First Report of Bio-catalytic *N*-formylation of Amines Using Ethylformate

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Supporting Information

Contents:

1. General information:

Analytical grade solvents and commercially available reagents were used without further purification. Melting points were determined with a SRS-OptiMelt digital melting point apparatus and are uncorrected. ^{1}H and ^{13}C NMR spectra were recorded on a BrukerAvance II-400 spectrometer using tetramethylsilane (TMS) as an internal standard. Chemical shift values are given in ppm (δ) relative to TMS and coupling constants *J* are given in Hz. LCMS analyses were performed on THERMO MSQ PLUS mass spectrometer. IR spectra were recorded on Shimadzu DRS Prestige 21. Column chromatographic purifications were performed on a CombiflashRf (Teledyne Isco) with silica gel using the mobile phase indicated. Chiral purity of the products were analyzed using a Waters UPLC equipped with Chiralpack-IB 5 µm (4.6 mm Ø x 250 mml) column.

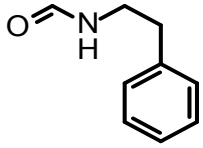
2. General procedure for the *N*-formylation of amines (2a-2z):

Method-A: To a mixture of amine (5.0 mmol) and ethyl formate (7.5 mmol) in THF (5.0 ml) was added Novozyme 435® CALB (Lipase acrylic resin from Candida antarctica ≥5,000 U/g, recombinant, expressed in Aspergillus niger) (20% w/w), and the mixture was stirred at room temperature. After complete consumption of starting material (1- 8 h), the reaction mixture was filtered off, solid was washed with THF and the combined organic layers was evaporated to afford the *N*-formylated product in pure form.

Method-B: To a mixture of amine (5.0 mmol) and ethyl formate (15.0 to 25.0 mmol) was added Novozyme 435® CALB (20% w/w) and the reaction mixture was stirred at room temperature for 1-8 h or until starting material was fully consumed. The reaction mixture was diluted with THF and the product was isolated following the same procedure as **Method A**.

3. Spectroscopic data for compounds (2a-2x):

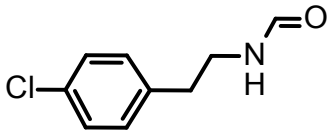
_N_-phenethylformamide (2a)[1]



Yield: 99%, yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.06 (br. s., 1H), 7.98 (s, 1H), 7.29-7.25 (m, 2H), 7.24-7.18 (m, 3H), 3.34-3.29 (m, 2H), 2.78-2.67 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.0, 139.2, 128.6, 128.3, 126.1, 35.0.

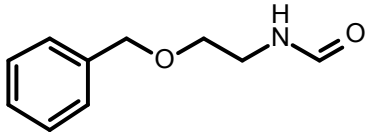
_N_-[2-(4-chlorophenyl) ethyl] formamide (2b)



Yield: 99%, light yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.05 (br. s., 1H), 7.97 (s, 1H), 7.37-7.30 (m, 2H), 7.29-7.21 (m, 2H), 3.34-3.29 (m, 2H), 2.74-2.67 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.1, 138.3, 130.6, 128.2, 38.5, 34.2.

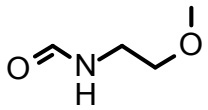
_N_-(2-benzyloxyethyl)formamide (2c)



Yield: 99%, viscous liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.22-8.06 (m, 1H), 8.05-7.89 (m, 1H), 7.42-7.29 (m, 5H), 4.48 (s, 2H), 3.52-3.43 (m, 2H), 3.41-3.32 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.2, 138.3, 128.3, 128.2, 127.6, 127.5, 71.9, 68.3, 37.1.

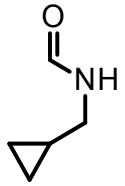
***N*-(2-methoxyethyl) formamide (2d)[2]**



Yield: 95%, yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.08 (brs, 1H), 7.99 (s, 1H), 3.38-3.29 (m, 2H), 3.27-3.19 (m, 5H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.1, 70.5, 57.9, 36.9.

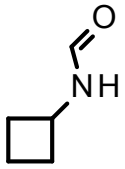
***N*-(cyclopropylmethyl)formamide (2e)[3]**



Yield: 94%, yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.21-8.02 (m, 1H), 8.02-7.89 (m, 1H), 3.03-2.84 (m, 2H), 0.98-0.79 (m, 1H), 0.46-0.36 (m, 2H), 0.21-0.07 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.9, 45.1, 41.4, 10.7, 3.2.

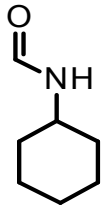
***N*-cyclobutylformamide (2f)[4]**



Yield: 98%, viscous liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.50-7.97 (m, 1H), 7.97 - 7.62 (m, 1H), 4.39-4.14 (m, 1H), 2.28-2.02 (m, 2H), 1.98-1.77 (m, 2H), 1.70-1.45 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 159.9, 42.5, 30.2, 14.7.

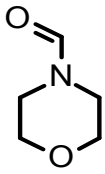
_N_-cyclohexylformamide (2g)[5]



Yield: 94%, viscous colourless liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.11-7.89 (m, 2H), 3.64-3.51 (m, 1H), 1.71-1.59 (m, 4H), 1.31-1.09 (m, 6H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.0, 46.1, 32.4, 25.2, 24.4.

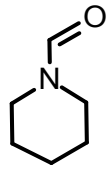
Morpholine-4-carbaldehyde (2h)[1]



Yield: 91%, light yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.0 (s, 1H), 3.60-3.54 (m, 2H), 3.53-3.48 (m, 2H), 3.42-3.34 (m, 4H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.1, 66.9, 65.9, 45.2, 40.1.

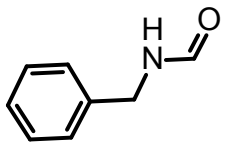
Piperidine-1-carbaldehyde (2i)[1]



Yield: 90%, viscous liquid.

^{1}H NMR (400 MHz, $CDCl_3$) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.09-7.95 (m, 1H), 3.56-3.43 (m, 2H), 3.38-3.25 (m, 2H), 1.75-1.64 (m, 2H), 1.64-1.49 (m, 4H). ^{13}C NMR (100 MHz, $CDCl_3$) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.7, 46.7, 40.5, 26.4, 24.9, 24.5.

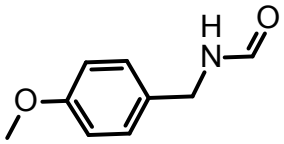
***N*-benzylformamide (2j)[5]**



Yield: 99%, white solid; M. P.: 59-61°C.

^{1}H NMR (400 MHz, DMSO-d_6): δ 8.51 (brs, 1H), 8.13 (s, 1H), 7.47-7.24 (m, 5H), 4.30 (d, *J* = 6.1 Hz, 2H). ^{13}C NMR (100 MHz, DMSO-d_6): 161.0, 138.9, 128.4, 127.3, 126.9, 40.7;

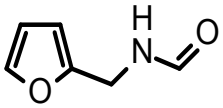
***N*-[(4-methoxyphenyl)methyl]formamide (2k)[6]**



Yield: 99%, white solid; M. P.: 76-78°C.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.43 (brs, 1H), 8.09 (s, 1H), 7.23-7.10 (m, 2H), 6.94-6.86 (m, 2H), 4.28-4.16 (d, *J*=5.8 Hz, 2H), 3.72 (s, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.9, 158.4, 130.9, 128.7, 113.7, 55.1.

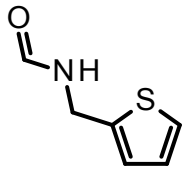
***N*-(2-furylmethyl)formamide (2l)[7]**



Yield: 99%, brown liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.49 (brs, 1H), 8.06 (s, 1H), 7.58 (s, 1H), 6.46-6.32 (m, 1H), 6.32-6.18 (m, 1H), 4.28 (d, *J*=5.8 Hz, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.9, 151.8, 142.3, 110.5, 106.9, 33.9.

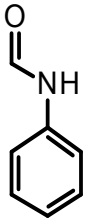
***N*-(2-thienylmethyl)formamide (2m)[3]**



Yield: 99%, viscous liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.6 (brs, 1H), 8.17-8.00 (m, 1H), 7.51-7.30 (m, 1H), 7.08-6.84 (m, 2H), 4.53-4.36 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.9, 141.9, 126.7, 125.6, 125.2, 35.7.

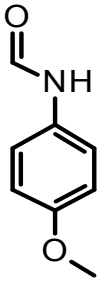
***N*-phenylformamide (2n)[1]**



Yield: 87%, dark brown liquid.

^{1}H NMR (400 MHz, $CDCl_3$) *mixture of rotamers is observed*, δ: 8.84 (brs, 1H), 8.70 (d, *J*=11.37 Hz, 1H), 8.37 (d, *J*=1.59 Hz, 1H), 7.85 (br s, 1H), 7.57 (d, *J* = 7.7 Hz, 2H), 7.31-7.38 (m, 4H), 7.09-7.22 (m, 4H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 159.9, 130.6, 114.9, 110.2, 106.2.

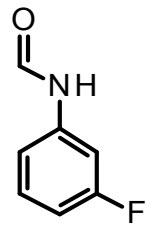
***N*-(4-methoxyphenyl)formamide (2o)[5]**



Yield: 97%, dark black solid; M. P.: 76-78°C

^{1}H NMR (400 MHz, $CDCl_3$) mixture of rotamers is observed; δ: 8.61-8.46 (m, 1H), 8.46-8.22 (m, 2H), 7.69-7.51 (m, 1H), 7.50-7.40 (m, 2H), 7.11-6.98 (m, 2H), 6.94-6.71 (m, 4H), 3.80 (d, *J*=5.7 Hz, 6H).^{13}C NMR (100 MHz, $CDCl_3$) mixture of rotamers is observed, major rotamer is given; δ =163.3, 159.1, 129.5, 121.8, 121.6, 114.8, 114.2, 55.5.

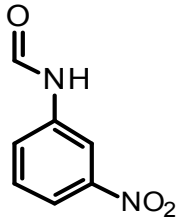
***N*-(3-fluorophenyl)formamide (2p)[8]**



Yield: 80%, white solid; M. P.: 63-64°C

^{1}H NMR (400MHz, DMSO-d6) *mixture of rotamers is observed*, ratio= (76:24) Major isomer δ: 10.44 - 10.34 (br.s, 1H), 8.32 - 8.28 (m, 1H), 7.60 - 7.54 (m, 1H), 7.39 - 7.26 (m, 2H), 6.93 - 6.85 (m, 1H). Minor isomer δ: 10.30 - 10.21 (m, 1H), 8.88 - 8.82 (m, 1H), 7.39 - 7.26 (m, 1H), 7.14 - 7.08 (m, 1H), 7.04 - 6.99 (m, 1H), 6.93 - 6.85 (m, 1H). ^{13}C NMR (100 MHz, DMSO-d6) *mixture of rotamers is observed*, *major rotamer is given*; δ = 159.9, 139.9,130.4, 114.9, 110.2, 106.1, 104.1.

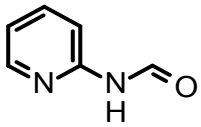
***N*-(3-fluorophenyl)formamide (2q)[9]**



Yield: 29%, light yellow solid; M. P.: 135-137°C.

^{1}H NMR (400MHz, DMSO-d6) *mixture of rotamers is observed*, ratio= (84:16) Major isomer δ: 10.67 (brs, 1H), 8.64-8.58 (m, 1H), 8.42-8.35 (m, 1H), 7.98-7.85 (m, 2H), 7.65-7.58 (m, 1H). Minor isomer δ: 10.52-10.44 (m, 1H), 8.98-8.92 (m, 1H), 8.04-8.01 (m, 1H), 7.98-7.85 (m, 1H), 7.71-7.66 (m, 1H), 7.65-7.58 (m, 1H). ^{13}C NMR (100 MHz, DMSO-d6) *mixture of rotamers is observed*, *major rotamer is given*; δ = 160.4, 147.9, 139.2, 130.3, 125.1, 118.2, 113.3.

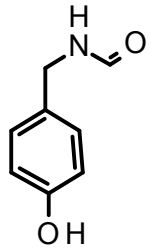
***N*-(2-pyridyl)formamide (2r)[1]**



Yield: 78%, white solid; M. P.: 73-74 °C

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*; δ: 10.65-10.55 (s, 2H), 9.32-9.26 (d, 1H), 8.35-8.26 (m, 3H), 8.25-8.21(m, 1H), 7.75-7.71 (m, 2H), 7.11-7.09 (m, 2H), 6.95-6.89 (d, 1H). ^{13}C NMR (101 MHz, DMSO-d_6) *mixture of rotamers is observed*; δ: 162.2, 160.3, 151.6, 151.2, 148.2, 148.1, 138.7, 138.3, 119.8, 119.2, 113.8, 111.1.

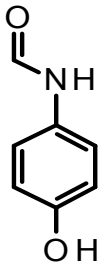
***N*-[(4-hydroxyphenyl) methyl] formamide (2s)[7]**



Yield: 91%, white solid; M. P.: 124-126 °C.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 9.60-8.72 (m, 1H), 8.48 - 8.27 (m, 1H), 8.09 (s, 1H), 7.07 (d, *J*=8.4 Hz, 2H), 6.72 (d, *J*=8.4 Hz, 2H), 4.18 (d, *J*=6.1 Hz, 2H). ^{13}C NMR (101MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.9, 156.4, 129.1, 128.8, 115.1, 40.4.

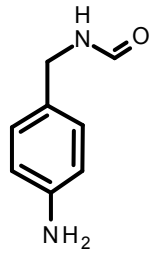
***N*-(4-hydroxyphenyl)formamide (2t)[10]**



Yield: 90%, dark solid; M. P.: 135-137°C

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 9.94 (s, 1H), 9.28 (brs, 1H), 8.21 (d, *J*=1.96 Hz, 1H), 7.45-7.40 (m, 2H), 6.80-6.72 (m, 2H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 158.63, 153.3, 129.8, 120.6, 114.9.

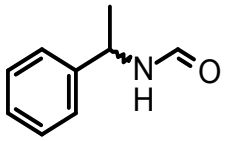
***N*-[(4-aminophenyl)methyl]formamide (2u)[11]**



Yield: 80%, yellow semisolid.

^{1}H NMR (400 MHz, DMSO-d_6) δ : 8.28 (br s, 1H) 8.05 (s, 1H) 6.97-6.87 (m, 2H) 6.57-6.45 (m, 2H), 5.04-4.96 (m, 2H) 4.12-4.00 (m, 2H).^{13}C NMR (101 MHz, DMSO-d_6) δ: 160.7, 147.6, 128.4, 125.8, 113.7, 40.5.

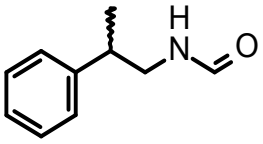
***Rac-N*-(1-phenylethyl)formamide (2v)**



Yield**:** 94%, light yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.57-8.55 (m., 1H), 8.06(br. S, 1H), 7.34-7.31 (m, 4H), 7.26-7.21(m, 1H), 5.05-4.98 (m, 1H), 1.38-1.36 (d, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.1, 144.1, 128.3, 126.8, 126, 46.6, 22.4.

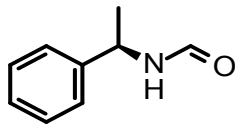
***Rac-N*-(2-phenylpropyl)formamide (2w)**



Yield: 95%, yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.01 (brs, 2H), 7.32-7.26 (m, 2H), 7.25-7.18 (m, 3H), 3.34-3.25 (m, 2H), 2.94-2.87 (m, 1H), 1.21-1.19 (d, 3H).^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.3, 144.8, 128.6, 127.3, 126.5, 44.3, 39.3, 19.6.

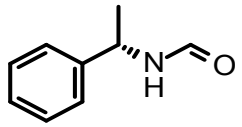
***N*-[(1*R*)-1-phenylethyl]formamide (2x)[9]**



Yield: 92%, light yellow liquid.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.53 (brs, 1H), 8.00 (s, 1H), 7.43-7.29 (m, 4H), 7.27-7.19 (m, 1H), 5.11-4.95 (m, 1H), 1.41-1.34 (m, 3H). ^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.1, 144.2, 128.3, 126.7, 125.9, 46.6, 22.5.

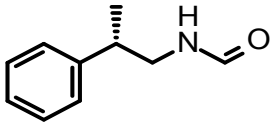
***N*-[(1*S*)-1-phenylethyl]formamide (2y)[12]**



Yield: 95%, yellow oil.

^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.59 (br. s., 1H), 8.06 (s, 1H), 7.43-7.29 (m, 4H), 7.27-7.19 (m, 1H), 5.09-4.95 (m, 1H), 1.41-1.34 (m, 3H).^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 160.1, 144.1, 128.3, 126.9, 125.9, 46.6, 22.4.

***N*-[(2*S*)-2-phenylpropyl]formamide (2*z*)**

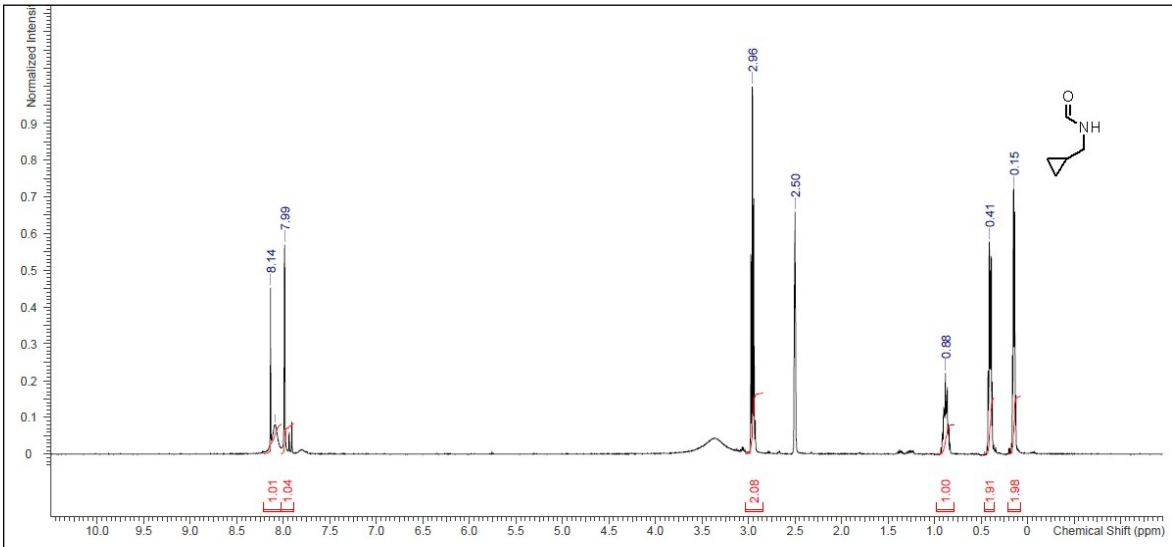


Yield: 90%, light yellow oil.

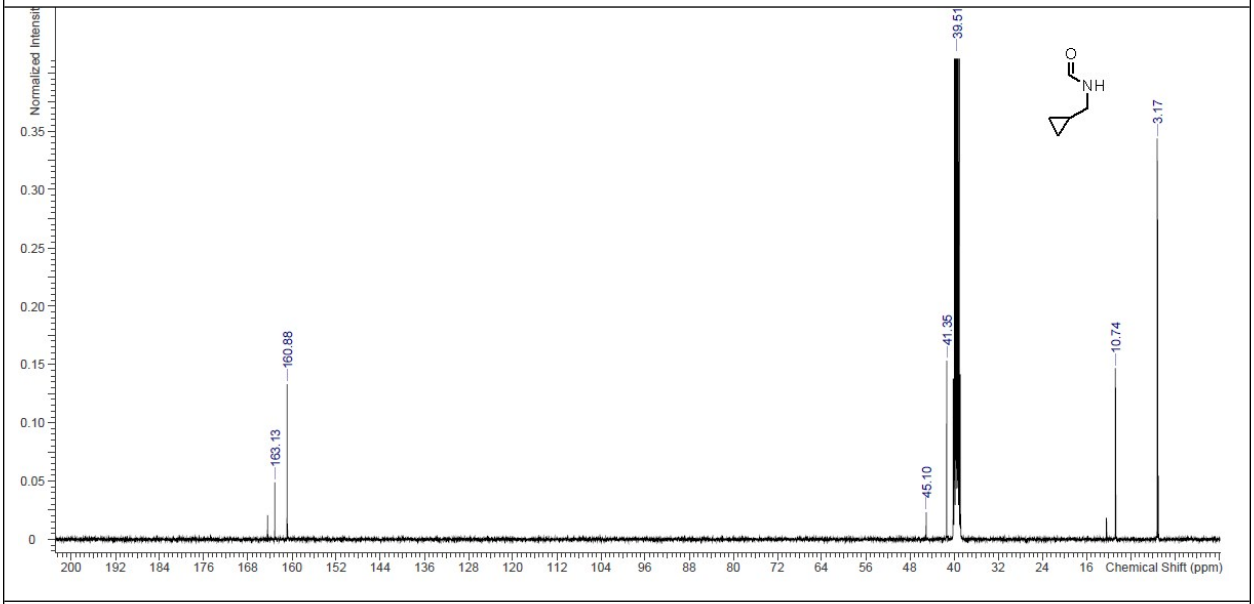
^{1}H NMR (400 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 8.13-7.91 (m, 2H), 7.36-7.27 (m, 2H), 7.24-7.18 (m, 3H), 3.32-3.21 (m, 2H), 2.97-2.85 (m, 1H), 1.21-1.15 (m, 3H).^{13}C NMR (100 MHz, DMSO-d_6) *mixture of rotamers is observed*, *major rotamer is given*; δ: 161.1, 145.6, 128.4, 127.1, 126.3, 44.1, 39.1, 19.4.

4. NMR and HPLC spectra of some representative synthesized compounds:

***N*-(cyclopropylmethyl)formamide (2e)**

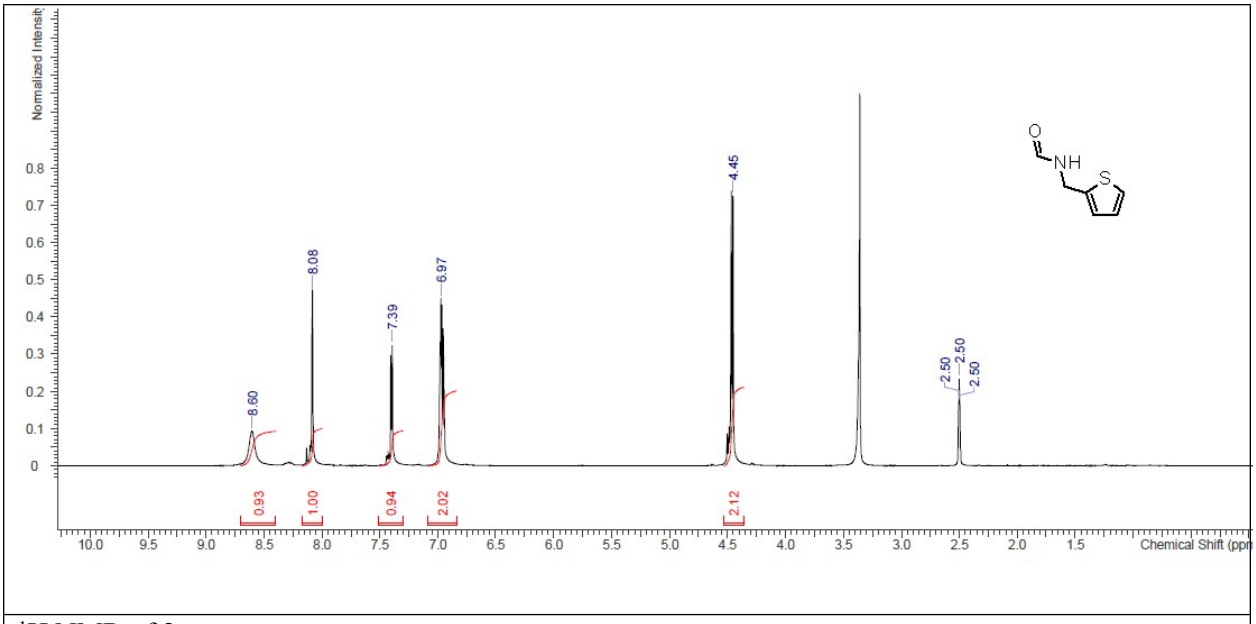


^{1}H NMR of **2e**

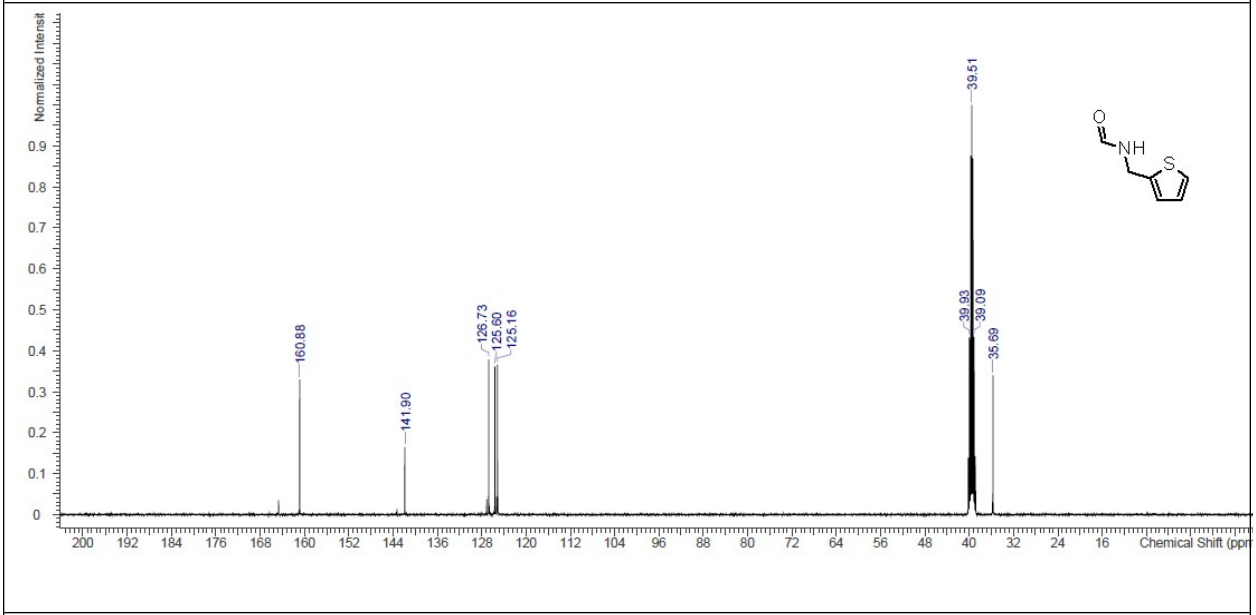


^{13}C NMR of **2e**

***N*-(2-thienylmethyl)formamide (2m)**

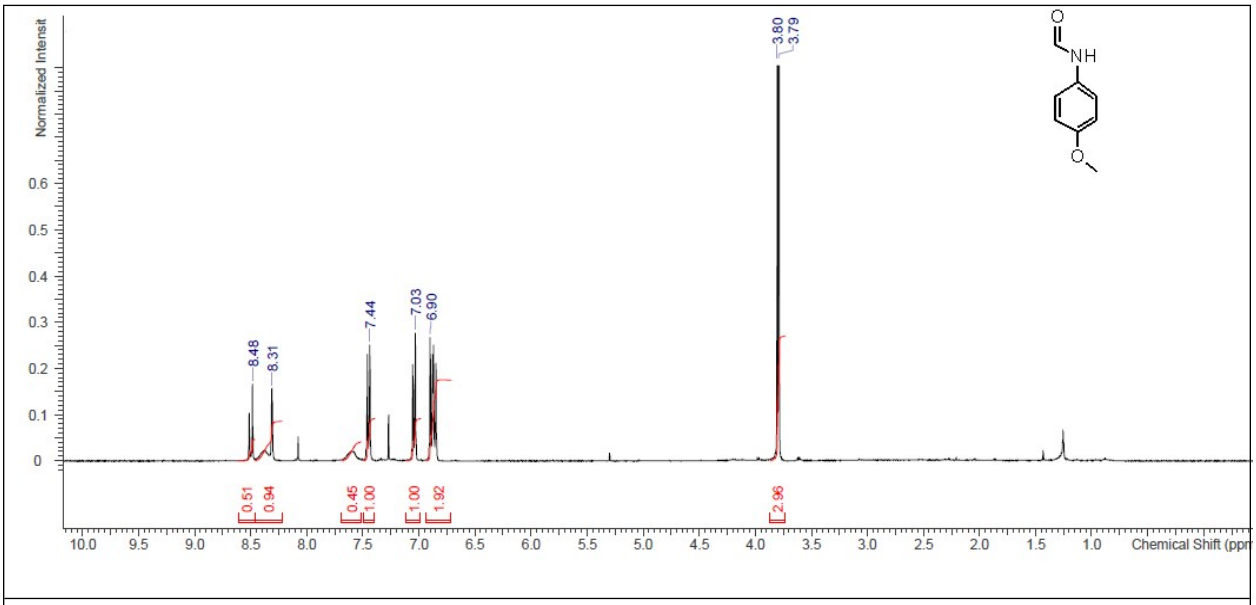


^{1}H NMR of **2m**

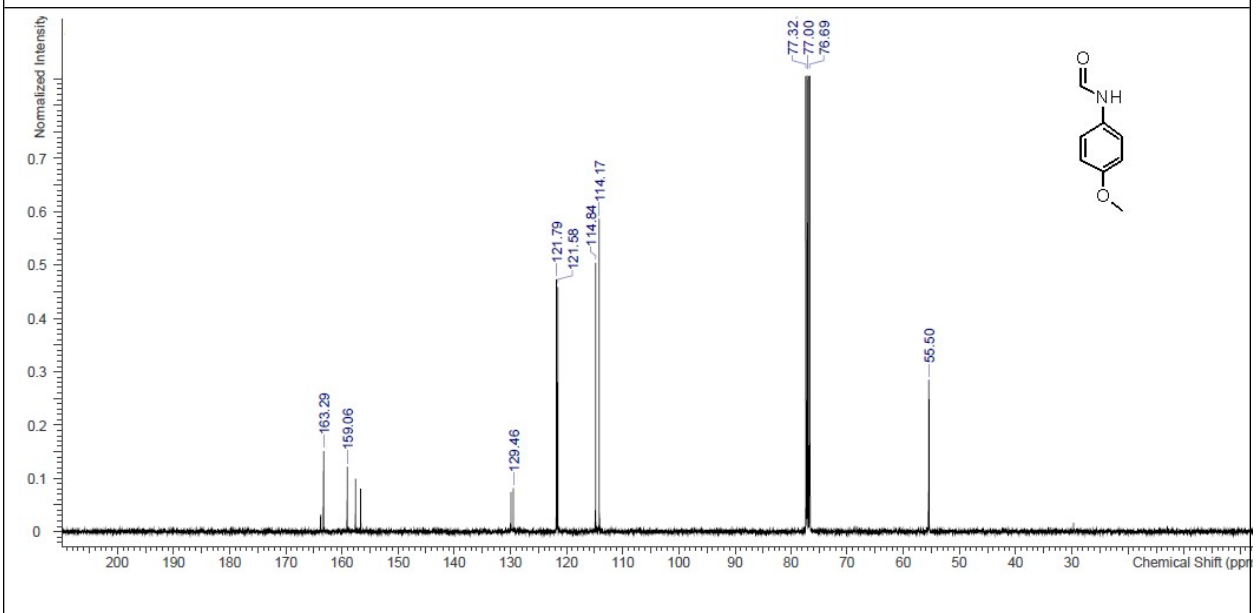


^{13C} NMR of **2m**

***N*-(4-methoxyphenyl)formamide (2o)**

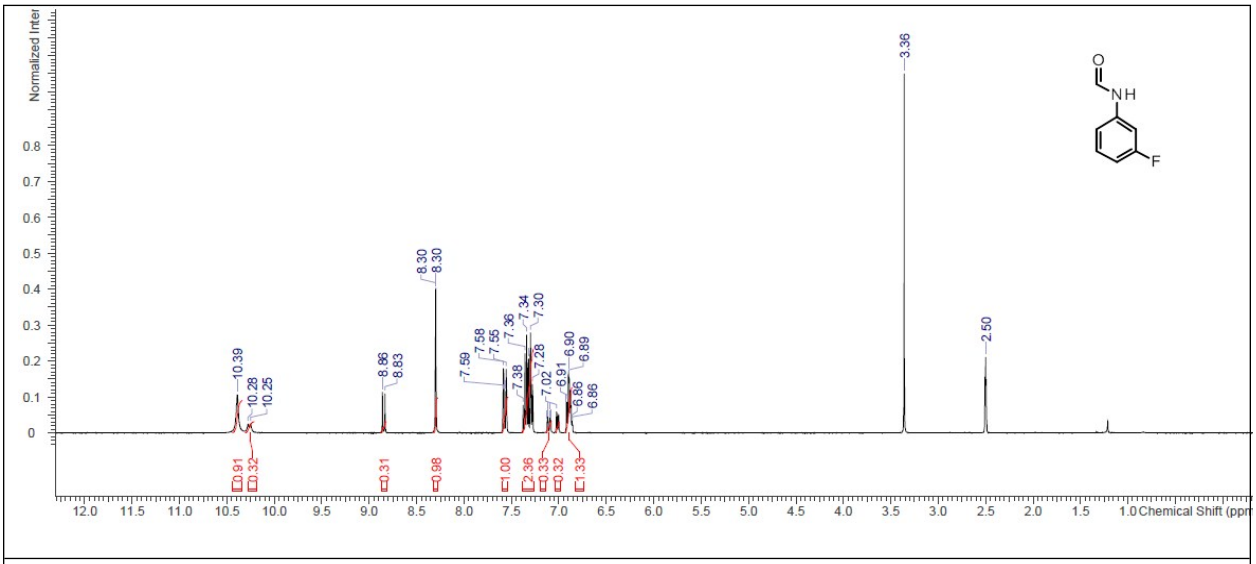


^{1}H NMR of **2o**

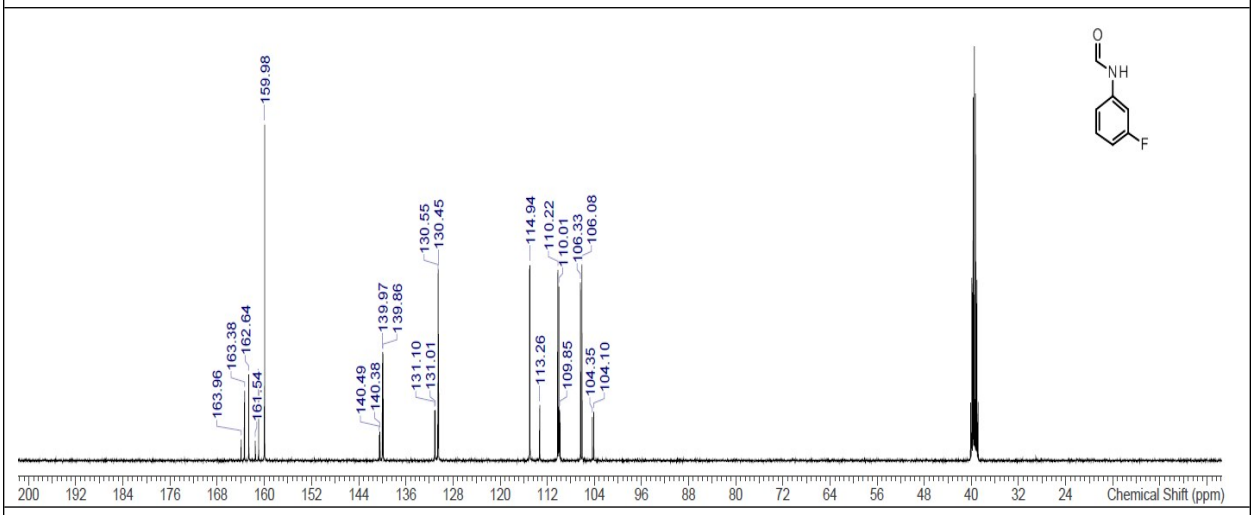


^{13}C NMR of **2o**

***N*-(3-fluorophenyl)formamide (2p)**

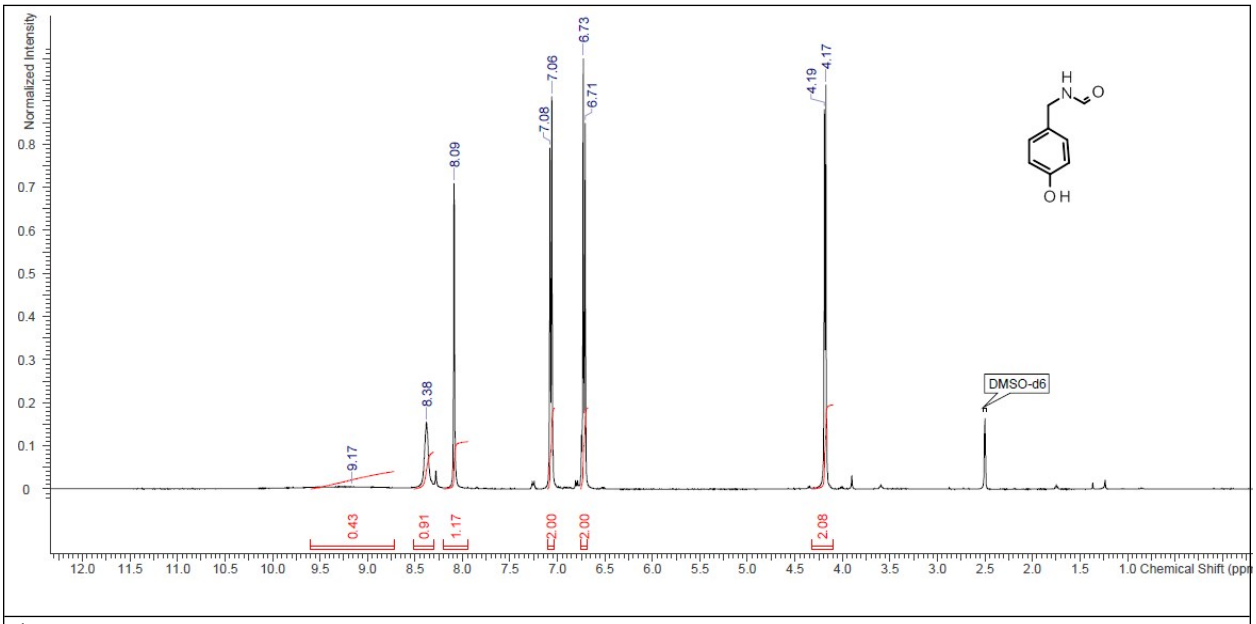


^{1}H NMR of **2p**

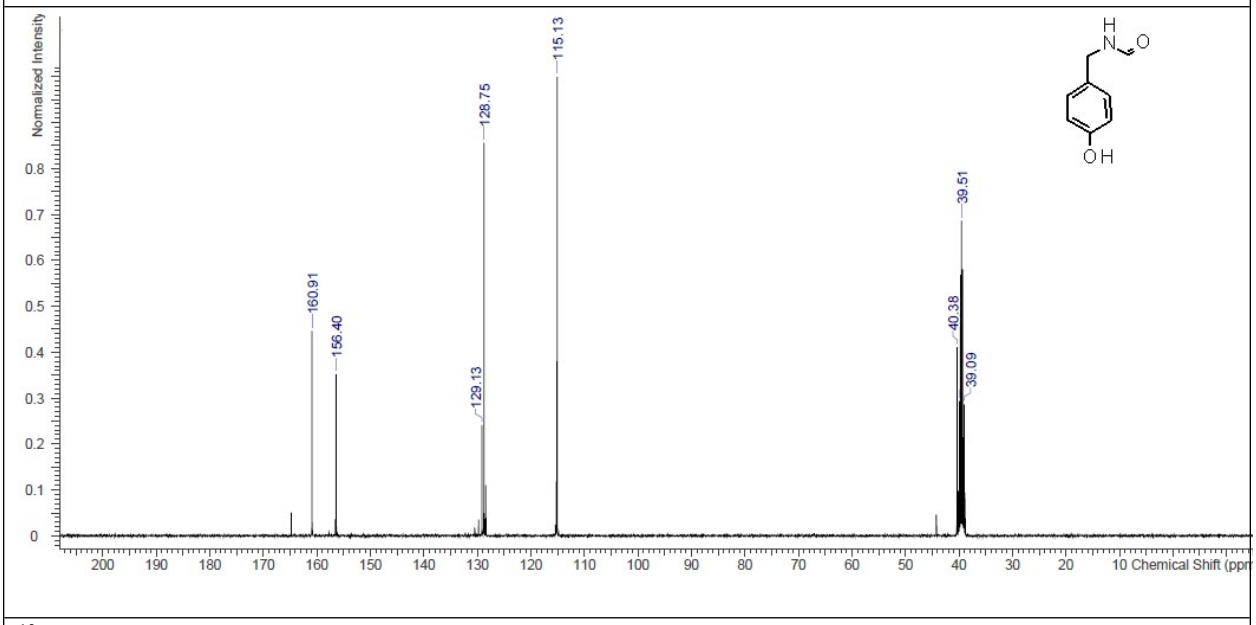


^{13}C NMR of **2p**

***N*-[(4-hydroxyphenyl)methyl]formamide (2s)**

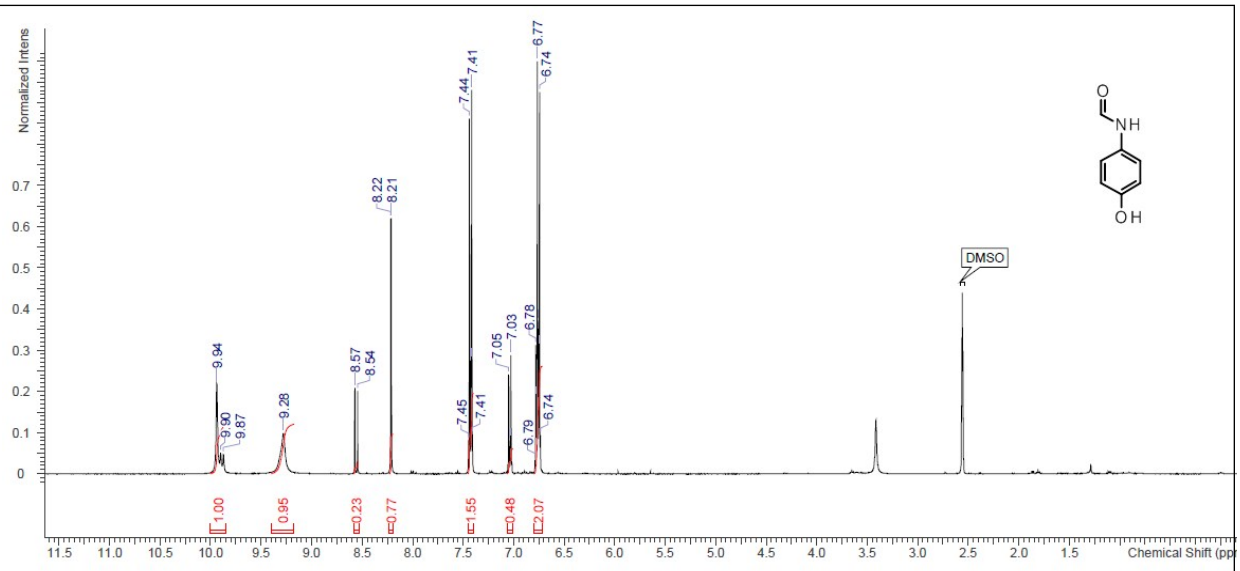


^{1}H NMR of **2s**

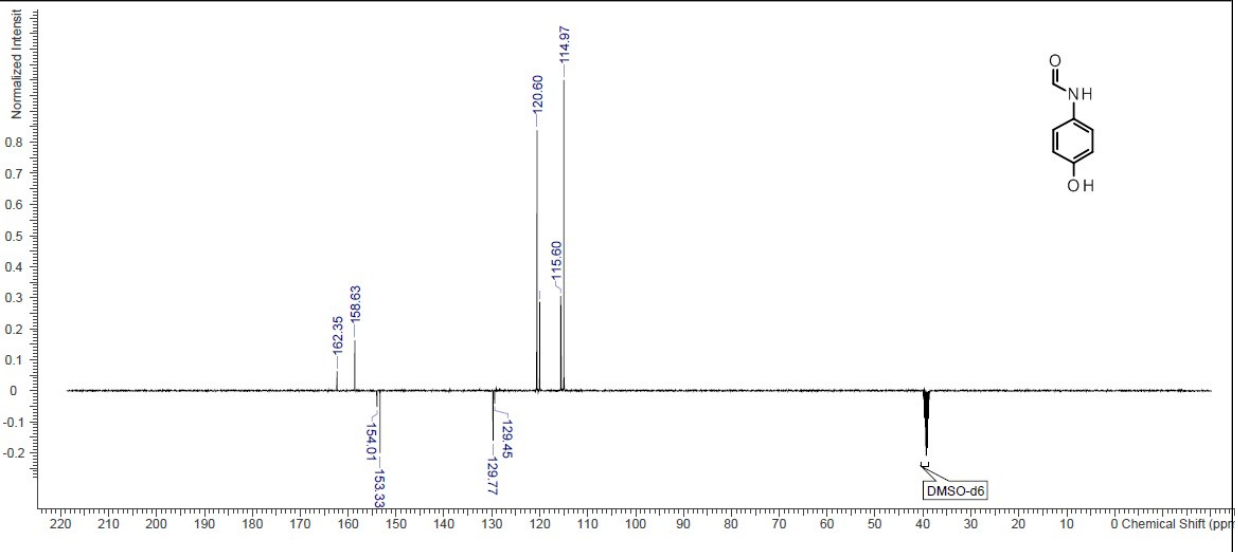


^{13}C NMR of **2s**

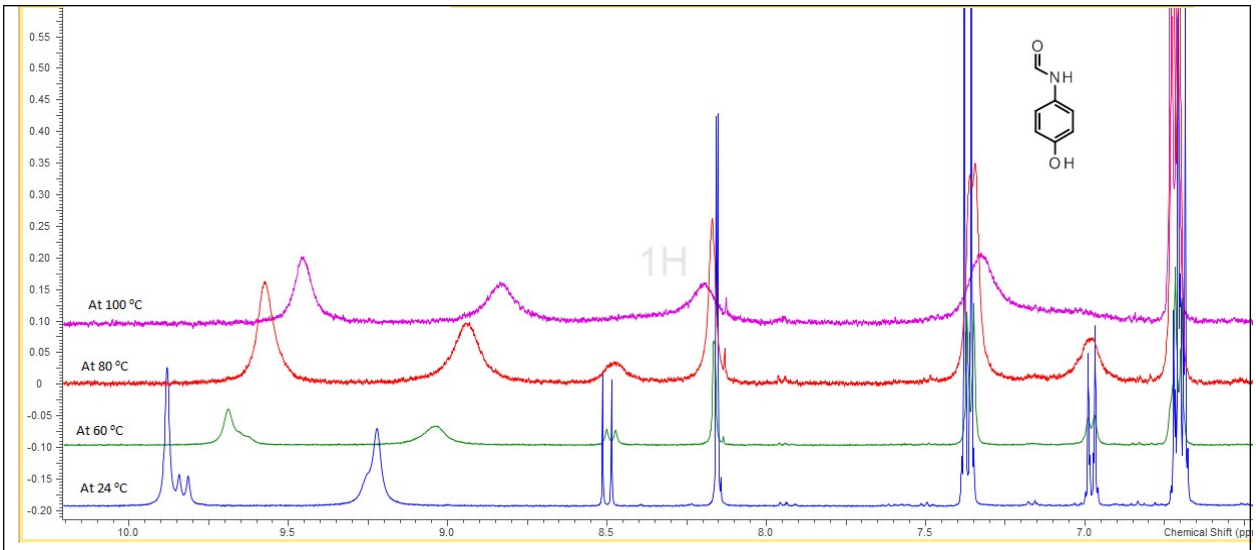
***N*-(4-hydroxyphenyl)formamide (2t)**



^{1}H NMR of **2t**

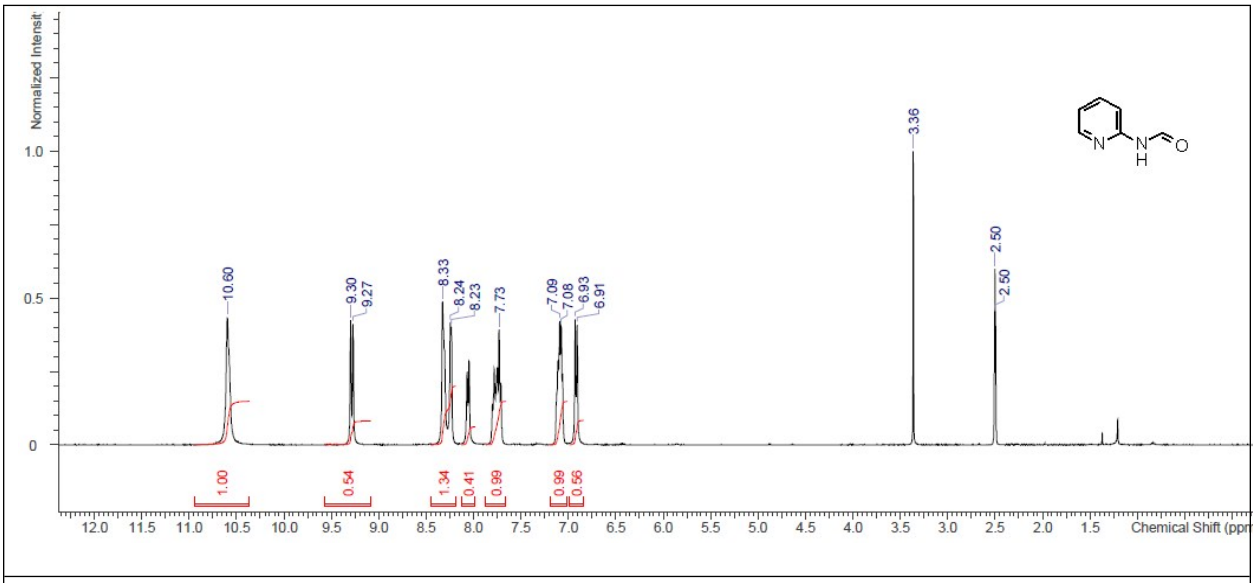


^{13}C NMR of **2t**

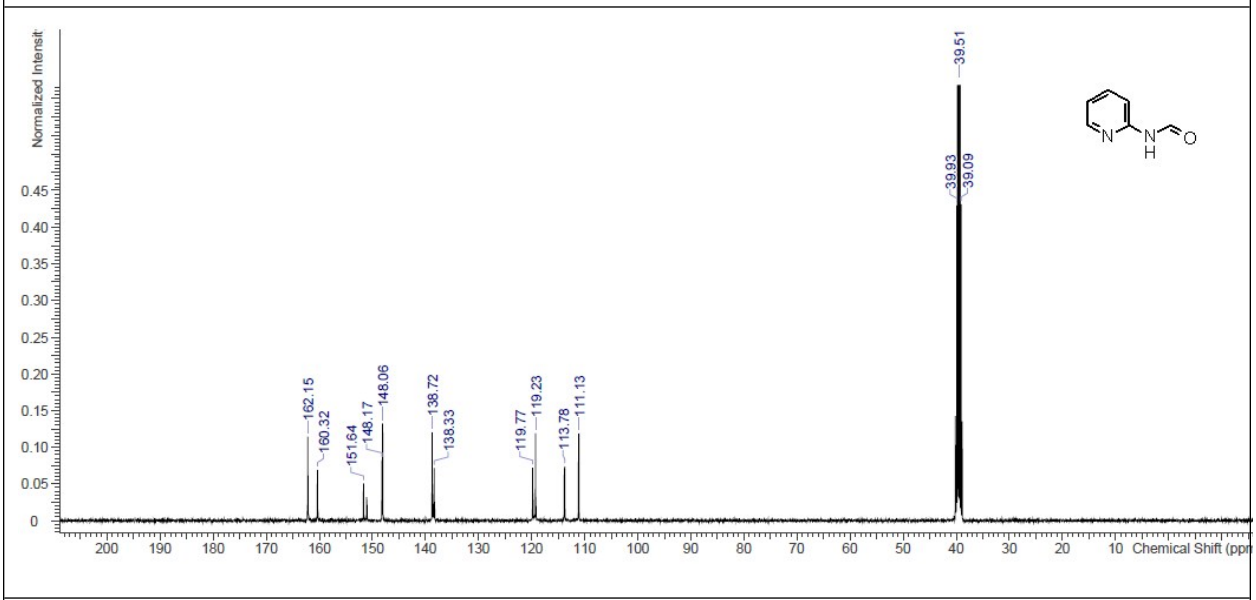


VT ^{1}H NMR experiment of **2t**

***N*-(2-pyridyl)formamide (2r)**

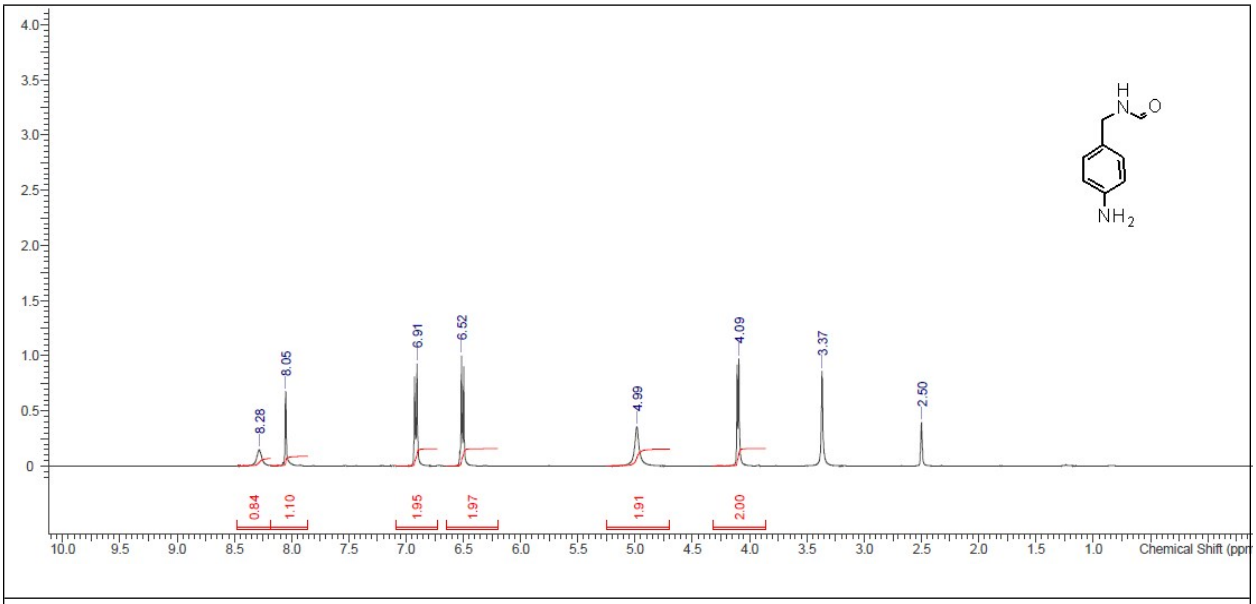


^{1}H NMR of **2r**

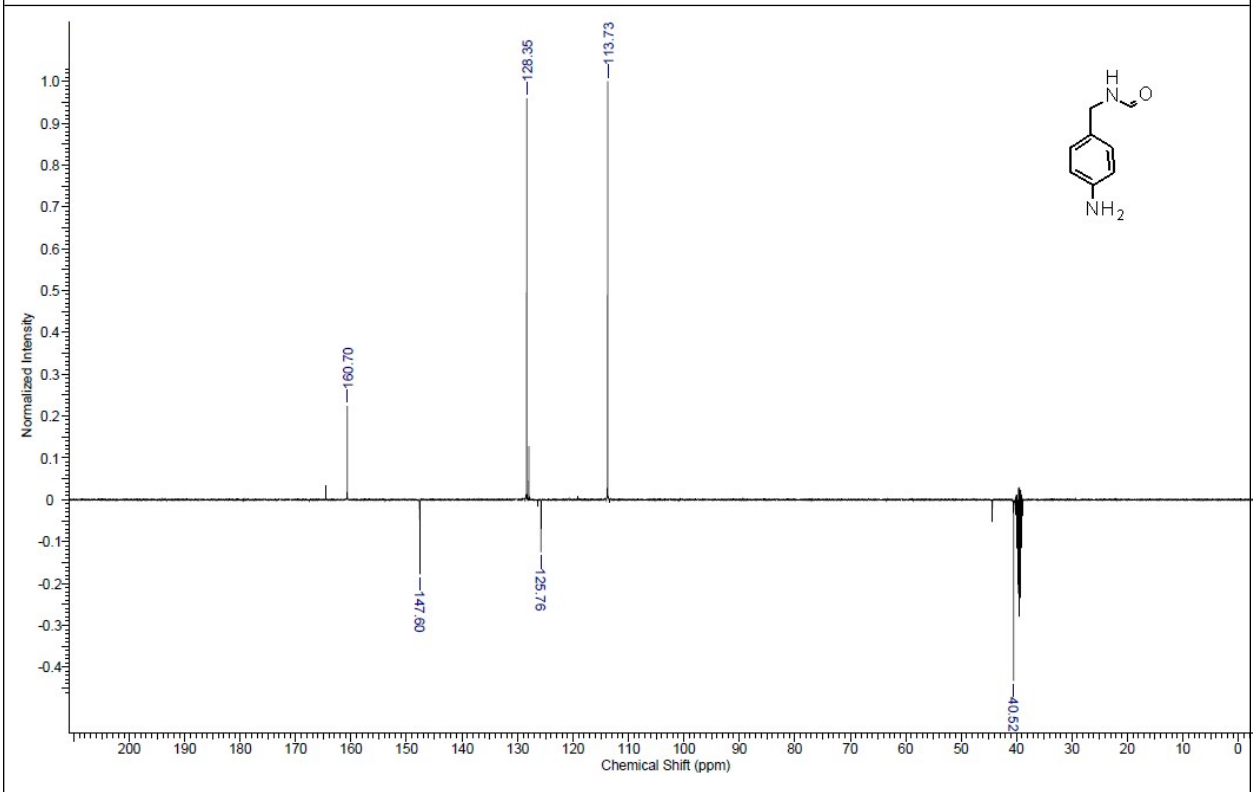


^{13}C NMR of **2r**

***N*-[(4-aminophenyl)methyl]formamide (2u)**

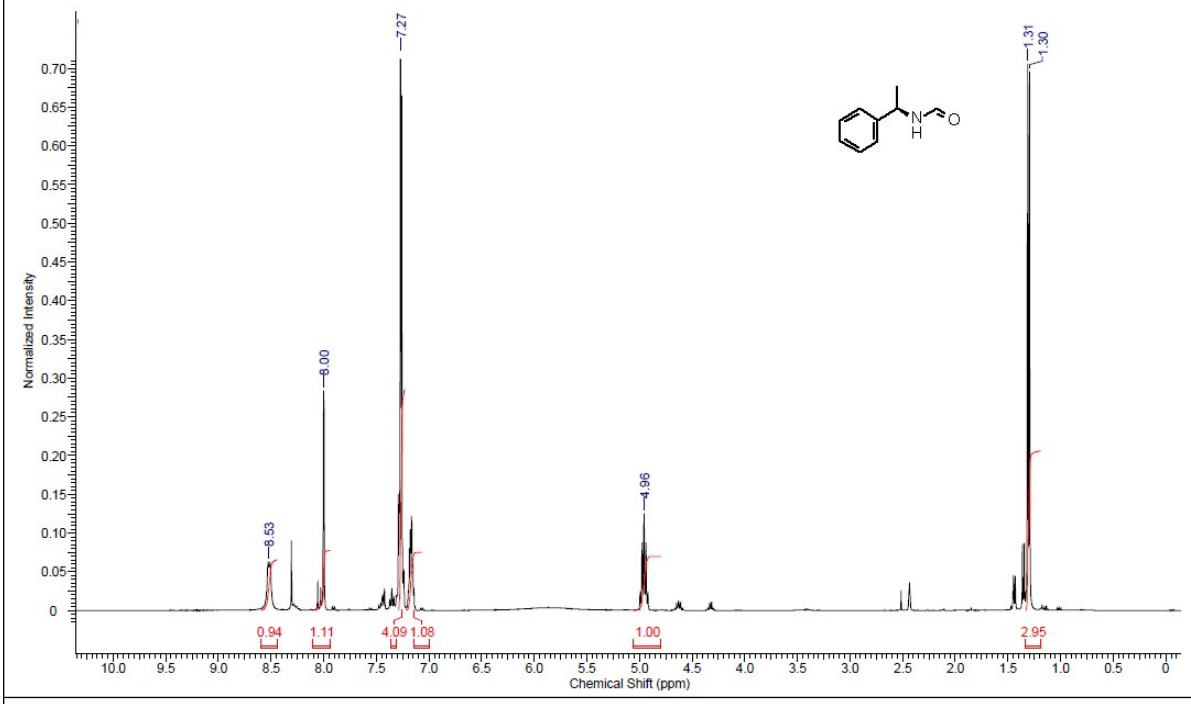


^{1}H NMR of **2u**

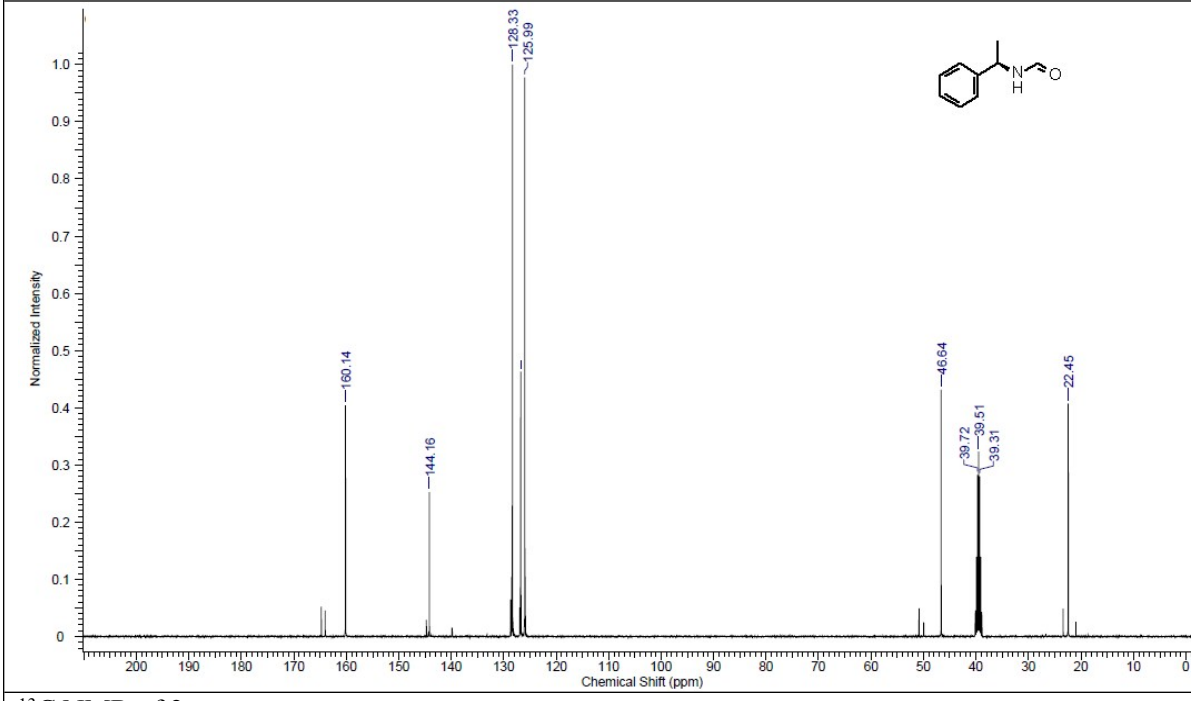


^{13}C NMR of **2u**

***N*-[(1R)-1-phenylethyl]formamide (2x)**

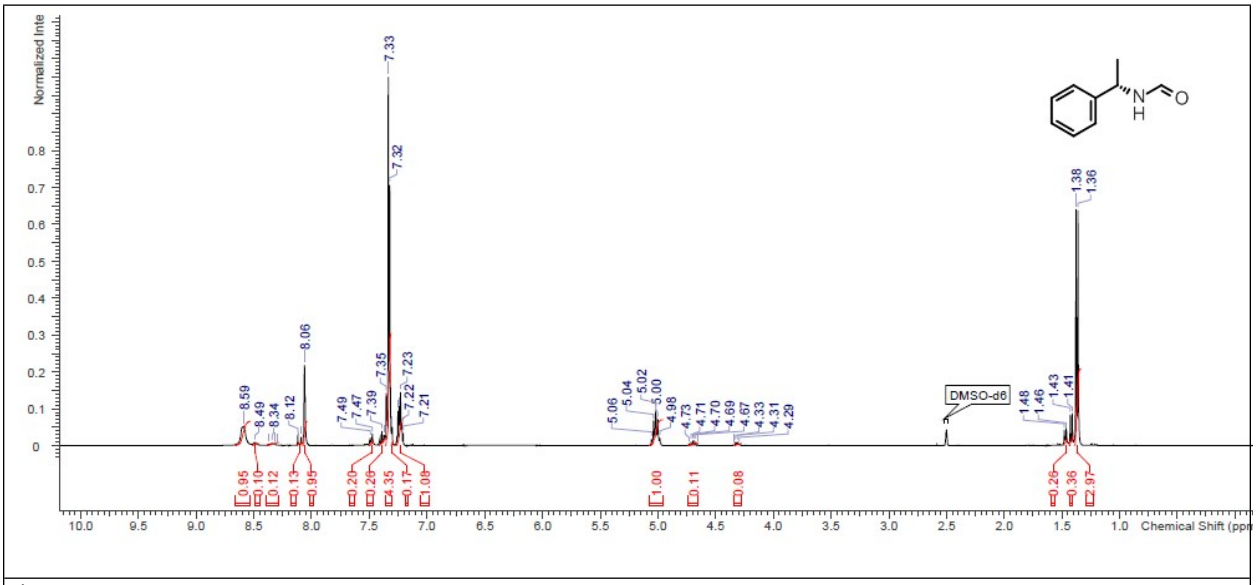


^{1}H NMR of **2x**

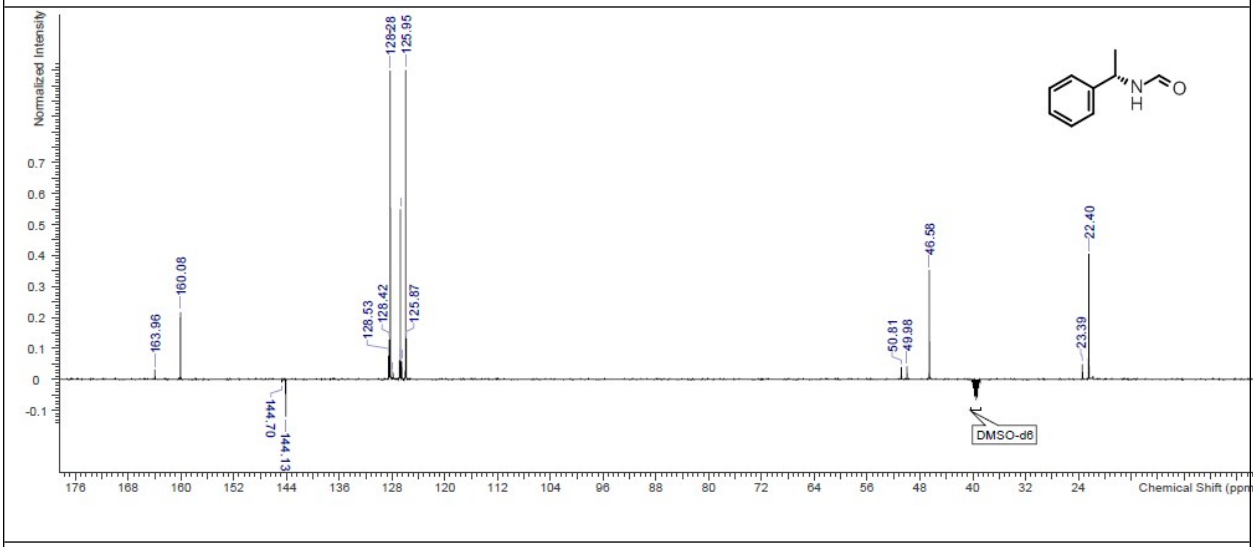


^{13}C NMR of **2x**

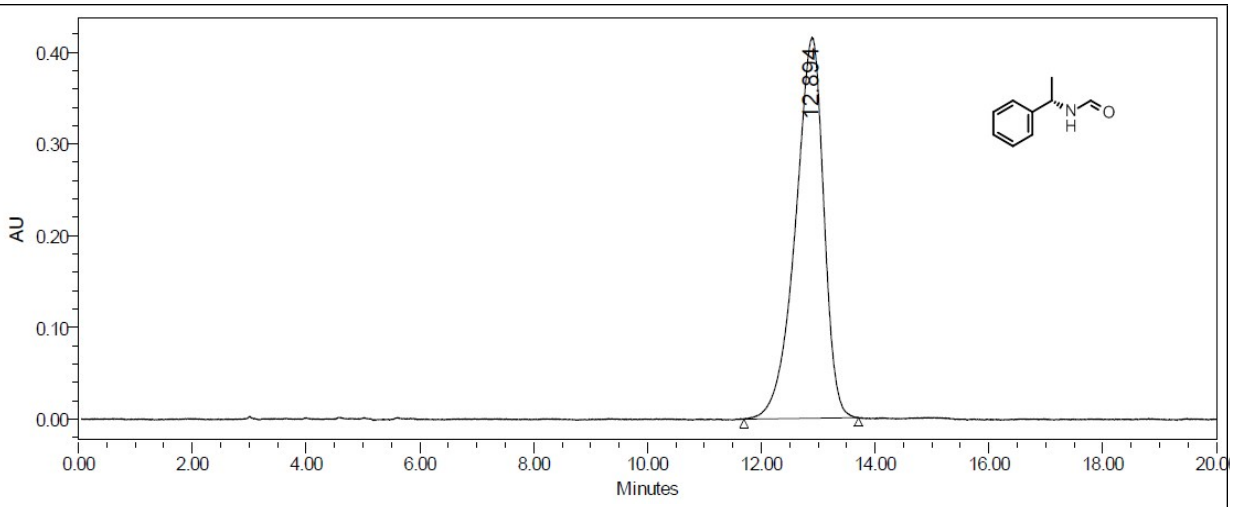
***N*-[(1S)-1-phenylethyl]formamide (2y)**



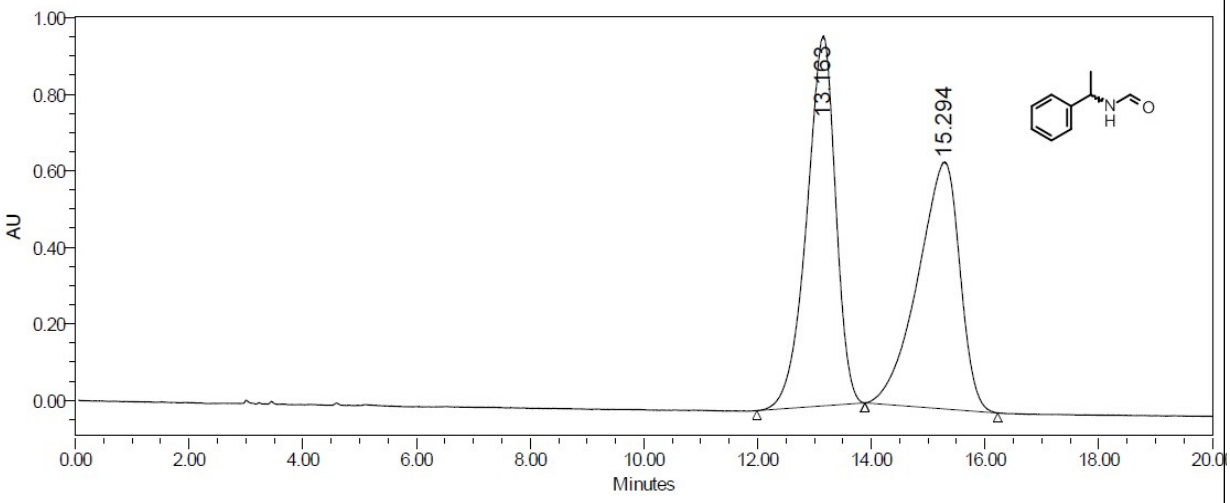
^{1}H NMR of **2y**



^{13}C NMR of **2y**

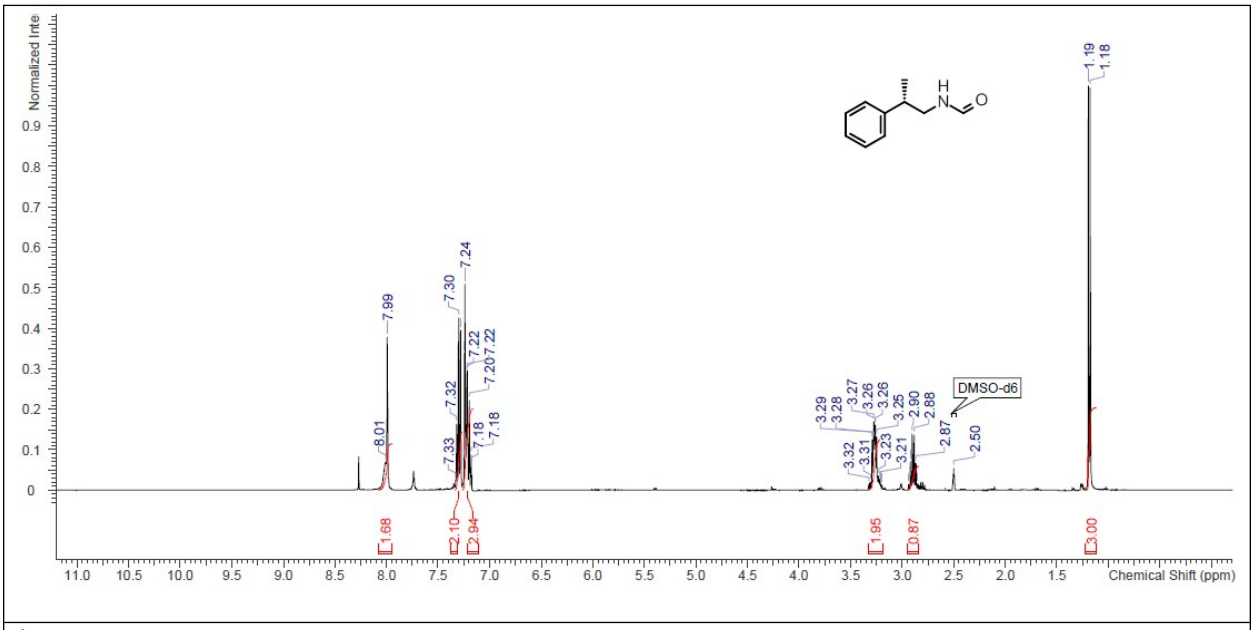


Chiral HPLC spectra of **2y**
Column: Chiralpack-IB 5 µm (4.6 mm Ø x 250 mml), Eluent: Hexane:2-Butanol; 90:10, Flow Rate: 1 ml/min. λ_{max} 210 nm.

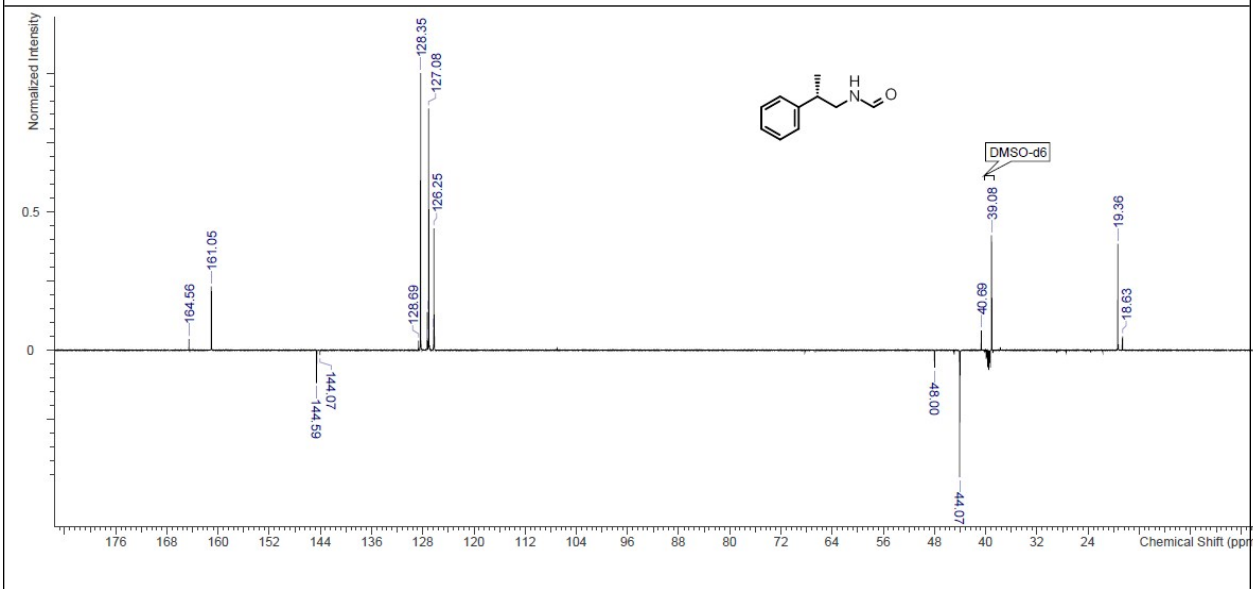


Chiral HPLC spectra of racemic-**2v**
Column: Chiralpack-IB 5 µm (4.6 mm Ø x 250 mml), Eluent: Hexane:2-Butanol; 90:10, Flow Rate: 1 ml/min. λ_{max} 210 nm.

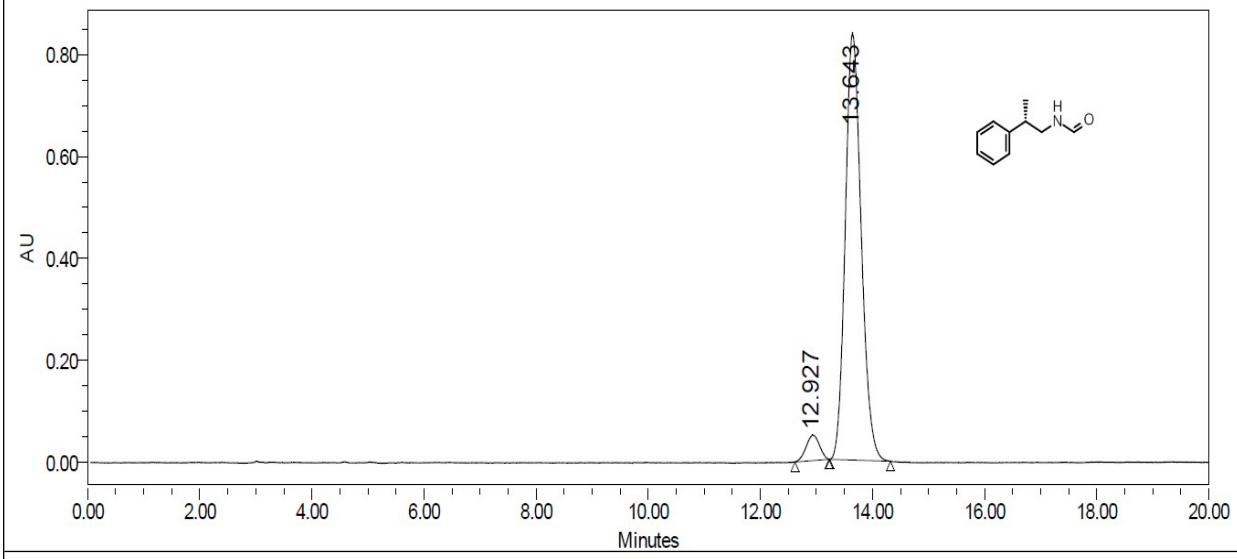
***N*-[(2*S*)-2-phenylpropyl]formamide (2*z*)**



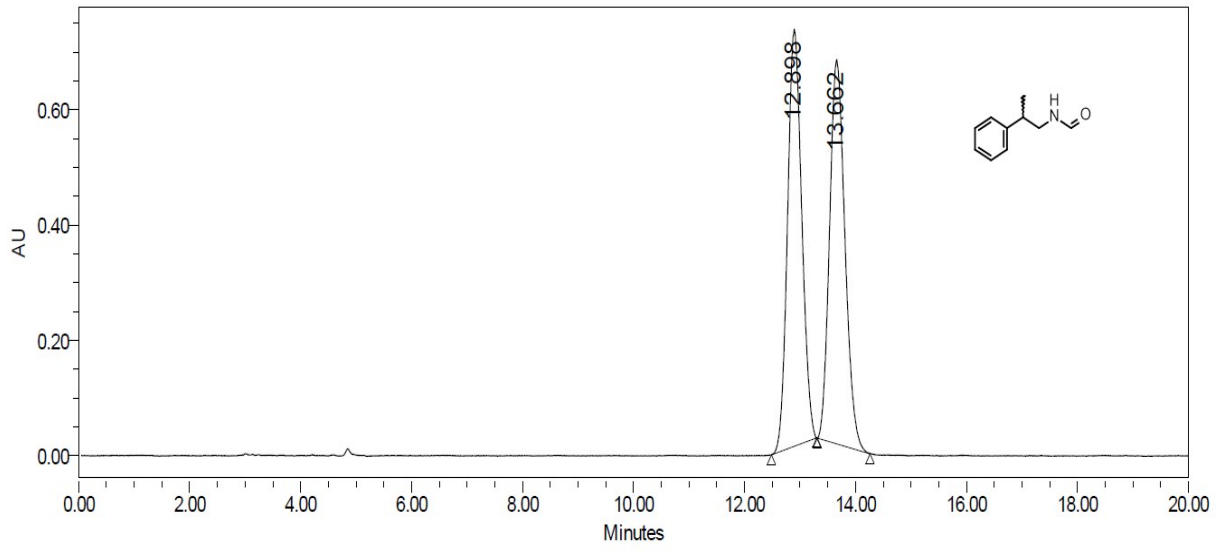
^{1}H NMR of 2z



^{13}C NMR of 2z



Chiral HPLC spectra of **2z**
Column: Chiralpack-IB 5 µm (4.6 mm Ø x 250 mml), Eluent: Hexane:2-Butanol; 90:10, Flow Rate: 1 ml/min. λ_{max} 210 nm.



Chiral HPLC spectra of racemic-**2w**
Column: Chiralpack-IB 5 µm (4.6 mm Ø x 250 mml), Eluent: Hexane:2-Butanol; 90:10, Flow Rate: 1 ml/min. λ_{max} 210 nm.

5. Kinetic study

Kinetics of *N*-formylation of 4-methoxybenzylamine:

Concentration of the products were calculated using quantitative HPLC data. Calibration curve using product and starting material was constructed within the linear dynamic range of the HPLC instrument. Samples were withdrawn at regular intervals (10 µl and diluted to 4ml) and were analyzed for product and starting material concentration. Initial reaction rates were calculated using linear part of the curve.

Series of experiments were carried out using various concentrations of 4-methoxybenzylamine (0.096 M 0.18M, 0.35M, 0.65M, 0.91M, and 1.13M) shown in table 1. Initial reaction rates were calculated using linear part of the curve (Fig 1, Table 2). Lineweaver-Burk plot for calculation of K_m and V_{max} was plotted using 1/V vs 1/[S] curve (Fig 3, Table 3). Kinetic constants (V_{max}, K_m, K_{cat}, K_{cat}/K_m) is given in table 4.

Typical procedure:

To a mixture of 4-methoxybenzylamine (**1k**) (0.02 mol) and ethyl formate (0.03 mol, 1.50 eq) in THF (14 ml) was added Novozyme 435® CALB (Lipase acrylic resin from Candida antarctica ≥5,000 U/g) (274 mg), and the mixture was stirred at room temperature (24 °C) at 300 rpm. Progress of the reaction was monitored using HPLC as tabulated in (Table 1) by withdrawing 10 µL (weighed) and diluted with 4 mL of methanol. This solution was used for HPLC analysis.

Time	0.18M	0.35M	0.66M	0.91M	1.13M	0.096m	0.51M
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.50	0.03	0.05	0.09	0.08	0.10	0.01	0.06
5.00	0.05	0.09	0.14	0.13	0.16	0.02	0.10

Table 1 Molar conversion of 4-methoxybenzylamine at various concentration against time (Initial)

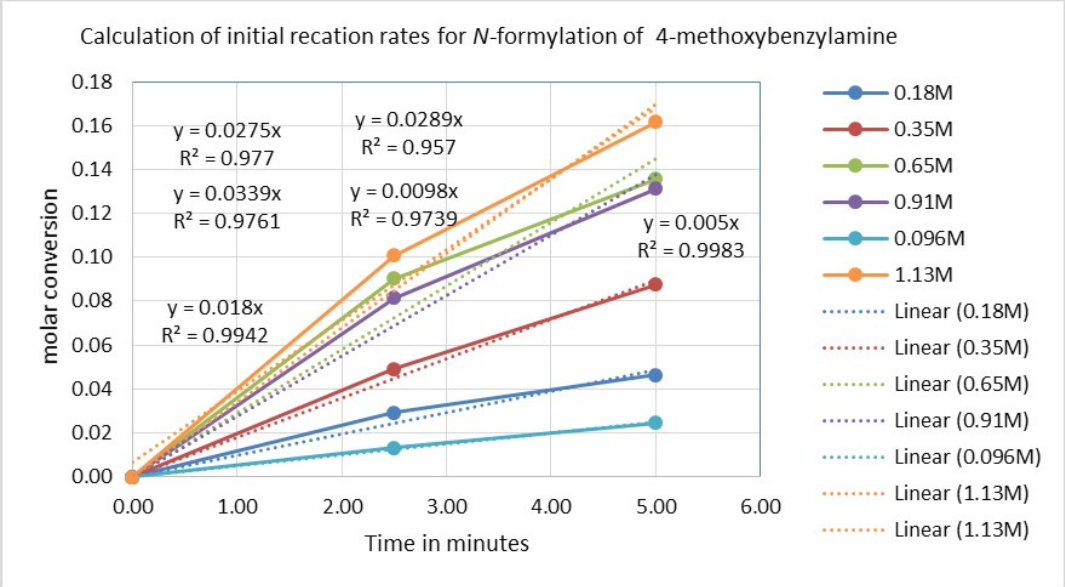


Fig. 1 Concentration time profile for *N*-formylation of 4-methoxybenzylamine

Table 2 Initial reaction rates and 4-methoxybenzylamine concentration

Molar concentration	Initial reaction rates (M $min^{-1)}$
0	0
0.096	0.005
0.18	0.0098
0.35	0.018
0.65	0.0275
0.91	0.0289
1.13	0.0339

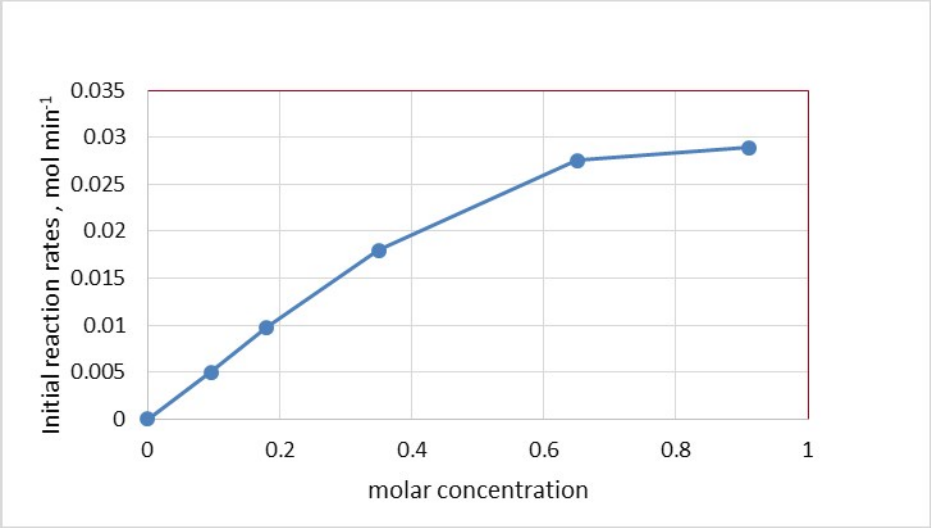


Fig. 2 Initial reaction rates vs 4-methoxybenzylamine concentration

Table 3 Lineweaver-Burk plot for calculation of K_m and V_{max}

Molar concentration	Initial reaction rates	1/[S]	1/V
0	0		
0.096	0.005	10.417	200.000
0.18	0.0098	5.556	102.041
0.35	0.018	2.857	55.556
0.65	0.0275	1.538	36.364
0.91	0.0289	1.099	34.602
1.13	0.0339	0.885	29.499

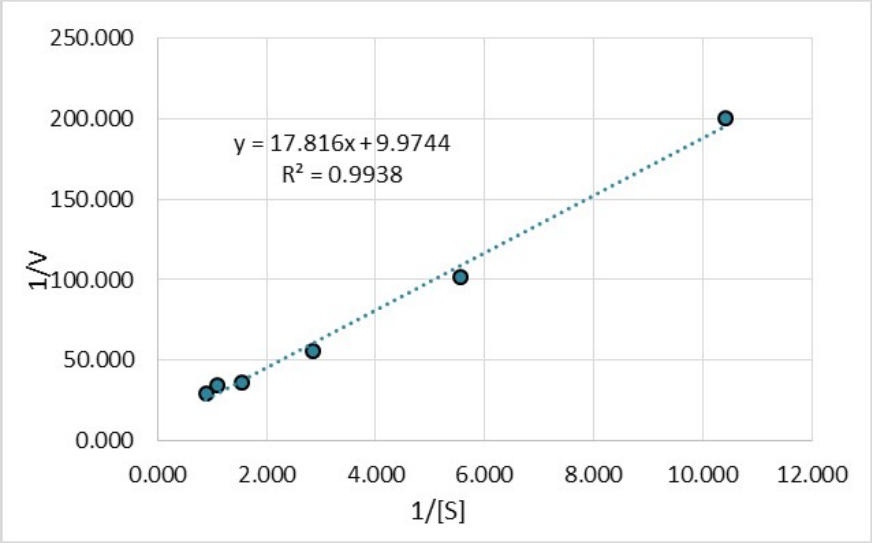


Fig. 3 Lineweaver-Burk plot for calculation of K_m and V_{max}

Table 4 Kinetic constants for *N*-formylation reaction of 4-methoxybenzylamine with ethyl formate using Novozyme 435® CALB.

Vmax ($M\ min^{-1}$)	Km (M)	k_{cat} (min^{-1})	k_{cat}/Km ($M^{-1}\ min^{-1}$)
0.100	1.8	$0.42X10^2$	$0.23X10^2$

5. References:

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