1st generation dendrimeric antioxidants containing Meldrum`s acid moieties as surface groups

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Supporting information

1. ^{1}H, ^{13}C NMR, IR, HRMS spectra of the synthesized compounds (new compounds)

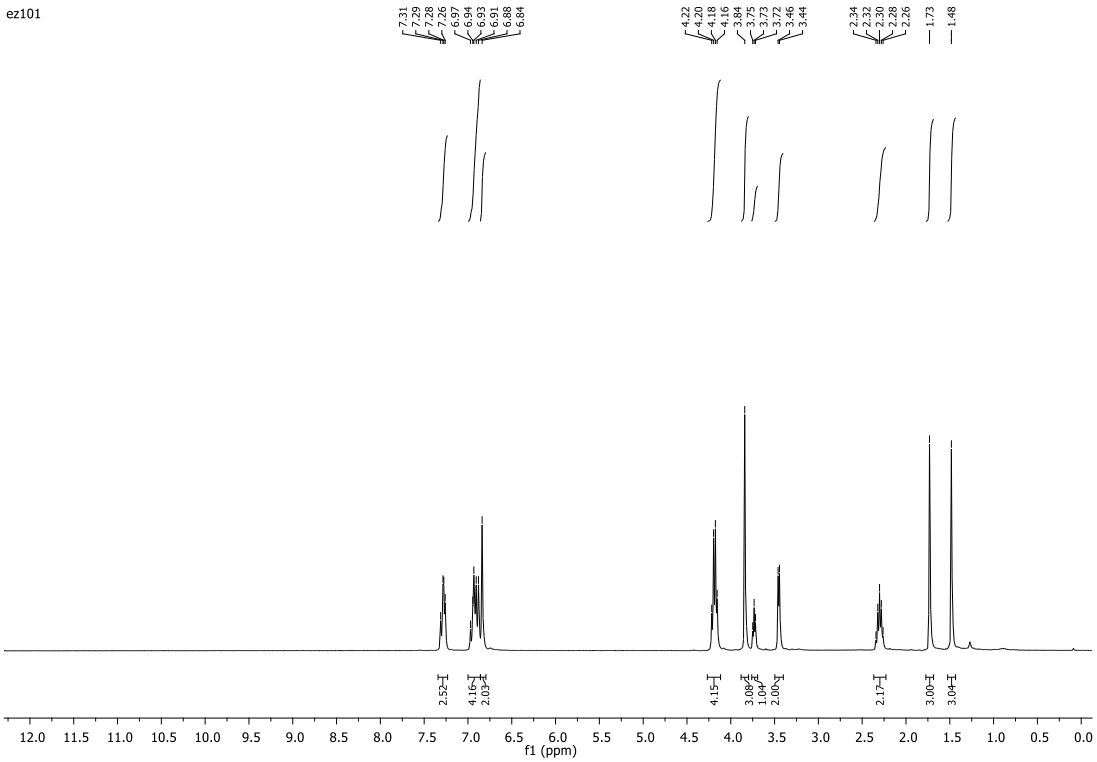
2. Inhibition curves of free radicals (for derivatives of arylmethyl Meldrum`s acids)

3. Kinetic curves in various solvents for compound 13a

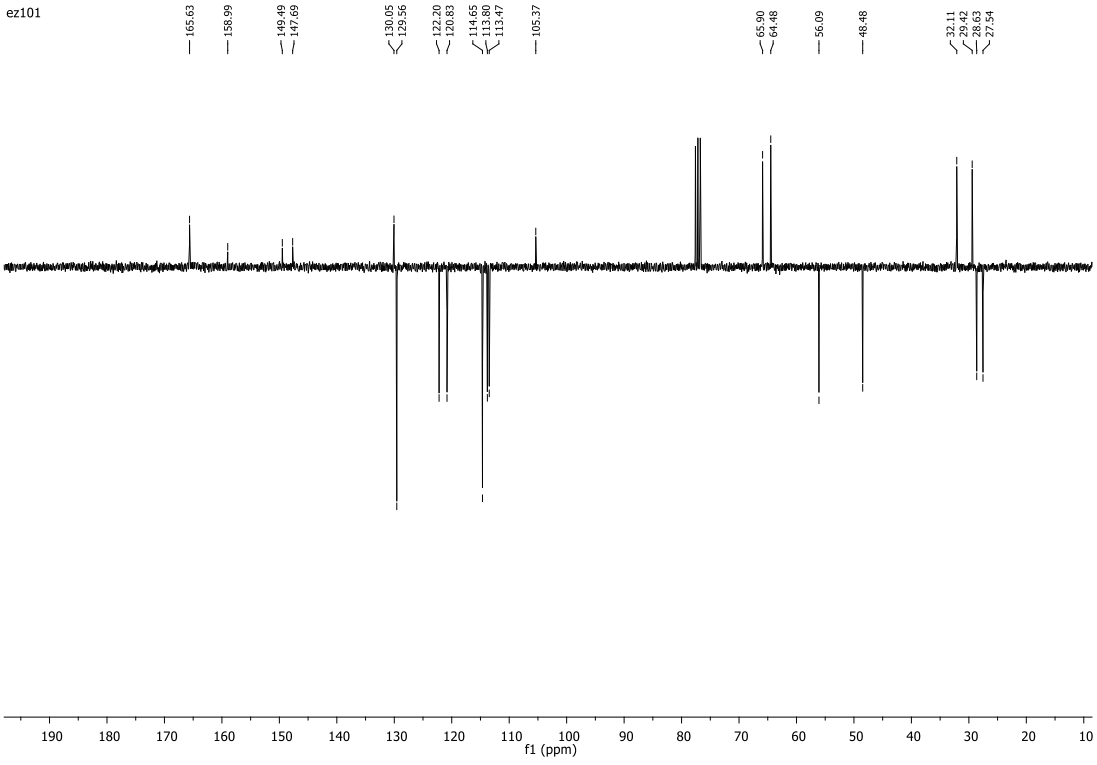
4. ^{1}H NMR spectra before and after autooxidation of representative 1st generation dendrimeric arylmethyl Meldrum`s acids

5-[3-Methoxy-4-(3-phenoxypropoxy)benzyl]-2,2-dimethyl-1,3-dioxane-4,6-dione (**13a**)

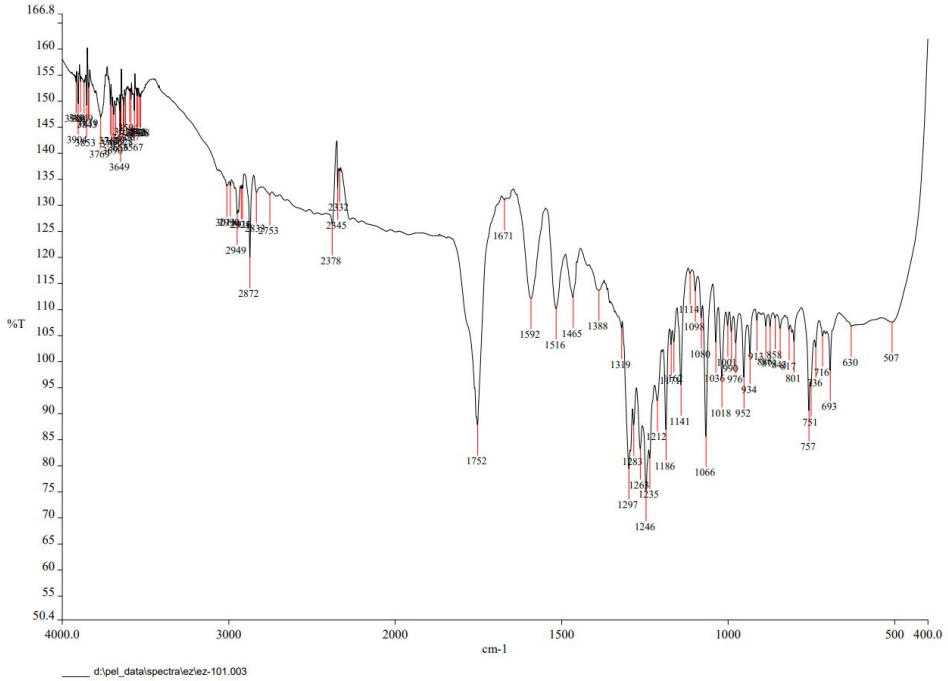
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



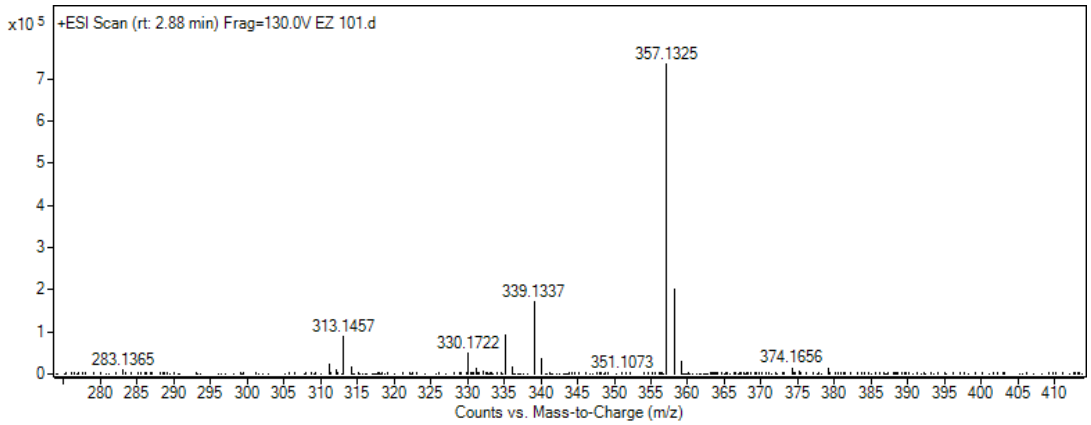
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

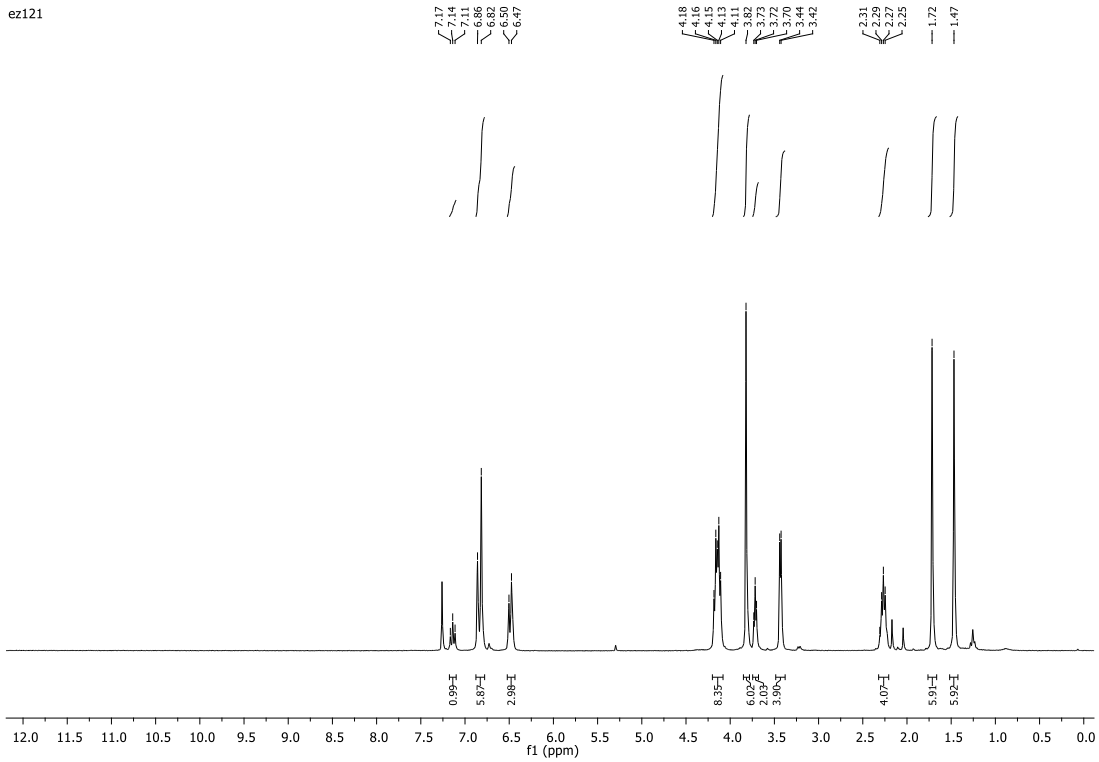


HRMS spectrum

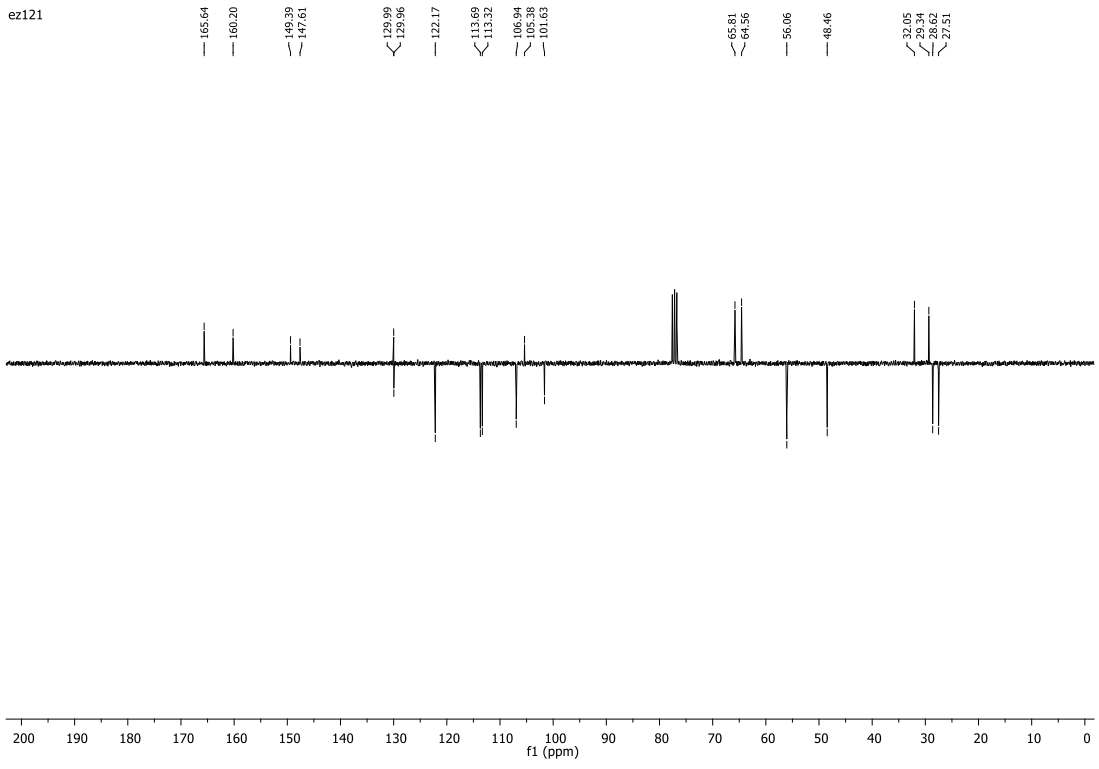


Resorcinol – arylmethyl Meldrum`s acid conjugate **13b**

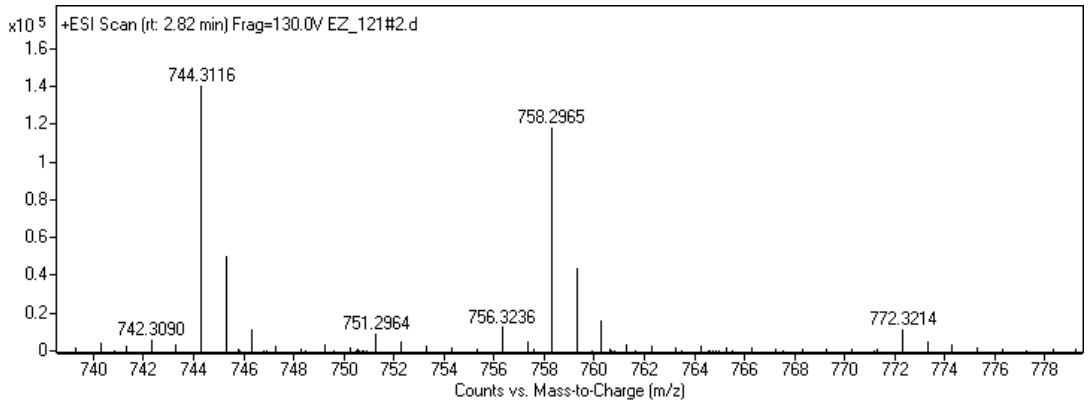
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

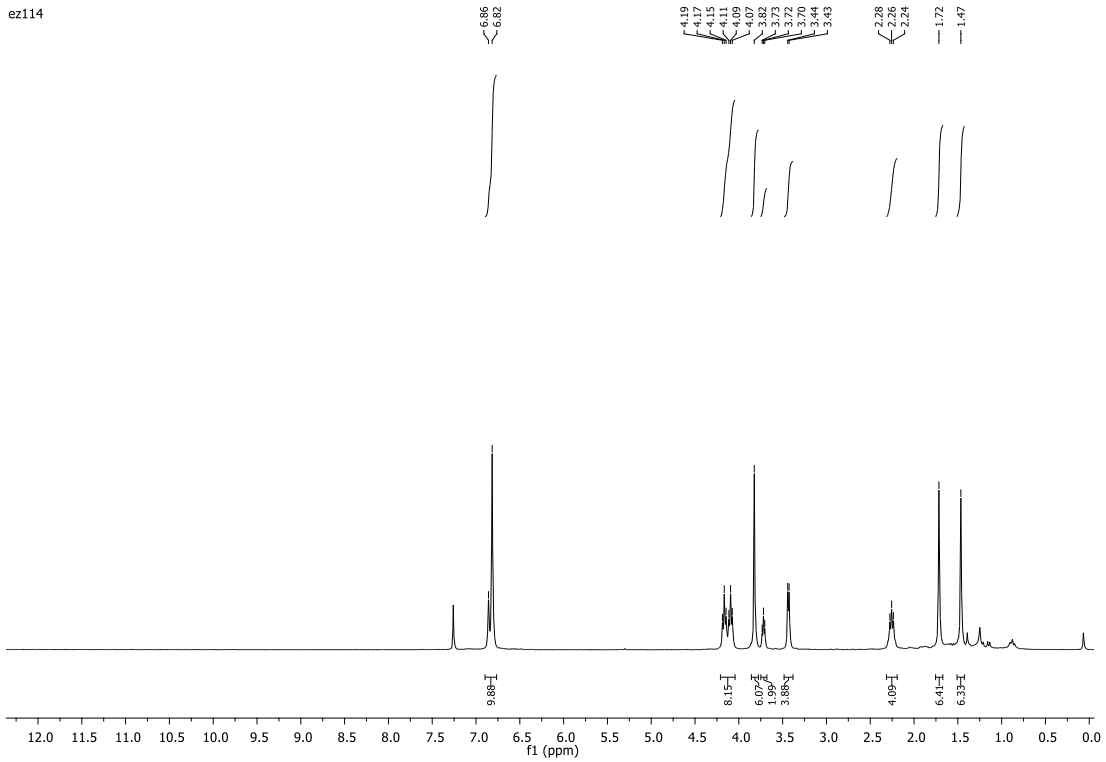


HRMS spectrum

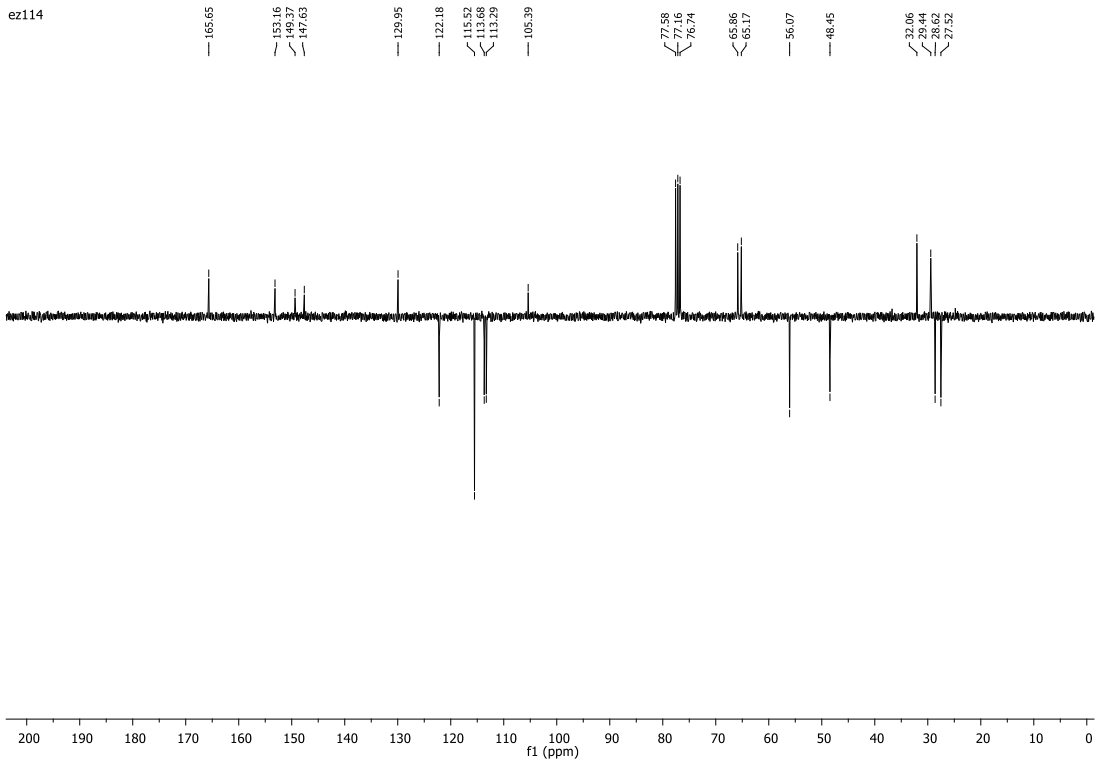


Quinol – arylmethyl Meldrum`s acid conjugate **13c**

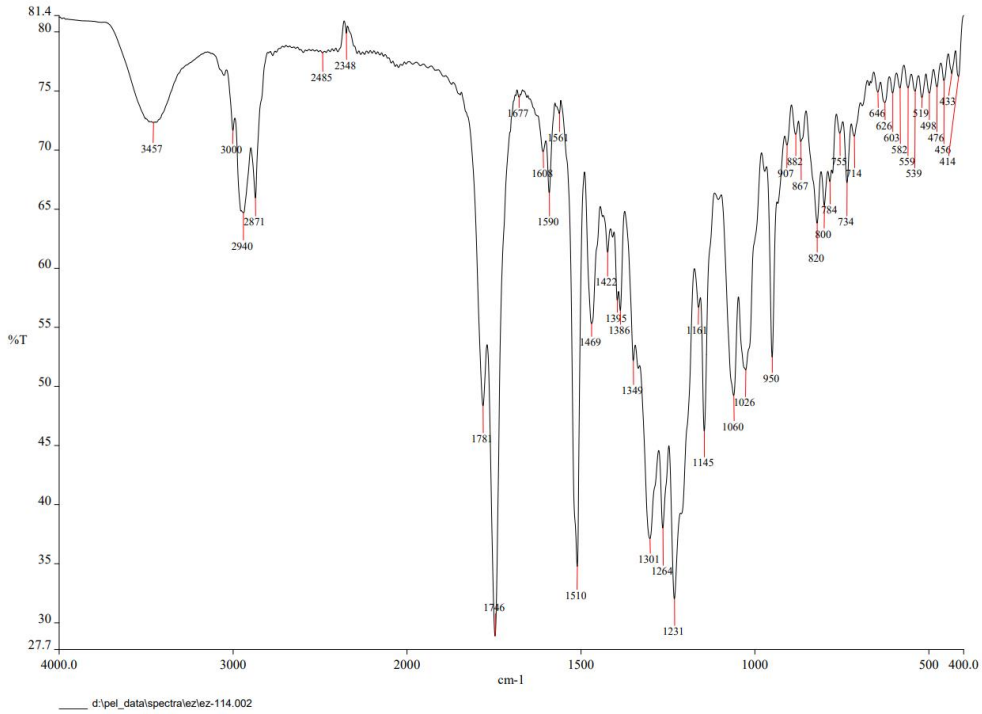
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



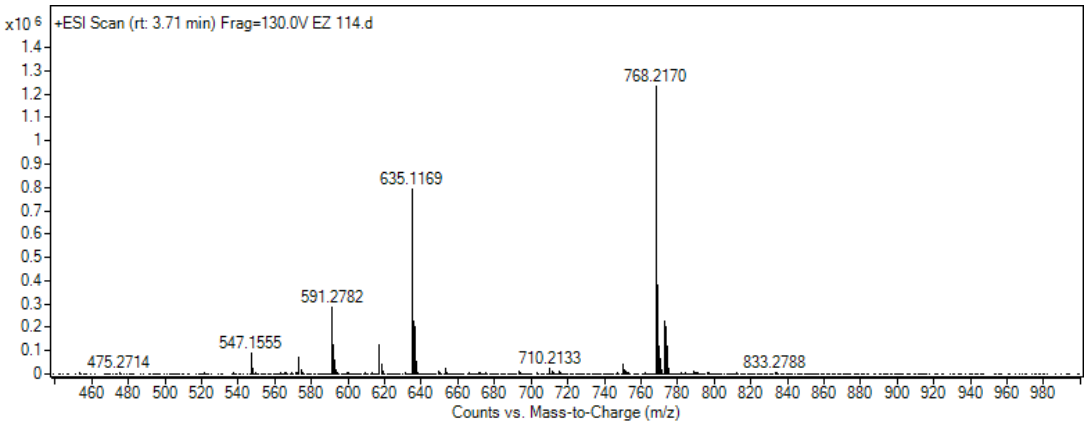
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

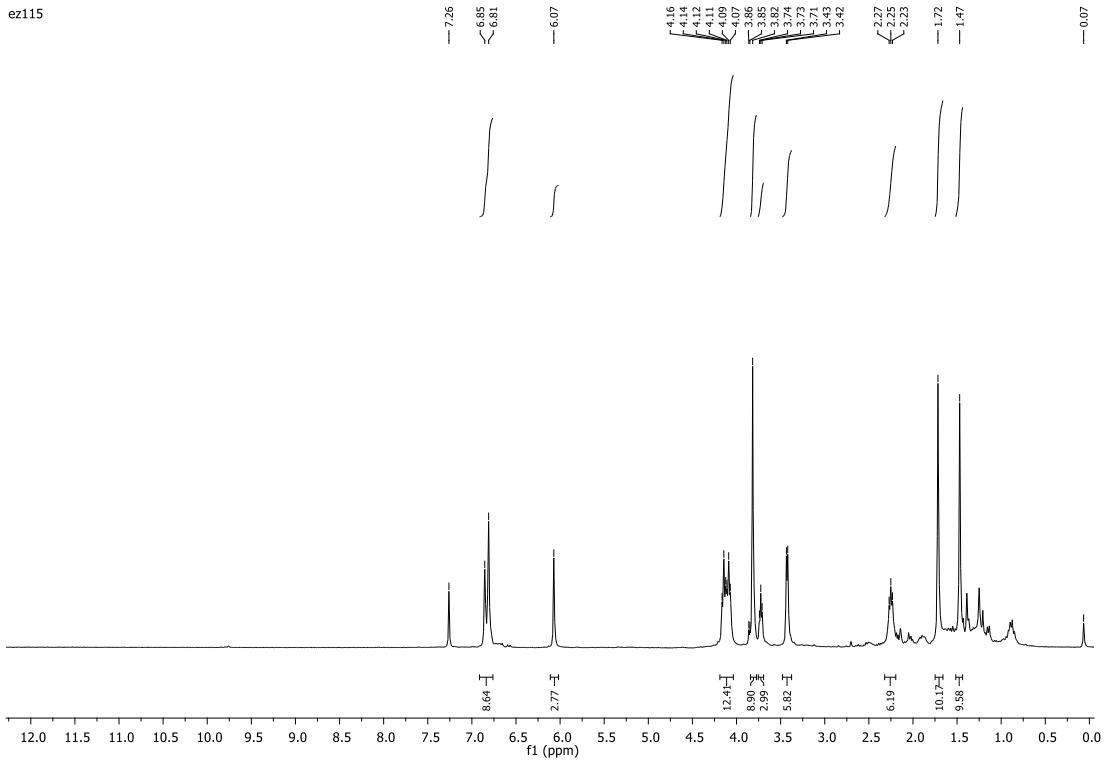


HRMS spectrum

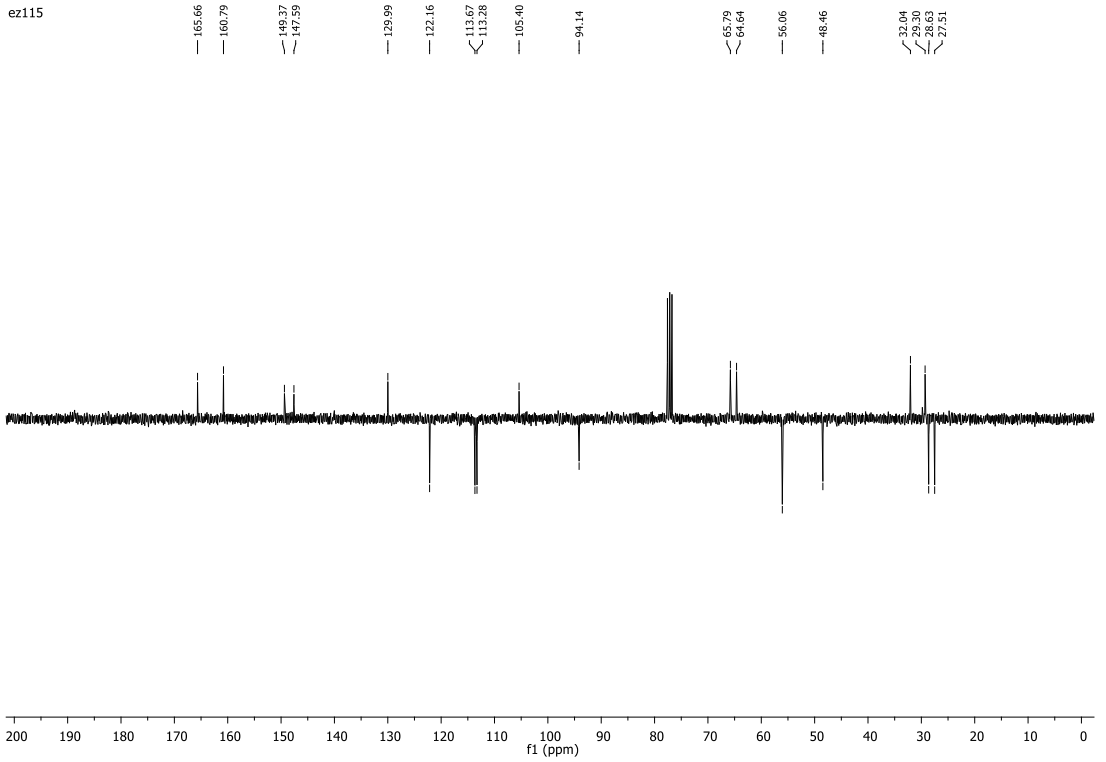


Phloroglucinol – arylmethyl Meldrum`s acid conjugate **13d**

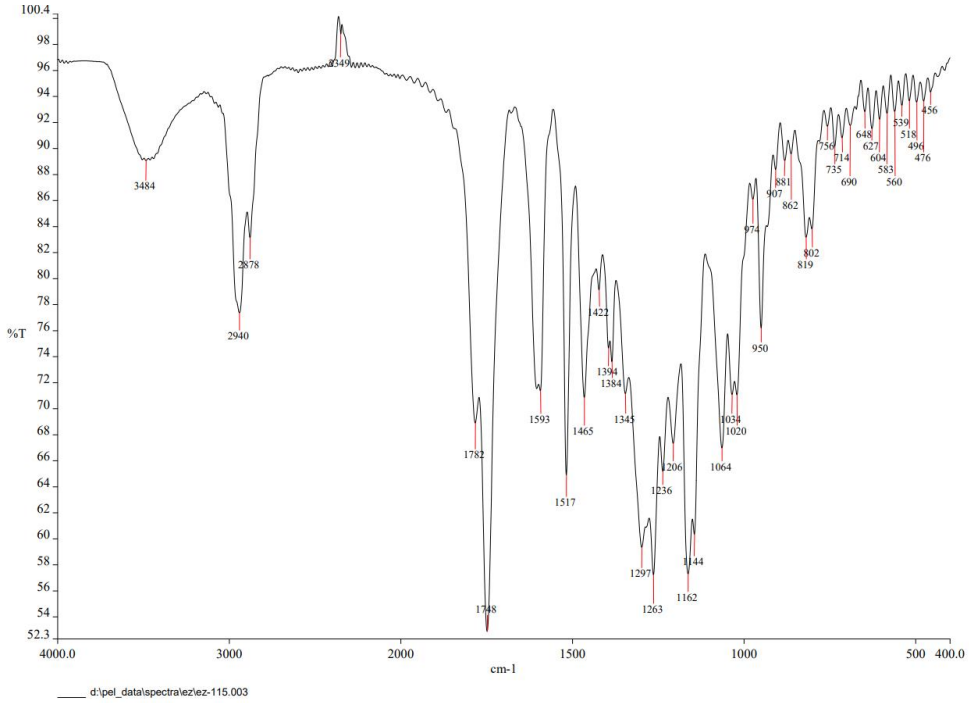
^{1}H NMR spectrum ($CDCl_3$, 300 MHz



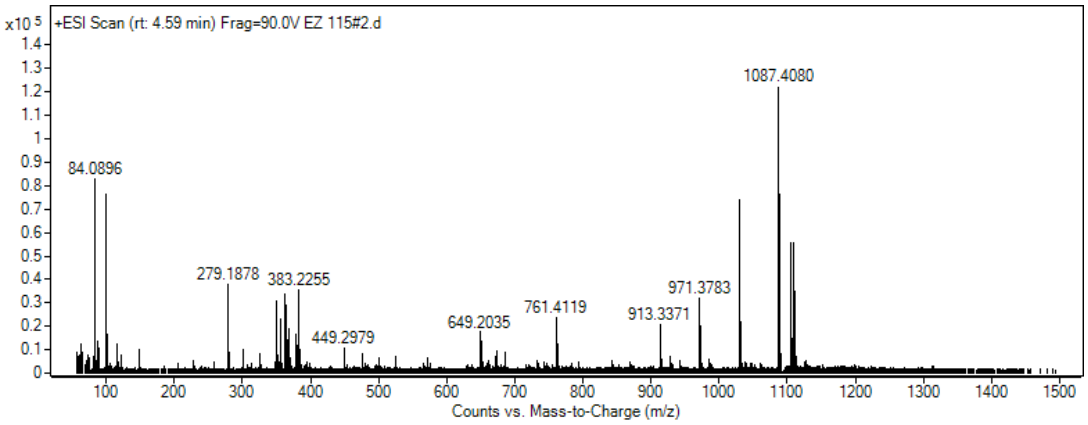
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

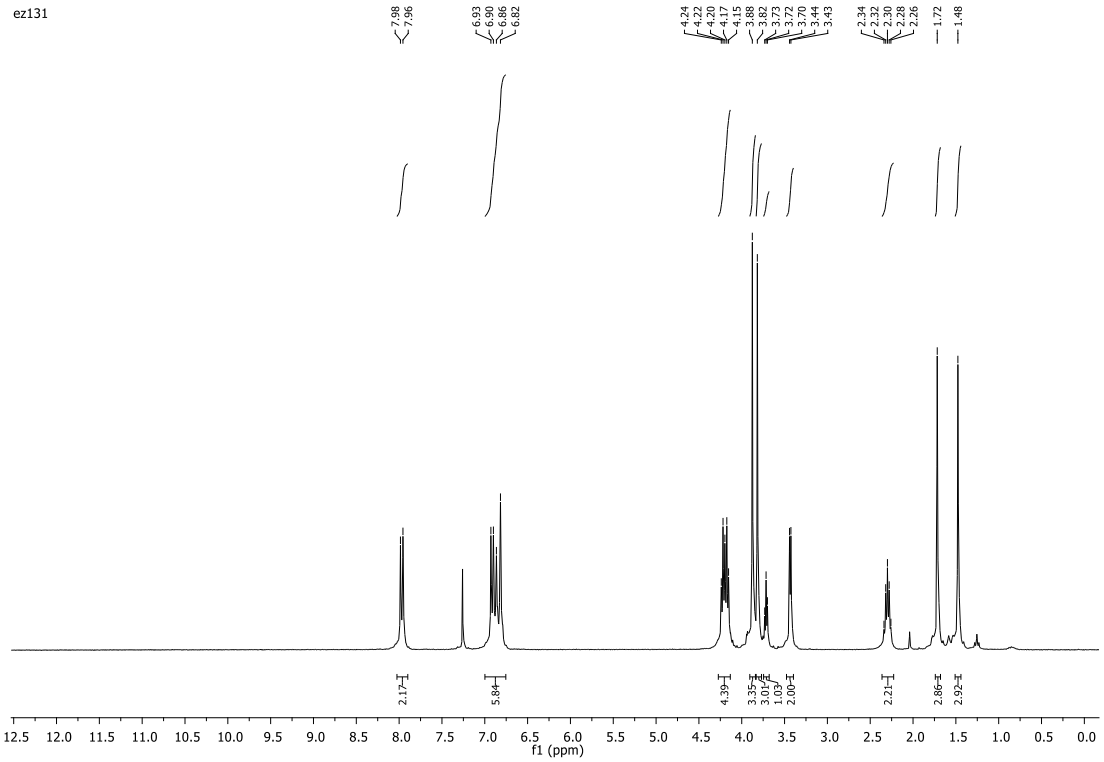


HRMS spectrum

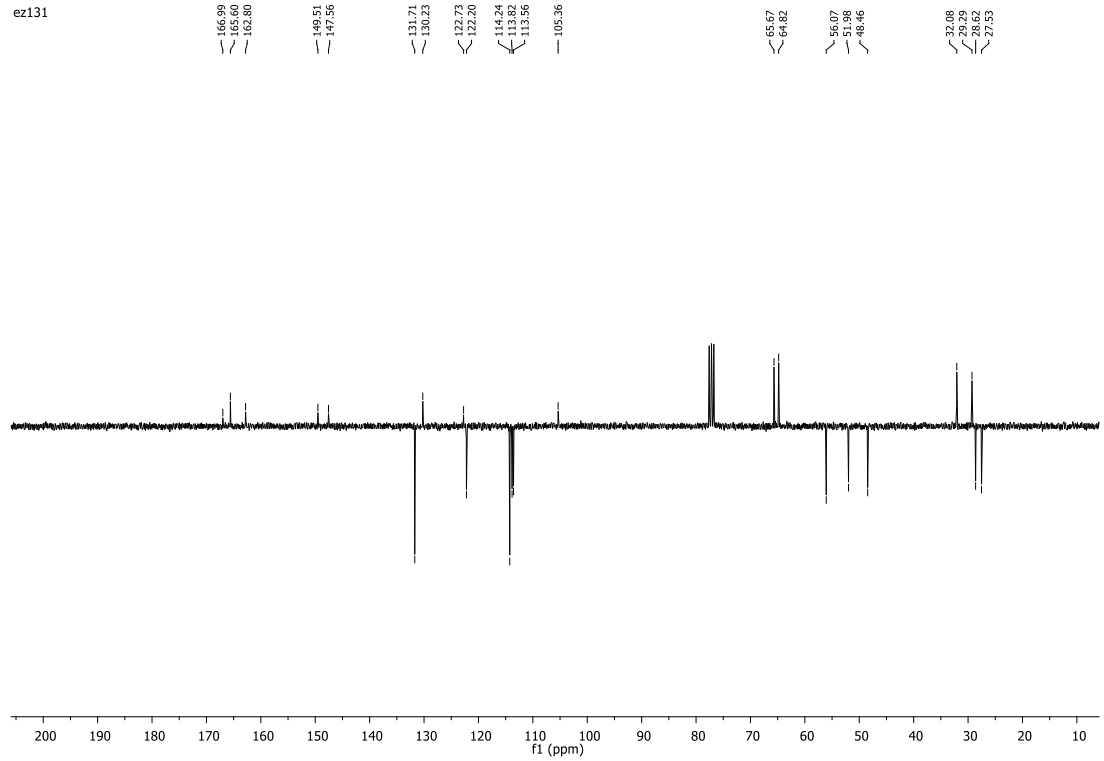


5-{4-[3-(4-Methoxycarbonylphenoxy)propoxy]-3-methoxybenzyl}-2,2-dimethyl-1,3-dioxane-4,6-dione (**13e**)

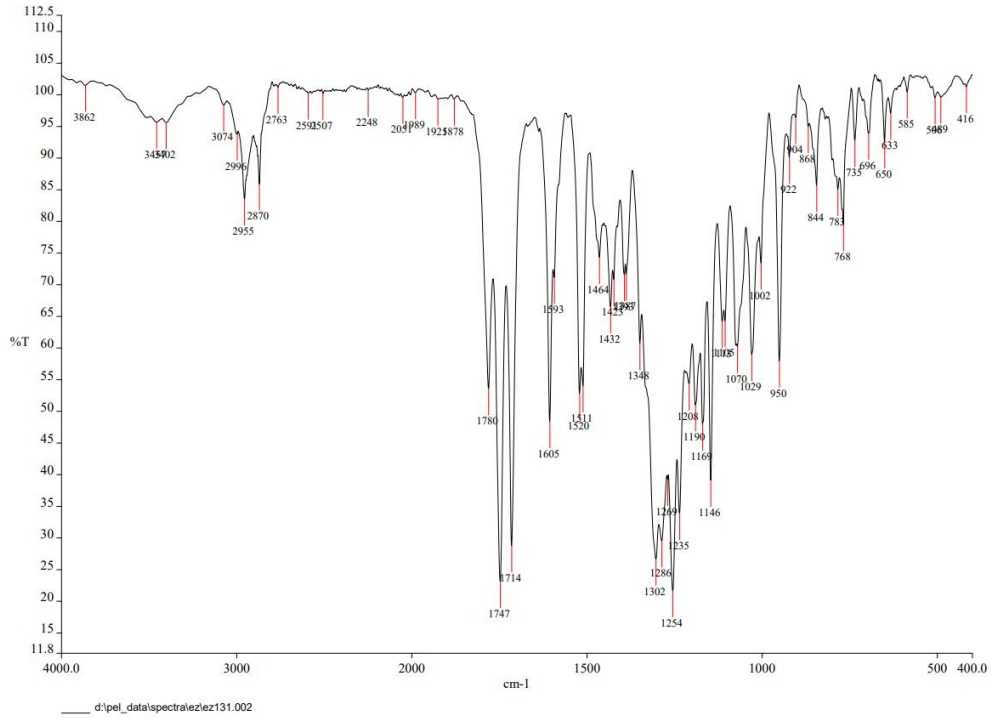
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



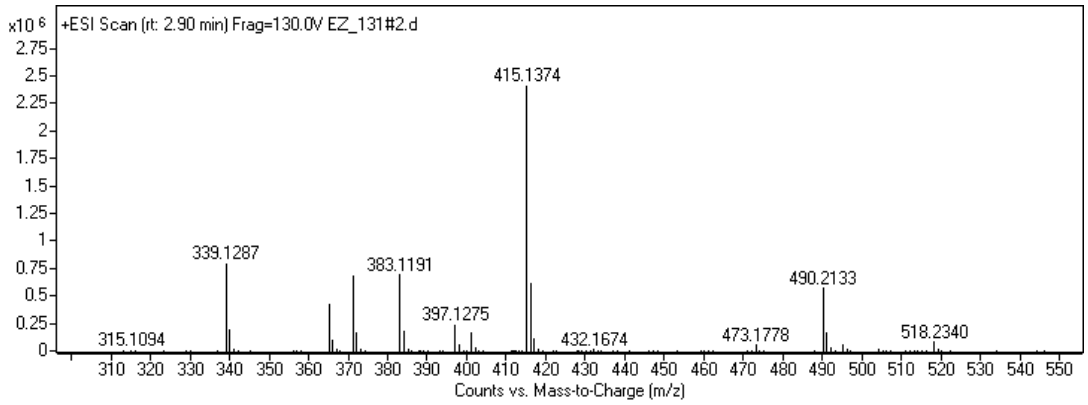
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

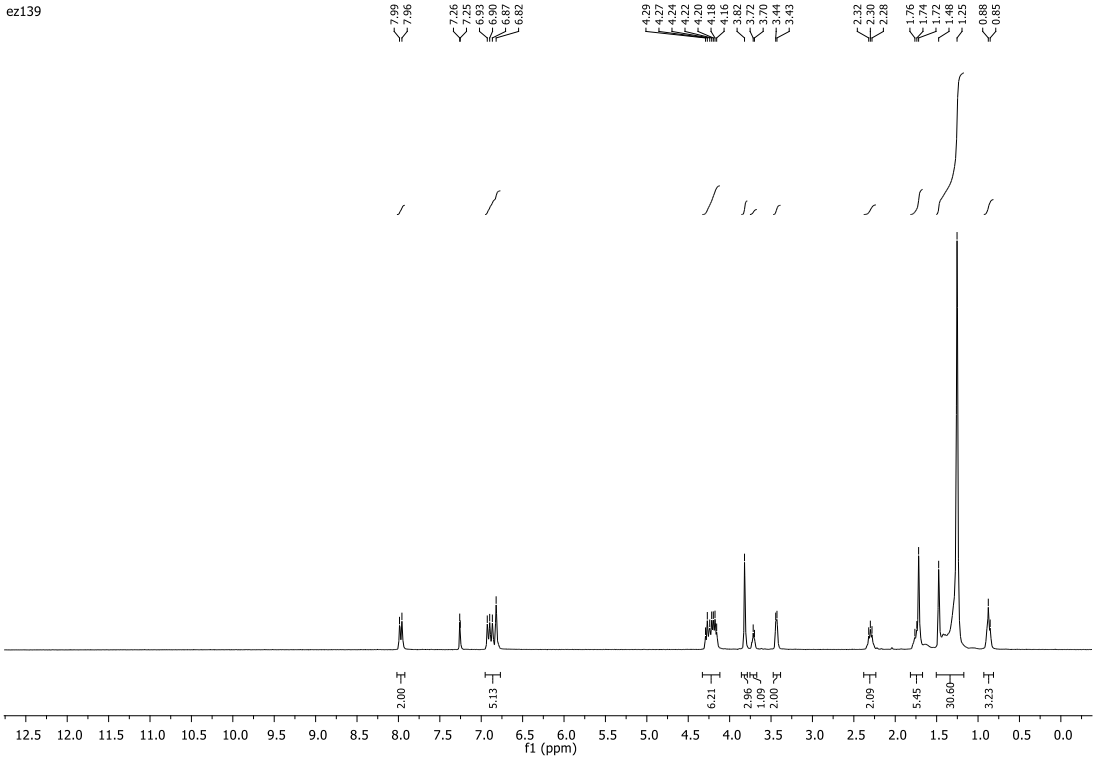


HRMS spectrum

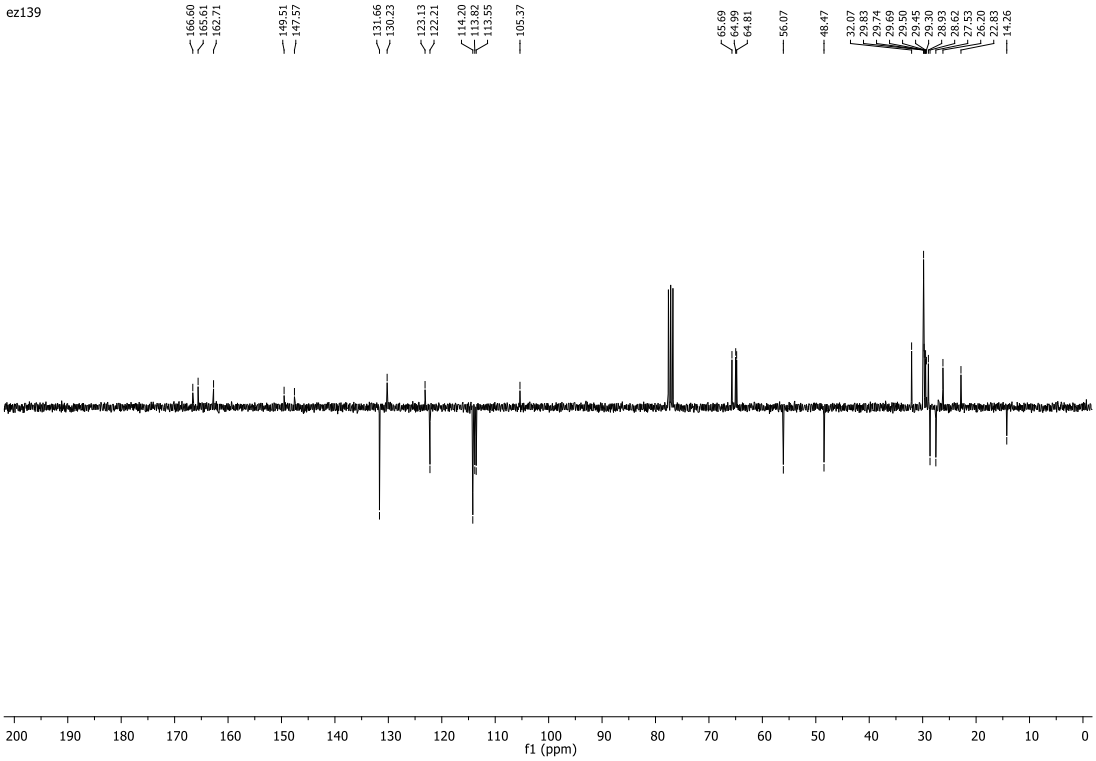


5-{4-[3-(4-Cetoxycarbonylphenoxy)propoxy]-3-methoxybenzyl}-2,2-dimethyl-1,3-dioxane-4,6-dione (**13f**)

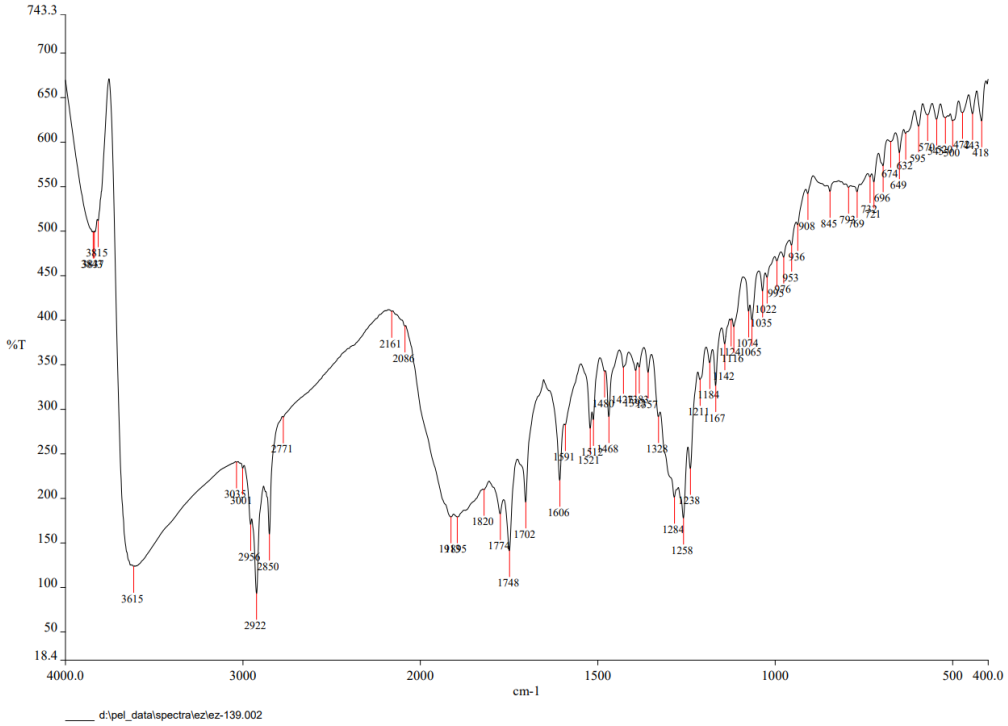
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



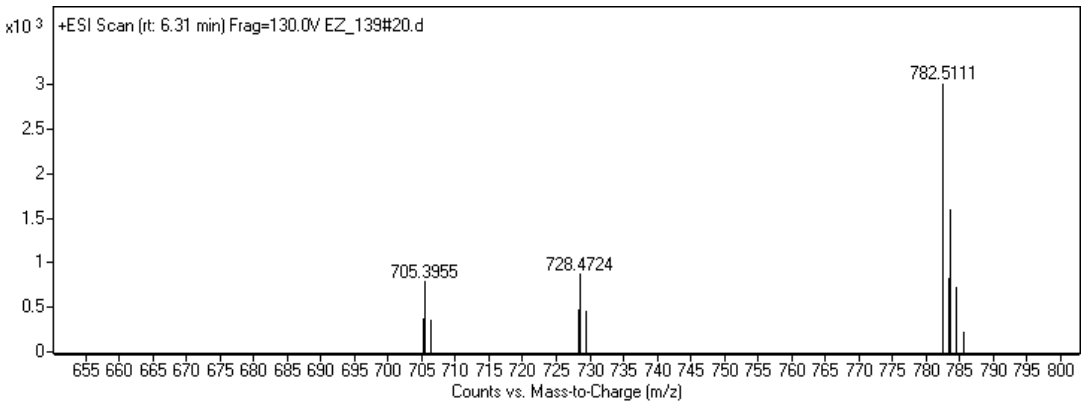
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

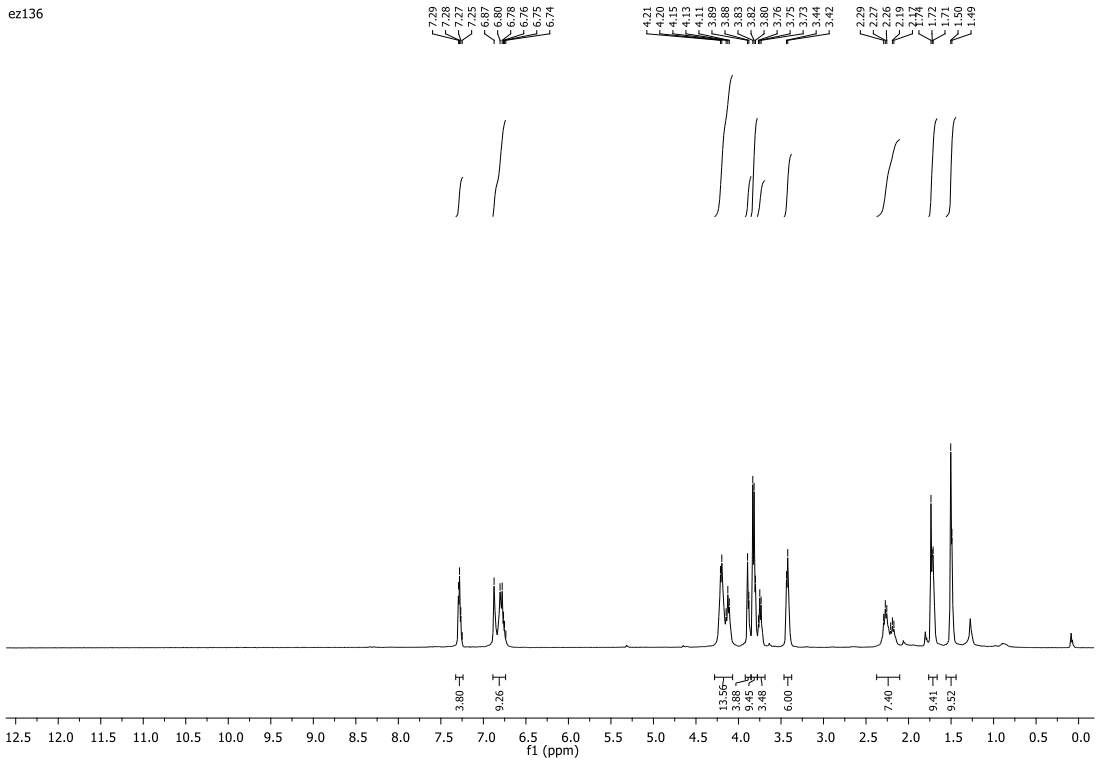


HRMS spectrum

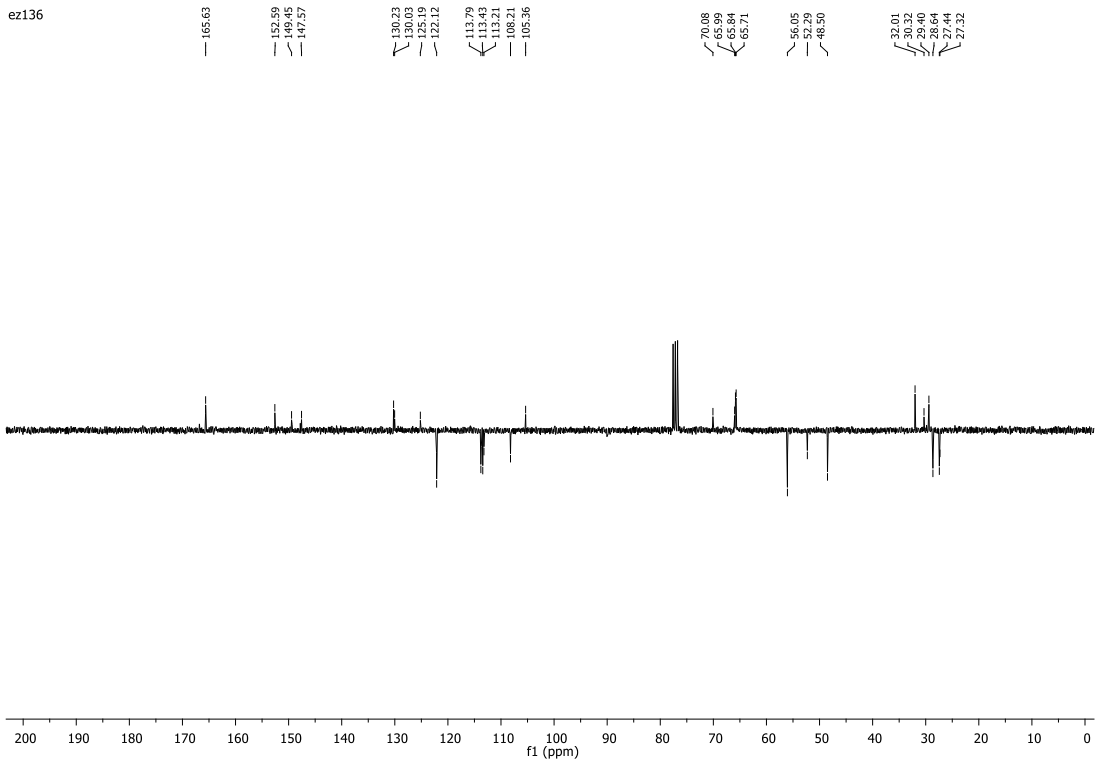


Methyl gallate – arylmethyl Meldrum`s acid conjugate **13g**

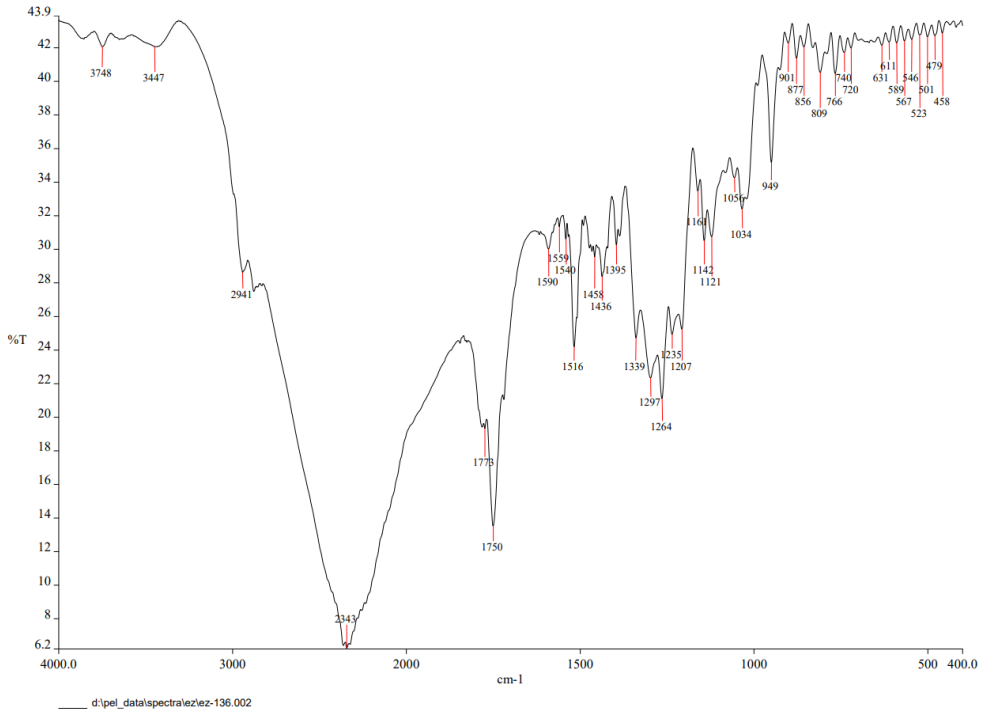
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



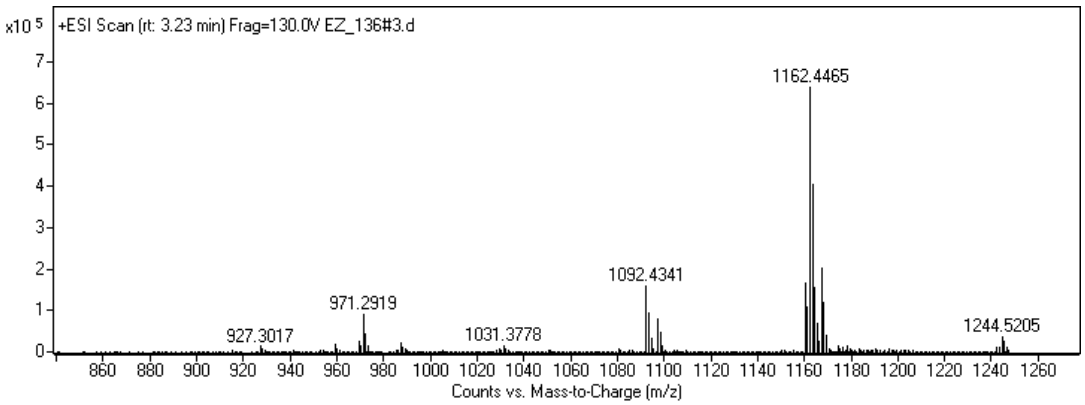
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

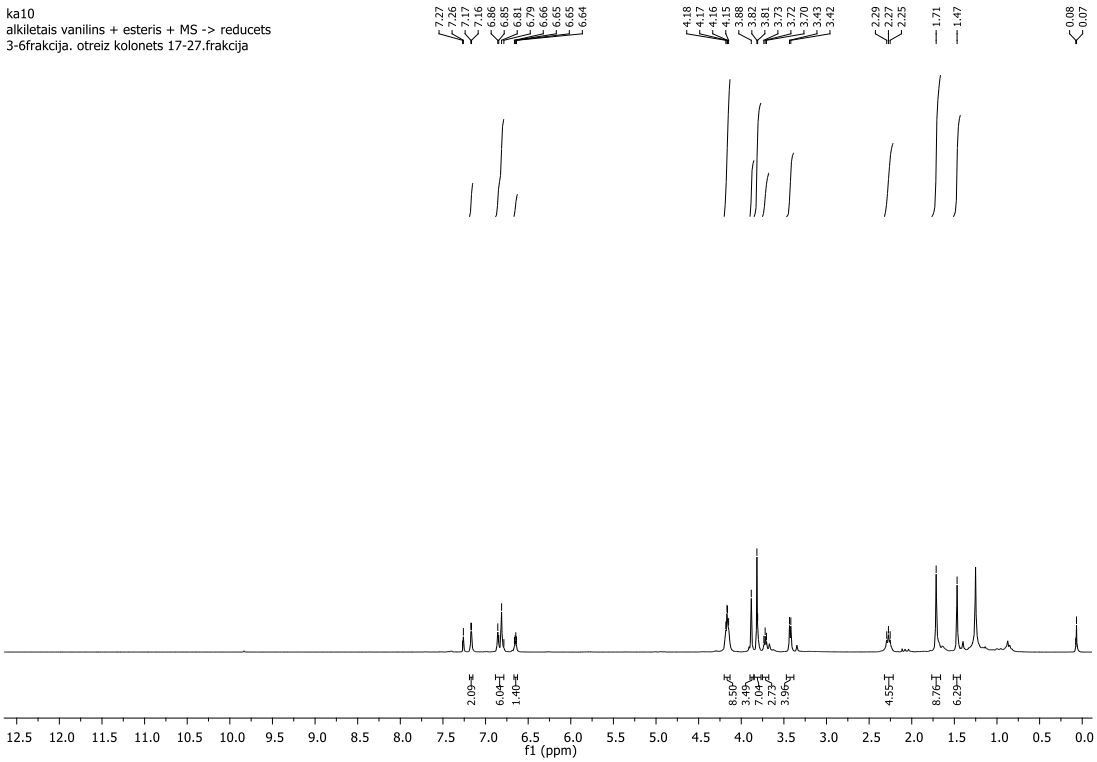


HRMS spectrum

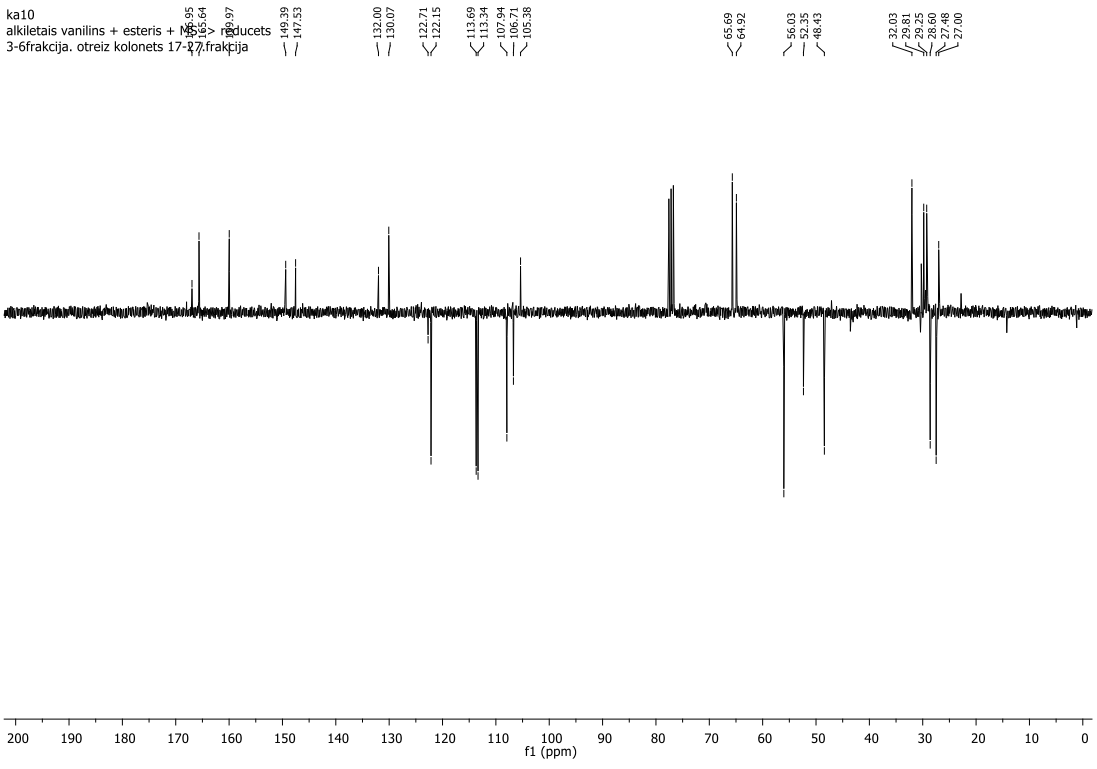


Methyl α-resorcylate – arylmethyl Meldrum`s acid conjugate **13h**

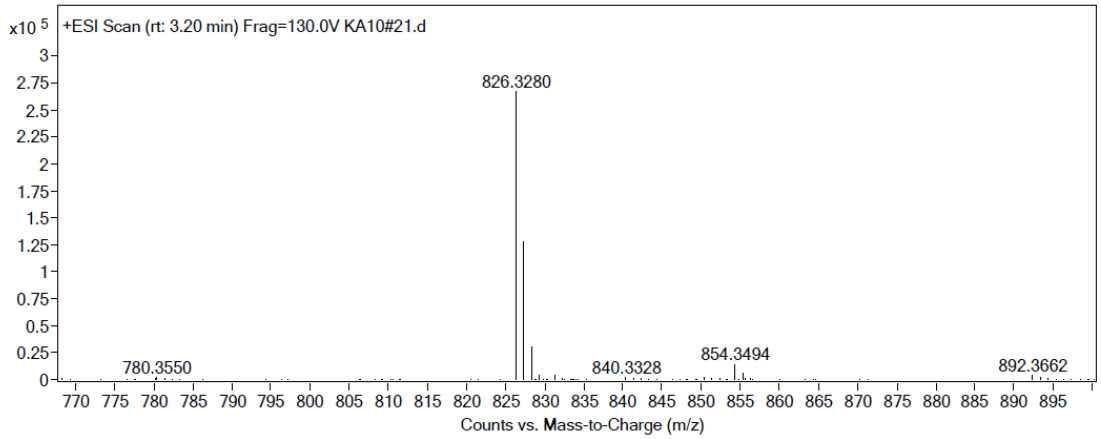
^{1}H NMR spectrum (300 MHz, $CDCl_3$)



^{13}C NMR spectrum (75 MHz, $CDCl_3$)

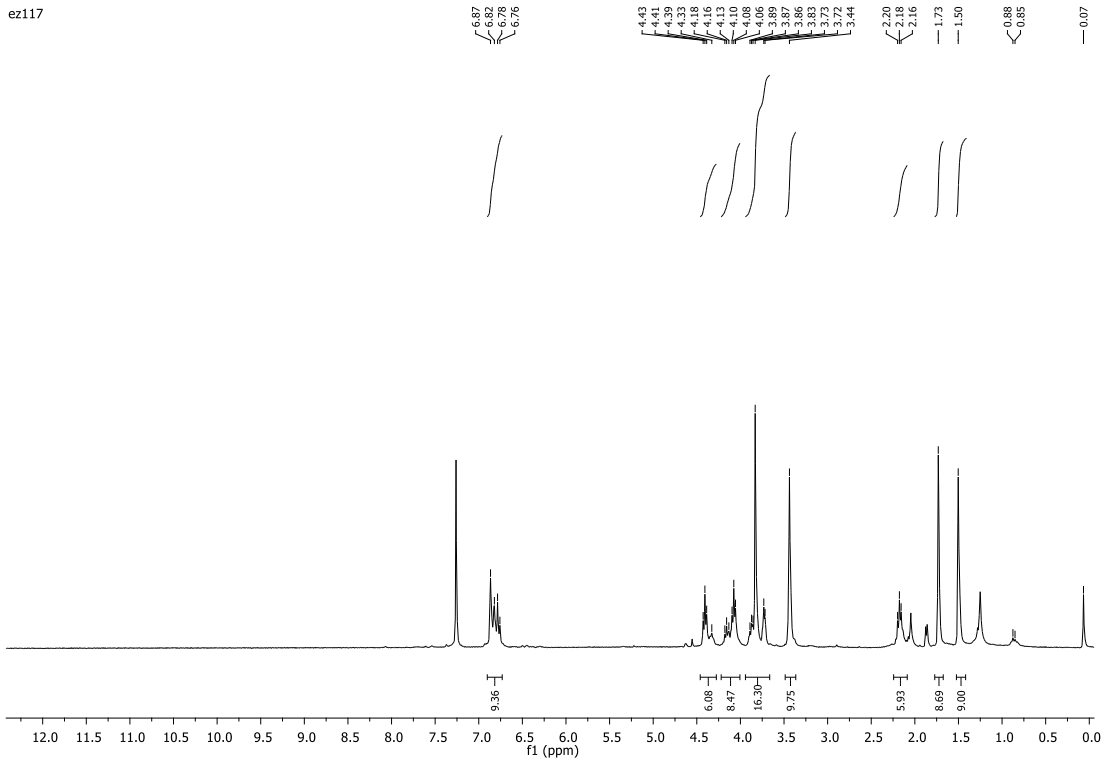


HRMS spectrum

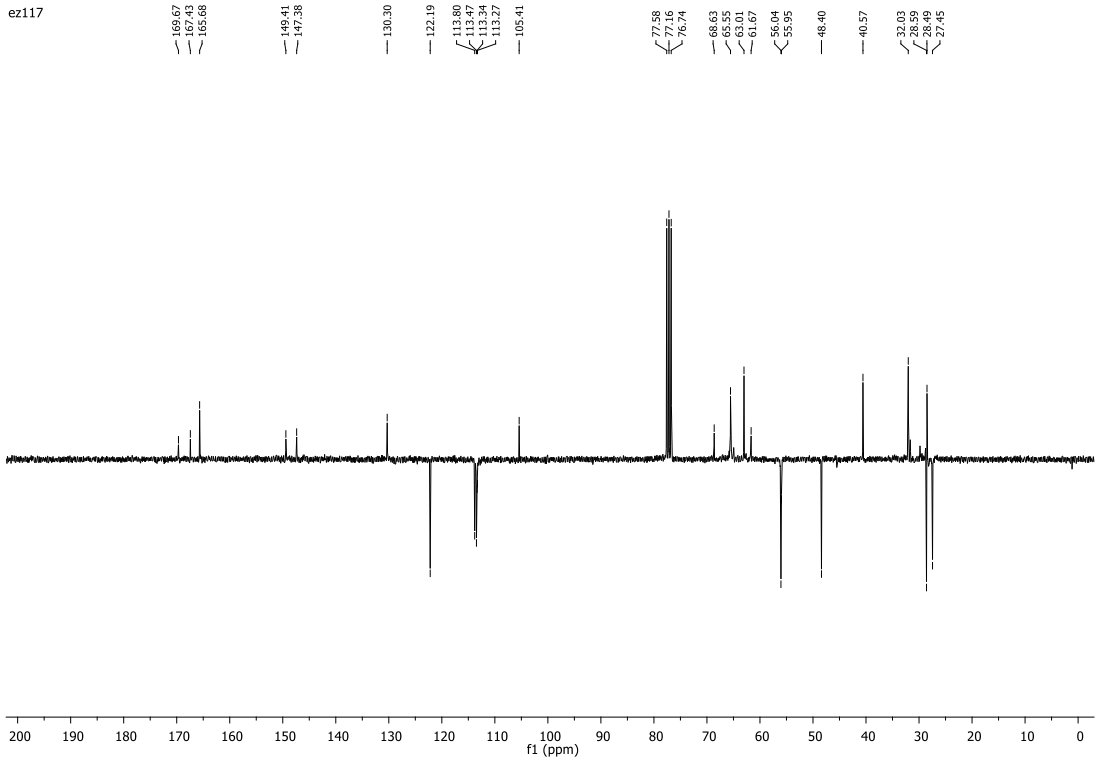


Glycerol – arlymethyl Meldrum`s acid conjugate **13i**

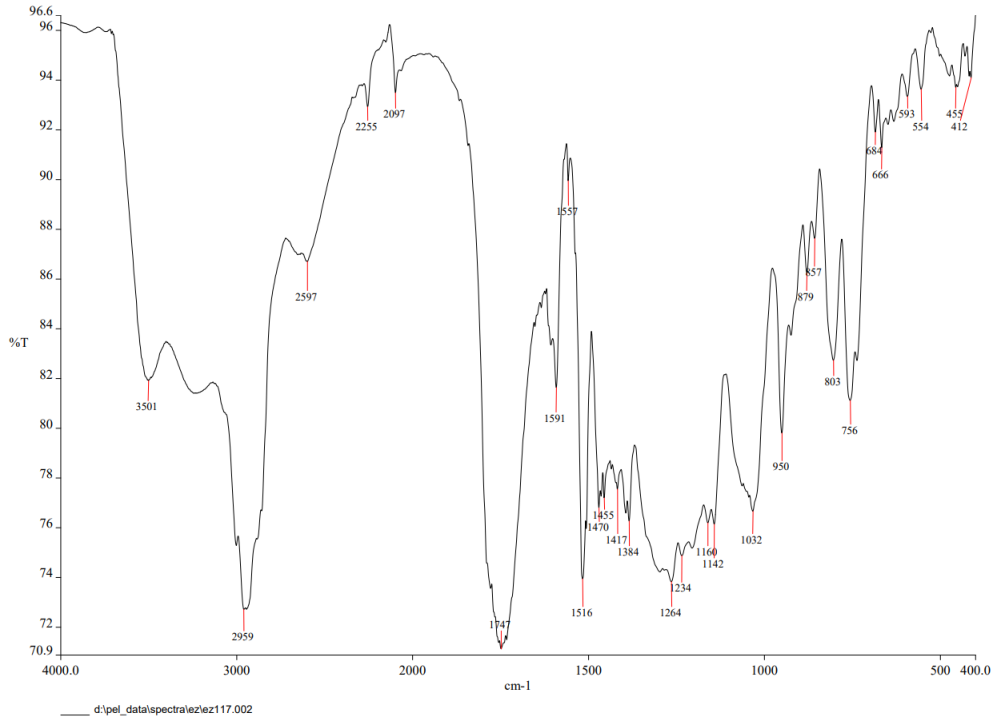
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

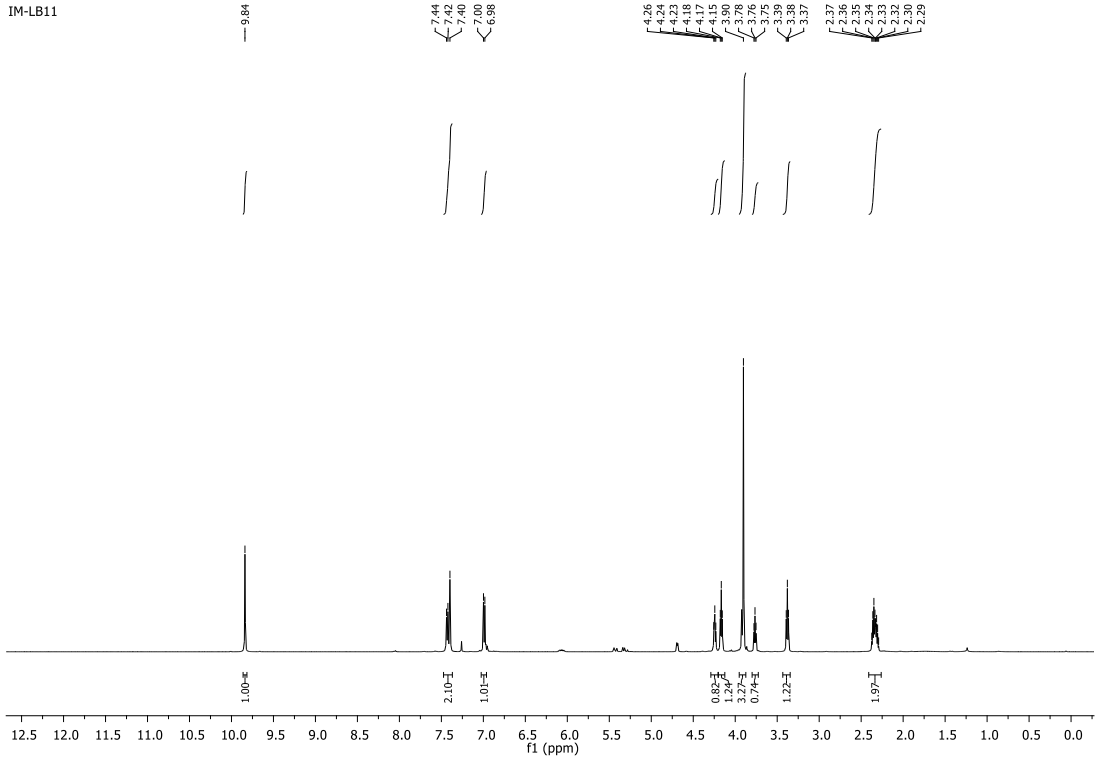


IR spectrum (KBr)

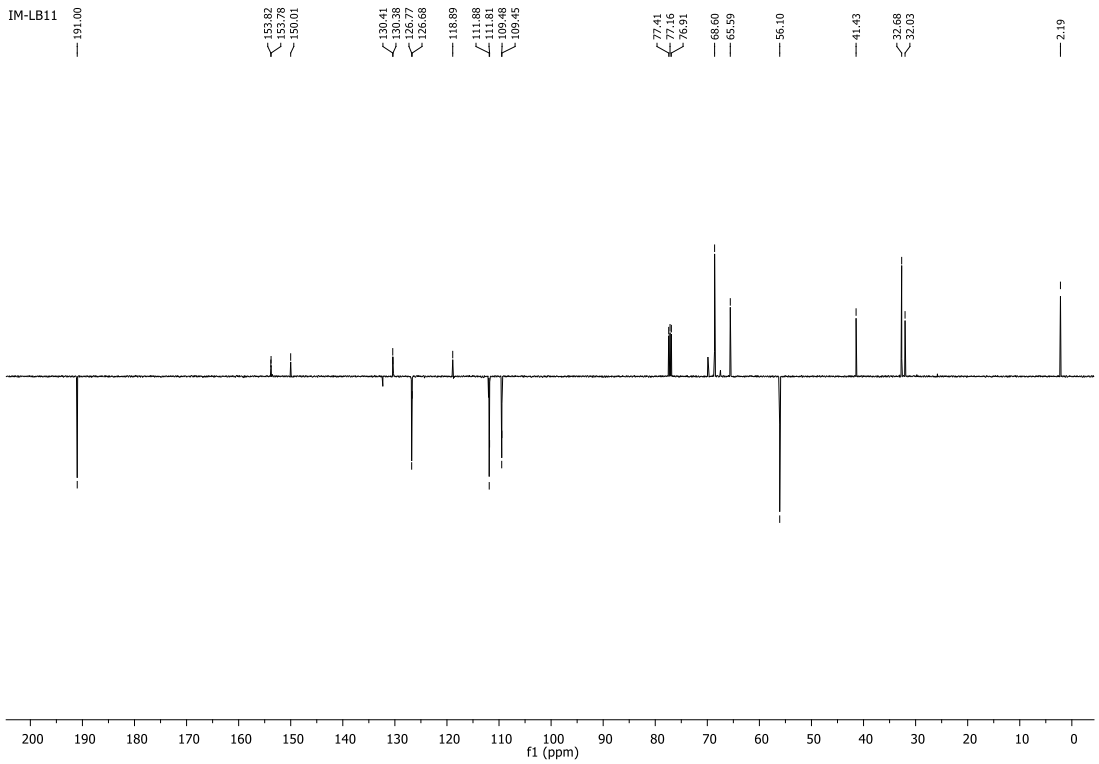


4-(3-Chloropropoxy)-3-methoxybenzaldehyde (**19b**) and 4-(3-iodopropoxy)-3-methoxybenzaldehyde (**19c**)

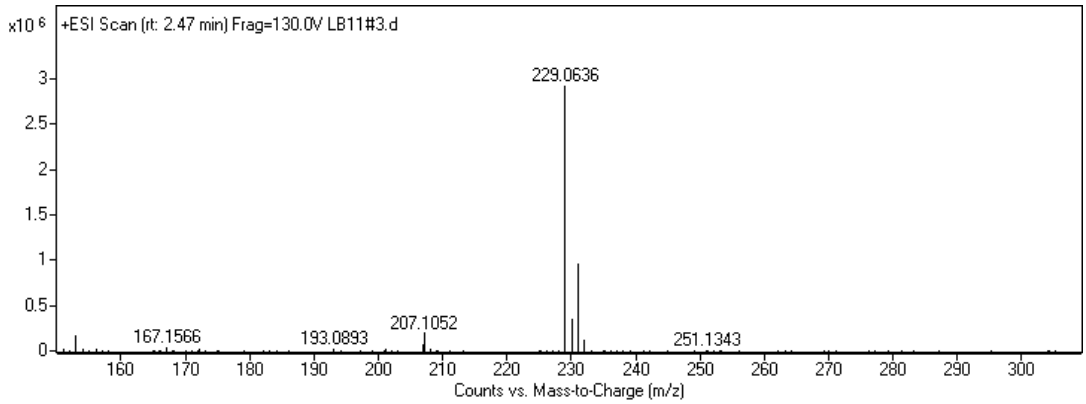
^{1}H NMR spectrum (500 MHz, $CDCl_3$)

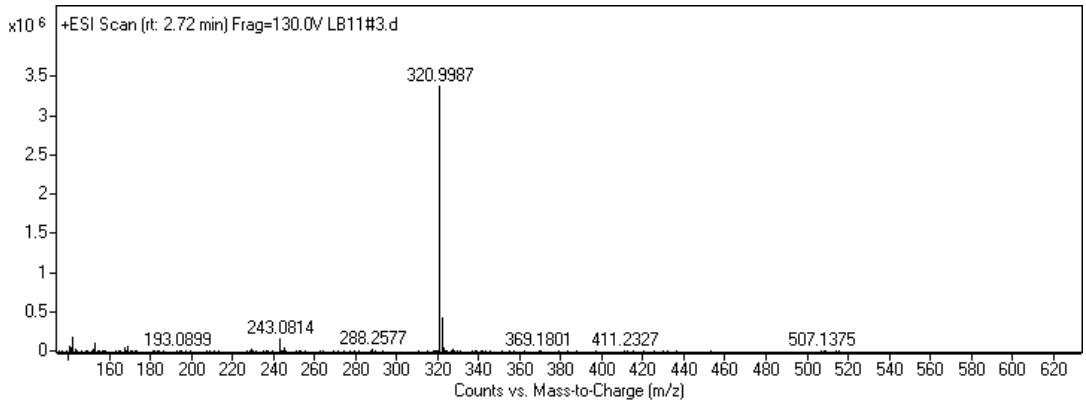


^{13}C NMR spectrum (126 MHz, $CDCl_3$)



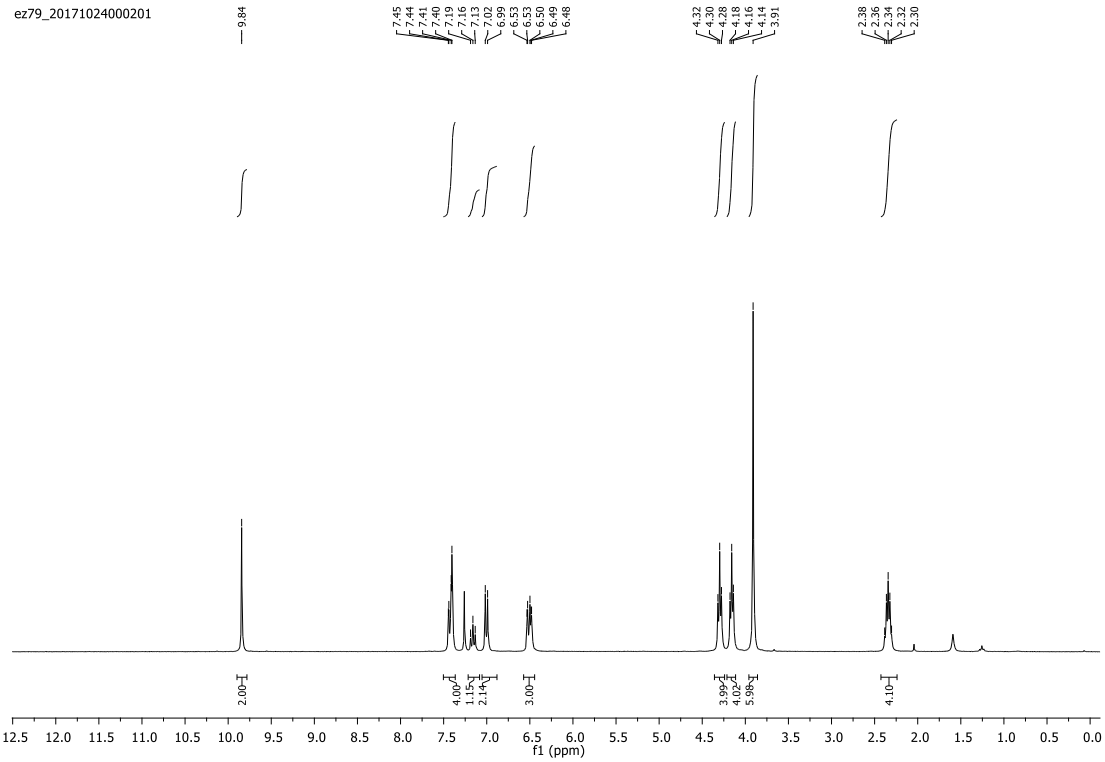
HRMS spectrum



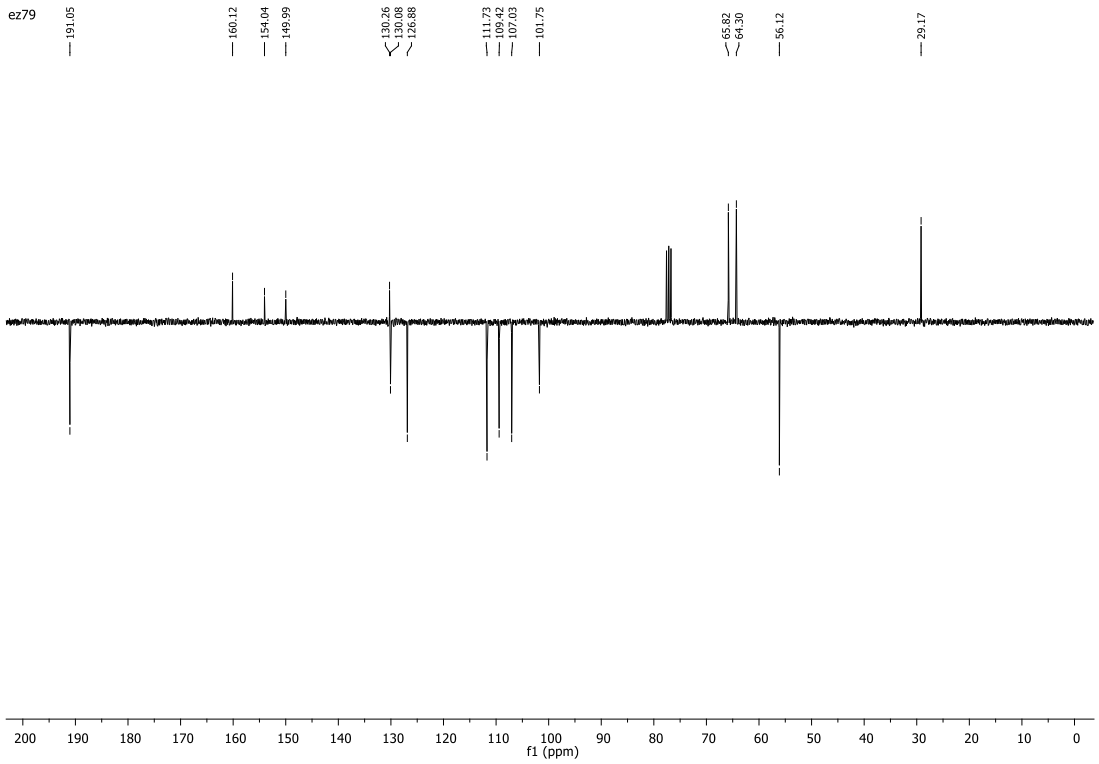


Resorcinol – aldehyde conjugate **21b**

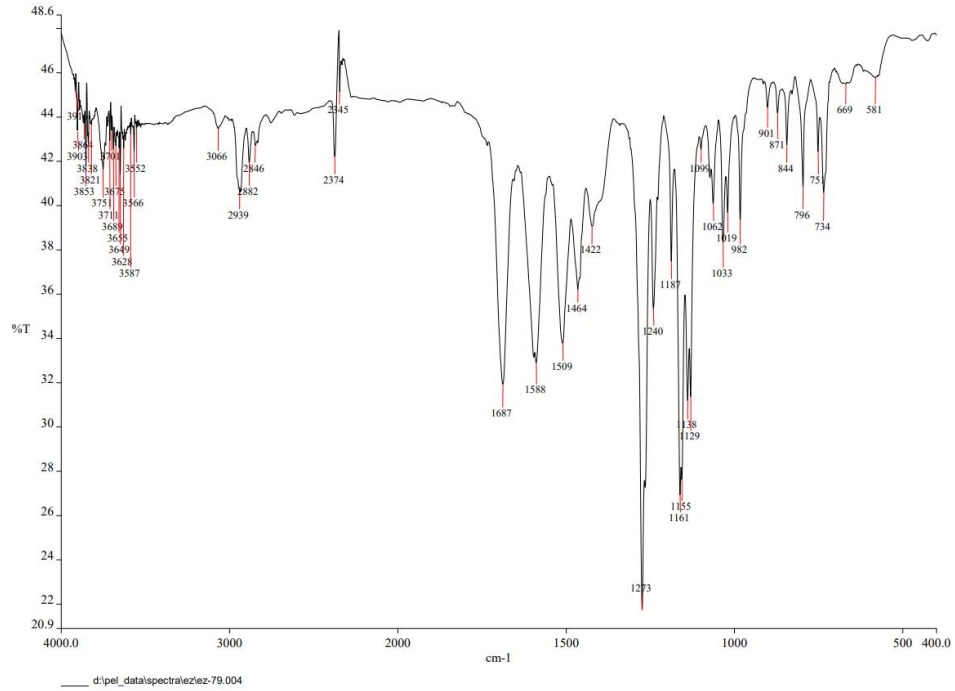
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



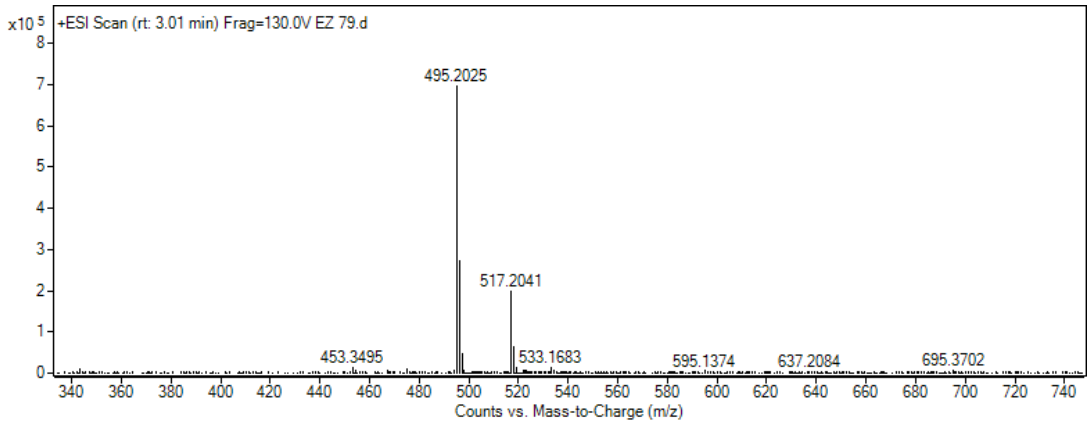
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

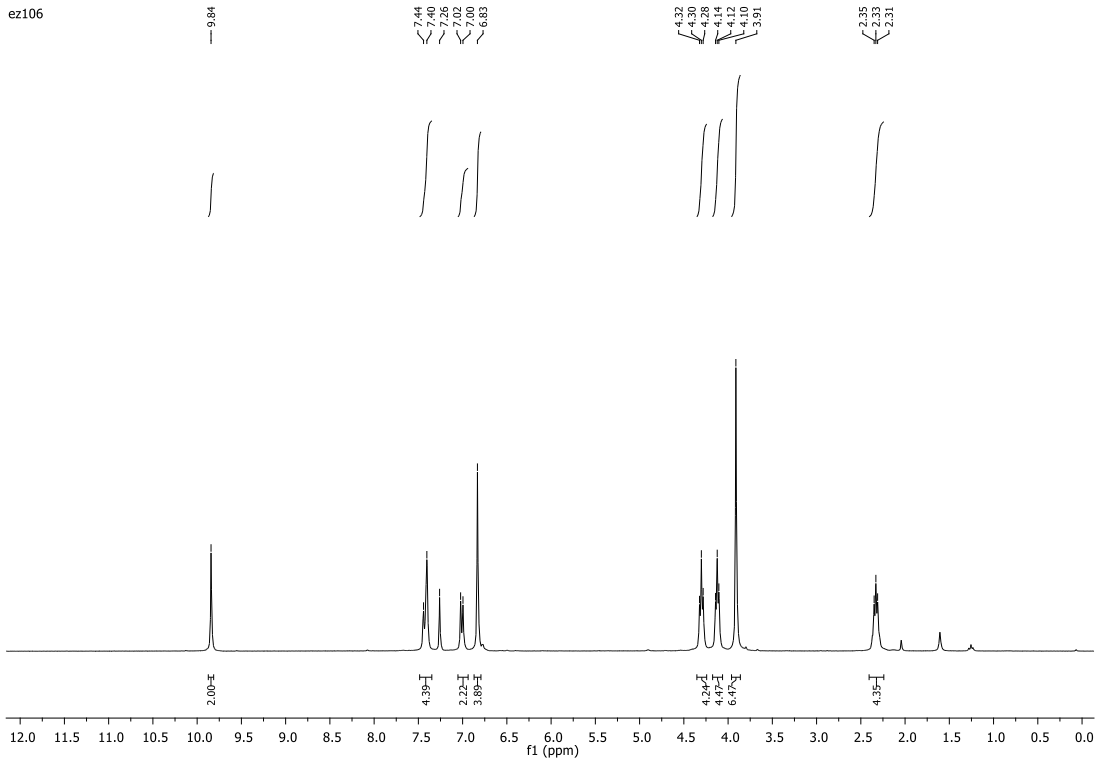


HRMS spectrum

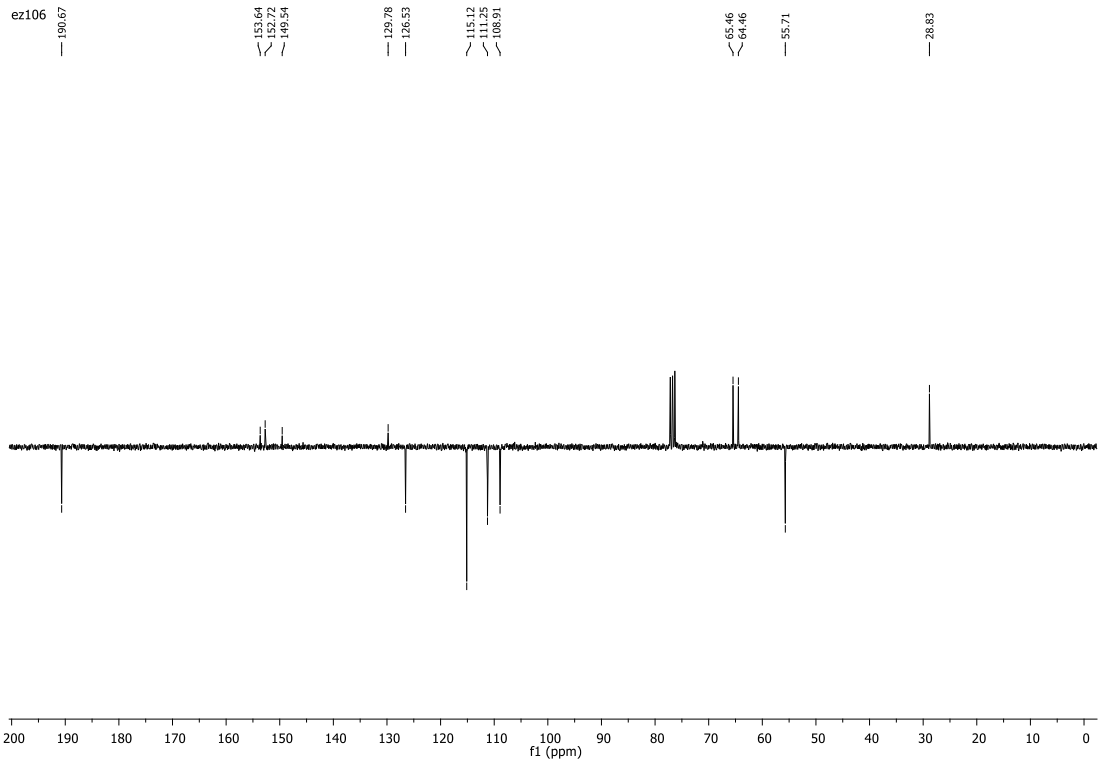


Quinol – aldehyde conjugate **21c**

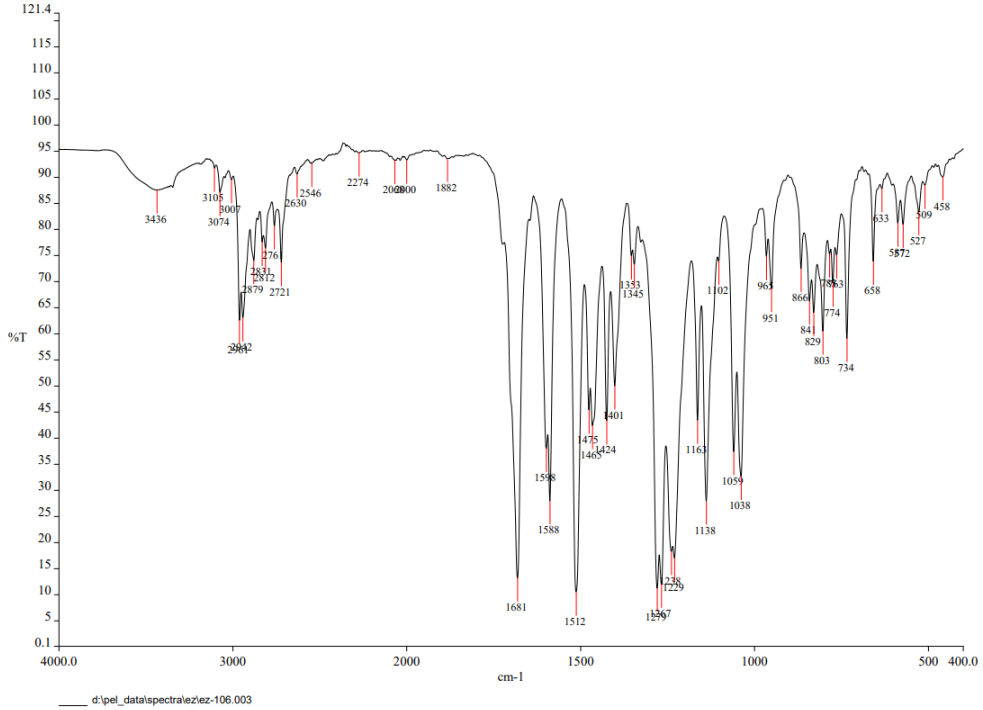
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



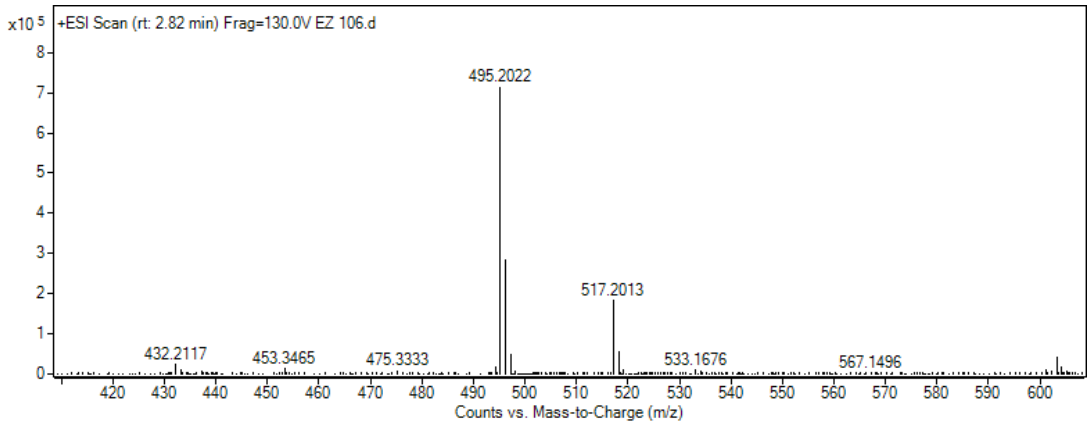
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

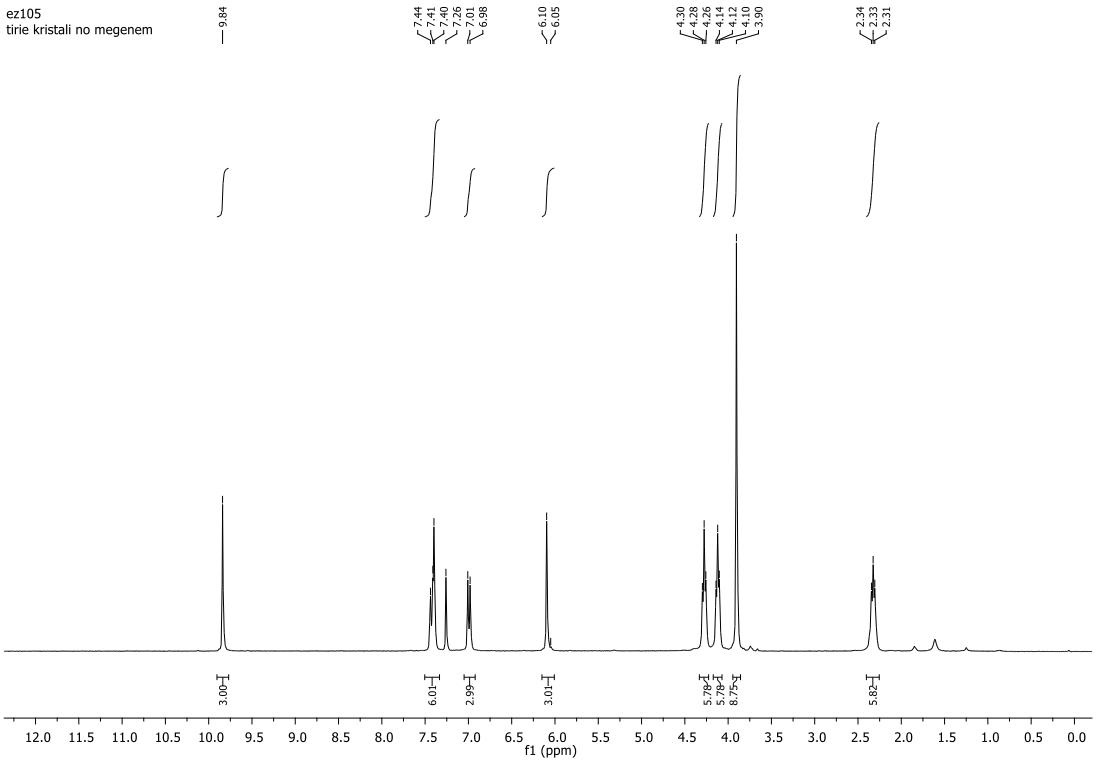


HRMS spectrum

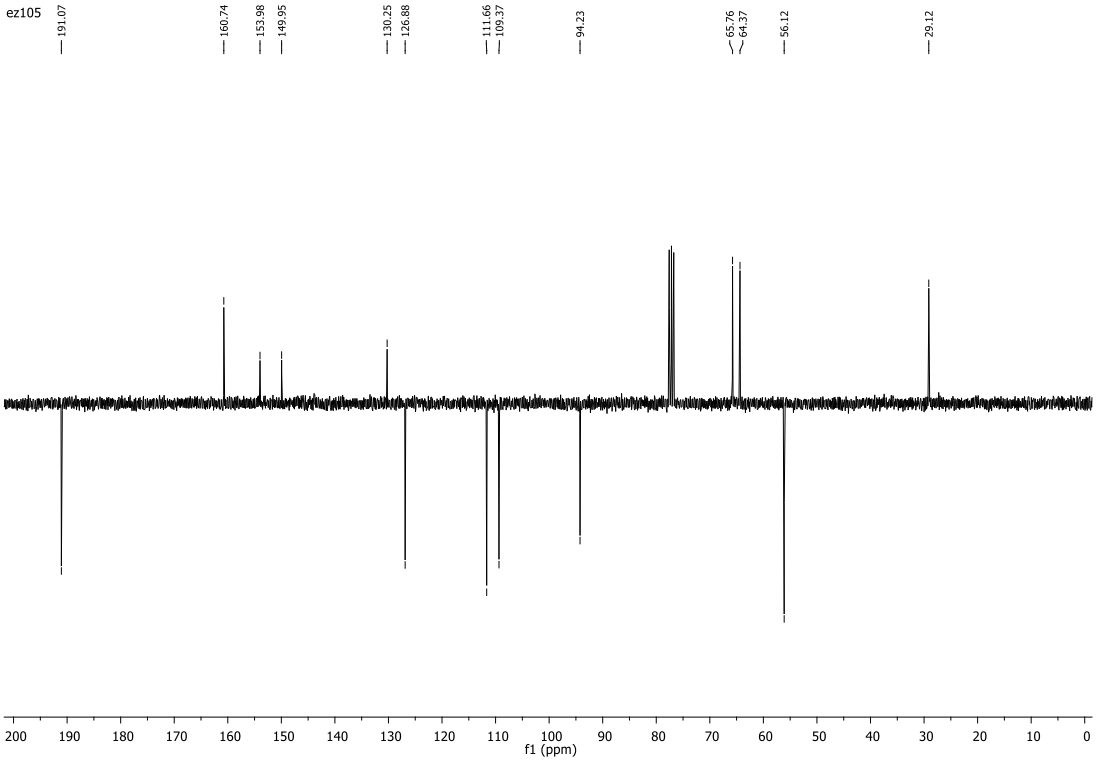


Phloroglucinol – aldehyde conjugate **21d**

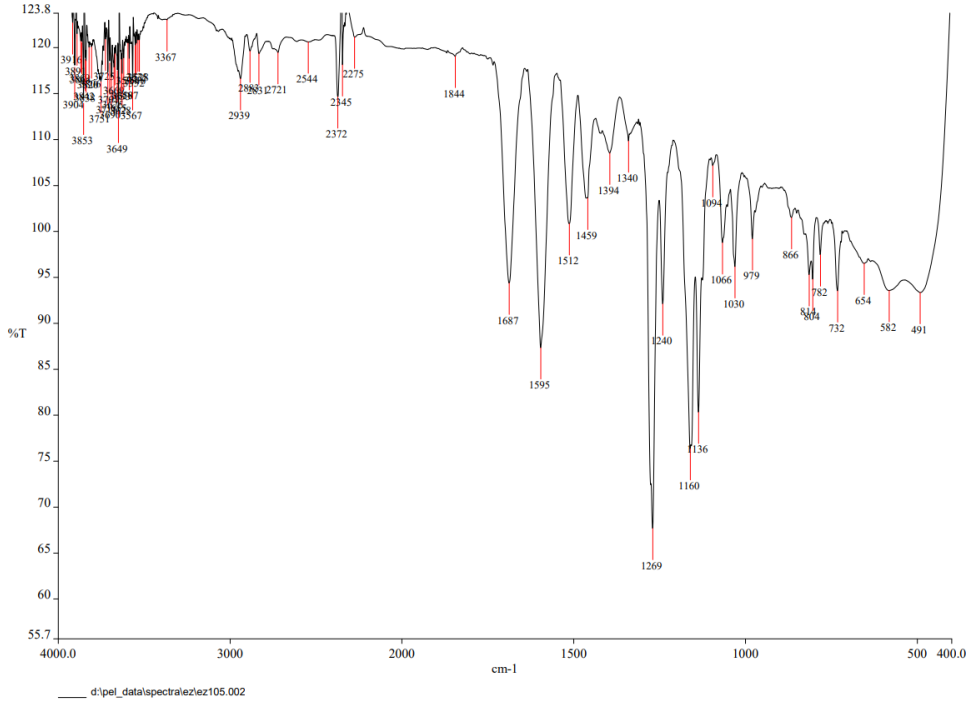
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



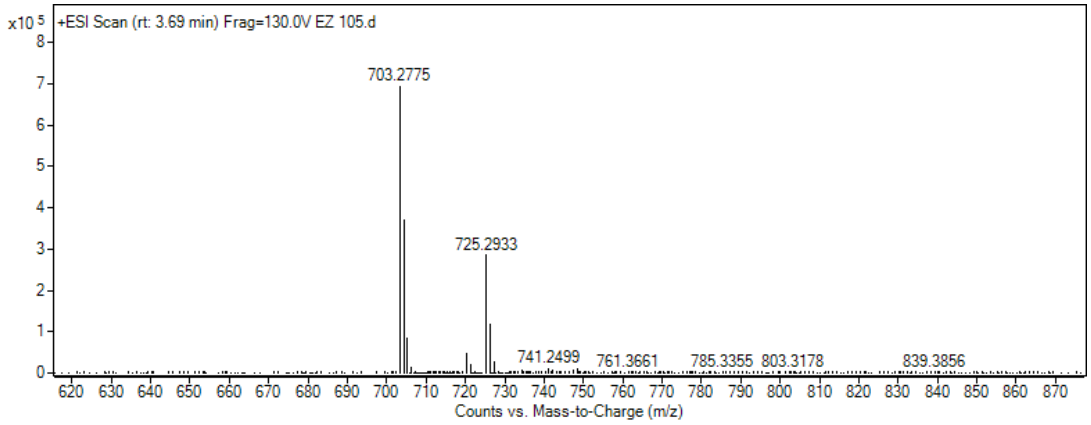
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

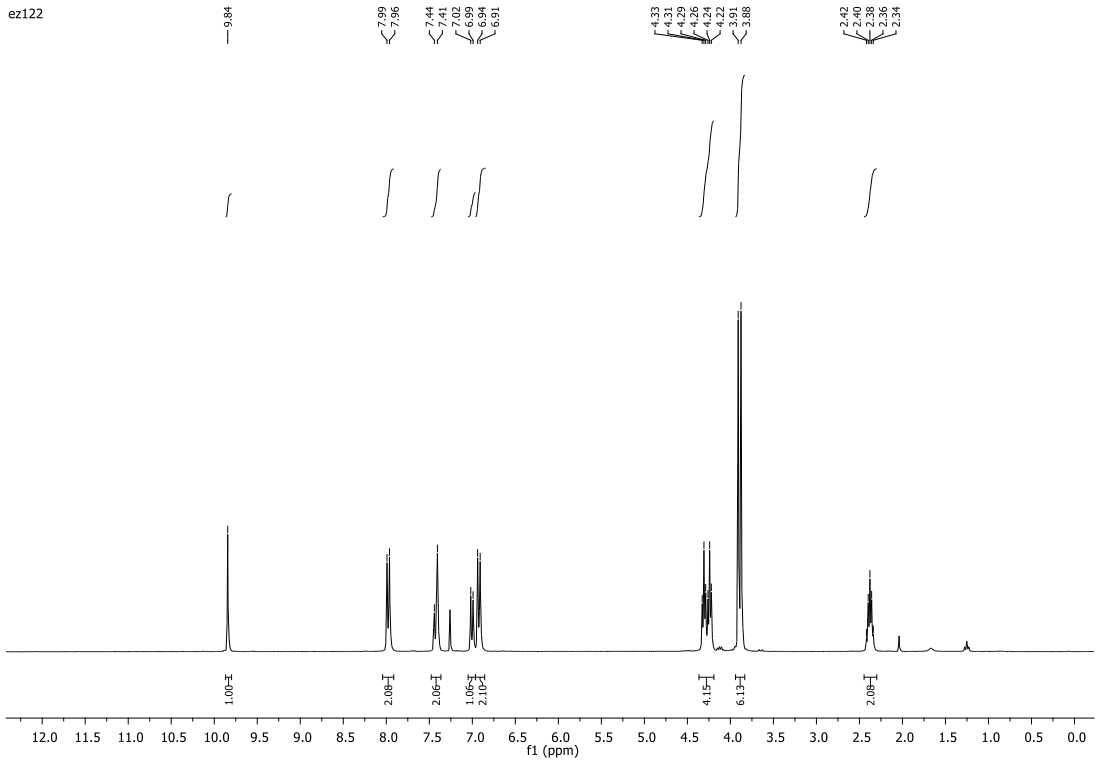


HRMS spectrum

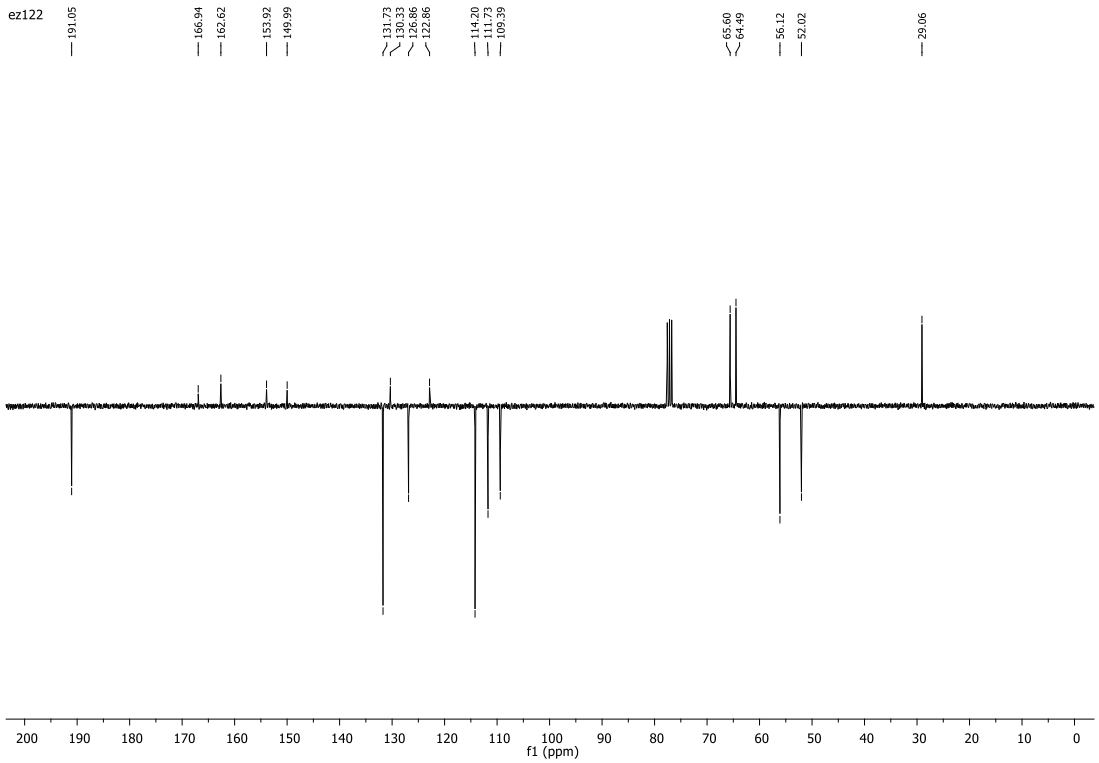


Methyl 4-[3-(4-formyl-2-methoxyphenoxy)propoxy]benzoate (**21e**)

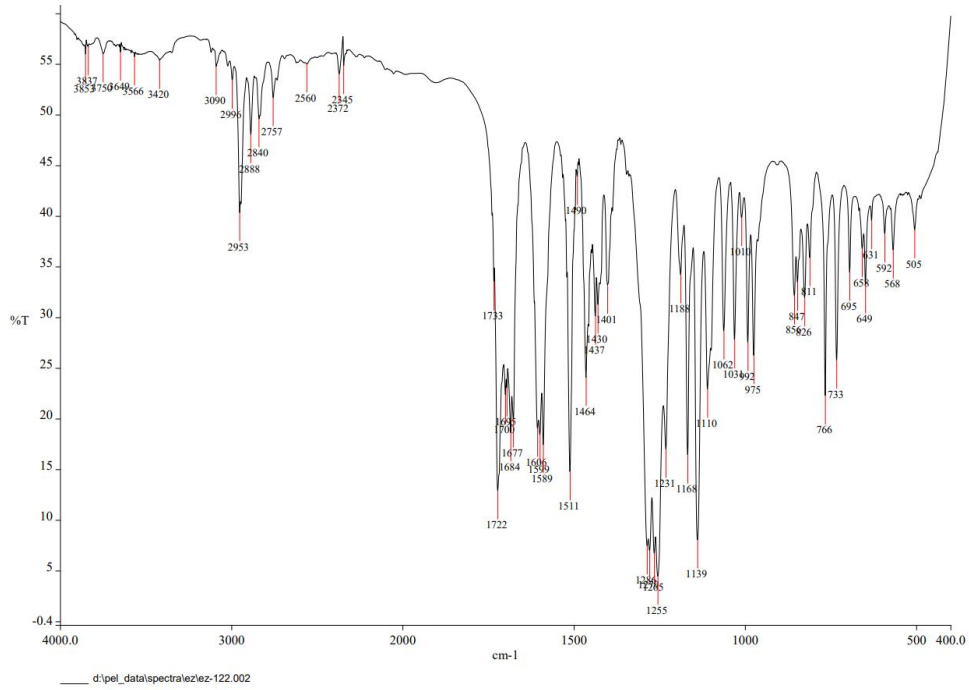
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



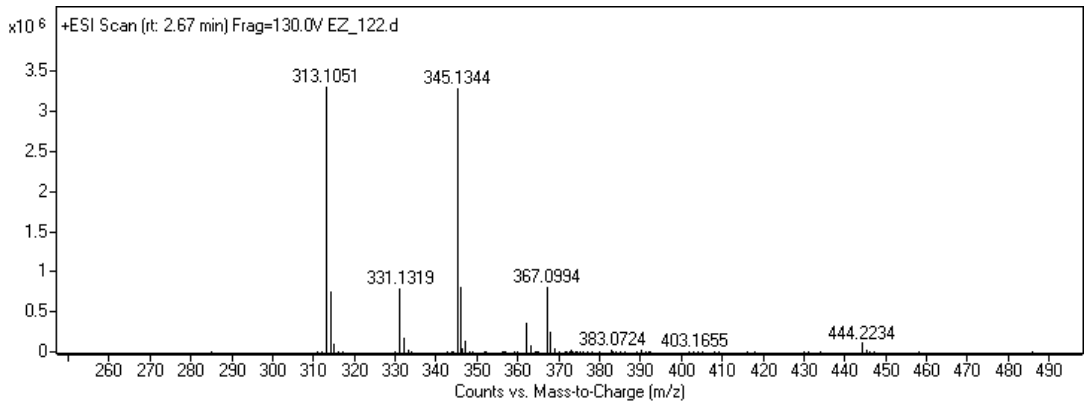
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

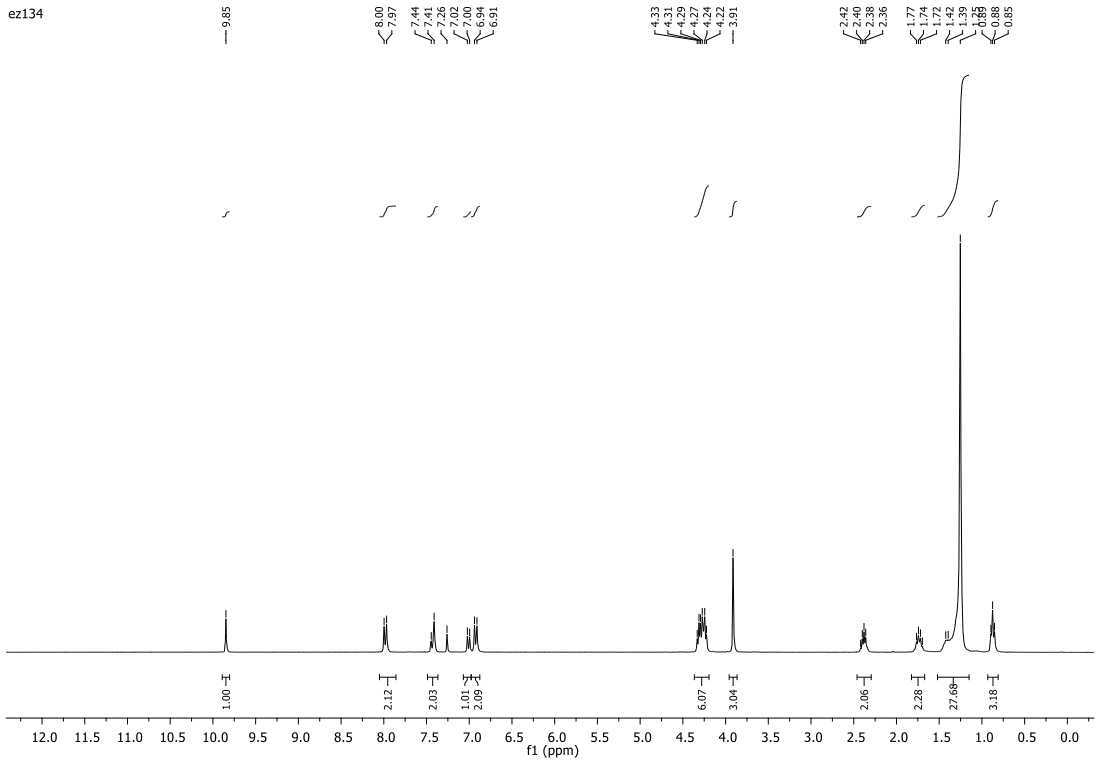


HRMS spectrum

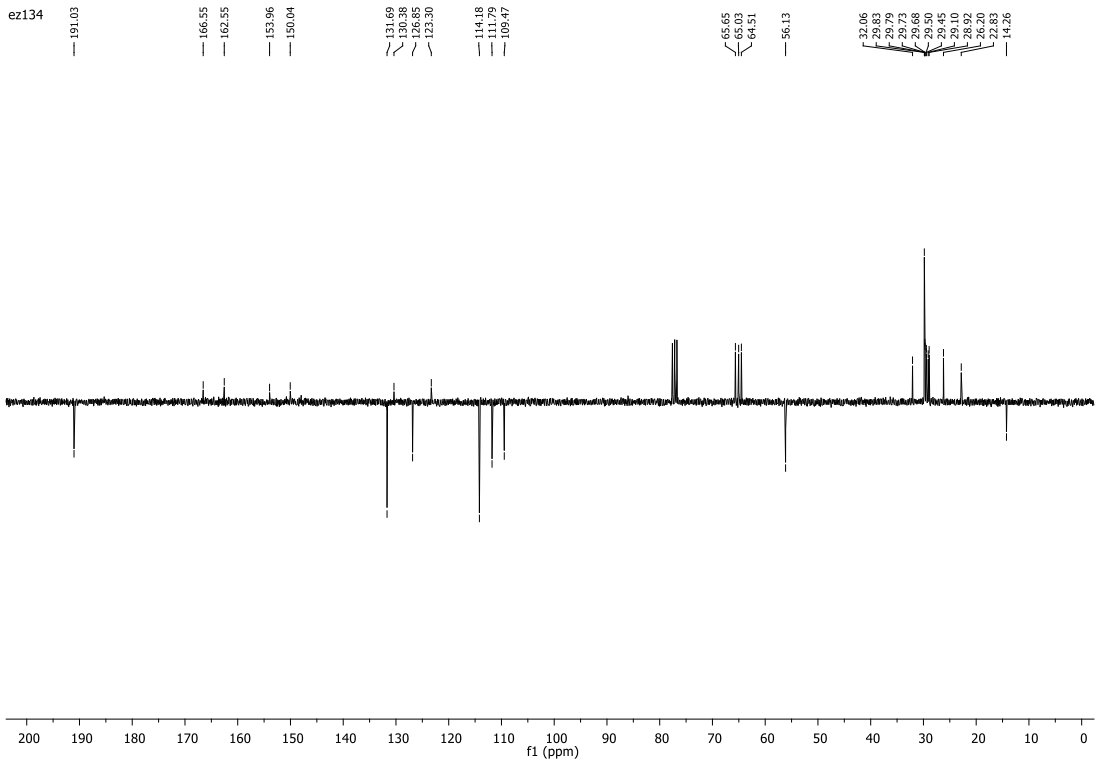


Cetyl 4-[3-(4-formyl-2-methoxyphenoxy)propoxy]benzoate (**21f**)

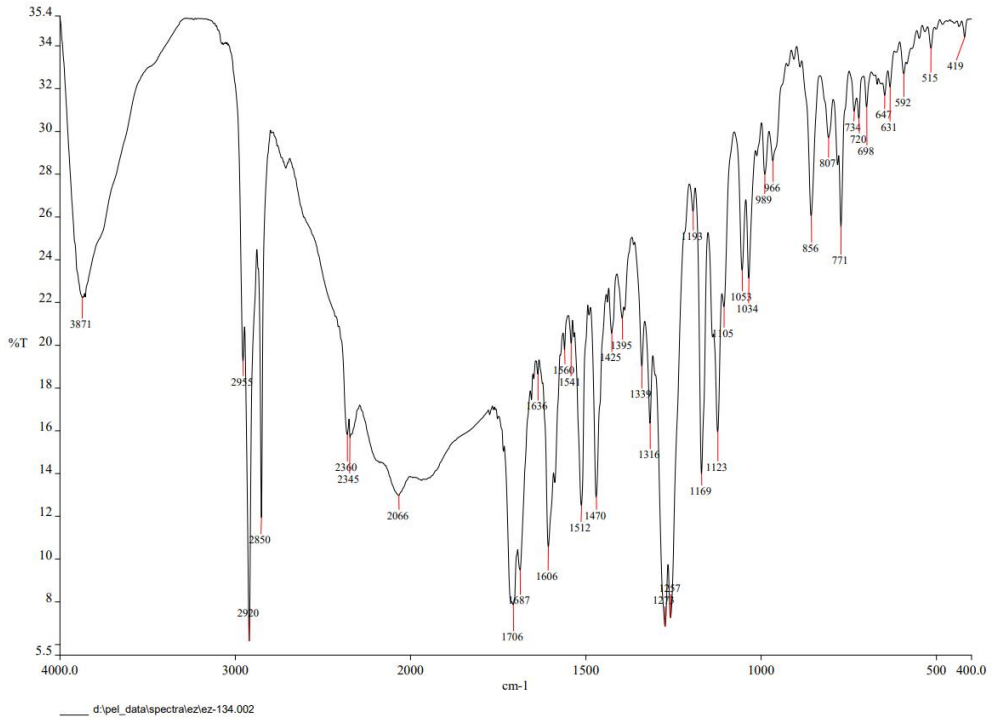
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



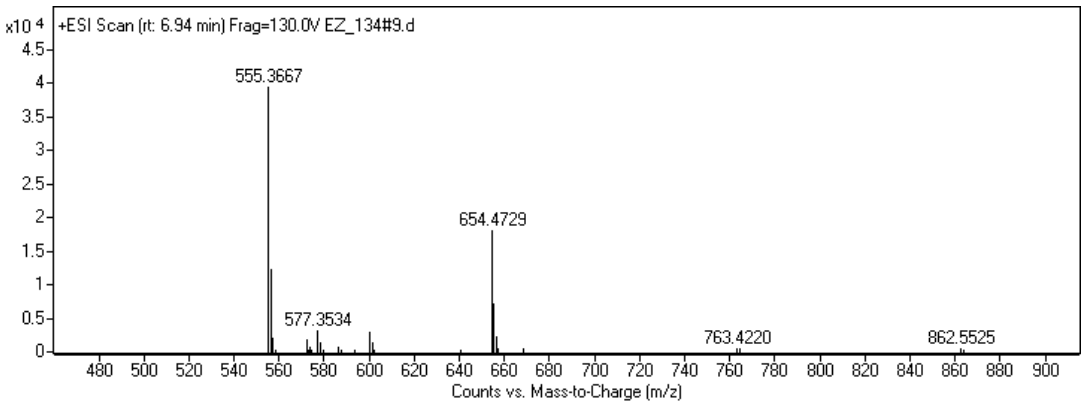
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

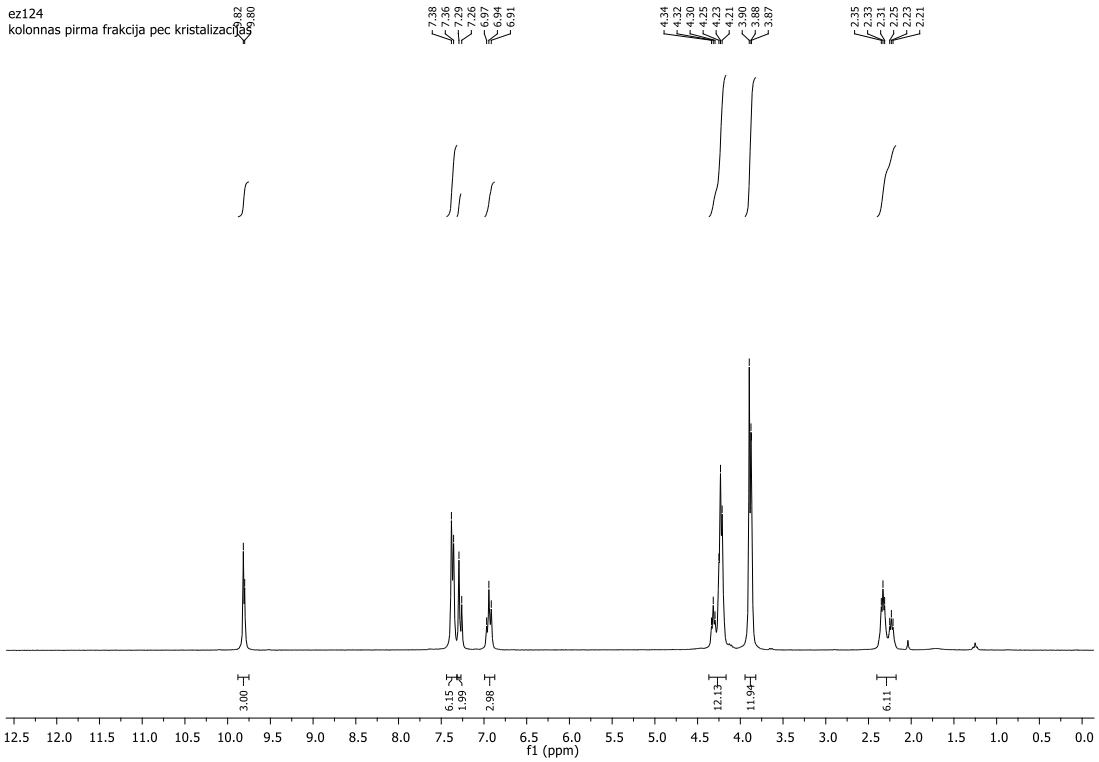


HRMS spectrum

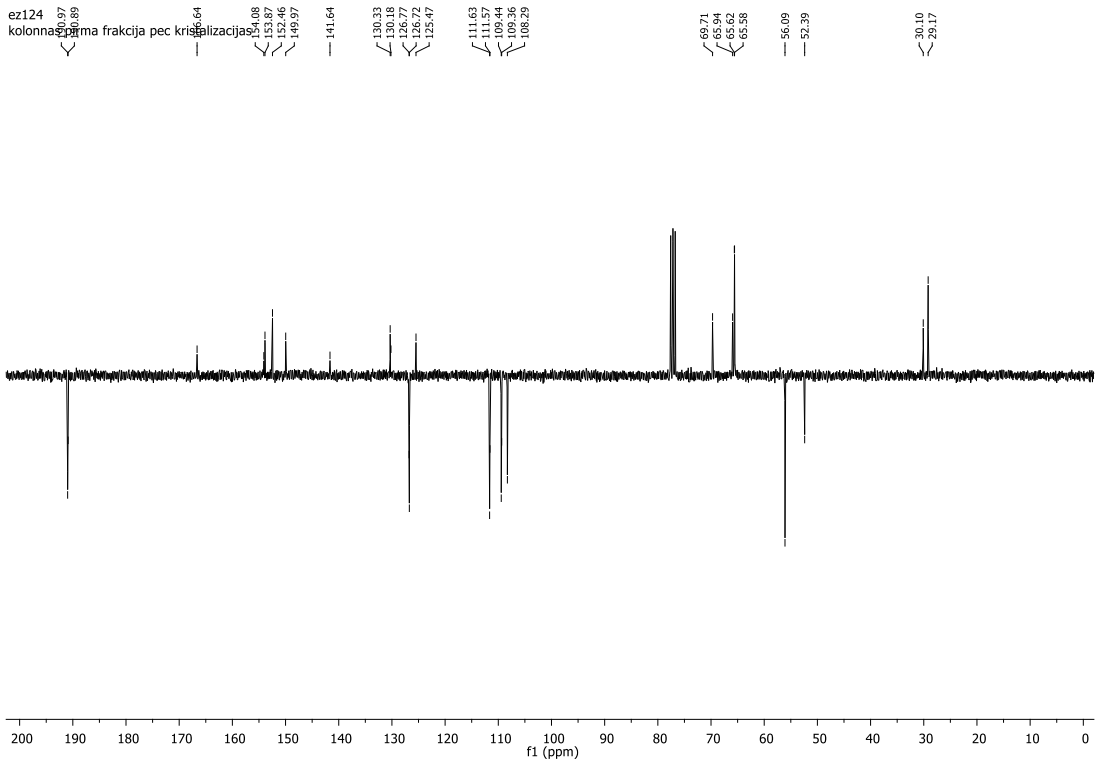


Methyl 3,4,5-tris[3-(4-formyl-2-methoxyphenoxy)propoxy]-benzoate (**21g**)

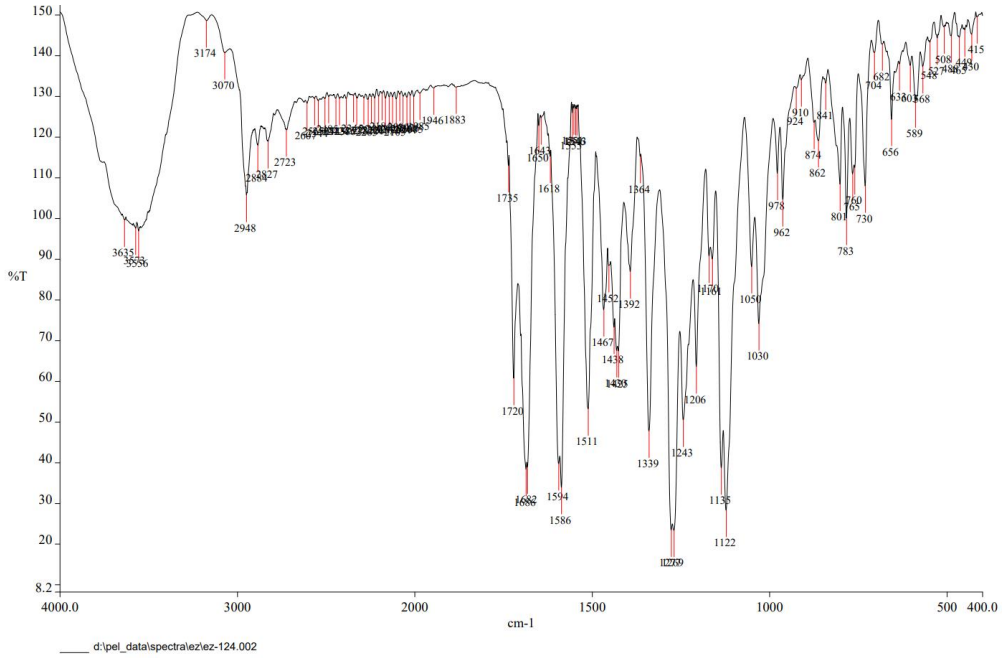
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

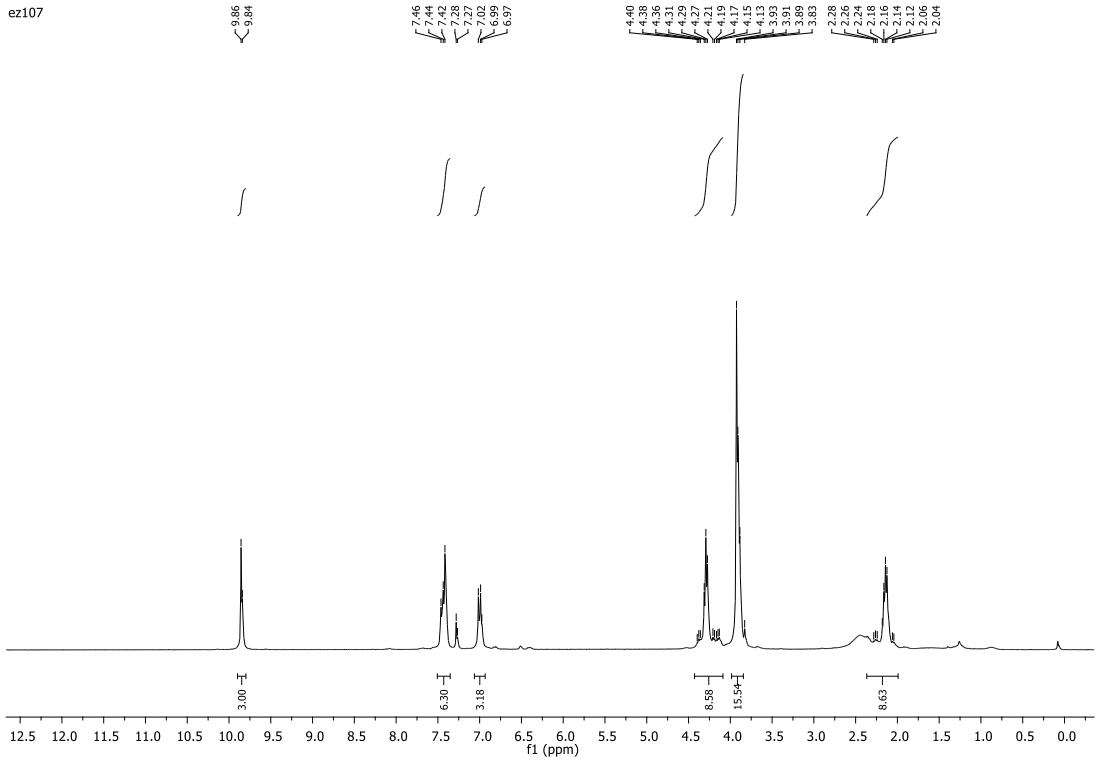


IR spectrum (KBr)

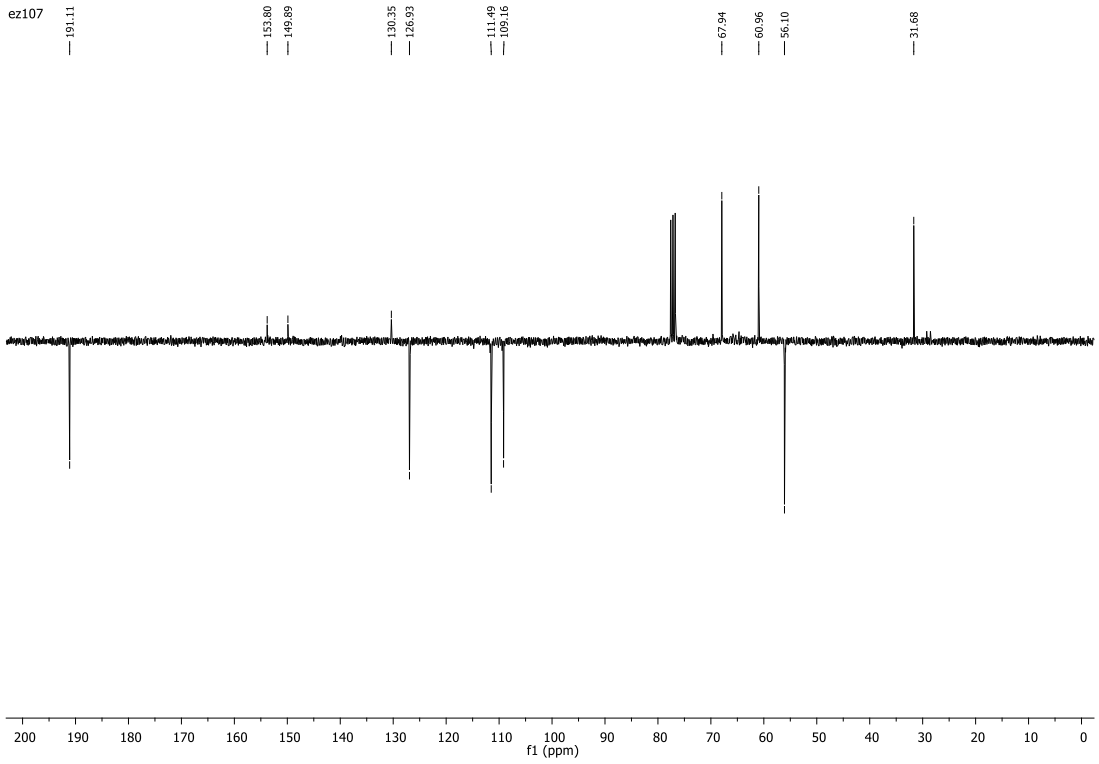


Glycerol – aldehyde conjugate **21i**

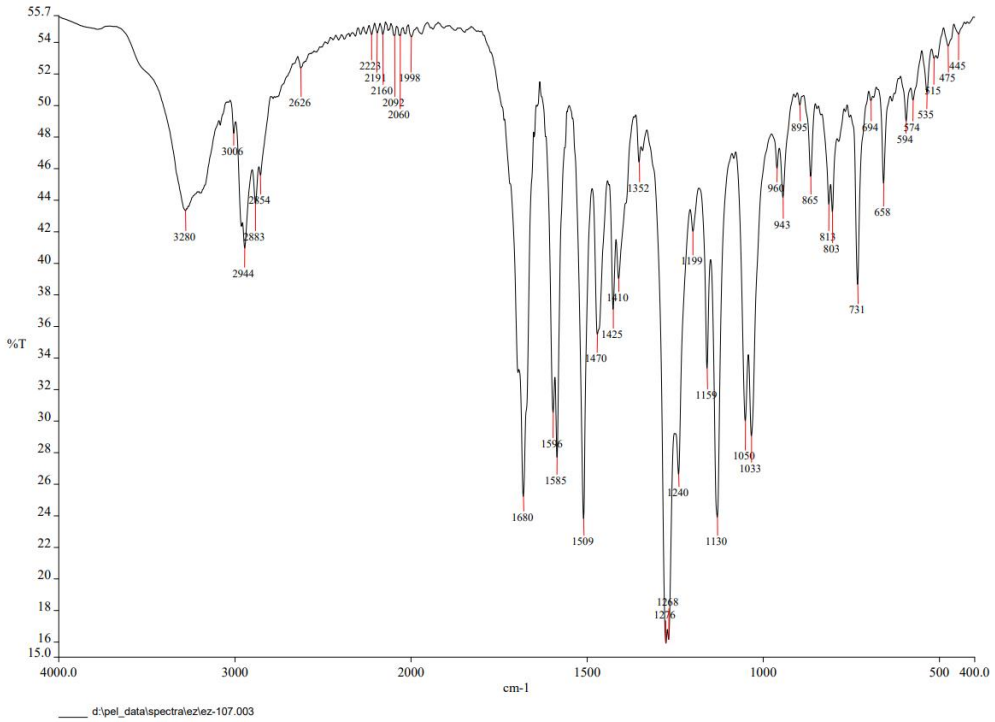
^{1}H NMR spectrum $CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

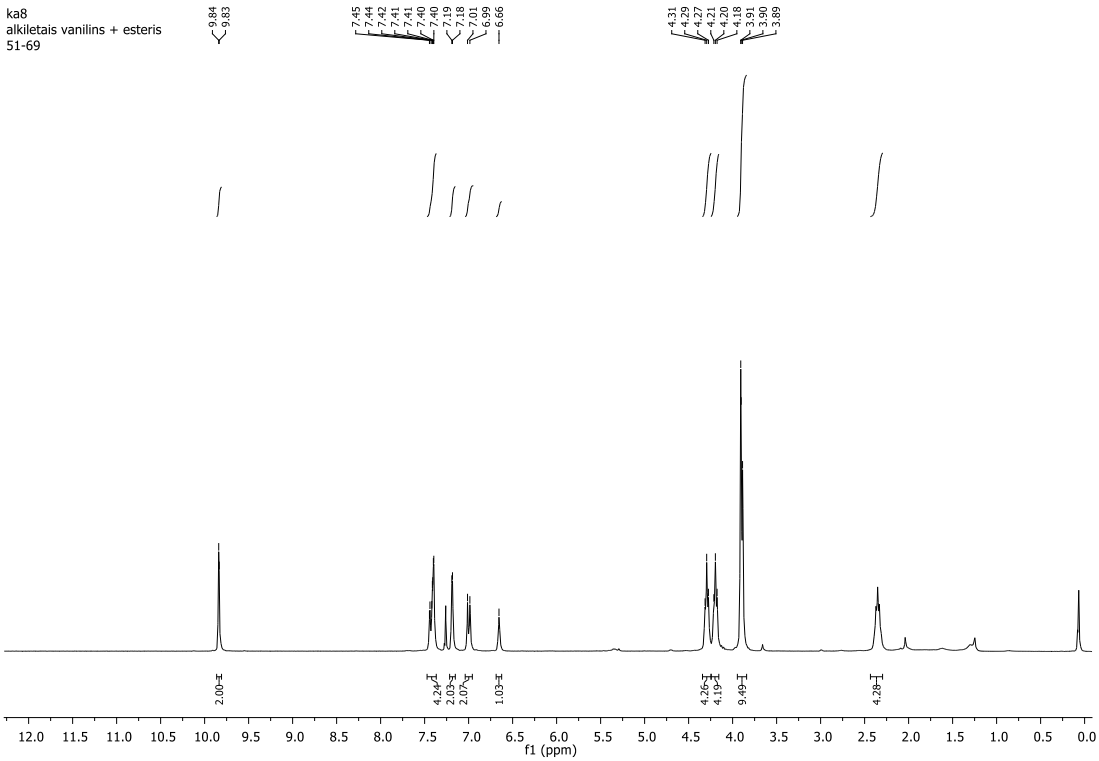


IR spectrum (KBr)

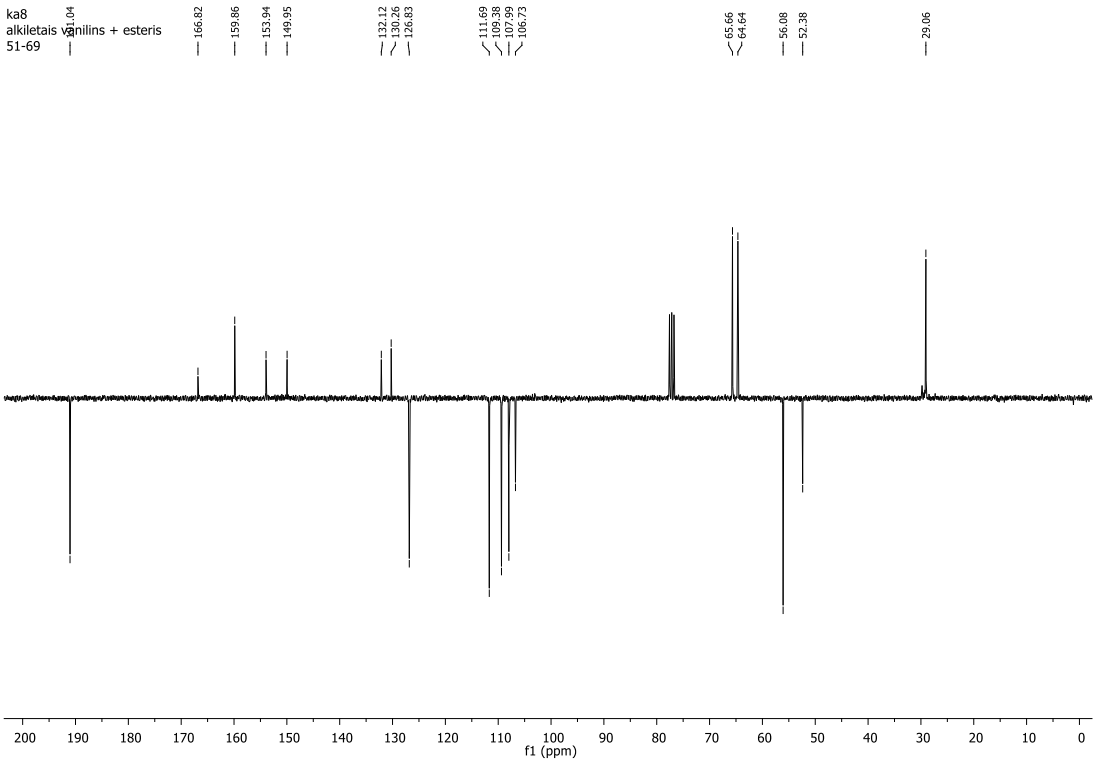


Methyl 3,5-di[3-(4-formyl-2-methoxyphenoxy)propoxy]-benzoate (**21h**)

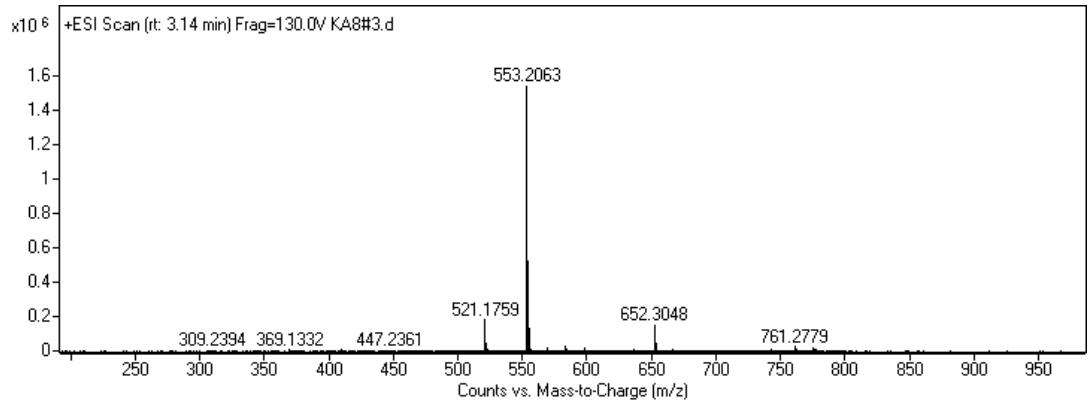
^{1}H NMR spectrum (300 MHz, $CDCl_3$)



^{13}C NMR spectrum (75 MHz, $CDCl_3$)

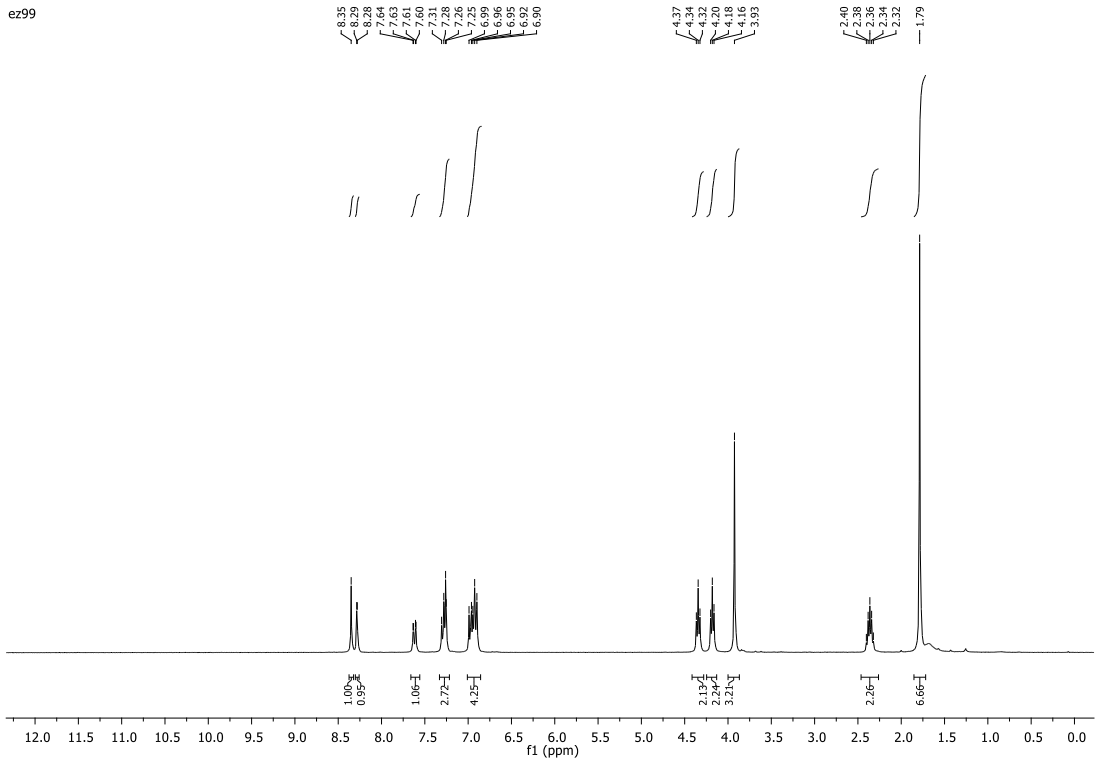


HRMS spectrum

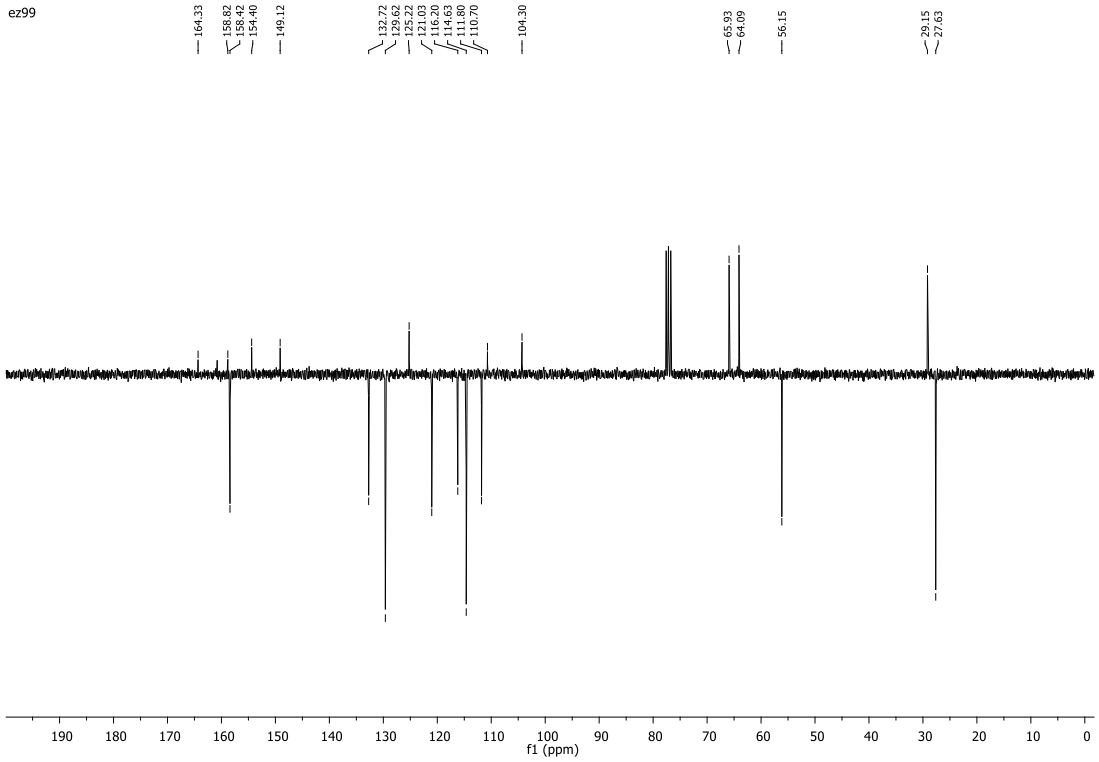


5-(3-Methoxy-4-(3-phenoxypropoxy)benzylidene)-2,2-dimethyl-1,3-dioxane-4,6-dione (**23a**)

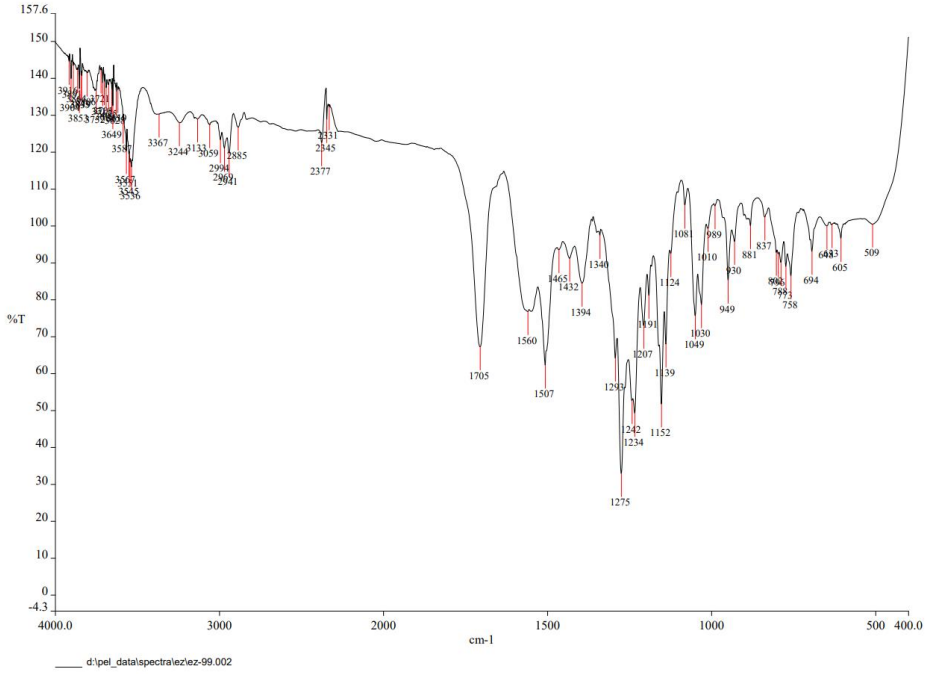
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



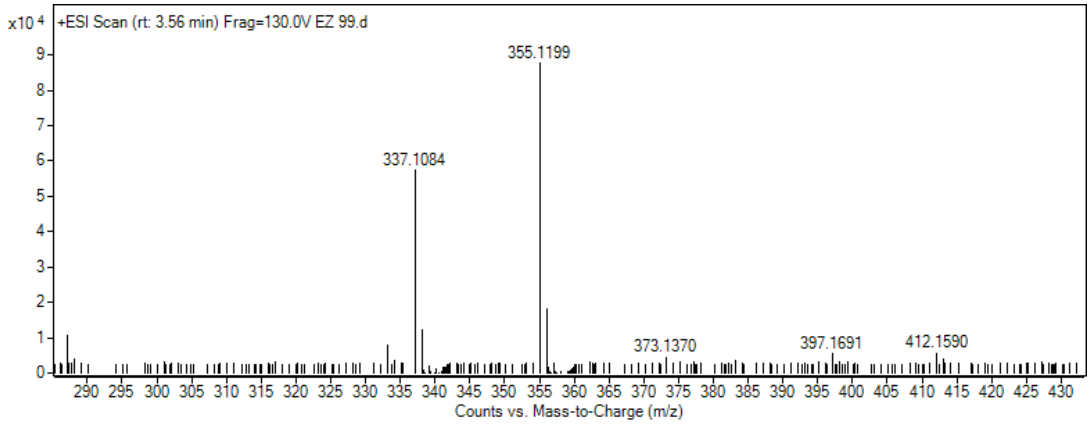
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum

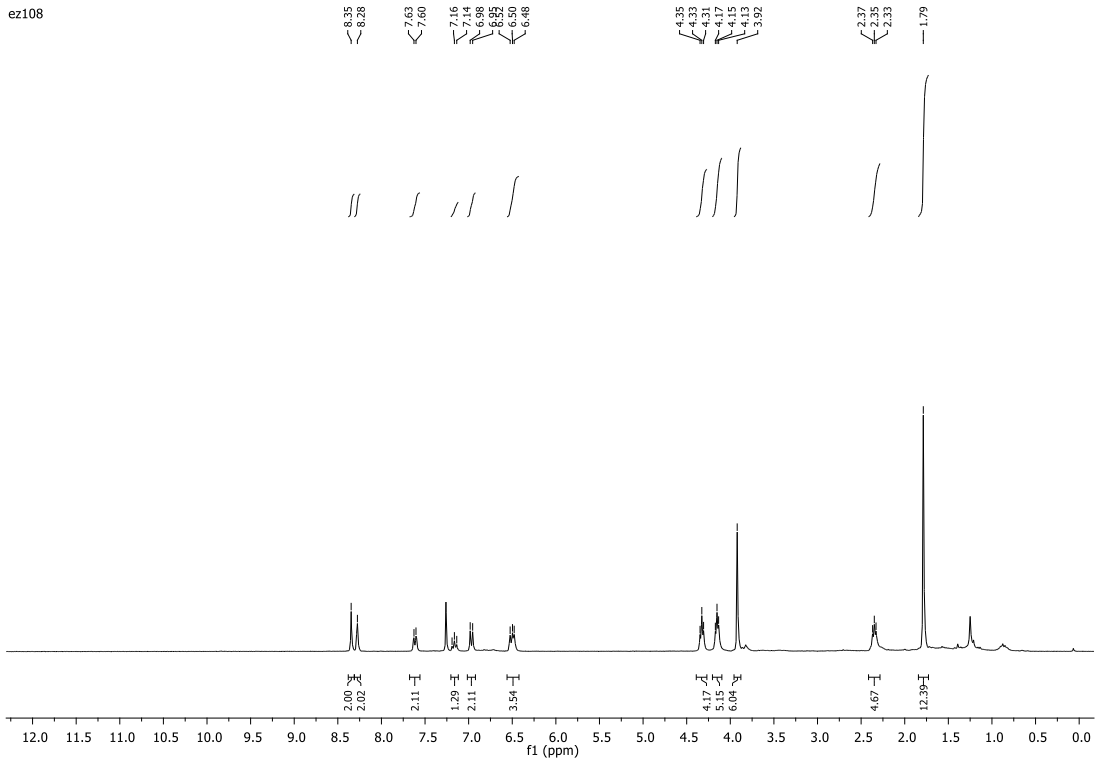


HRMS spectrum

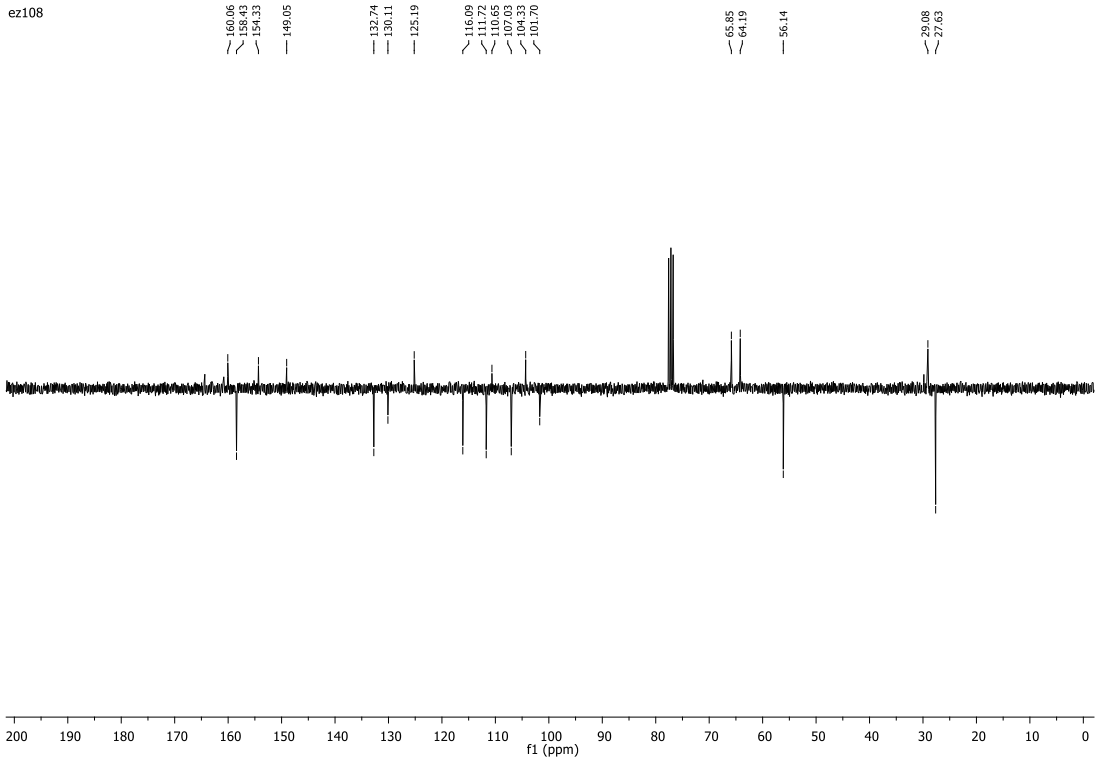


Resorcinol – arylidene Meldrum`s acid conjugate **23b**

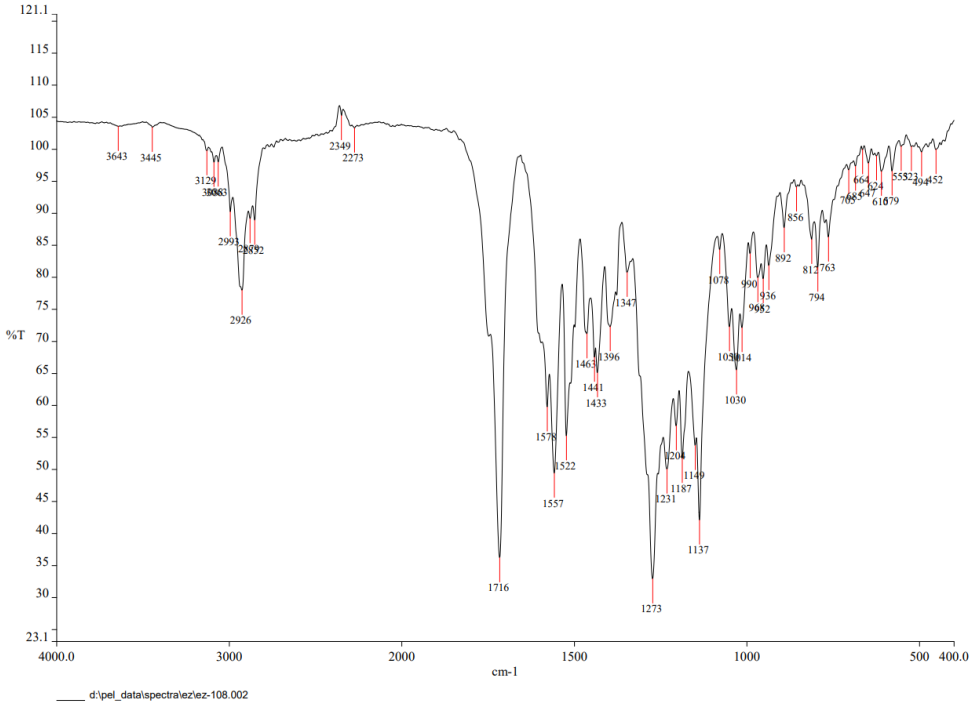
^{1}H NMR spectrum ($CDCl_3$, 300 MHz), δ, ppm



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

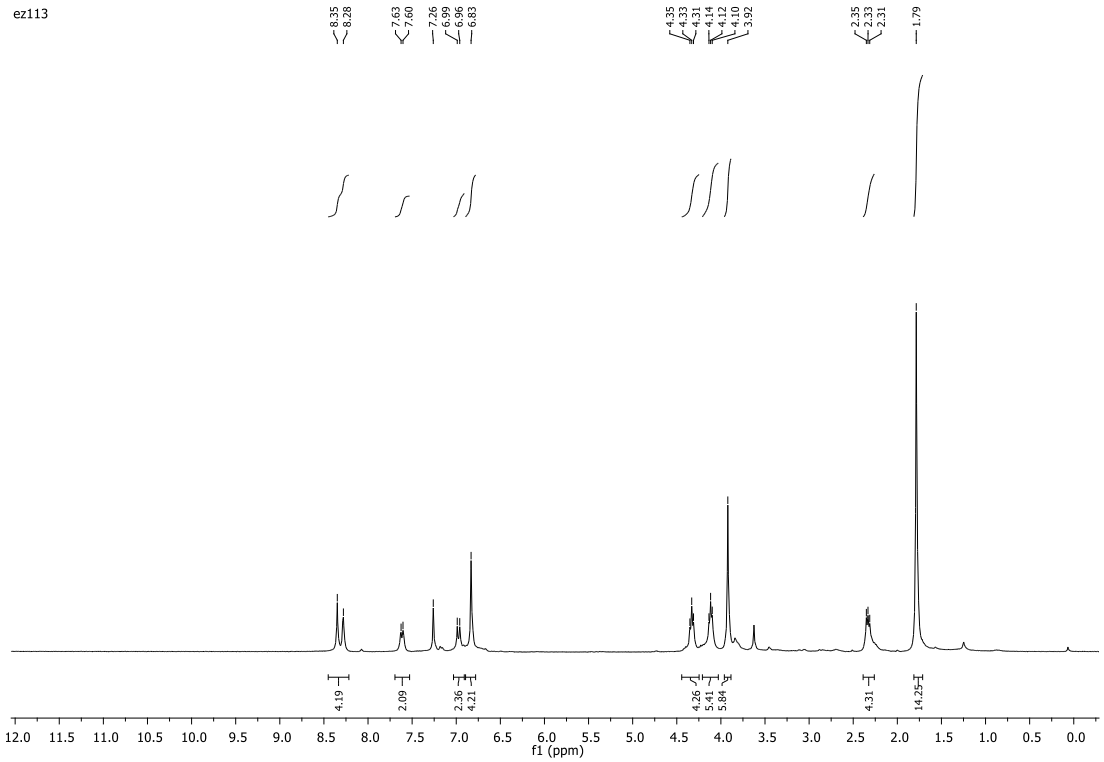


IR spectrum (KBr)

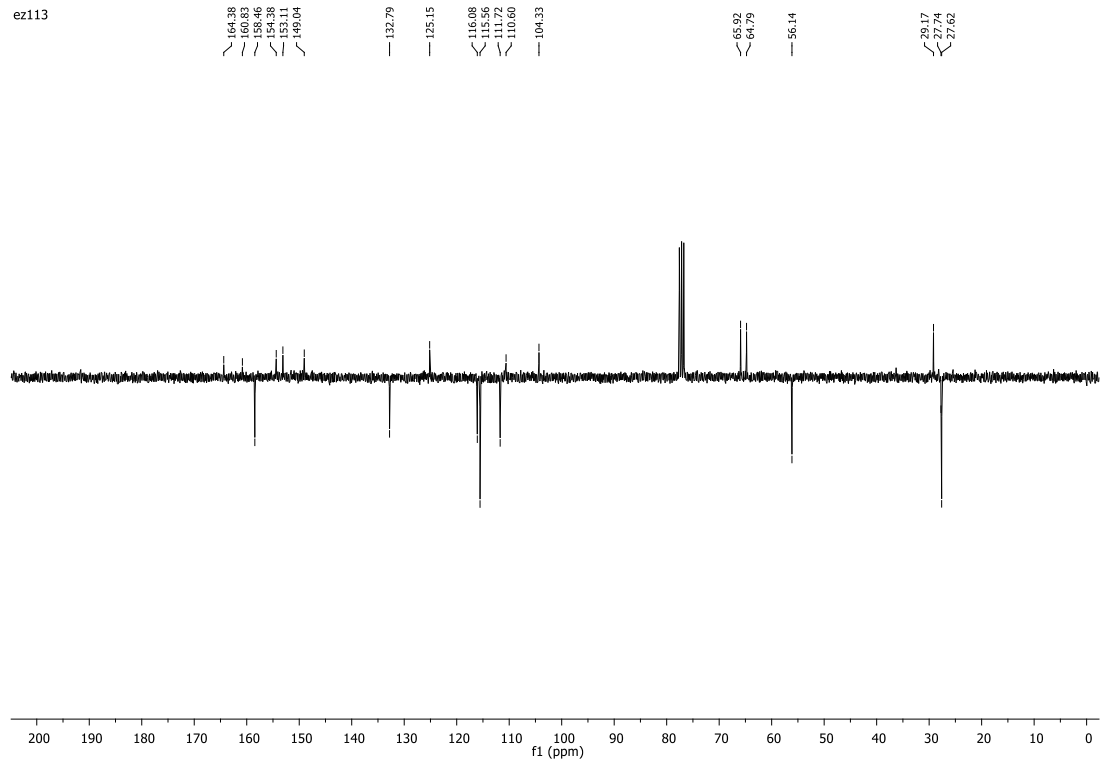


Quinol – arylidene Meldrum`s acid conjugate **23c**

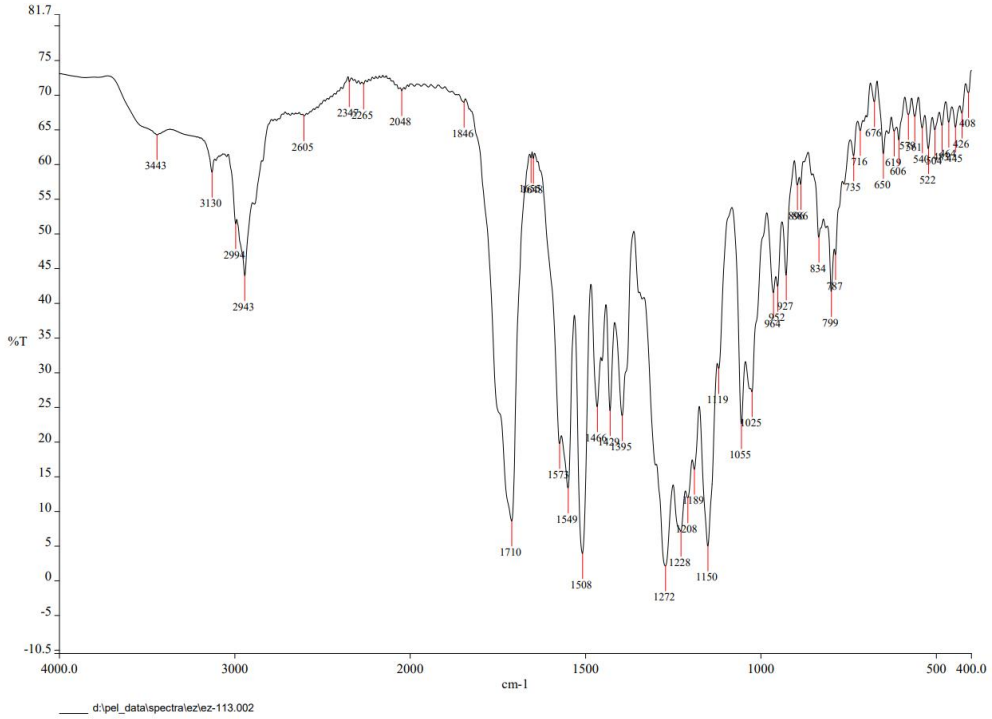
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



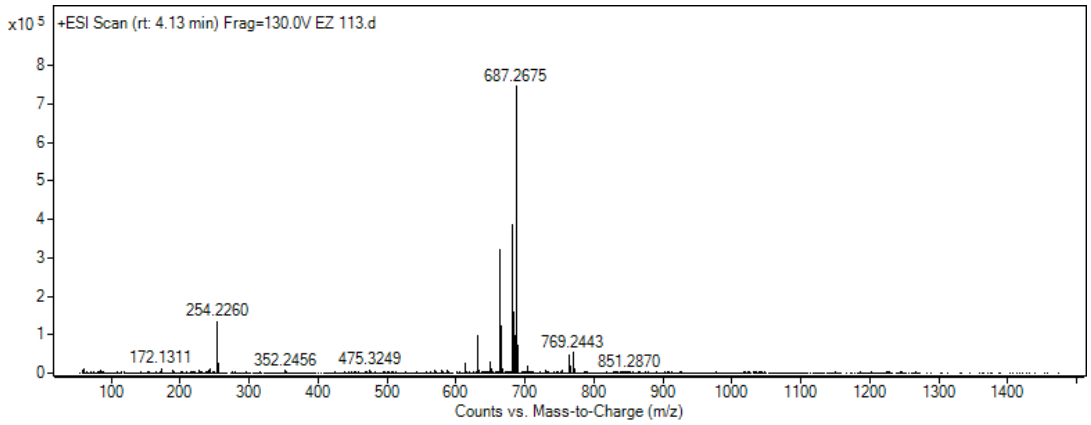
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

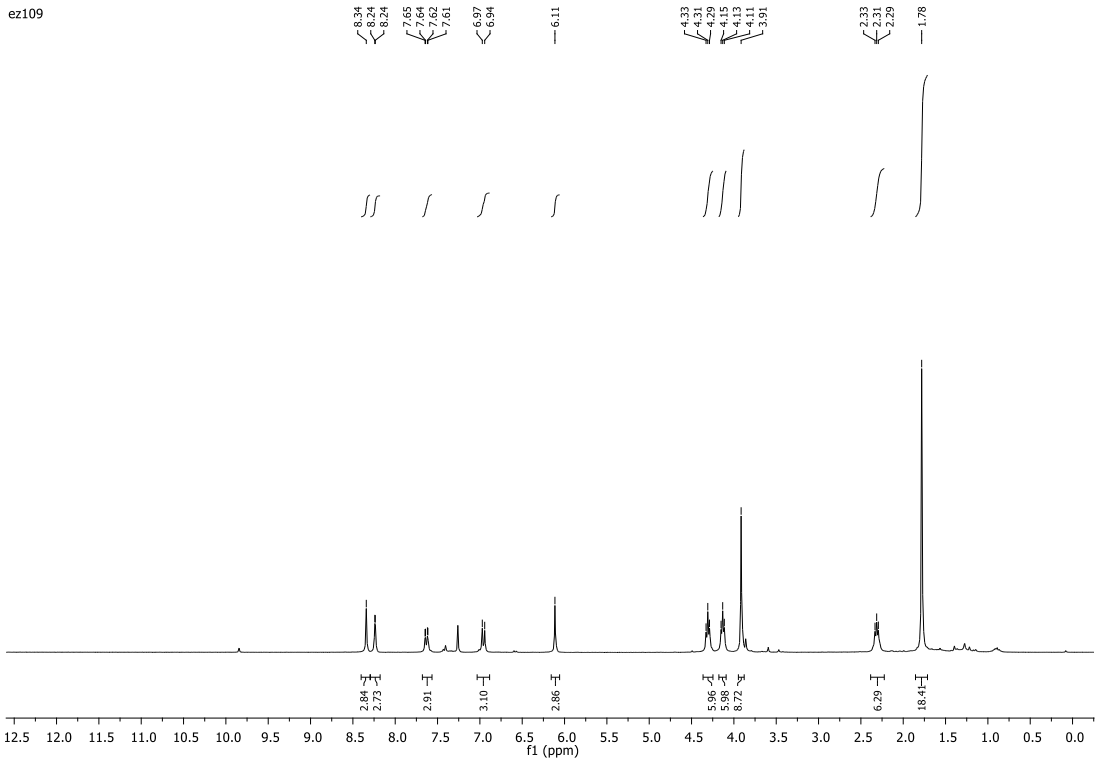


HRMS spectrum

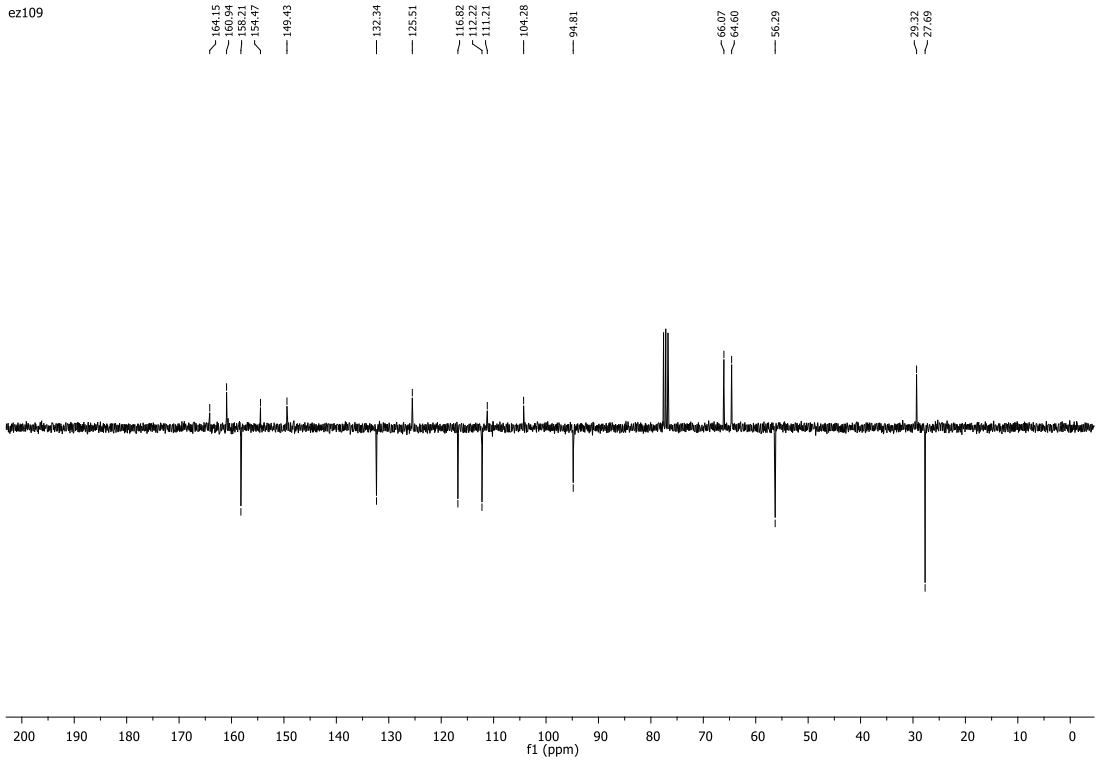


Phloroglucinol – arylidene Meldrum`s acid conjugate **23d**

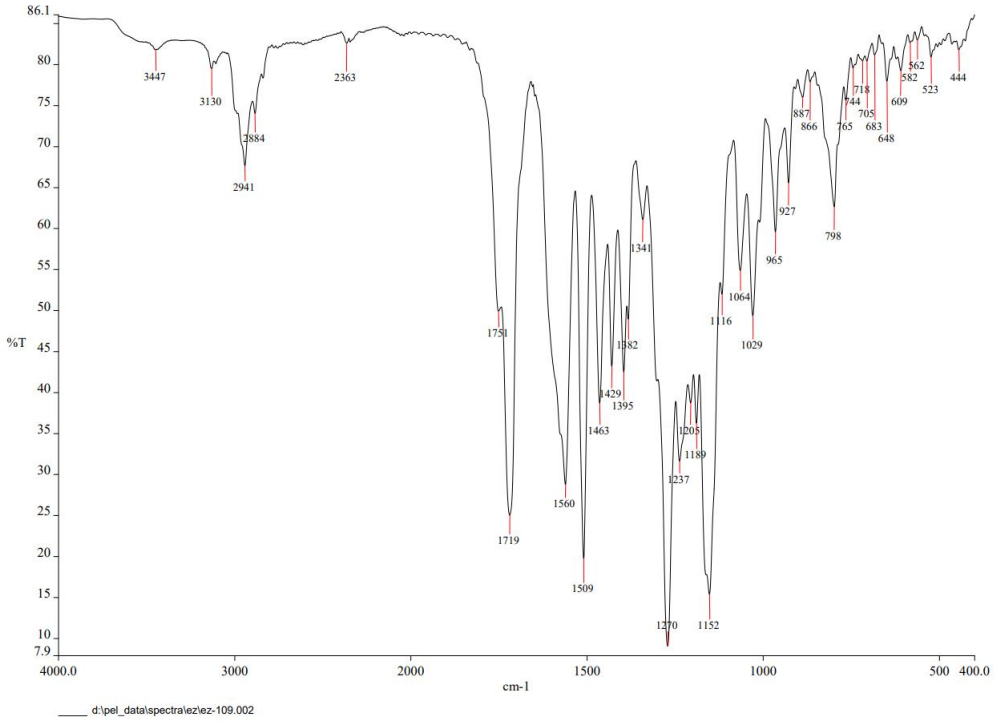
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



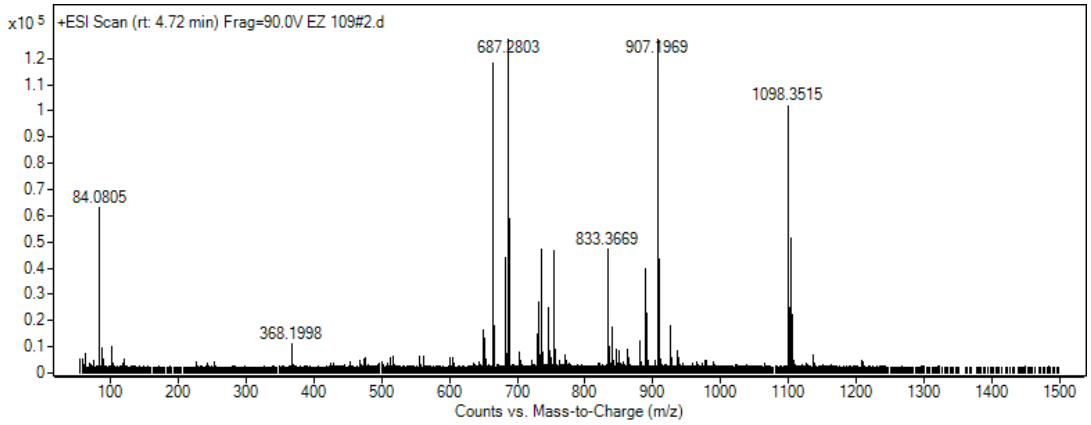
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

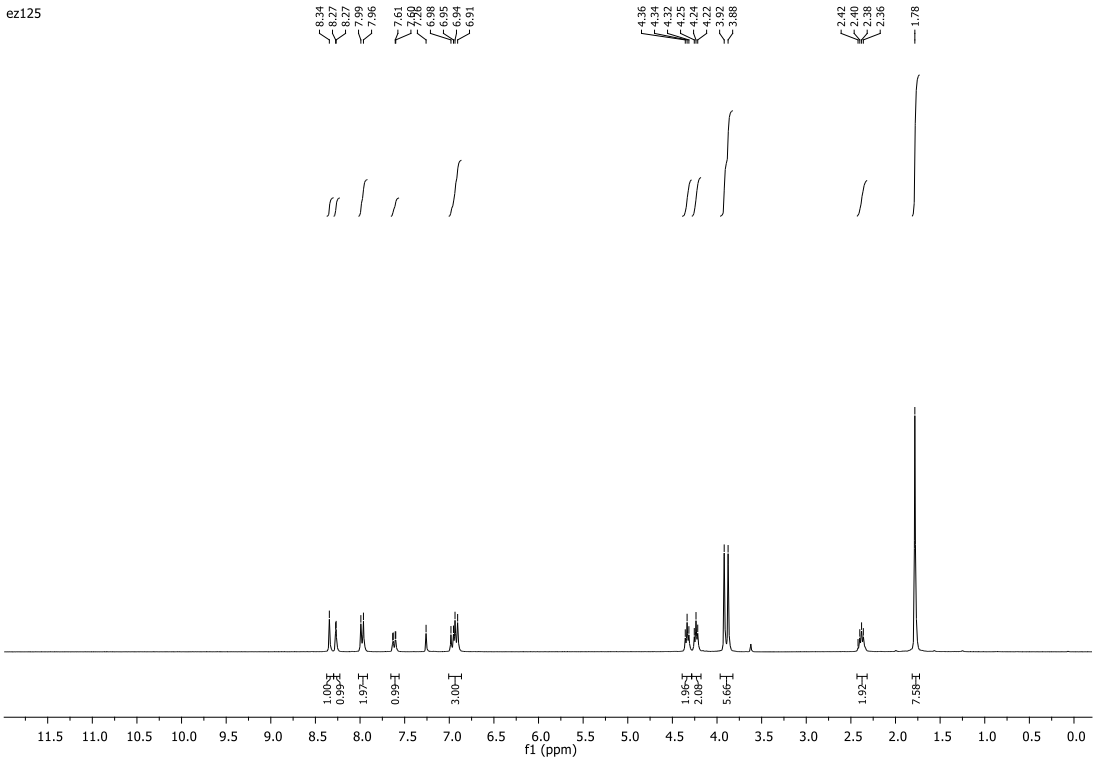


HRMS spectrum

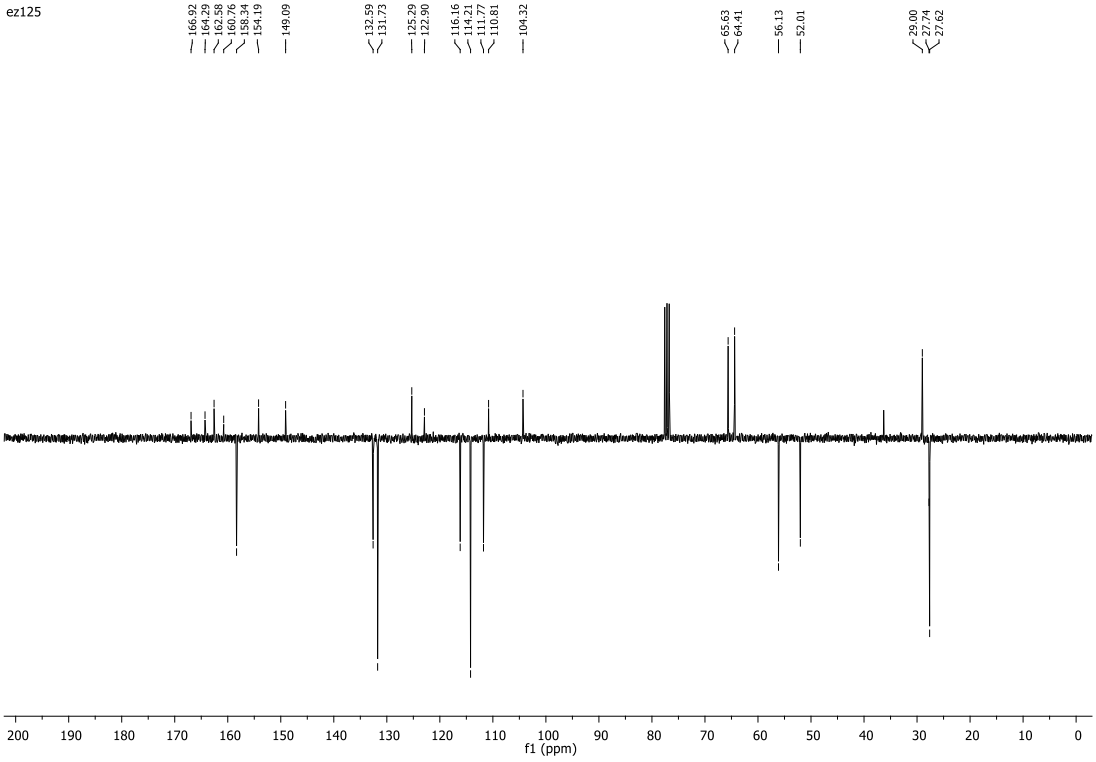


5-{4-[3-(4-Methoxycarbonylphenoxy)propoxy]-3-methoxybenzylidene}-2,2-dimethyl-1,3-dioxane-4,6-dione (**23e**)

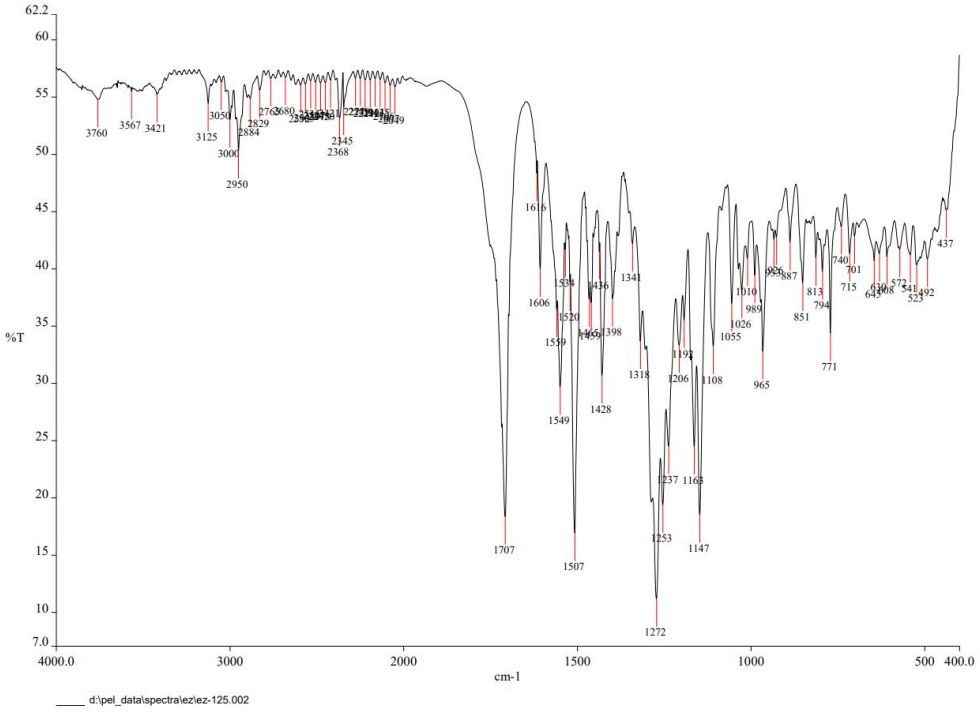
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



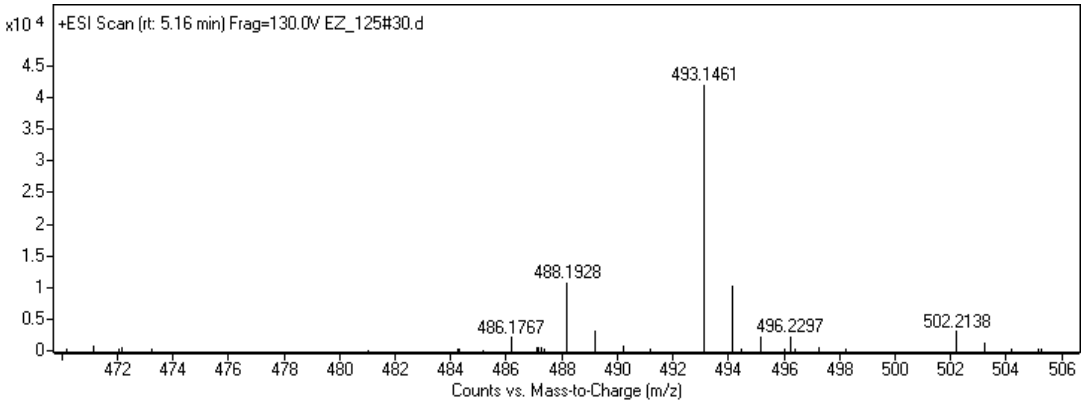
^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



IR spectrum (KBr)

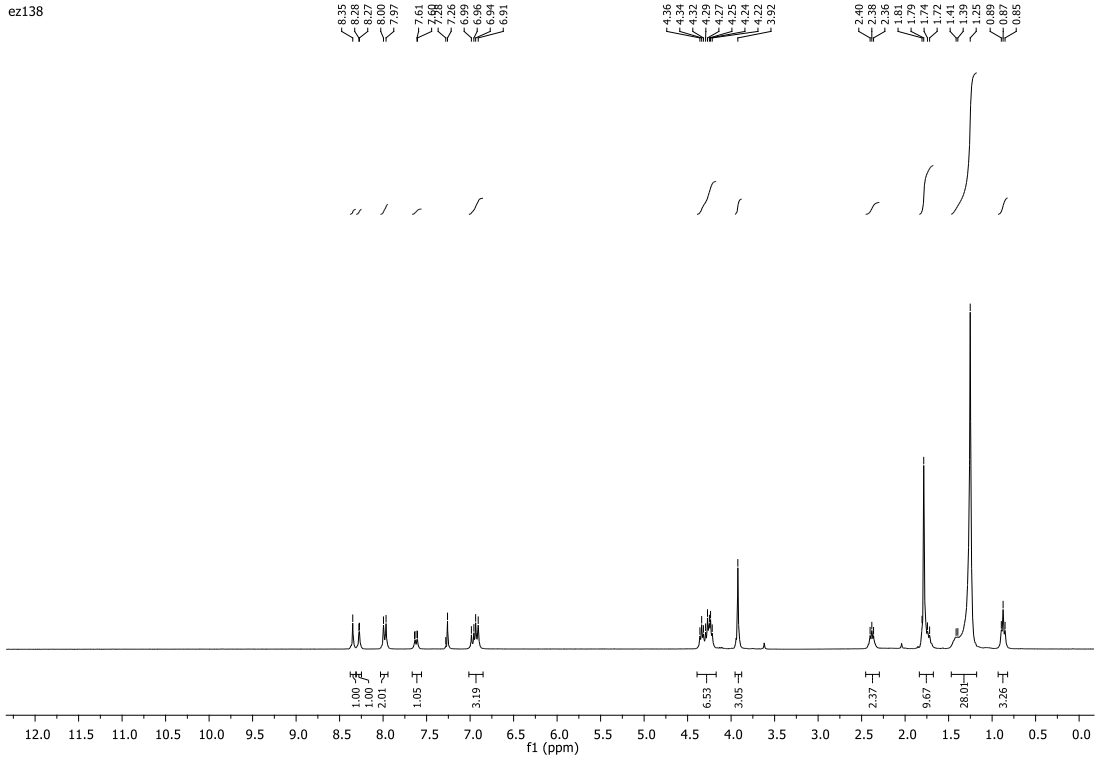


HRMS spectrum

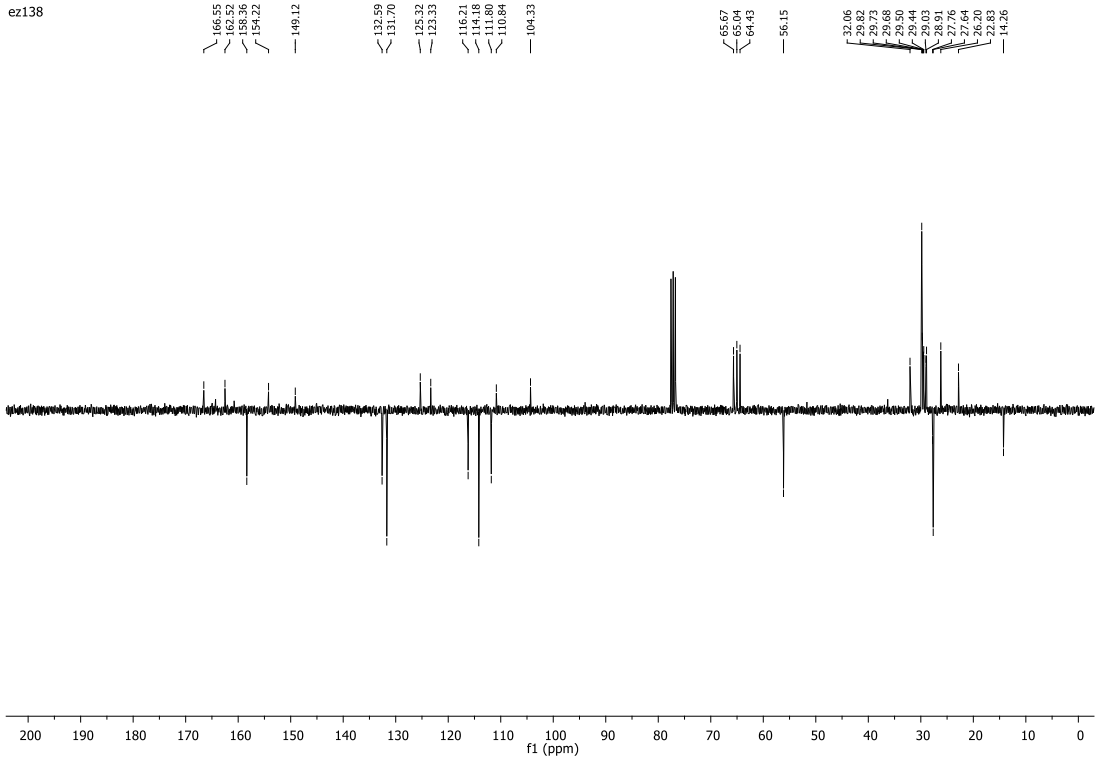


5-{4-[3-(4-Cetoxycarbonylphenoxy)propoxy]-3-methoxybenzylidene}-2,2-dimethyl-1,3-dioxane-4,6-dione (**23f**)

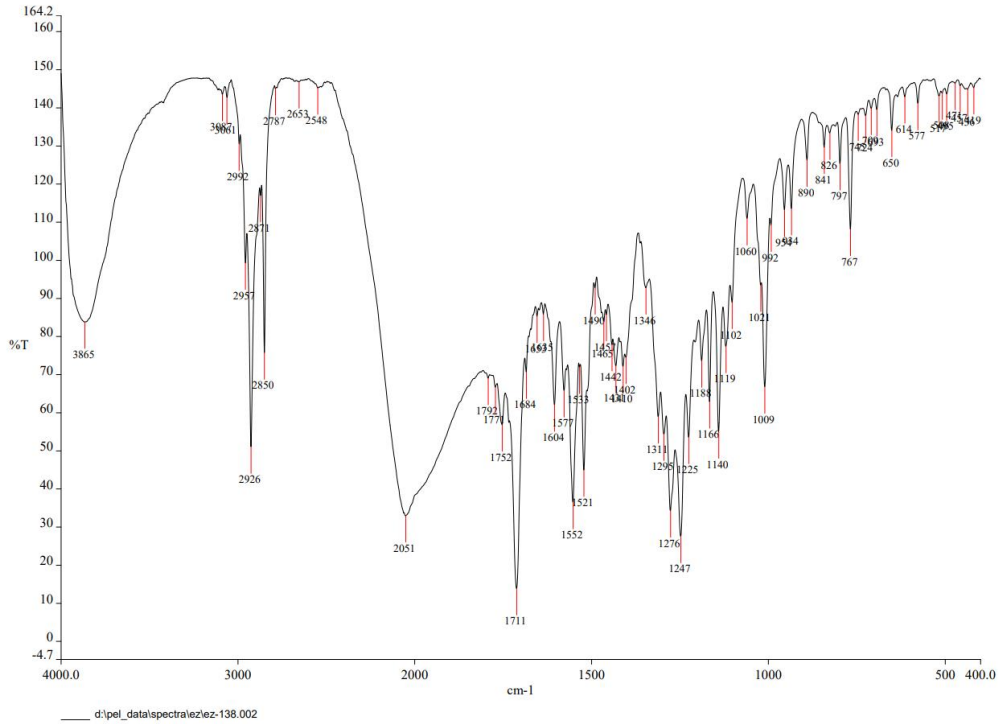
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

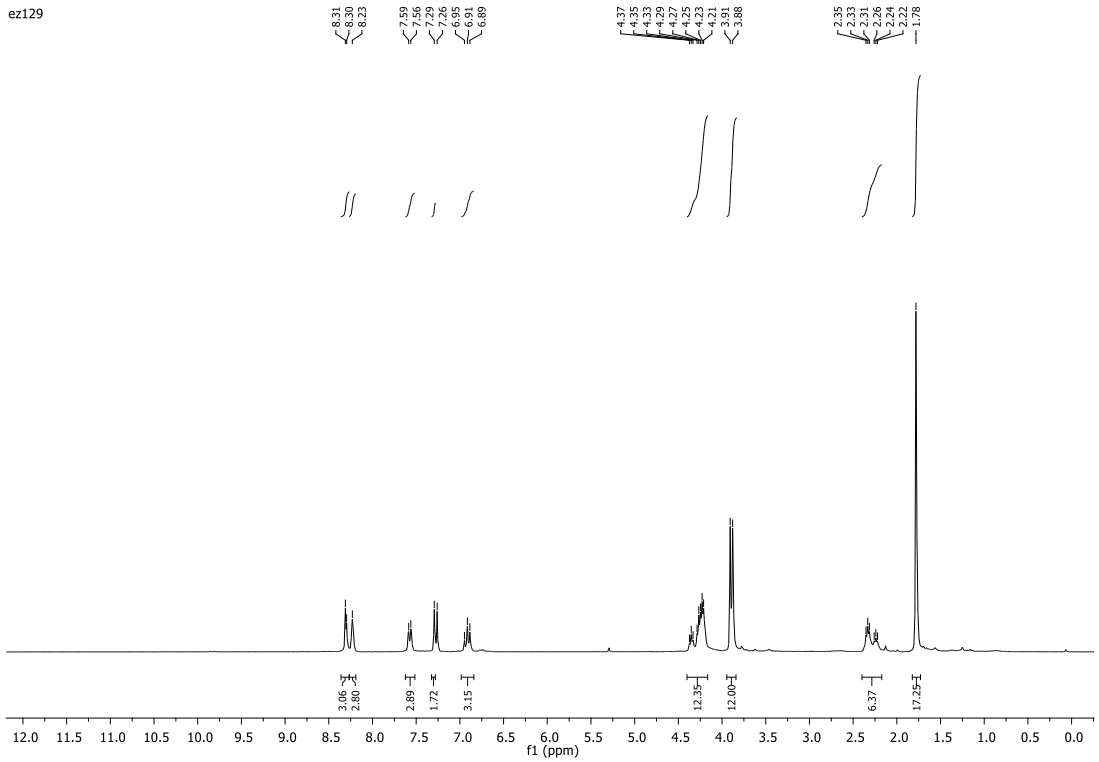


IR spectrum (KBr)

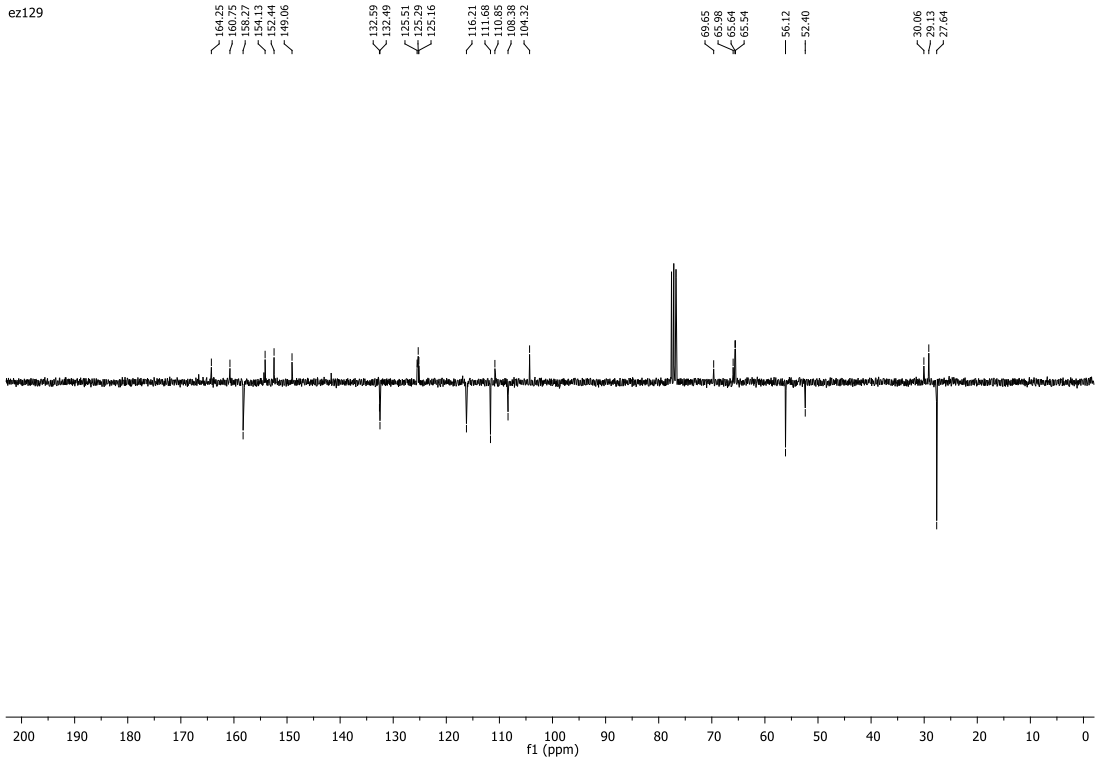


Methyl gallate – arylidene Meldrum`s acid conjugate (**23g**)

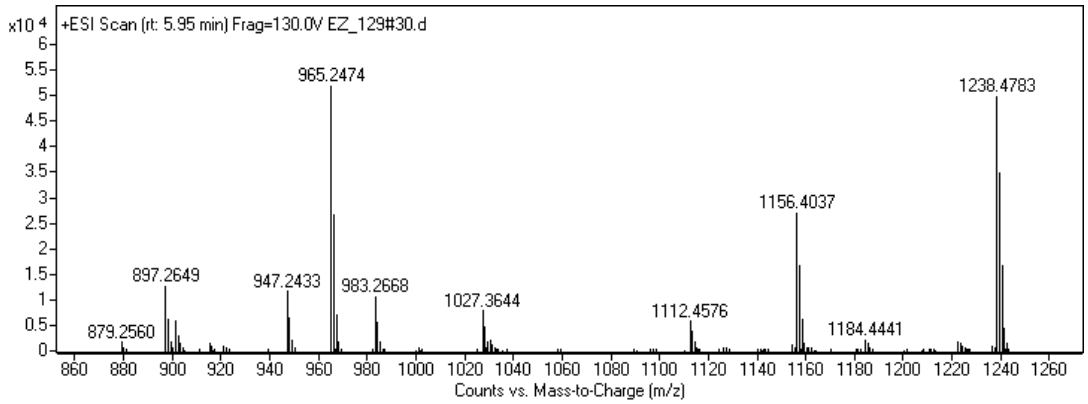
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

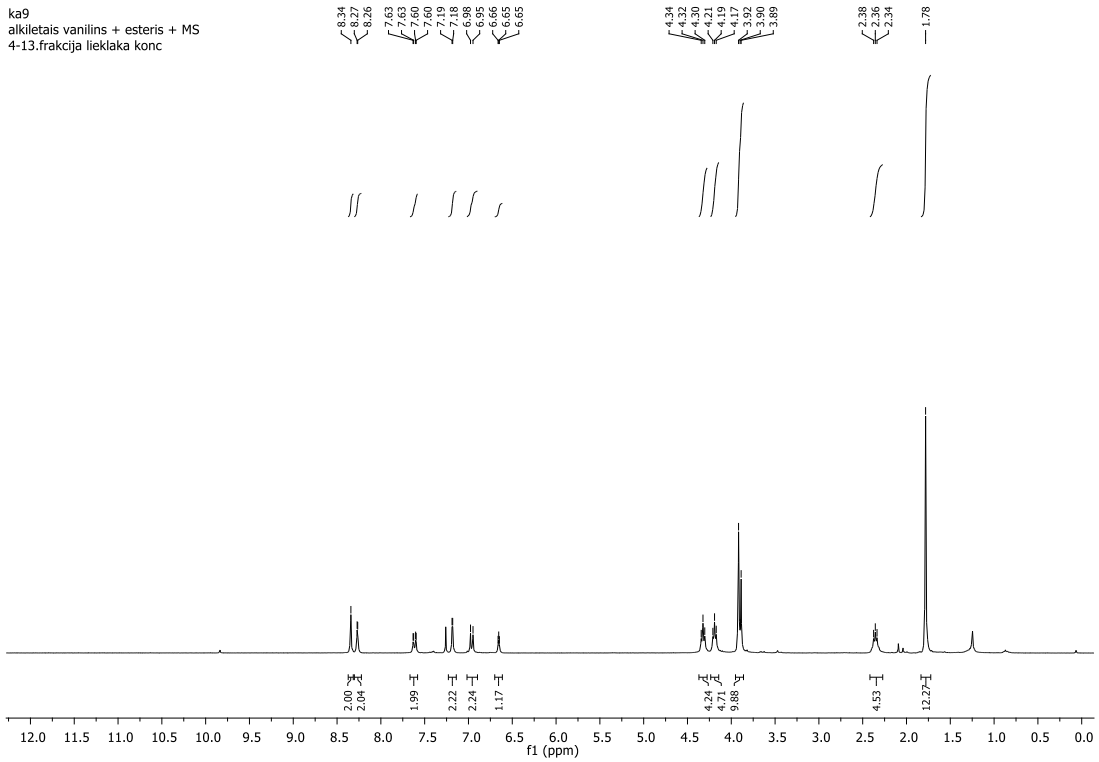


HRMS spectrum

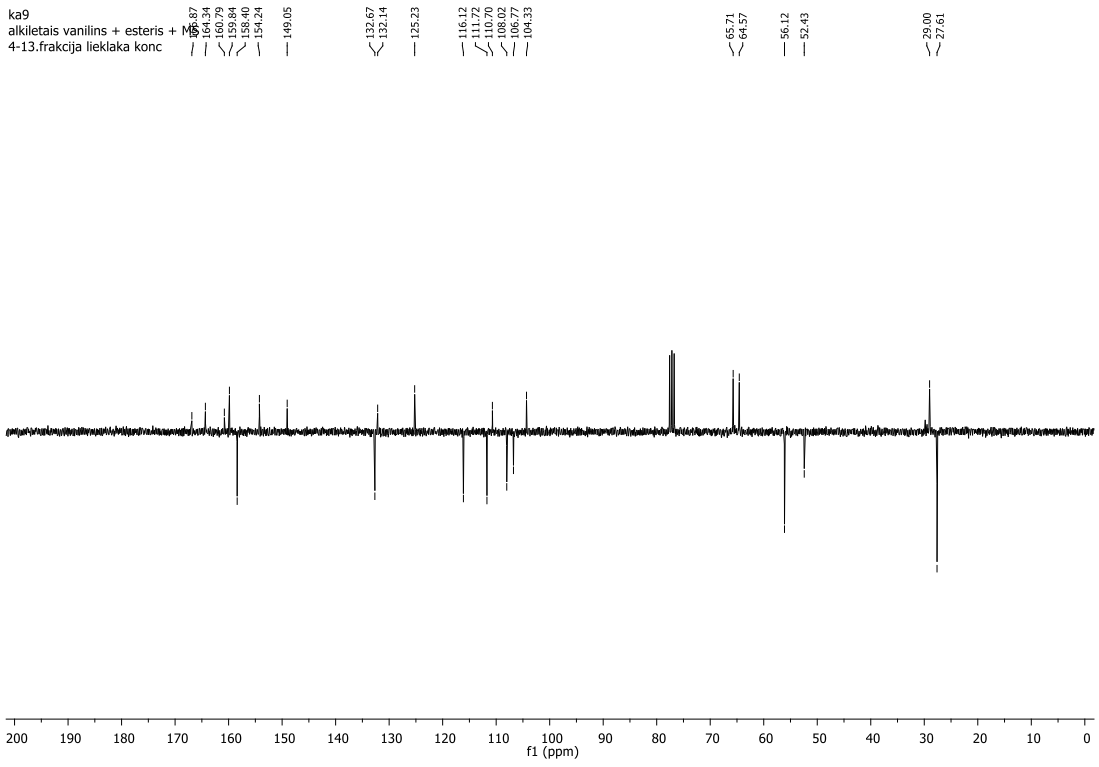


Methyl α-resorcylate – arylidene Meldrum`s acid conjugate **23h**

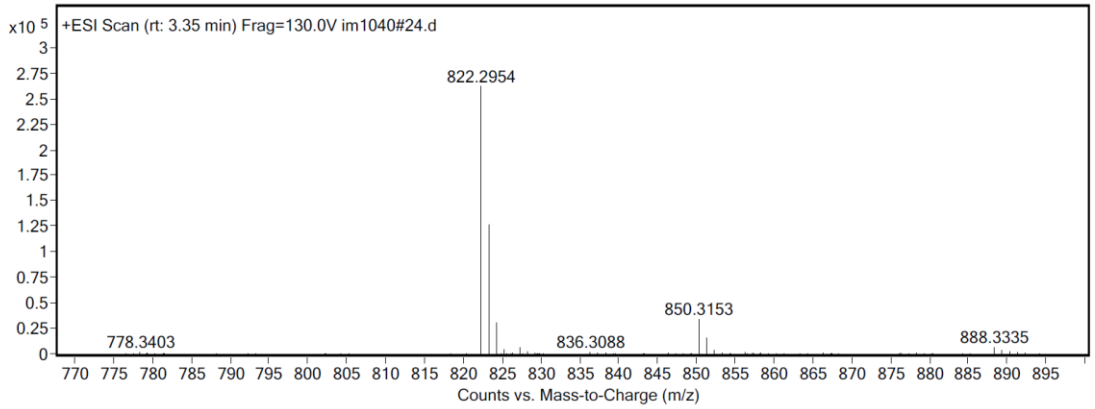
^{1}H NMR spectrum (300 MHz, $CDCl_3$)



^{13}C NMR spectrum (75 MHz, $CDCl_3$)

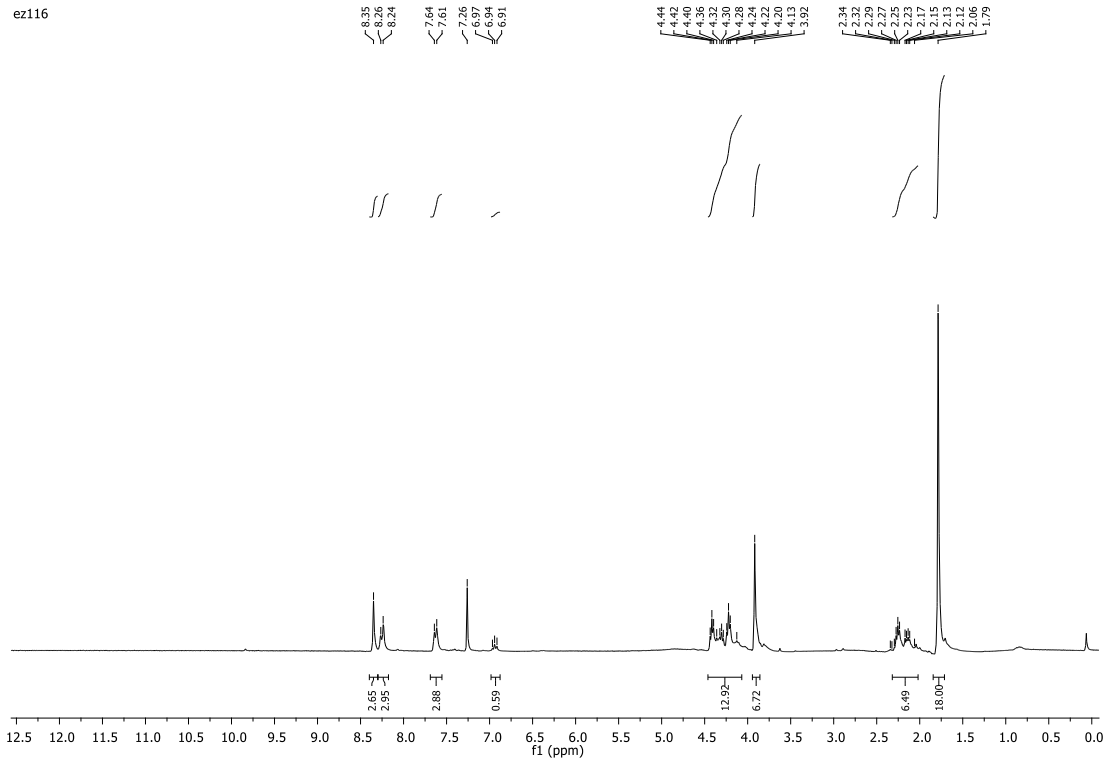


HRMS spectrum

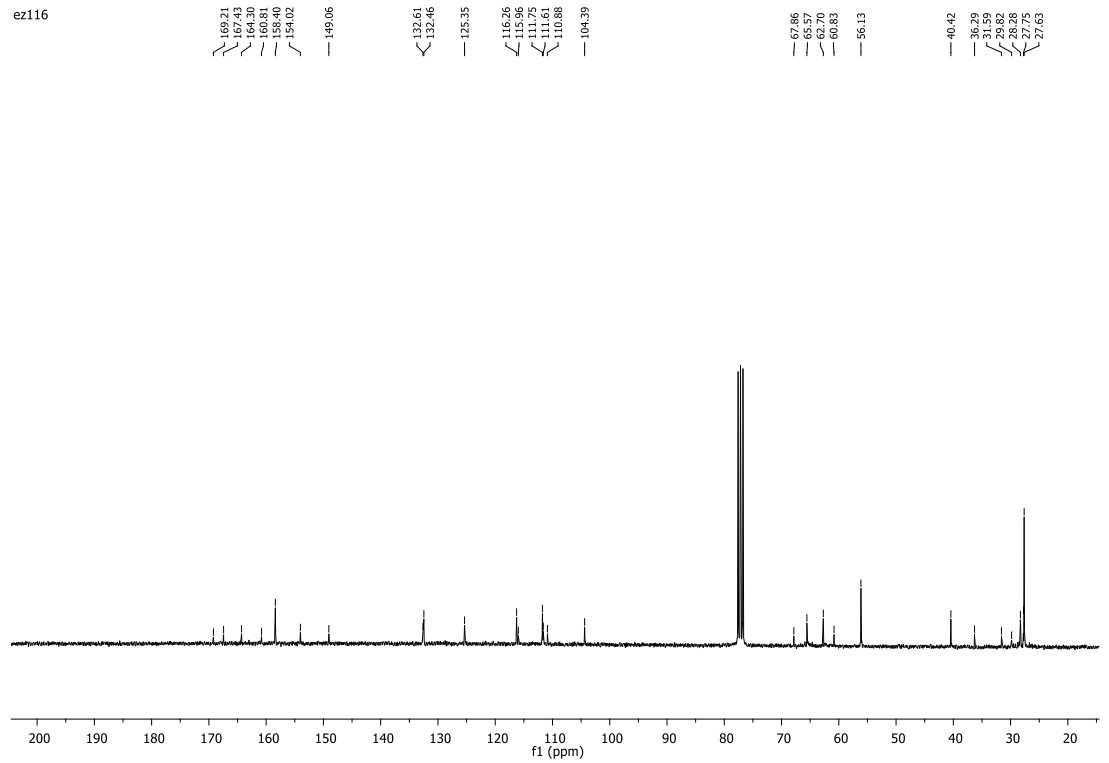


Glycerol – arylidene Meldrums`s acid conjugate **23i**

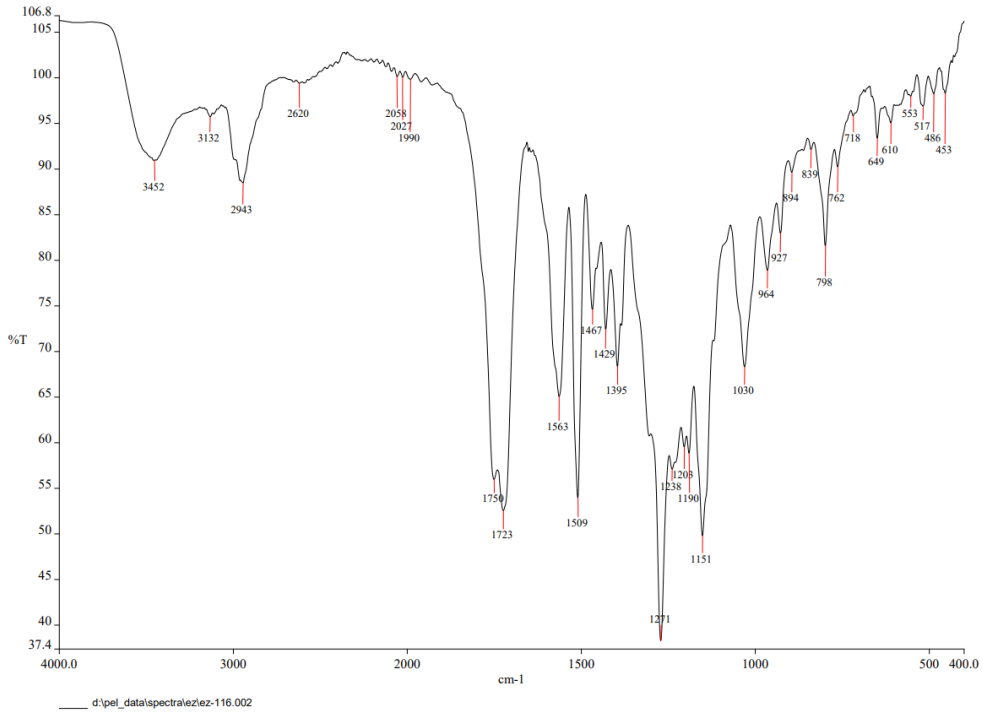
^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

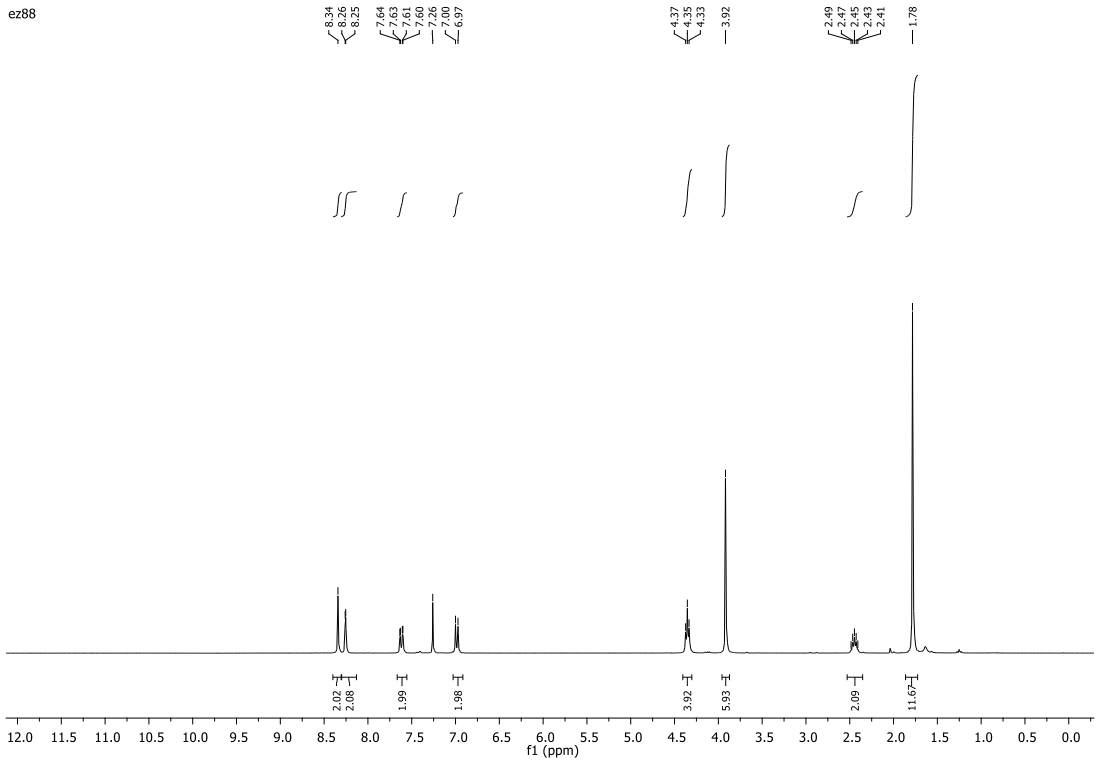


IR spectrum (KBr)

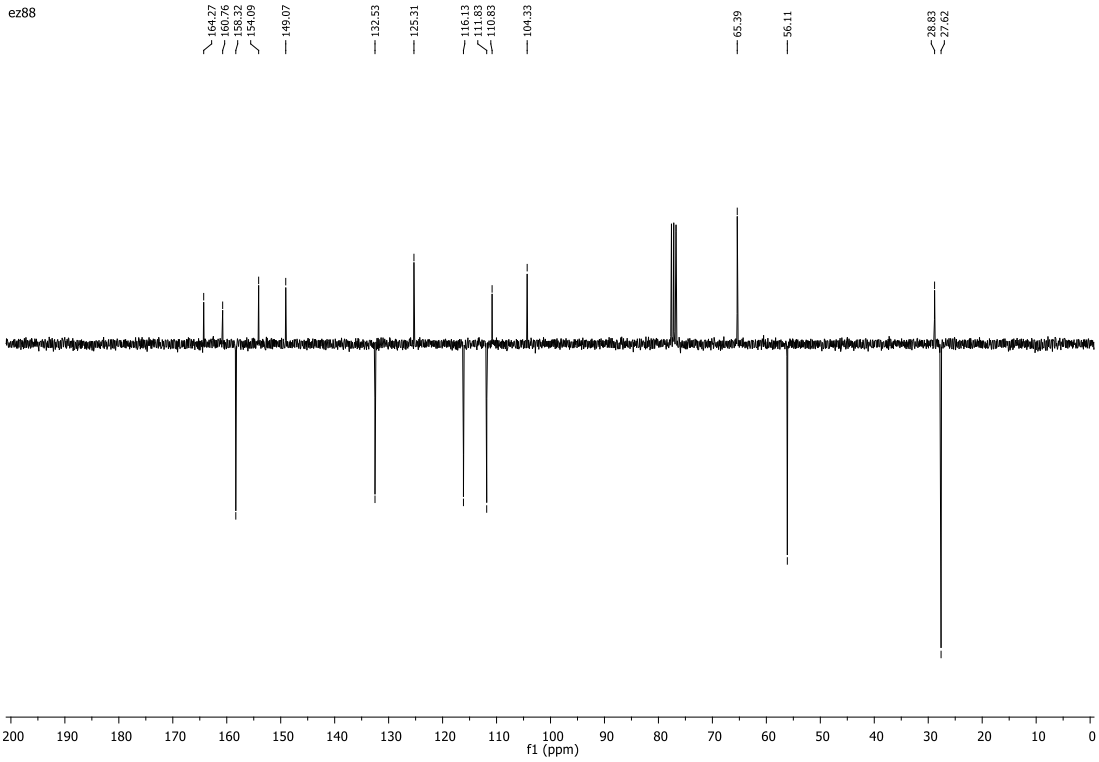


Dimer **24**

^{1}H NMR spectrum ($CDCl_3$, 300 MHz)

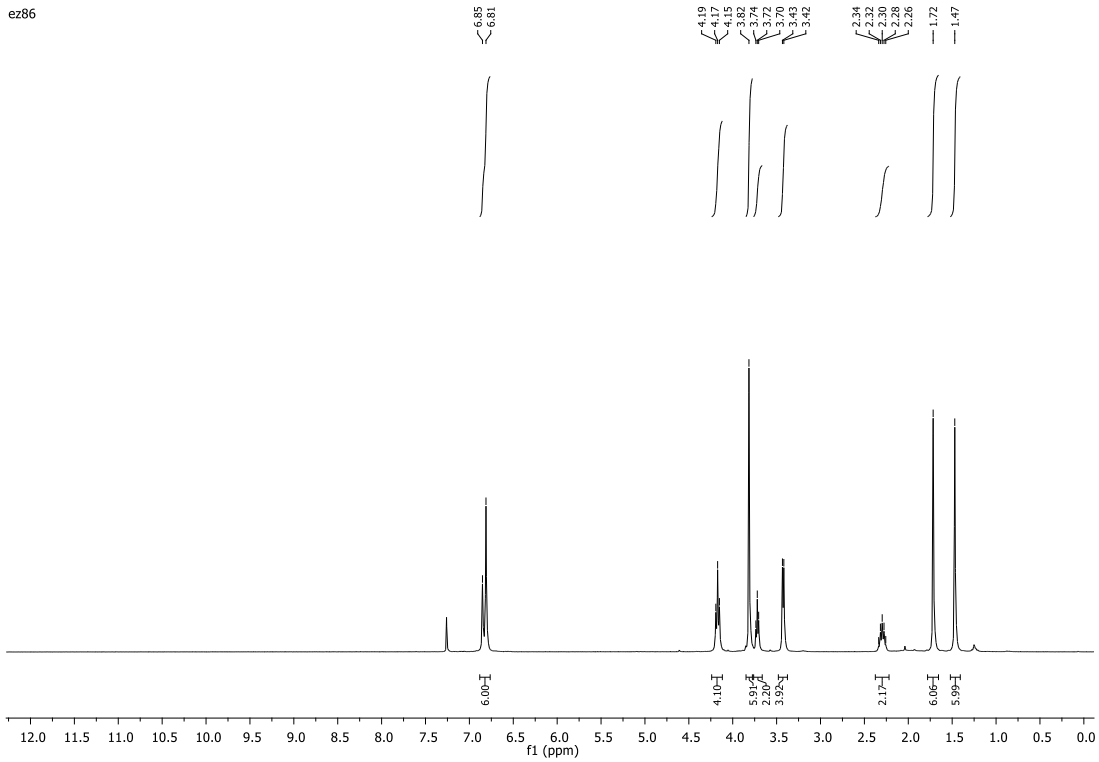


^{13}C NMR spectrum ($CDCl_3$, 75 MHz)

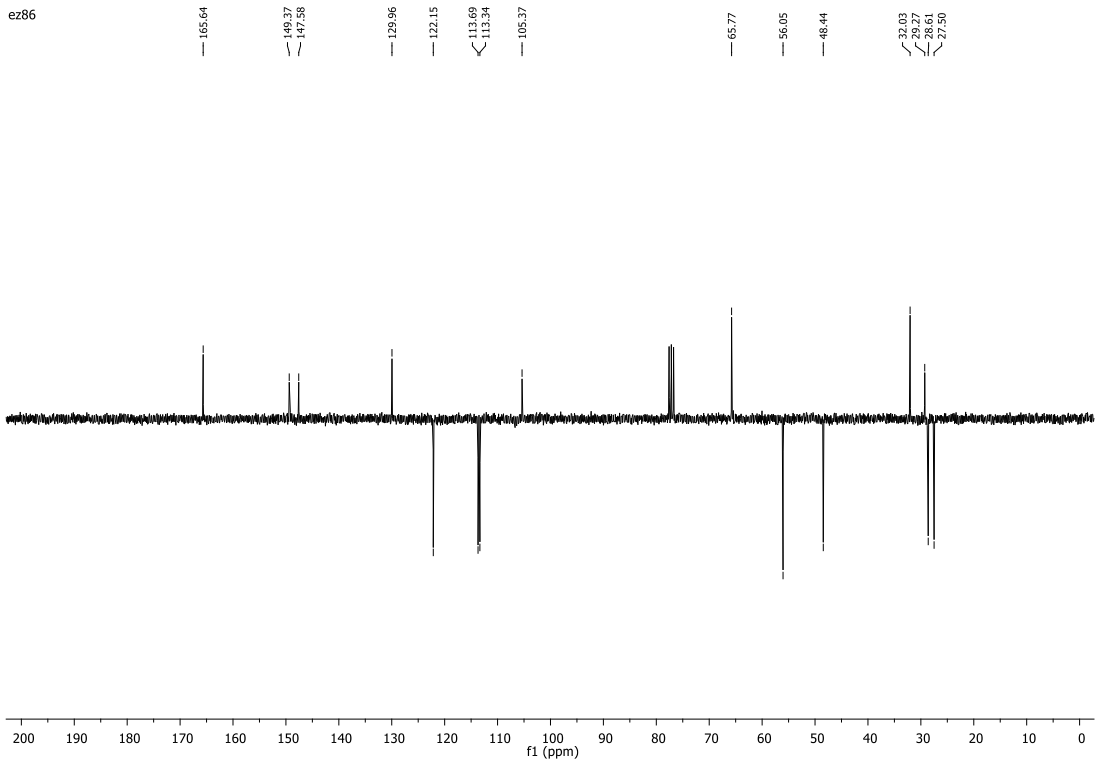


Dimer **25**

^{1}H NMR spectrum ($CDCl_3$, 300 MHz)



^{13}C NMR spectrum ($CDCl_3$, 75 MHz)



Inhibition curves of free radicals

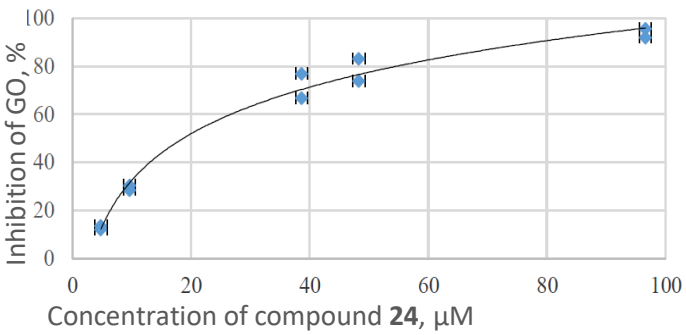
GO test

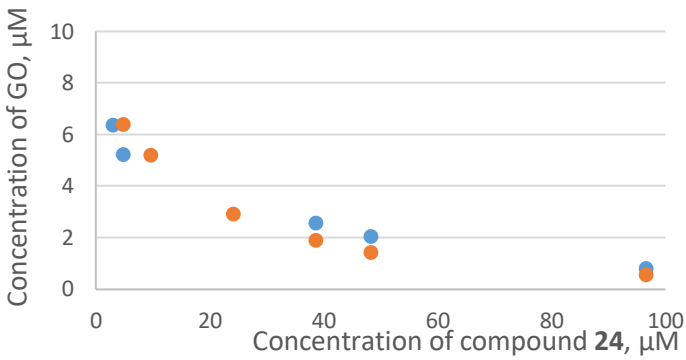
The absorbtion of the solution was measured at 428 nm.

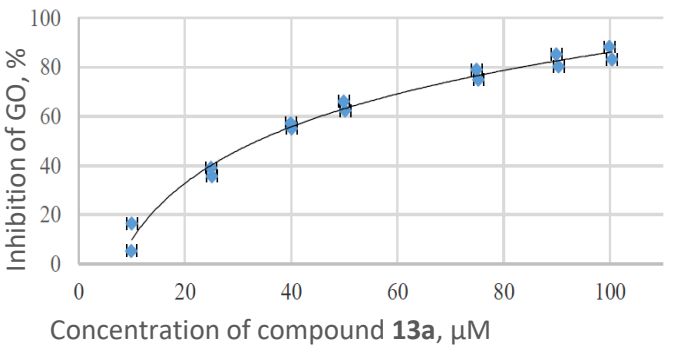
A calibration curve (Conc. = (Abs.+0.0304)/0.1215 (R^2 = 0.9999)) was used to convert the absorbtion to the concentration. Inhibition was calculated as follows: $AA=(Conc._{blank}-Conc._{sample})/Conc._{blank}*100$

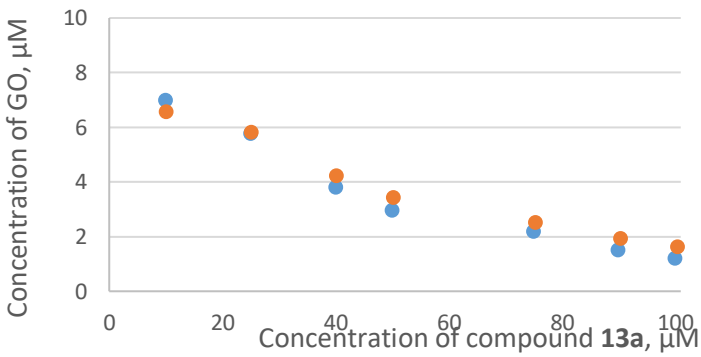
In order to calculate antiradical activity AA curves into coordinations «concentration of antioxidant»-«inhibition of GO» was concentrated. Then the curves were used to find the AA when molar ratio antioxidant:GO ir 1:1 (both concentrations are the identical).

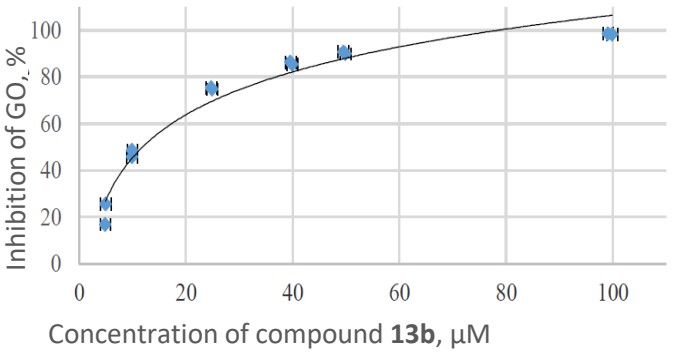
In order to calculate IC_{50} curves into coordinations «concentration of antioxidant» – «concentration of GO» were constructed. Than $IC_{50}^{\#}$ (concentration which inhibited 50% of free radical) for particular sample was calculated. In order to give IC_{50} values in comparable scale for all compounds and to esclude impact of slight differences in the starting concentration of GO matematical correction was done and all reasults were recalculated to the GO solution with starting concentration 100 µM. Following equation was used: $IC_{50} = 100*IC_{50}^{\#}/Conc.blank$.

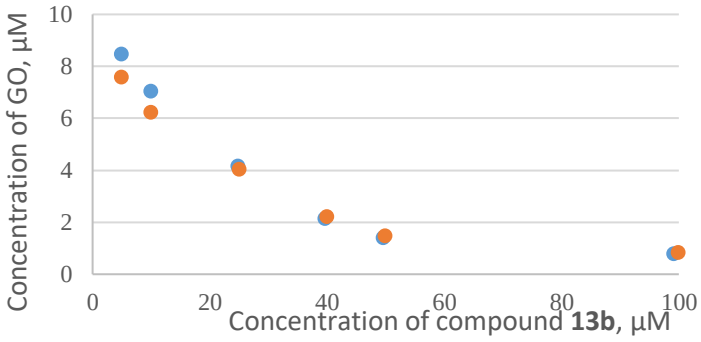


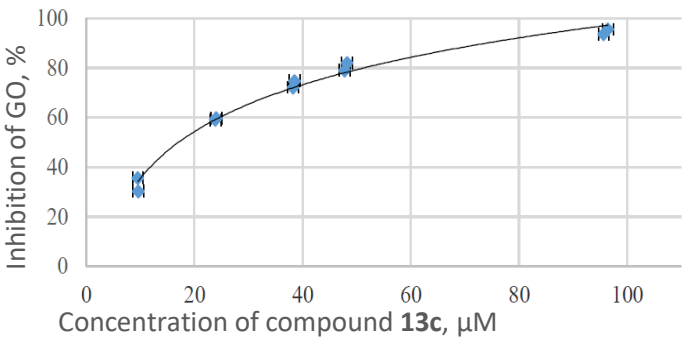


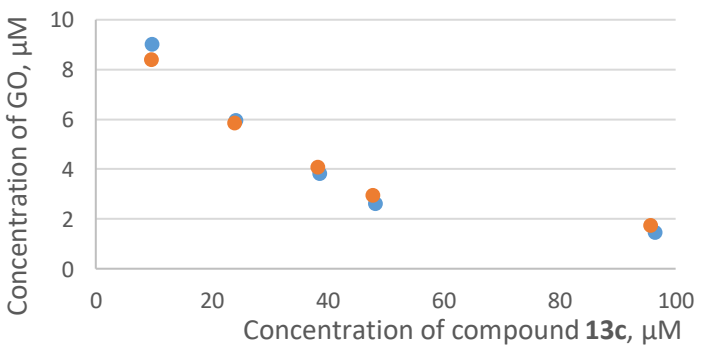


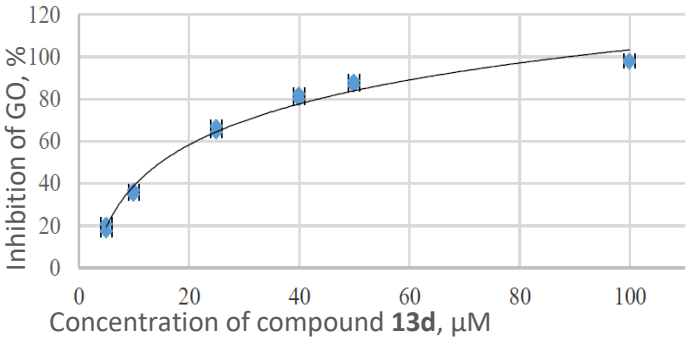


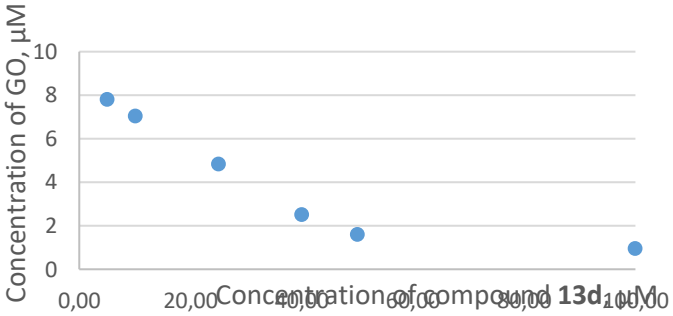


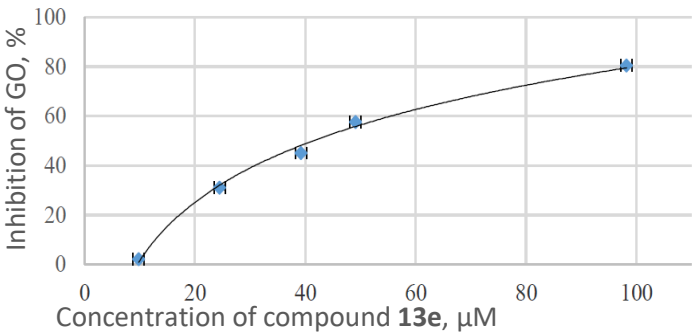


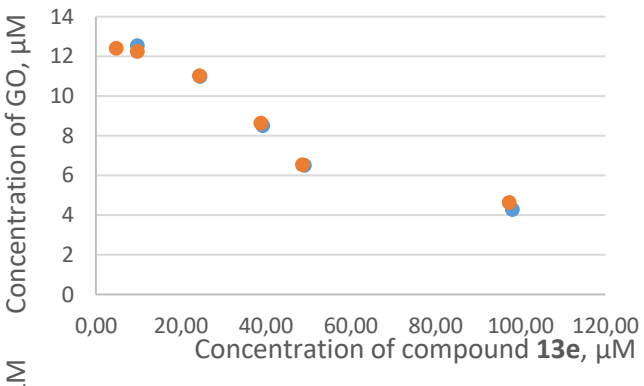


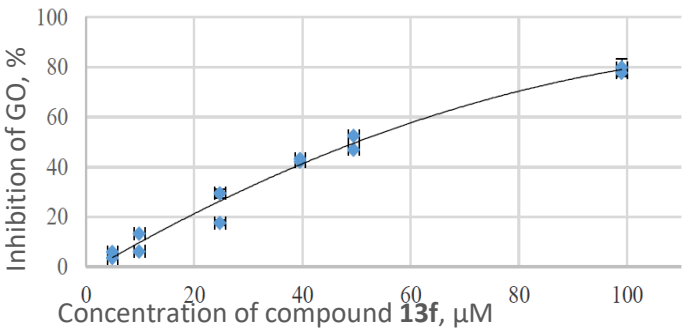


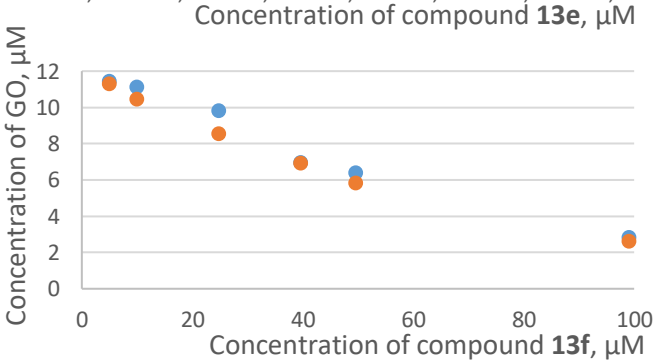

Inhibition of GO, %
Concentration of compound **13d**, μM

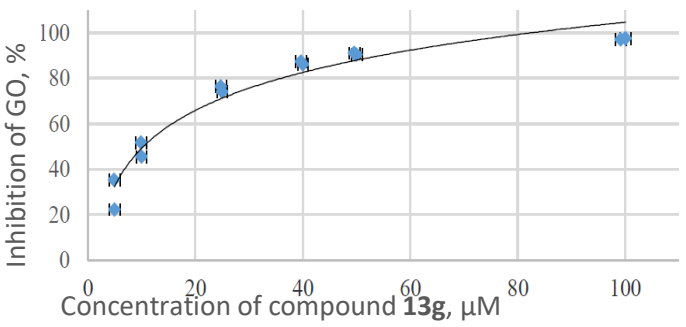

Concentration of GO, μM
Concentration of compound **13d**, μM

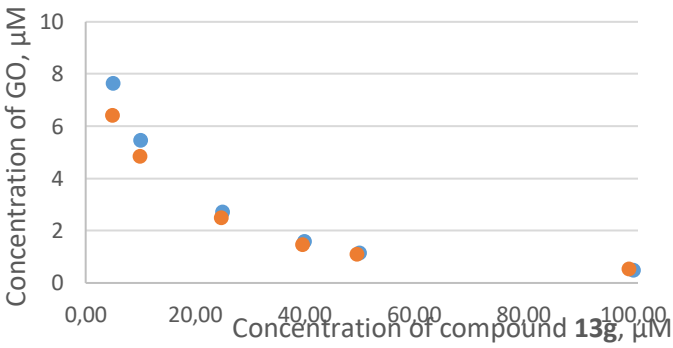

Inhibition of GO, %
Concentration of compound **13e**, μM

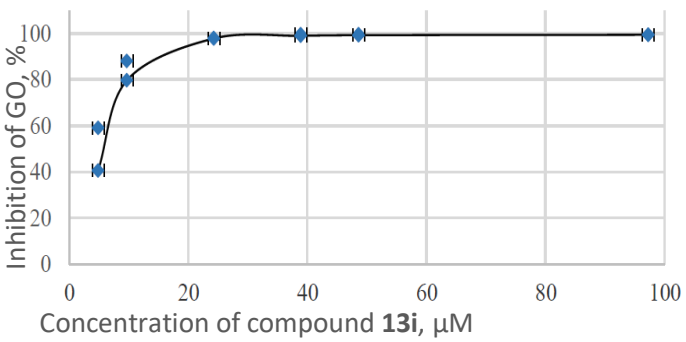

Concentration of GO, μM
Concentration of compound **13e**, μM

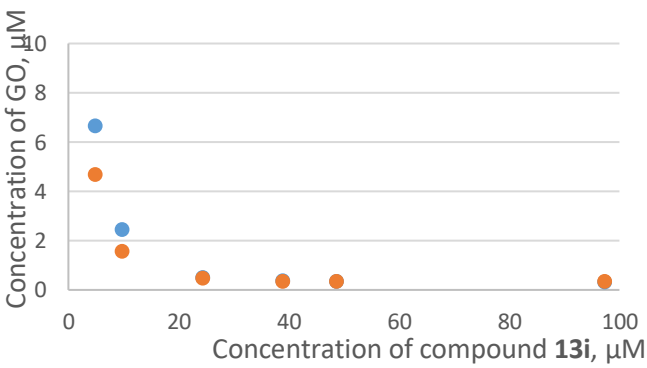

Inhibition of GO, %
Concentration of compound **13f**, μM


Concentration of GO, μM
Concentration of compound **13f**, μM

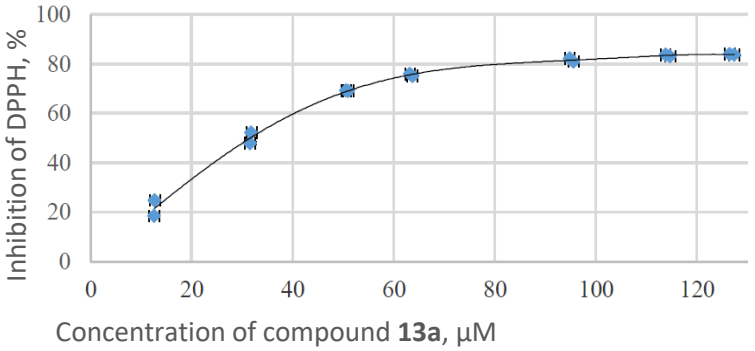

Inhibition of GO, %
Concentration of compound **13g**, μM

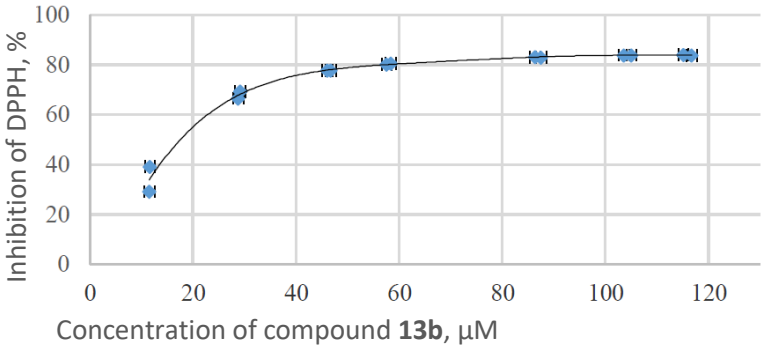

Concentration of GO, μM
Concentration of compound **13g**, μM

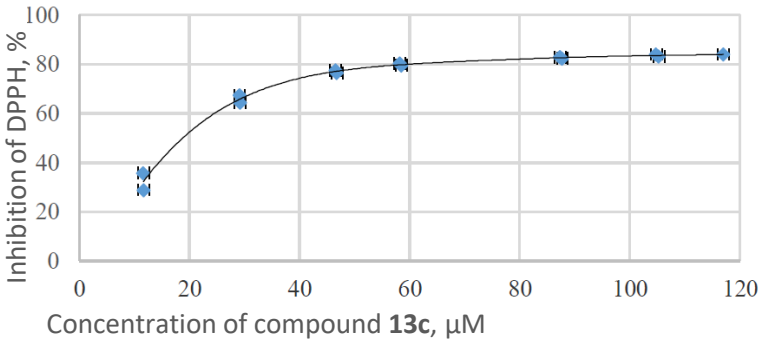

Inhibition of GO, %
Concentration of compound **13i**, μM

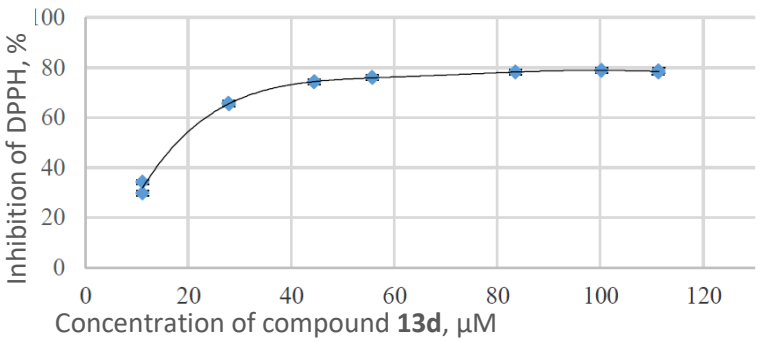

Concentration of GO, μM
Concentration of compound **13i**, μM

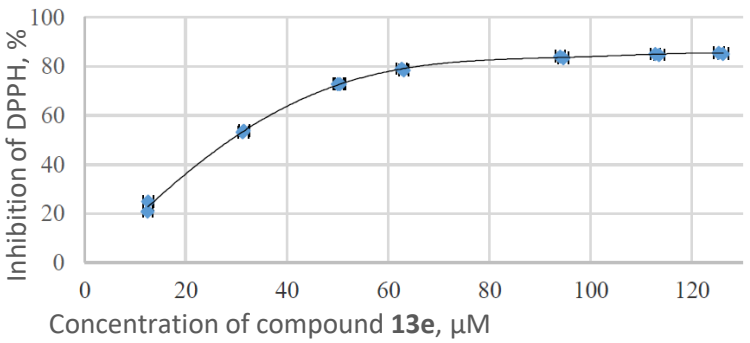
DPPH test

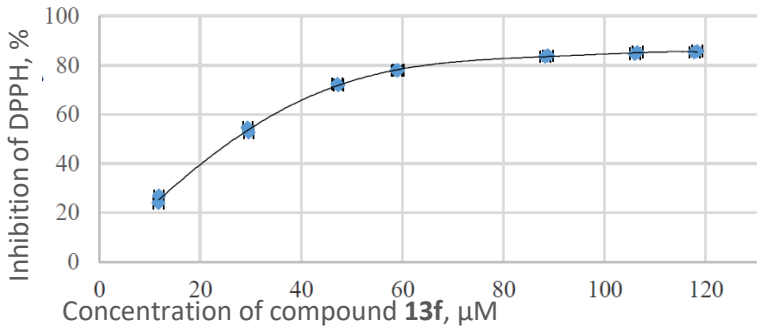

Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound **13a**, μM

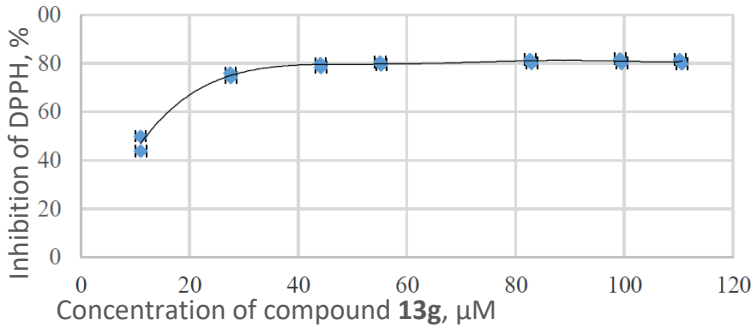

Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound **13b**, μM

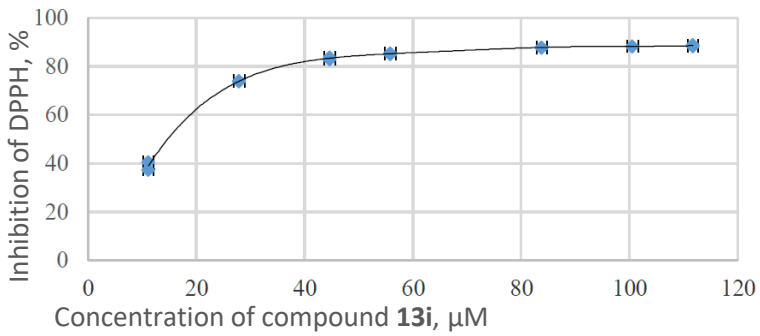

Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound **13c**, μM


Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound **13d**, μM


Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound **13e**, μM

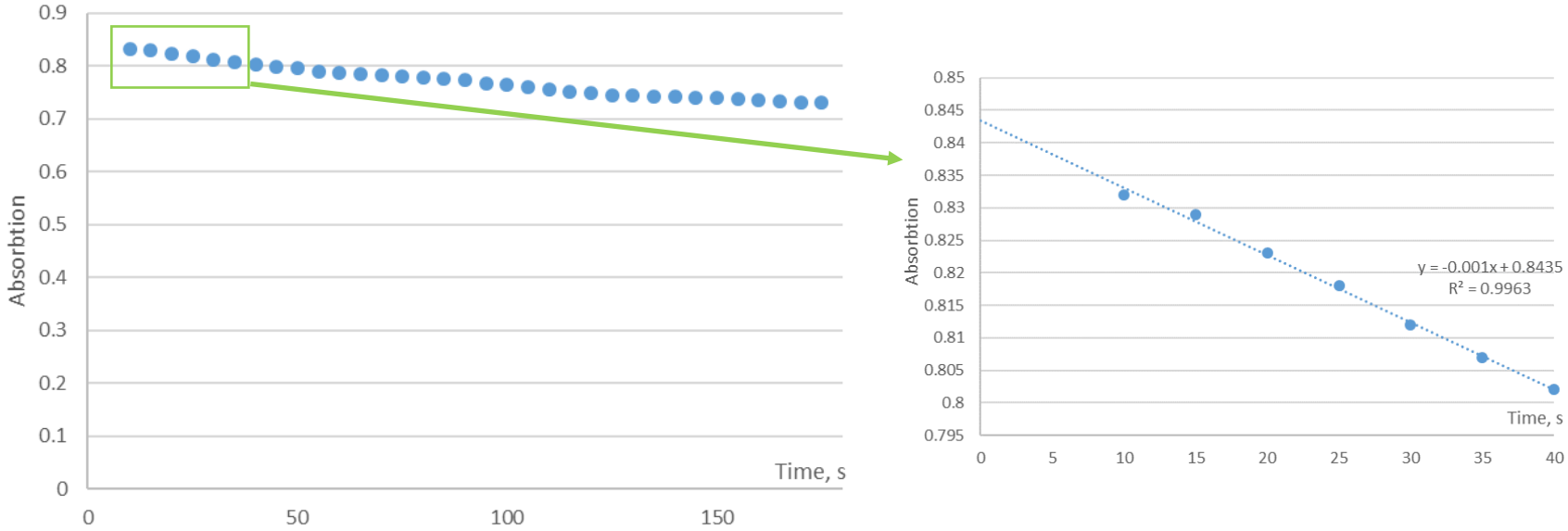

Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound 13f, µM

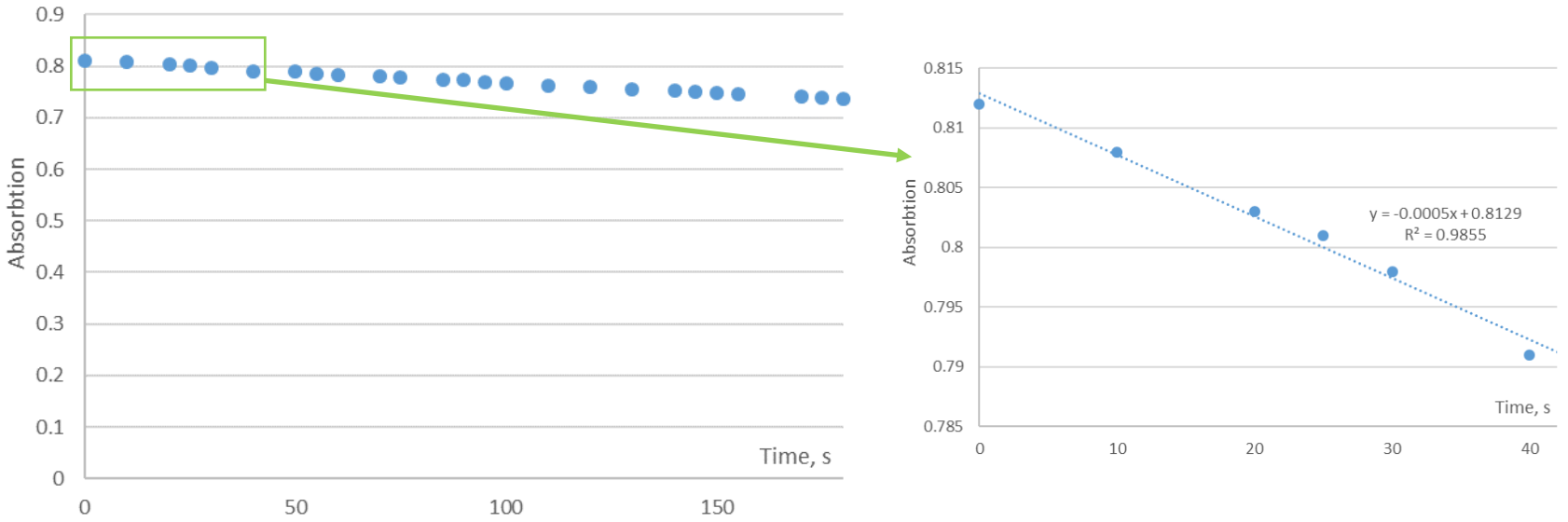

Inhibition of DPPH, %
00
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound 13g, µM


Inhibition of DPPH, %
100
80
60
40
20
0
0
20
40
60
80
100
120
Concentration of compound 13i, µM

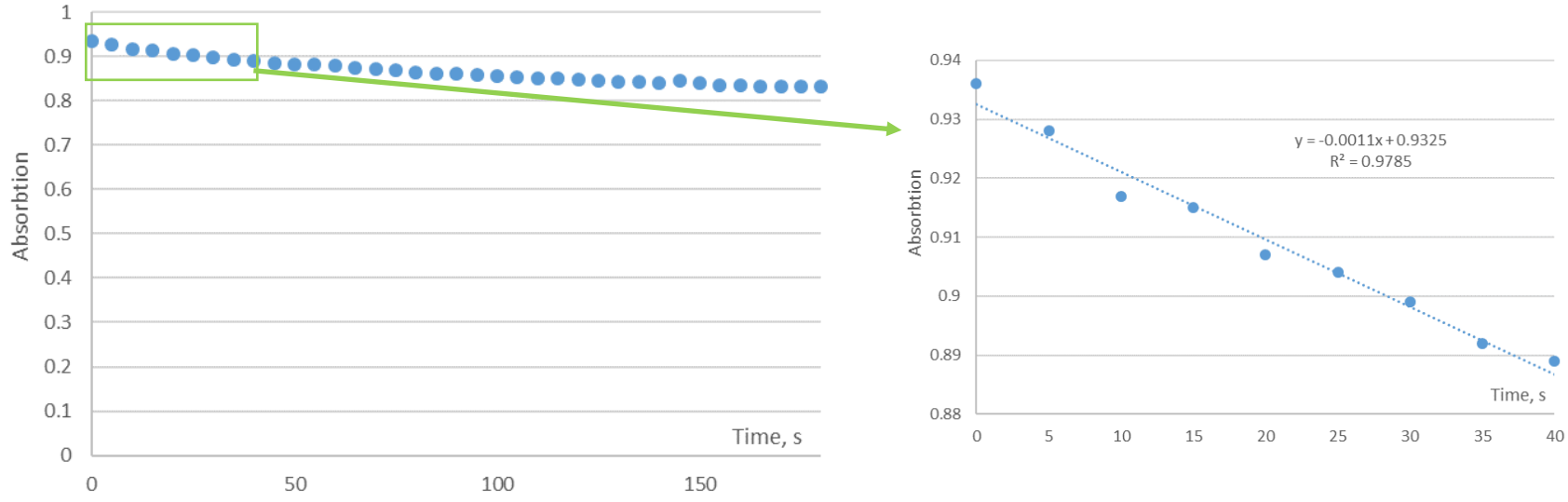
Kinetic curves in various solvents for compound 13a

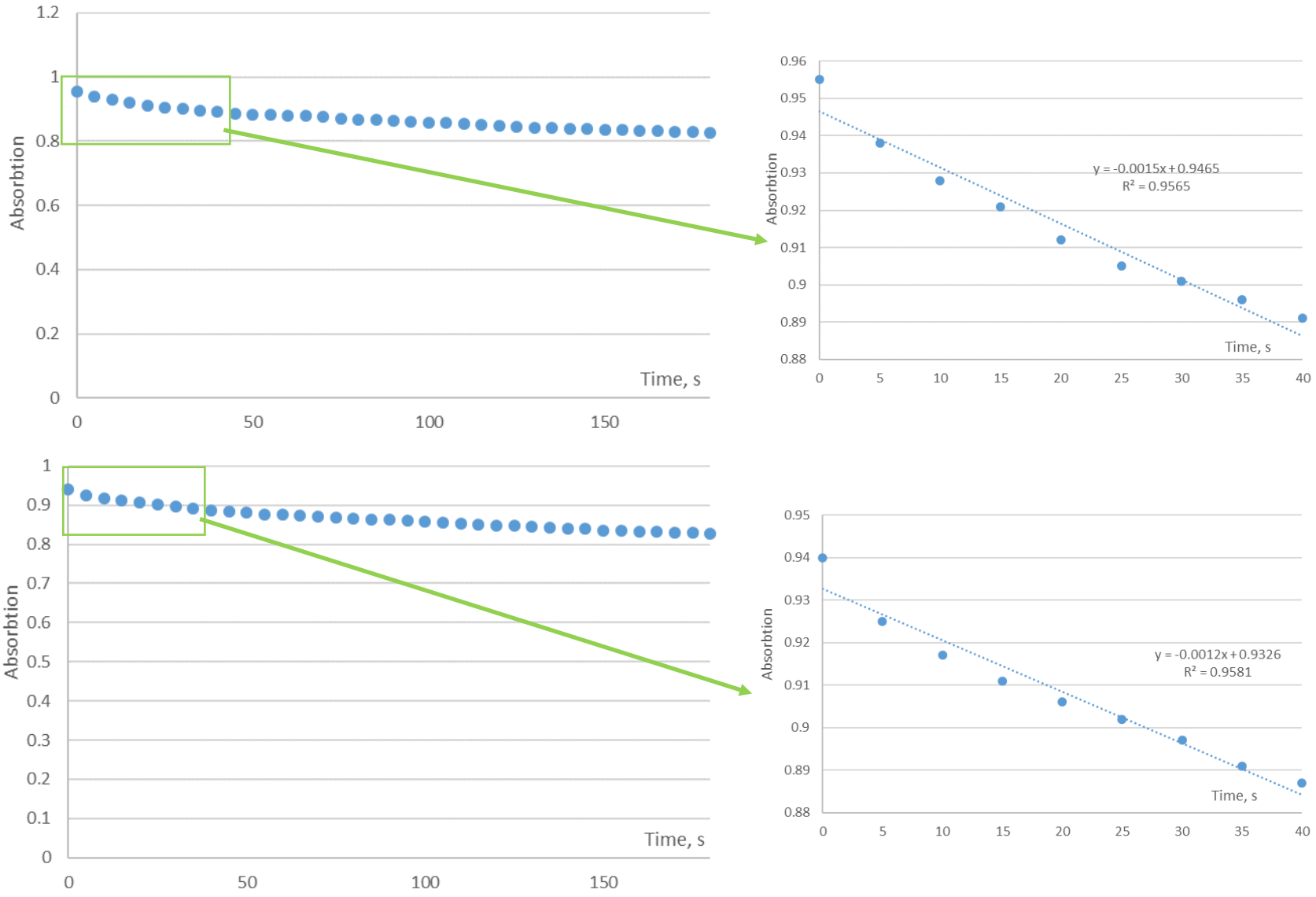
Kinetic curves in EtOAc:



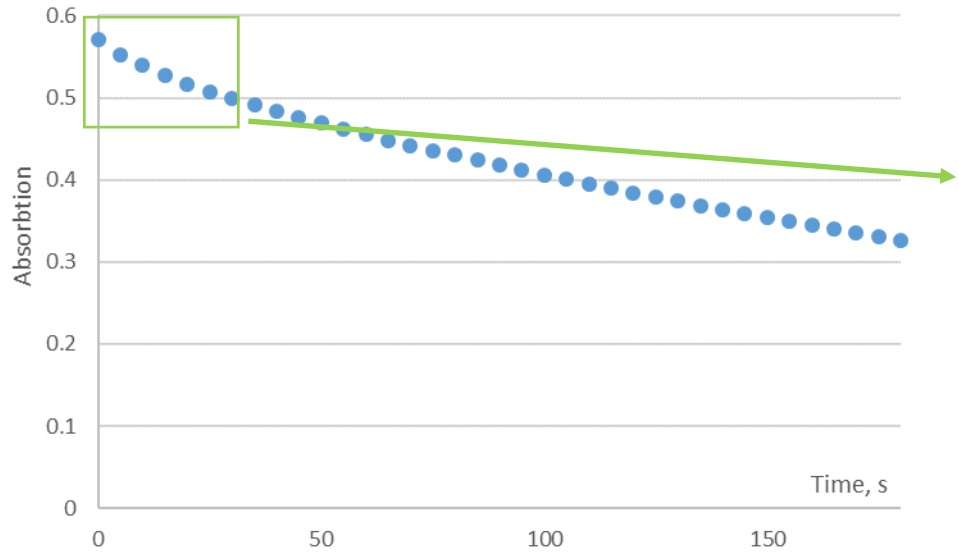


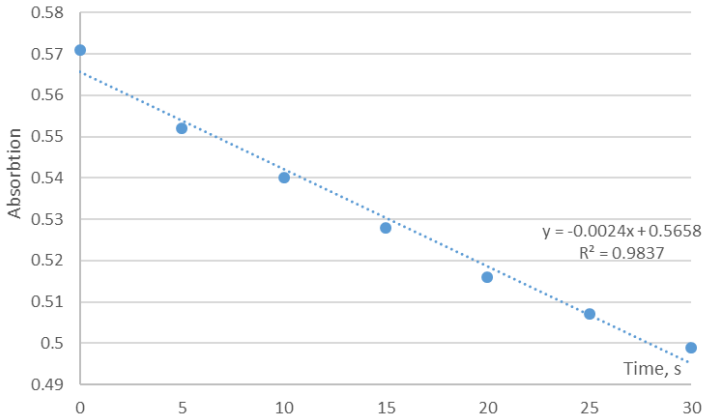
Kinetic curves in MTBE:

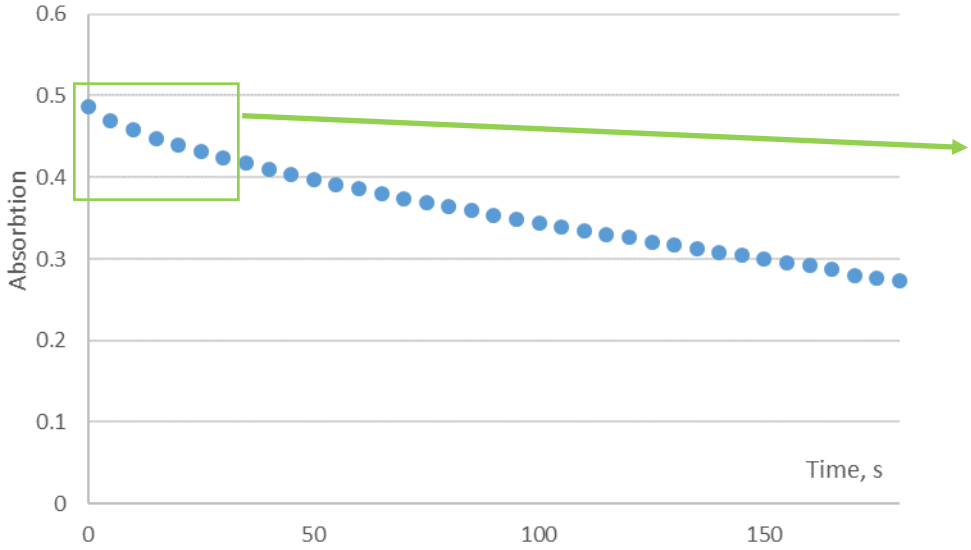


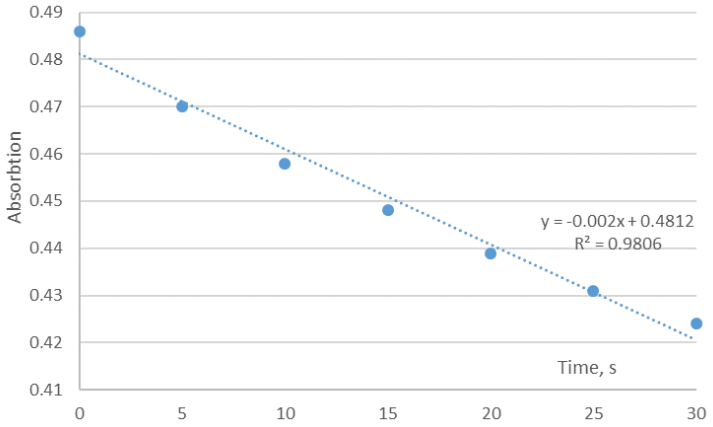


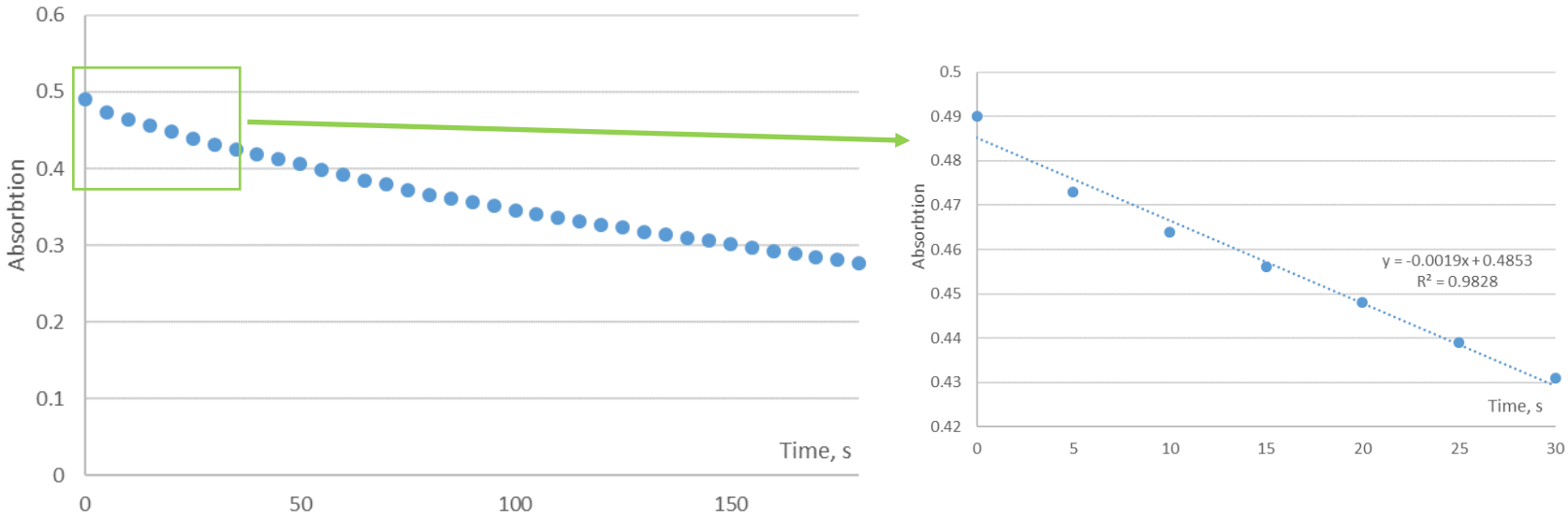
Kinetic curves in MeOH:


Absorbtion
Time, s
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150

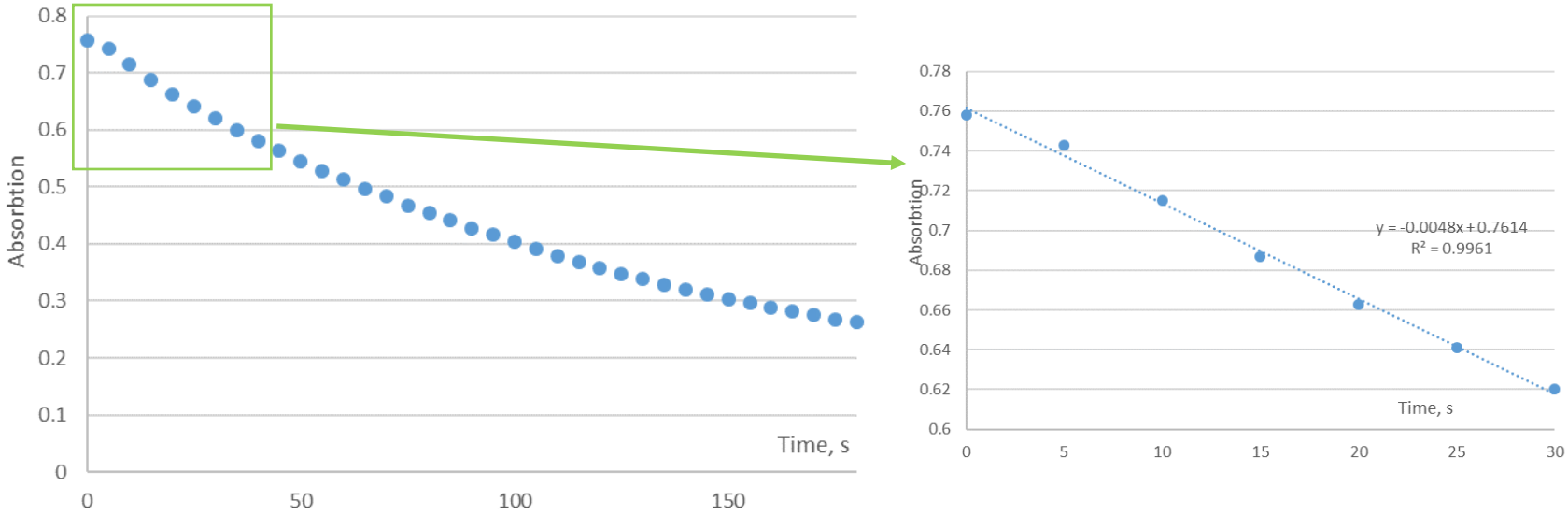

Absorbtion
Time, s
y = -0.0024x + 0.5658
R² = 0.9837
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.5
0.49
0
5
10
15
20
25
30

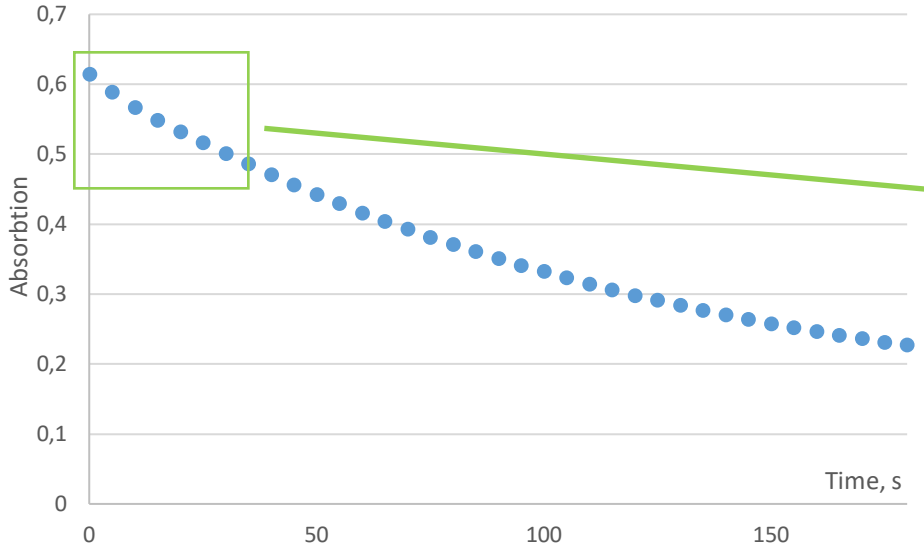

Absorbtion
Time, s
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150

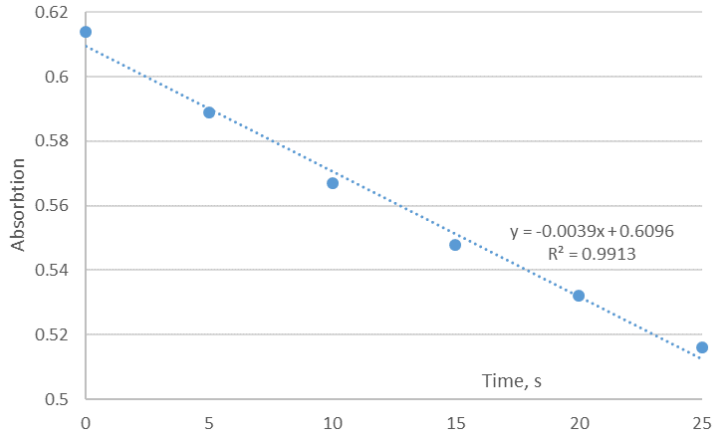

Absorbtion
Time, s
y = -0.002x + 0.4812
R² = 0.9806
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0
5
10
15
20
25
30

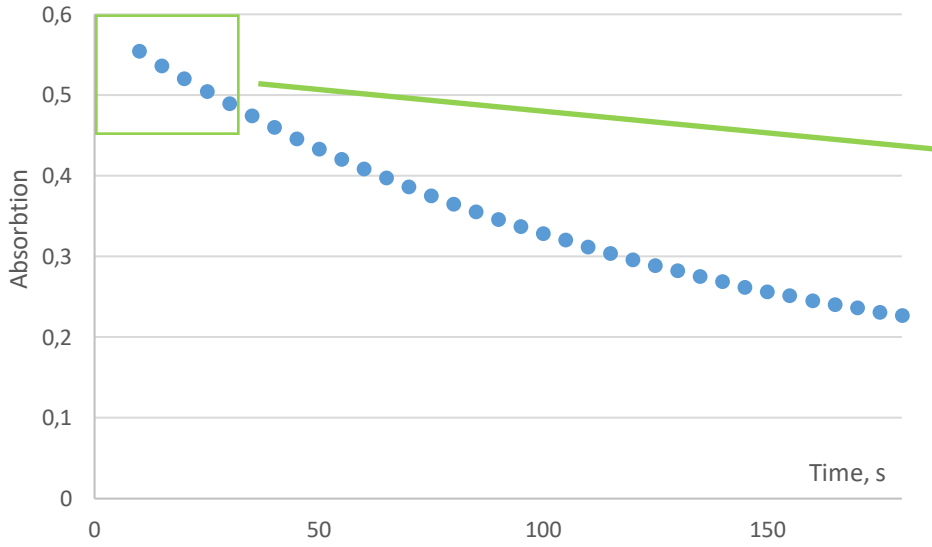


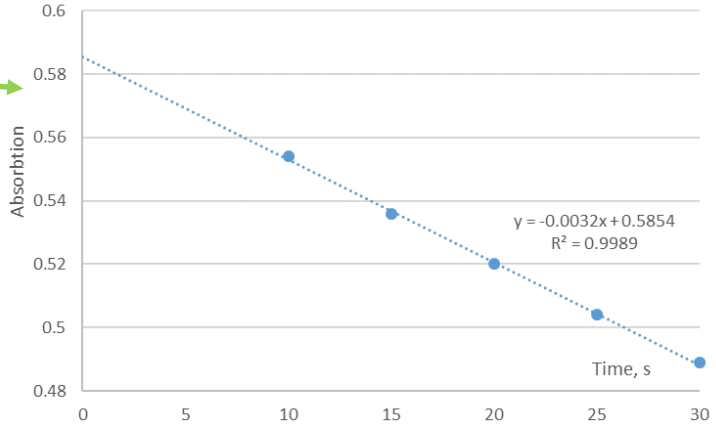
Kinetic curves in EtOH (96%):



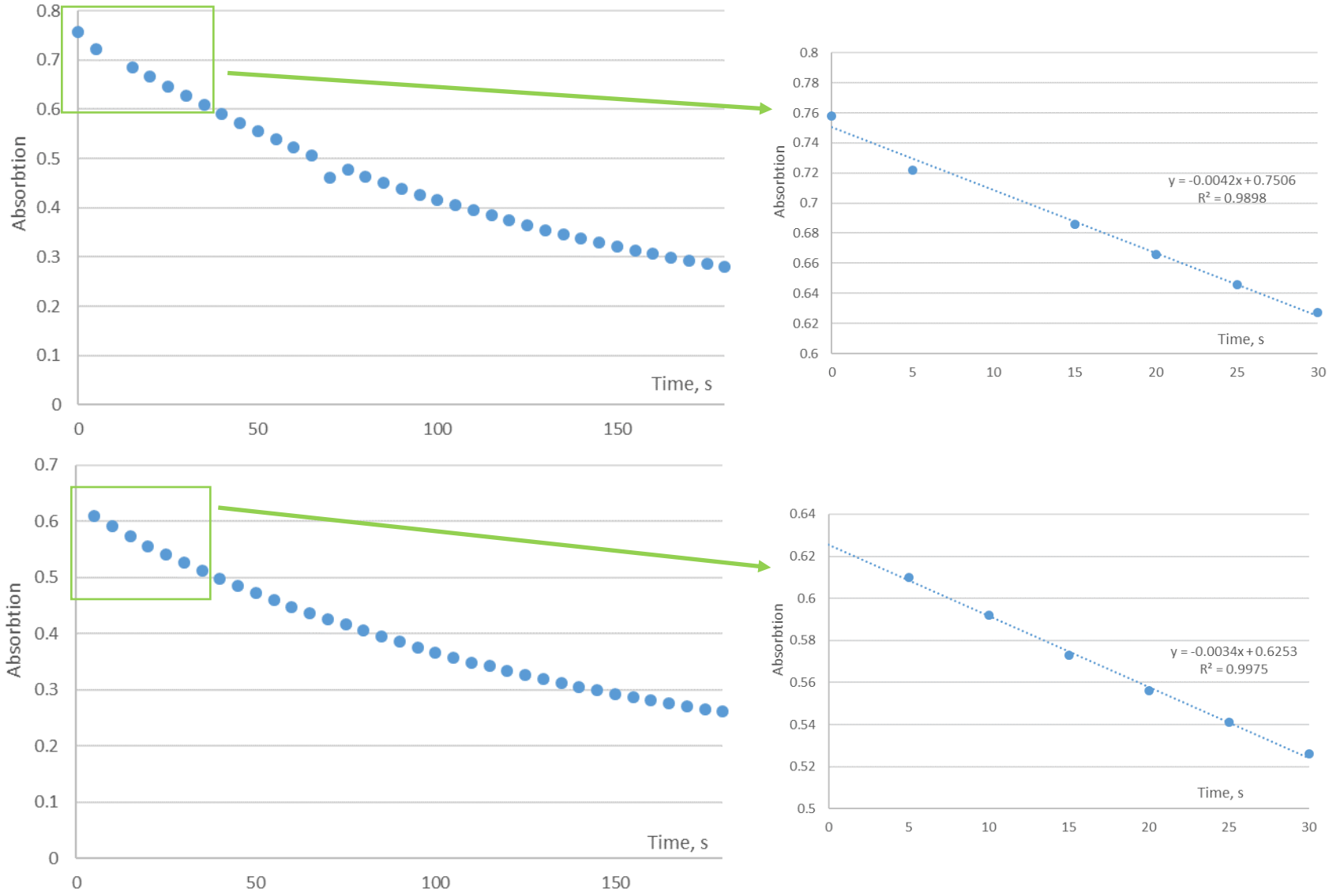

0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Absorbtion
0
50
100
150
Time, s

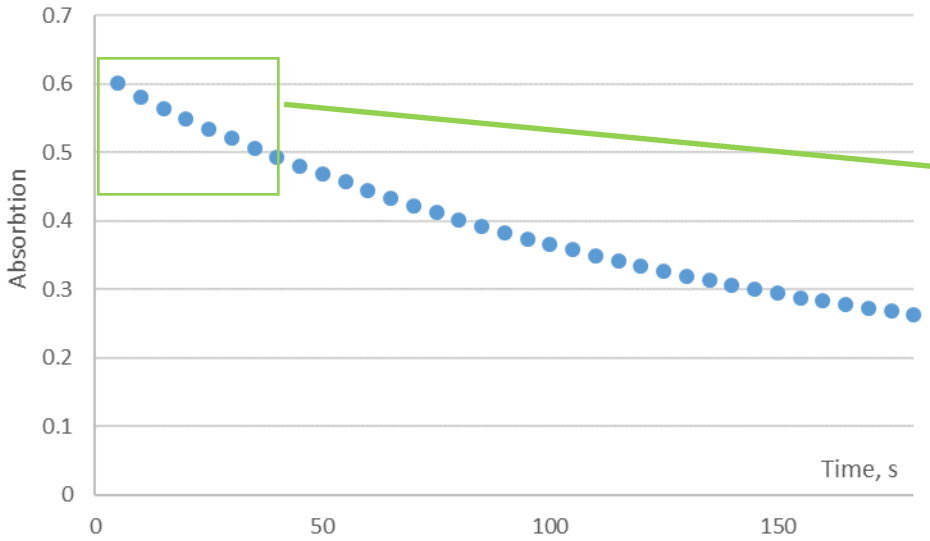

0.62
0.6
0.58
0.56
0.54
0.52
0.5
Absorbtion
y = -0.0039x + 0.6096
R² = 0.9913
Time, s
0
5
10
15
20
25

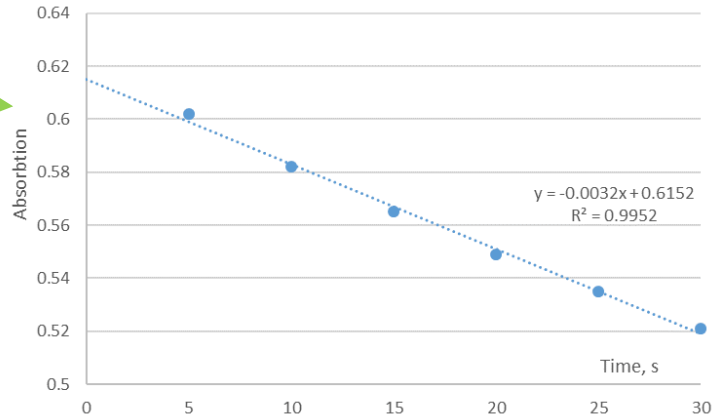

0,6
0,5
0,4
0,3
0,2
0,1
0
Absorbtion
0
50
100
150
Time, s


0.6
0.58
0.56
0.54
0.52
0.5
0.48
Absorbtion
y = -0.0032x + 0.5854
R² = 0.9989
Time, s
0
5
10
15
20
25
30

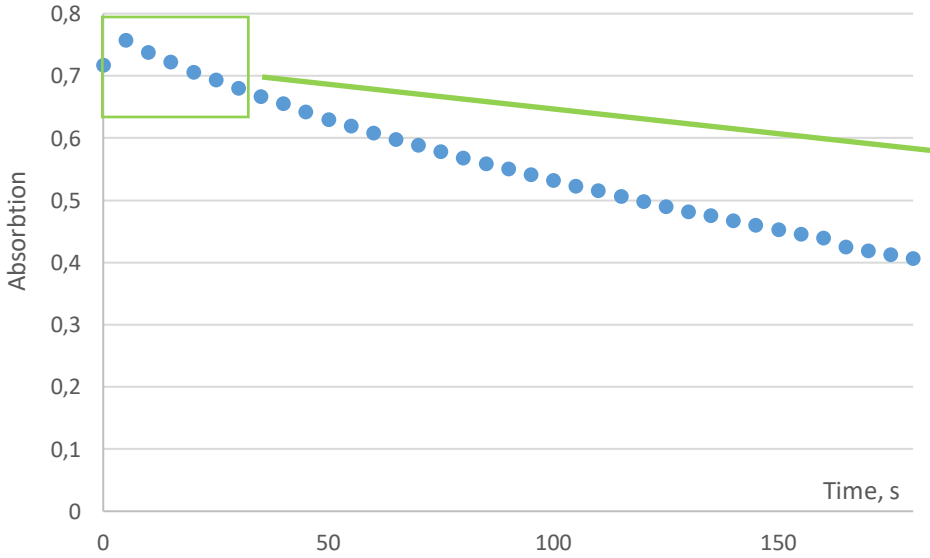
Kinetic curves in EtOH (96%) with AcOH additive:

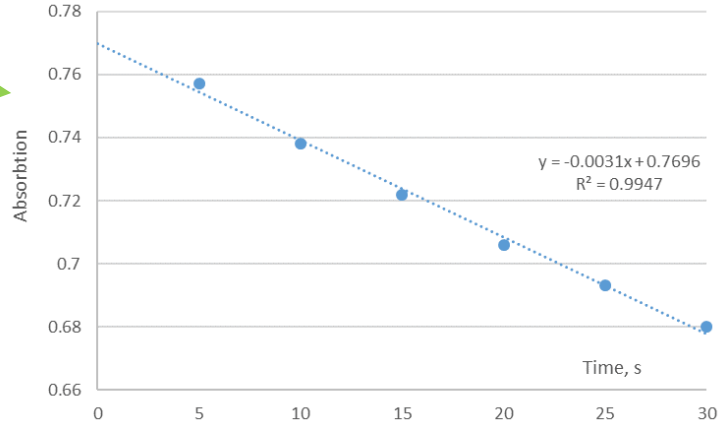


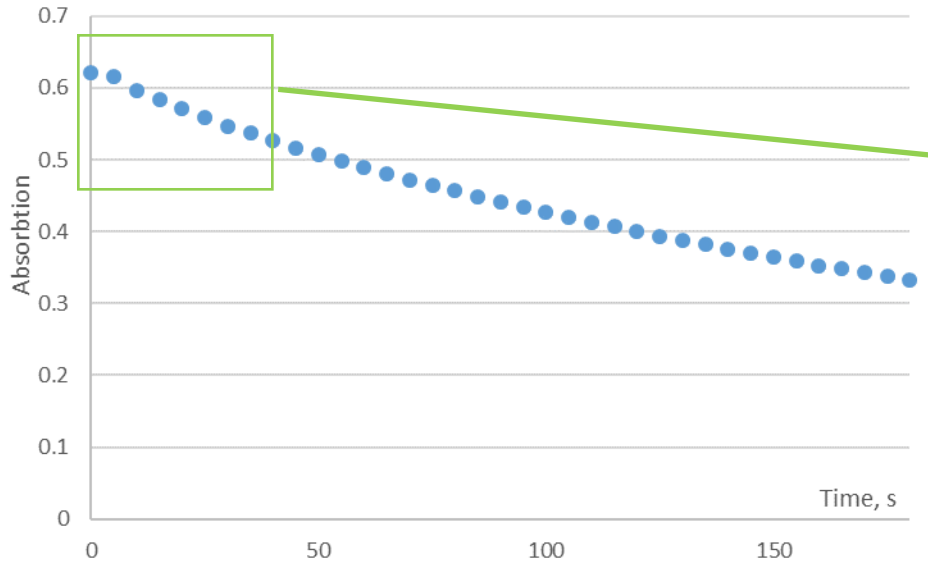


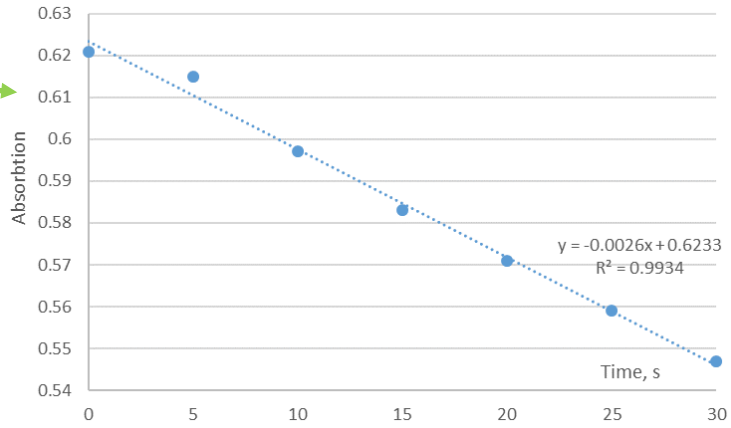


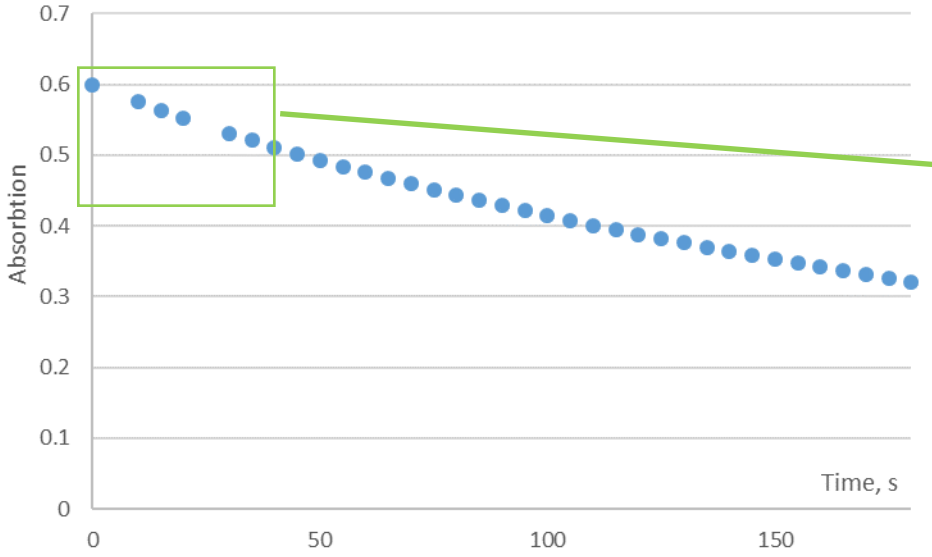
Kinetic curves in EtOH (96%) with malonic acid additive:

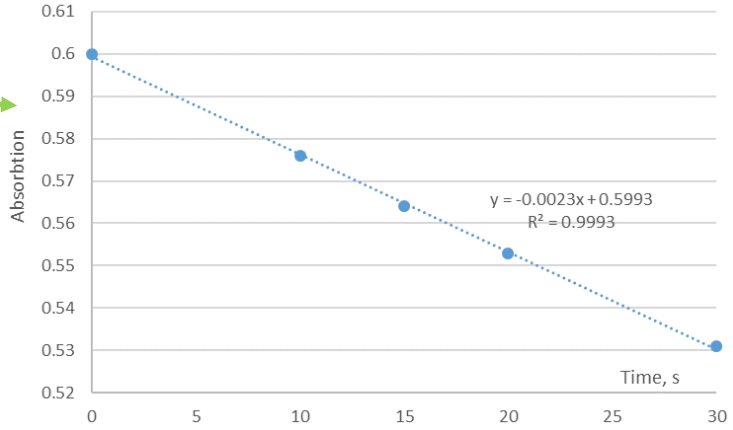




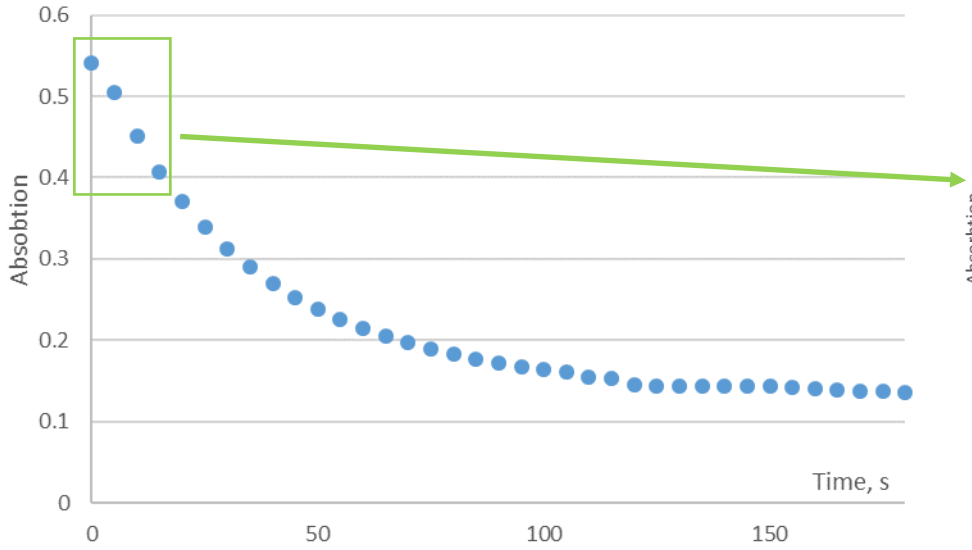

Absorbtion
Time, s
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150

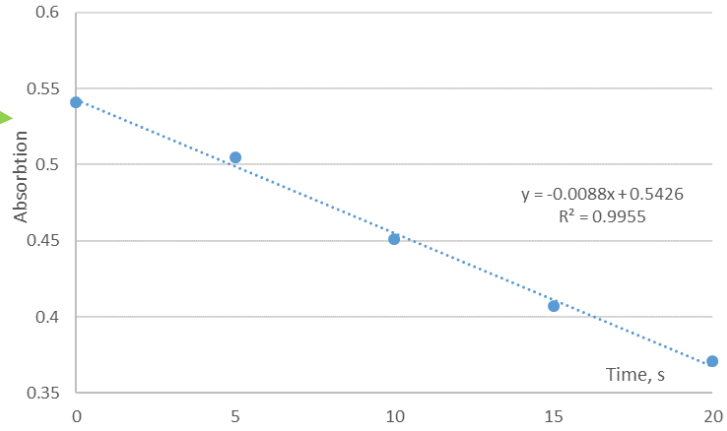

Absorbtion
Time, s
y = -0.0026x + 0.6233
R² = 0.9934
0.63
0.62
0.61
0.6
0.59
0.58
0.57
0.56
0.55
0.54
0
5
10
15
20
25
30

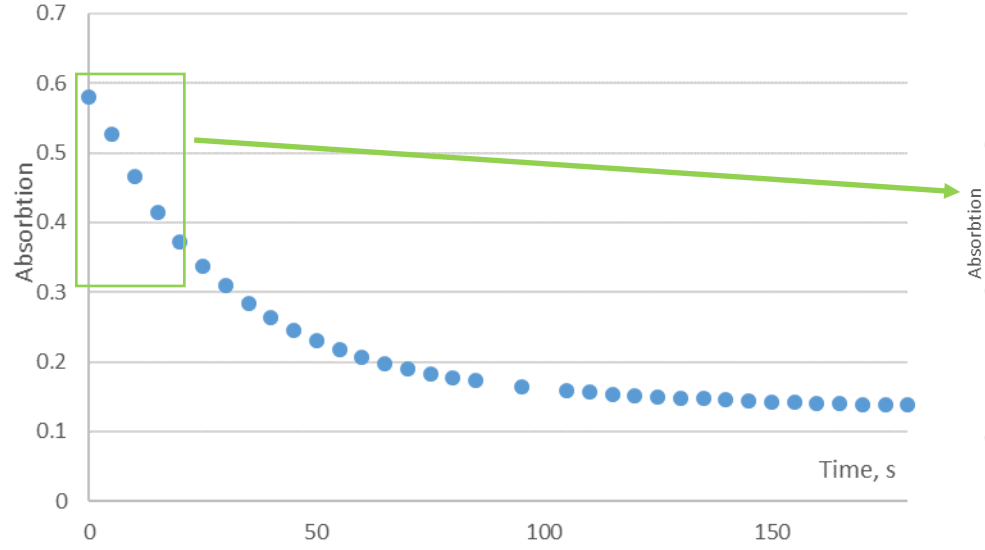

Absorbtion
Time, s
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150

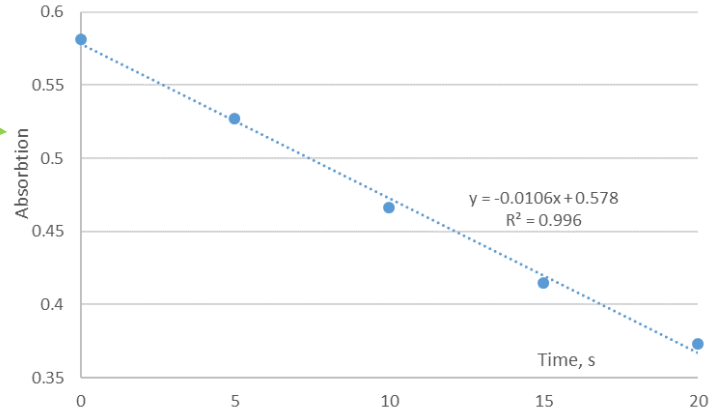

Absorbtion
Time, s
y = -0.0023x + 0.5993
R² = 0.9993
0.61
0.6
0.59
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0
5
10
15
20
25
30

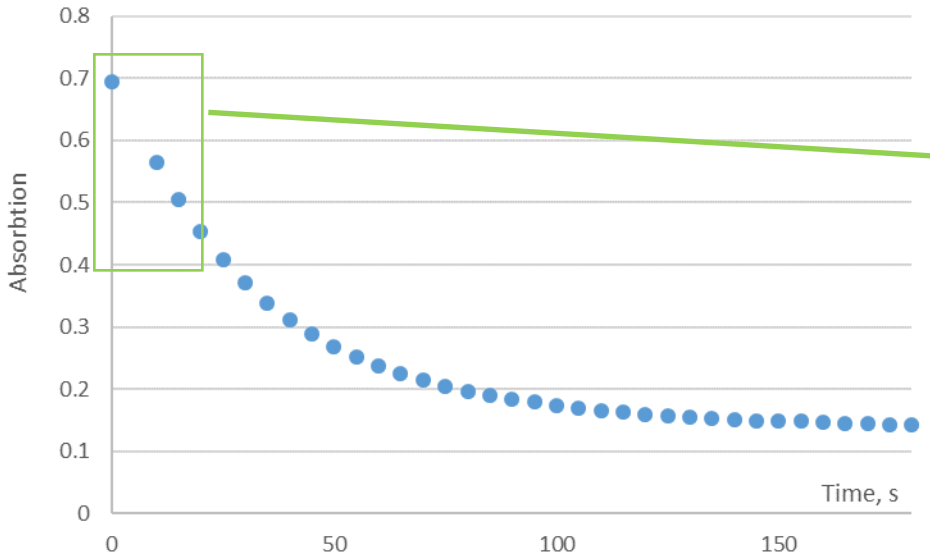
Kinetic curves in EtOH (96%) with Py additive:

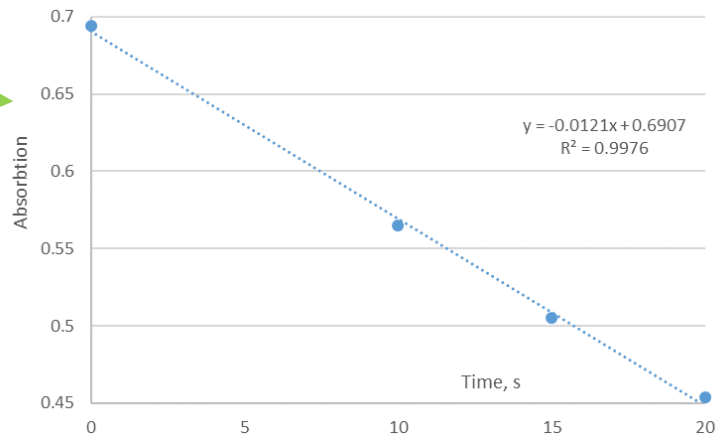




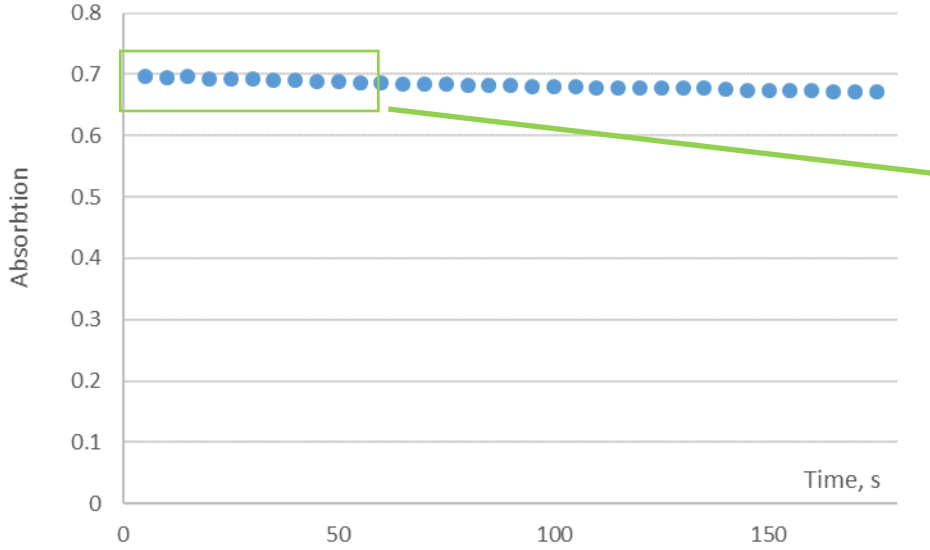


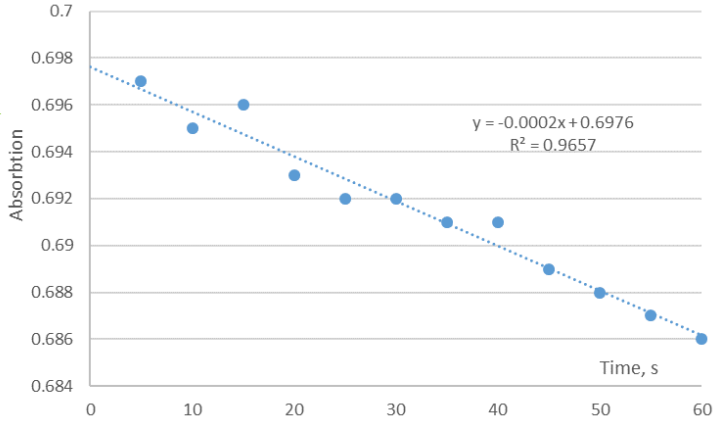


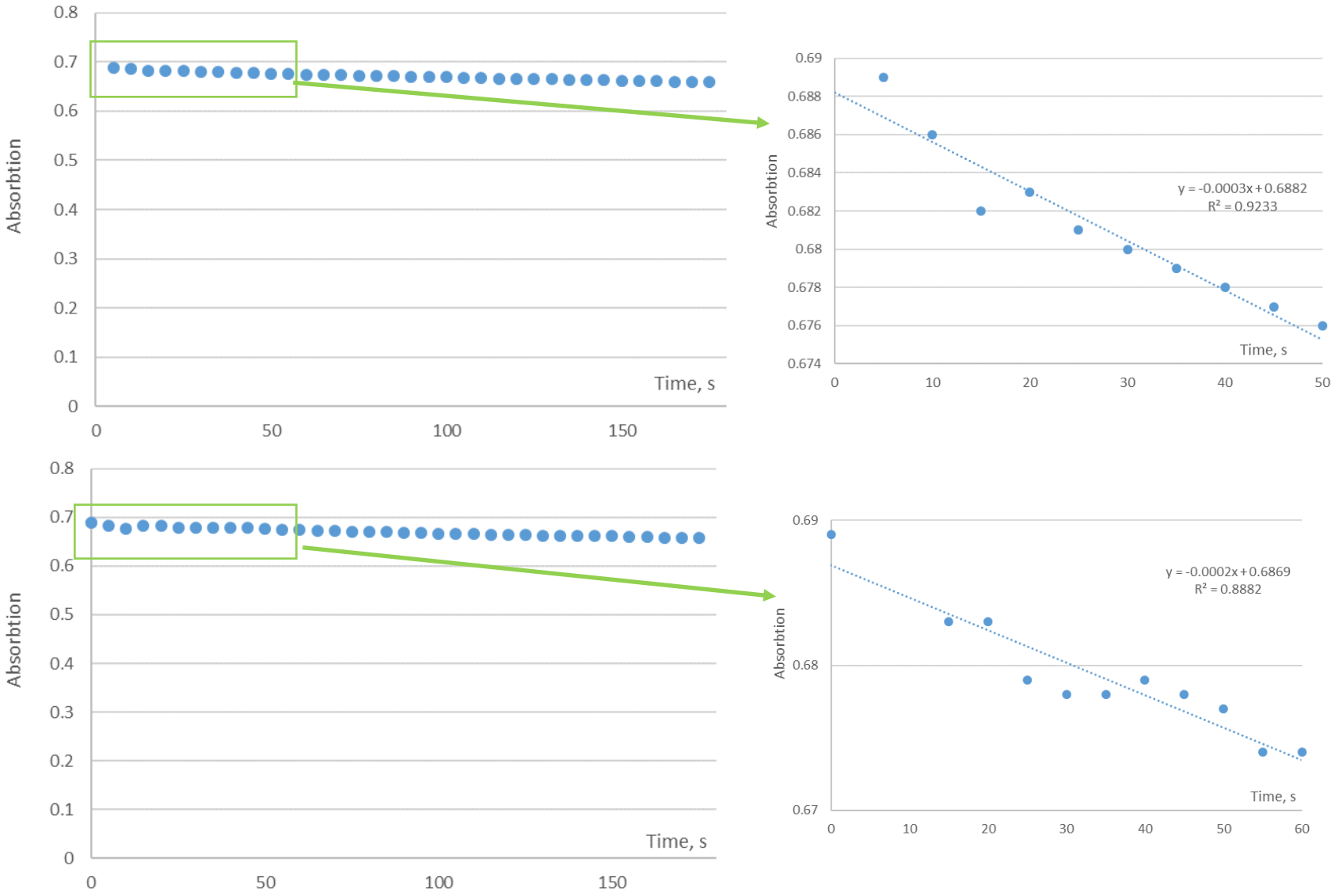




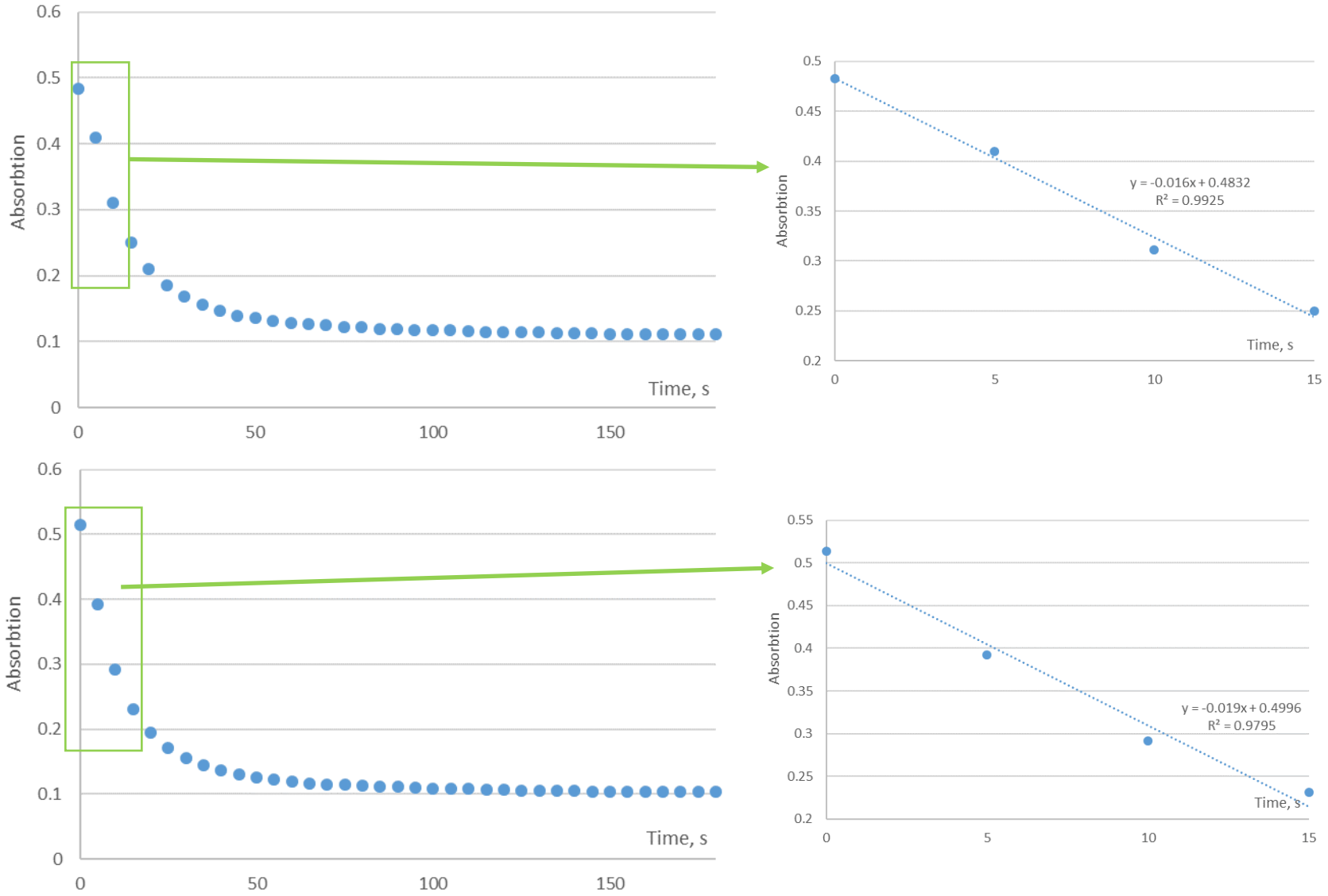
Kinetic curves in DCM:

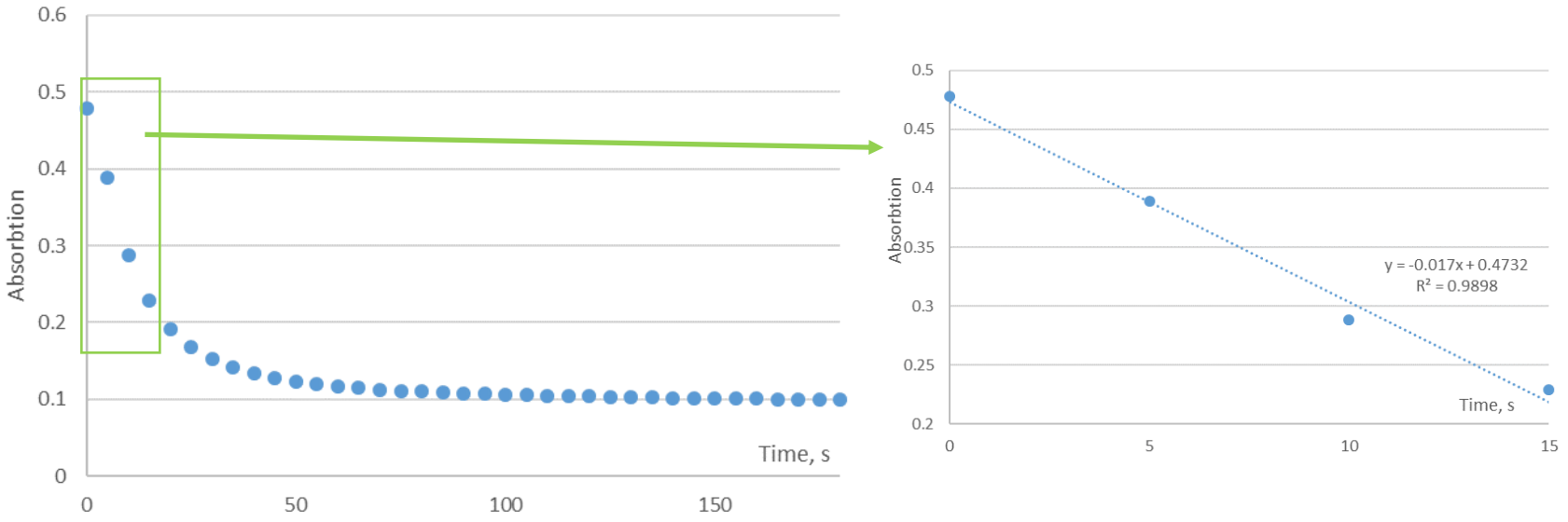




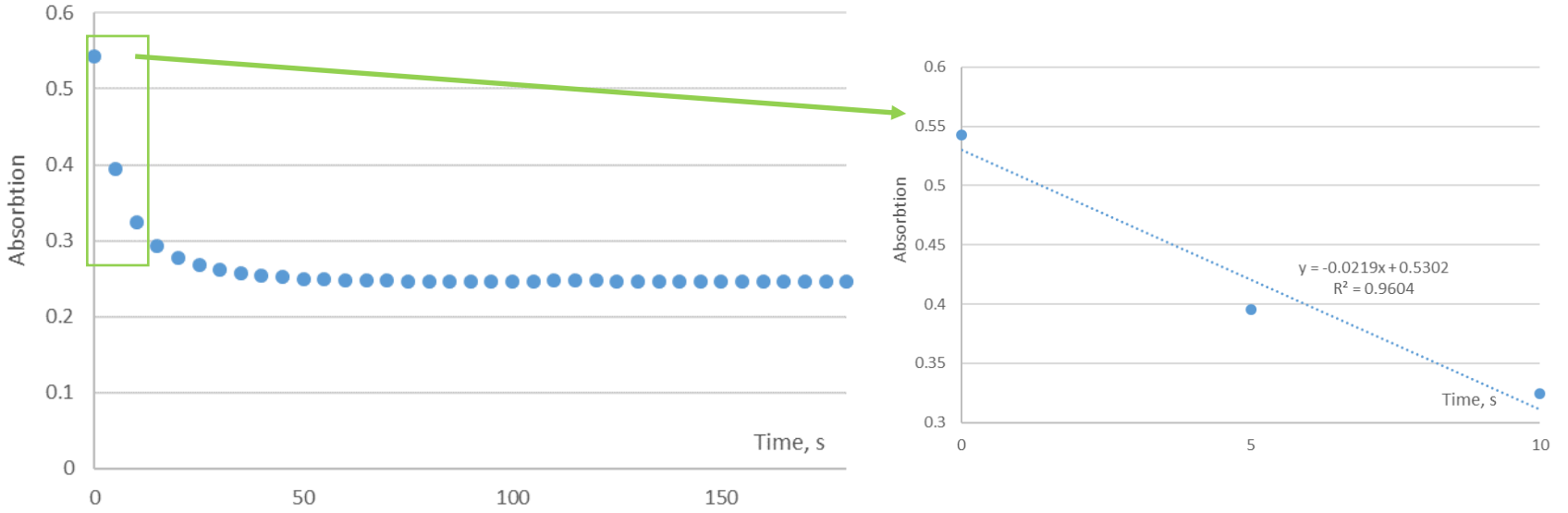

Absorbtion
Time, s
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
Absorbtion
Time, s
0.69
0.688
0.686
0.684
0.682
0.68
0.678
0.676
0.674
0
10
20
30
40
50
y = -0.0003x + 0.6882
R² = 0.9233
Absorbtion
Time, s
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150
Absorbtion
Time, s
0.69
0.68
0.67
0
10
20
30
40
50
60
y = -0.0002x + 0.6869
R² = 0.8882

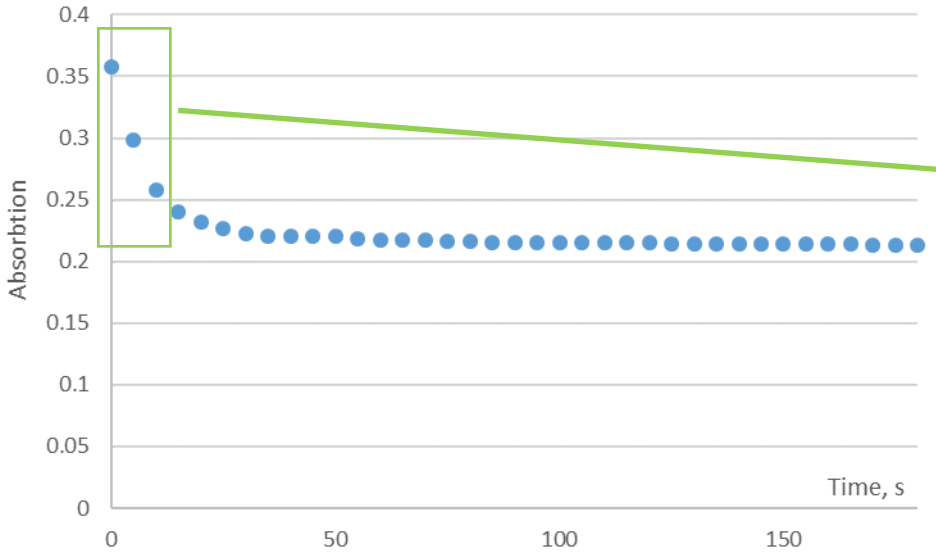
Kinetic curves in acetone:

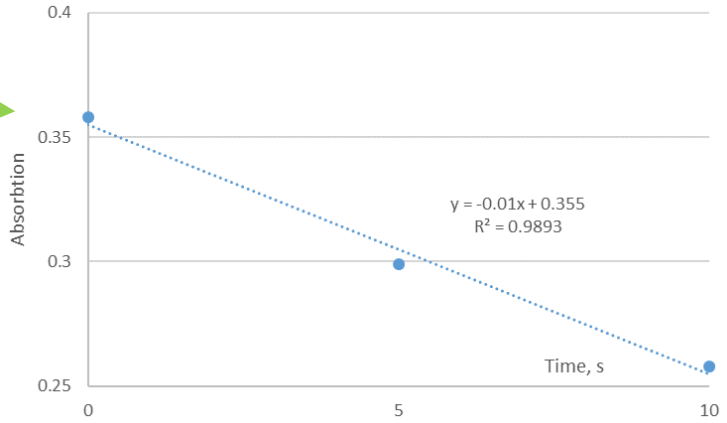


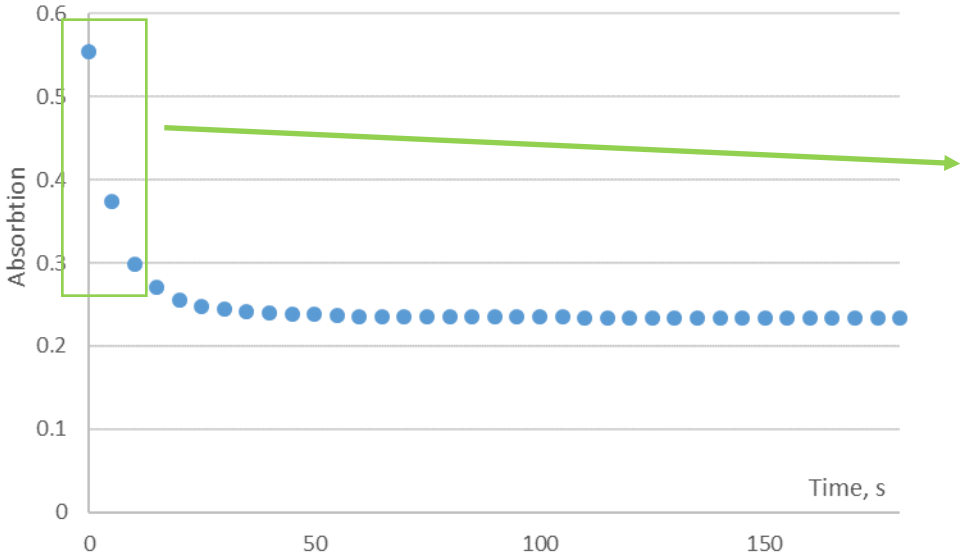


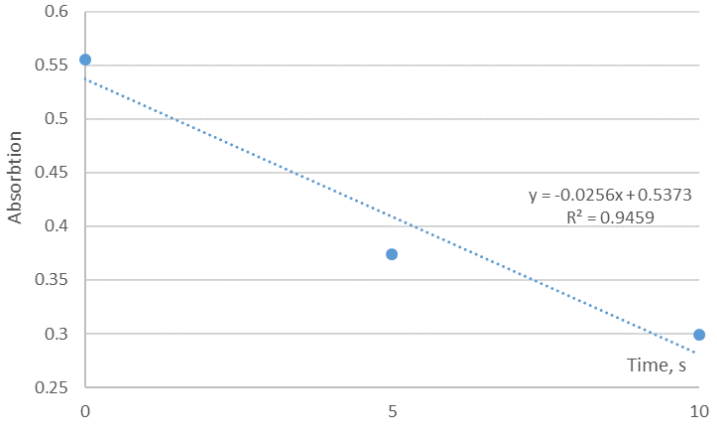
Kinetic curves in DMSO:



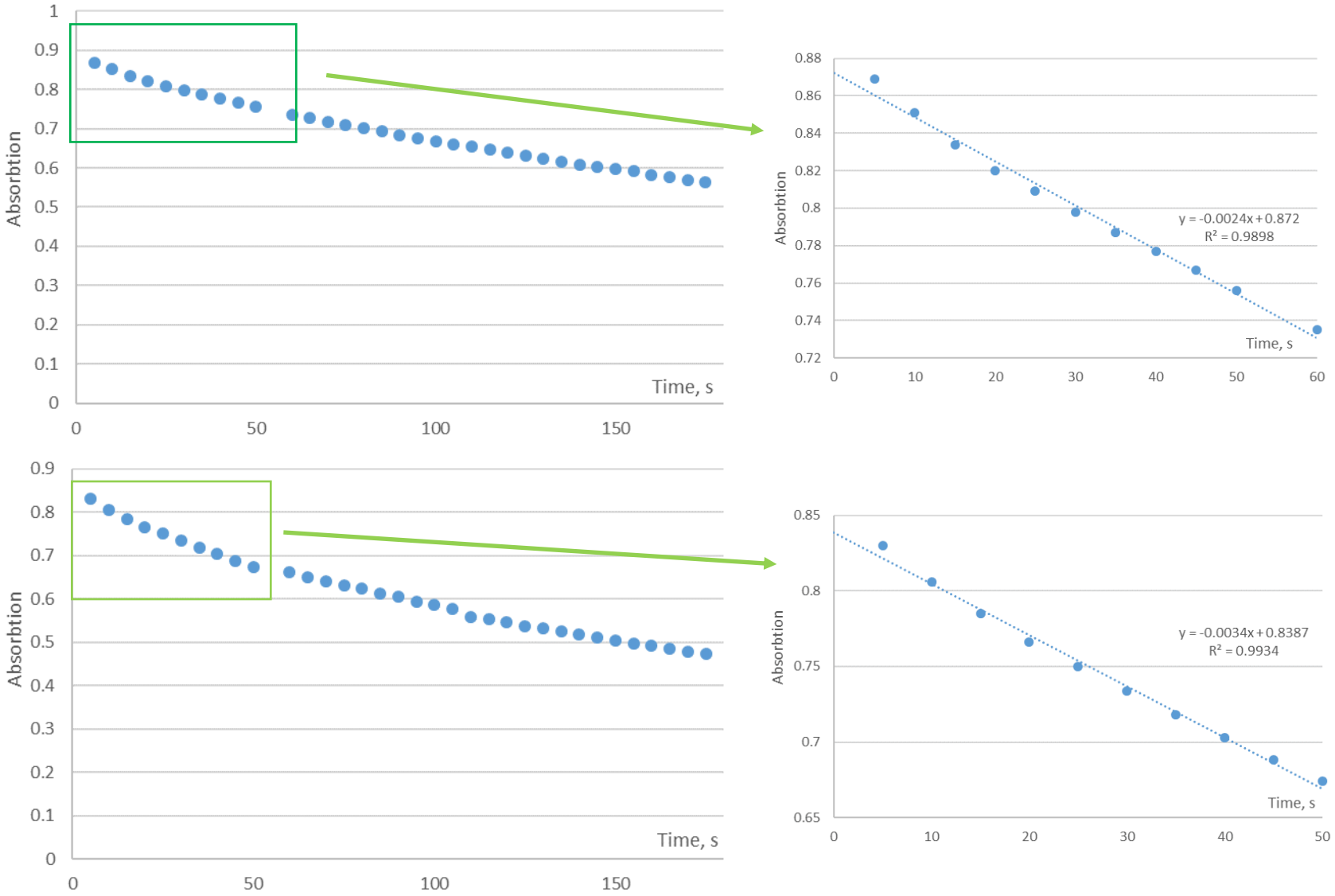

Absorbtion
Time, s
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
150


Absorbtion
Time, s
y = -0.01x + 0.355
R² = 0.9893
0.4
0.35
0.3
0.25
0
5
10


Absorbtion
Time, s
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
150


Absorbtion
Time, s
y = -0.0256x + 0.5373
R² = 0.9459
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0
5
10

Kinetic curves in absolute EtOH:



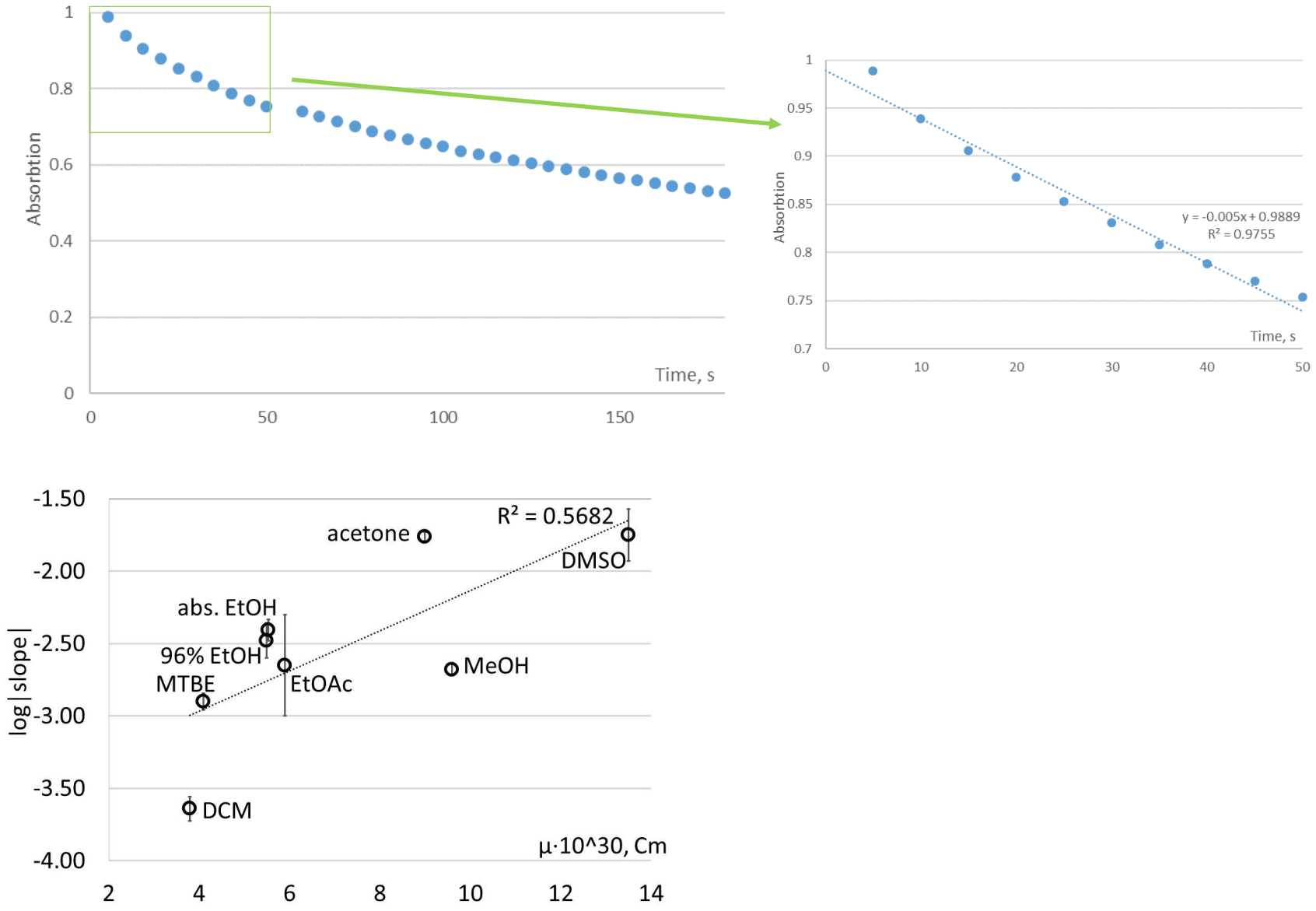


Fig. S1. Correlation between dipole moment of the solvents and log|slope|

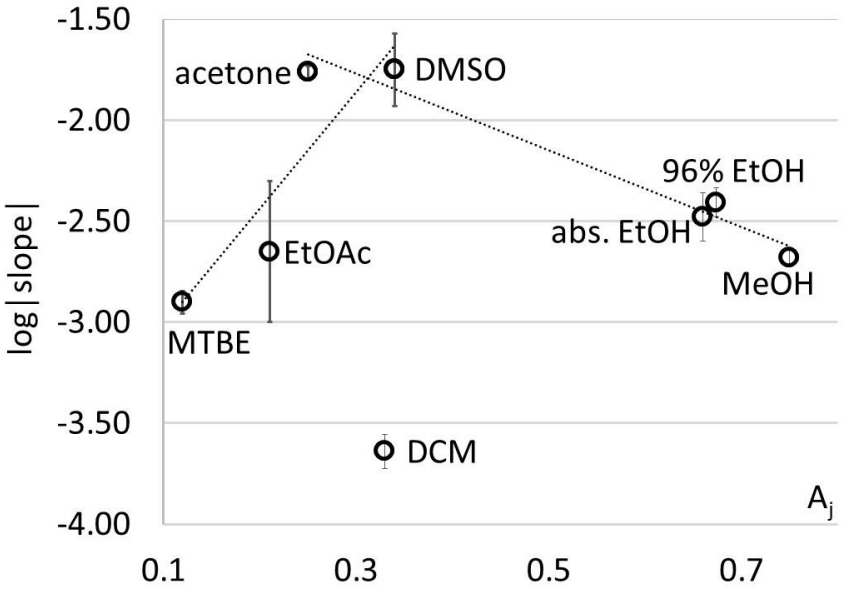


Fig. S2. Correlation between solvent acidity A_j and log|slope|

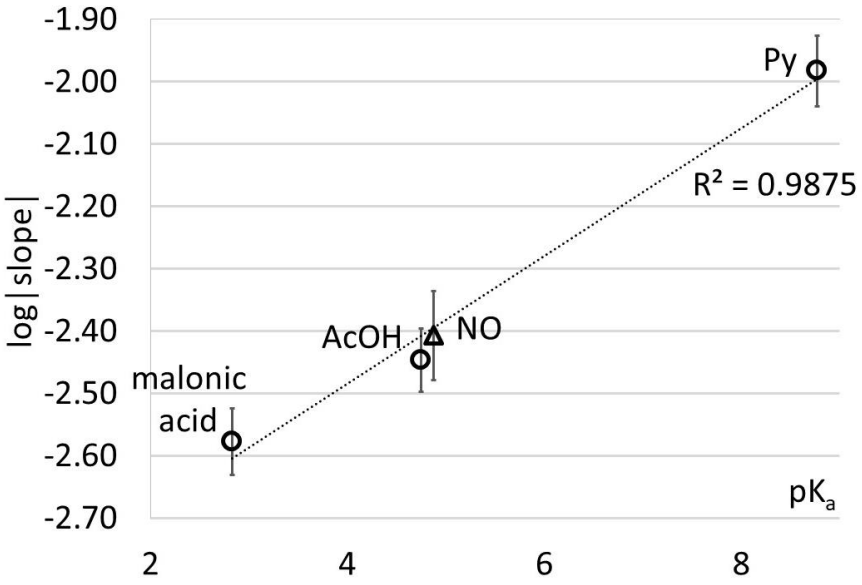
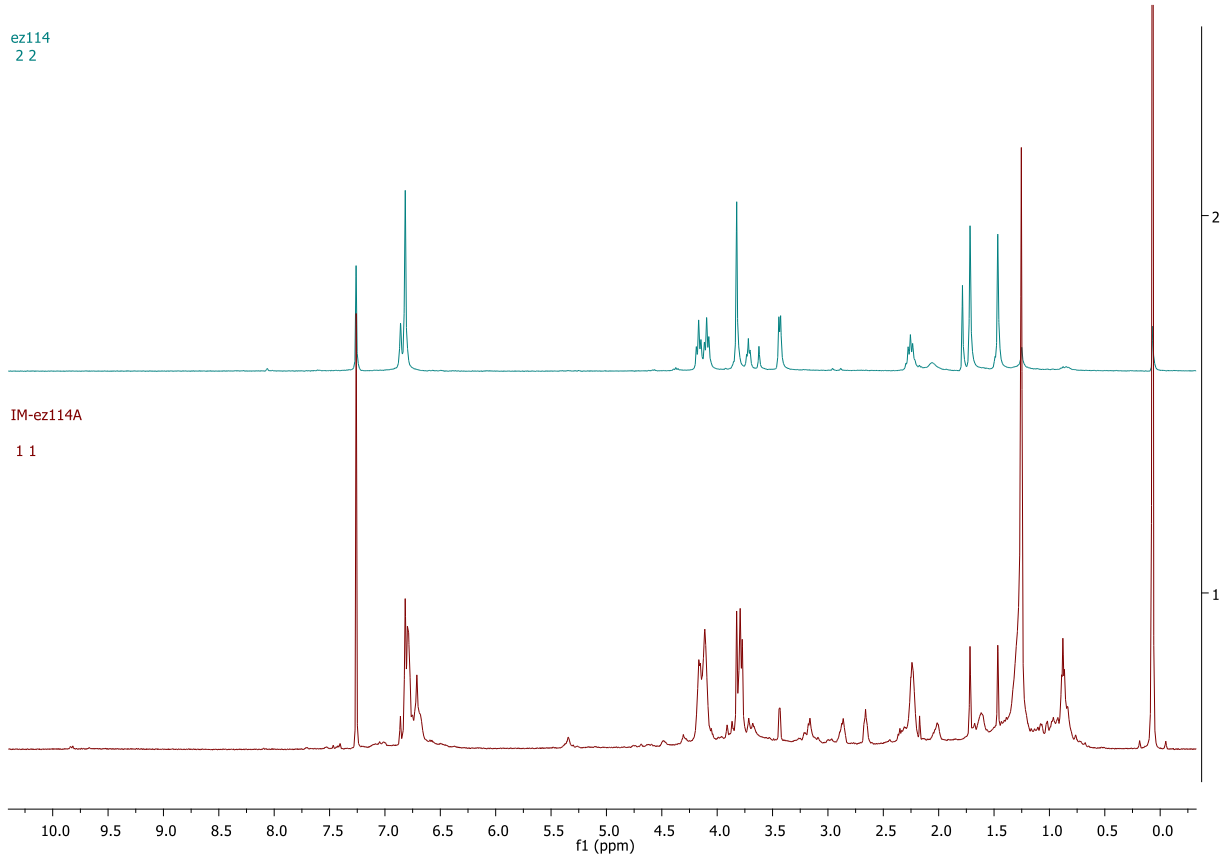


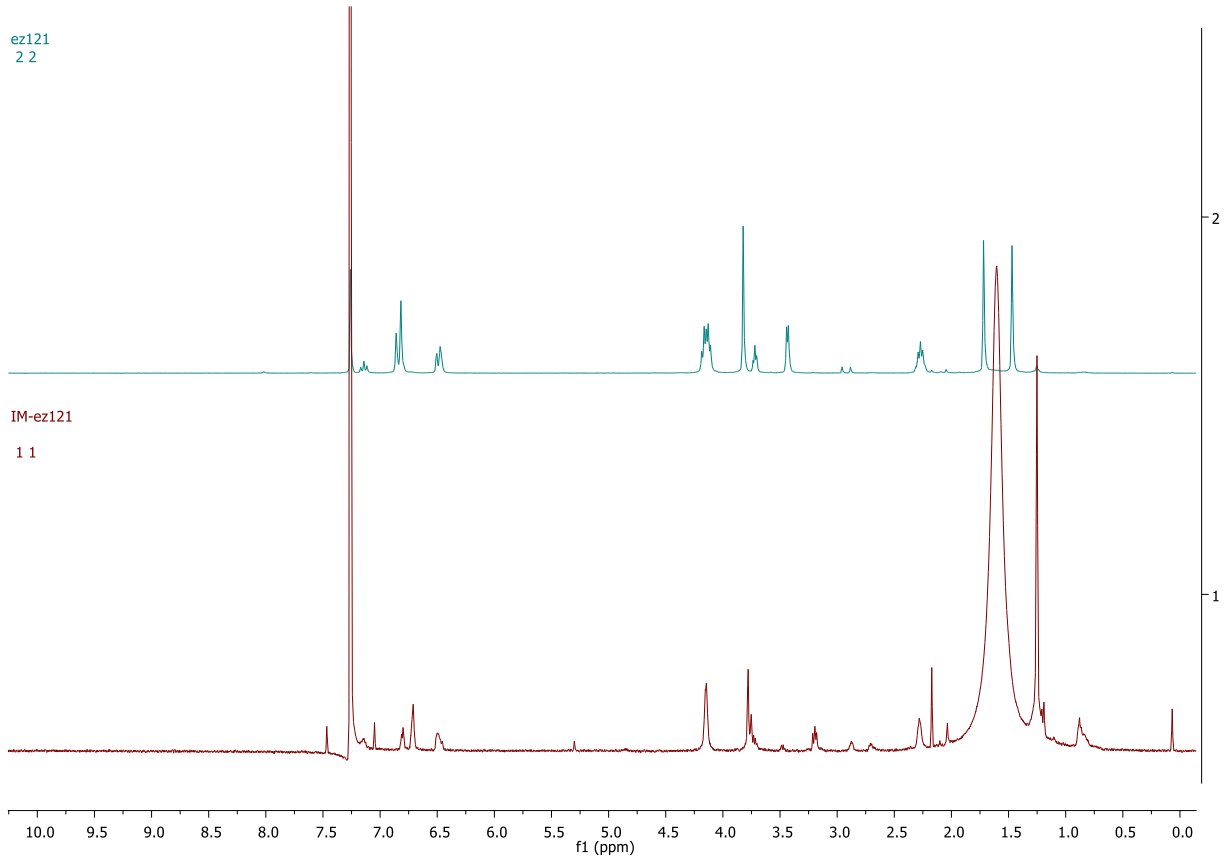
Fig. S3. Correlation between pKa values of the additives and log|slope|. The triangle corresponds to the sample without the additive (the provided pKa value coresponds to the Meldrum`s acid derivatives itself)

^{1}H NMR spectra before and after autooxidation

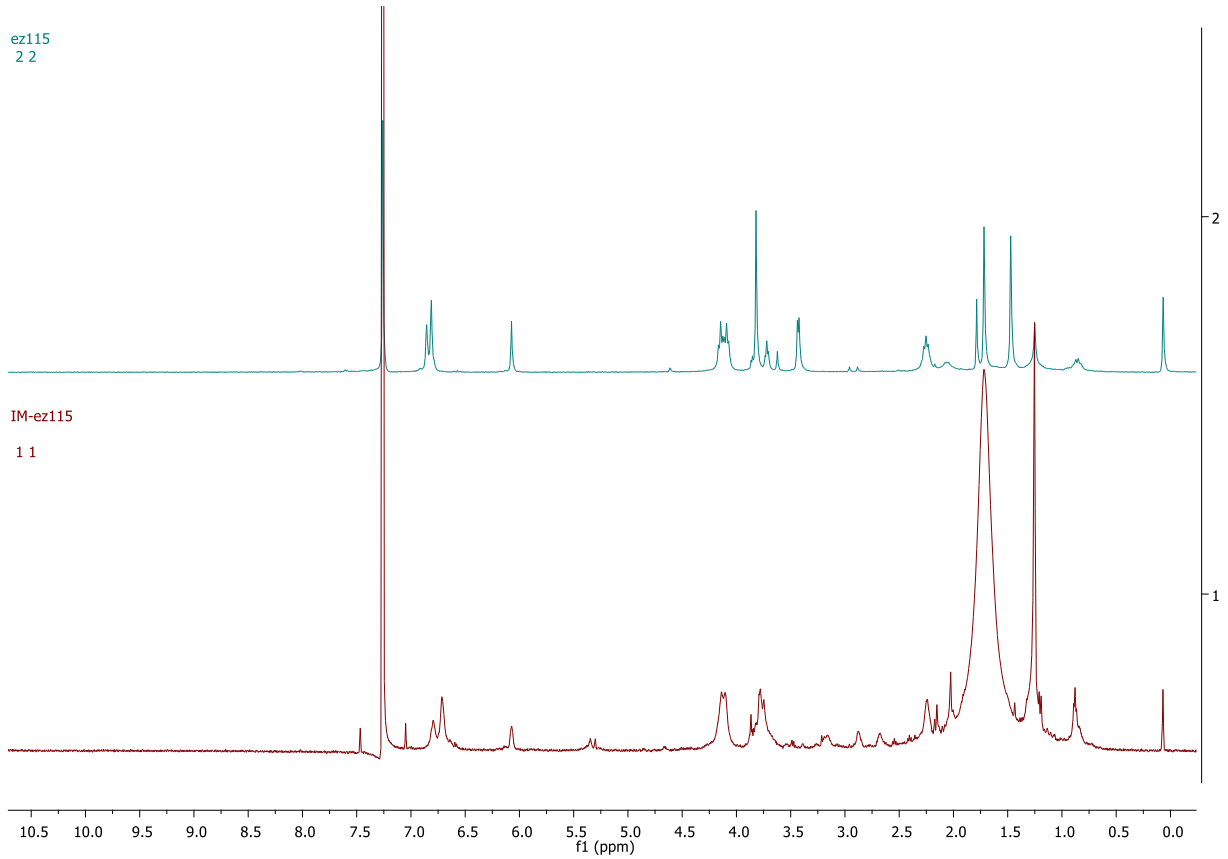
Spectra for freshly prepared compounds were registered on Bruker Avance 300 apparatus (300 MHz, $CDCl_3$). Spectra after autooxidation were registered on Bruker Avance 500 apparatus (500 MHz, $CDCl_3$).



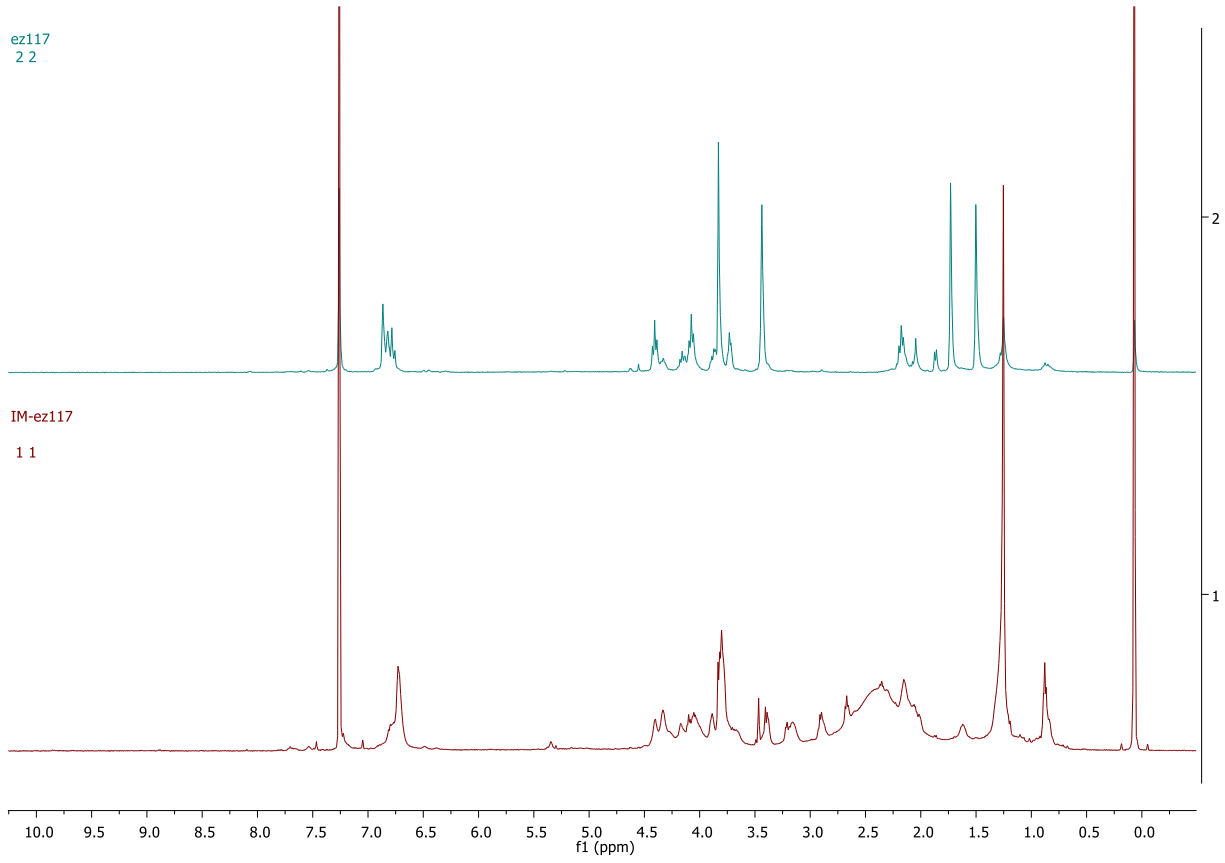
^{1}H NMR spectra for freshly prepared compound **13c** and after long-term storage



^{1}H NMR spectra for freshly prepared compound **13b** and after long-term storage



^{1}H NMR spectra for freshly prepared compound **13d** and after long-term storage



^{1}H NMR spectra for freshly prepared compound **13i** and after long-term storage