ELECTRONIC SUPPLEMENTARY INFORMATION

Bridged Flavinium Catalysed Diimide Reduction of Enamides in Water

Barrie J. Marsh, Emma L Heath and David R. Carbery*

Department of Chemistry, University of Bath, Bath, BA2 7AY, UK,
E-mail: D.Carbery@bath.ac.uk

Contents
Experimental section:
I General Information.
II Procedure and experimental data for synthesis of Novel Compounds.
III Experimental data for isolated reduced products 3a-c, f, g.
IV 1H and 13C NMR spectra for Novel Compounds.

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. 1H and 13C NMR were performed on a Brüker Avance 300 spectrometer. Chemical shifts values (δ) are reported in ppm relative to Me4Si (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

\[ \text{N-(E-propenyl)-oxazolidinone } 2f \]

To dry toluene (50 mL) were added 2-oxazolidinone (870 mg, 10 mmol), butyraldehyde (706 \( \mu \)L, 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 \textit{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\(^{-1}\)) \( \nu_{\text{max}} \): 2683, 2927, 2878, 1747, 1671, 1412.

\(^1\)H NMR (300 MHz, CDCl\(_3\)): \( \delta \) 6.63 (1H, dt, \( J = 14.3, 1.5 \) Hz, NCH=CH), 4.85 (1H, dt, \( J = 14.3, 6.7 \) Hz, NCH=CH), 4.45-4.37 (2H, m, OCH\(_2\)CH\(_2\)N), 3.71-3.63 (2H, m, OCH\(_2\)CH\(_2\)N), 2.09 2.10 (1H, qd, \( J = 7.2, 1.4 \), CH=CHCH\(_3\)), 2.07 (1H, qd, \( J = 7.2, 1.4 \), CH=CHCH\(_3\)) 1.05 (3H, t, \( J = 7.2 \) Hz, CH\(_3\)).

\(^13\)C NMR (75 MHz, CDCl\(_3\)): \( \delta \) 155.9, 123.6, 113.4, 62.5, 43.0, 23.4, 14.8.

HRMS (ESI) Calcd. for C\(_7\)H\(_{12}\)NO\(_2\) (M+H)\(^+\): 142.0868. Found: 142.0871; Calcd. for C\(_7\)H\(_{11}\)NNaO\(_2\) (M+Na)\(^+\): 164.0687. Found: 164.0685.

Enamides 2a\(^1\), 2c\(^2\), 2d\(^3\), 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 H2O (1 mL) and immediately followed by NH2NH2.H2O (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 MgSO4 and solvent subsequently removed in vacuo.

NMR (1H) 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\(^{-1}\)) \(\nu_{\text{max}}: 2976, 2937, 1664\). 1H NMR (300 MHz, CDCl\(_3\)): \(3.24\) (2H, t, \(J = 7.3\) Hz, C\(\text{H}_2\text{N}\)), \(3.13\) (2H, t, \(J = 7.9\) Hz, C\(\text{H}_2\text{O}\)), \(2.25\) (2H, t, \(J = 7.9\) Hz, C\(\text{H}_2\text{N}\)), \(1.88\) (2H, app pen, \(J = 7.3\) Hz, C\(\text{H}_2\text{O}\)), \(1.31-1.41\) (2H, m, CH2), \(1.15\) (2H, hex, \(J = 7.3\) Hz, CH\(_2\text{C}_\text{H}_2\text{CH}_3\)) \(0.79\) (3H, t, \(J = 7.3\) Hz, CH\(_2\text{C}_\text{H}_3\)). 13C NMR (75 MHz, CDCl\(_3\)): \(175.0, 47.1, 42.2, 31.1, 29.3, 20.0, 17.9, 13.8\).

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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 H2O (1 mL) and immediately followed by NH2NH2.H2O (246 μL, 5 mmol). Product 3b was isolated as a clear oil (49 mg, 88%).

FTIR (film/cm⁻¹) $\nu_{\text{max}}$: 2873, 2952, 1737.

$^1$H NMR (300 MHz, CDCl₃): $\delta$ 3.22-3.34 (4H, m, CH₂N), 2.30 (2H, t, $J = 8.1$ Hz, COCH₂), 1.94 (2H, pen, $J = 8.1$ Hz, CH₂), 1.13-1.15 (6H, m, CH₃), 1.04 (3H, t, $J = 7.3$ Hz, CH₂CH₃).

$^{13}$C NMR (68 MHz, CDCl₃): $\delta$ 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$_2$O (1 mL) and immediately followed by NH$_2$NH$_2$·H$_2$O (246 μL, 5 mmol). Product 3c isolated as a clear oil (77.0 mg, 91%).

FTIR (film/cm$^{-1}$) $\nu_{\text{max}}$: 2976, 2936, 1662. $^1$H NMR (300 MHz, CDCl$_3$): $\delta$ 3.24 (2H, t, $J$ = 7.3 Hz, CH$_2$N), 3.12 (2H, t, $J$ = 8.3 Hz, CH$_2$O), 2.25 (2H, t, $J$ = 8.3 Hz, CH$_2$N), 1.87 (2H, app pen, $J$ = 7.3 Hz, CH$_2$O), 1.33-1.15 (6H, m, CH$_3$), 0.74 (3H, t, $J$ = 7.3 Hz, CH$_2$CH$_3$). $^{13}$C NMR (68 MHz, CDCl$_3$): $\delta$ 174.8, 47.1, 42.5, 31.5, 31.1, 27.2, 26.5, 22.5, 17.8, 13.9.
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$_2$O (1 mL) and immediately followed by NH$_2$NH$_2$.H$_2$O (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 (1H) analysis at this juncture confirmed complete consumption of starting enamide, with product 3a isolated as a clear oil (67 mg, 95%).

FTIR (film/cm$^{-1}$) $\nu_{max}$: 2976, 2932, 1663. $^1$H NMR (300 MHz, CDCl$_3$): δ 4.26 (2H, t, $J = 7.8$ Hz, OCH$_2$CH$_2$N), 3.50 (2H, t, $J = 7.8$ Hz, OCH$_2$C$_2$H), 3.20 (2H, t, $J = 7.2$ Hz, C$_2$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$_3$). $^{13}$C NMR (68 MHz, CDCl$_3$): δ 158.5, 61.7, 44.5, 43.9, 40.6, 29.3, 19.8, 13.6.
Supporting Information

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 H₂O (1 mL) and immediately followed by NH₂NH₂.H₂O (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 MgSO₄ and solvent subsequently removed in vacuo. NMR (¹H) 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) ν max: 2953, 2874, 1736. ¹H NMR (300 MHz, CDCl₃): δ 4.25 (2H, app t, J = 7.4 Hz, OC₃H₂CH₂N), 3.49 (2H, app t, J = 7.4 Hz, OCH₂C₅H₄N), 3.18 (2H, app t, J = 7.8 Hz, C₅H₂N), 1.43-1.50 (2H, m, CH₂), 1.23-1.24 (6H, b s, CH₂), 0.81 (3H, t, J = 7.4 Hz, CH₂C₅H₃). ¹³C NMR (68 MHz, CDCl₃): δ 158.5, 61.7, 44.5, 44.2, 31.4, 27.3, 26.3, 22.5, 13.9.

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

Enamide 2f