ELECTRONIC SUPPLEMENTARY INFORMATION

Bridged Flavinium Catalysed Diimide Reduction of Enamides in Water

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Experimental section:

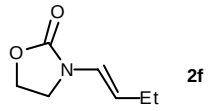
I General Information

All reactions were carried out in oven- or flame-dried glassware under an inert atmosphere. Reactions were monitored by thin-layer chromatography using pre-coated MN Alugram Sil G/UV254 silica gel 60 aluminium backed plates. Visualisation was accomplished by UV lamp (254nm), or with either potassium permanganate dip with heat or iodine on silica as an indicator. Flash column chromatography was performed on chromatography grade, silica 60Å particle size 35-70 micron from Fisher Scientific using the solvent system as stated. Commercial grade reagents and solvents were used without further purification, except when dried (as indicated) by passing through anhydrous alumina columns using an Innovative Technology Inc. PS-400-7 solvent purification system. ^{1}H and ^{13}C NMR were performed on a Brüker Avance 300 spectrometer. Chemical shifts values (δ) are reported in ppm relative to Me_4Si (δ= 0.00 ppm). The proton spectra are reported as follows δ (number of protons, multiplicity, coupling constant *J*, proton identity where possible). Multiplicities are indicated by s (singlet), d (doublet), t (triplet), q (quartet), pen (pentet), hex (sextet) and m (multiplet) and br (broad). Thin film infra-red spectra were recorded using PerkinElmer Spectrum RX FT-IR and SPECTRUM ONE instruments on KBr plates. High resolution mass spectra (HRMS) were obtained on a Brüker μTOF using either positive or negative electrospray ionisation (ESI) as stated.

II Procedures and Experimental Data

Representative procedure for the preparation of lactam and oxazolidinone enamides

N-(E-propenyl)-oxazolidinone 2f



2f

To dry toluene (50 mL) were added 2-oxazolidinone (870 mg, 10 mmol), butyraldehyde (706 μL, 10 mmol) and pyridinium *p*-toluene sulfonate (25 mg, 0.001 mmol, 0.1 mol%) were heated at reflux in a Dean-Stark apparatus for 18 hours. The reaction was allowed to cool before washing with $NaHCO_3$ (sat.) (20 mL), separated and subsequent extraction with diethyl ether (3 x 25 mL). the combined organic extracts were dried over $MgSO_4$ and solvent removed *in vacuo*. Enamide **2f** was purified by Kugelröhr distillation (bp 145-150 °C (7.6 x 10^{-1} Torr) to afford the enamide as a clear liquid (446 mg, 31%).

Boiling Point: 145-150 °C (7.6 x 10^{-1} Torr)
FTIR (film/cm^{-1}) υ_{max}: 2683, 2927, 2878, 1747, 1671, 1412.
^{1}H NMR (300 MHz, $CDCl_3$): δ 6.63 (1H, dt, *J* = 14.3, 1.5 Hz, NCH=C*H*), 4.85 (1H, dt, *J* = 14.3, 6.7 Hz, NC*H*=CH), 4.45-4.37 (2H, m, OCH_2CH_2N), 3.71-3.63 (2H, m, OCH_2CH_2N), 2.09 2.10 (1H, qd, *J* = 7.2, 1.4, CH=CHC*H*HCH$_3$), 2.07 (1H, qd, *J* = 7.2, 1.4, CH=CHC*H*HCH$_3$) 1.05 (3H, t, *J* = 7.2 Hz, CH_3).
^{13}C NMR (75 MHz, $CDCl_3$): δ 155.9, 123.6, 113.4, 62.5, 43.0, 23.4, 14.8.
HRMS (ESI) Calcd. for $C_7H_{12}NO_2$ $(M+H)^+$: 142.0868. Found: 142.0871; Calcd. for $C_7H_{11}NNaO_2$ $(M+Na)^+$: 164.0687. Found: 164.0685.

Enamides **2a**[1], **2c**[2], **2d**[2], **2e**[1] **2g**[3] and **2h**[3] are known and were confirmed against reported literature. Enamide **2b** is commercial and was purchased from sigma-Aldrich. Enamides **2i** and **2h** were synthesised according to the procedures of Kobayashi.[4,5]

Reduced products **3a**, **3b**, **3c**, **3d** were compared against authentic commercial samples. Products **3e** **3f**[6] **3g**[7] and **3j**[8] were confirmed against reported literature.

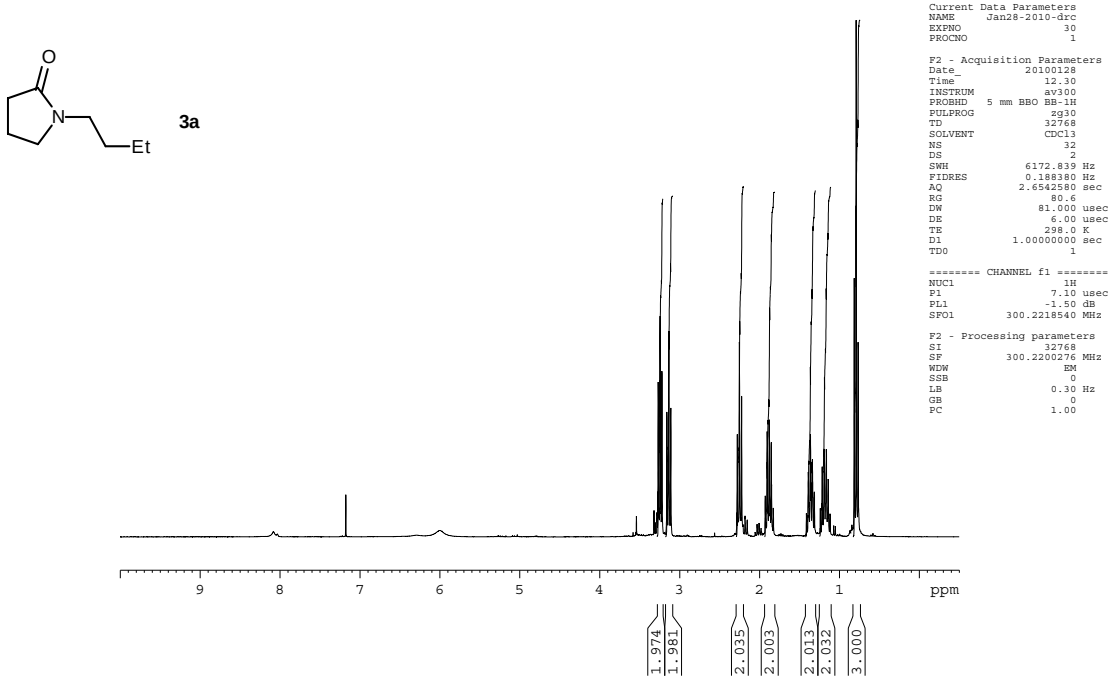
Isolated reduced products have been characterised and are presented with ^{1}H NMR and ^{13}NMR spectra.

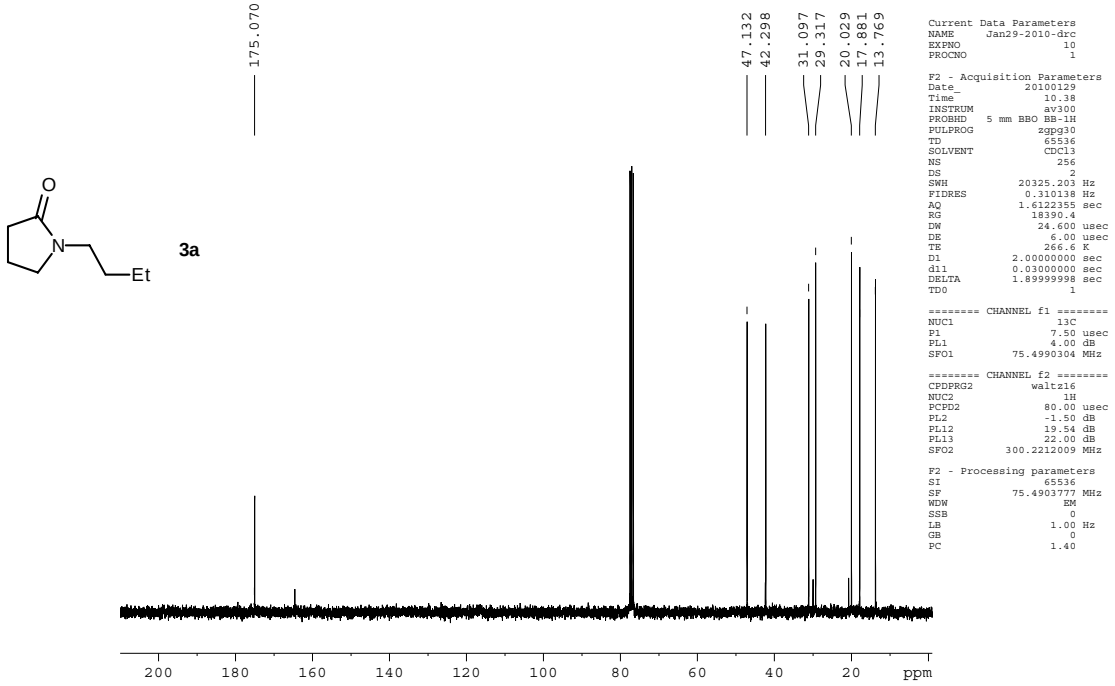
Representative Procedure for the Flavinium-Catalysed reduction of Enamides.

1-butylpyrrolidin-2-one (3a)

Flavinium catalyst **1b** (8.5 mg, 5 mol%), and enamide **2a** (69.5 mg, 0.5 mmol) were dissolved in H_2O (1 mL) and immediately followed by $NH_2NH_2.H_2O$ (246 μL, 5 mmol). The reaction was then placed under an oxygen atmosphere (1 atm) and heated to 100 °C for 18 hours. After this period, the reaction was cooled and the organic product extracted with diethyl ether (4 x 5 mL). The combined organics were dried over $MgSO_4$ and solvent subsequently removed *in vacuo.* NMR (^{1}H) analysis at this juncture confirmed complete consumption of starting enamide, with product **3a** isolated as a clear oil (65.6 mg, 93%).

FTIR (film/cm^{-1}) υ_{max}: 2976, 2937, 1664. ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.24 (2H, t, *J* = 7.3 Hz, C*H*$_2$N), 3.13 (2H, t, *J* = 7.9 Hz, C*H*$_2$O), 2.25 (2H, t, *J* = 7.9 Hz, CH_2N), 1.88 (2H, app pen, *J* = 7.3 Hz, CH_2O), 1.31-1.41 (2H, m, CH_2), 1.15 (2H, hex, *J* = 7.3 Hz, $CH_2CH_2CH_3$ 0.79 (3H, t, *J* = 7.3 Hz, CH_2CH_3). ^{13}C NMR (75 MHz, $CDCl_3$): δ 175.0, 47.1, 42.2, 31.1, 29.3, 20.0, 17.9, 13.8.

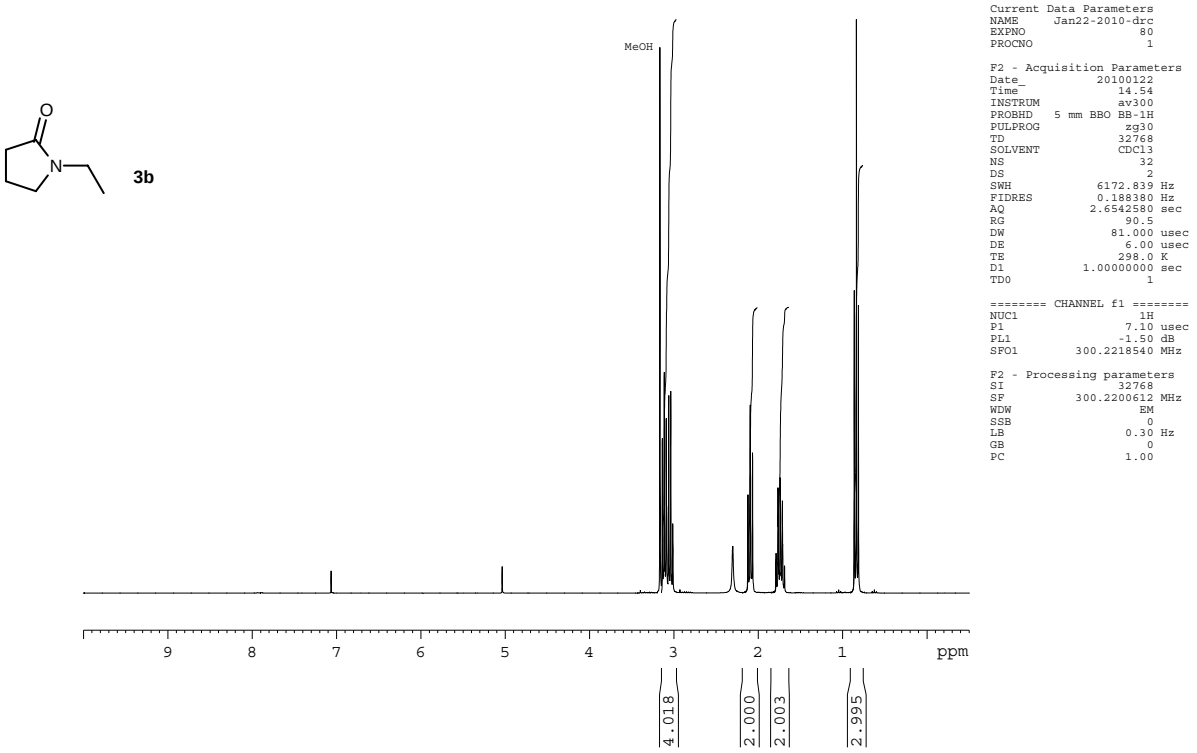


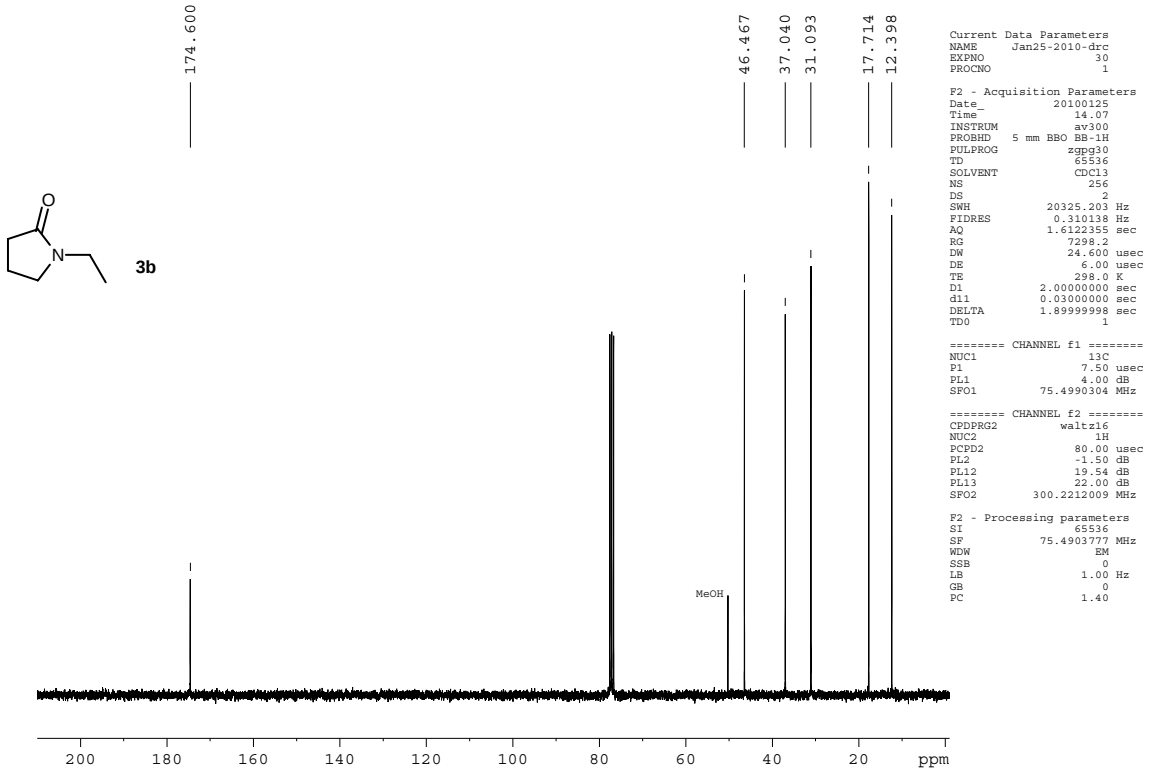


1-ethylpyrrolidin-2-one (3b)

Following representative procedure with flavinium catalyst **1b** (8.0 mg, 5 mol%), and enamide **2b** (55.5 mg, 0.5 mmol) were dissolved in H_2O (1 mL) and immediately followed by $NH_2NH_2.H_2O$ (246 μL, 5 mmol). Product **3b** was isolated as a clear oil (49 mg, 88%).

FTIR (film/cm^{-1}) υ_{max}: 2873, 2952, 1737.
^{1}H NMR (300 MHz, $CDCl_3$): δ 3.22-3.34 (4H, m, C*H*$_2$N), 2.30 (2H, t, *J* = 8.1 Hz, C(O)C*H*2), 1.94 (2H, pen, *J* = 8.1 Hz, CH_2), 1.13-1.15 (6H, m, CH_2), 1.04 (3H, t, *J* = 7.3 Hz, CH_2CH_3).
^{13}C NMR (68 MHz, $CDCl_3$): δ 174.6, 46.5, 37.0, 31.1, 17.7, 12.4.

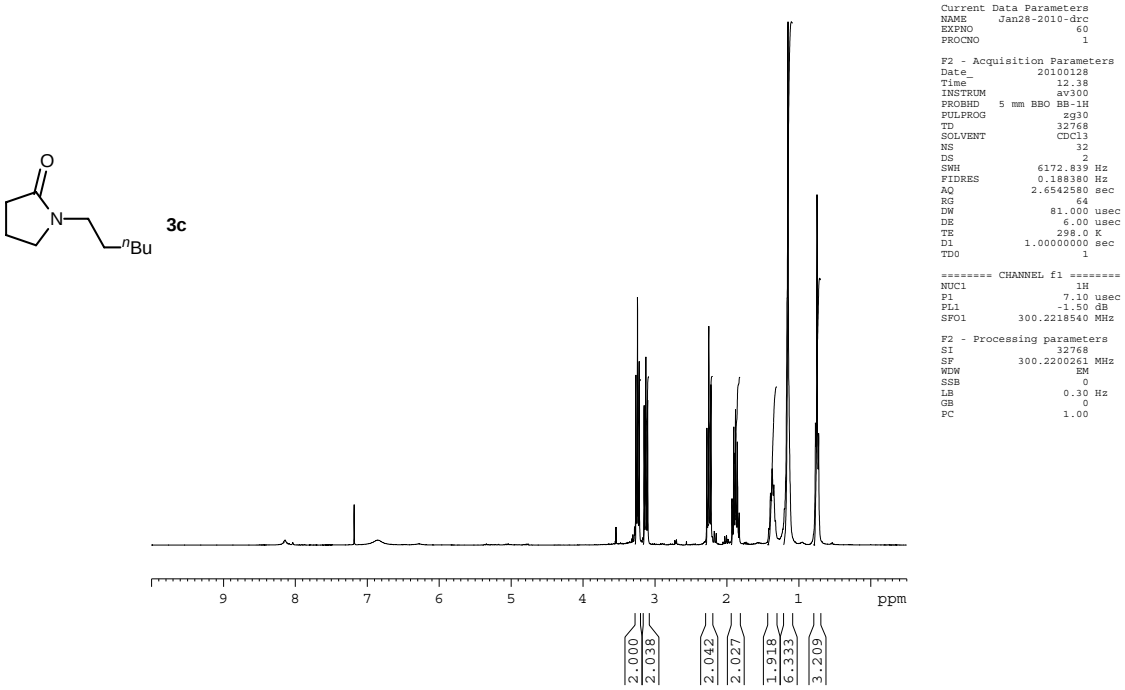


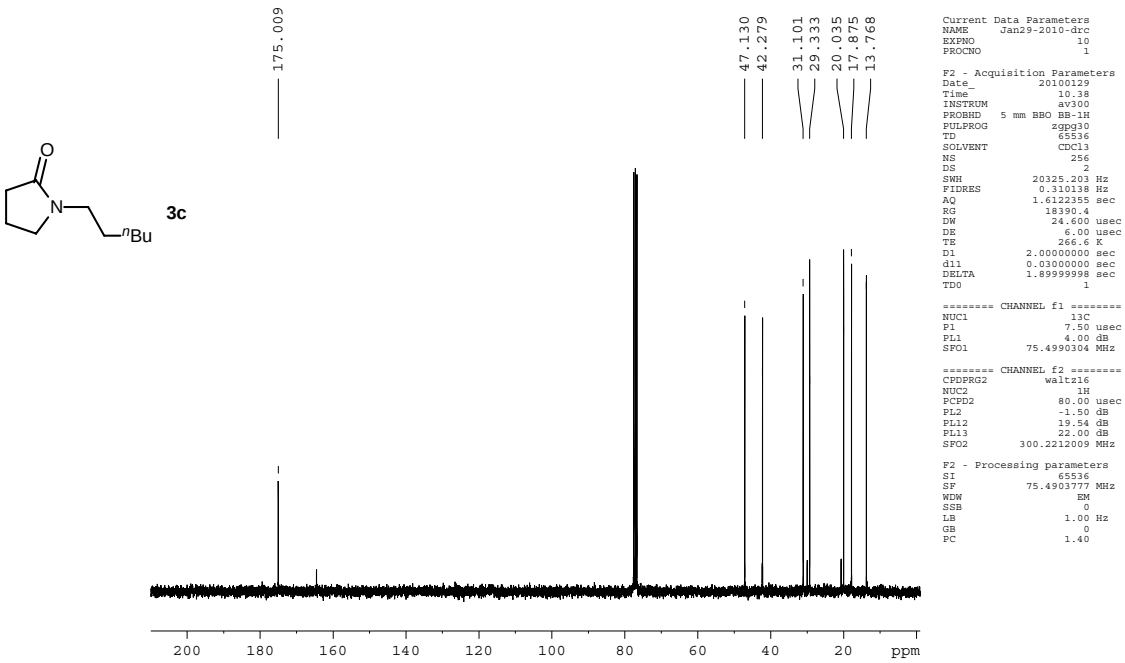


1-hexylpyrrolidin-2-one (3c)

Following representative procedure with flavinium catalyst **1b** (8.0 mg, 5 mol%), and enamide **2c** (83.5 mg, 0.5 mmol) were dissolved in H_2O (1 mL) and immediately followed by $NH_2NH_2.H_2O$ (246 μL, 5 mmol). Product **3c** isolated as a clear oil (77.0 mg, 91%).

FTIR (film/cm^{-1}) υ_{max}: 2976, 2936, 1662. ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.24 (2H, t, *J* = 7.3 Hz, C*H*$_2$N), 3.12 (2H, t, *J* = 8.3 Hz, C*H*$_2$O), 2.25 (2H, t, *J* = 8.3 Hz, CH_2N), 1.87 (2H, app pen, *J* = 7.3 Hz, CH_2O), 1.35-1.39 (2H, m, CH_2), 1.13-1.15 (6H, m, CH_2), 0.74 (3H, t, *J* = 7.3 Hz, CH_2CH_3). ^{13}C NMR (68 MHz, $CDCl_3$): δ 174.8, 47.1, 42.5, 31.5, 31.1, 27.2, 26.5, 22.5, 17.8, 13.9.

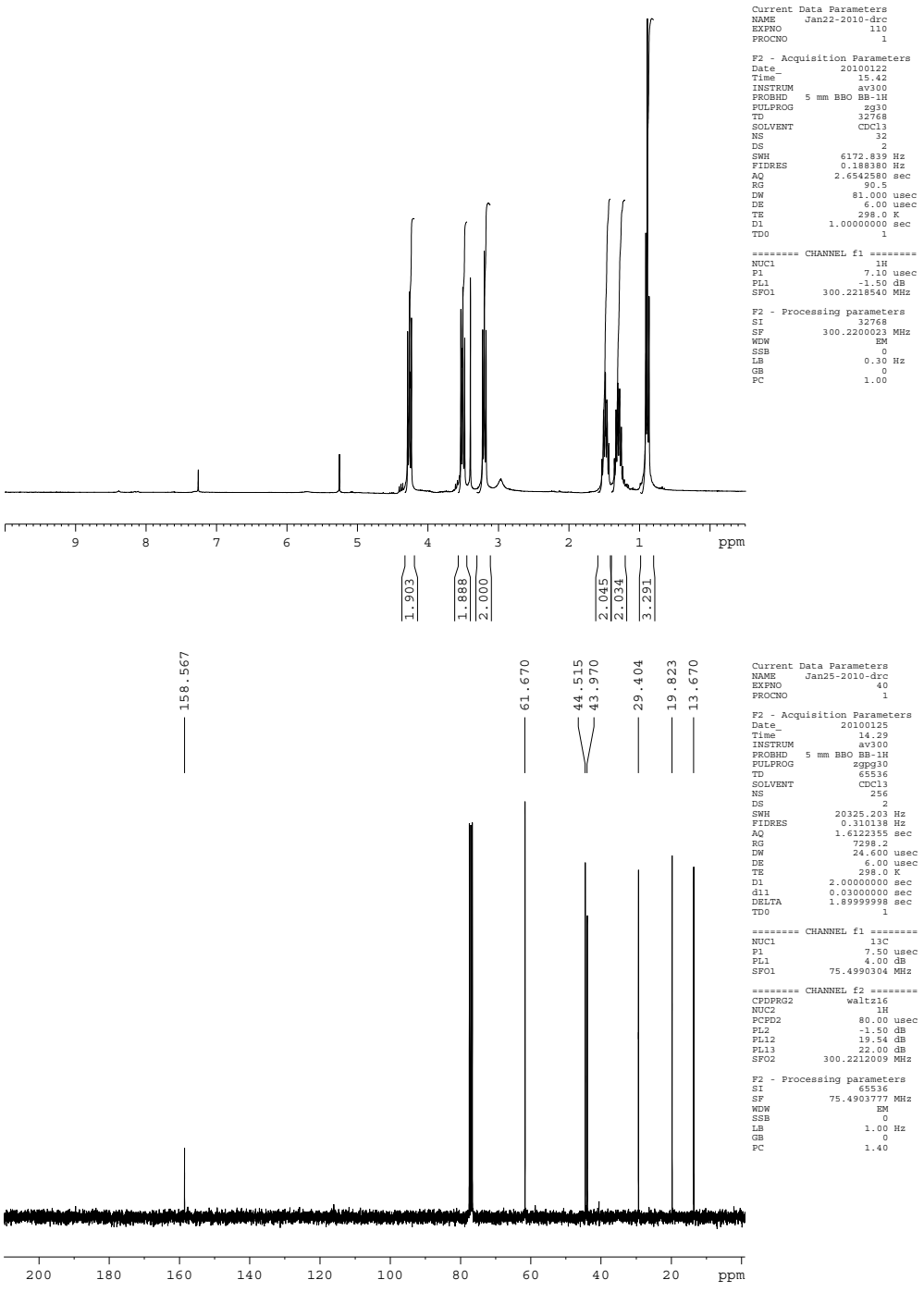




3-butyloxazolidin-2-one (3f)

Following representative procedure with flavinium catalyst **1b** (8.0 mg, 5 mol%), and enamide **2f** (70.5 mg, 0.5 mmol) were dissolved in H_2O (1 mL) and immediately followed by $NH_2NH_2.H_2O$ (246 µL, 2 mmol). The reaction was then placed under an oxygen atmosphere (1 atm) and heated to 100 °C for 18 hours. After this period, the reaction was cooled and the organic product extracted with diethyl ether (4 x 5 mL). The combined organics were dried over $MgSO_4$ and solvent subsequently removed *in vacuo.* NMR (^{1}H) analysis at this juncture confirmed complete consumption of starting enamide, with product **3a** isolated as a clear oil (67 mg, 95%).

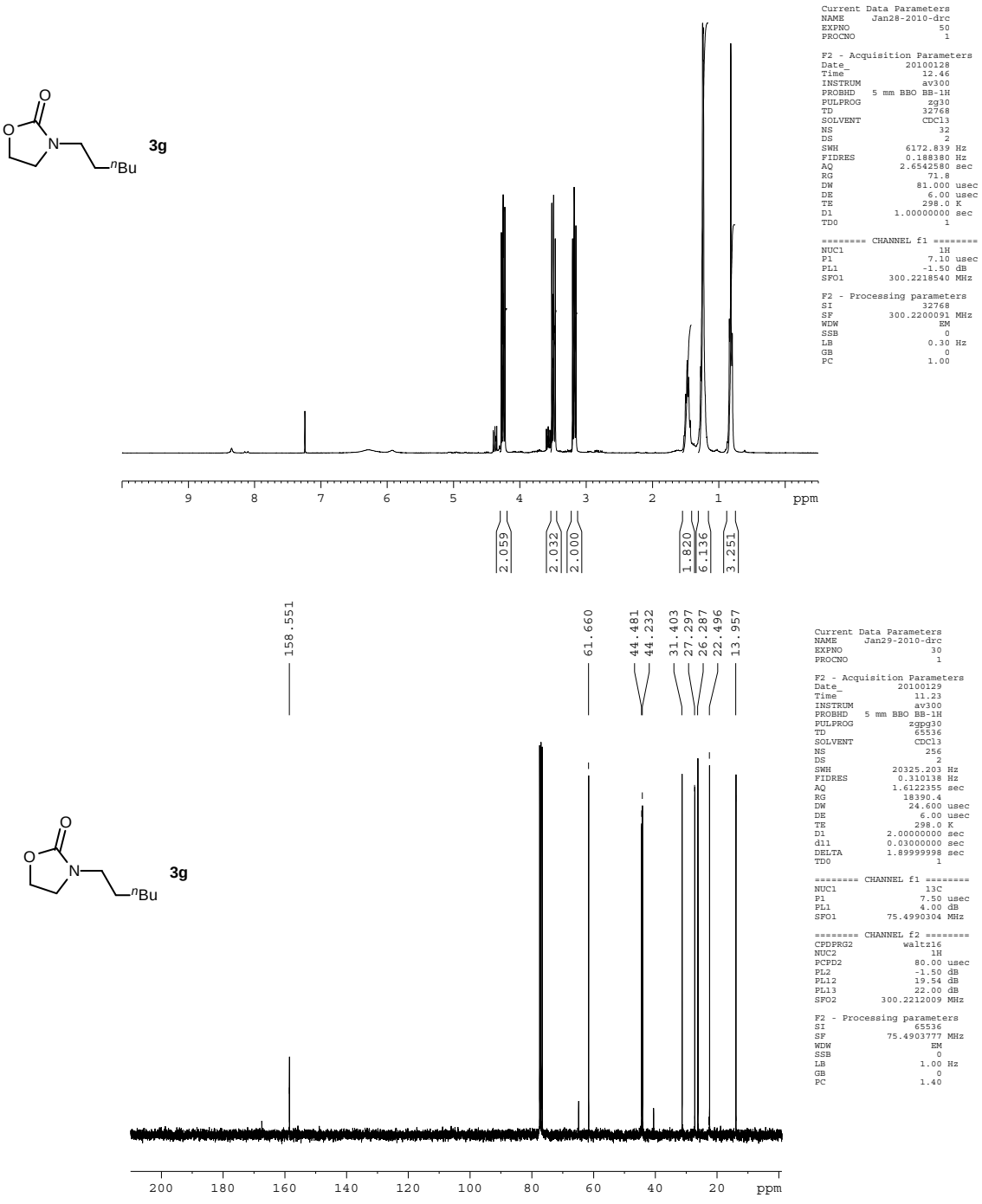
FTIR (film/cm^{-1}) υ_{max}: 2976, 2932, 1663. ^{1}H NMR (300 MHz, $CDCl_3$): δ 4.26 (2H, t, *J* = 7.8 Hz, OC*H*$_2$CH$_2$N), 3.50 (2H, t, *J* = 7.8 Hz, OCH$_2$C*H*$_2$N), 3.20 (2H, t, *J* = 7.2 Hz, C*H*$_2$N), 1.48 (2H, t, *J* = Hz CH$_2$), 1.28 (2H, hex, CH$_2$), 0.88 (3H, t, *J* = 7.2 Hz, CH$_2$C*H*$_3$). ^{13}C NMR (68 MHz, $CDCl_3$): δ 158.5, 61.7, 44.5, 43.9, 40.6, 29.3, 19.8, 13.6.



3-hexyloxazolidin-2-one (3g)

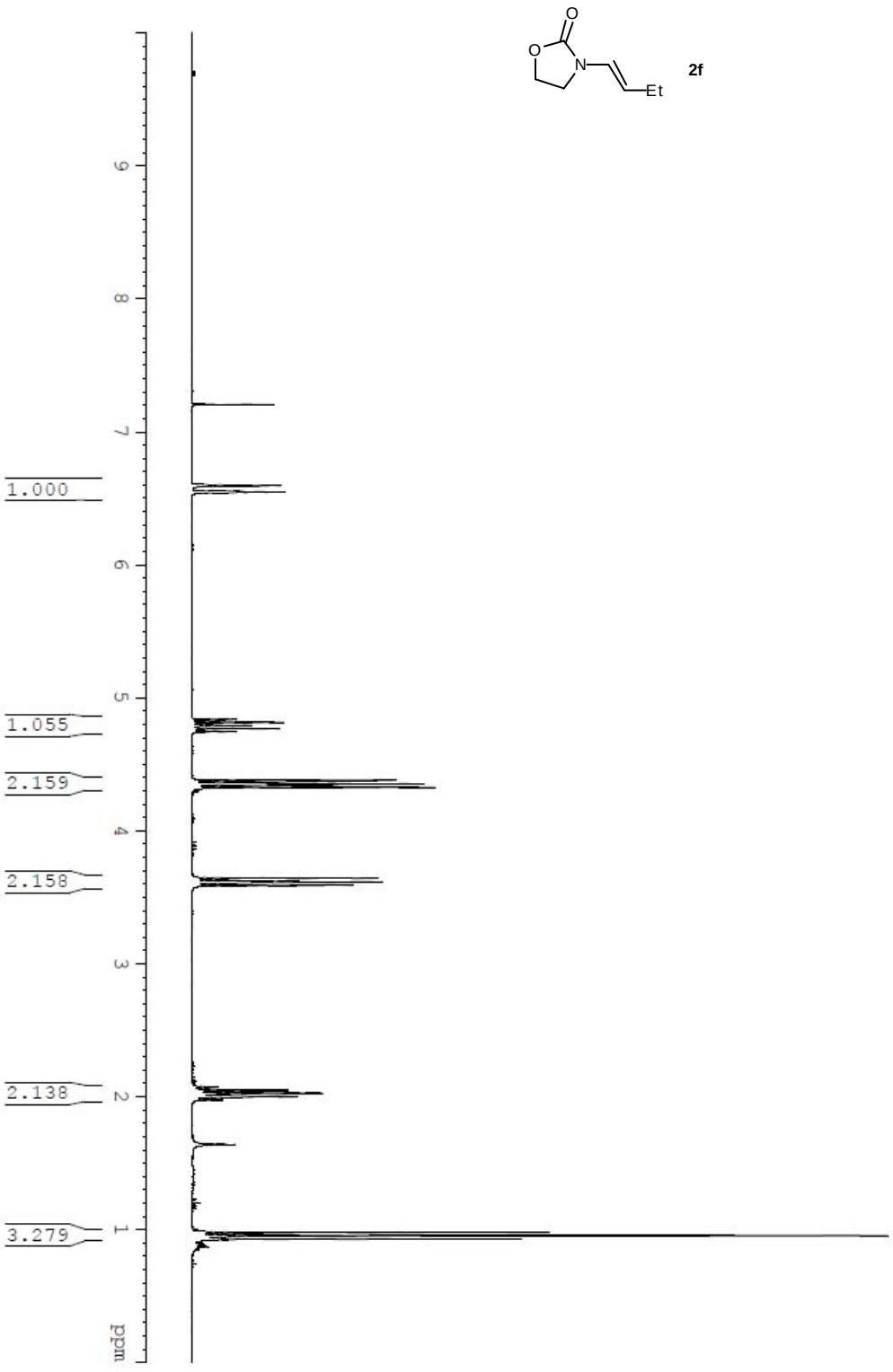
Following representative procedure with flavinium catalyst **1b** (8.0 mg, 5 mol%), and enamide **2g** (84.5 mg, 0.5 mmol) were dissolved in H_2O (1 mL) and immediately followed by $NH_2NH_2.H_2O$ (246 μL, 2 mmol). The reaction was then placed under an oxygen atmosphere (1 atm) and heated to 100 °C for 18 hours. After this period, the reaction was cooled and the organic product extracted with diethyl ether (4 x 5 mL). The combined organics were dried over $MgSO_4$ and solvent subsequently removed *in vacuo.* NMR (^{1}H) analysis at this juncture confirmed complete consumption of starting enamide, with product **3a** isolated as a clear oil (78 mg, 92%).

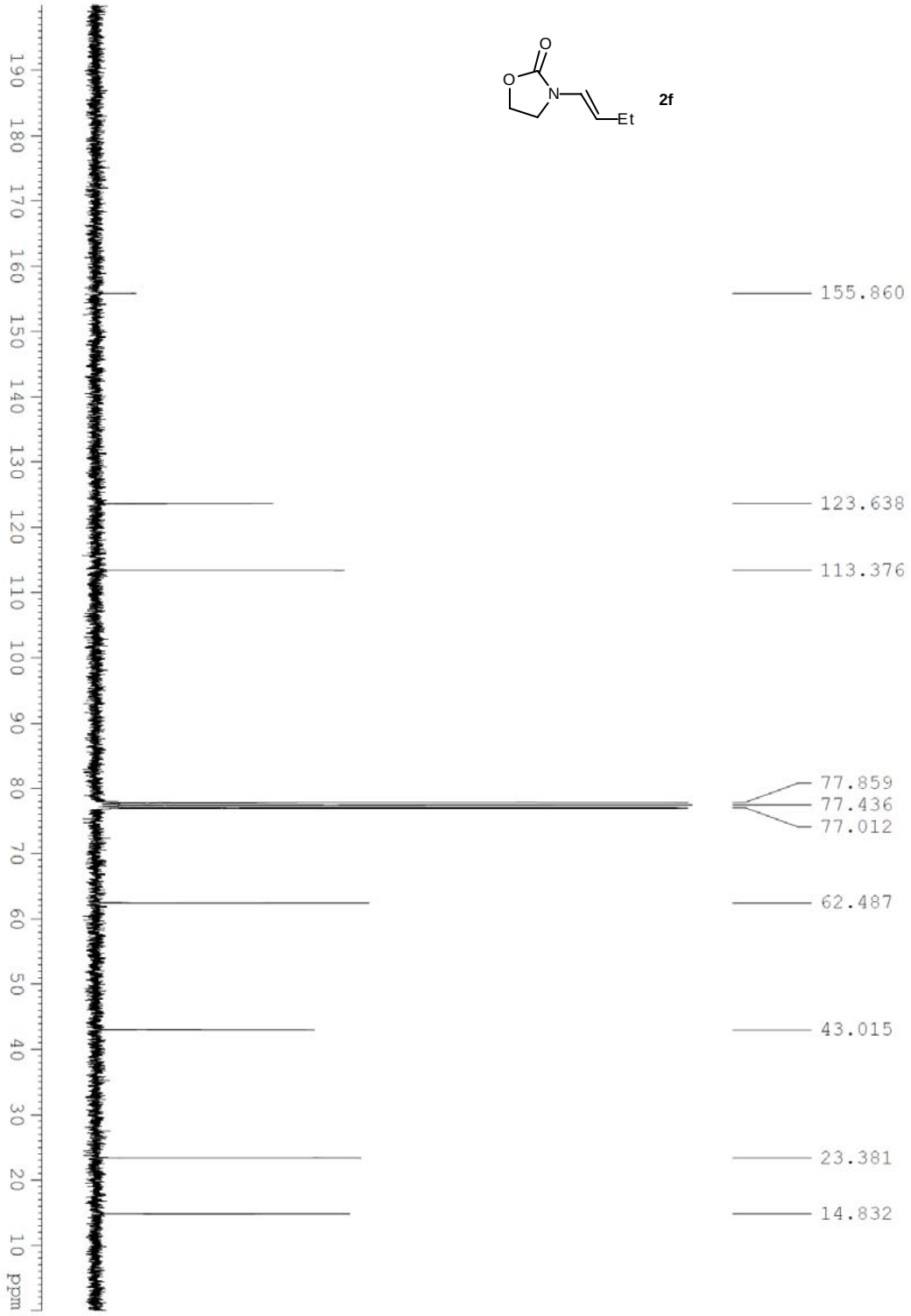
FTIR (film/cm^{-1}) υ_{max}: 2953, 2874, 1736. ^{1}H NMR (300 MHz, $CDCl_3$): δ 4.25 (2H, app t, *J* = 7.4 Hz, OCH_2CH_2N), 3.49 (2H, app t, *J* = 7.4 Hz, OCH_2CH_2N), 3.18 (2H, app t, *J* = 7.8 Hz, CH_2N), 1.43-1.50 (2H, m, CH_2), 1.23-1.24 (6H, b s, CH_2), 0.81 (3H, t, *J* = 7.4 Hz, CH_2CH_3). ^{13}C NMR (68 MHz, $CDCl_3$): δ 158.5, 61.7, 44.5, 44.2, 31.4, 27.3, 26.3, 22.5, 13.9.



III ^{1}H AND ^{13}C NMR SPECTRA FOR NOVEL COMPOUNDS:

Enamide **2f**





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