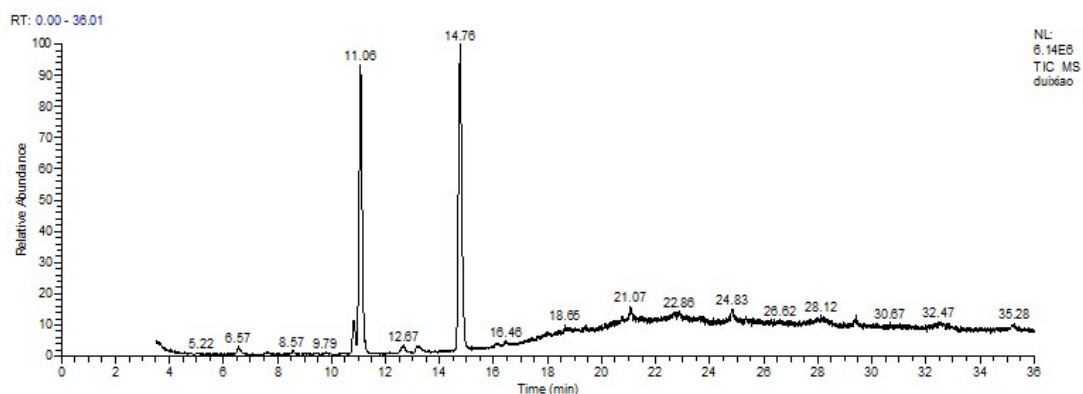
DSDJJB #2438 RT: 8.32 AV: 1 AV: 5 SB: 12 2431-2438 2440-2445 NL:
T: [0.0] + c EI Fullms [25.00-500.00]



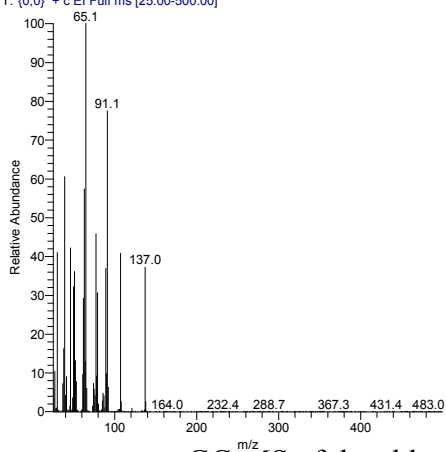
DSDJJB #3627 RT: 12.37 AV: 1 AV: 5 SB: 12 3620-3625 3629-3634 NL:
T: [0.0] + c EI Full ms [25.00-500.00]



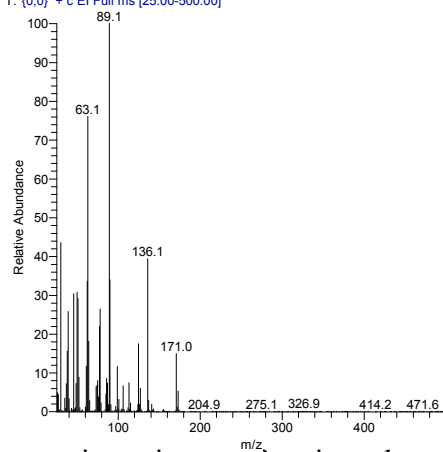
GC-MS of the chlorination reaction mixture of 4-*t*-butyltoluene



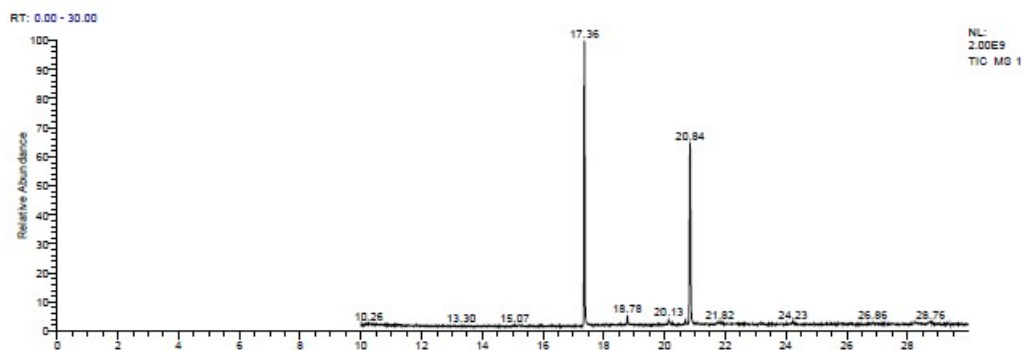
duixiao #2225 RT: 11.06 AV: 1 AV: 5 SB: 12 2218-2223 2227-2232 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



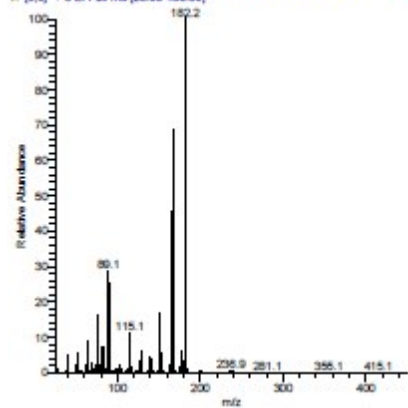
duixiao #3311 RT: 14.76 AV: 1 AV: 5 SB: 12 3304-3309 3313-3318 NL:
T: {0,0} + c EI Full ms [25.00-500.00]



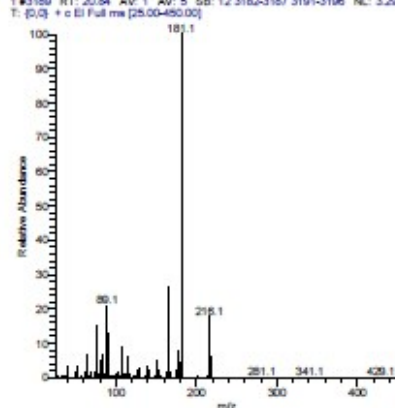
GC-MS of the chlorination reaction mixture of *p*-nitrotoluene



1 #2156 RT: 17.36 AV: 1 AV: 5 SB: 12 2150-2164 2169-2173 NL: 3.38E8
T: {0,0} + c EI Full ms [25.00-450.00]



1 #3159 RT: 20.84 AV: 1 AV: 5 SB: 12 3152-3167 3191-3196 NL: 3.29E8
T: {0,0} + c EI Full ms [25.00-450.00]



GC-MS of the chlorination reaction mixture of 4,4'-dimethylbiphenyl