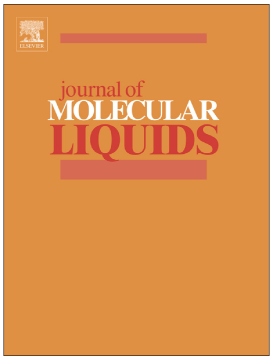

Deep eutectic solvent (DES) as dual solvent/catalyst for synthesis of α-diazocarbonyl compounds using aldol-type coupling

Maryam Kazemi Miraki, Jamshid Azarnia Mehraban, Elahe Yazdani, Akbar Heydari

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Deep eutectic solvent (DES) as dual solvent/catalyst for synthesis of α-diazocarbonyl compounds using aldol-type coupling

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Abstract

Deep eutectic solvent (DES) was employed as dual solvent/catalyst in the green synthesis of α-diazocarbonyl compounds using aldol-type coupling. α-Diazocarbonyl compounds are important synthetic intermediates with useful application for synthesis of amino alcohols and acids and many natural products. Moreover, the method is environmentally friendly because of avoidance of toxic solvents or hazardous catalysts.

Introduction

Solvents play a very important role in a number of areas, particularly in the synthesis. Solvents generally as the largest single component by weight in most reactions are a clear target for concern and interest due to the growing importance placed upon ‘greenness’[1]. However, the use of green solvents still remains a lasting challenge, even when conventional hazardous volatile organic solvents (VOCs, commonly used as reaction media in organic procedures) can cause well-established environmental and safety-related problems [2]. Many alternative solvents such as water, supercritical fluids, room temperature ionic liquids (RTILs) have been proposed [1]. ILs are relatively a new class of promising solvents which are gaining increasing interest by both scientific and industrial communities due to solving the economic challenges as well as environmental ones.

However, the low vapor pressures [3, 4], the low volatility and less toxicity allow greener synthesis with reduced environmental impacts, in contrast to volatile organic solvents[5-7].

Each of these alternatives has some great benefits, but each also has significant limitations, including reactivity problems, solubility issues, high price, the need for exotic reactors and toxicity [8]. A recent alternative solvent is the category of deep eutectic solvents (DES) which is regarded as ionic liquids analogues (ILA). Although they share many characteristics and properties with ILs, they represent a different type of solvent [9]. Deep Eutectic Solvents (DES) are emerging as new class of superior green solvents with the intrinsic favourable properties of low cost, low toxicity, non-flammability, minimum volatility, biodegradability and suitability for many industrial applications [10]. In metal deposition, DESs were applied as media and electrolytes for plating of metals [11, 12]. Additionally, they have been utilized in the electropolishing of stainless steel, for the removal of residual palm oil-based biodiesel catalyst and as template-delivery agents [13, 14]. DES have been extensively explored in certain contexts, [15] however, they have not received as much attention for their potential in synthesis [16-21].

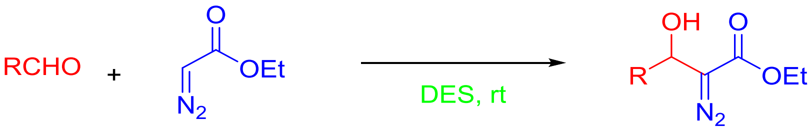
This family covers a considerable range of different mixtures. Conventionally, deep eutectic solvents are synthesized by complexion of the different ratios of ammonium or phosphonium based salts with varieties of hydrogen bond donors such as: alcohols, carboxylic acids, esters, ethers, amides, halides, amines, amino acids and many more and hydrated metal salts of chlorides, nitrates and acetates for the decrease in the freezing point of the mixture relative to the melting points of the individual components [22]. In addition, metal halides based DESs were also reported later [23]. The most commonly employed DES, is the 1:2 molar mixture of choline chloride and urea which affords a viscous liquid at room temperature [9]. In 2013, a new class of DES has been reported that potassium carbonate has been used as a salt with glycerol as a hydrogen bond donor (HDB) [24].

α-Diazocarbonyl compounds have attracted attention because they undergo diverse synthetically useful transformations. The α-diazocarbonyl compounds are widely used as potential source of amino alcohols and acids and useful synthetic intermediates for many natural products [25]. Although the synthesis of diazocarbonyl compounds can be achieved by a number of routes [26]. one potentially attractive method is to carry out a substitution reaction on a readily available diazo compound. The most straightforward synthesis of versatile α-diazo carbonyl compounds involves the condensation of aldehydes and acyldiazomethanes. This is usually carried out by reaction with a strong base, such as butyllithium, [27] lithium diisopropylamide (LDA), [28, 29] sodium hydride or potassium hydroxide, [30-33] 1,8-diazabicyclo- [5.4.0]undec-7-ene (DBU), [34] potassium tert-butoxide (KOtBu), [35] Pyrrolidine, [36] quaternary ammonium hydroxide [37] and Piperidine [38] under controlled conditions in organic solvents to promote this addition. However, some of the methods require low temperatures, absolute anhydrous conditions or expensive reagents. Moreover, the use of strong bases may not be compatible with certain functional groups in the substrates and make these reactions less attractive for synthetic organic chemists.

Therefore, developing of milder base conditions for the synthesis of α-diazo carbonyl compounds is highly desirable. For this purpose, heterogeneous catalysts have been playing an increasingly important role in a variety of organic transformations. Likhar and co- workers have reported efficient synthesis of α-diazocarbonyl catalyzed by supported ionic liquid, [39] heterogeneous nanocrystalline magnesium oxide (nano-MgO) [40] and magnesium/lanthanum mixed oxide (Mg/LnO) [41]. In brief, the above reactions afforded α- diazo compounds through a heterogeneous-catalyzed c-c bond forming process. The separation of the desired product and the catalyst from the reaction mixture can be challenging in heterogeneous catalytic reaction. Filtration and centrifugation are available routes to recover heterogeneous catalysts but these methods can result in catalyst lose. Also typical separations are difficult to apply for nanoparticles with less than 100 nm diameter [42]. Therefore expensive ultra-centrifugation is often the only way to separate product and catalyst.

These problems encourage researchers to design new green and catalyst- free strategies, such as solvent-free methods or the use of media with dual solvent/catalyst roles, for example, trifluoroethanol (TFE) [43, 44] and deep eutectic solvents (DES) [16, 45] for chemical synthesis.

As part of our ongoing studies to search for new carbon-carbon bond formation processes using diazo compounds, [46] we decided to investigate the use of DES as dual solvent/catalyst in the reaction between ethyl diazoacetate (EDA) and carbonyl compounds (Scheme 1).



Scheme 1. The aldol-type coupling by the reaction of various aldehydes with ethyl diazoacetate (EDA)

Results and Discussion

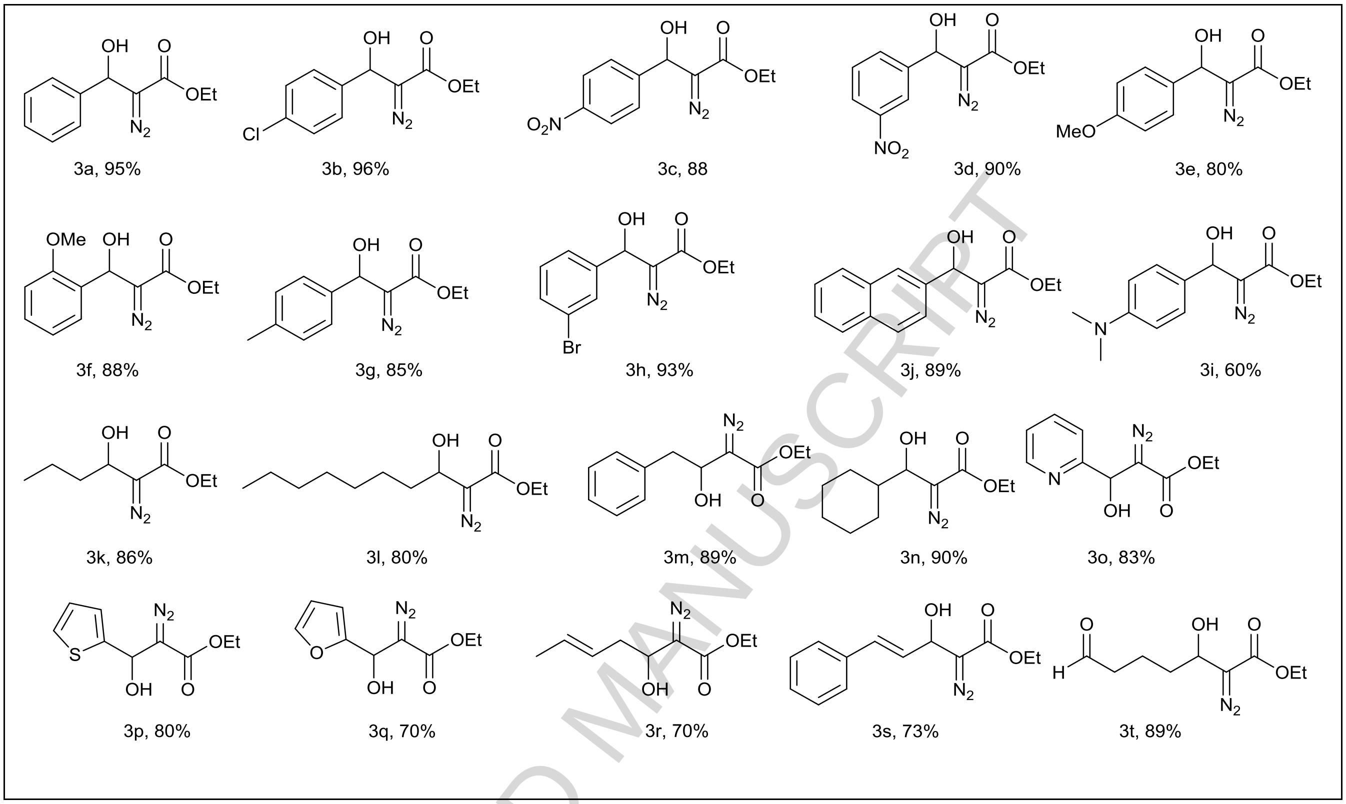
For the direct condensation of aldehydes with diazoacetate to occur, first we used ethyl diazoacetate (1.2 mmol) and benzaldehyde (1.0 mmol) as the substrates in DES as dual solvent/catalyst at room temperature (Scheme 2).

Scheme 2. The aldol-type coupling by the reaction of benzaldehyde with ethyl diazoacetate (EDA)

After the appropriate time, the desired product was prepared in excellent yields. Since the initial experiments suggested that DES could give favorable yields, this catalytic system was chosen, and we proceeded to optimize other conditions. The first experiment is to test the effect of the base in our reaction. We observed that in the absence of the base in glycerol, corresponding product was not obtained after long time. In the next step, using K_2CO_3 as base in the glycerol led to formation of the product in negligible yield after 24h. Subsequently, we considered effect of different molar ratios of potassium carbonate to glycerol (1:5, 1:7, 1:10,) in the reaction and tested the model reaction in the different DES ratios as shown in table 1.the best result was obtained in 1:5 molar raito. Hence we subsequently investigated its substrate scope. A variety of different aromatic aldehydes, containing electron-withdrawing or donating groups, heterocyclic aldehydes and aliphatic aldehydes react with EDA in DES to afford the corresponding products.

As expected, all aromatic and heterocyclic aldehydes were extremely reactive and the process was complete after 2 h. aliphatic aldehydes afforded high yields of the desired products albeit in longer reaction times (4h) and the results are summarized in Tables 1. Furthermore, Glutaraldehyde bearing two carbonyl groups could be successfully converted into the corresponding product after over longer reaction times (5 h) in DES led to the selective formation of the monocondensation derivative (89%). It was observed that on the other hand, α,β-Unsaturated aldehydes such as cinnamaldehyde, curton aldehyde gave moderate yields of the corresponding compounds in reasonable time.

Table 1: Aldol-type reactions of various aldehydes with ethyl diazoacetate



Experimental

All compounds have been prepared from Aldrich and Merck companies and used without further purifications. IR spectra (KBr) were recorded by Nicolet IR100 instrument. ^{1}H-NMR spectra were recorded by Brucker 250 and 500 MHz. NMR chemical shifts were expressed in ppm versus the chemical shift of tetramethylsilane (TMS) as an internal reference. Mass spectra were obtained on a 5975C VL MSD apparatus at ionization potential of 70 eV.

General Procedure:

Preparation of the DESs

DESs were prepared according to the procedure reported in the literature [17]. The preparation method involved mixing of different molar ratios potassium carbonate to glycerol at 80 °C for a period of 2 hours until a clear solution was obtained. The mixture (prepared DES) was used without any purification.

General Procedure for Aldol-Type Coupling of Aldehydes with EDA

A mixture of carbonyl compound (1.0 mmol) and EDA (1.2 mmol) was stirred in DES at room temperature for the appropriate time. Completion of the reaction was confirmed by TLC. After the completion of reaction, water (50 mL) was added to the reaction mixture and extracted with EtOAc (3 × 20 mL) and dried over Na_2SO_4. The solvent was removed under reduced pressure to give the crude product and was purified using column chromatography (ethyl acetate/hexane).

Conclusion

In conclusion, the developments of general methods for the C-C bond formation with dual solvent/catalysts are highly desired from synthetic, industrial, and environmental viewpoints. Thus, DES affords a readily accessible, inexpensive, and efficient dual solvent/catalyst for the C-C bond formation. Moreover, the method is environmentally friendly because of avoiding the use of toxic solvents or hazardous catalysts.

Acknowledgments

We acknowledge Tarbiat Modares University for partial support of this work.

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Supporting information

Deep eutectic solvent (DES) as dual solvent/catalyst for synthesis of α-diazocarbonyl compounds using aldol-type coupling

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Table of Contents

Experimental Procedures

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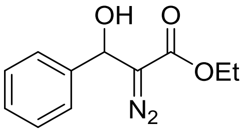
General Procedure for Aldol-Type Coupling of Aldehydes with EDA

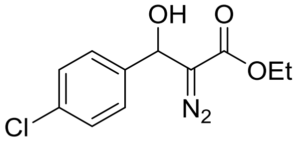
A mixture of carbonyl compound (1.0 mmol) and EDA (1.2 mmol) was stirred in DES at room temperature for the appropriate time. Completion of the reaction was confirmed by TLC. After the completion of reaction, water (50 mL) was added to the reaction mixture and extracted with EtOAc (3 × 20 mL) and dried over Na_2SO_4. The solvent was removed under reduced pressure to give the crude product and was purified using column chromatography (ethyl acetate/hexane).

Ethyl 2-diazo-3-hydroxy-3-phenylpropanoate



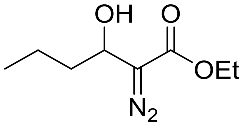
IR (KBr): ν =3430, 2983, 2101, 1680, 1531, 1350, 1293, 1113, 1036, 730 cm^{-1}.
^{1}H NMR (500 MHz, $CDCl_3$): 1.23 (t, J = 7.1 Hz, 3H), 3.64 (br s, 1H), 4.23(q, J = 7.1 Hz, 2H), 5.89 (s, 1H), 7.26–7.42 (m, 5H).

Ethyl 3-(4-chlorophenyl)-2-diazo-3-hydroxypropanoate



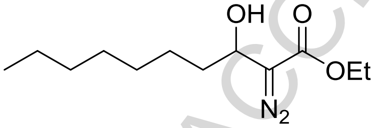
IR (KBr): ν = 3386, 2988, 2844, 2099, 1699, 1590, 1487, 1358, 1290, 1095, 829 cm^{1}.
^{1}H NMR (500 MHz, DMSO):1.19 (t, J = 7.1 Hz, 3H), 4.16 (q, J = 6.05 Hz, 2H), 5.62 (s, 1H), 6.47 (br s, 1H), 7.39 (d, J = 8.60 Hz, 2H), 7.42 (d, J = 8.55 Hz, 2H).

Ethyl 2-diazo-3-hydroxyhexanoate



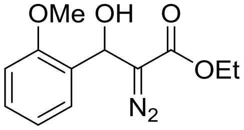
IR (KBr): ν = 3438, 2961, 2875, 2095, 1658, 1460, 1378, 1293, 1101, 1020, 752 cm^{-1}.
^{1}H NMR (500 MHz, $CDCl_3$): δ 4.68 (t, *J* = 7.7 Hz, 1H), 4.22 (q, *J* = 7.2 Hz, 2H), 2.80 (br s, 1H), 1.74-1.68 (m, 1H), 1.60-1.54 (m, 1H), 1.53-1.48 (m, 1H), 1.46-1.40 (m, 1H), 1.29 (t, *J* = 7.2 Hz, 3H), 0.95 (t, *J* = 6.8 Hz, 3H);

Ethyl 2-diazo-3-hydroxydecanoate



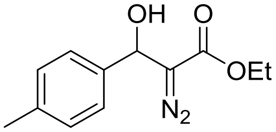
^{1}H NMR (500 MHz, $CDCl_3$): 1.11 (t, J = 7.2 Hz, 3H), 1.13-1.78 (m, 15H), 2.89 (d, J = 8.7 Hz, 1H), 4.24 (q, J = 7.1 Hz, 2H), 4.67 (t, J = 6.9 Hz, 1H). EI – MS: *m/z* (%) = 41 (100), 56 (69),69 (60), 87 (30), 115 (25), 143 (28), 241 (M^{+}, 3).

Ethyl 2-diazo-3-hydroxy-3-(2-methoxyphenyl)propanoate



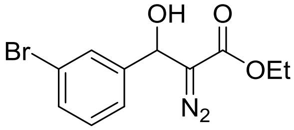
IR (KBr): ν = 3433, 2122, 1659, 1252, 1026, 823, 762, 619 cm^{-1}.
^{1}H NMR (250 MHz, DMSO): 1.30 (t, J = 7.1 Hz, 3H), 3.38 (s, 3H), 3.92 (s, 1H), 4.33 (q, J = 7.1, 2H), 5.76 (s, 1H), 6-96-7.79 (m, 4H).

Ethyl 2-diazo-3-hydroxy-3-(p-tolyl)propanoate



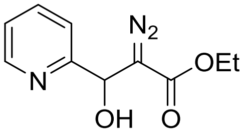
IR (KBr): ν = 3444, 3270, 2111, 1684, 1045, 822, 761, 619 cm^{-1}.
^{1}H NMR (250 MHz, DMSO):1.24 (t, J = 7.25 Hz, 3H), 2.56 (s, 3H), 4.24 (q, J = 6.50 Hz, 2H), 5.66 (d, J = 3.25 Hz, 1H), 6.30 (d, J = 3.75 Hz, 1H), 7.23 (d, J = 7.75, 2H), 7.32 (d, J = 7 Hz, 2H). EI – MS: *m/z* (%) = 43 (14), 77 (60), 91 (80), 104 (90), 119 (100), 160 (95), 234 (M$^+$, 14).

Ethyl 3-(3-bromophenyl)-2-diazo-3-hydroxypropanoate



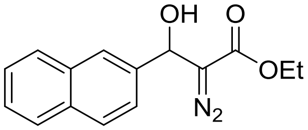
IR (KBr): ν = 3422, 3255, 2983, 2096, 1689, 1343, 1285, 1036, 760 cm^{-1}.
^{1}H NMR (250 MHz, DMSO):1.20 (t, J = 7 Hz, 3H), 4.18 (q, J = 7.83 Hz, 2H), 5.65 (d, J = 4 Hz, 1H), 6.47 (d, J = 4.75 Hz, 1H), 7.34 – 7.57 (m, 4H). EI – MS: *m/z* (%) = 51 (25), 69 (50), 77 (72), 89 (100), 117 (61), 158 (48), 185 (91), 198 (60), 224 (58), 298 (M$^+$, 15).

Ethyl 2-diazo-3-hydroxy-3-(pyridin-2-yl)propanoate



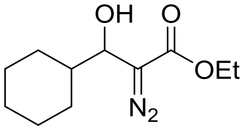
IR (KBr): ν = 3377, 2982, 2927, 2097, 1687, 1375, 1339, 1287, 1111, 1038, 752 cm^{-1}. ^{1}H NMR (250 MHz, DMSO):1.21 (t, J = 6.5 Hz, 3H), 4.18 (q, J = 7 Hz, 2H), 5.71 (s, 1H), 5.77 (s, 1H), 7.39- 8.53 (m, 4H).

Ethyl 2-diazo-3-hydroxy-3-(naphthalen-2-yl)propanoate



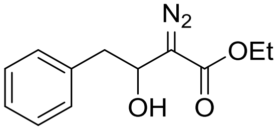
IR (KBr): ν = 3257, 2983, 2095, 1686, 1374, 1282, 1046, 794 cm^{-1}.
^{1}H NMR (250 MHz, DMSO):1.23 (t, J = 7Hz, 3H), 4.26 (q, J = 7.9 Hz, 2H), 6.32 (d, J = 4 Hz, 1H), 6.48 (d, J = 4.25 Hz, 1H), 7.52 – 7.97 (m, 7H).

Ethyl 3-cyclohexyl-2-diazo-3-hydroxypropanoate



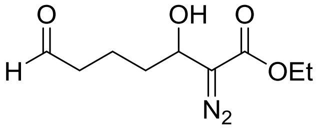
IR (KBr): ν = 3350, 2930, 2093, 1677, 1449, 1381, 1287, 1102, 740 cm^{-1}.
^{1}H NMR (500 MHz, CDCl$_3$): d 0.92–1.31 (m, 8H), 1.45–1.80 (m, 5H), 2.00 (d, J = 12.35 Hz, 1H), 2.90 (br s, 1H), 4.20 (q, J = 7.25 Hz, 2H), 4.27 (d, J = 8.25 Hz, 1H);

Ethyl 2-diazo-3-hydroxy-4-phenylbutanoate

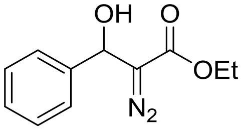


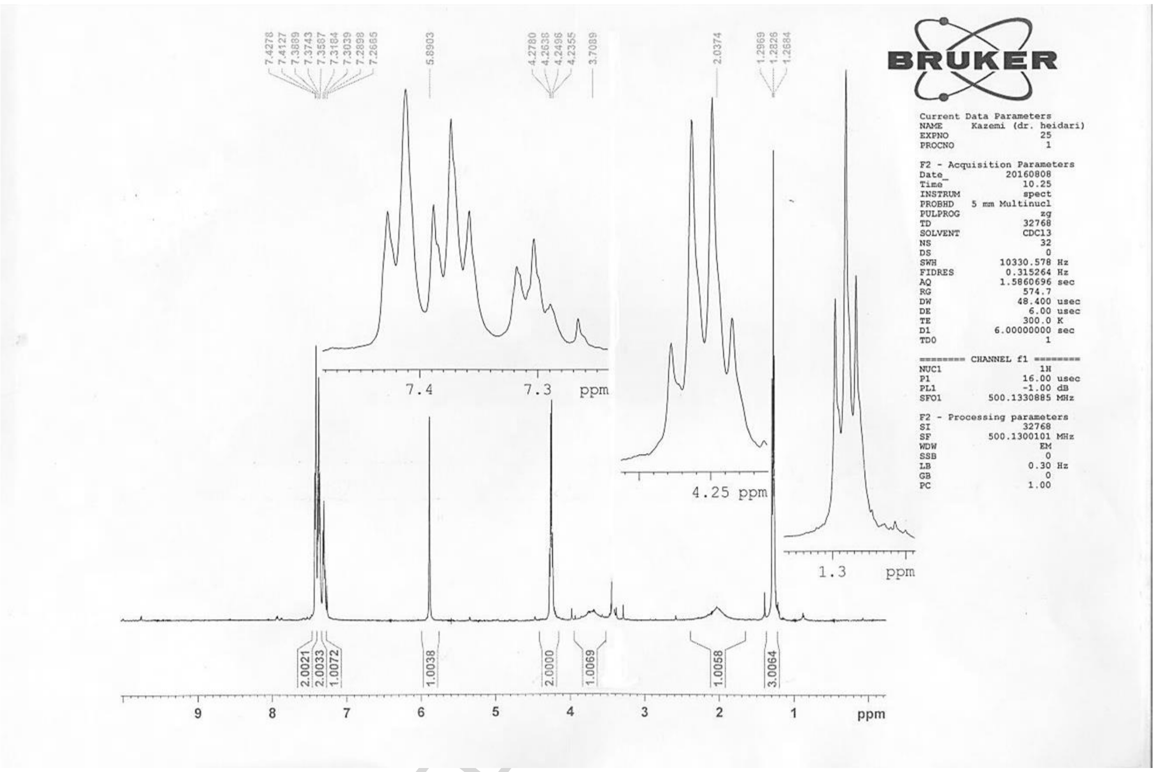
IR (KBr): ν = 3350, 2930, 2093, 1677, 1493, 1449, 1381, 1287, 1102, 740 cm^{-1}.
^{1}H NMR (500 MHz, CDCl$_3$):1.23 (t, J = 7.9 Hz, 3H), 4.20 (q, J = 7.1 Hz, 2H), 4.87 (t, J = 6.9 Hz, 1H), 6.66 (s, 1H), 7.17-7.31 (m, 5H).

Ethyl 2-diazo-3-hydroxy-7-oxoheptanoate



IR (KBr): ν = 3444, 2922, 2855, 2093, 1734, 1536, 1450, 1246, 1016, 750 cm^{-1}.
^{1}H NMR (500 MHz, CDCl$_3$): 1.55 (br,3H), 1.95 (dm, 2H), 3.61 (AB-q, ^{3}J = 5.3, ^{2}J = 11.1 Hz, 2H), 3.61(AB-q, ^{3}J = 3.8, ^{2}J = 23.0, 2H), 3.93 (t, J = 5.3 Hz, 1H),4.27 (q, J = 5.2 Hz, 2H), 4.83 (br s, 1H), 8.01 (s, 1H).





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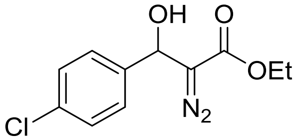
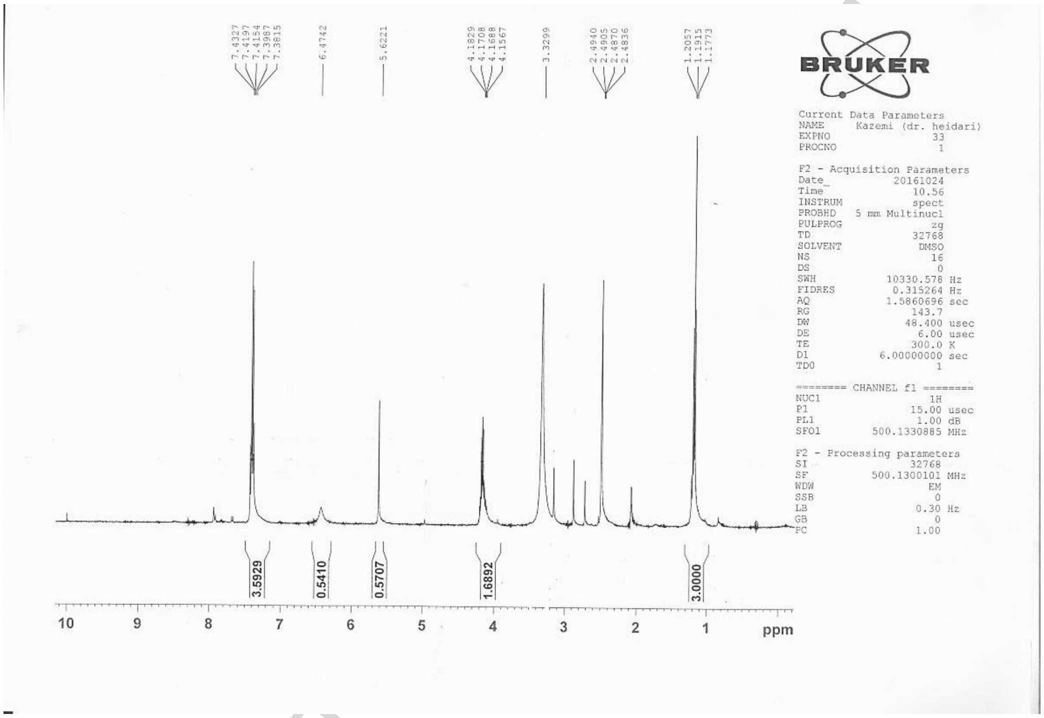
Current Data Parameters
NAME     Kazemi (dr. heidari)
EXPNO                    25
PROCNO                    1

F2 - Acquisition Parameters
Date_              20160808
Time                  10.25
INSTRUM               spect
PROBHD   5 mm Multinucl
PULPROG                  zg
TD                    32768
SOLVENT               CDC13
NS                       32
DS                        0
SWH              10330.578 Hz
FIDRES            0.315264 Hz
AQ               1.5860696 sec
RG                    574.7
DW                   48.400 usec
DE                     6.00 usec
TE                    300.0 K
D1               6.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                     1H
P1                    16.00 usec
PL1                   -1.00 dB
SFO1           500.1330885 MHz

F2 - Processing parameters
SI                    32768
SF             500.1300101 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```



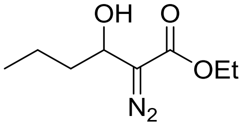


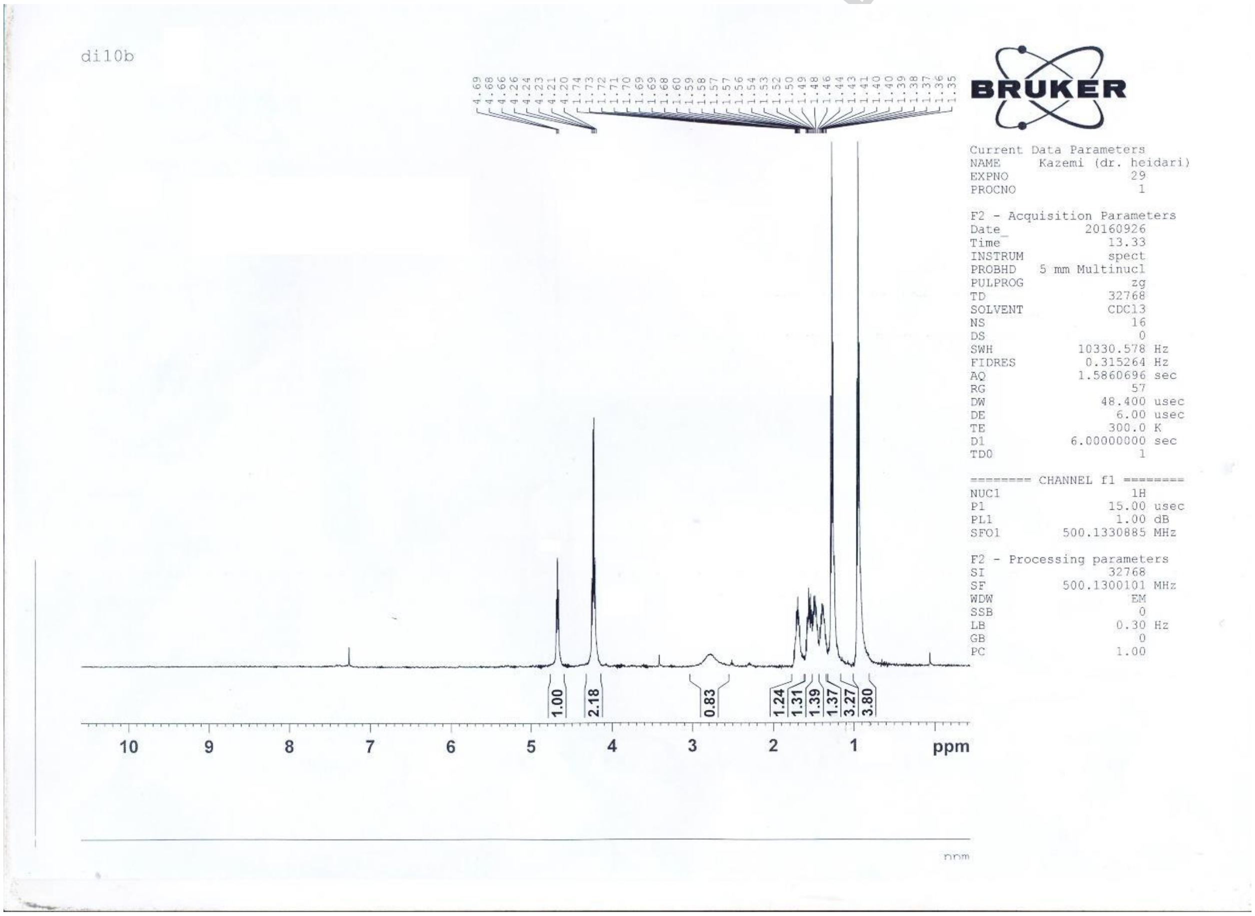
```
Current Data Parameters
NAME      Kazemi (dr. heidari)
EXPNO                     33
PROCNO                     1

F2 - Acquisition Parameters
Date_               20161024
Time                   10.56
INSTRUM                spect
PROBHD   5 mm Multinucl
PULPROG                   zg
TD                     32768
SOLVENT                 DMSO
NS                        16
DS                         0
SWH             10330.578 Hz
FIDRES           0.315264 Hz
AQ              1.5860696 sec
RG                     143.7
DW                 48.400 usec
DE                   6.00 usec
TE                  300.0 K
D1             6.00000000 sec
TD0                        1

======== CHANNEL f1 ========
NUC1                      1H
P1                  15.00 usec
PL1                  1.00 dB
SFO1         500.1330885 MHz

F2 - Processing parameters
SI                     32768
SF           500.1300101 MHz
WDW                       EM
SSB                        0
LB                   0.30 Hz
GB                         0
PC                      1.00
```





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Current Data Parameters
NAME     Kazemi (dr. heidari)
EXPNO                     29
PROCNO                     1

F2 - Acquisition Parameters
Date_               20160926
Time                   13.33
INSTRUM                spect
PROBHD   5 mm Multinucl
PULPROG                   zg
TD                     32768
SOLVENT                CDCl3
NS                        16
DS                         0
SWH               10330.578 Hz
FIDRES             0.315264 Hz
AQ                1.5860696 sec
RG                        57
DW                    48.400 usec
DE                      6.00 usec
TE                     300.0 K
D1                6.00000000 sec
TD0                        1

======== CHANNEL f1 ========
NUC1                      1H
P1                     15.00 usec
PL1                     1.00 dB
SFO1          500.1330885 MHz

F2 - Processing parameters
SI                     32768
SF            500.1300101 MHz
WDW                       EM
SSB                        0
LB                      0.30 Hz
GB                         0
PC                      1.00
```

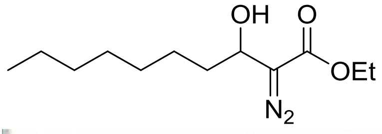

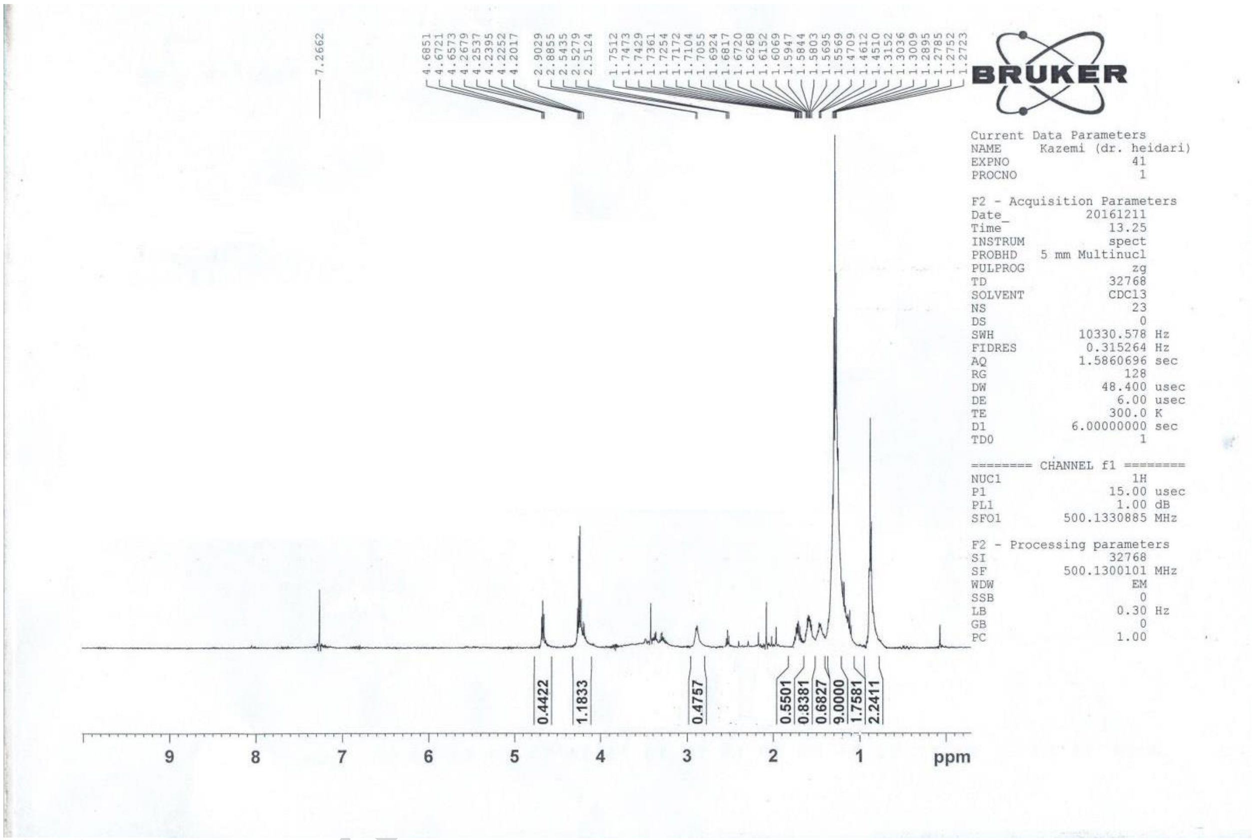

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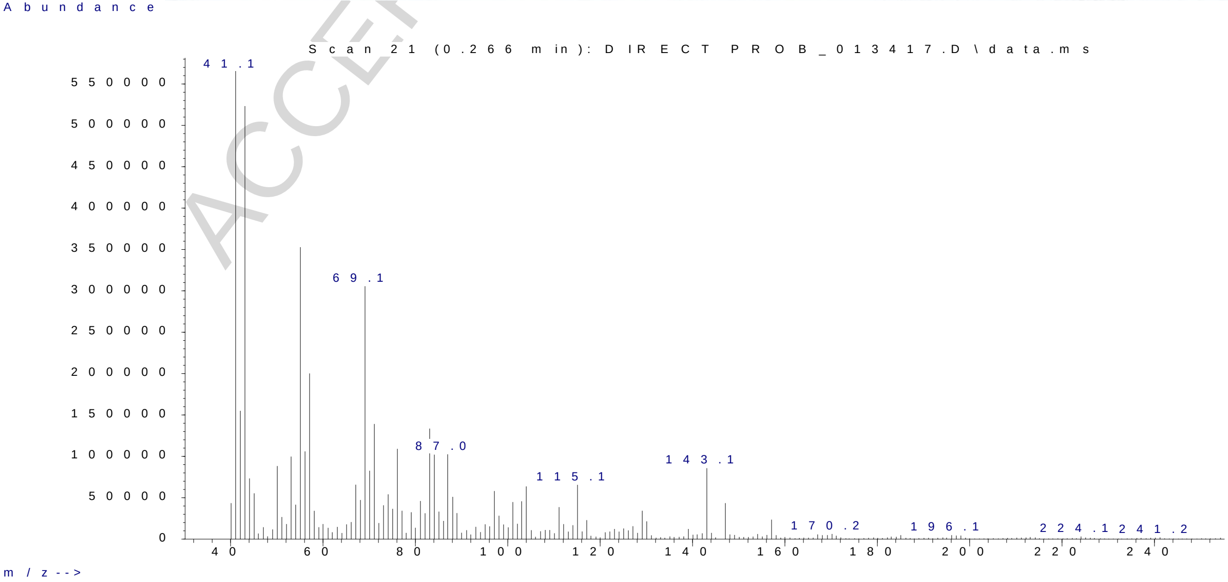
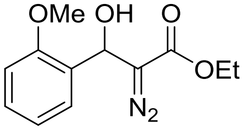
Current Data Parameters
NAME     Kazemi (dr. heidari)
EXPNO                   41
PROCNO                   1

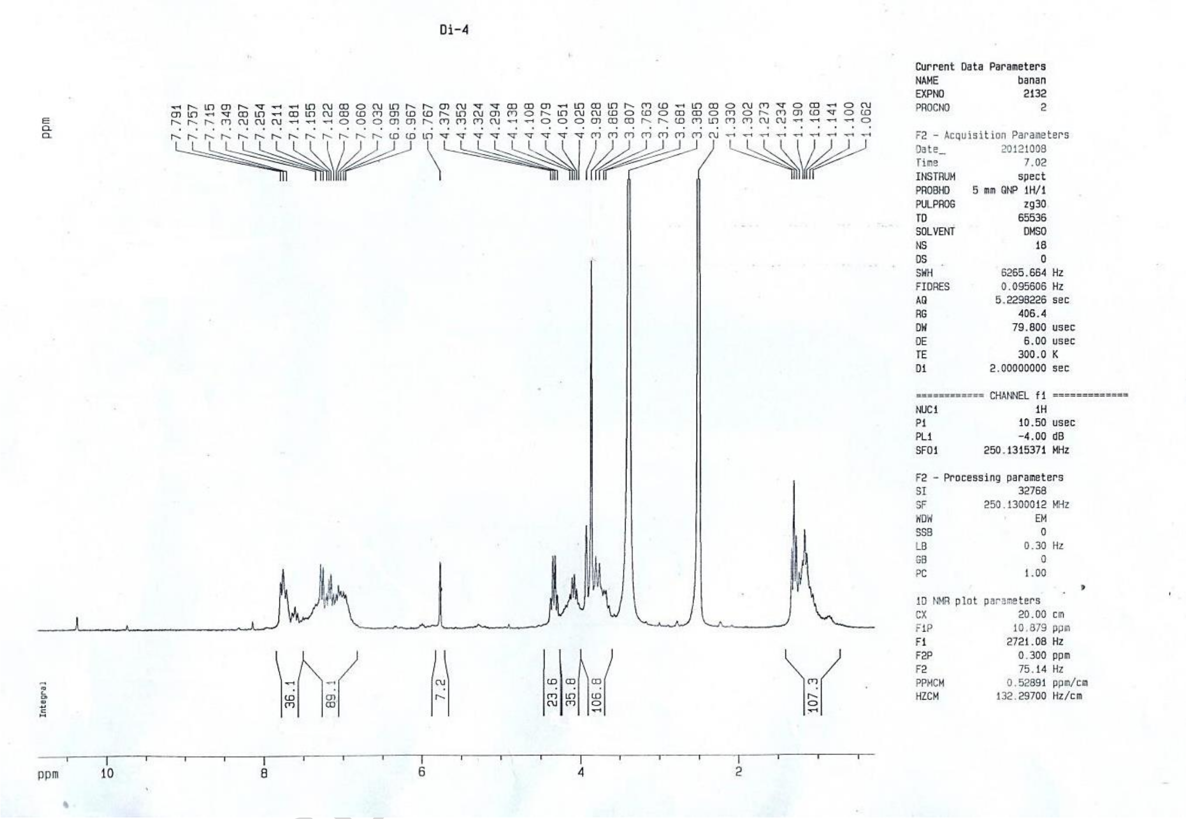
F2 - Acquisition Parameters
Date_             20161211
Time                 13.25
INSTRUM              spect
PROBHD   5 mm Multinucl
PULPROG                 zg
TD                   32768
SOLVENT              CDCl3
NS                      23
DS                       0
SWH             10330.578 Hz
FIDRES           0.315264 Hz
AQ              1.5860696 sec
RG                     128
DW                  48.400 usec
DE                    6.00 usec
TE                   300.0 K
D1              6.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                   15.00 usec
PL1                   1.00 dB
SFO1          500.1330885 MHz

F2 - Processing parameters
SI                   32768
SF            500.1300101 MHz
WDW                     EM
SSB                      0
LB                    0.30 Hz
GB                       0
PC                    1.00
```







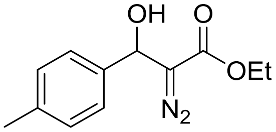
```
Current Data Parameters
NAME                 banan
EXPNO                 2132
PROCNO                   2

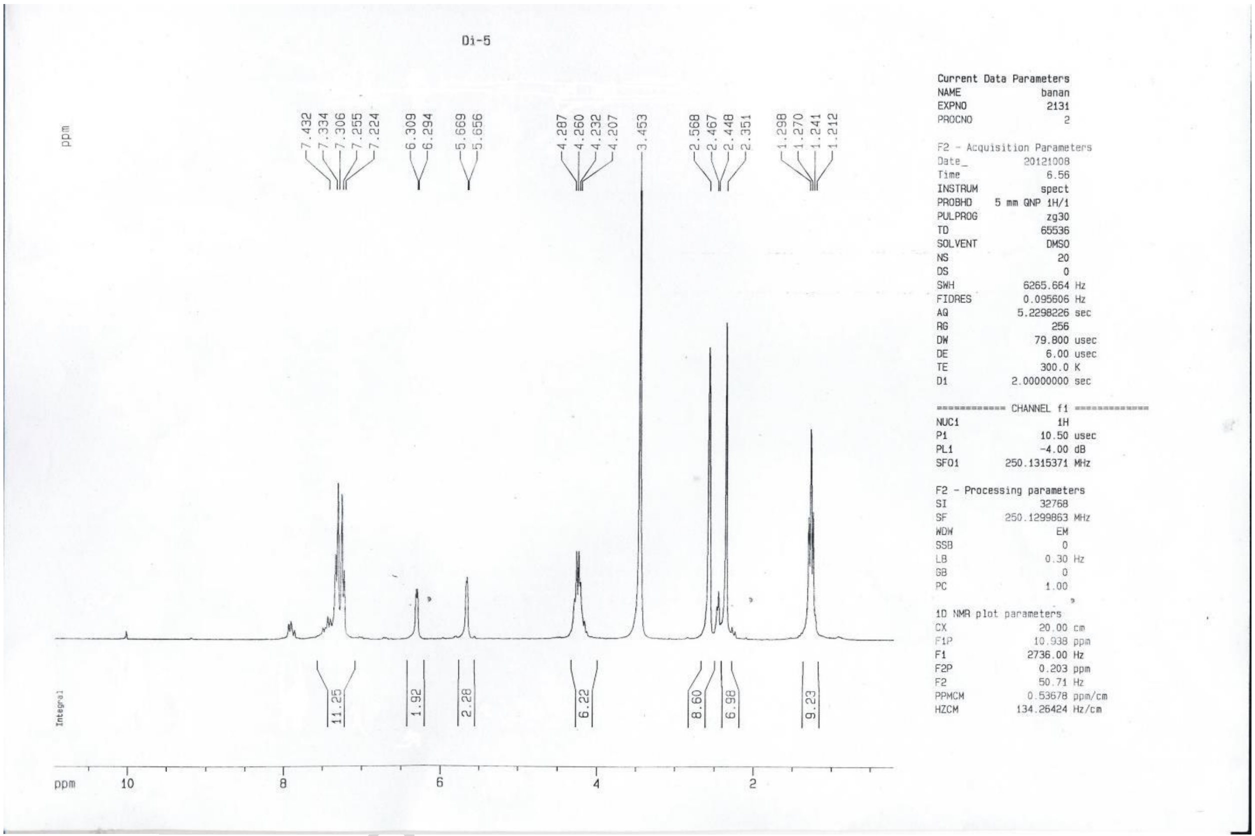
F2 - Acquisition Parameters
Date_             20121008
Time                  7.02
INSTRUM              spect
PROBHD     5 mm QNP 1H/1
PULPROG               zg30
TD                   65536
SOLVENT               DMSO
NS                      18
DS                       0
SWH            6265.664 Hz
FIDRES         0.095606 Hz
AQ           5.2298226 sec
RG                   406.4
DW             79.800 usec
DE               6.00 usec
TE                 300.0 K
D1          2.00000000 sec

============ CHANNEL f1 =============
NUC1                    1H
P1              10.50 usec
PL1               -4.00 dB
SF01       250.1315371 MHz

F2 - Processing parameters
SI                   32768
SF         250.1300012 MHz
WDW                     EM
SSB                      0
LB                 0.30 Hz
GB                       0
PC                    1.00

1D NMR plot parameters
CX                20.00 cm
F1P             10.879 ppm
F1              2721.08 Hz
F2P              0.300 ppm
F2                75.14 Hz
PPMCM       0.52891 ppm/cm
HZCM       132.29700 Hz/cm
```





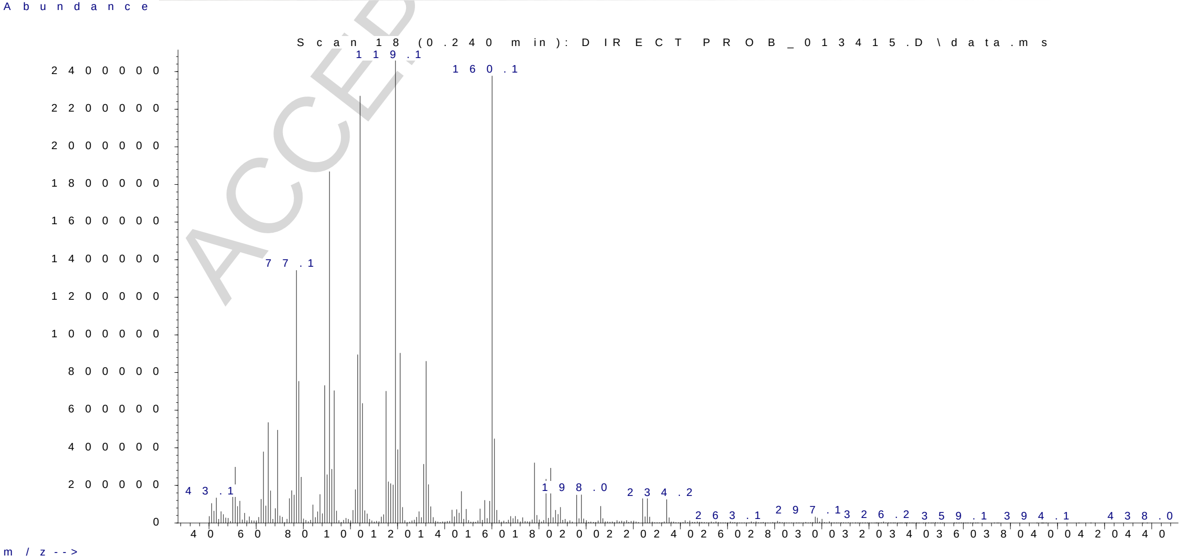
```
Current Data Parameters
NAME                banan
EXPNO                2131
PROCNO                  2

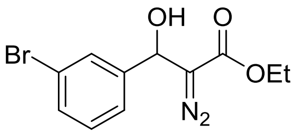
F2 - Acquisition Parameters
Date_            20121008
Time                 6.56
INSTRUM             spect
PROBHD     5 mm QNP 1H/1
PULPROG              zg30
TD                  65536
SOLVENT              DMSO
NS                     20
DS                      0
SWH              6265.664 Hz
FIDRES           0.095606 Hz
AQ              5.2298226 sec
RG                    256
DW                 79.800 usec
DE                   6.00 usec
TE                  300.0 K
D1             2.00000000 sec

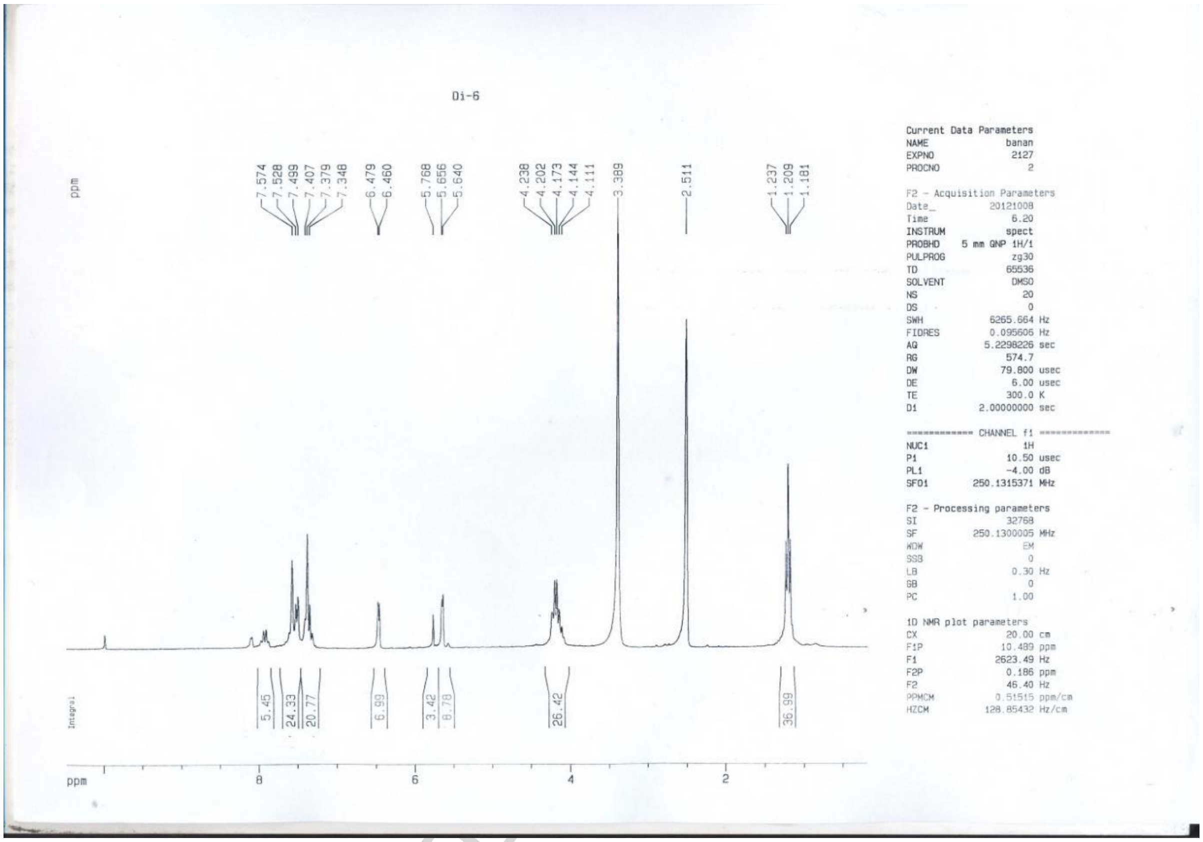
============ CHANNEL f1 ============
NUC1                   1H
P1                  10.50 usec
PL1                 -4.00 dB
SFO1          250.1315371 MHz

F2 - Processing parameters
SI                  32768
SF            250.1299863 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  20.00 cm
F1P                10.938 ppm
F1                2736.00 Hz
F2P                 0.203 ppm
F2                  50.71 Hz
PPMCM             0.53678 ppm/cm
HZCM            134.26424 Hz/cm
```







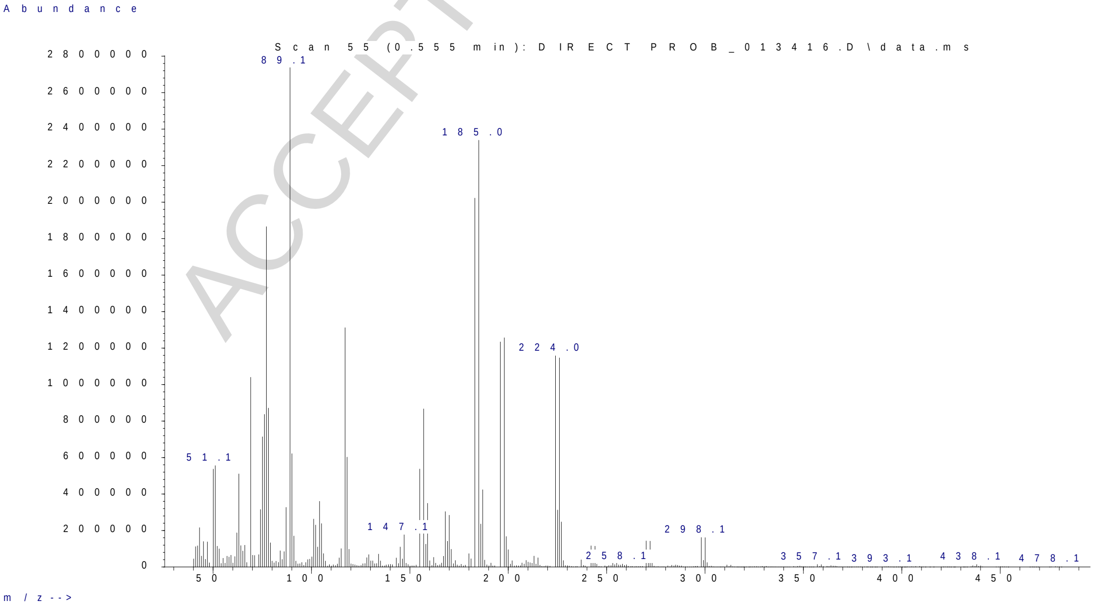
```
Current Data Parameters
NAME                banan
EXPNO                2127
PROCNO                  2

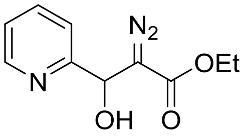
F2 - Acquisition Parameters
Date_            20121008
Time                 6.20
INSTRUM             spect
PROBHD     5 mm QNP 1H/1
PULPROG              zg30
TD                  65536
SOLVENT              DMSO
NS                     20
DS                      0
SWH              6265.664 Hz
FIDRES           0.095606 Hz
AQ              5.2298226 sec
RG                  574.7
DW                 79.800 usec
DE                   6.00 usec
TE                  300.0 K
D1             2.00000000 sec

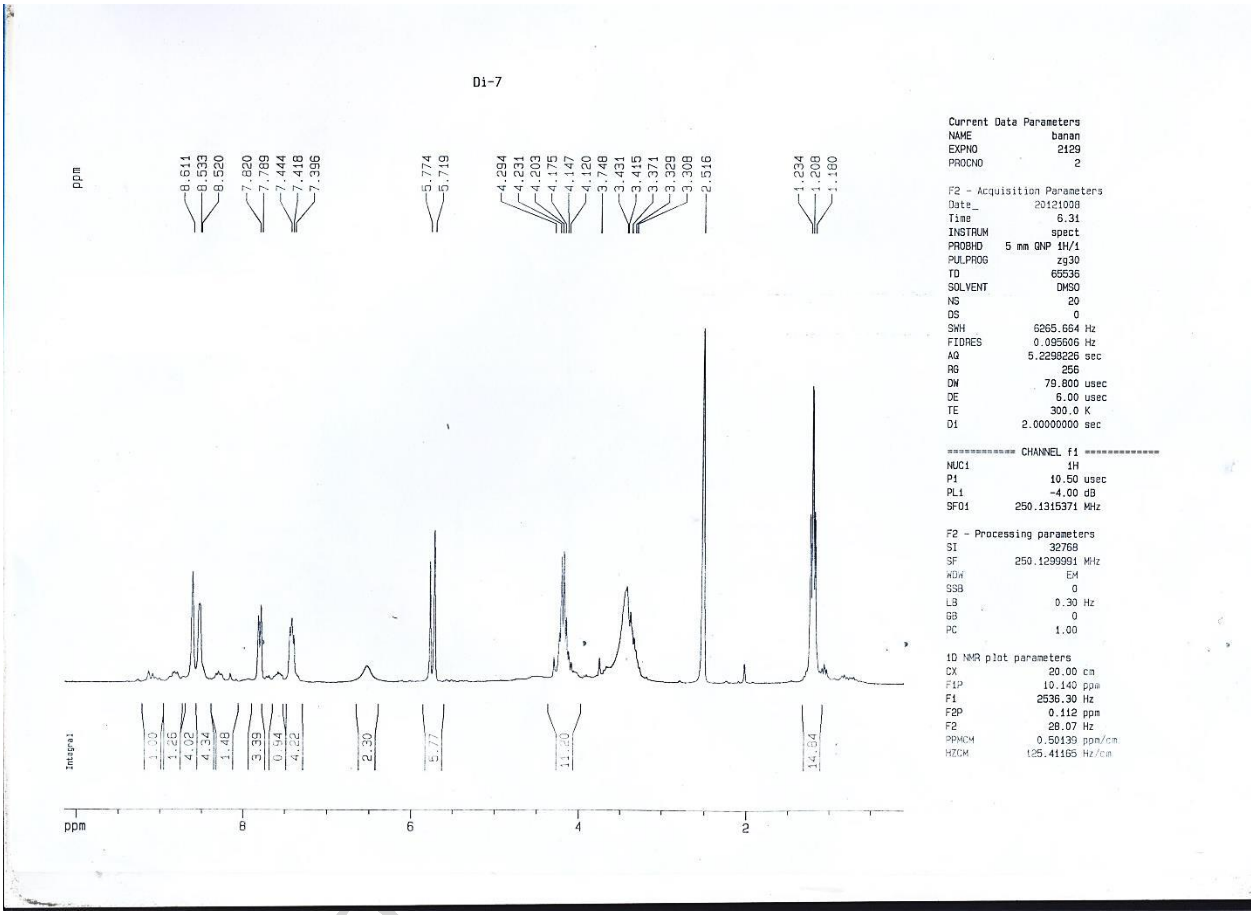
============ CHANNEL f1 ============
NUC1                   1H
P1                  10.50 usec
PL1                 -4.00 dB
SFO1          250.1315371 MHz

F2 - Processing parameters
SI                  32768
SF            250.1300005 MHz
WDW                    EM
SSB                     0
LB                   0.30 Hz
GB                      0
PC                   1.00

1D NMR plot parameters
CX                  20.00 cm
F1P                10.489 ppm
F1                2623.49 Hz
F2P                 0.186 ppm
F2                  46.40 Hz
PPMCM             0.51515 ppm/cm
HZCM            128.85432 Hz/cm
```







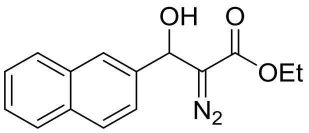
```
Current Data Parameters
NAME              banan
EXPNO              2129
PROCNO                2

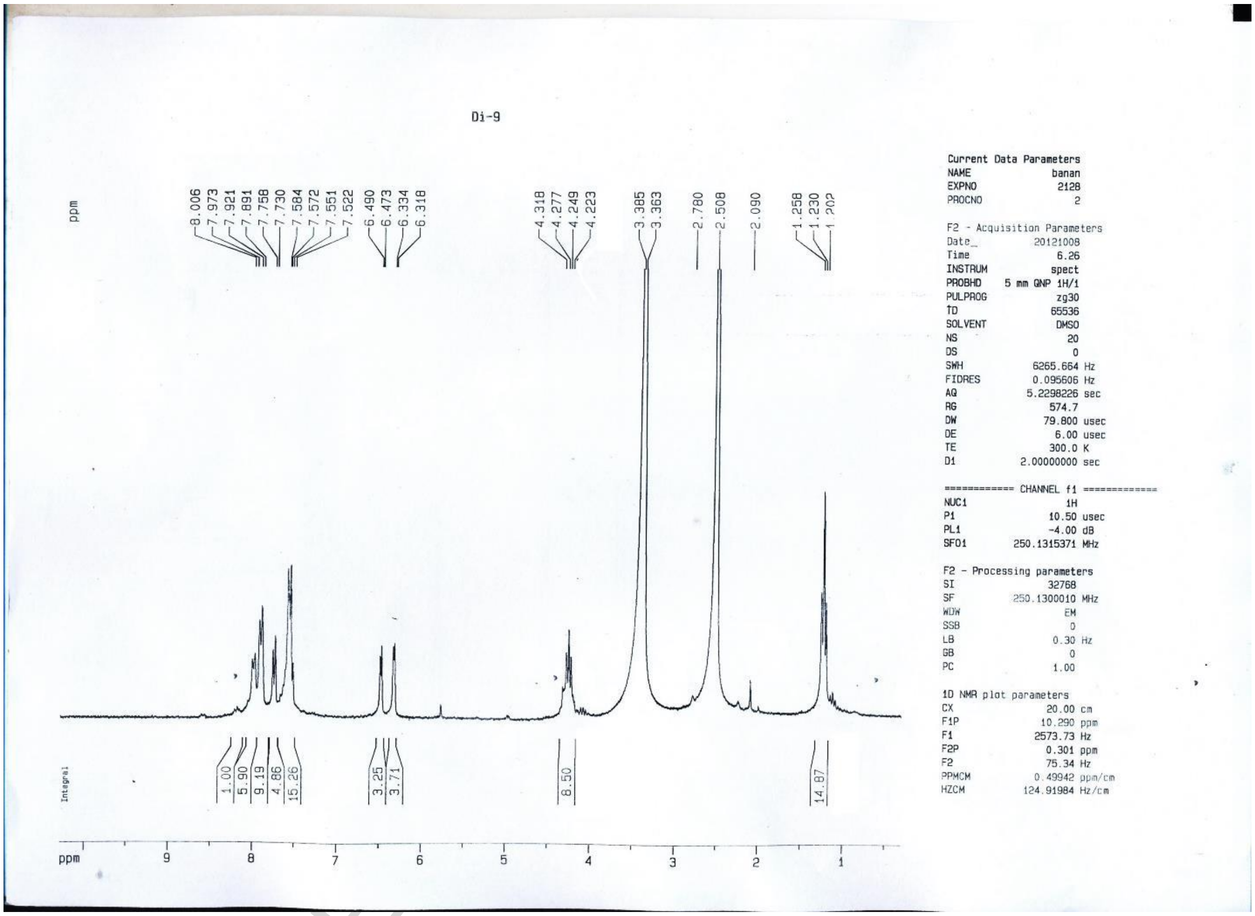
F2 - Acquisition Parameters
Date_          20121008
Time               6.31
INSTRUM           spect
PROBHD   5 mm QNP 1H/1
PULPROG            zg30
TD                65536
SOLVENT            DMSO
NS                   20
DS                    0
SWH            6265.664 Hz
FIDRES         0.095606 Hz
AQ            5.2298226 sec
RG                  256
DW               79.800 usec
DE                 6.00 usec
TE                300.0 K
D1           2.00000000 sec

============ CHANNEL f1 ============
NUC1                 1H
P1                10.50 usec
PL1               -4.00 dB
SFO1        250.1315371 MHz

F2 - Processing parameters
SI                32768
SF          250.1299991 MHz
WDW                  EM
SSB                   0
LB                 0.30 Hz
GB                    0
PC                 1.00

1D NMR plot parameters
CX                20.00 cm
F1P              10.140 ppm
F1              2536.30 Hz
F2P               0.112 ppm
F2                28.07 Hz
PPMCM           0.50139 ppm/cm
HZCM          125.41165 Hz/cm
```





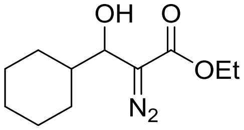
```
Current Data Parameters
NAME                banan
EXPNO                2128
PROCNO                  2

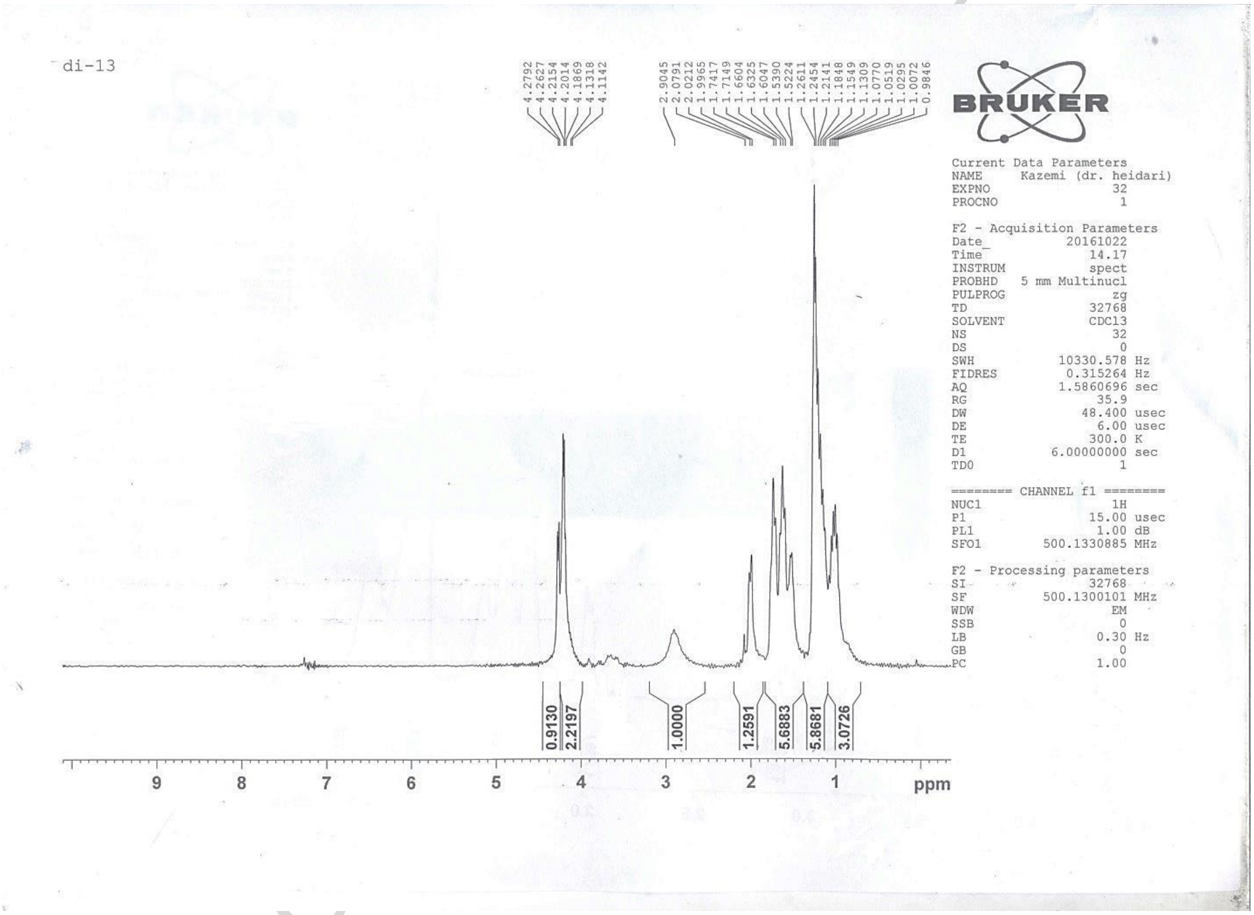
F2 - Acquisition Parameters
Date_           20121008
Time                6.26
INSTRUM            spect
PROBHD    5 mm QNP 1H/1
PULPROG             zg30
TD                 65536
SOLVENT             DMSO
NS                    20
DS                     0
SWH             6265.664 Hz
FIDRES          0.095606 Hz
AQ             5.2298226 sec
RG                 574.7
DW                79.800 usec
DE                  6.00 usec
TE                 300.0 K
D1            2.00000000 sec

============ CHANNEL f1 ============
NUC1                  1H
P1                 10.50 usec
PL1                -4.00 dB
SFO1      250.1315371 MHz

F2 - Processing parameters
SI                 32768
SF        250.1300010 MHz
WDW                   EM
SSB                    0
LB                  0.30 Hz
GB                     0
PC                  1.00

1D NMR plot parameters
CX                 20.00 cm
F1P               10.290 ppm
F1               2573.73 Hz
F2P                0.301 ppm
F2                 75.34 Hz
PPMCM            0.49942 ppm/cm
HZCM           124.91984 Hz/cm
```



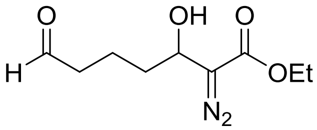


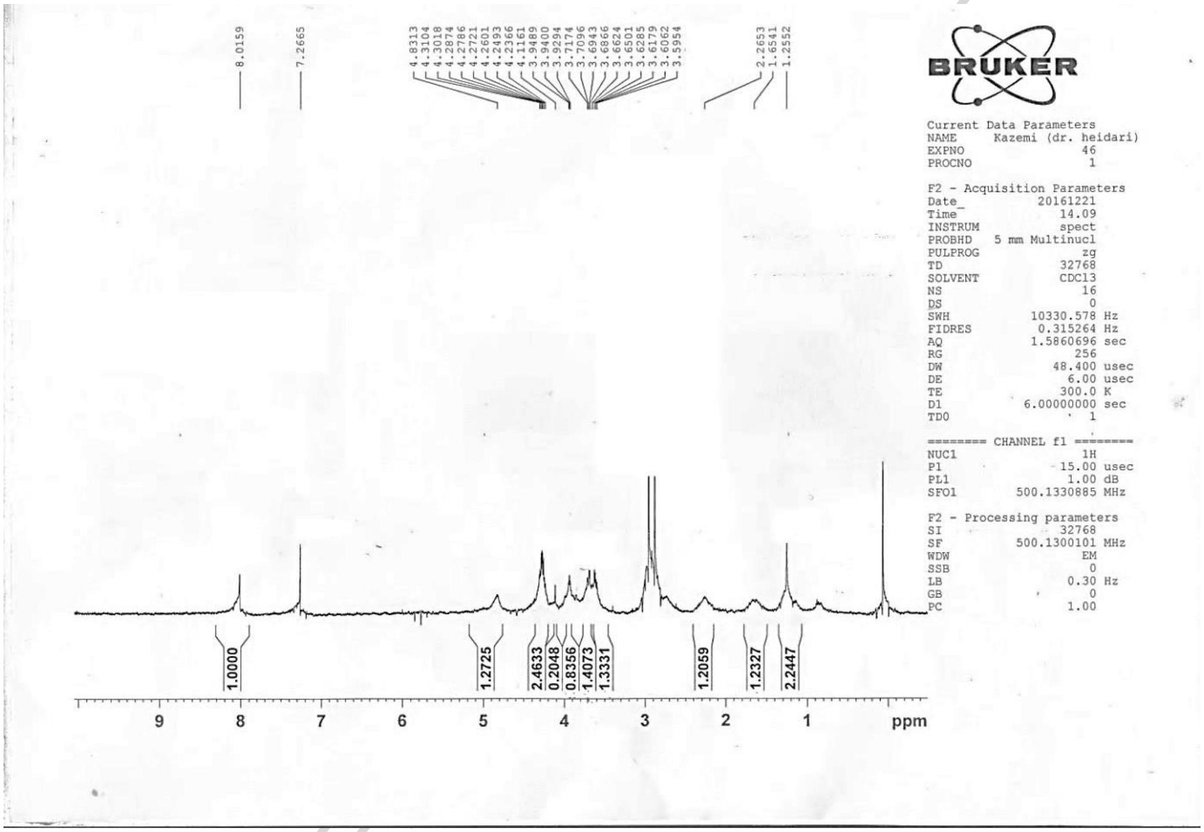
```
Current Data Parameters
NAME     Kazemi (dr. heidari)
EXPNO                     32
PROCNO                     1

F2 - Acquisition Parameters
Date_             20161022
Time                 14.17
INSTRUM              spect
PROBHD   5 mm Multinucl
PULPROG                 zg
TD                   32768
SOLVENT              CDCl3
NS                      32
DS                       0
SWH             10330.578 Hz
FIDRES           0.315264 Hz
AQ              1.5860696 sec
RG                    35.9
DW                  48.400 usec
DE                    6.00 usec
TE                   300.0 K
D1             6.00000000 sec
TD0                      1

======== CHANNEL f1 ========
NUC1                    1H
P1                   15.00 usec
PL1                   1.00 dB
SFO1         500.1330885 MHz

F2 - Processing parameters
SI                   32768
SF           500.1300101 MHz
WDW                     EM
SSB                      0
LB                    0.30 Hz
GB                       0
PC                    1.00
```





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Current Data Parameters
NAME     Kazemi (dr. heidari)
EXPNO                    46
PROCNO                    1

F2 - Acquisition Parameters
Date_              20161221
Time                  14.09
INSTRUM               spect
PROBHD   5 mm Multinucl
PULPROG                  zg
TD                    32768
SOLVENT               CDCl3
NS                       16
DS                        0
SWH             10330.578 Hz
FIDRES           0.315264 Hz
AQ              1.5860696 sec
RG                      256
DW                   48.400 usec
DE                     6.00 usec
TE                    300.0 K
D1               6.00000000 sec
TD0                       1

======== CHANNEL f1 ========
NUC1                     1H
P1                    15.00 usec
PL1                    1.00 dB
SFO1        500.1330885 MHz

F2 - Processing parameters
SI                    32768
SF          500.1300101 MHz
WDW                      EM
SSB                       0
LB                     0.30 Hz
GB                        0
PC                     1.00
```

Graphical Abstract

Graphical Abstract

Deep eutectic solvent (DES) as dual solvent/catalyst for synthesis of α-diazocarbonyl compounds using aldol-type coupling

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Highlight
Complication reaction is short time
Mild reaction condition, high selectivity, efficiency, simple workup
Excellent yields
Green solvent (DESs)