Electronic Supplementary Material (ESI) for Organic Chemistry Frontiers.

ESI for:

Organocatalytic N-Formylation of Amines by CO_2 under Batch and Continuous Flow

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SUPPORTING INFORMATION:

32 pages, 6 figures, 1 table, 1 scheme

Contents:

S3: General considerations

All commercial reagents were used as received and all reactions were carried out under air unless stated otherwise. DBU@polystyrene was purchased from Aldrich (595128-5g), DBU = 1,8-diazabicyclo[5.4.0]undec-7-ene, polymer bound (1%DVB, 100-200 Mesh). Note that the loading may vary between 1.5-2.5 mmol/g. This catalyst was analyzed by elemental analysis prior to its use in the catalytic studies. Trimethoxy silane was purchased from ABCR, with a pricing of 158 Euros for 25 g (AB111484-25g).

^{1}H and ^{13}C NMR spectra were recorded at room temperature or at 398 K using a Bruker Advance 300 Ultrashield spectrometer operating at 300 and 75 MHz, respectively, a Bruker Advance 400 Ultrashield spectrometer operating at 400 and 100 MHz, respectively, or Bruker Advance 500 Ultrashield spectrometer operating at 500 and 125 MHz, respectively.

All ^{1}H NMR spectra are reported in parts per million (ppm) downfield of TMS and are measured relatively to the signal for $CHCl_3$ (7.26 ppm) and DMSO (2.50 ppm). All ^{13}C NMR spectra are reported in parts per million (ppm) relative to residual $CHCl_3$ (77.16 ppm) and DMSO (39.52 ppm) and were obtained with ^{1}H decoupling. Coupling constants, J, are reported in Hertz. IR spectra were recorded on a Bruker Tensor 27/Diamond ATR FT-IR spectrometer or a Thermo Scientific iS50 FT-IR spectrometer. Elemental analyses of the polystyrene-supported catalysts were performed on a LECO CHNS 932 micro-analyzer at the Universidad Complutense de Madrid (Spain) or by MEDAC LTD, UK. Flash chromatography was performed using 60 mesh silica gel on a Combiflash RF TeledineISCO. Thin layer chromatography was carried out using Merck TLC Silica gel 60 F254 aluminum sheets. Components were visualized by UV light (λ = 254 nm) and/or by phosphomolybdic acid, *p*-anisaldehyde, ninhydrin solution or $KMNO_4$ solution.

For additional details about the flow setup please check the supporting info of our previous work.[1,2]

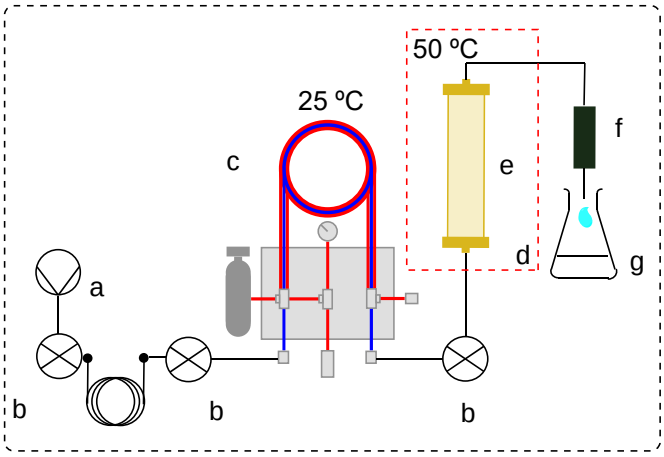
[1] N. Zanda, A. Sobolewska, E. Alza, A. W. Kleij and M. À. Pericàs, *ACS Sustainable Chem. Eng.* **2021**, *9*, 12, 4391–4397.

[2] N. Zanda, L. Zhou, E. Alza, A. W. Kleij and M. À. Pericàs, Green Chem. **2022**, *24*, 4628–4633.

S4: Experimental flow protocol

- Catalyst is charged in the tube
- The system is primed with dry solvent and the catalyst is swollen
- The auto-collector is calibrated
- Feed is charged in the loop through a syringe (by hand)
- Flow is turned off from the HPLC pump
- When the feed arrives to the Tube-in-Tube reactor (T-i-T), the CO_2 manometer is opened at the desired pressure. The T-in-T is then primed three times with cycles of opening and closing the gas exit. At the end, the exit key is closed
- The heat exchanger is then turned on at the desired temperature
- Changing of vials in the auto-collector is done when needed to collect different fractions of product

S5: Reaction optimization in flow using Omnifit column as PBR



a. HPLC pump
b. Check-valve (CV)
c. Tube-in-Tube Reactor
d. Heat exchanger
e. Packed-bed reactor (PBR)
f. Back pressure regulator (BPR)
g. Collection

Scheme S1: Setup used in the initial experiments using an Omnifit column.

Table S1: Optimization of the reaction conditions under continuous flow.

Entry	Flow rate mL/min	τ (min)	T-i-T pressure (bar)	Si-H (equiv)	T (ºC)	BPR (bar)	Conversion (%)
1	0.069	60	1	3	70	8	91
2	0.139	30	1	3	70	8	90
3	0.139	30	1	3	70	13	90
5	0.208	20	1	3	70	10	75
6	0.208	20	1	3	80	10	> 99
7	0.208	20	2	3	80	10	> 99 (97)[a]
8	0.277	15	1	2	80	10	51
9	0.277	15	1	2	90	10	66
10	0.208	20	1	2	90	10	91(74)[b]

General procedure: the catalyst DBU@PS **C1** (2 g, 2.37 mmol/g) is placed in an Omnifit column (heated by oil circulation) in the up-flow configuration, the substrate and the silane ($(MeO)_3SiH$, 3 equiv) in ACN (0.2 M) are flowed through the T-i-T reactor (1 bar CO_2) and then led through the PBR. Finally, the system is closed by two black 75 psi BPRs and the liquid is finally collected. [a] Selectivity 97%. [b] Selectivity was 74%, the increase of the reaction temperature allows the formation of *N*,*N*-dimethylaniline.

The pressure read on the pump was at 33 bar, thus, considering the maximum pressure of 41 bar allowed for the Omnifit column, we decided to use a PFA tubing as a Packed Bed Reactor (PBD).

S6: Example of a crude product obtained under batch operation

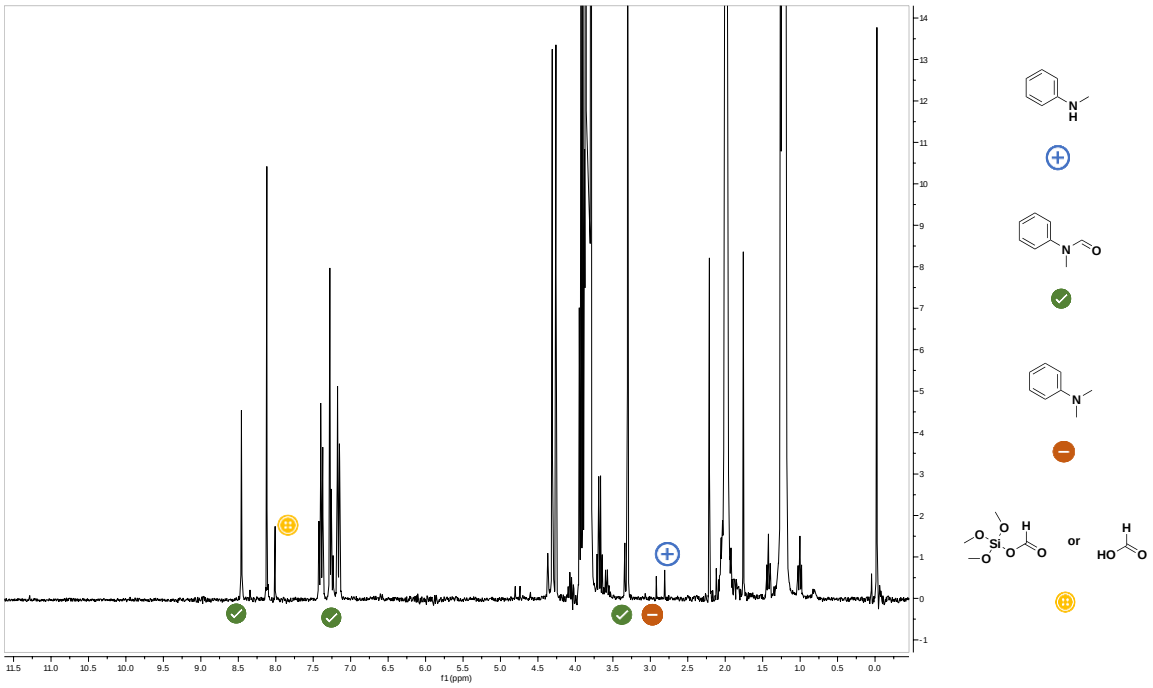


Figure S1. ^{1}H NMR crude of a typical reaction in batch mode. It shows the characteristic signals of main products and starting material. Substrate used: *N*-methylaniline.

At 8 ppm a peak appears that is assigned to the product of the hydrosilylation of CO_2 prior to hydrolysis to provide formic acid. The (small) peak at 11.3 ppm is tentatively assigned to formic acid.

S7: Example of a crude product from flow operation

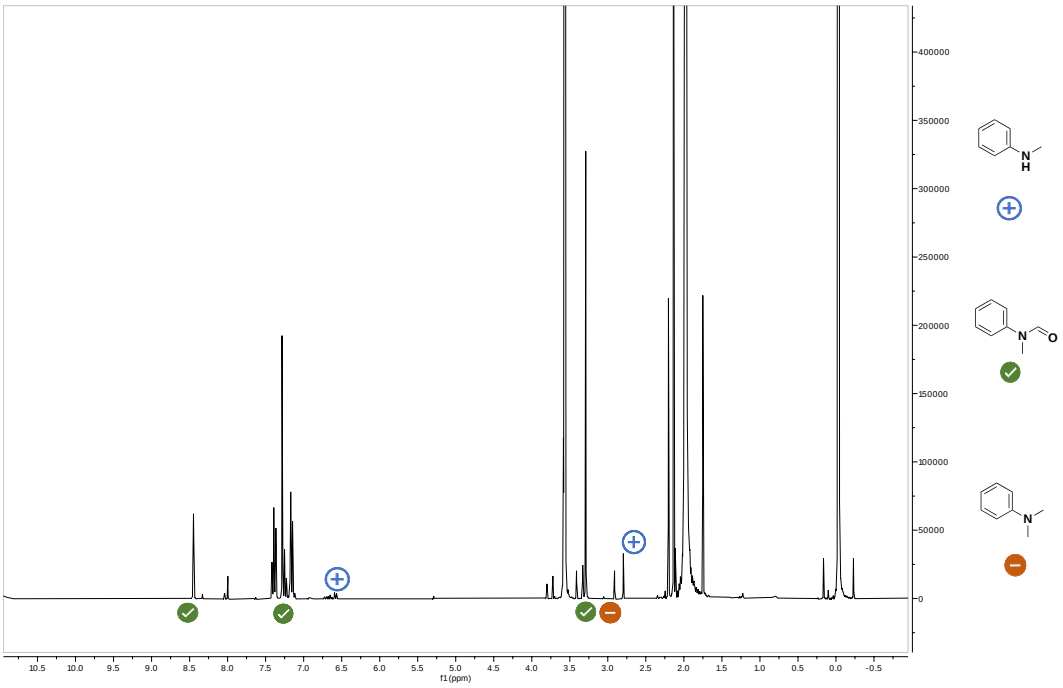
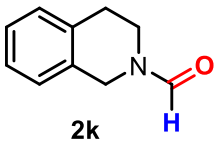


Figure S2. ^{1}H NMR of a crude of a typical reaction product prepared under continuous flow. The spectrum shows the characteristic signals of the main products and starting material.

S8: Variable temperature ^{1}H NMR analysis of 2k



2k

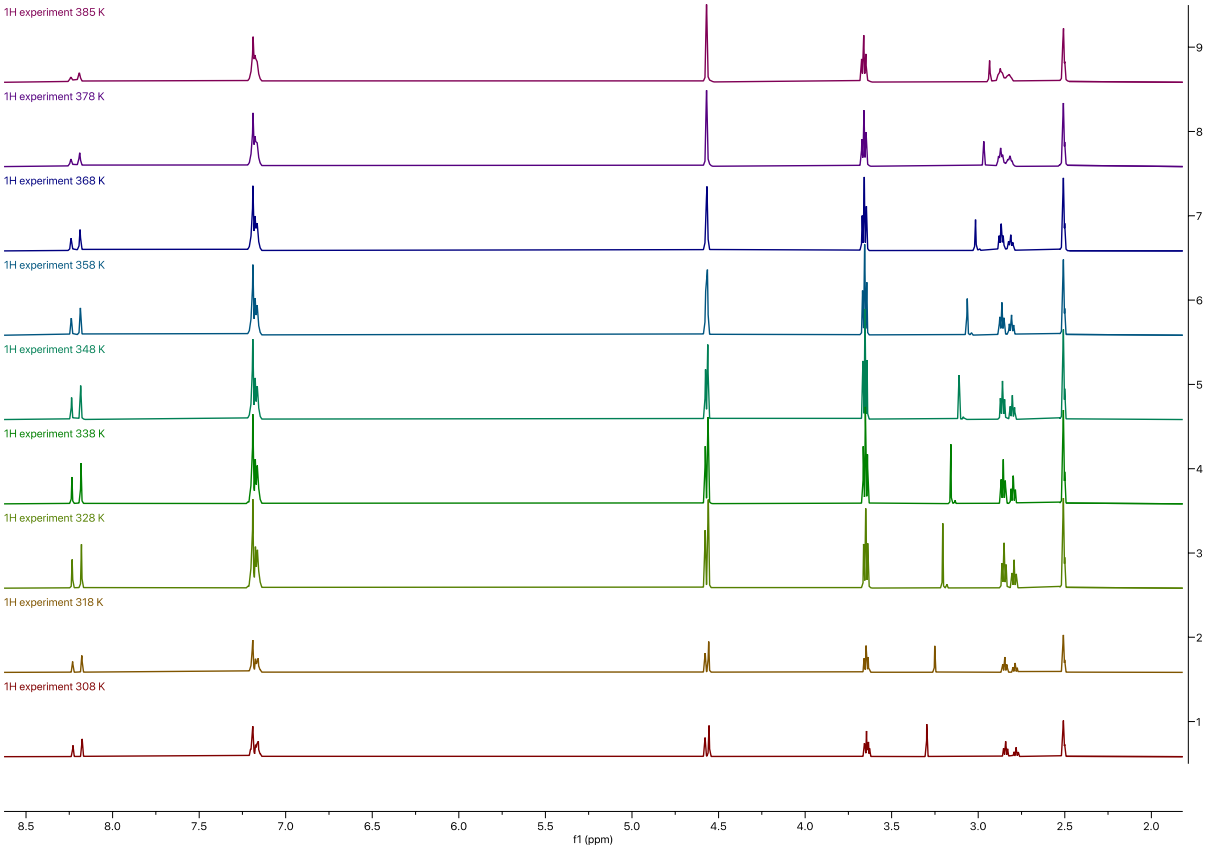
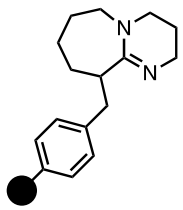
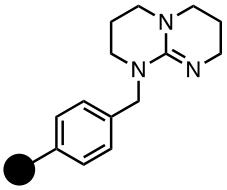


Figure S3. Variable temperature ^{1}H NMR analysis (298-385 K) of compound **2k**. Details: 20 mg of product **2k** were dissolved in DMSO-d_6 and analyzed by ^{1}H NMR. The spectra were recorded using 8 scans at each given temperature. The observed splitting (298 K) is ascribed to a slow *N*-pyramidal inversion at r.t.

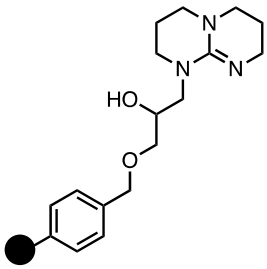
S9: Preparation and information of/on supported catalysts



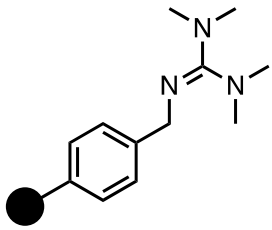
Polystyrene-supported DBU (DBU@polystyrene) C1: was purchased from Sigma Aldrich, CAS: 595128-5g, 1,8-diazabicyclo[5.4.0]undec-7-ene, polymer-bound (1%DVB, 100-200 Mesh). Note that the loading may vary between 1.5-2.5 mmol/g. The catalyst was analyzed by elemental analysis prior to its use in the catalytic studies. Please note that different batches of catalyst were used in the experiments described in the manuscript, the loading was determined by elemental analysis in each case.



Polystyrene supported TBD (TBD@PS) C2: was purchased from Sigma Aldrich. CAS: 01961-5G-F, 1,5,7-triazabicyclo[4.4.0]dec-5-ene bound, (2% DVB, 100-200 Mesh) with a TBD loading of 2.4 mmol/g.

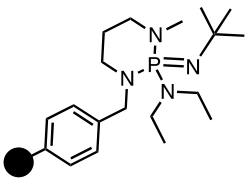


Merrifield supported catalyst TBD@Merrifield C3: Prepared according a reported procedure,[1] f_{exp} = 0.740 mmol/g.

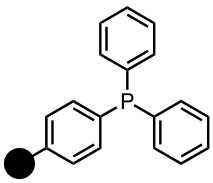


Polystyrene-supported 1,1,3,3-tetramethylguanidine (PS-TMG) C4: was prepared according to a reported procedure.[3] A mixture of Merrifield resin (6.5 g, 1.3 mmol g^{-1} loading, 100-200 mesh, cross-linked with 1% DVB) and dry 1,4-dioxane (50 mL) was stirred under nitrogen for 30 min at rt to swell the polymeric material. Then 1,1,3,3-tetramethylguanidine (4.28 g, 37.2 mmol) was added and the reaction was shaken for 16 h at 70 °C under nitrogen. The heterogeneous mixture was then diluted with H_2O (10 mL), filtered, and the catalyst successively washed with MeOH (3 × 20 mL), CH_2Cl_2 (3 × 20 mL) and *n*-pentane (3 ×20 mL). Finally, the beads (white color) were dried overnight under vacuum at 50 ºC. f_{exp} = 1.011 mmol/g.

[3] Z. Wang, R. Gérardy, G. Gauron, C. Damblon and J-C. M. Monbaliu, *React. Chem. Eng*. **2019**, *4*, 17-26.

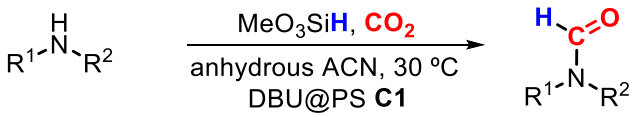


Polystyrene-supported 2-*tert*-butylimino-2-diethylamino-1,3-di-1,3-dimethylperhydro-1,3,2-diazaphosphorine, BEMP@PS, C5: was purchased from Sigma Aldrich. CAS: 536490-1G (1% DVB, 100-200 Mesh), loading of active sites is 2.5 mmol/g.

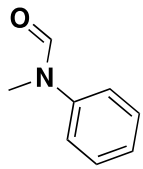


Polystyrene-bound triphenylphosphine, PPh_3@PS, C6: was purchased from Sigma Aldrich. CAS: 39319-11-4, 93094-25G, (1% DVB, 100-200 Mesh). The phosphine loading is 1.6 mmol/g.

S11: Synthesis and characterization of the N-formylated products

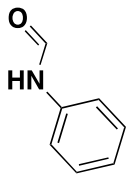


General procedure for the synthesis of compounds 2a-2p in batch: Catalyst **C1** (*f* = 1.91 mmol/g, 15.7 mg, 10% mol% loading) was added to a 20 mL glass vial at room temperature, then a solution of **1a** (0.3 mmol, 32.5 μL, 1 equiv) in dry acetonitrile (0.45 mL) was added. The vial was left under a CO_2 atmosphere for 10 minutes and then trimethoxysilane (1.5 mmol, 0.191 mL, 5 equiv) was added. Finally, a CO_2 balloon was connected to the reaction vessel and the reaction mixture stirred at 150 rpm for 18 h. Then, the crude product was filtered and the resin beads were extracted by EtOAc (3 × 8 mL). The organic fractions were then washed with water and the organic phase dried over $MgSO_4$. The solvent was concentrated in vacuo and the product was isolated after purification by flash column chromatography using 3:7 (v/v) cyclohexane/ethyl acetate as eluent.

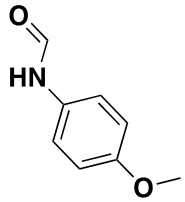


***N*-methyl-*N*-phenylformamide (2a).**[4] 0.35 mmol, 0.045 g, 95% yield transparent oil, mixture of rotamers 95:5. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.45 (s, 1H), 8.33 (s, 1H, minor rotamer), 7.42 – 7.34 (m, 2H), 7.28 – 7.21 (m, 1H), 7.17 – 7.12 (m, 2H), 3.32 (s, 3H, minor rotamer), 3.29 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.3, 162.2, 142.2, 129.6, 129.1, 126.4, 126.3, 123.6, 122.4, 36.9, 32.0.

***N*-phenylformamide (2b).**[4] 0.350 mmol, 0.041 g, 95% yield, transparent oil, mixture of rotamers 53:47. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.94 (bs, 1H), 8.74 – 8.67 (m, 1H), 8.37 – 8.32 (m, 1H), 8.07 (bs, 1H), 7.59 – 7.51 (m, 2H), 7.39 – 7.26 (m, 4H), 7.22 – 7.14 (m, 1H), 7.17 – 7.06 (m, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.1, 159.6, 137.1, 136.9, 129.8, 129.1, 125.3, 124.9, 120.2, 118.9.



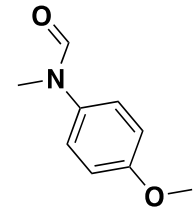
***N*-(4-methoxyphenyl)formamide (2c).**[5] 0.049 g, 93% yield, dark oil, mixture of rotamers 52:48. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.56 – 8.45 (m, 2H, N-H and H-CO), 8.33 – 8.23 (m, 1H), 7.77 (bs, 1H), 7.49 – 7.37 (m, 2H), 7.09 – 6.99 (m, 2H), 6.92 – 6.79 (m, 4H), 3.79 (s, 3H), 3.77 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 163.4, 159.3, 157.7, 156.8, 130.1, 129.8, 122.0, 121.6, 115.0, 114.3, 55.6, 55.6.



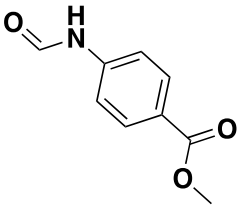
[4] M. Hulla, F. D. Bobbink, S. Das, P. J. Dyson, *ChemCatChem* **2016**, *8*, 3338-3342.

[5] B-X. Leong, Y.-C. Teo, C. Condamines, M.-C. Yang, M.-D. Su and C.-W. So, *ACS Catal.* **2020**, *10*, 14824–14833.

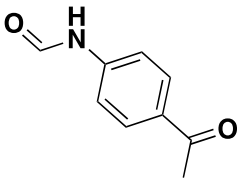
***N*-(4-methoxyphenyl)-*N*-methylformamide (2d).**[6] 0.027 g, 55% yield, transparent oil, mixture of rotamers 92:8. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.34 (s, 1H), 8.31 (s, 1H, minor rotamer), 7.33 – 7.28 (m, 2H, minor rotamer), 7.14 – 7.06 (m, 2H), 6.96 – 6.89 (m, 2H), 3.82 (s, 3H), 3.81 (s, 3H, minor rotamer), 3.31 (s, 3H, minor rotamer), 3.27 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.6, 158.5, 135.4, 124.8, 114.9, 55.7, 32.8.



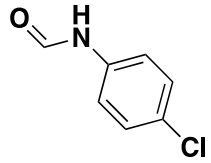
Methyl 4-formamidobenzoate (2e).[7,8] 0.051 g, 81% yield, white solid, mixture of rotamers 57:43. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.88 – 8.81 (m, 1H, minor rotamer), 8.55 – 8.46 (m, 1H, minor rotamer), 8.45 – 8.40 (m, 1H), 8.07 – 7.97 (m, 3H), 7.66 – 7.60 (m, 2H), 7.17 – 7.11 (m, 2H, minor rotamer), 3.91 (s, 3H, minor rotamer), 3.90 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 166.7, 166.4, 162.1, 159.2, 141.1, 141.1, 131.7, 131.1, 126.8, 126.3, 119.2, 117.3, 52.3, 52.2.



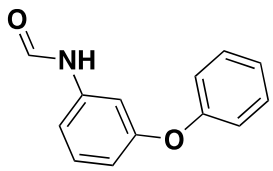
***N*-(4-Acetylphenyl)formamide (2f).**[9] 0.033 g, 67% yield, white solid, mixture of rotamers 60:40. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.95 – 8.82 (m, 2H, N-H and H-CO minor rotamer), 8.47 – 8.37 (m, 1H), 8.26 (bs, 1H), 8.00 – 7.87 (m, 3H), 7.71 – 7.63 (m, 2H), 7.21 – 7.14 (m, 2H, minor rotamer), 2.58 (s, 3H, minor rotamer), 2.57 (s, 3H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 197.3, 197.0, 162.2, 159.5, 141.5, 141.4, 133.8, 133.3, 130.6, 129.9, 119.4, 117.3, 26.6.



***N*-(4-chlorophenyl)formamide (2g).**[10] 0.035 g, 76% yield, white solid, mixture of rotamers 58:42. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.71 – 8.64 (m, 1H), 8.57 (bs, 1H), 8.43 – 8.37 (m, 1H), 7.61 (bs, 1H), 7.55 – 7.49 (m, 2H), 7.38 – 7.27 (m, 4H), 7.10 – 7.03 (m, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 159.2, 135.5, 135.4, 130.9, 130.0, 120.0, 129.3, 121.4, 120.2, 29.8.



***N*-(3-phenoxyphenyl)formamide (2h).**[11] 0.050 g, 78% yield, transparent oil, mixture of rotamers 53:47. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.79 – 8.71 (m, 1H), 8.71 – 8.65 (m, 1H), 8.36 – 8.28 (m, 1H), 7.94 (bs, 1H), 7.44 – 7.28 (m, 9H), 7.21 – 7.16 (m, 1H), 7.16 – 7.10 (m, 1H), 7.10 – 7.01 (m, 4H), 6.91 – 6.72 (m, 4H).**^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.7, 159.4, 158.8, 158.0, 156.8, 156.4, 138.4, 138.4, 130.9, 130.2, 130.0, 129.9, 124.1, 123.7, 119.5, 119.3, 115.0, 114.9, 114.8, 113.1, 110.6, 108.8.



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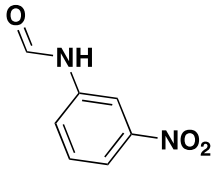
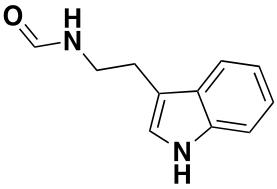
11 E. Surmiaka, C. G. Neochoritis, B. Musielak, A. Twarda-Clapa, K. Kurpiewska, G. Dubin, C. Camacho, T. A. Holak and A. Dömling, *Eur. J. Med. Chem.* **2017**, *126*, 384-407.

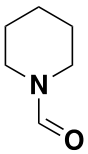
***N*-(3-nitrophenyl)formamide (2i).**[12] 0.044 g, 88% yield, white solid, mixture of rotamers 84:16. **^{1}H NMR** (400 MHz, DMSO-d_6) δ 10.65 (s, 1H), 10.51 – 10.42 (m, 1H, minor rotamer), 8.98 – 8.90 (m, 1H, minor rotamer), 8.59 (t, *J* = 2.2 Hz, 1H), 8.37 (d, *J* = 1.8 Hz, 1H), 8.02 – 7.98 (m, 1H, minor rotamer), 7.95 – 7.82 (m, 2H), 7.70 – 7.64 (m, 1H, minor rotamer), 7.59 (t, *J* = 8.1 Hz, 1H). **^{13}C NMR** (101 MHz, DMSO-d_6) δ 162.7, 160.3, 148.4, 147.9, 139.9, 139.2, 130.7, 130.3, 125.1, 123.1, 118.1, 117.8, 113.3, 111.6.



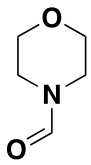
***N*-[2-(1*H*-indol-3-yl)ethyl]formamide (2j).**[13] 0.032 g, 56% yield, white solid, mixture of rotamers 82:18. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.48 (bs, 1H), 8.06 – 8.01 (m, 1H), 7.86 – 7.79 (m, 1H, minor rotamer), 7.62 – 7.56 (m, 1H), 7.57 – 7.53 (m, 1H, minor rotamer), 7.39 – 7.33 (m, 1H), 7.24 – 7.18 (m, 1H), 7.16 – 7.09 (m, 1H), 7.02 – 6.97 (m, 1H), 6.95 – 6.92 (m, 1H, minor rotamer), 5.80 (bs, 1H), 3.65 – 3.57 (m, 2H), 3.49 – 3.42 (m, 2H, minor rotamer), 3.01 – 2.95 (m, 2H), 2.95 – 2.90 (m, 2H, minor rotamer). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 164.8, 161.5, 136.6, 136.5, 127.3, 126.9, 122.9, 122.4, 122.3, 122.2, 119.6, 119.5, 118.7, 118.4, 112.4, 111.6, 111.5, 111.4, 42.1, 38.4, 27.4, 25.2.



3,4-dihydroisoquinoline-2(1*H*)-carbaldehyde (2k).[14] 0.043g, 89% yield, transparent oil, mixture of rotamers 63:37. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.23 (s, 1H, minor rotamer), 8.18 (s, 1H), 7.24 – 7.05 (m, 6H), 4.67 (s, 2H), 4.52 (s, 2H, minor rotamer), 3.80 – 3.74 (m, 2H, minor rotamer), 3.67 – 3.59 (m, 2H), 2.91 – 2.87 (m, 2H), 2.87 – 2.83 (m, 2H, minor rotamer). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.7, 161.2, 134.5, 133.6, 132.3, 131.8, 129.2, 128.9, 127.1, 126.8, 126.7, 126.5, 125.9, 47.3, 43.2, 42.3, 38.0, 29.8, 28.0.

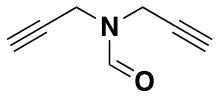


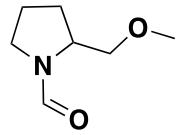
1-Piperidinecarboxaldehyde (2l).[15] 75% (^{1}H NMR yield), transparent oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.97 (s, 1H), 3.50 – 3.41 (m, 2H), 3.32 – 3.23 (m, 2H), 1.69 – 1.62 (m, 2H), 1.59 – 1.47 (m, 4H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 160.9, 46.9, 40.7, 26.7, 25.2, 24.8.



***N*-Formyl-morpholine (2m).**[16] 78% (^{1}H NMR yield), transparent oil. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.05 (s, 1H), 3.72 – 3.62 (m, 4H), 3.59 – 3.54 (m, 2H), 3.41 – 3.36 (m, 2H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.0, 67.4, 66.6, 45.9, 40.8.

[12] J. Yin, J. Zhang, C. Cai, G. Deng and H. Gong *Org. Lett.*, **2019**, *21*, 2, 387–392.
[13] C Li, M. Wang, X. Lu, L. Zhang, J. Jiang and L. Zhang *ACS Sustainable Chem. Eng.* **2020**, *8*, 11, 4353–4361.
[14] J. Ma, F. Zhang, J. Zhang and H. Gong, *Eur. J. Org. Chem*., **2018**, 4940-4948.
[15] M. Nasrollahzadeh, N. Motahharifar, M. Sajjadi, A. M. Aghbolagh, M. Shokouhimehr and Rajender S. Varma, *Green Chem.*, **2019**, *21*, 5144-5167.
[16] S. Nakai, T. Yatabe, K. Suzuki, Y. Sasano, Y. Iwabuchi, J.-y. Hasegawa, N. Mizuno, K. Yamaguchi, *Angew. Chem. Int. Ed.* **2019**, *58*, 16651-16660.

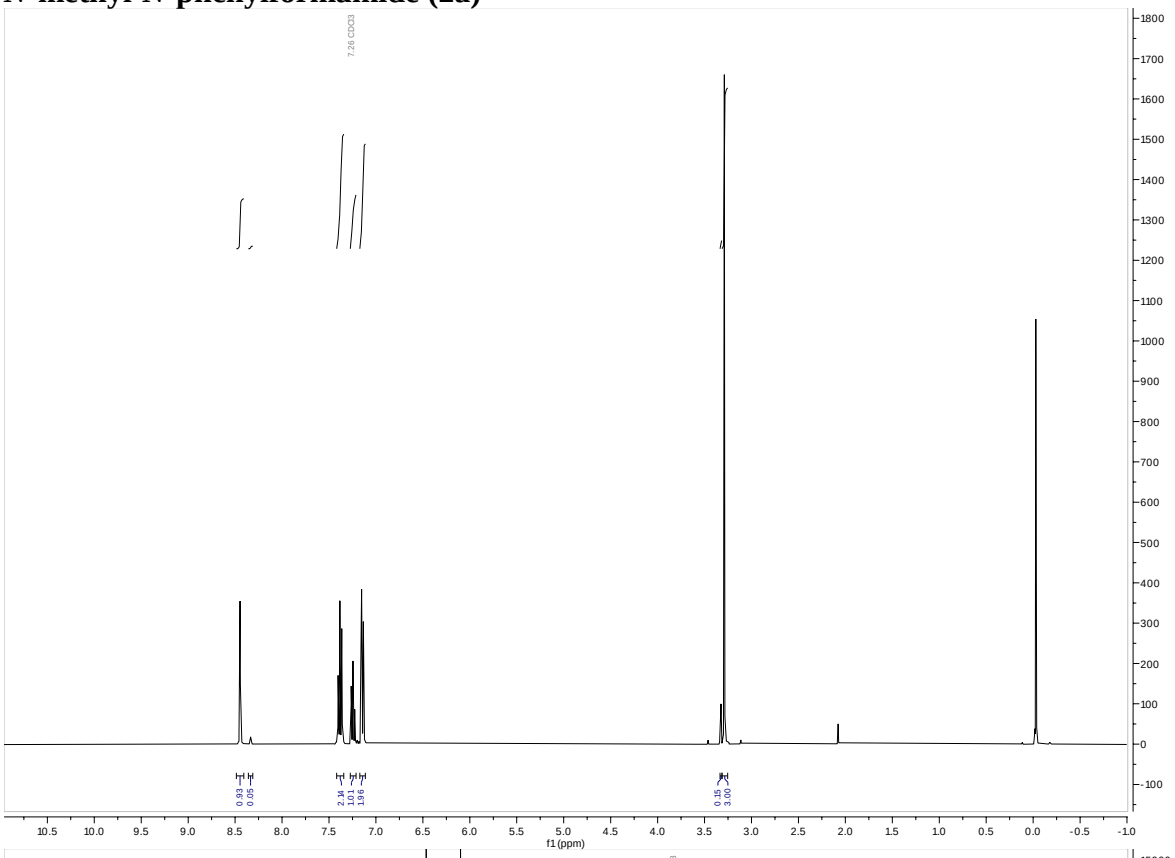
***N*,*N*-di(prop-2-yn-1-yl)formamide (2o)**. 0.025 g, white solid, 69% yield. **^{1}H NMR** (400 MHz, 
$CDCl_3$) δ 8.09 (s, 1H), 4.26 (d, *J* = 2.5 Hz, 2H), 4.14 (d, *J* = 2.5 Hz, 2H), 2.35 (t, *J* = 2.5 Hz, 1H), 2.23 (t, *J* = 2.5 Hz, 1H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 161.5, 77.2, 77.0, 74.1, 72.7, 36.2, 30.9. FT-IR (neat, *v* in cm^{-1}): 3241, 2120, 1659. **ESI-MS** $[C_7H_8NO]^+$: calcd, 122.0600; found, 122.0605.

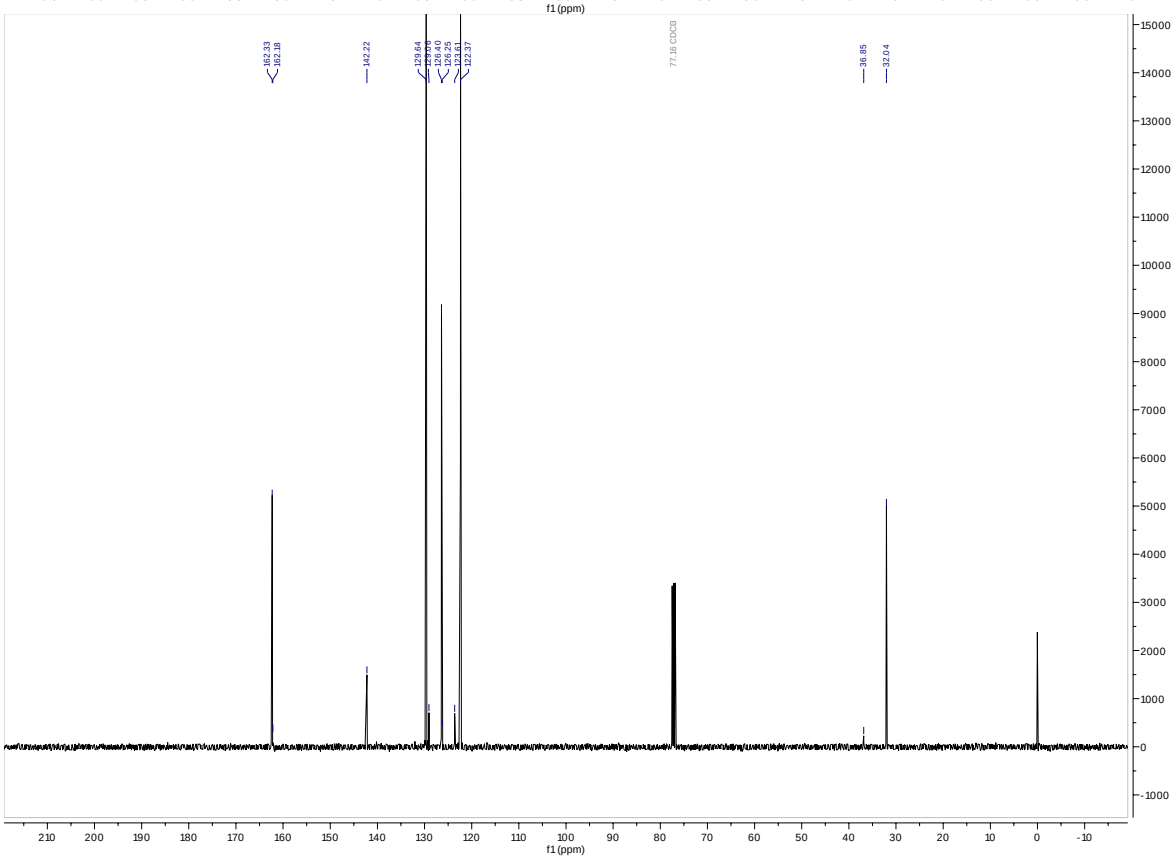
2-(methoxymethyl)pyrrolidine-1-carbaldehyde (2p).[17] 0.039 g, white solid, 78% yield. 
Mixture of rotamers 72:28. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.31 (s, 1H), 8.24 (s, 1H, minor rotamer), 4.19 – 4.10 (m, 1H, minor rotamer), 3.99 – 3.89 (m, 1H), 3.62 – 3.34 (m, 5H), 3.33 (s, 3H), 3.33 (s, 3H, minor rotamer), 3.29 – 3.23 (m, 1H), 2.08 – 1.66 (m, 6H). **^{13}C NMR** (101 MHz, $CDCl_3$) δ 162.0, 161.3, 75.5, 72.5, 59.2, 59.2, 56.9, 54.8, 47.1, 43.7, 28.0, 27.9, 24.0, 22.9.

[17] D. Seebach, H. Kalinowski, B. Bastani, G. Crass, H. Daum, H. Dorr, N. P. DuPreez, V. Ehrig, W. Langer, C. Nussler, H. Oei and M. Schmidt, *Helv. Chim. Acta* **1977**, *60*, 301-325.

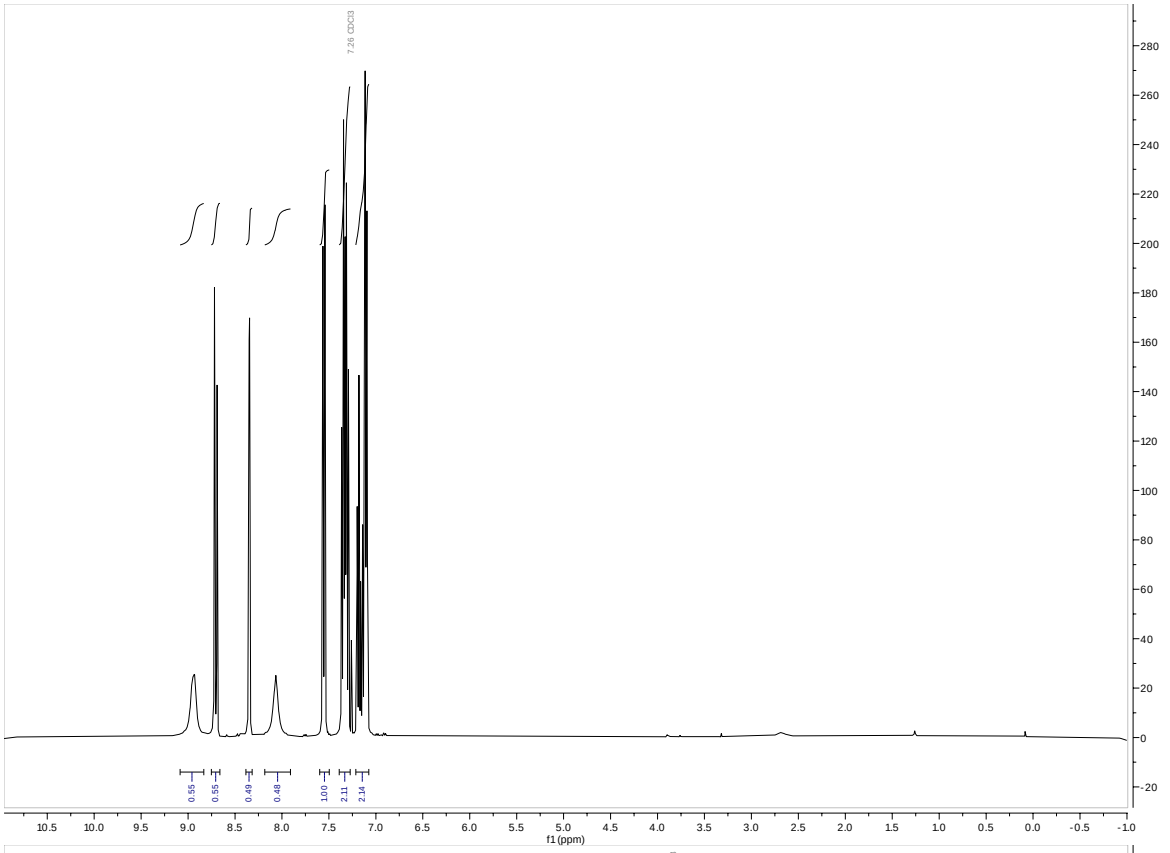
S15: ^{1}H NMR, ^{13}C NMR and FT-IR spectra of formylated products

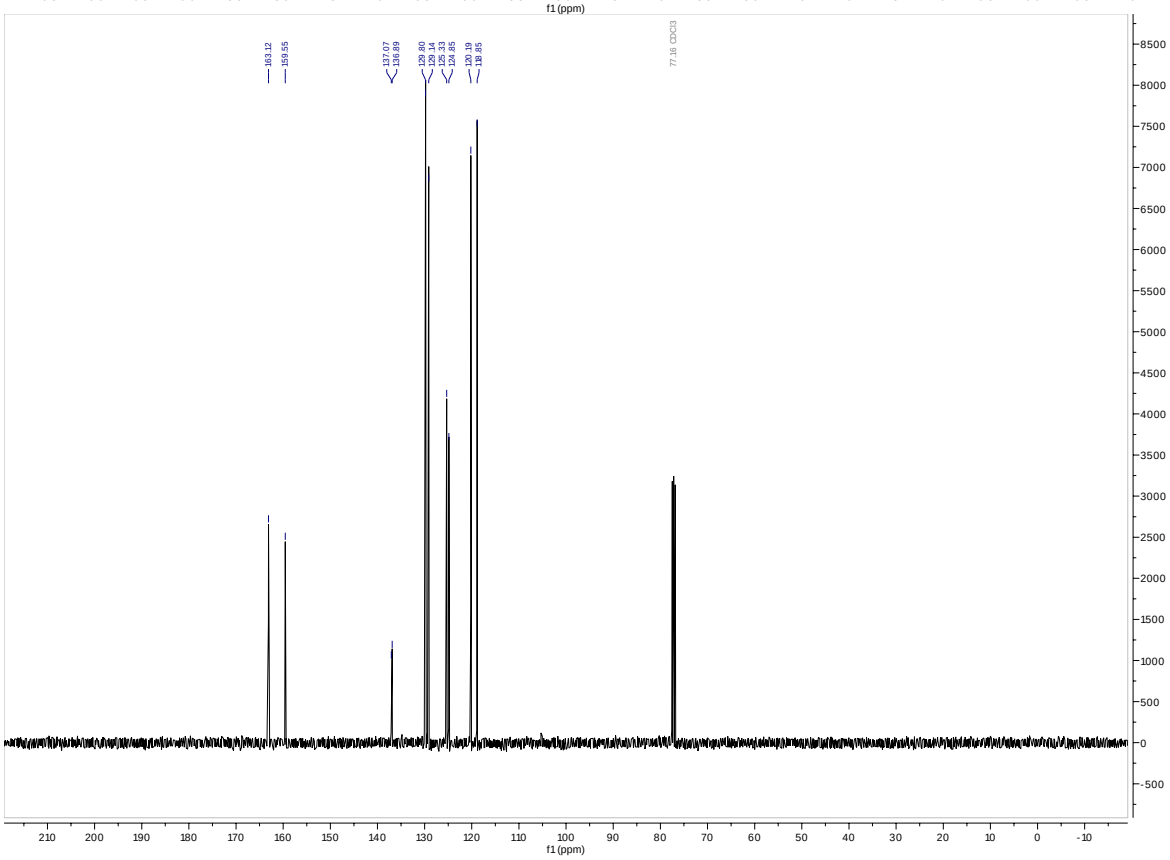
N-methyl-*N*-phenylformamide (2a)



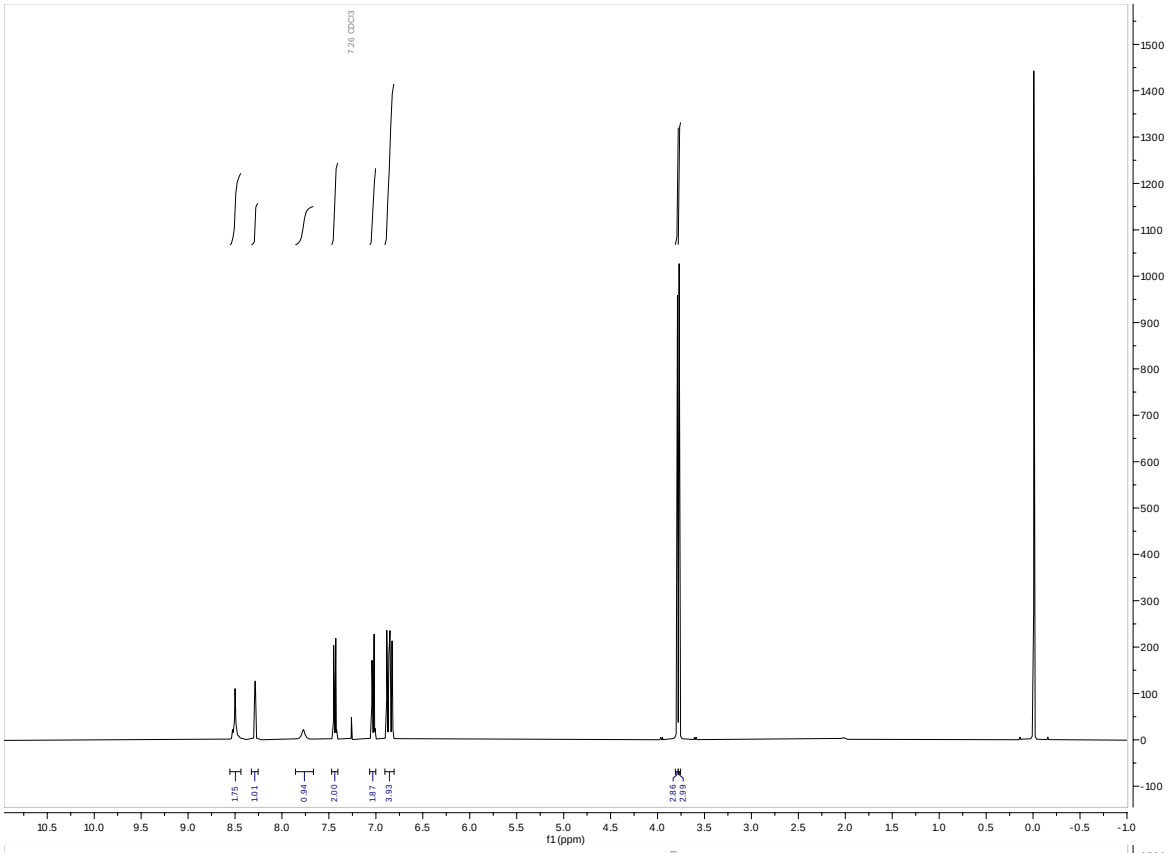


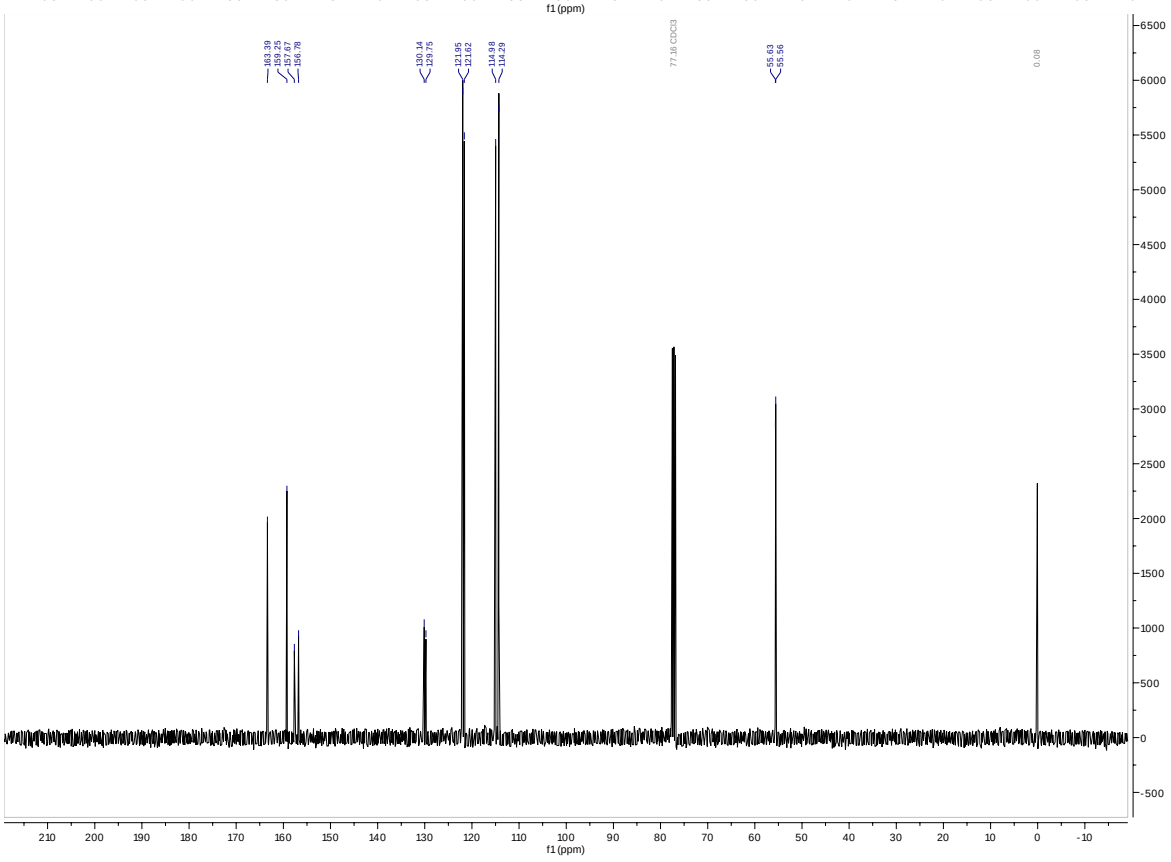
N-phenylformamide (2b)



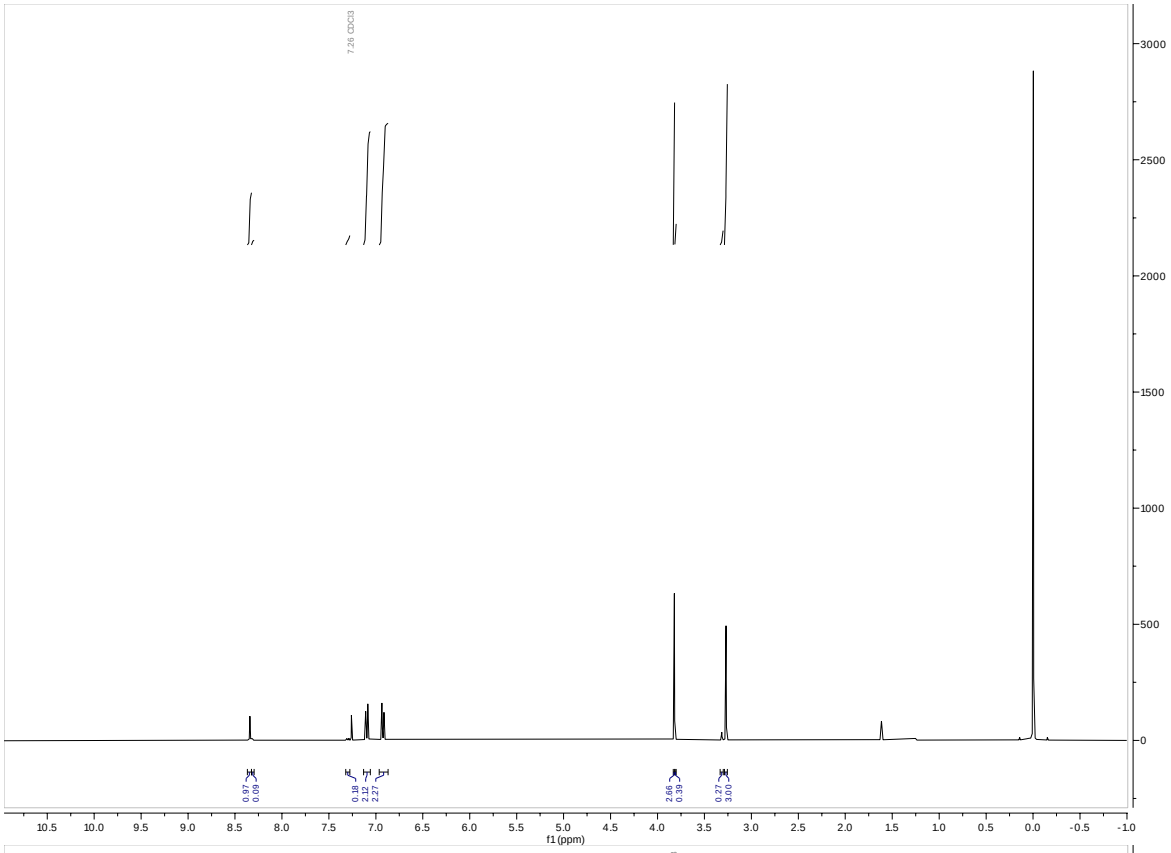


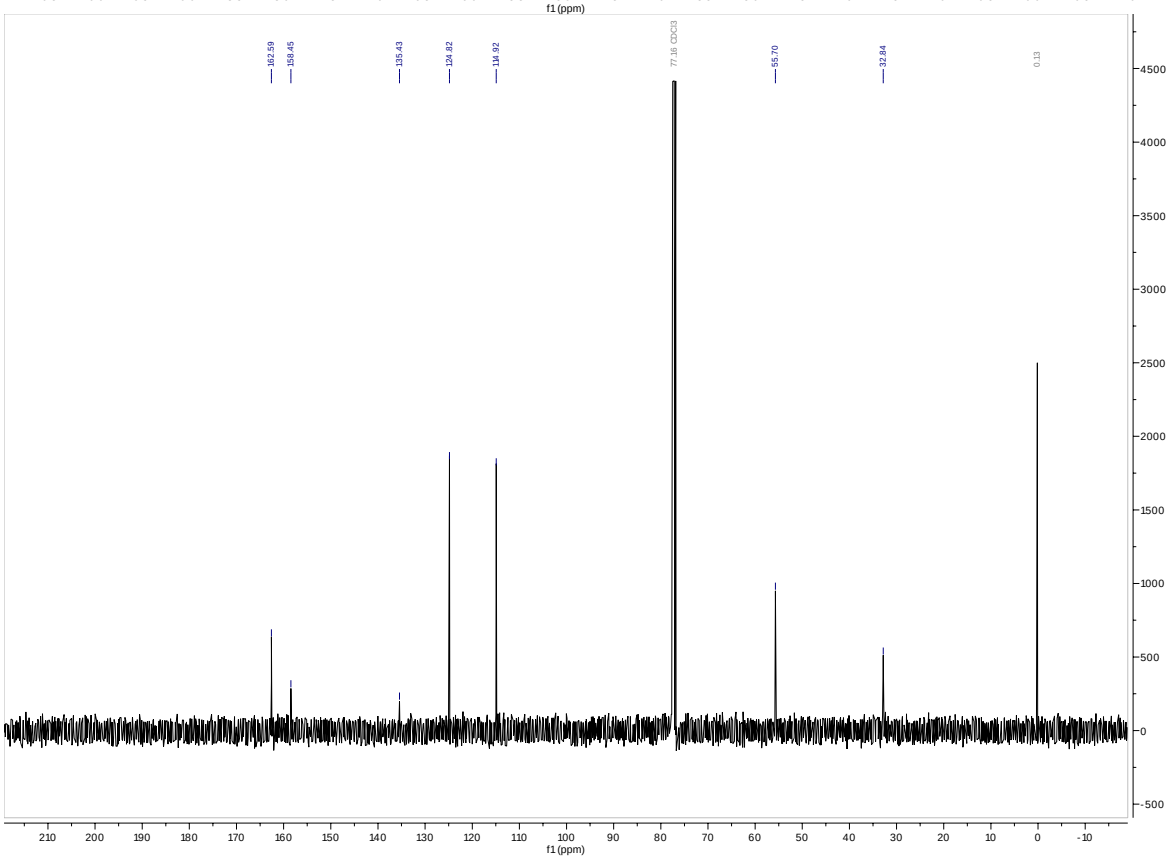
N-(4-methoxyphenyl)formamide (2c)



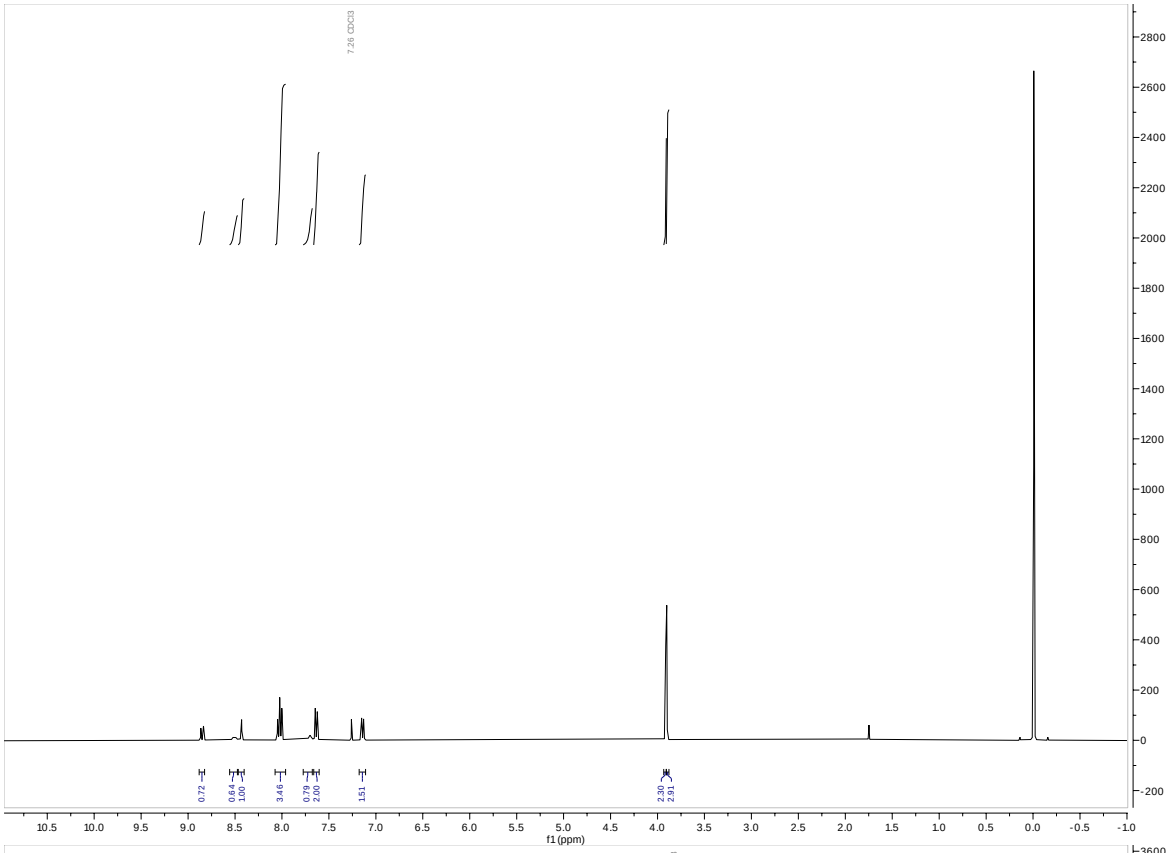


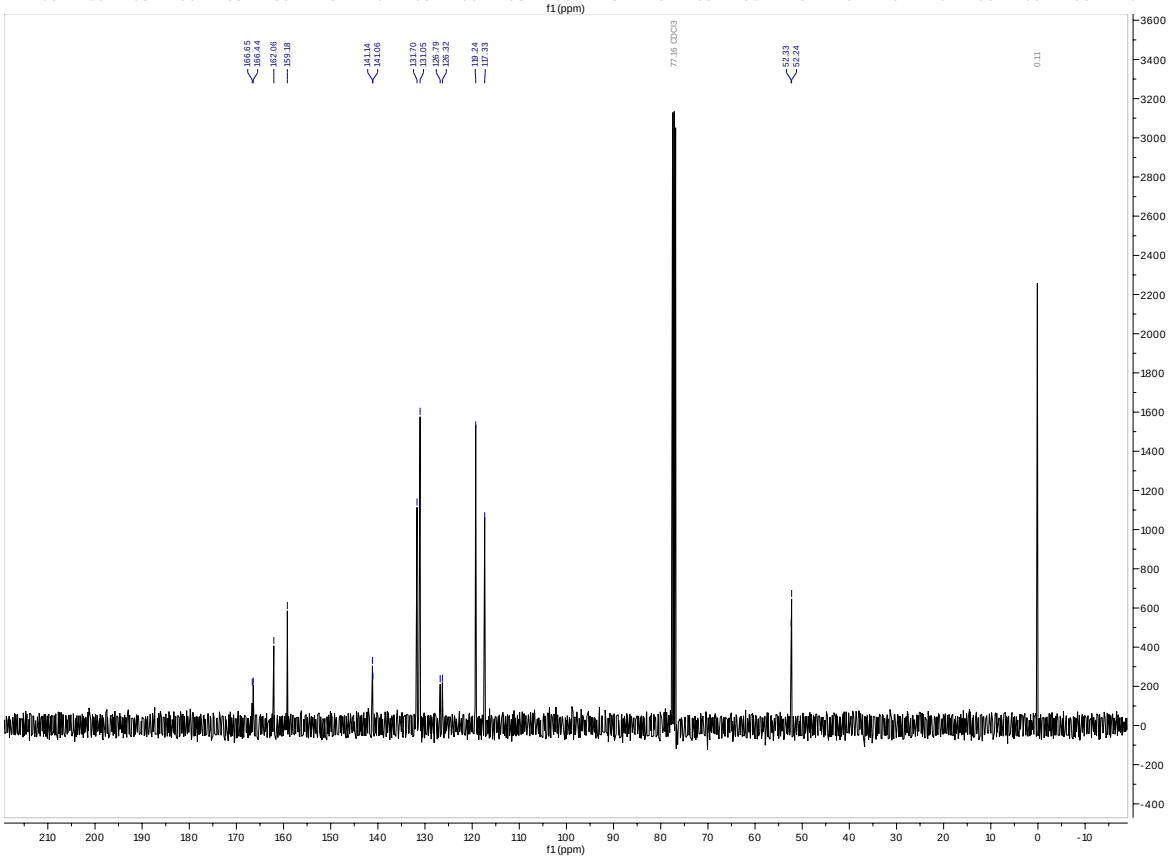
N-(4-methoxyphenyl)-*N*-methylformamide (2d)



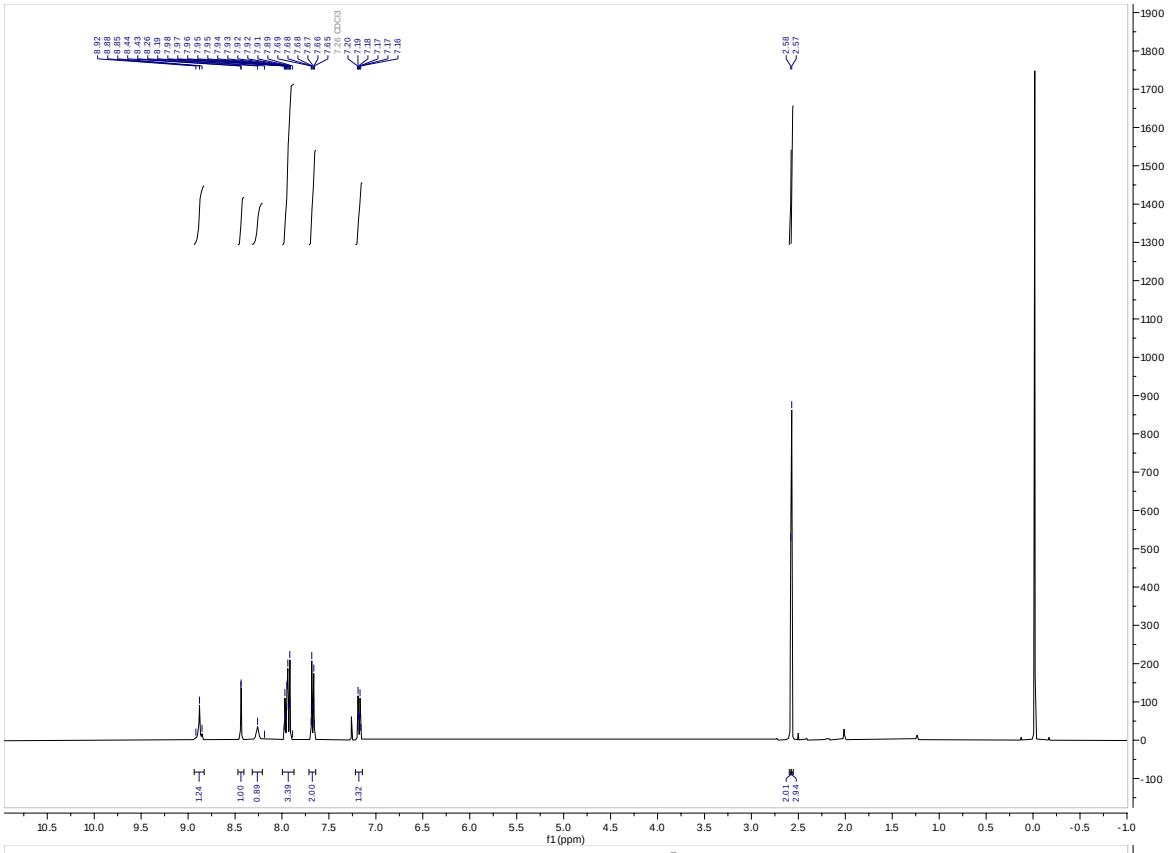


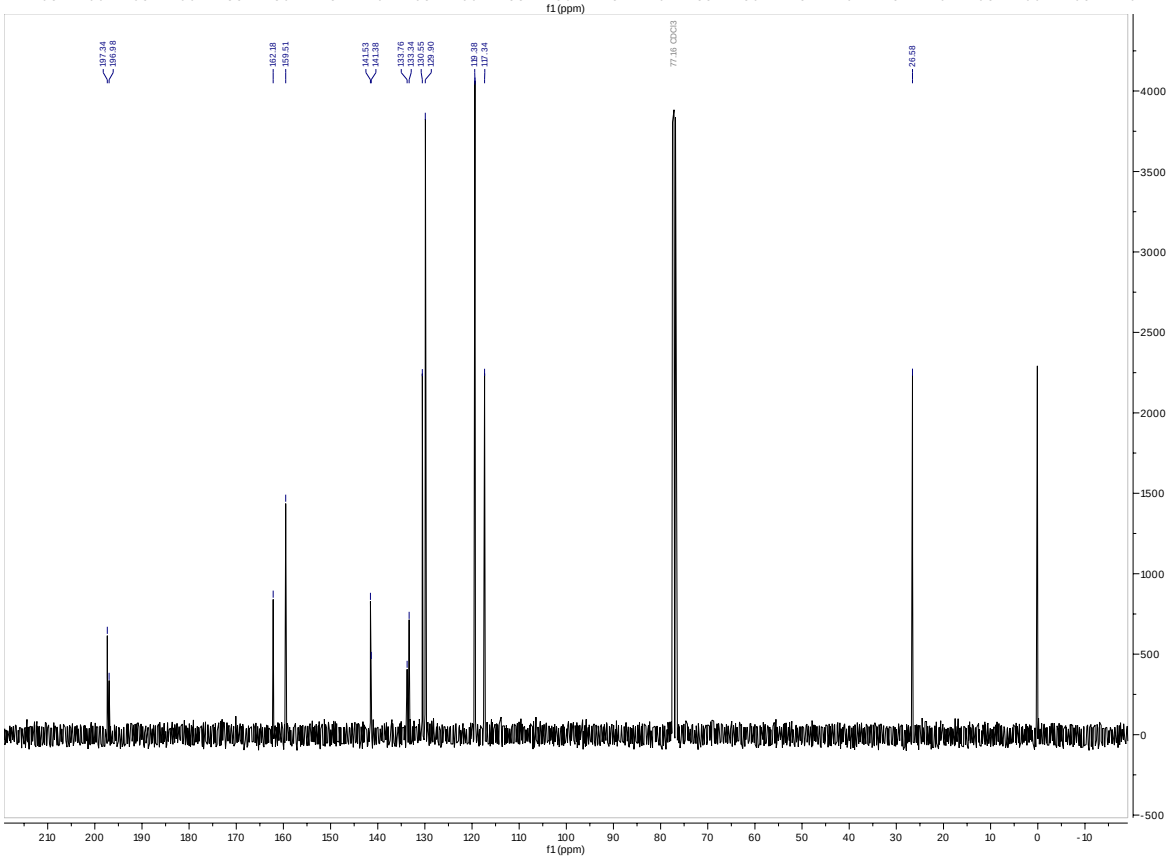
Methyl 4-formamidobenzoate (2e)



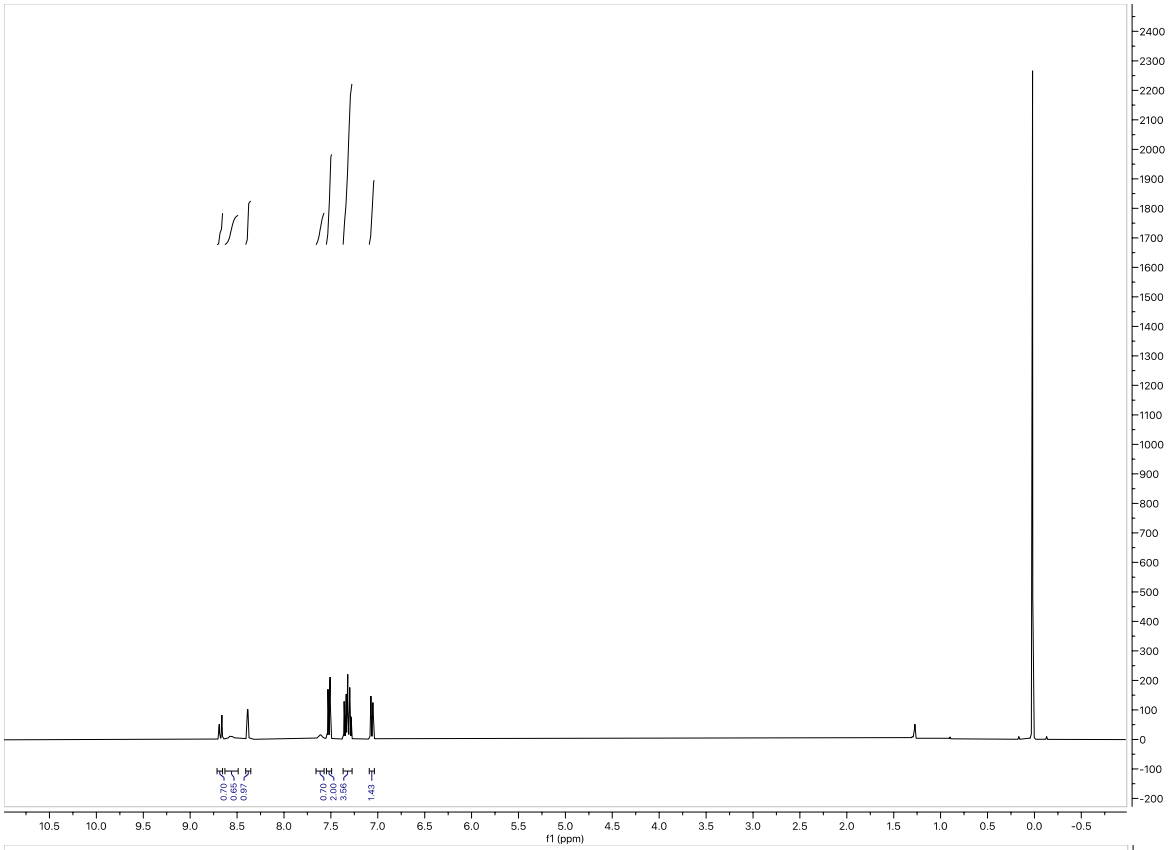


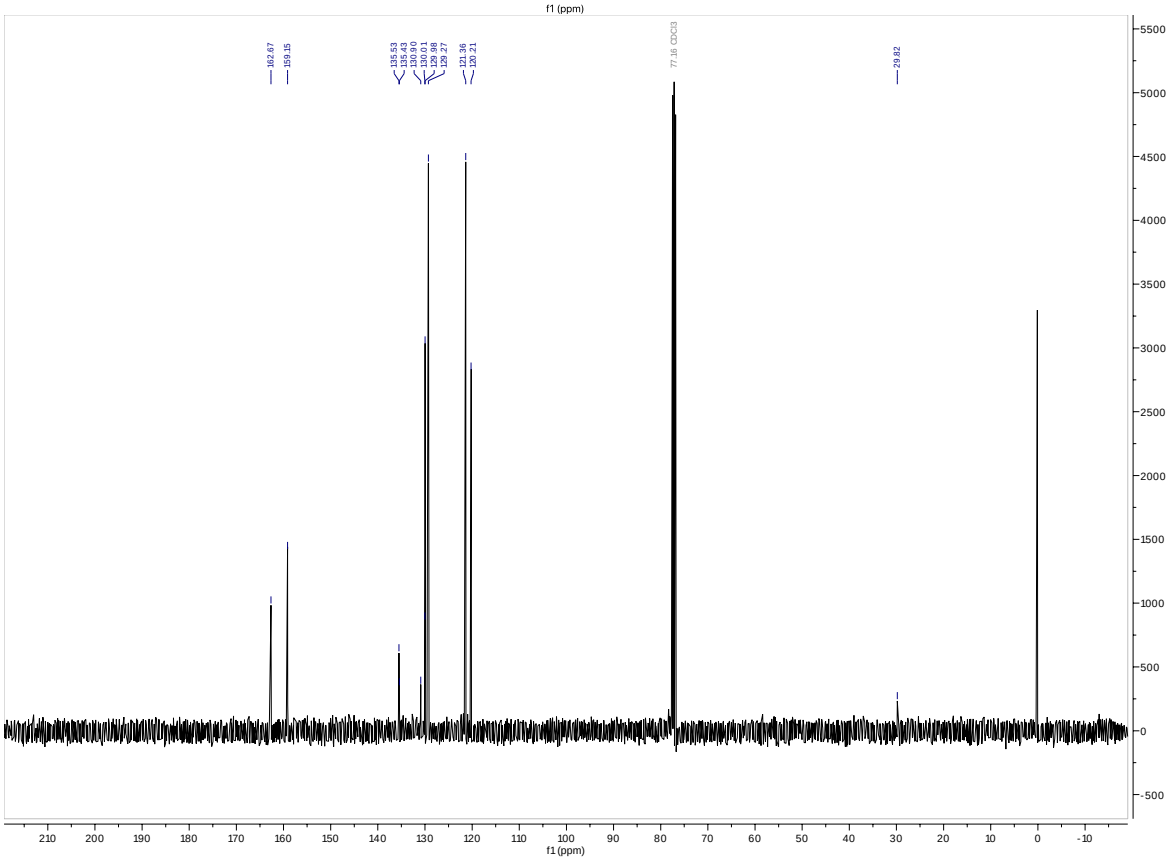
N-(4-Acetylphenyl)formamide (2f)



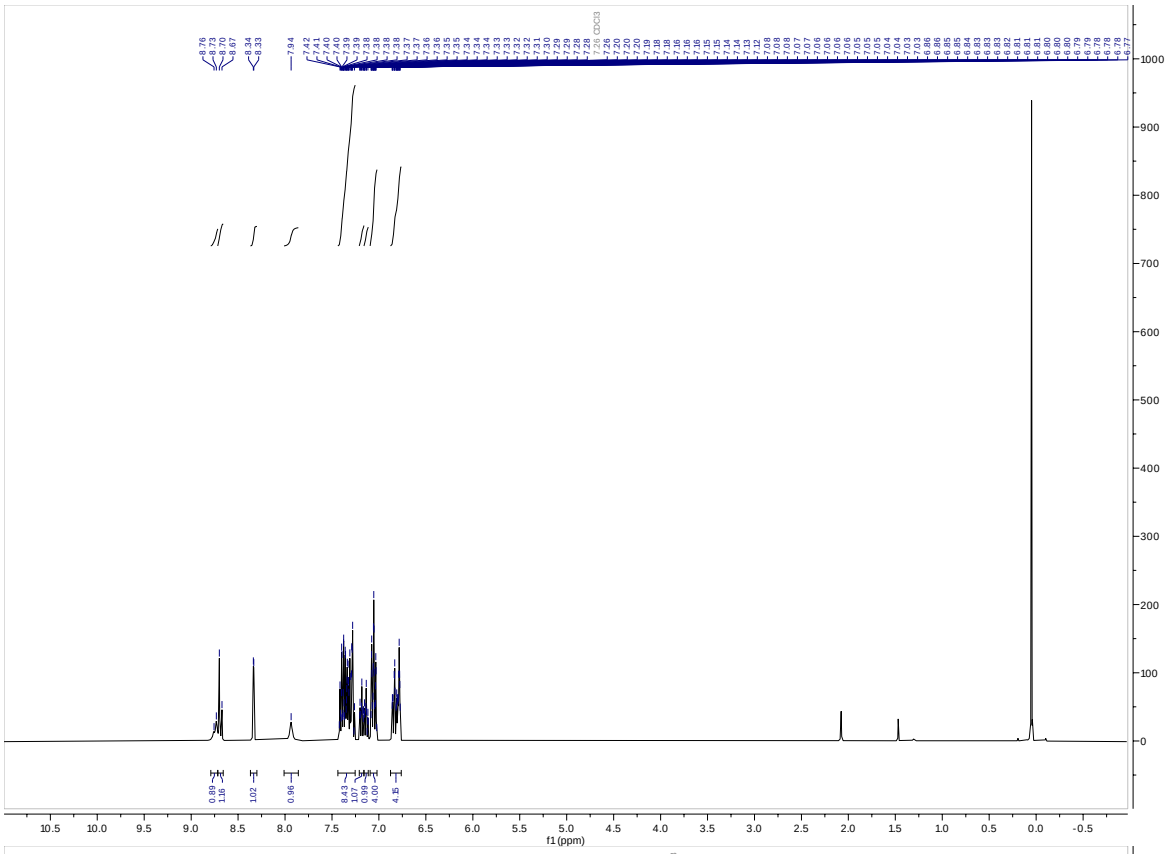


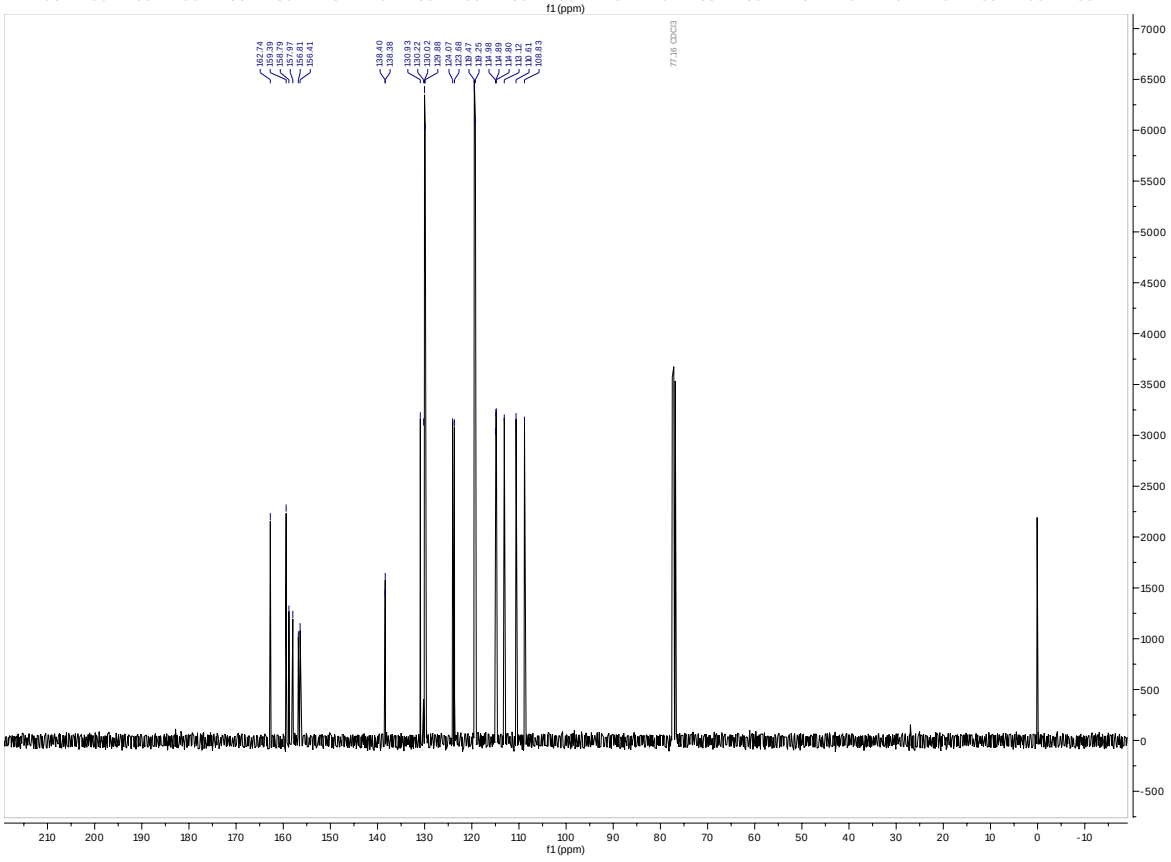
N-(4-chlorophenyl)formamide (2g)



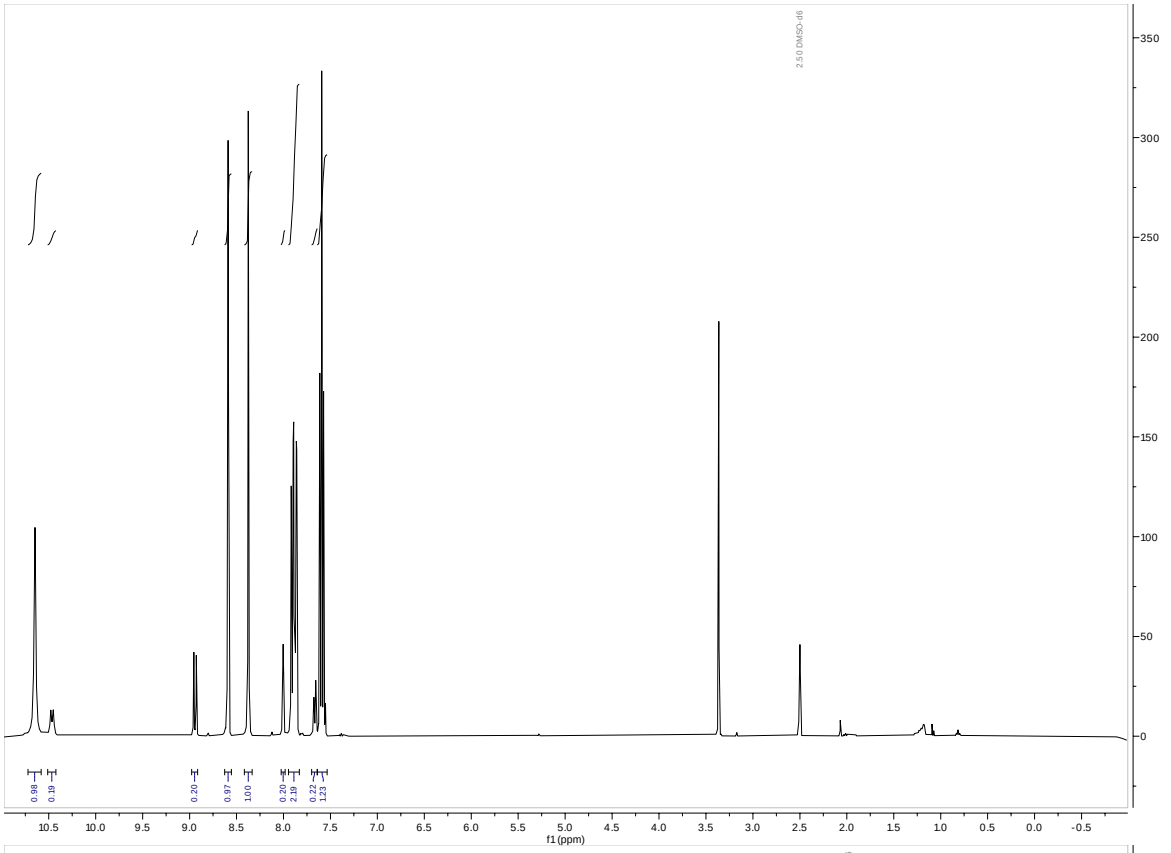


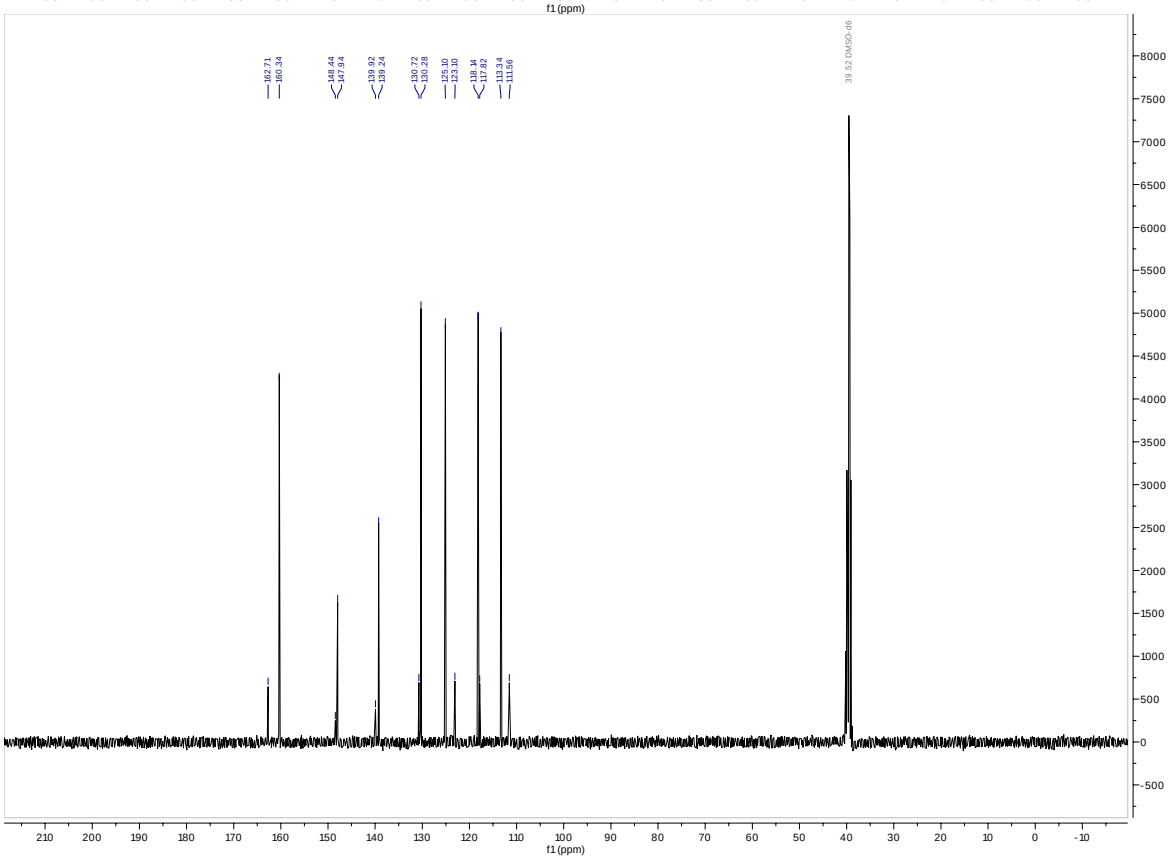
N-(3-phenoxyphenyl)formamide (2h)



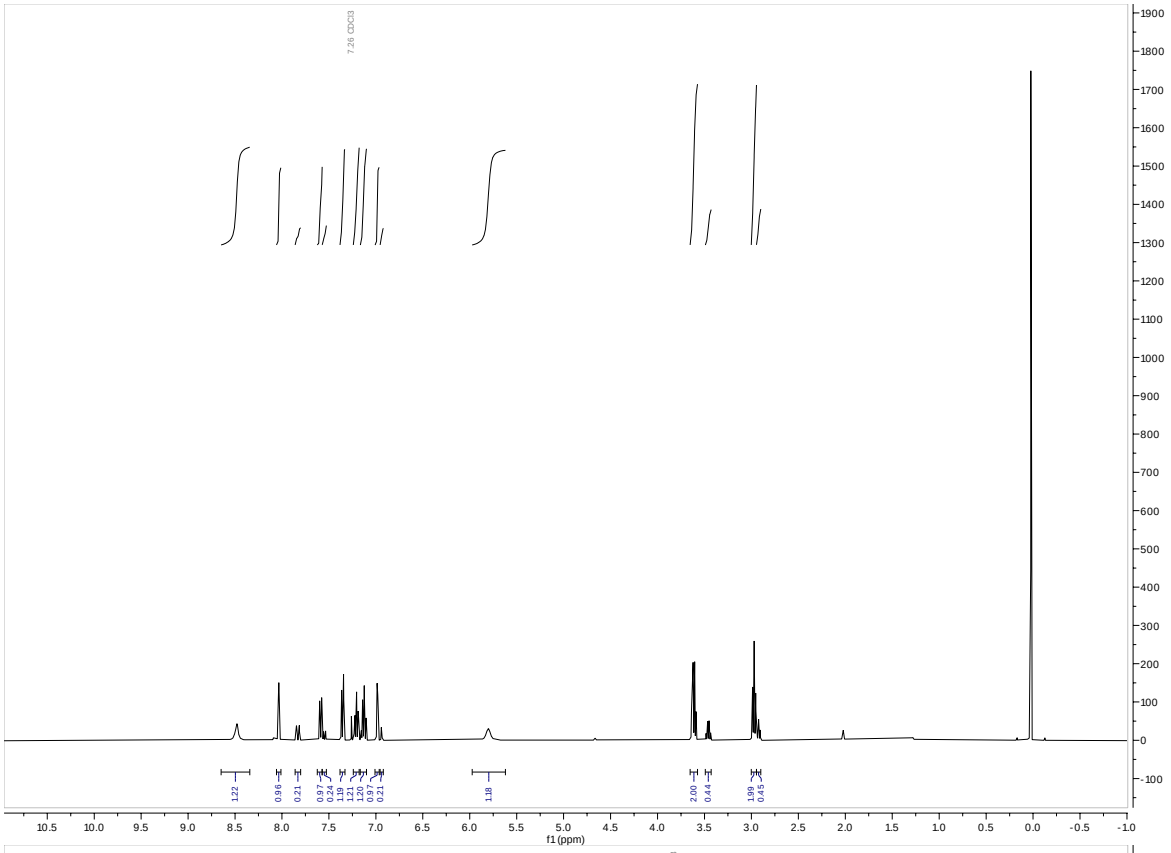


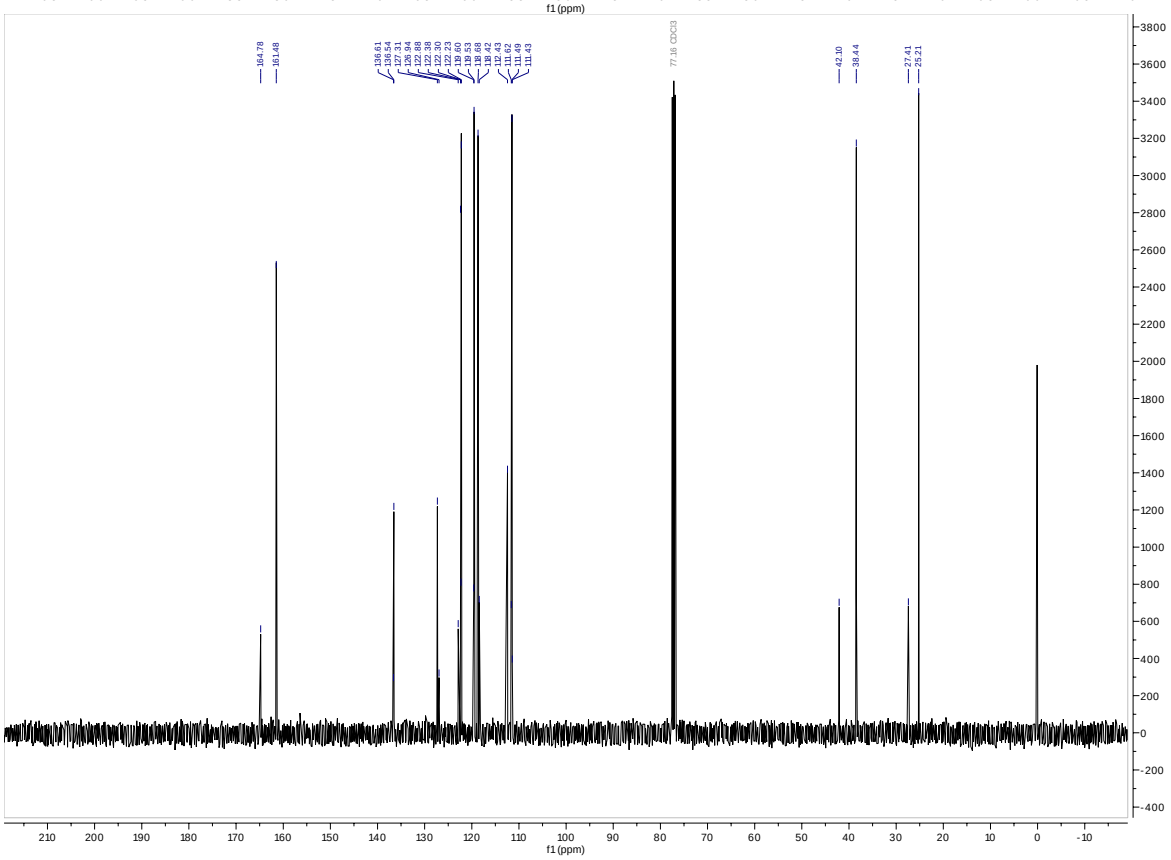
N-(3-nitrophenyl)formamide (2i)



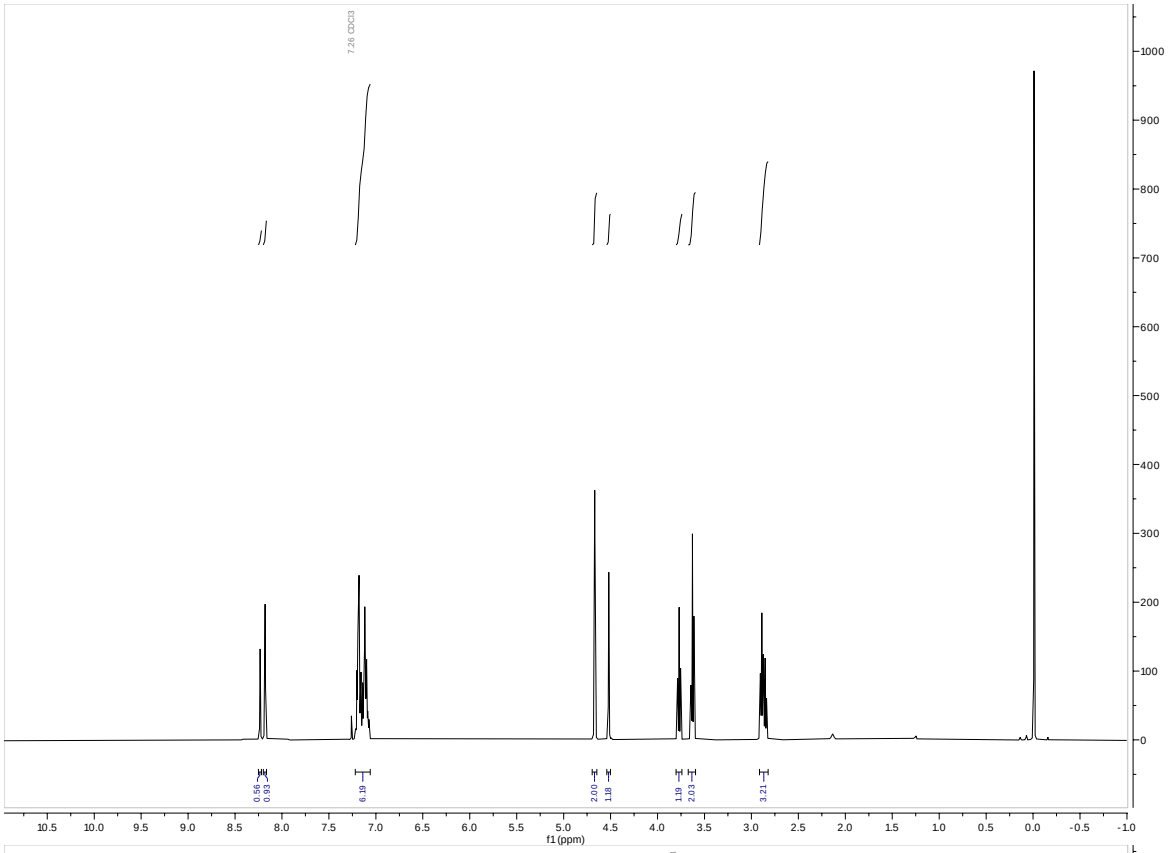


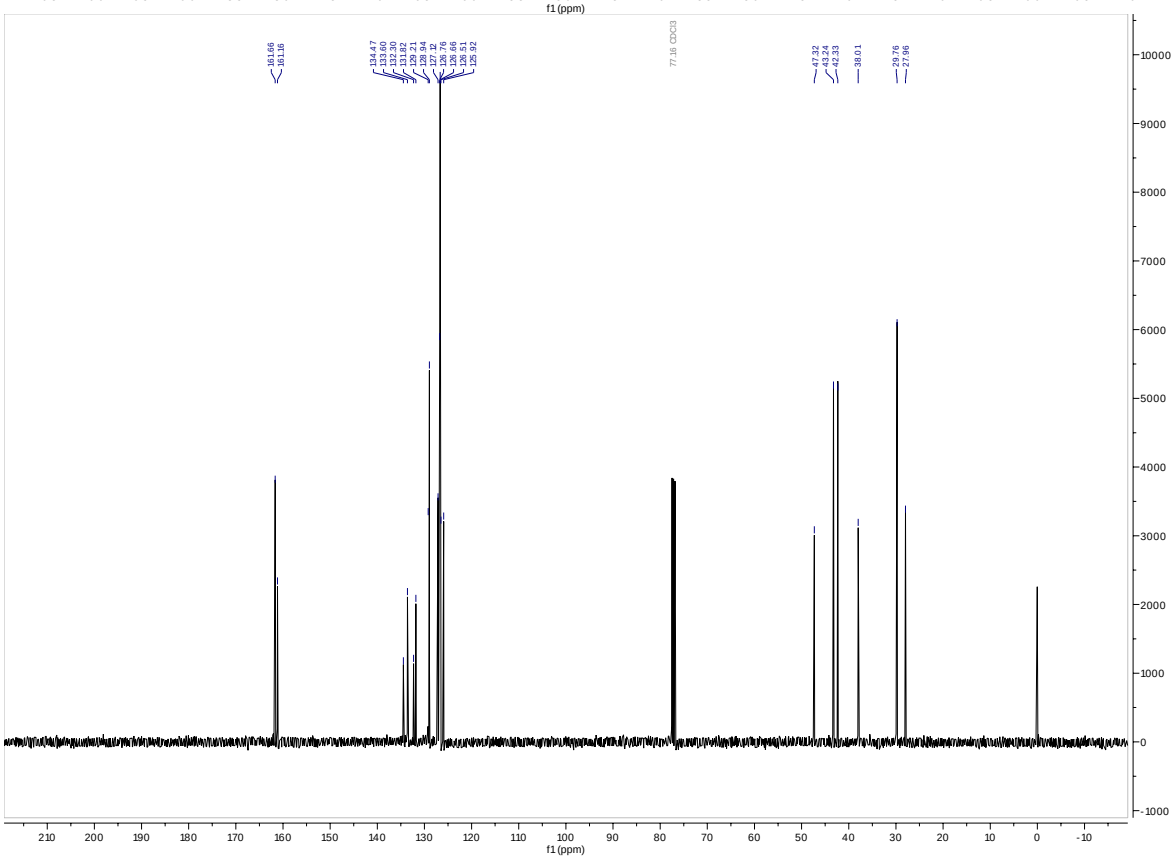
N-(2-(1*H*-indol-3-yl)ethyl)formamide (2j)



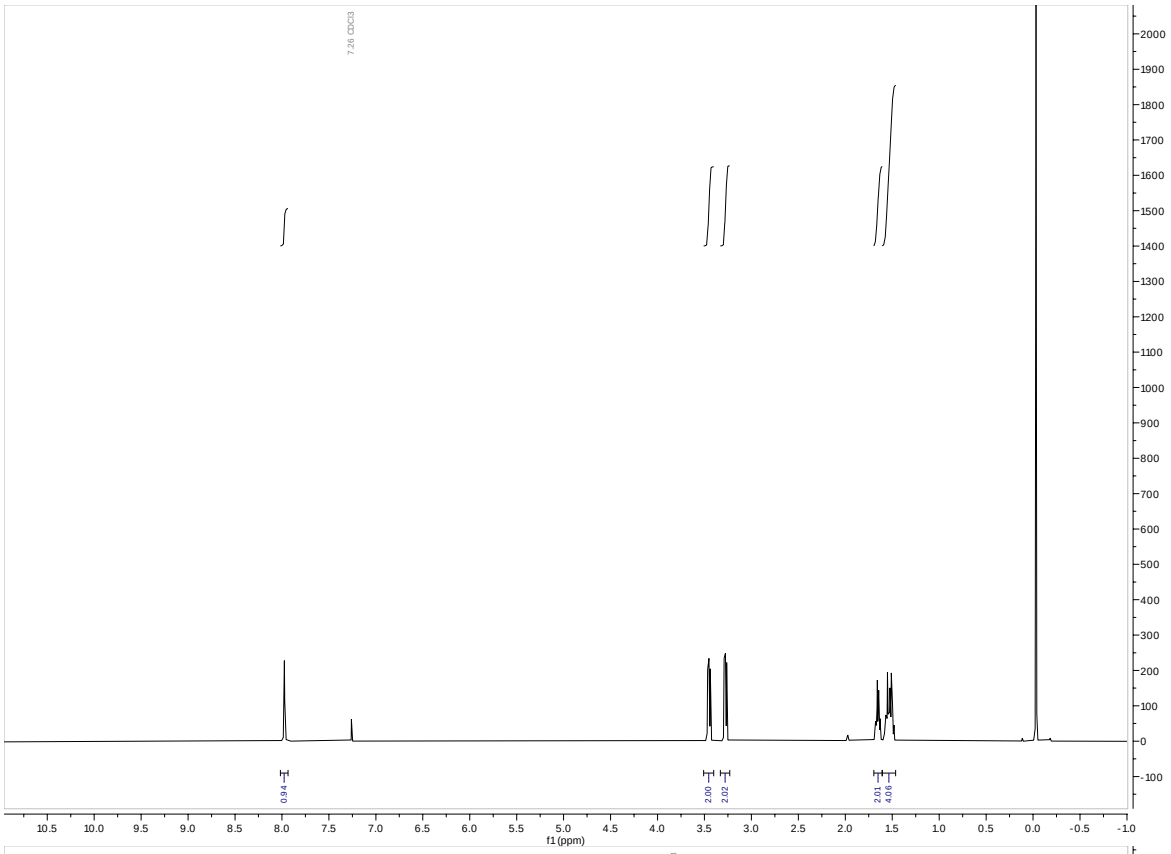


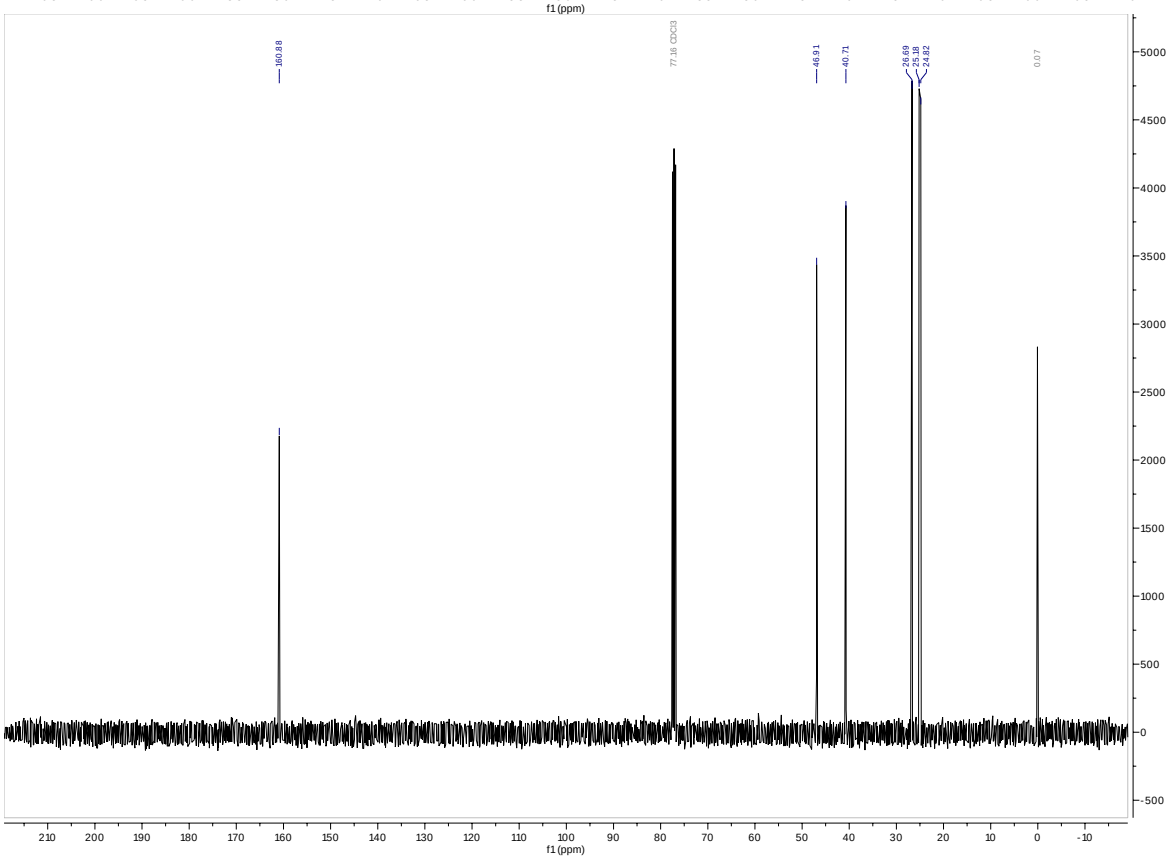
3,4-dihydroisoquinoline-2(1*H*)-carbaldehyde (2k)



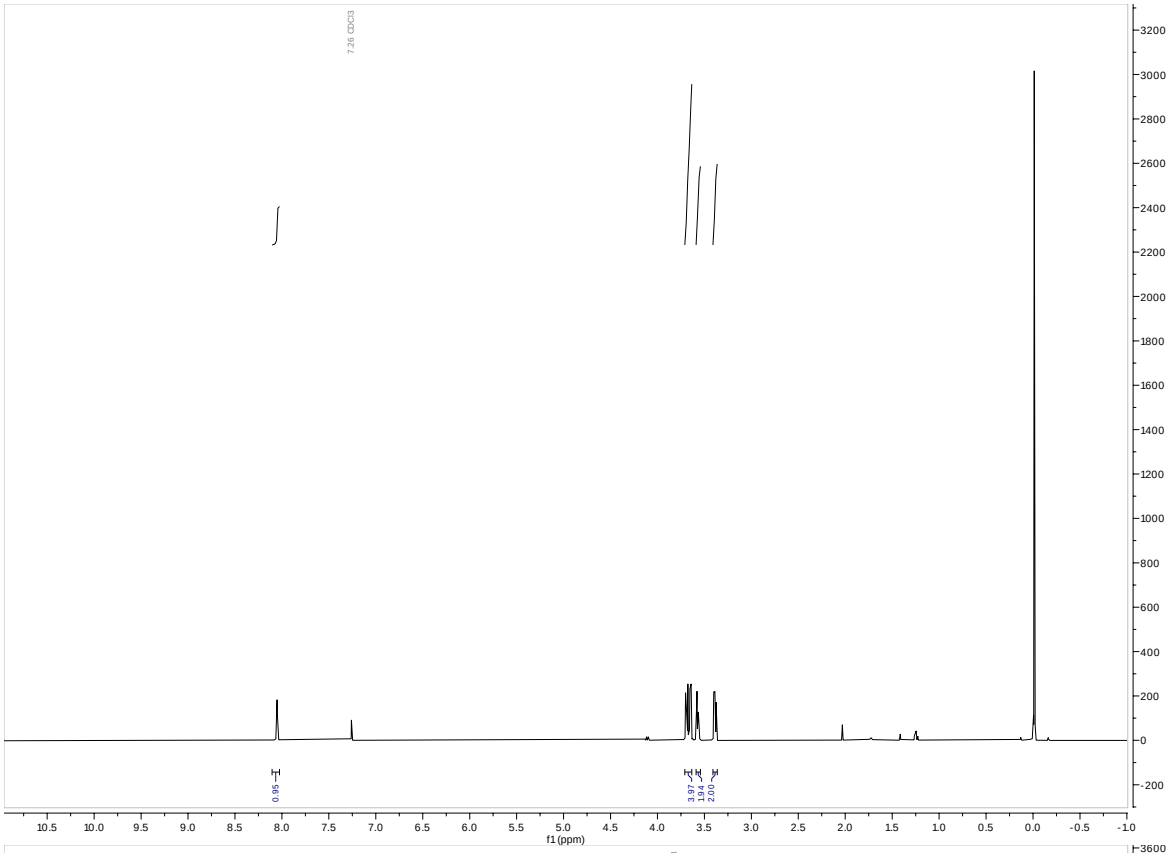


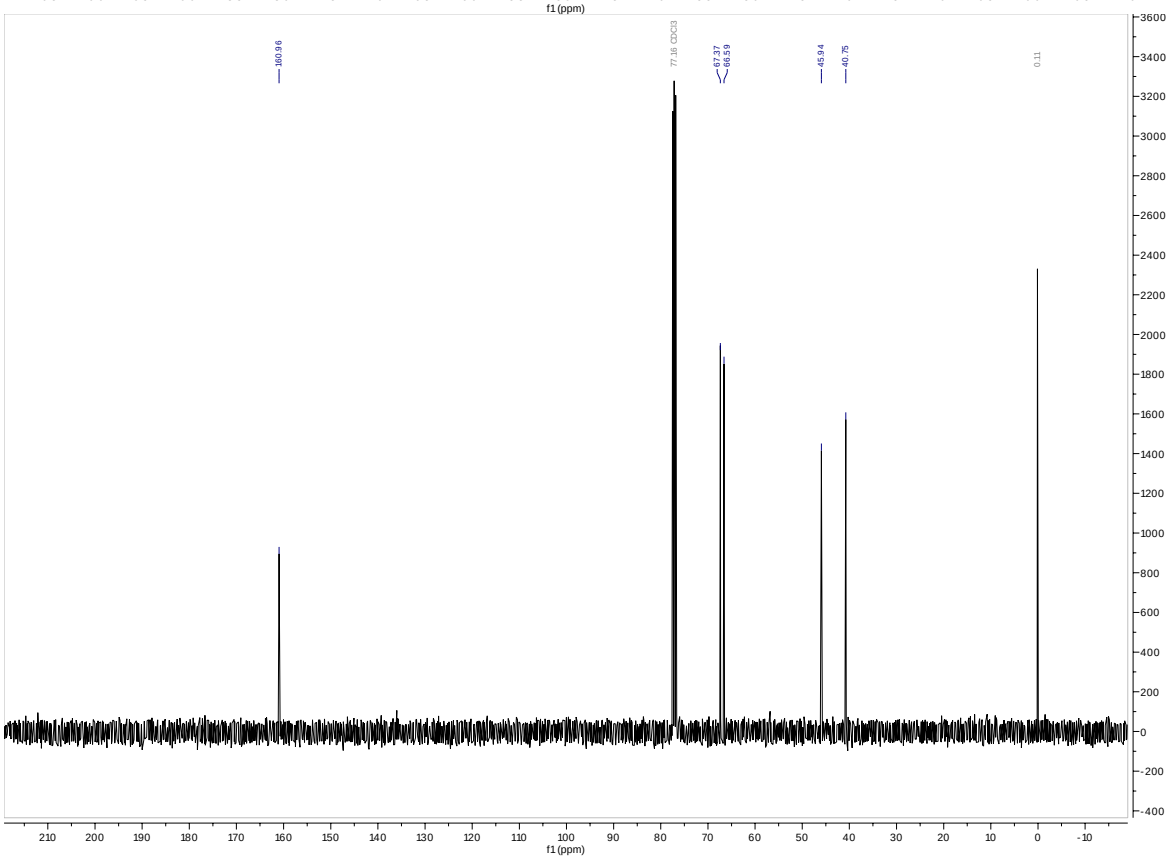
1-Piperidinecarboxaldehyde (2l)



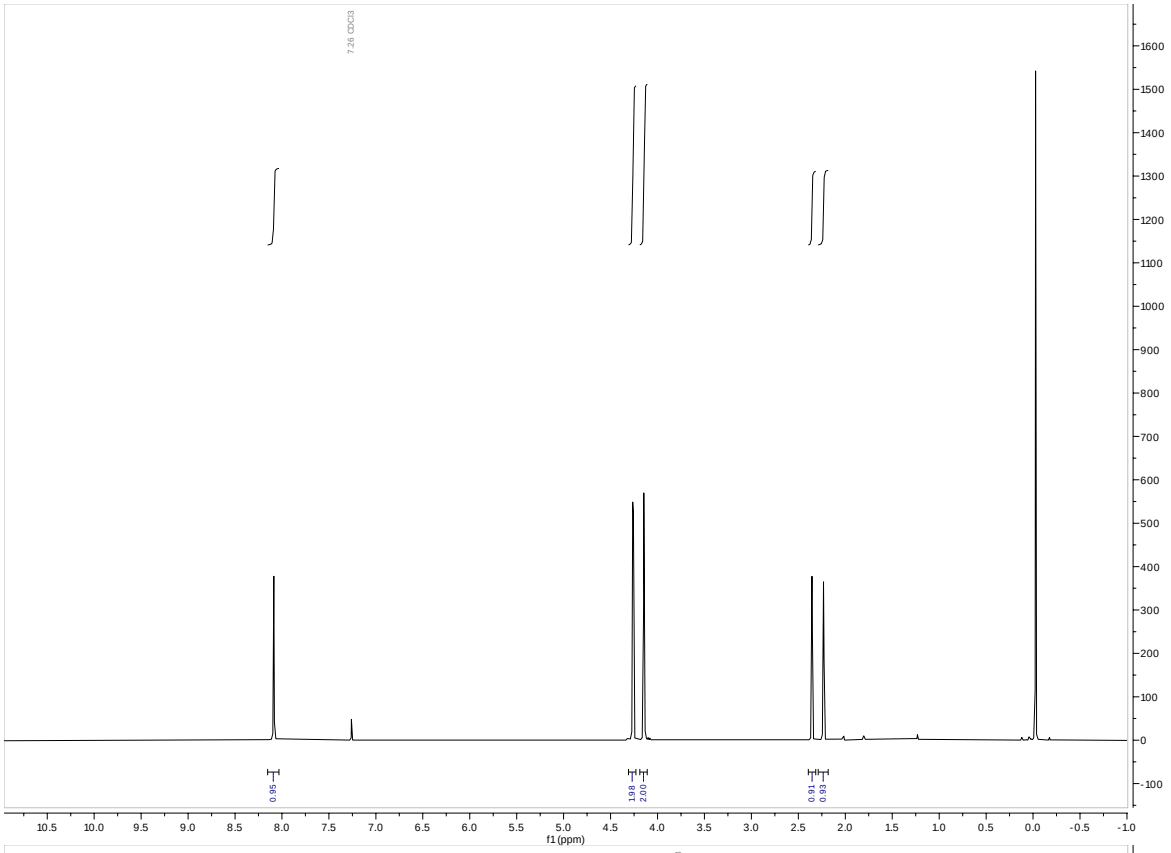


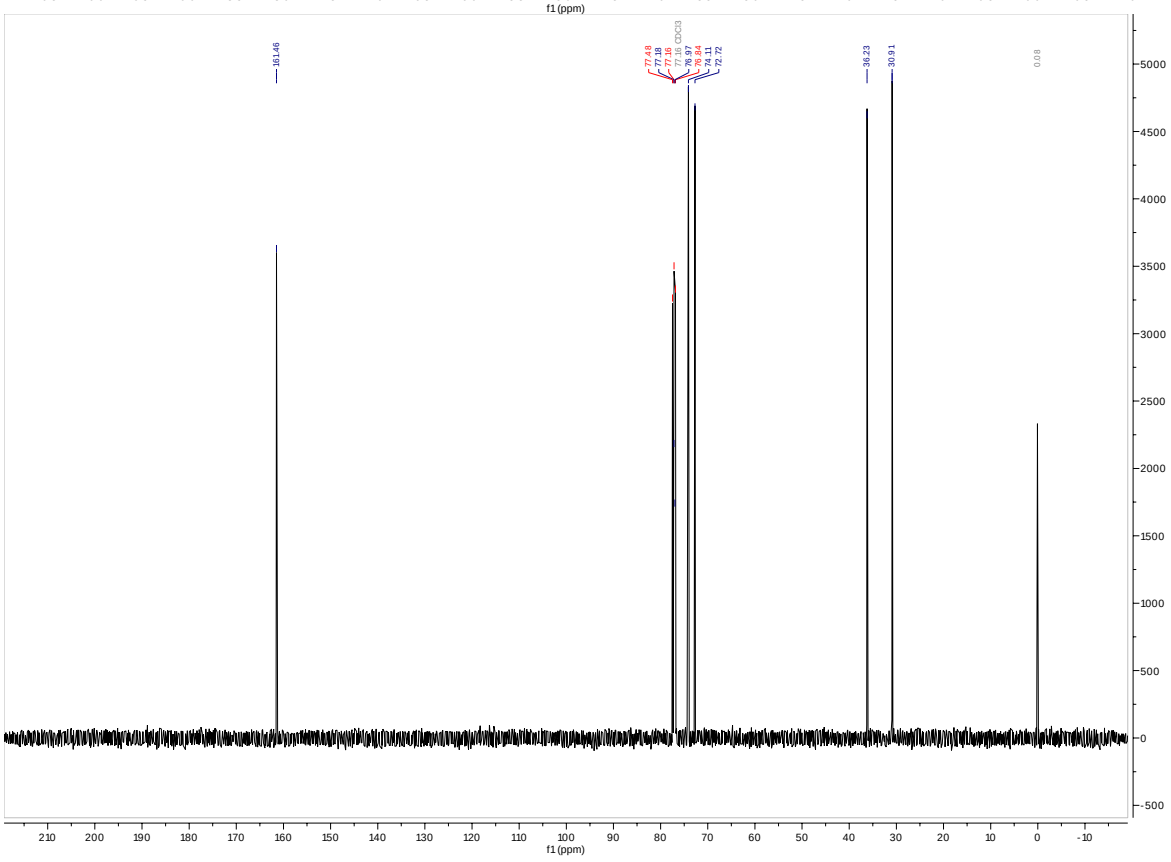
N-Formylmorpholine (2m)

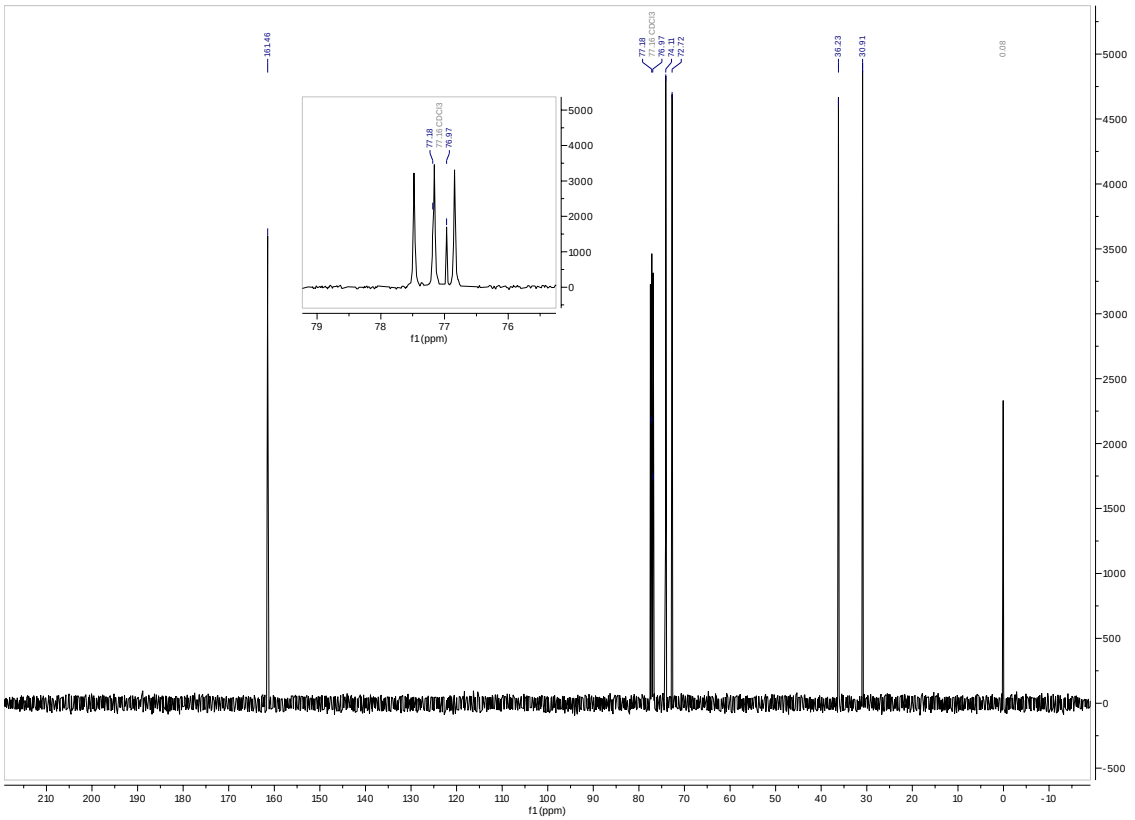


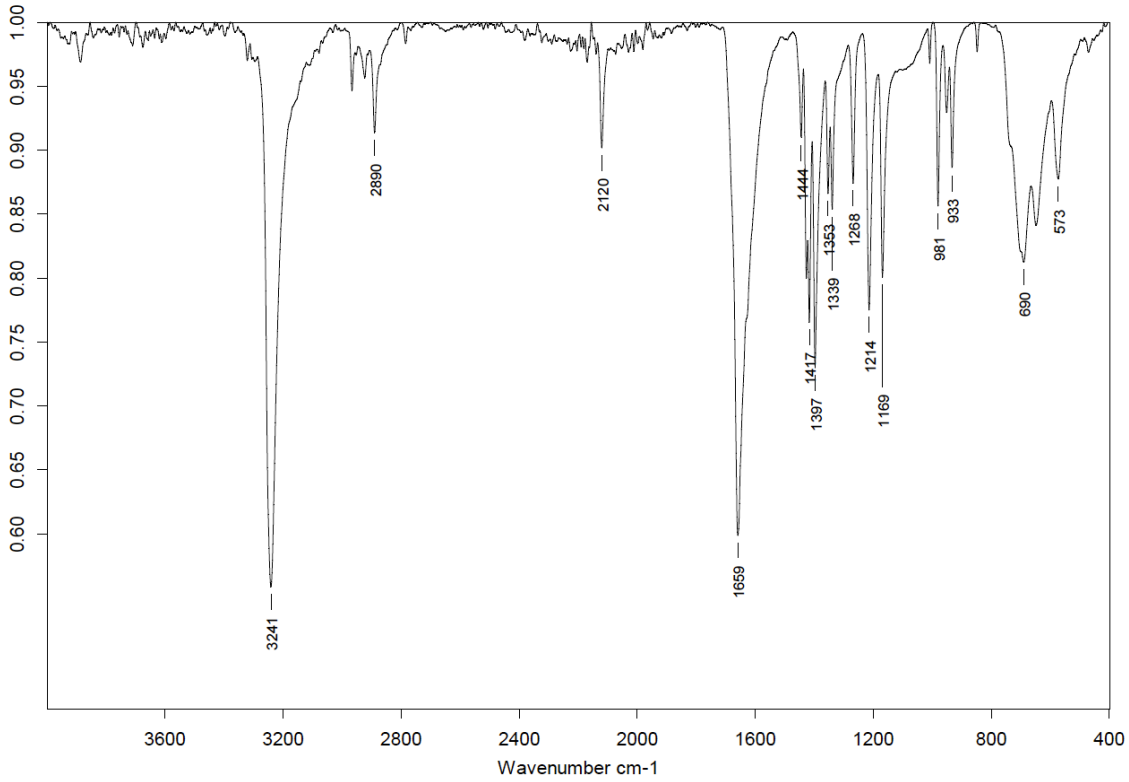


N,*N*-di(prop-2-yn-1-yl)formamide (2o)

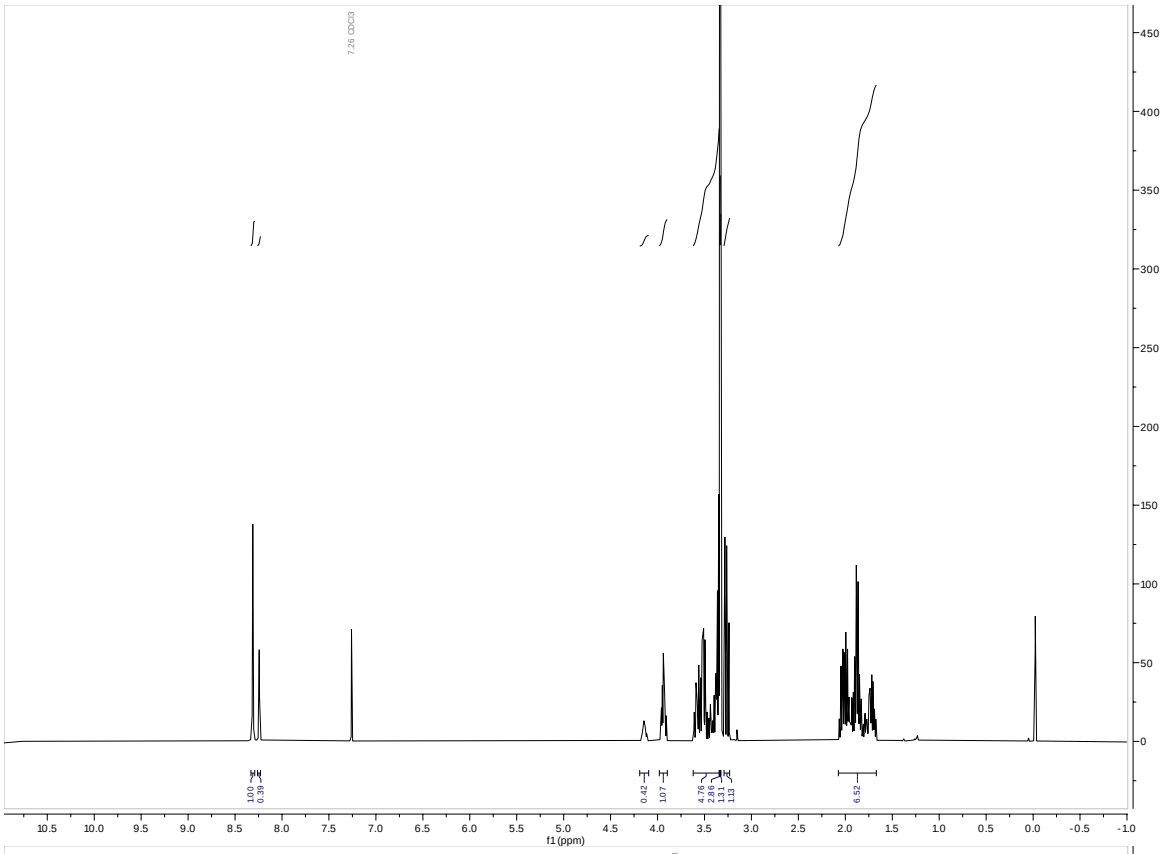


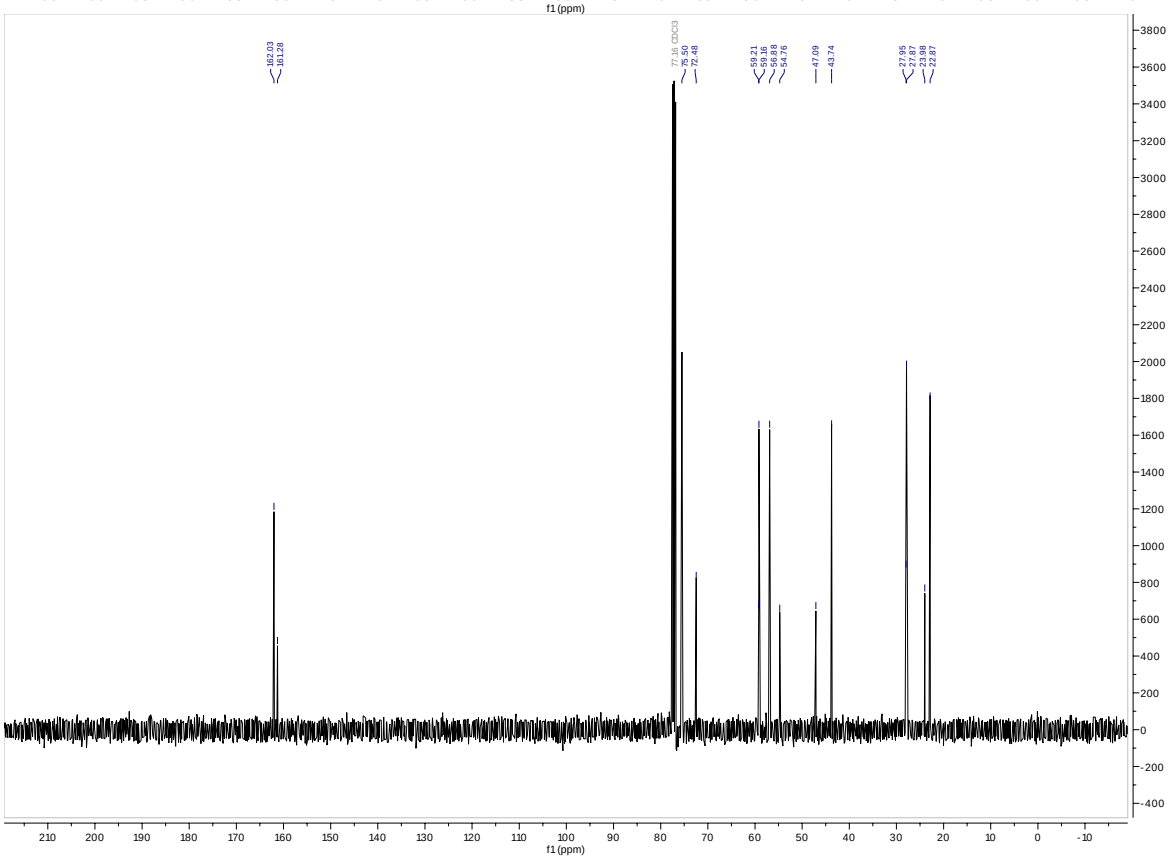



161.46
77.18
77.16 CDCl3
76.97
72.72
36.23
30.91
0.08
f1 (ppm)


3241
2890
2120
1659
1444
1417
1397
1353
1339
1268
1214
1169
981
933
690
573
Wavenumber cm-1

2-(Methoxymethyl)pyrrolidine-1-carbaldehyde (2p)





S31: Analysis of the catalyst DBU@PS C1 after the flow experiment

Figure S4: IR spectrum of the original DBU@PS **C1** catalyst

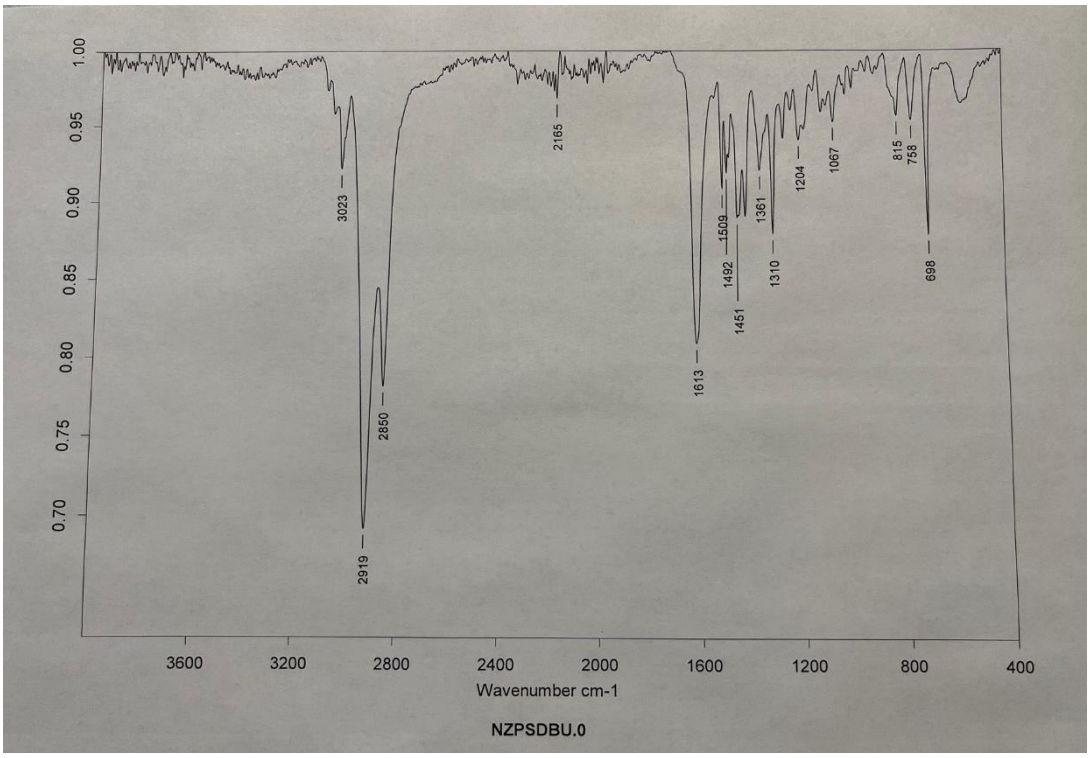


Figure S5: IR spectrum of the "used" DBU@PS **C1** catalyst after the flow experiment

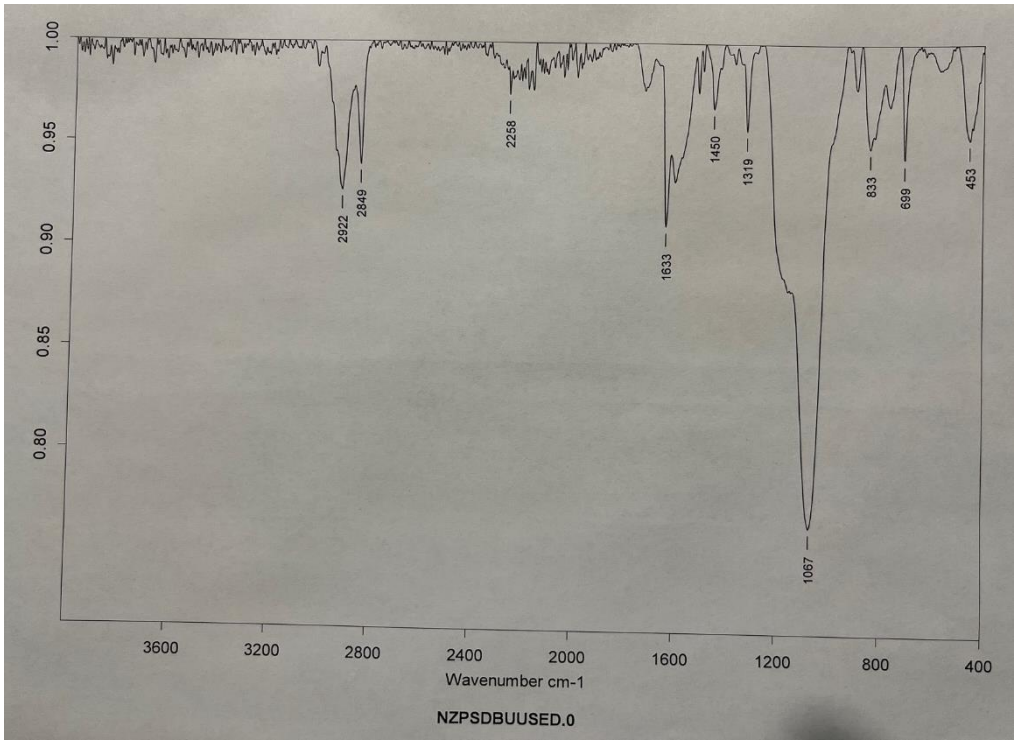
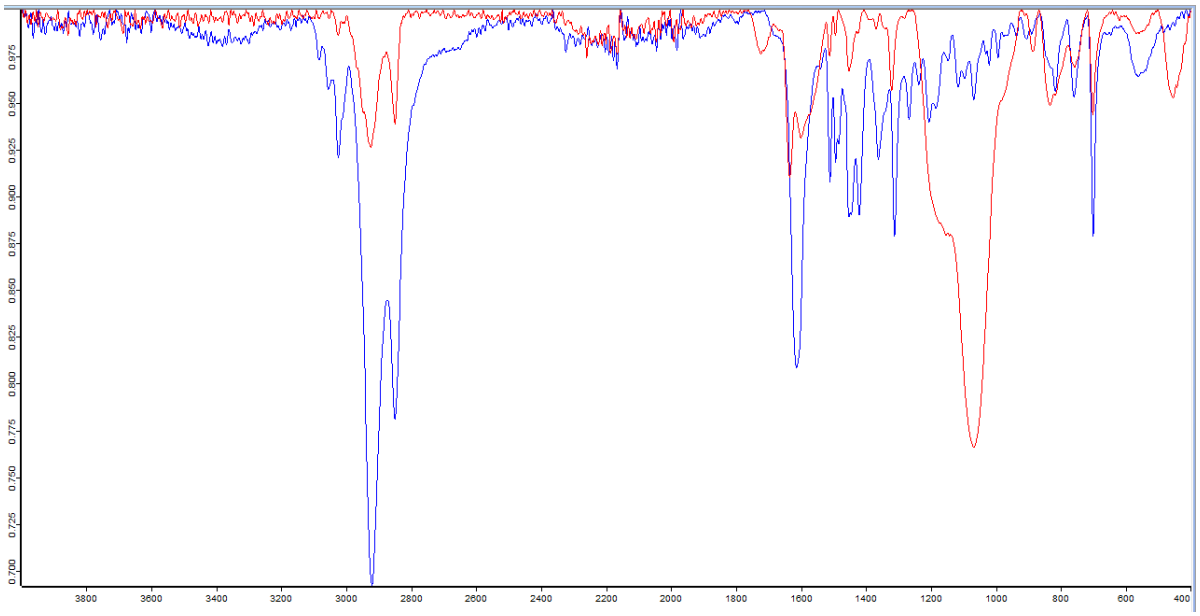


Figure S6: IR comparative between the original and used DBU@PS **C1** catalyst



Comments: please note that the solid catalyst was initially mixed with sand, which after the catalysis experiment run under continuous flow could not be (fully) separated. This is expressed in the increase in "SiO"-related bands in the IR spectrum (*red trace*). However, the fingerprint peaks of the supported DBU catalyst are retained after its use suggesting high stability of the system.