1,3-Dipolar Cycloadditions of Diazo Compounds in the Presence of Azides

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Materials

Silica gel (40 μm) was from SiliCycle. All chemicals and solvents were from Sigma–Aldrich (St. Louis, MO) unless indicated otherwise, and were reagent-grade and used without further purification, except for nisin, which was purified as described on page S6. Water was purified with an Arium Pro system from Sartorius (Göttingen, Germany). Slide-A-Lyzer Dialysis cassettes (2-kDa MWCO) were from Life Technologies (Grand Island, NY).

General Experimental

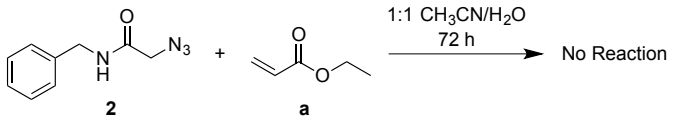
Temperature. All procedures were performed in air at ambient temperature (~22 °C) and pressure (1.0 atm) unless specified otherwise.

Solvent removal. The phrase "concentrated under reduced pressure" refers to the removal of solvents and other volatile materials using a rotary evaporator at water aspirator pressure (<20 torr) while maintaining the water-bath temperature below 40 °C. Residual solvent was removed from samples at high vacuum (<0.1 torr). The term "high vacuum" refers to vacuum achieved by mechanical belt-drive oil pump.

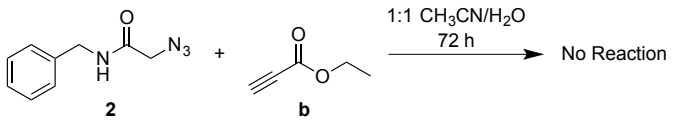
Instrumentation. ^{1}H and ^{13}C NMR spectra for all compounds were acquired on Bruker Spectrometers in the NMRFAM at the University of Wisconsin–Madison operating at operating at 400, 500, or 750 MHz for ^{1}H, and 126 or 189 MHz for ^{13}C. The chemical shift data are reported in units of δ (ppm) relative to residual solvent or TMS. Electrospray ionization (ESI) mass spectrometry was performed with a Waters (Micromass) AutoSpec or a Waters LCT, and MALDI–TOF mass spectrometry was performed using a Bruker microflex LRF at the Mass Spectrometry Facility in the Department of Chemistry at the University of Wisconsin–Madison. Absorbance measurements were made with an Infinite M1000 plate reader from Tecan (Männedorf, Switzerland).

Kinetic Experiments

Diazoacetamides were dissolved in a solvent to a concentration of 40 mM. In a clear 96-well plate, 50 μL of this stock solution was combined with 50 μL of a stock solution of a dipolarophile (5 equiv) to produce a final concentration of 20 mM of diazoacetamide. Absorbance was monitored at the wavelength of maximum absorbance by diazoacetamide **1**, which is 388 nm. Multiple readings were taken of each well every 60 s, followed by an orbital mixing period of 10 s. All assays were performed in triplicate and gave similar results, and an average of values was used for rate determinations. The formation of the expected products was confirmed by mass spectrometry and NMR spectroscopy. Reaction velocity was determined from the inverse of the slope of a semilog plot of $A_{388\ \mathrm{nm}}$ as a function of time, and the slope was used to calculate a pseudo–first-order rate constant (k') for the reaction, which was converted to a second-order rate constant ($k = k'$/[dipolarophile]).



N-Benzyl-2-azidoacetamide (**2**) (3.8 mg, 0.02 mmol) was dissolved with stirring in 0.5 mL of CH_3CN, and 0.5 mL of water was added. Ethyl acrylate (**a**) (0.011 mL, 0.1 mmol) was added, and the reaction mixture was stirred for 72 h. The reaction mixture was concentrated to dryness under high vacuum, and analyzed by ^{1}H NMR spectroscopy. No change to azidoacetamide **2** was apparent.



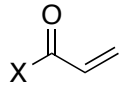
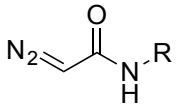
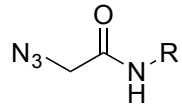
N-Benzyl-2-azidocetamide (**2**) (3.8 mg, 0.02 mmol) was dissolved with stirring in 0.5 mL of CH_3CN, and 0.5 mL of water was added. Ethyl propiolate (**b**) (0.011 mL, 0.1 mmol) was added, and the reaction mixture was stirred for 72 h. The reaction mixture was concentrated to dryness under high vacuum, and analyzed by ^{1}H NMR spectroscopy. No change to azidoacetamide **2** was apparent.

Competition Reactions

N-Benzyl-2-diazoacetamide[1] (**1**) (3.5 mg, 0.02 mmol) and *N*-benzyl-2-azidoacetamide[1] (**2**) (3.8 mg, 0.02 mmol) were dissolved in 0.50 mL of CH_3CN, and water (0.50 mL) was added to the resulting solution. DIBAC-amine (0.055 mg, 0.02 mmol) was added, and the reaction mixure was stirred for 24 h. The reaction mixture was then concentrated under reduced pressure, dried under high vacuum, and analyzed by ^{1}H-NMR spectroscopy.

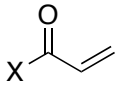
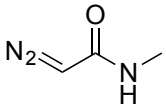
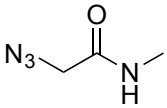
N-Benzyl-2-diazoacetamide[1] (**1**) (3.5 mg, 0.02 mmol) and *N*-benzyl-2-azidoacetamide[1] (**2**) (3.8 mg, 0.02 mmol) were dissolved in CH_3CN (0.5 mL) with stirring, and water (0.5 mL) was added to the resulting solution. Ethylacrylate (0.011 mL, 0.1 mmol) was added, and the reaction mixture was stirred for 24 h. The reaction mixture was then concentrated under reduced pressure, dried under high vacuum, and analyzed by ^{1}H-NMR spectroscopy. Spectral data were identical when the procedure was replicated with a reaction time extended to 72 h.

Table S1. Calculated activation parameters ($\Delta E^{\ddagger}$ and $\Delta G^{\ddagger}$) and experimental second-order rate constant (k) for 1,3-dipolar cycloadditions with diazoacetamides and azidoacetamides.

							
X		$\Delta E^{\ddagger}$ (kcal/mol)	$\Delta G^{\ddagger}$ (kcal/mol)	k (10^{-3} $M^{-1}s^{-1}$)[a]	$\Delta E^{\ddagger}$ (kcal/mol)	$\Delta G^{\ddagger}$ (kcal/mol)	k (10^{-3} $M^{-1}s^{-1}$)[a]
		R=Me		R=Bn (**1**)	R=Me		R=Bn (**2**)
OEt[c]	**a**	13.5	26.6	1.6	16.4	30.3	NR
Me	**c**	12.3	26.0	6.1	15.2	28.6	NR
NH_2	**d**	14.5	27.6	0.42	17.3	30.8	NR
NH*i*Pr[c]	**e**	15.2	29.0	0.17	17.9	31.9	NR
NMe_2	**f**	14.5	27.0	0.51	16.5	30.5	NR
OCT[c]	**g**	13.9	26.1	1.1	14.4	28.1	0.95[b]

[a]Reaction rates were measured in 1:1 CH_3CN/H_2O. NR, no reaction after 72 h. [b]Reaction rate was measured in CH_3CN. [c]In computations, Me was used instead of Et or *i*Pr, and underivatized cyclooctyne was used instead of OCT.

Table S2. **Distortion/interaction analysis for compounds investigated by experiment.** Energies were calculated at the M06-2X/6-31+G(2d,p) level of theory and include solvation corrections (water) on gas-phase geometries from the IEFPCM model (radii=UFF).

								
X	$\Delta E^{\ddagger}_{distortion}$ (kcal/mol)		$\Delta E^{\ddagger}_{int}$ (kcal/mol)	$\Delta E^{\ddagger}_{act}$ (kcal/mol)	$\Delta E^{\ddagger}_{distortion}$ (kcal/mol)		$\Delta E^{\ddagger}_{int}$ (kcal/mol)	$\Delta E^{\ddagger}_{act}$ (kcal/mol)
	dipolarophile	dipole			dipolarophile	dipole		
Me	16.8	7.0	–11.4	12.3	17.5	4.9	–7.2	15.2
OMe	17.7	7.1	–11.4	13.5	18.2	5.5	–7.2	16.4
NH_2	17.8	7.2	–10.5	14.5	18.2	5.7	–6.6	17.3
NHMe	18.5	7.1	–10.3	15.3	18.5	5.6	–6.2	17.9
NMe_2	17.7	7.1	–10.4	14.5	18.3	4.9	–6.6	16.5

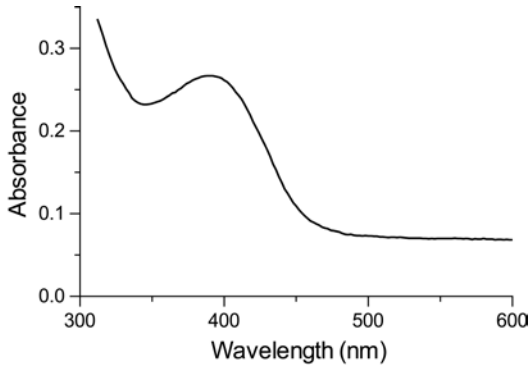


Figure S1. Ultraviolet spectrum of *N*-benzyl-2-diazoacetamide (**1**) in 1:1 CH_3CN/H_2O. λ_{max} = 388 nm; ε = 41.3 $M^{-1}cm^{-1}$ at 388 nm.

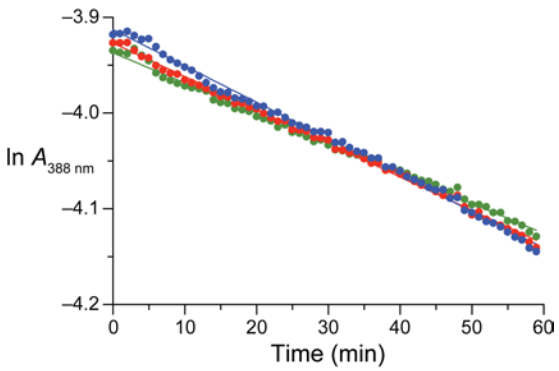


Figure S2. Representative kinetic plots, here for the reaction in triplicate of *N*-benzyl-2-diazoacetamide (**1**) and ethylacrylate. Data were fitted by linear regression; all values of R^2 are ≥0.995.

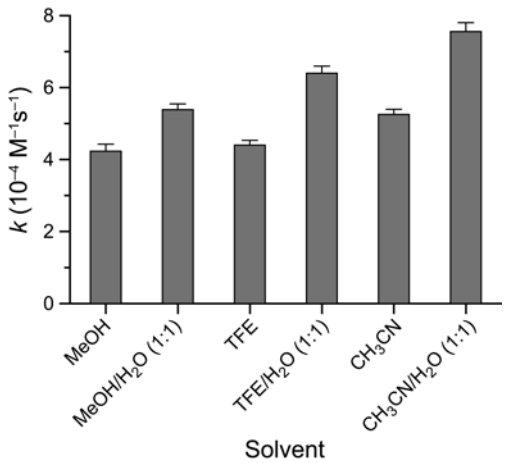


Figure S3. Effect of solvent on the second-order rate constant for the reaction of *N*-benzyl-2-diazoacetamide (**1**) and ethylacrylate. The addition of water generated an average increase of 39%. A 1:1 mixture of acetonitrile and water produced the fastest reaction rates.

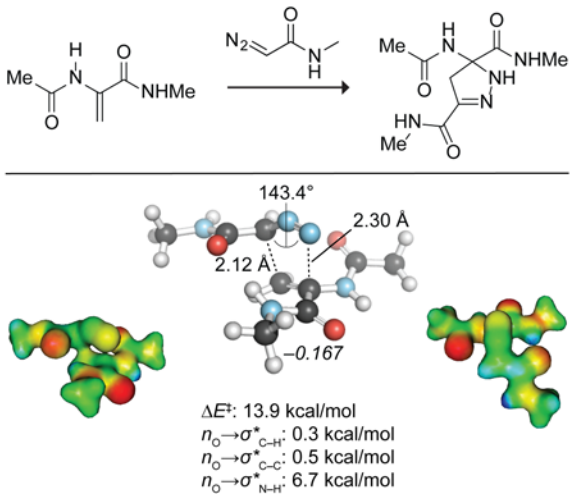


Figure S4. Computational analysis of the cycloaddition of *N*-methyl-2-diazoacetamide with 2-acetamido-*N*-methylacrylamide. Electrostatic potential maps were calculated at the B3LYP/6-31G(d) level of theory on M06-2X/6-31+G(2d,p) geometries. Activation energy, NBO interaction energies for three intermolecular interactions (kcal/mol), and change in dipolarophile charge (*italics*) were calculated at the M06-2X/6-31+G(2d,p) level of theory. Energies include solvation corrections (water) on gas-phase geometries using IEFPCM model (radii=UFF).

Labeling of Nisin

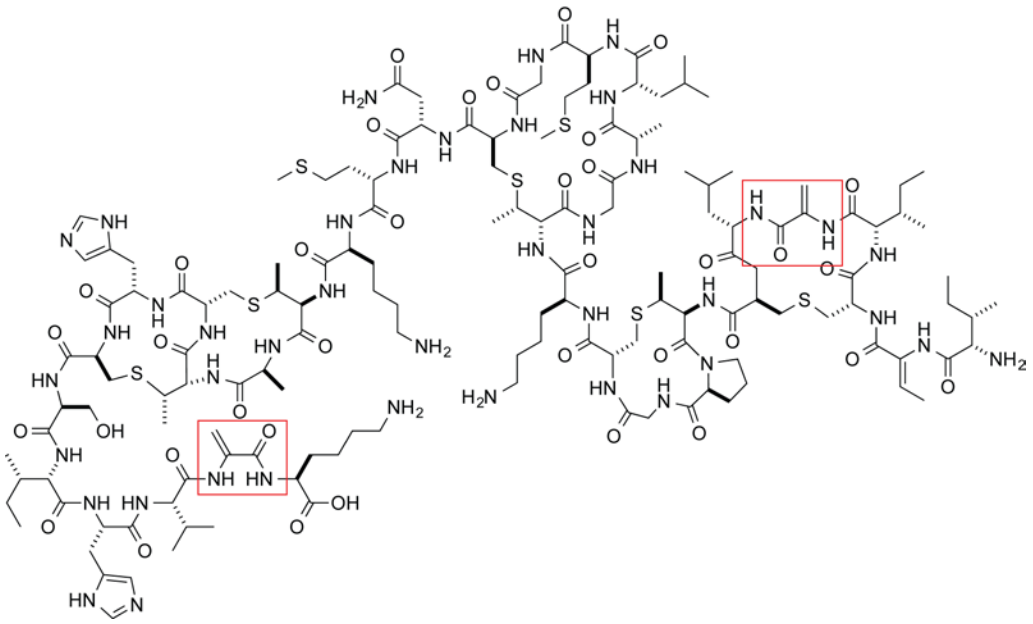
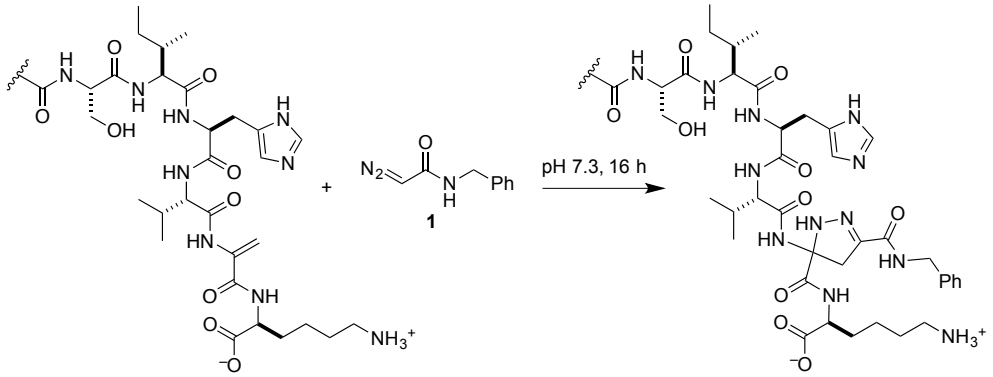
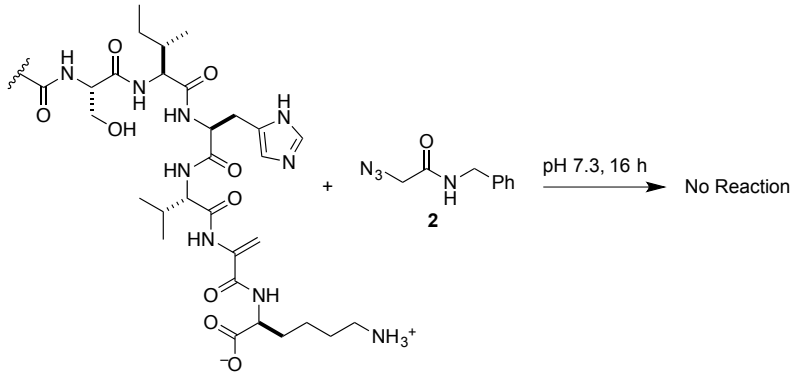


Figure S5. Structure of nisin with its two Dha residues highlighted in red boxes.

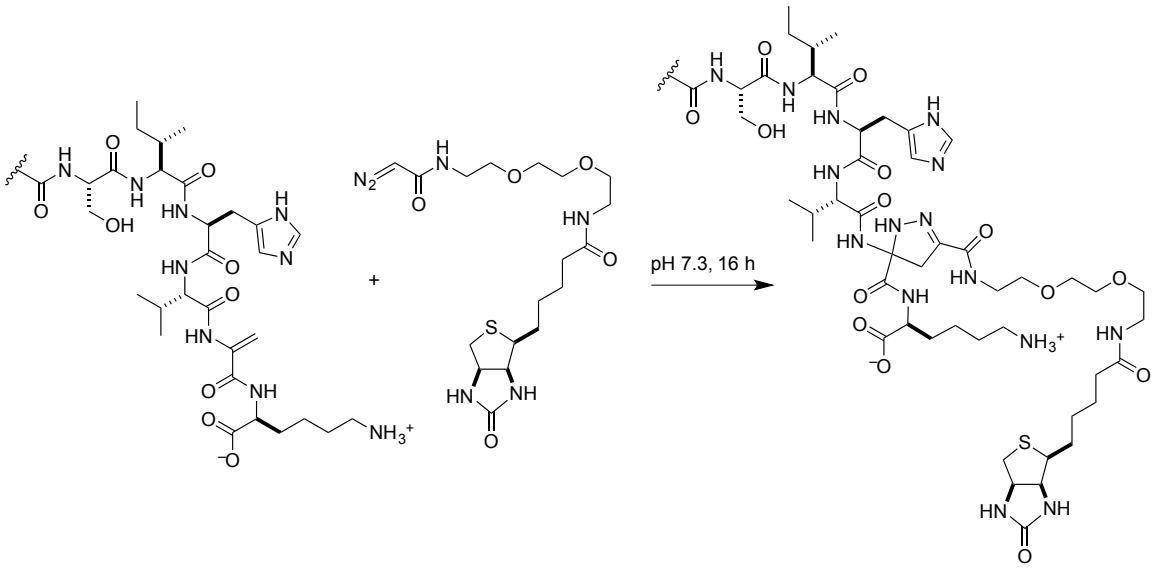
Enrichment of Nisin. Following a procedure reported previously,[2] 1.0 g of crude solids containing nisin from *Lactococcus lactis* (2.5% by mass, with the balance being NaCl and denatured milk solids) (0.01 g, 7.5×10^{-4} mmol) was dissolved in water (25 mL), and the resulting mixture was stirred vigorously for 15 min. While stirring, CH_2Cl_2 (20 mL) was added, whereupon stirring was ceased and the formation of a white precipitate was observed at the solvent interface. The mixture was transferred to two 50-mL tubes and subjected to centrifugation (15 min at 3000 rpm). The liquid was decanted, and the pellets were dried under high vacuum. The pellets were combined after addition of water (12.5 mL) and filtered through a small column of Celite to produce a clear and colorless solution that was lyophilized to a white solid of enriched nisin, which was used without further purification (0.036 g, approximately 70% nisin by mass based on the initial composition).



Enriched nisin (~70% by mass) (1 mg, 2.1×10^{-7} mmol) was dissolved with stirring in 0.5 mL of 10 mM sodium phosphate buffer (pH 7.3). Diazoacetamide **1** (0.5 mg, 2.8×10^{-6} mmol) was added, and the reaction mixture was stirred for 16 h. The resulting solution was analyzed by MALDI–TOF mass spectrometry using sinapic acid as a matrix and unlabeled nisin for internal calibration. See: Figure 3.

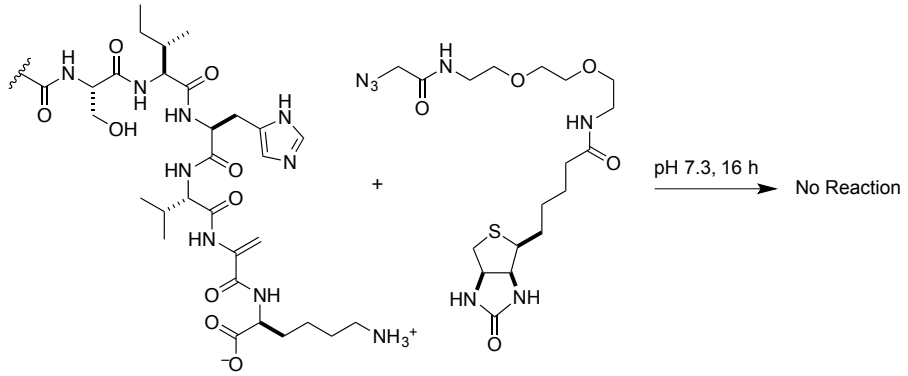


Enriched nisin (~70% by mass) (1 mg, 2.1×10^{-7} mmol) was dissolved with stirring in 0.5 mL of 10 mM sodium phosphate buffer (pH 7.3). Azidoacetamide **2** (0.6 mg, 3.2×10^{-6} mmol) was added, and the reaction mixture was stirred for 16 h. The resulting solution was analyzed by MALDI–TOF mass spectrometry using sinapic acid as matrix. No change in mass was observed from that of nisin. See: Figure 3.



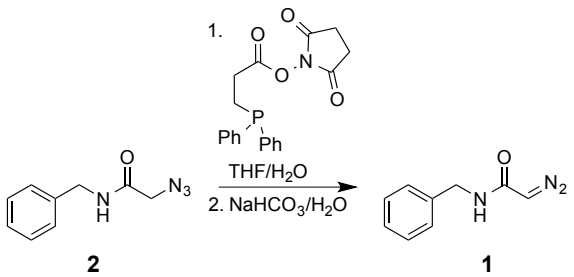
Nisin from *Lactococcus lactis* (2.5% by mass, with the balance being sodium chloride and denatured milk solids) (10 mg, 7.5×10^{-9} mmol) was dissolved with stirring in 1.0 mL of 10 mM sodium phosphate buffer (pH 7.3). A 0.5-mL solution of diazoacetamide–triglycol–biotin (0.002 g, 4.5×10^{-3} mmol) in 10 mM sodium phosphate buffer (pH 7.4) was added, and the reaction

mixture was agitated with a nutator for 16 h. Peptides purified by dialysis (2-kDa MWCO) into the same buffered solution, and analyzed by MALDI–TOF mass spectrometry using sinapic acid as matrix and unlabeled nisin for internal calibration. *m/z* calcd. for nisin + diazoacetamide–triglycol–biotin, 3796.6, found 3795.1.

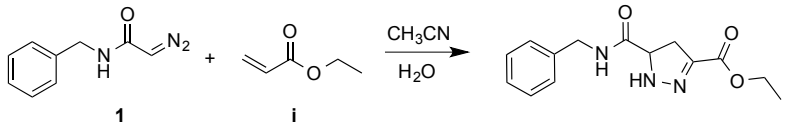


Nisin from *Lactococcus lactis* (2.5% by mass, with the balance being NaCl and denatured milk solids) (10 mg, 7.5×10^{-9} mmol) was dissolved with stirring in 1.0 mL of 10 mM sodium phosphate buffer (pH 7.3). A 0.5-mL solution of azidoacetamide–triglycol–biotin (0.002 g, 4.5×10^{-3} mmol) in 10 mM sodium phosphate buffer (pH 7.4) was added, and the reaction mixture was agitated with a nutator for 16 h. Peptides were purified by dialysis (2-kDa MWCO) into the same buffered solution, and analyzed by MALDI–TOF mass spectrometry using sinapic acid as a matrix and unlabeled nisin for internal calibration. No change in mass was observed from that of nisin.

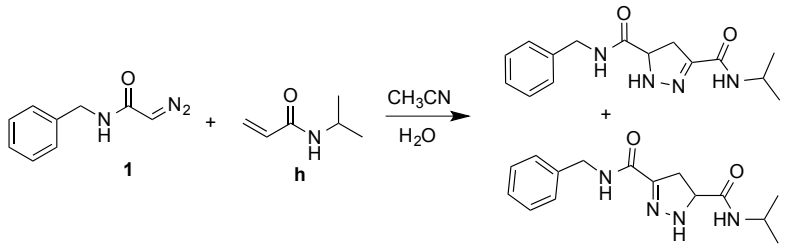
Synthetic Procedures



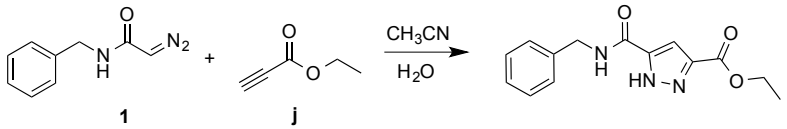
***N*-Benzyl-2-diazoacetamide** (**1**) was prepared from ***N*-benzyl-2-azidoacetamide** (**2**) according to a previous report[1] and had indistinguishable ^{1}H and ^{13}C NMR spectra and molecular mass.



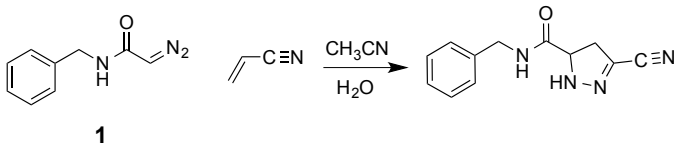
Ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate. *N*-Benzyl-2-diazoacetamide (**1**) (3.5 mg, 0.020 mmol) was dissolved in CH_3CN (0.5 mL) with stirring, and water was added (0.5 mL). Ethylacrylate (0.011 mL, 0.10 mmol) was added, and the reaction mixture was stirred overnight. The resulting solution was concentrated under reduced pressure and dried under high vacuum to provide the product as a mixture of isomers (5.5 mg, quant). Spectral characterization is provided for the major isomer (see HSQC and HMBC NMR spectra for isomer determination): ^{1}H NMR (500 MHz, CD_3CN, δ): 7.37–7.25 (m, 6H), 7.12 (d, J = 3.0 Hz, 1H), 4.42 (dd, J = 9.7, 3.0 Hz, 1H), 4.38 (d, J = 6.2 Hz, 2H), 4.23 (q, J = 7.1 Hz, 2H), 3.25 (dd, J = 17.4, 12.9 Hz, 1H), 2.95 (ddd, J = 17.4, 9.5, 1.2 Hz, 1H), 1.29 (t, J = 7.1 Hz, 3H). ^{13}C NMR (126 MHz, CD_3CN, δ): 172.42, 163.07, 143.40, 140.05, 129.43, 128.28, 128.02, 63.79, 61.67, 43.49, 37.03, 14.49. HRMS (ESI) *m*/*z* calcd. for $C_{14}H_{17}N_3O_3$ $[M+H]^+$ 276.1343, found 276.1348.



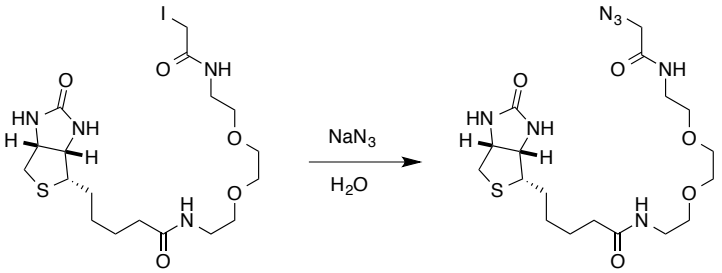
***N*^{5}-Benzyl-*N*^{3}-isopropyl-pyrazoline-3,5-dicarboxamide**. *N*-Benzyl-2-diazoacetamide (**1**) (3.5 mg, 0.02 mmol) was dissolved with stirring in 0.5 mL of CH_3CN, and 0.5 mL of water was added. *N*-Isopropyl acrylamide (**h**) (0.011 mL, 0.1 mmol) was added, and the reaction mixture was stirred for 4 h. The resulting solution was concentrated under reduced pressure, dried under high vacuum, and purified by chromatography on silica gel (1:1 EtOAc/hexanes) to provide the product as a 1:0.72 mixture of isomers (5.5 mg, 96%). ^{1}H NMR (500 MHz, CD_3CN, δ): 7.66 (ddd, J = 49.6, 5.7, 3.3 Hz, 0.7H), 7.48–7.40 (m, 1H), 7.36–7.22 (m, 8.5H), 6.76–6.66 (m, 2H), 6.59 (s, 1H), 4.41 (d, J = 6.4 Hz, 2H), 4.36 (d, J = 6.1 Hz, 1.4H), 4.31 (ddd, J = 12.8, 9.4, 3.6 Hz, 0.7H), 4.22 (ddd, J = 12.5, 9.2, 3.4 Hz, 1H), 4.18 (m, 0.7H), 4.01 (ddt, J = 13.2, 8.3, 6.6 Hz, 0.7 H), 4.01 (ddt, J = 13.2, 8., 6.6 Hz, 1H), 3.24 (dt, J = 17.6, 12.2 Hz, 1.7H), 2.89 (dddd, J = 17.7, 9.1, 3.4, 1.3 Hz, 1.7H), 1.14 (dd, J = 6.7, 1.1 Hz, 4.2H), 1.10 (dd, J = 6.6, 2.1 Hz, 6H). ^{13}C NMR (126 MHz, CD_3CN, δ): 172.56, 171.43, 168.38,162.54, 161.53, 148.45, 147.93, 140.43, 140.10, 133.18, 132.17, 129.62, 129.34, 129.31, 128.18, 128.16, 127.90, 127.85, 68.60, 63.36, 43.32, 43.06, 42.00, 41.80, 39.51, 37.01, 36.91, 31.04, 29.57, 24.44, 23.59 22.58, 22.51, 22.47, 14.26, 11.25. HRMS (ESI) *m*/*z* calc'd for $C_{14}H_{17}N_3O_3$ $[M+H]^+$ 289.1660, found 289.1656.



Ethyl 5-(benzylcarbamoyl)-1*H*-pyrazole-3-carboxylate. *N*-Benzyl-2-diazoacetamide (**1**) (3.5 mg, 0.02 mmol) was dissolved with stirring in 0.5 mL of CH_3CN, and 0.5 mL of water was added. Ethyl propiolate (**j**) (0.011 mL, 0.1 mmol) was added, and the reaction mixture was stirred overnight. The resulting solution was concentrated under reduced pressure and dried under high vacuum to provide the product as a white solid (5.5 mg, quant). ^{1}H NMR (500 MHz, MeOD, δ): 7.38–7.19 (m, 6H), 4.56 (s, 2H), 4.38 (q, J = 7.1 Hz, 2H), 1.38 (t, J = 7.1 Hz, 3H). ^{13}C NMR (126 MHz, MeOD, δ): 139.97, 129.54, 128.53, 128.24, 109.35, 62.40, 43.84, 14.54. HRMS (ESI) *m*/*z* calc'd for $C_{14}H_{15}N_3O_3$ $[M+H]^+$ 274.1187, found 274.1193.

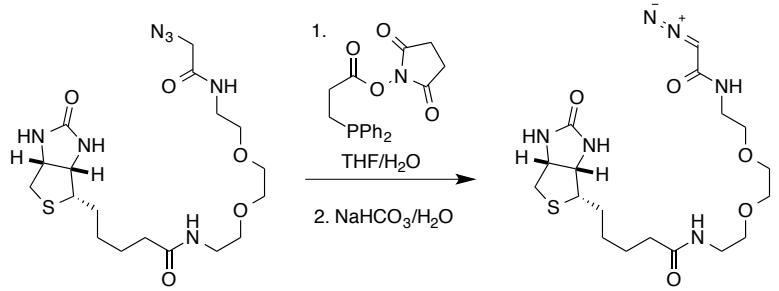


***N*-Benzyl-3-cyano-4,5-dihydro-1*H*-pyrazole-5-carboxamide**. *N*-Benzyl-2-diazoacetamide (**1**) (3.5 mg, 0.02 mmol) was dissolved with stirring in 0.5 mL of CH_3CN, and 0.5 mL of water was added. Acrylonitrile (0.010 mL, 0.1 mmol) was added, and the reaction mixture was stirred overnight. The resulting solution was concentrated under reduced pressure and dried under high vacuum to provide the product as a white solid (0.005 g, quant). ^{1}H NMR (500 MHz, CD_3CN, δ): 7.15–7.02 (m, 6H), 6.96 (s, 1H), 4.25–4.18 (m, 1H), 4.14 (d, J = 6.1 Hz, 2H), 3.03 (dd, J = 17.1, 13.1 Hz, 1H), 2.81 (ddd, J = 17.1, 9.4, 1.0 Hz, 1H). ^{13}C NMR (126 MHz, CD_3CN, δ): 172.86, 141.59, 131.14, 130.01, 129.77, 126.07, 117.21, 65.07, 45.28, 40.26. HRMS (ESI) *m*/*z* calc'd for $C_{12}H_{12}N_4O$ $[M+H]^+$ 229.1084, found 229.1079.

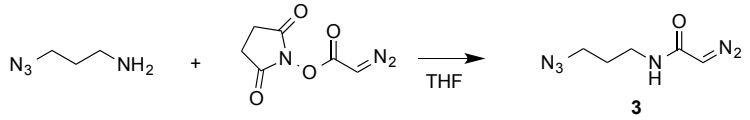


Azidoacetamide–triglycol–biotin. Biotin–triglycol–iodoacetamide (Thermo Scientific product #21334) (10 mg, 0.001 mmol) was dissolved with stirring in 0.25 mL of water, and the resulting solution was cooled to 0 °C. Sodium azide (30 mg, 0.084 mmol) was added, and the reaction mixture was allowed to warm to room temperature overnight. Solvent was removed under reduced pressure. The resulting residue was triturated into 5 mL of DCM and filtered, and the filtrate was washed with 5 mL of DCM. The combined organics were concentrated under reduced pressure to provide azidoacetamide–triglycol–biotin as a high purity white solid

(0.014 g, 98%) that was used without further purification. ^{1}H NMR (750 MHz, $CDCl_3$, δ): 7.16 (t, J = 5.8 Hz, 1H), 6.91 (s, 1H), 6.77 (t, J = 5.7 Hz, 1H), 5.87 (s, 1H), 4.50 (dd, J = 7.8, 4.8 Hz, 1H), 4.30 (dd, J = 8.0, 4.7 Hz, 1H), 3.97 (s, 2H), 3.61 (s, 3H), 3.57 (q, J = 5.2 Hz, 4H), 3.48 (q, J = 5.4 Hz, 2H), 3.46–3.38 (m, 1H), 3.13 (td, J = 7.3, 4.5 Hz, 1H), 2.89 (dd, J = 12.9, 4.8 Hz, 1H), 2.74 (d, J = 12.8 Hz, 1H), 2.22 (t, J = 7.6 Hz, 2H), 1.75–1.62 (m, 3H), 1.47–1.37 (m, 2H). ^{13}C NMR (126 MHz, $CDCl_3$, δ): 173.51, 167.26, 164.35, 70.23, 70.08, 70.02, 69.67, 61.85, 60.34, 55.78, 52.59, 40.63, 39.33, 39.22, 36.13, 28.33, 28.19, 25.72. HRMS (ESI) m/z calc'd for $C_{18}H_{31}N_7O_5S$ $[M+H]^+$ 458.2181, found 458.2185.

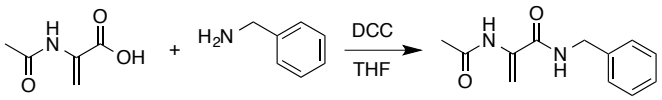


Diazoacetamide–triglycol–biotin. Azidoacetamide–triglycol–biotin (37 mg, 0.08 mmol) was dissolved with stirring in 0.75 mL of 10% v/v H_2O in THF. *N*-Succinimidyl 3-(diphenylphosphino)propionate[1] (0.03 g, 0.086 mmol) was added, and the reaction mixture was stirred overnight. A saturated aqueous solution of $NaHCO_3$ (1 mL) was added, and the reaction mixture was stirred vigorously for 6 h. The reaction mixture was salted with NaCl (50 mg) and extracted into DCM (6 × 5 mL), and the combined organics were dried over $NaSO_4$(s), and concentrated under reduced pressure to a pale yellow solid. The residue was purified by chromatography over silica gel (10% v/v MeOH in DCM) to give diazoacetamide–triglycol–biotin as a pale yellow solid (0.023 g, 62%). ^{1}H NMR (500 MHz, $CDCl_3$, δ): 6.56 (s, 2H), 6.41 (s, 1H), 5.29 (s, 1H), 4.52 (dd, J = 7.8, 4.9 Hz, 1H), 4.33 (td, J = 5.1, 2.4 Hz, 1H), 3.69–3.35 (m, 10H), 3.17 (td, J = 7.4, 4.7 Hz, 1H), 2.92 (dd, J = 12.8, 4.9 Hz, 1H), 2.74 (d, J = 12.9 Hz, 1H), 2.24 (t, J = 7.2 Hz, 2H), 1.80–1.60 (m, 6H), 1.54–1.37 (m, 2H). ^{13}C NMR (126 MHz, $CDCl_3$, δ): 173.56, 164.01, 70.42, 70.28, 70.00, 69.84, 61.78, 60.29, 55.46, 47.17, 40.67, 39.62, 39.31, 36.10, 28.05, 28.03, 25.49. HRMS (ESI) m/z calc'd for $C_{18}H_{30}N_6O_5S$ $[M+Na]^+$ 465.1891, found 465.1905.



***N*-(3-Azidopropyl)-2-diazoacetamide**. NHS-Diazoacetamide[3] (0.094 g, 0.5 mmol) was dissolved in THF (1.0 mL) with stirring, and the solution was cooled to 0 °C. A 0.20-mL solution of 3-azidopropanamine (0.10 g, 0.5 mmol) in Et_2O was added, and the reaction mixture was allowed to warm to room temperature overnight. The reaction mixture was then concentrated under reduced pressure, and purified by chromatography on silica gel (1:1 EtOAc/hexanes) to provide *N*-(3-azidopropyl)-2-diazoacetamide as a yellow oil (0.05 g, 60%).

^{1}H NMR (500 MHz, CD_3CN, δ): 6.18 (s, 1H), 4.95 (s, 1H), 3.33 (t, J = 6.8 Hz, 2H), 3.24 (q, J = 6.5 Hz, 1H), 1.70 (p, J = 6.7 Hz, 1H). ^{13}C NMR (126 MHz, CD_3CN, δ): 168.16, 51.41, 49.03, 39.29, 31.50. HRMS (ESI) m/z calc'd for $C_{14}H_{17}N_3O_3$ $[M+H]^+$ 169.0833, found 169.0832.



2-Acetamido-*N*-benzylacrylamide. 2-Acetamidoacrylic acid (0.260 g, 2.0 mmol) and DCC (0.413 g, 2.0 mmol) were suspended in THF (5 mL), and the mixture was cooled to –5 °C. Benzylamine (0.214 g, 2.0 mmol) was added, and the reaction mixture was allowed to warm to room temperature overnight. The reaction mixture was then concentrated under reduced pressure and purified by chromatography on silica gel (1:1 EtOAc/hexanes) to provide 2-acetamido-*N*-benzylacrylamide as a white solid (0.18 g, 41%). ^{1}H NMR (500 MHz, $CDCl_3$, δ): 8.13 (s, 1H), 7.39–7.27 (m, 5H), 6.49 (s, 1H), 6.46 (d, J = 1.8 Hz, 1H), 5.20 (d, J = 1.7 Hz, 1H), 4.53 (d, J = 5.8 Hz, 2H), 2.13 (s, 3H). ^{13}C NMR (126 MHz, $CDCl_3$, δ): 171.88, 166.59, 139.98, 136.88, 131.59, 130.60, 130.49, 103.57, 46.90, 27.50. HRMS (ESI) m/z calc'd for $C_{12}H_{14}N_2O_2$ $[M+H]^+$ 219.1129, found 219.1125.

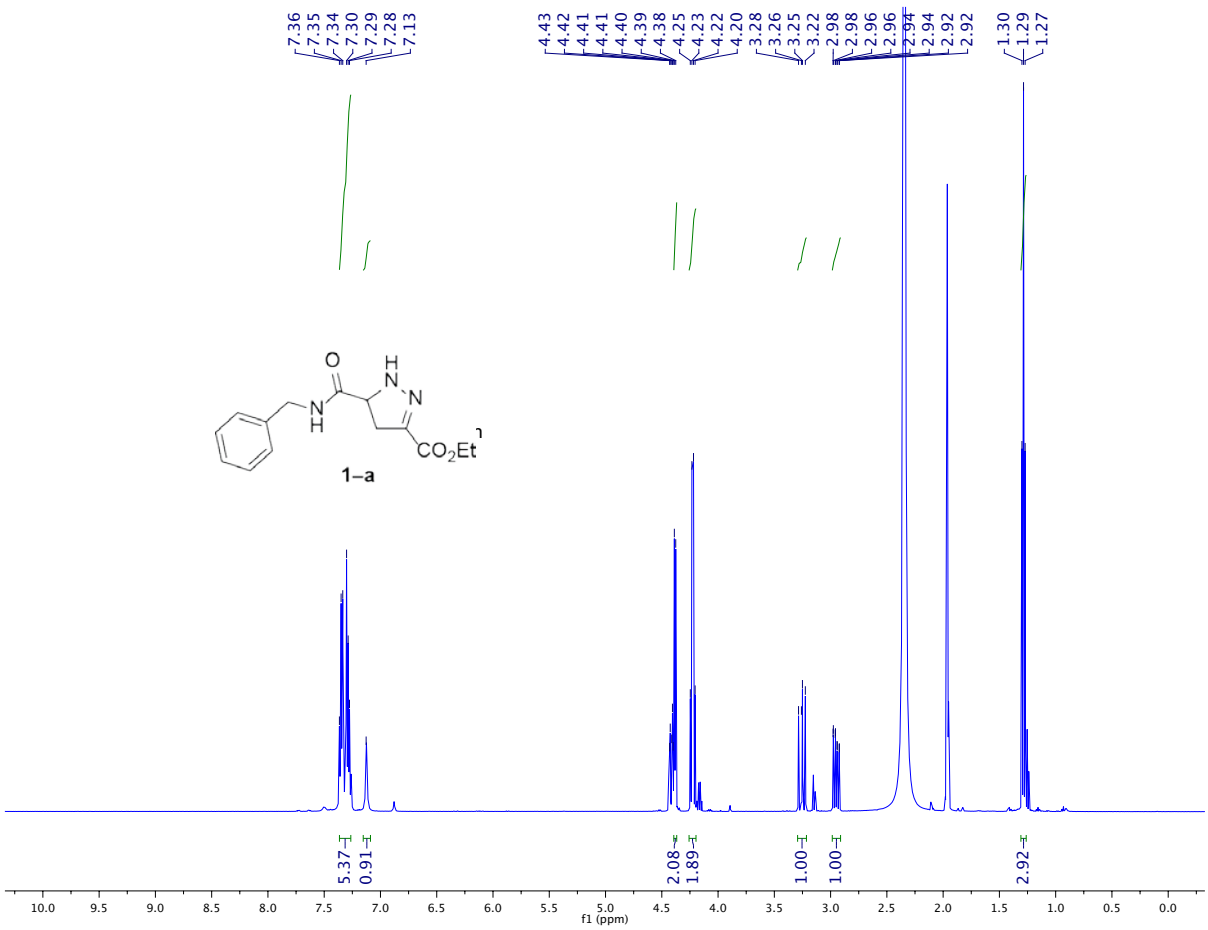


Figure S6. ^{1}H-NMR spectrum (500 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

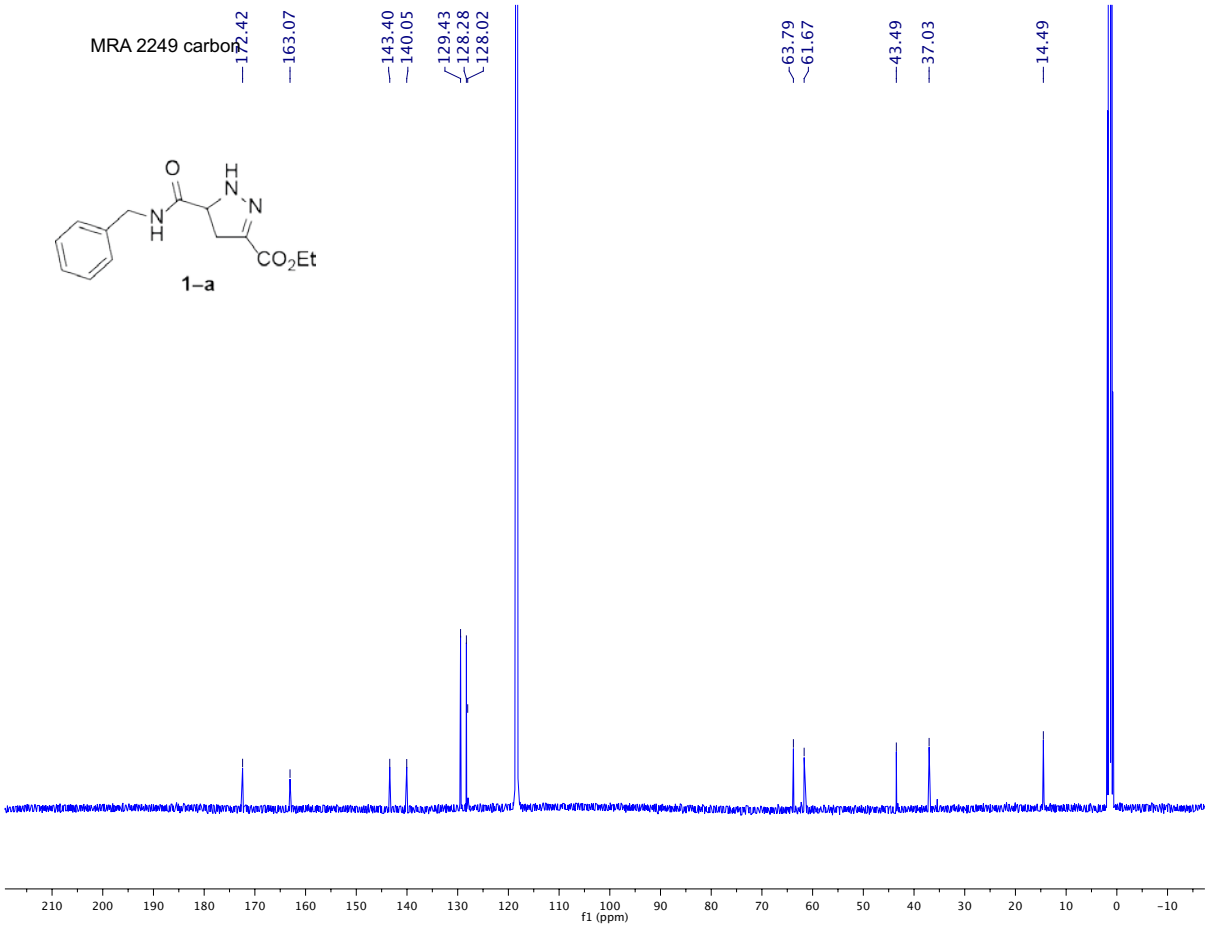


Figure S7. ^{13}C-NMR spectrum (126 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

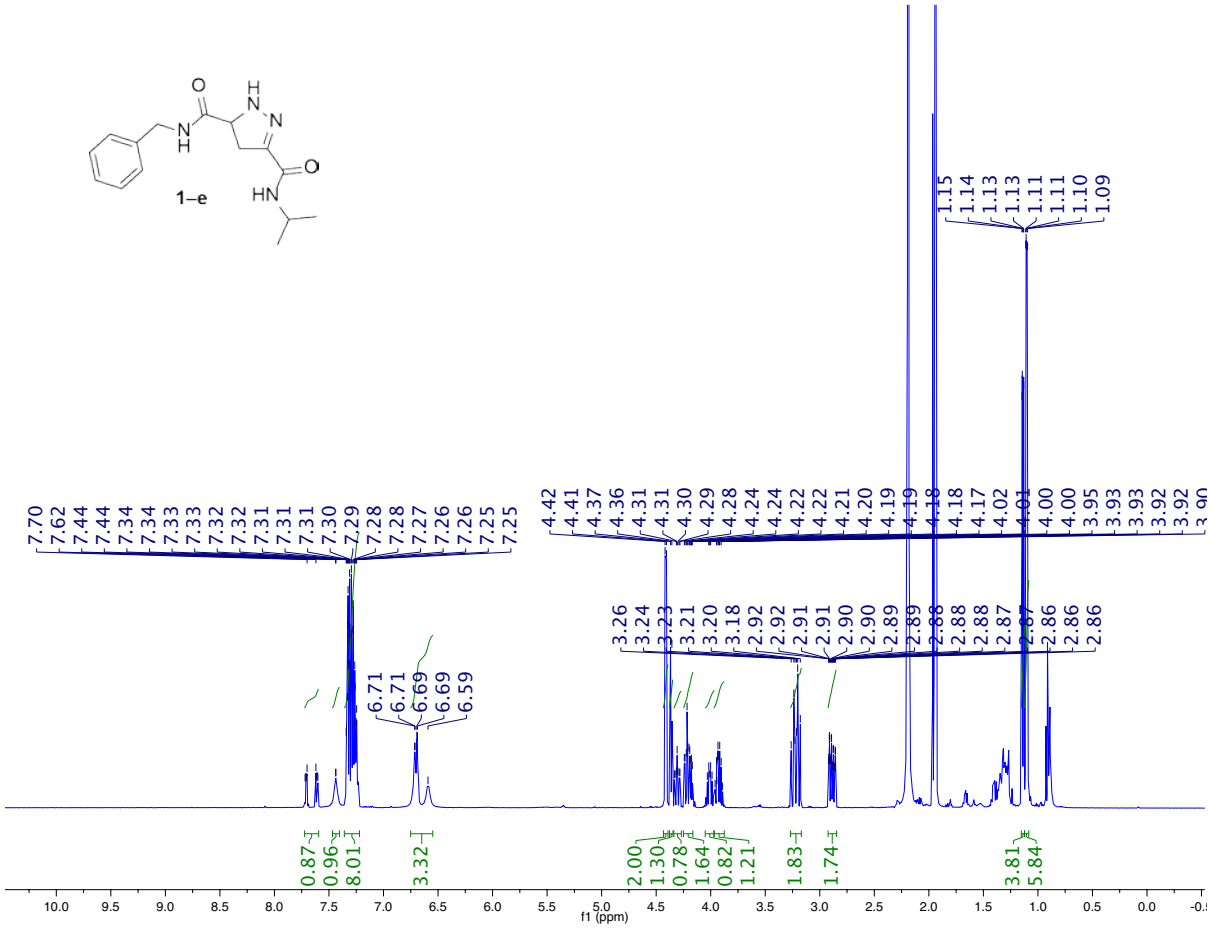


Figure S8. ^{1}H-NMR spectrum (500 MHz) of N^5-benzyl-N^3-isopropyl-pyrazoline-3,5-dicarboxamide (mixed isomers) in CD_3CN.

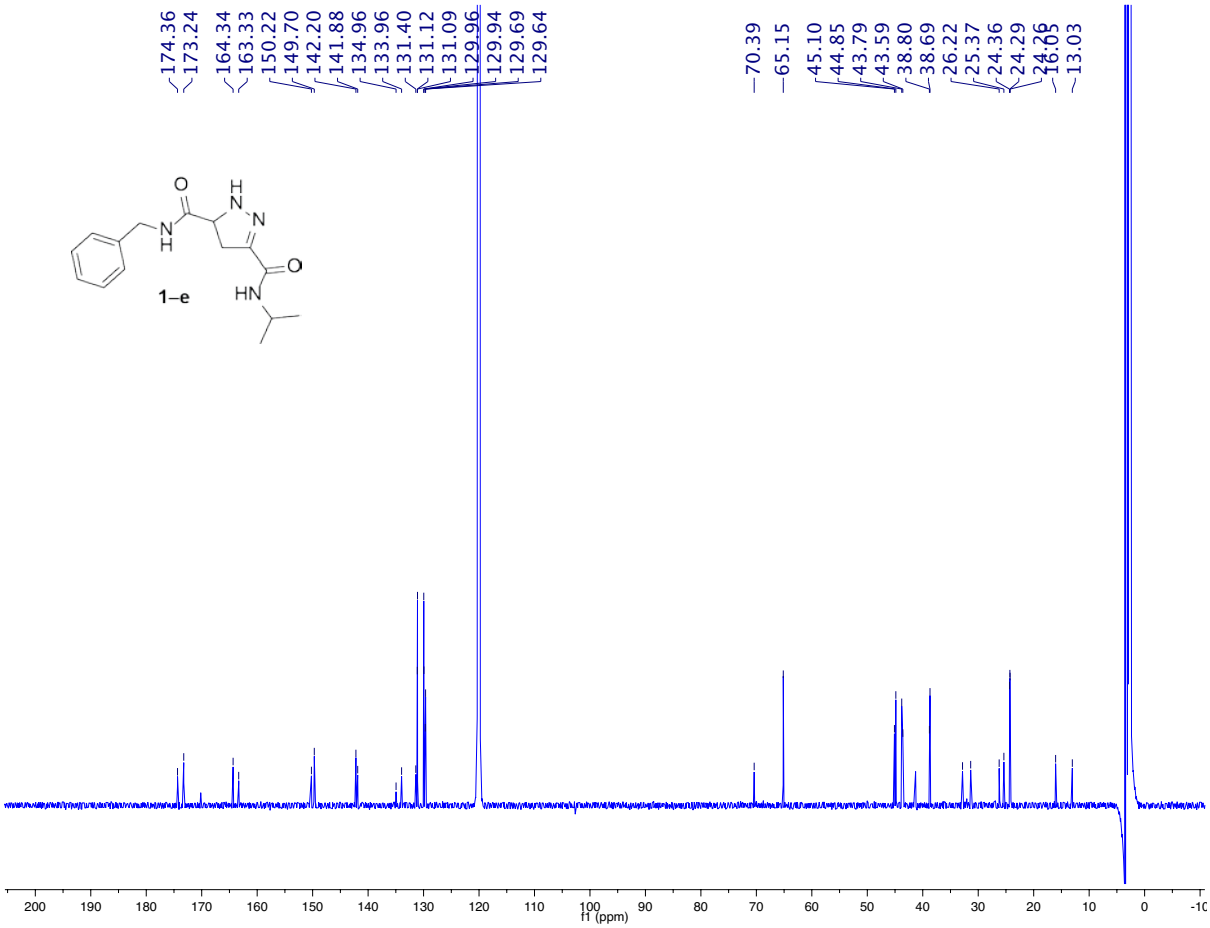


Figure S9. ^{13}C-NMR spectrum of N^5-benzyl-N^3-isopropyl-pyrazoline-3,5-dicarboxamide (mixed isomers) in CD_3CN (126 MHz).

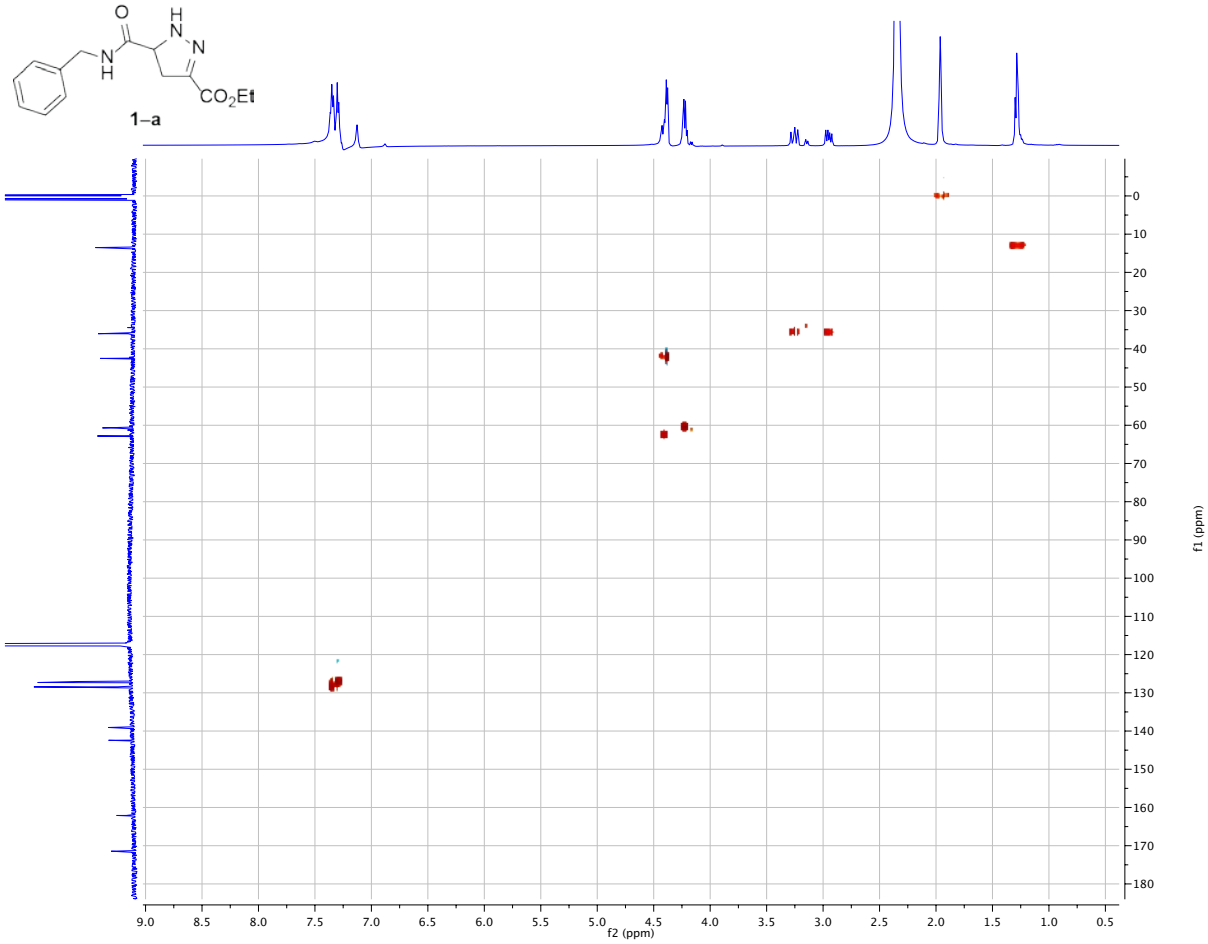


Figure S10. $^{1}H,^{13}C$-HSQC NMR spectrum (500,126 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

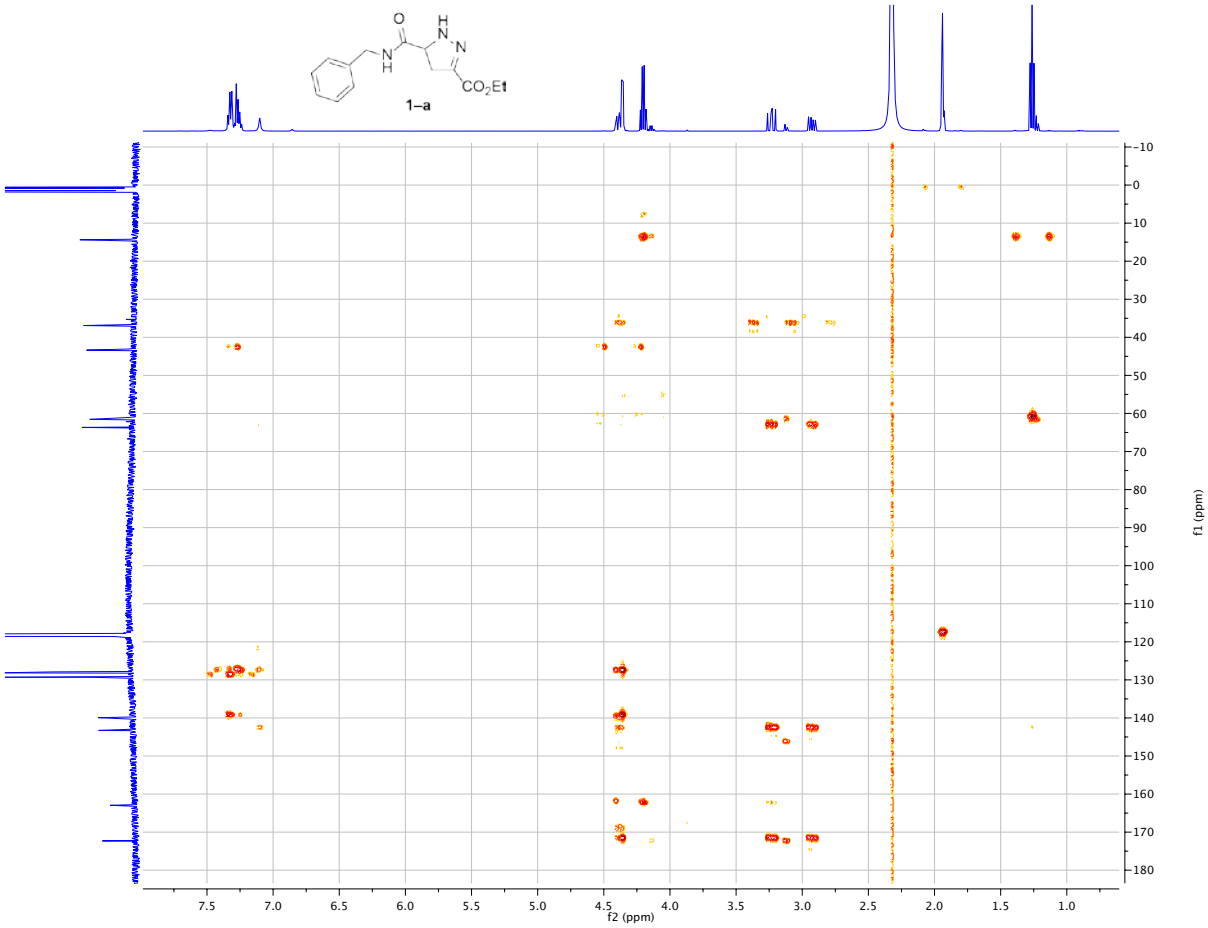


Figure S11. $^{1}H,^{13}C$-HMBC NMR spectrum (500,126 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

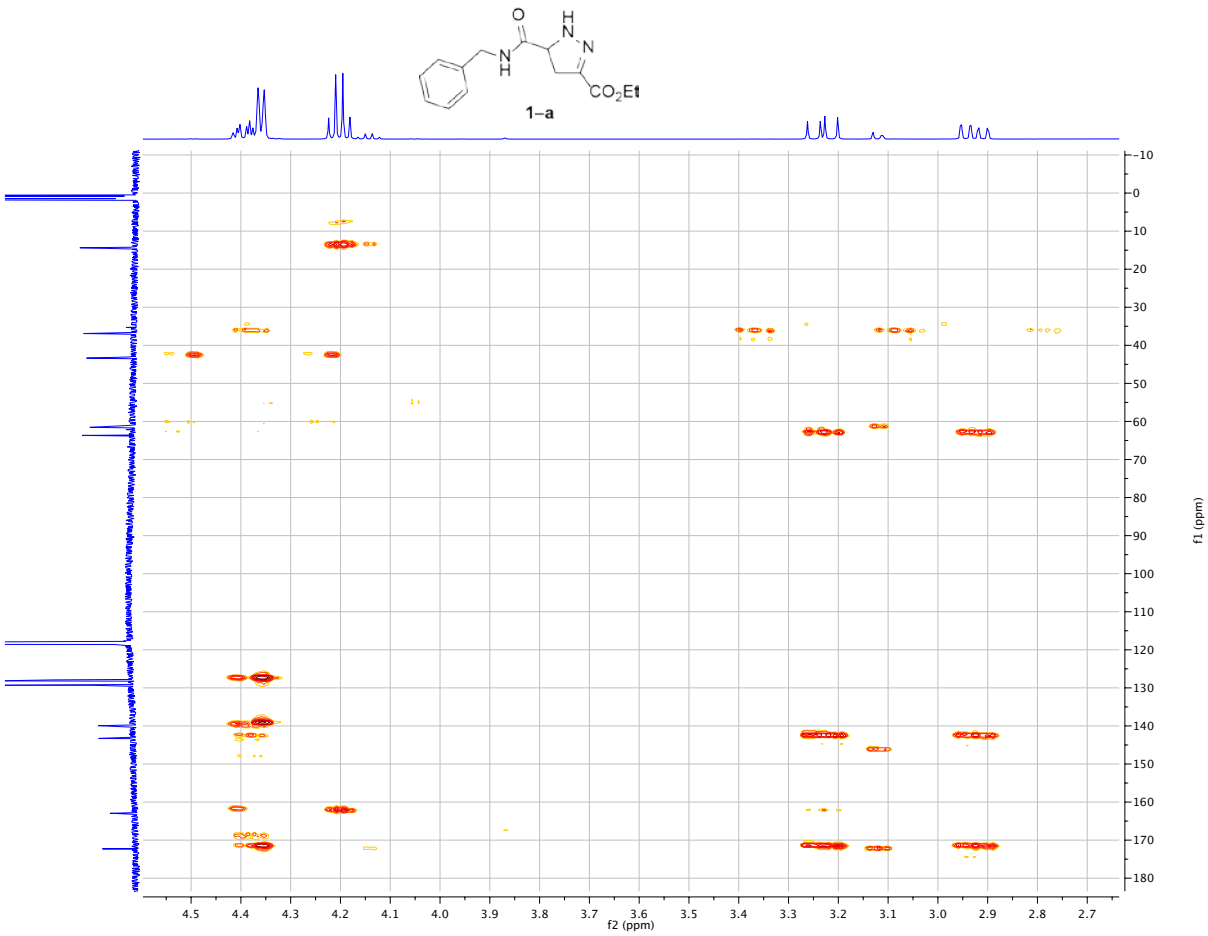


Figure S12: $^{1}H,^{13}C$-HMBC NMR spectrum (500,126 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

Figure S13. Enlargement of Figure S12. $^{1}H,^{13}C$-HMBC NMR spectrum (500,126 MHz) of ethyl 5-(benzylcarbamoyl)-4,5-dihydro-1*H*-pyrazole-3-carboxylate in CD_3CN.

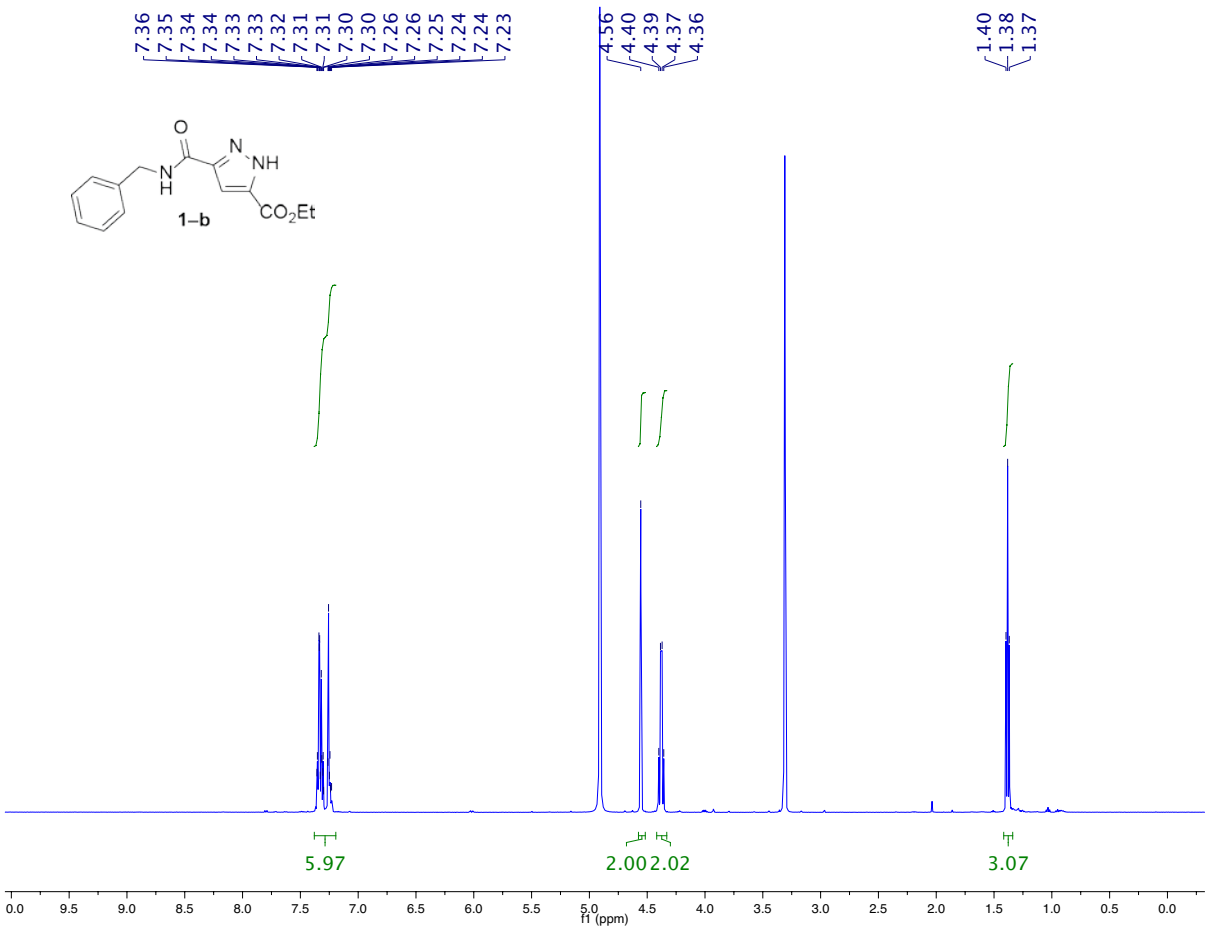


Figure S14. ^{1}H-NMR spectrum (500 MHz) of ethyl 5-(benzylcarbamoyl)-1*H*-pyrazole-3-carboxylate in MeOD.

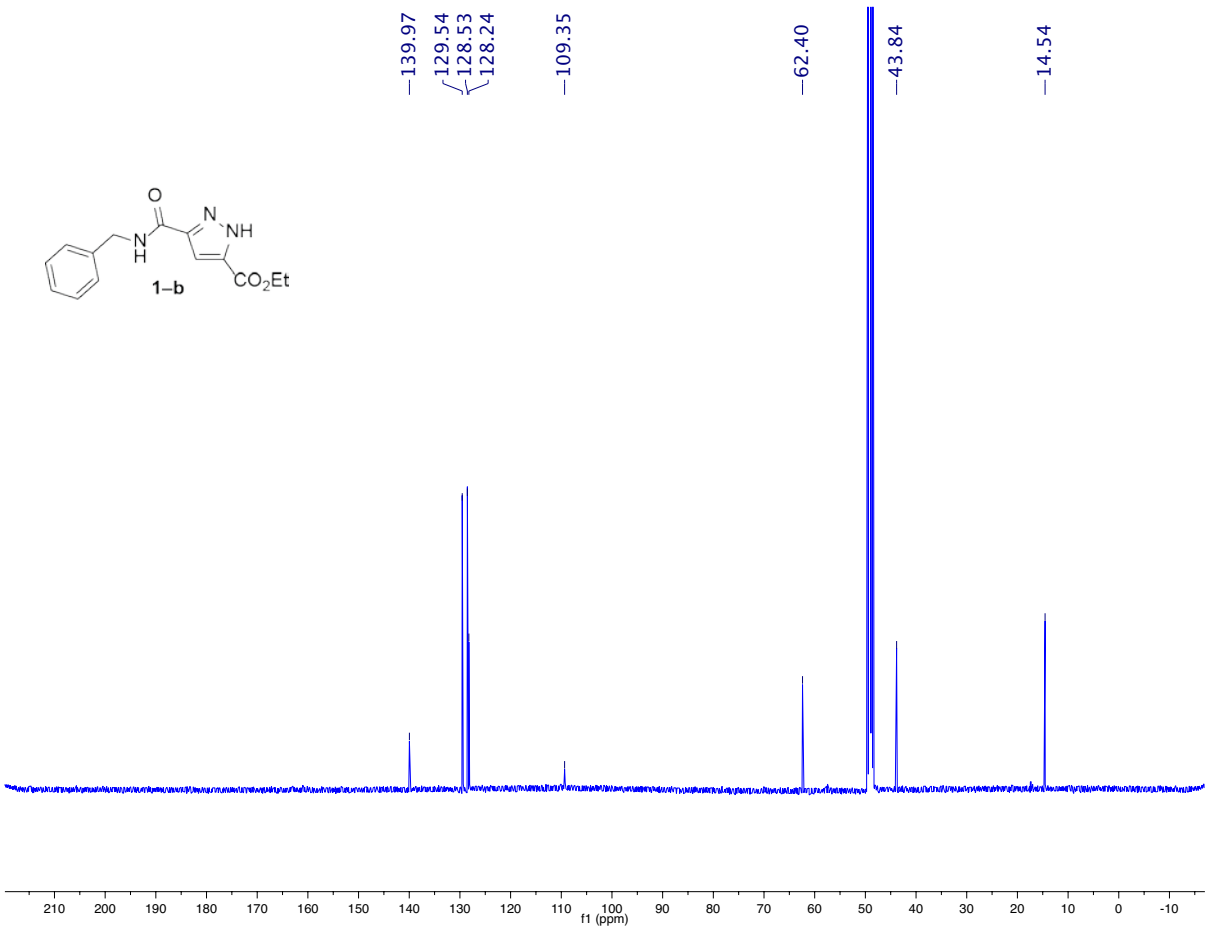


Figure S15. ^{13}C-NMR spectrum (126 MHz) of ethyl 5-(benzylcarbamoyl)-1*H*-pyrazole-3-carboxylate in MeOD.

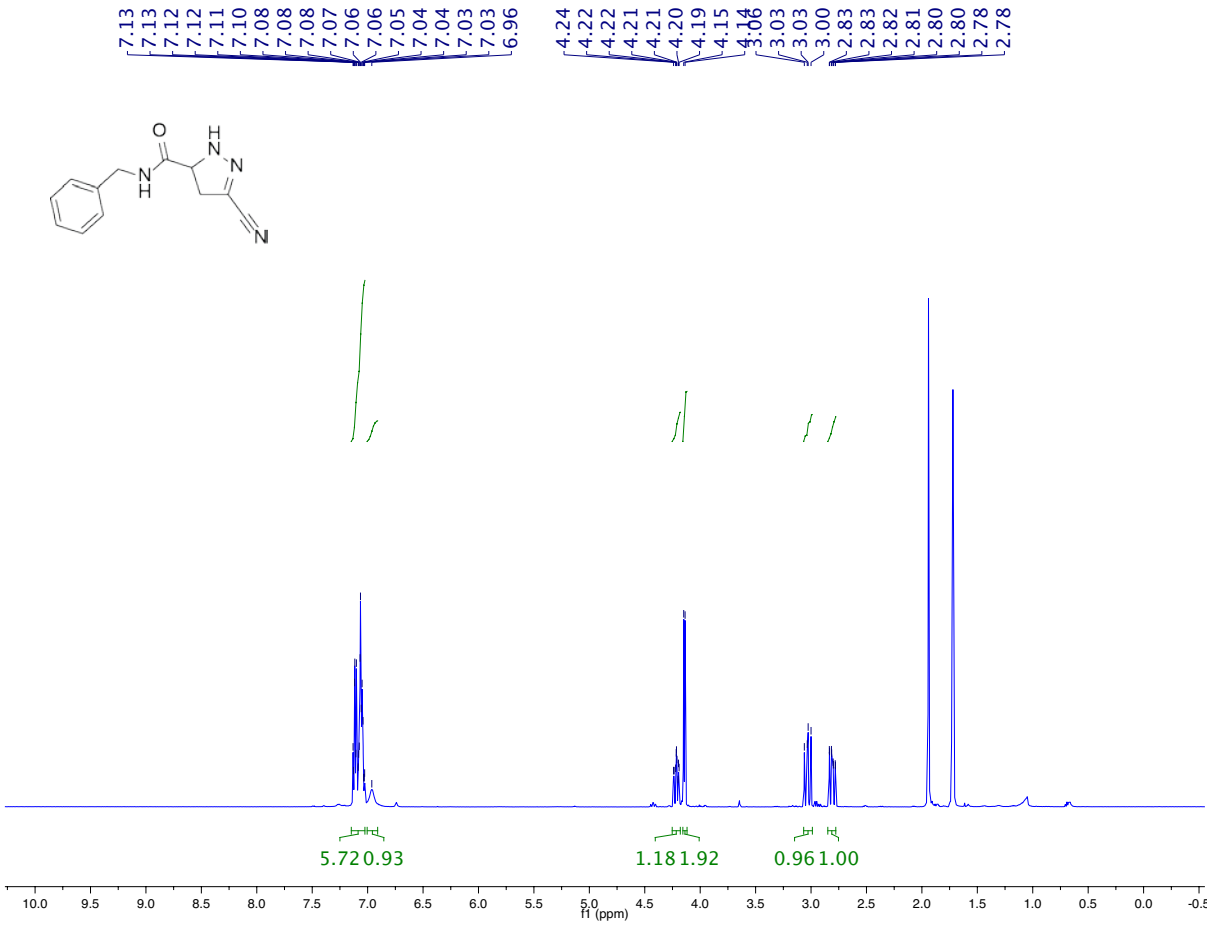


Figure S16. ^{1}H-NMR spectrum (500 MHz) of *N*-benzyl-3-cyano-4,5-dihydro-1*H*-pyrazole-5-carboxamide in CD_3CN.

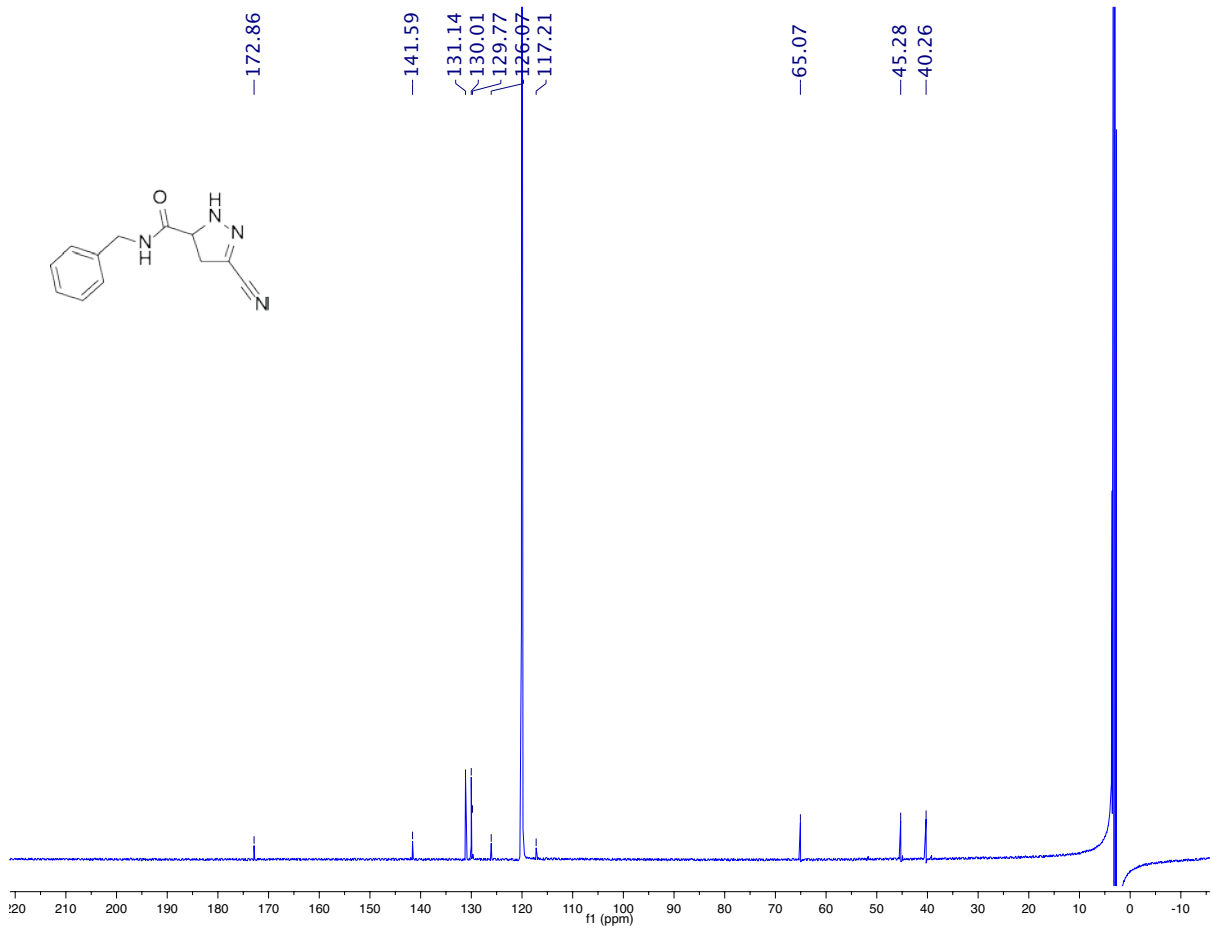


Figure S17. ^{13}C-NMR spectrum (126 MHz) of *N*-benzyl-3-cyano-4,5-dihydro-1*H*-pyrazole-5-carboxamide in CD_3CN.

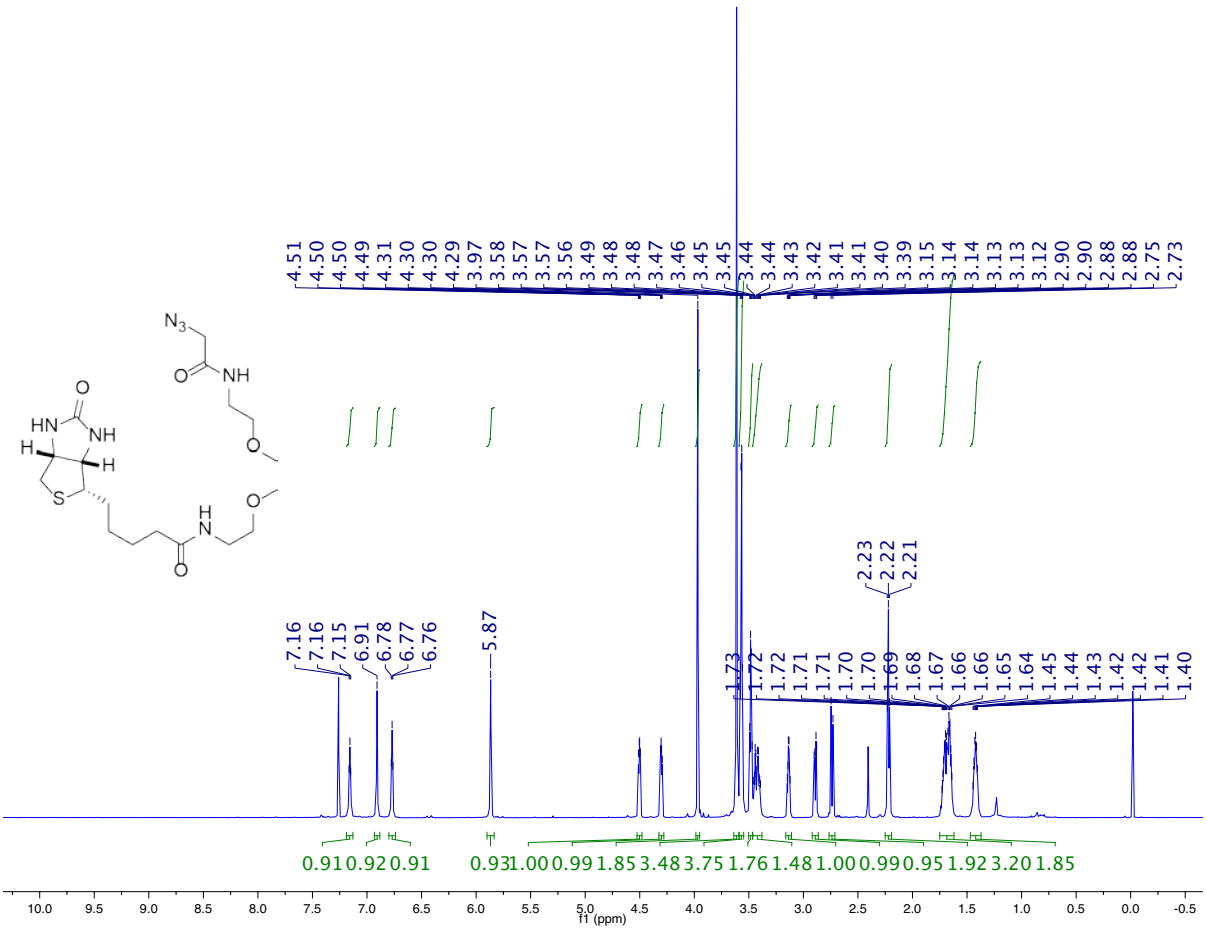


Figure S18. ^{1}H-NMR spectrum (750 MHz) of azidoacetamide–triglycol–biotin in $CDCl_3$.

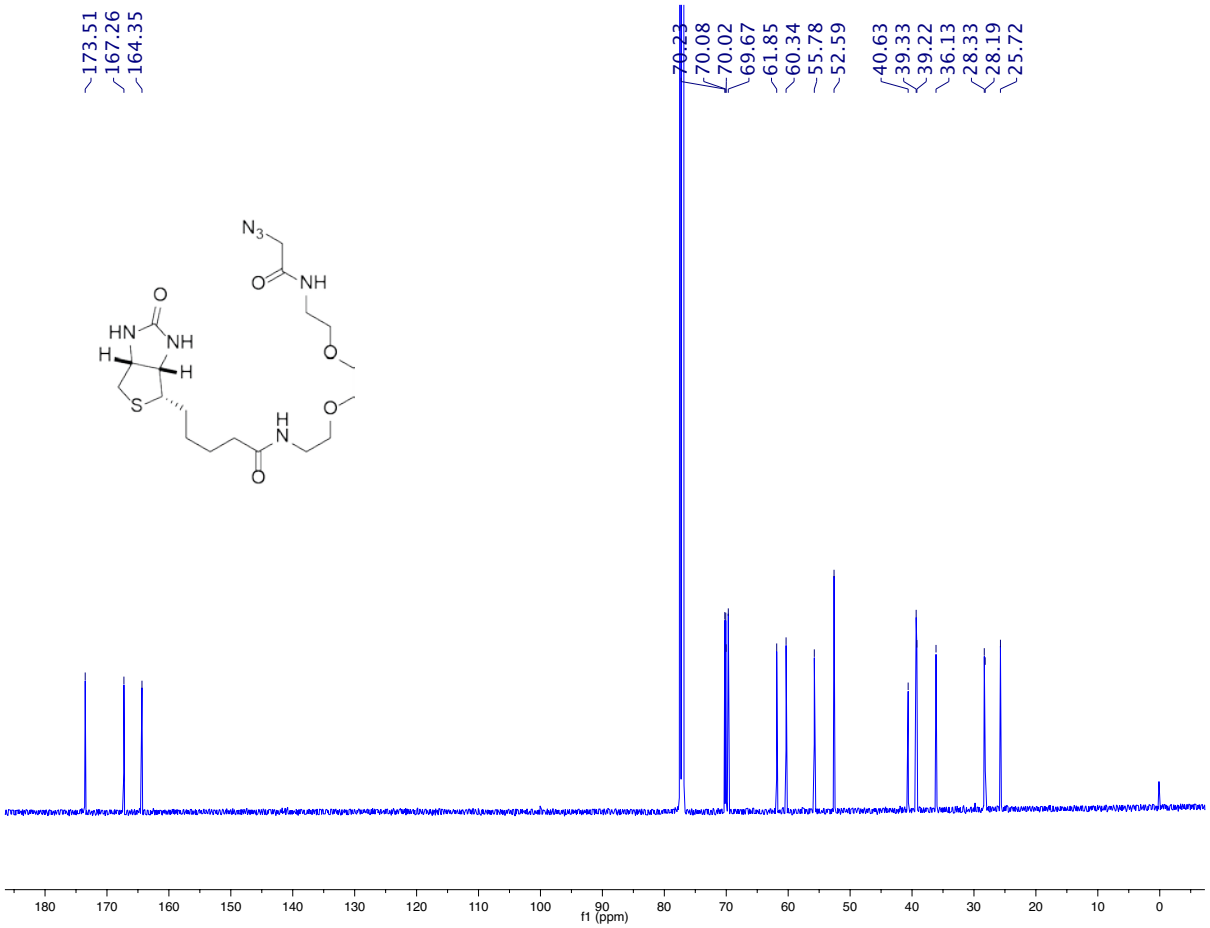


Figure S19. ^{13}C-NMR spectrum (126 MHz) of azidoacetamide–triglycol–biotin in $CDCl_3$.

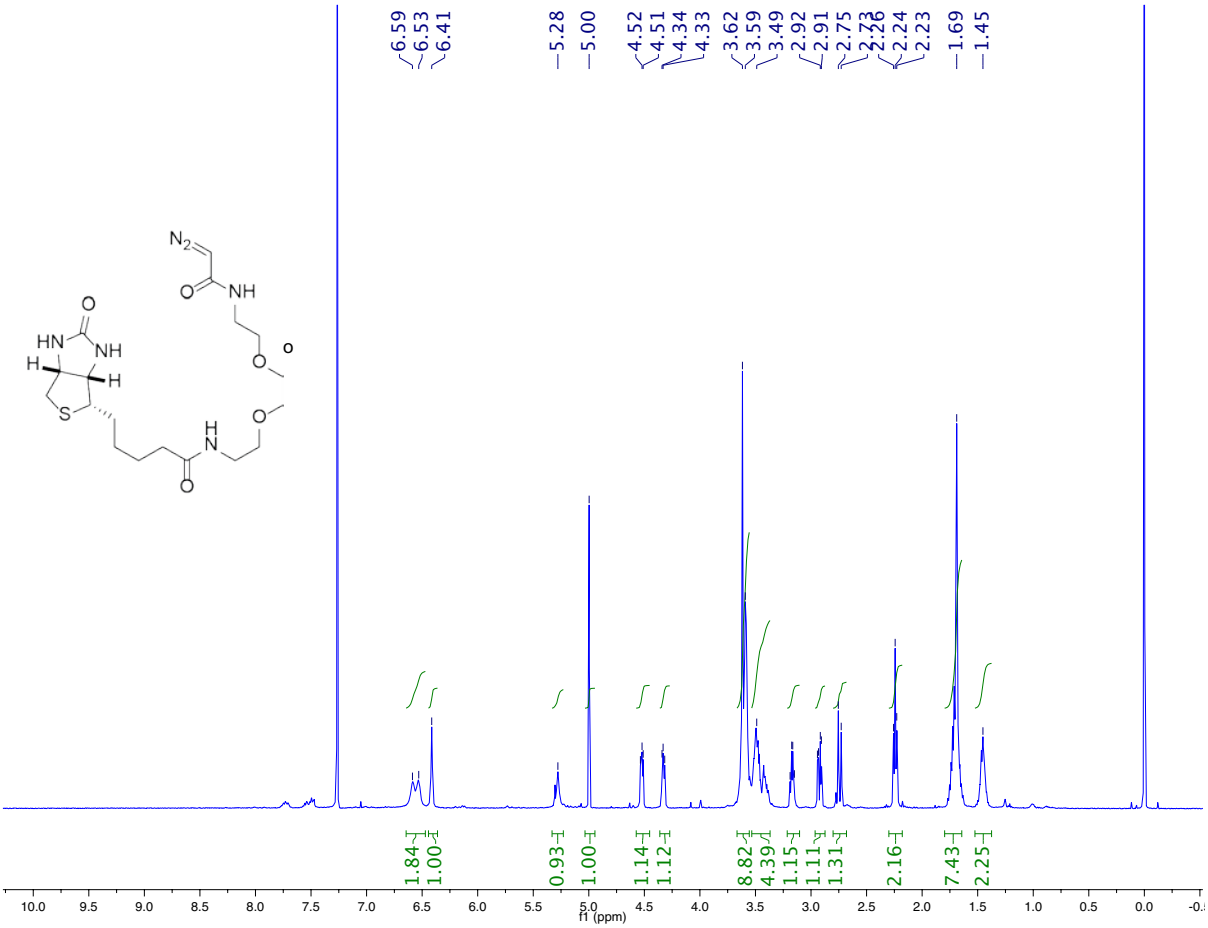


Figure S20. ^{1}H-NMR spectrum (500 MHz) of diazoacetamide–triglycol–biotin in CD_3CN.

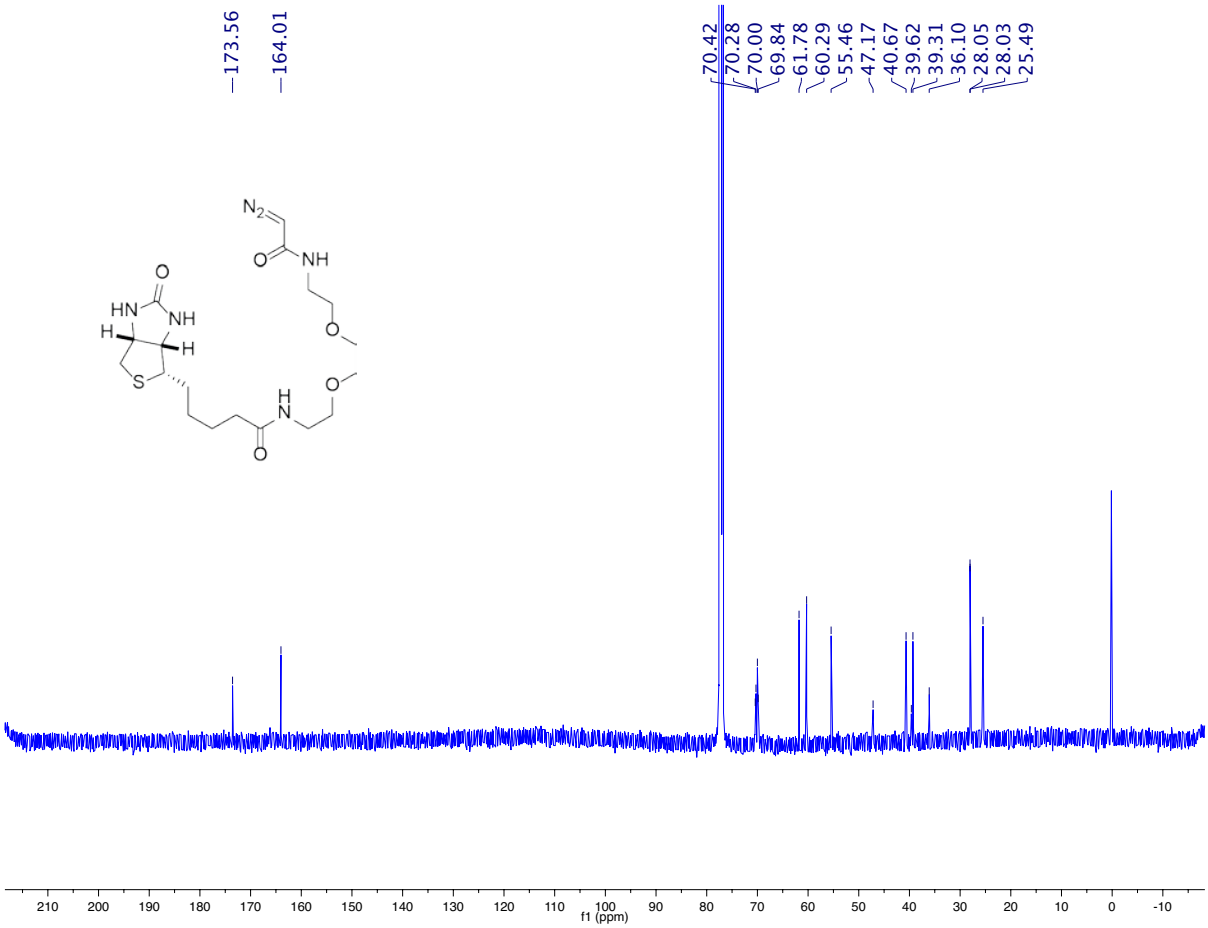


Figure S21. ^{13}C-NMR spectrum (126 MHz) of diazoacetamide–triglycol–biotin in $CDCl_3$.

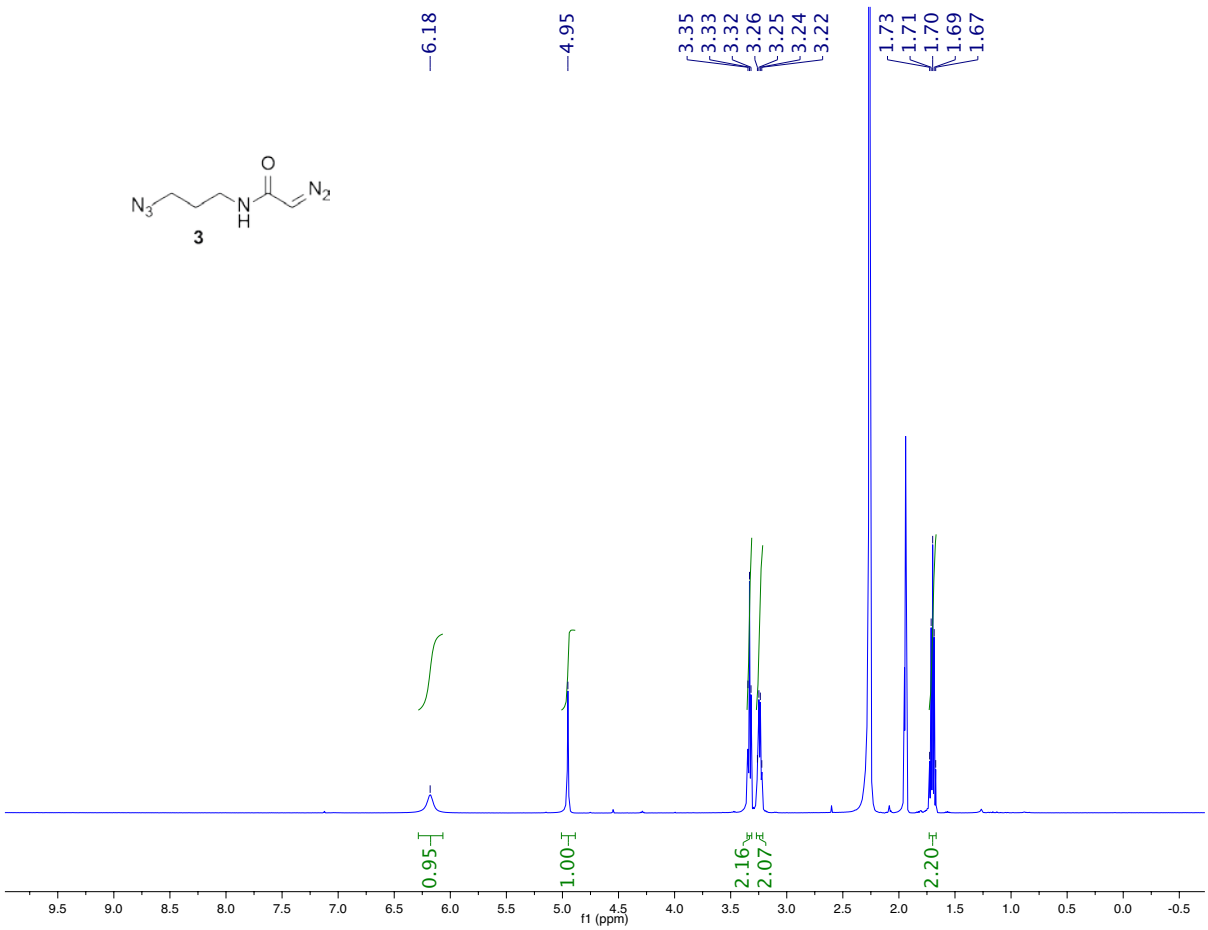


Figure S22. ^{1}H-NMR spectrum (500 MHz) of *N*-(3-azidopropyl)-2-diazoacetamide in CD_3CN.

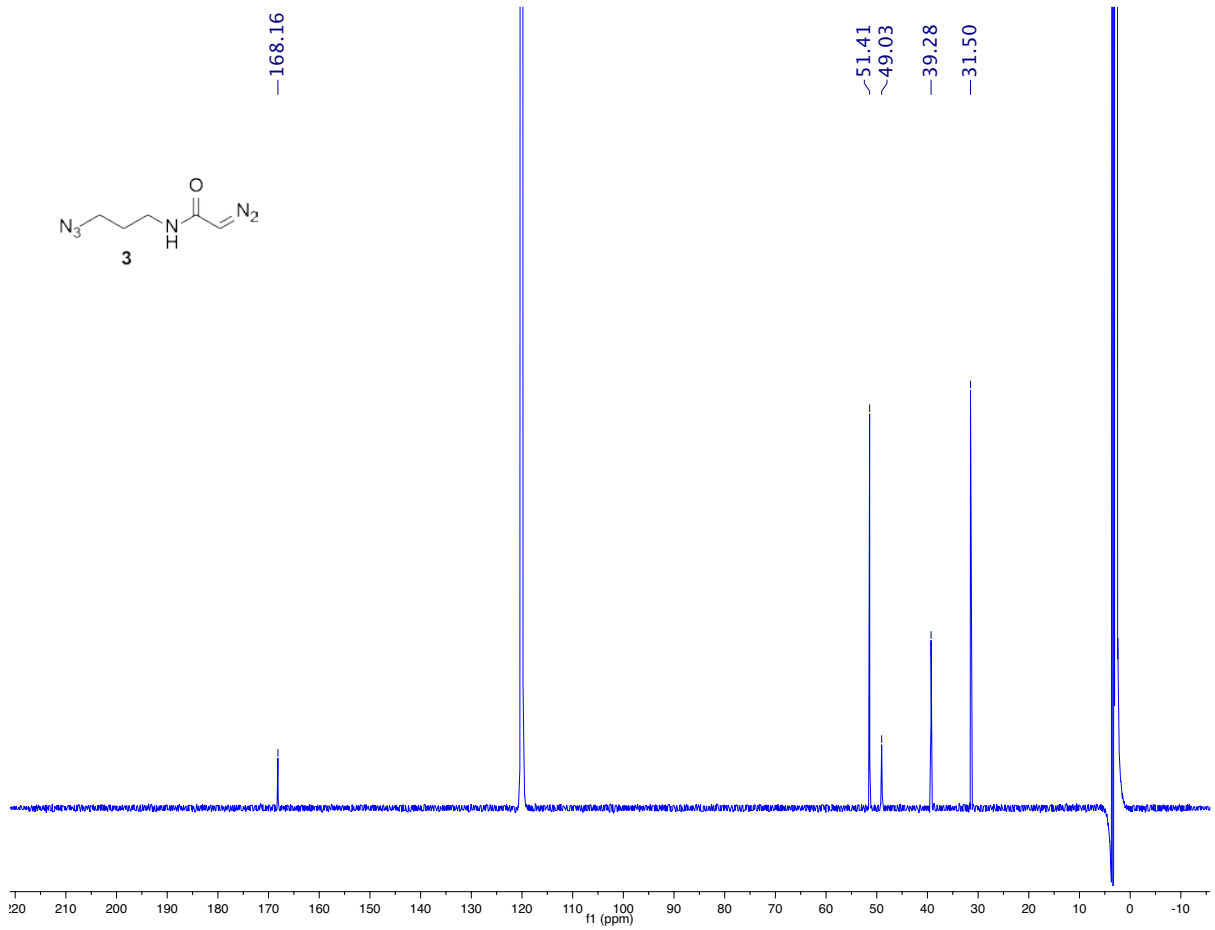


Figure S23. ^{13}C-NMR spectrum (126 MHz) of *N*-(3-azidopropyl)-2-diazoacetamide in CD_3CN.

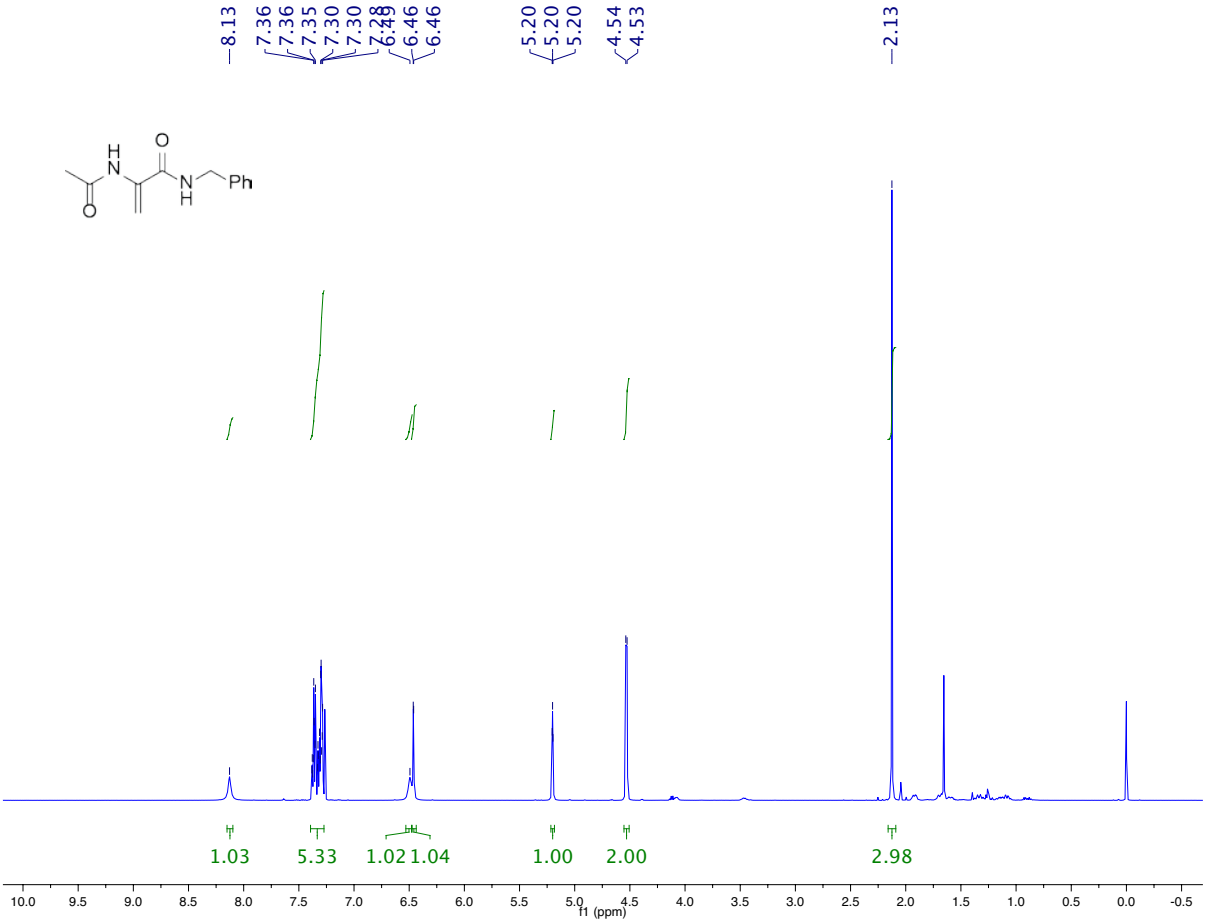


Figure S24. ^{1}H NMR spectrum (500 MHz) of 2-acetamido-*N*-benzylacrylamide in $CDCl_3$.

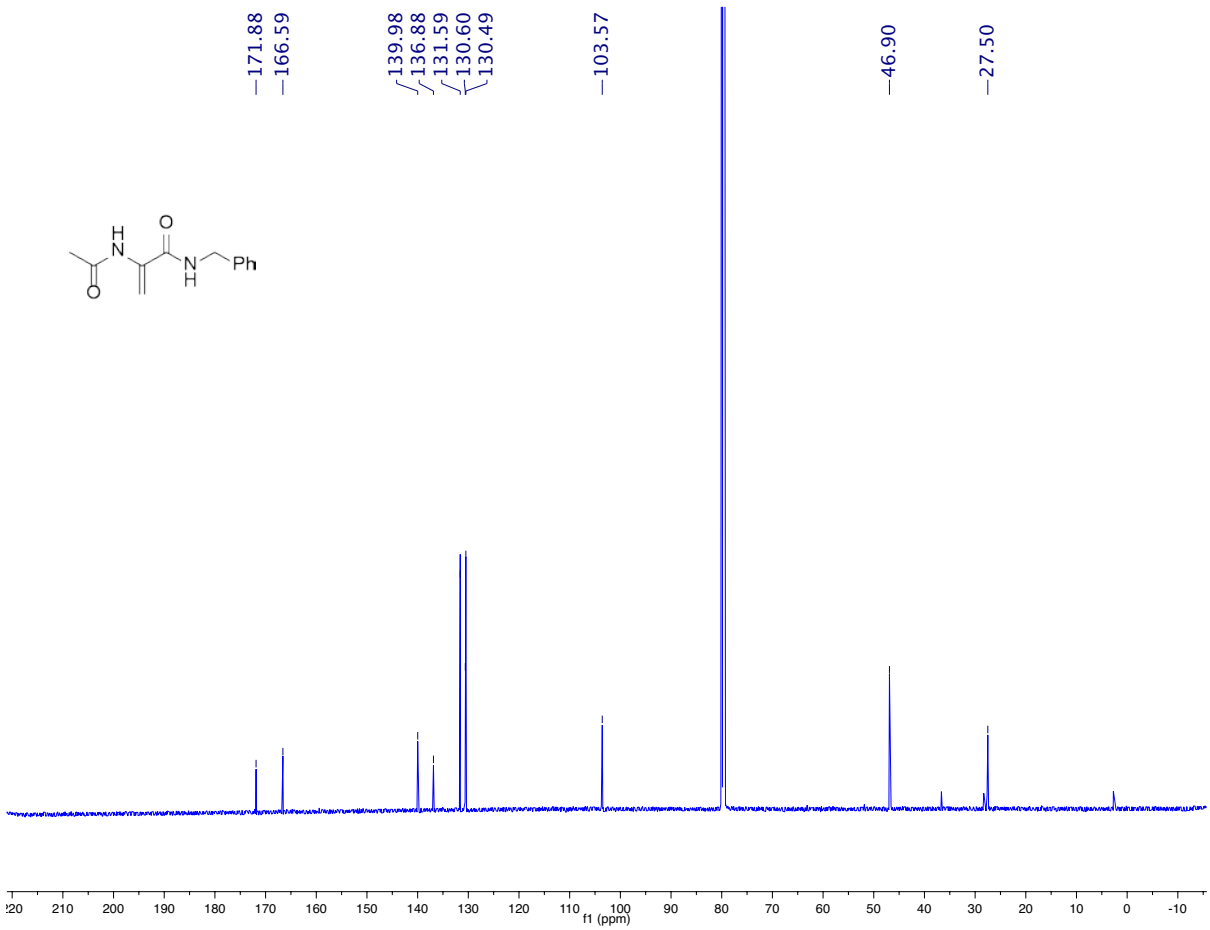


Figure S25. ^{13}C NMR spectrum (126 MHz) of 2-acetamido-*N*-benzylacrylamide in $CDCl_3$.

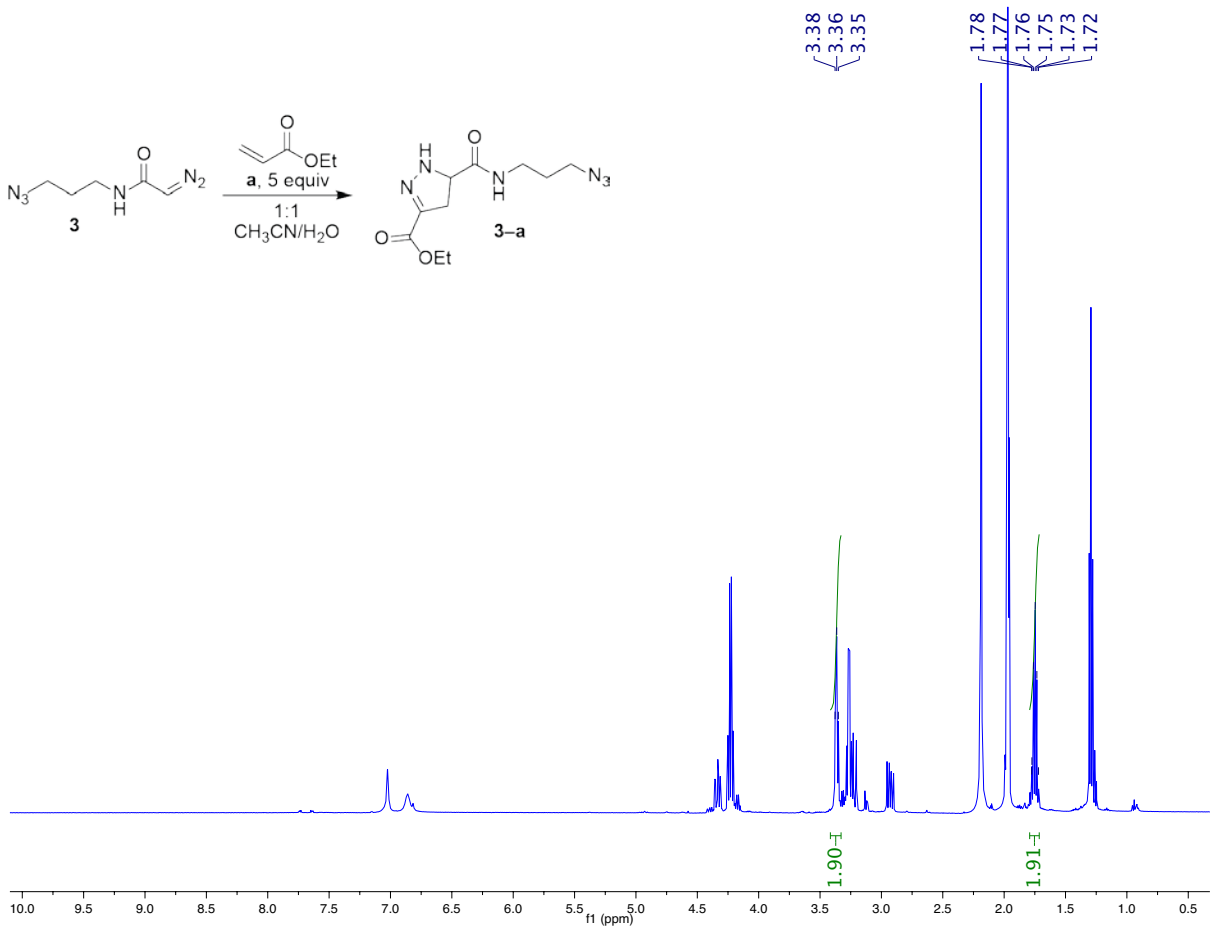


Figure S26. ^{1}H-NMR spectrum (500 MHz) of *N*-(3-azidopropyl)-2-diazoacetamide competition reaction with ethylacrylate in CD_3CN.

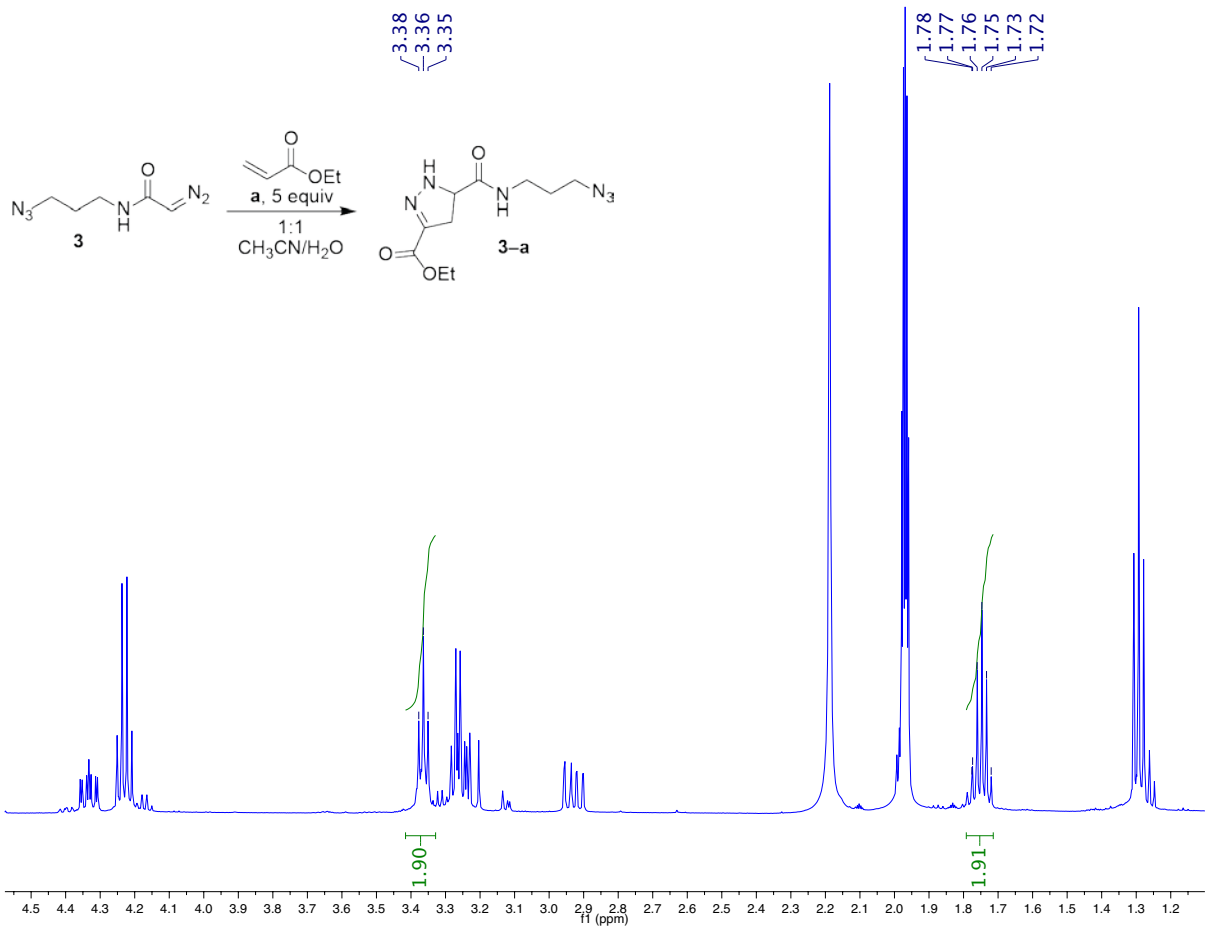


Figure S27. Enlargement of Figure S26. ^{1}H-NMR spectrum (500 MHz) of *N*-(3-azidopropyl)-2-diazoacetamide competition reaction with ethylacrylate in CD_3CN.

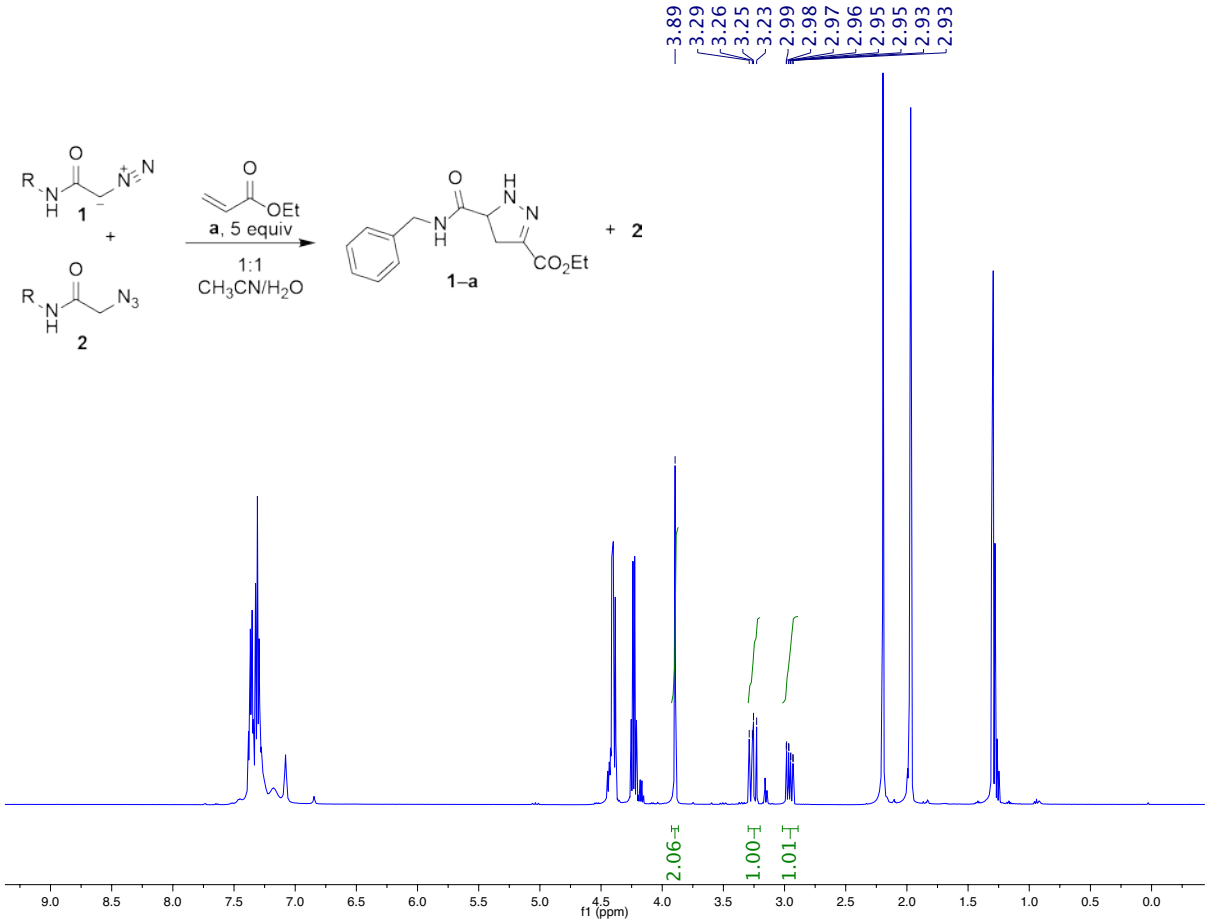


Figure S28. ^{1}H-NMR spectrum (500 MHz) of diazoacetamide **1** (1 equiv) and azidoacetamide **2** (1 equiv) with ethylacrylate (5 equiv) after 24 h in CD_3CN.

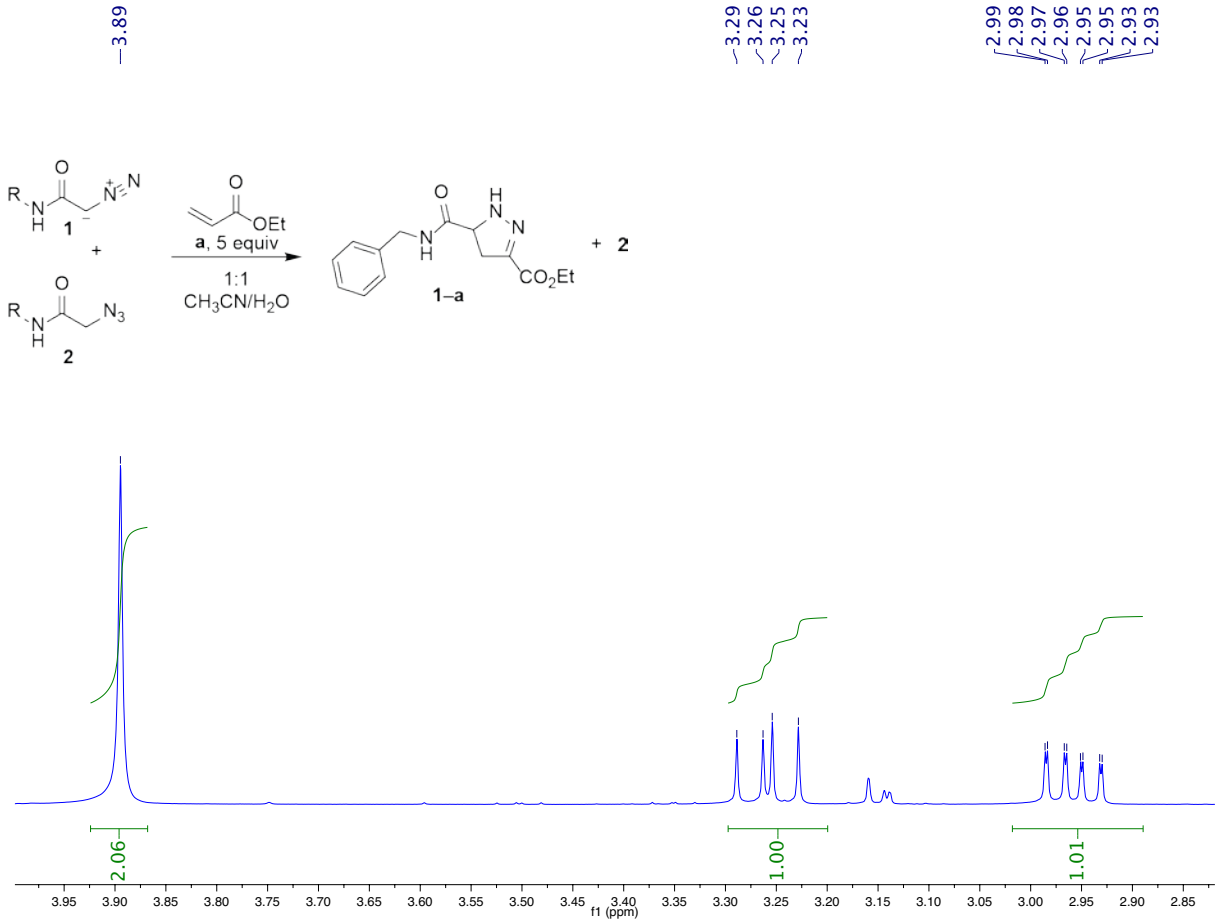


Figure S29. Enlargement of Figure S28. ^{1}H-NMR spectrum (500 MHz) of diazoacetamide **1** (1 equiv) and azidoacetamide **2** (1 equiv) with ethylacrylate (5 equiv) after 24 h in CD_3CN.

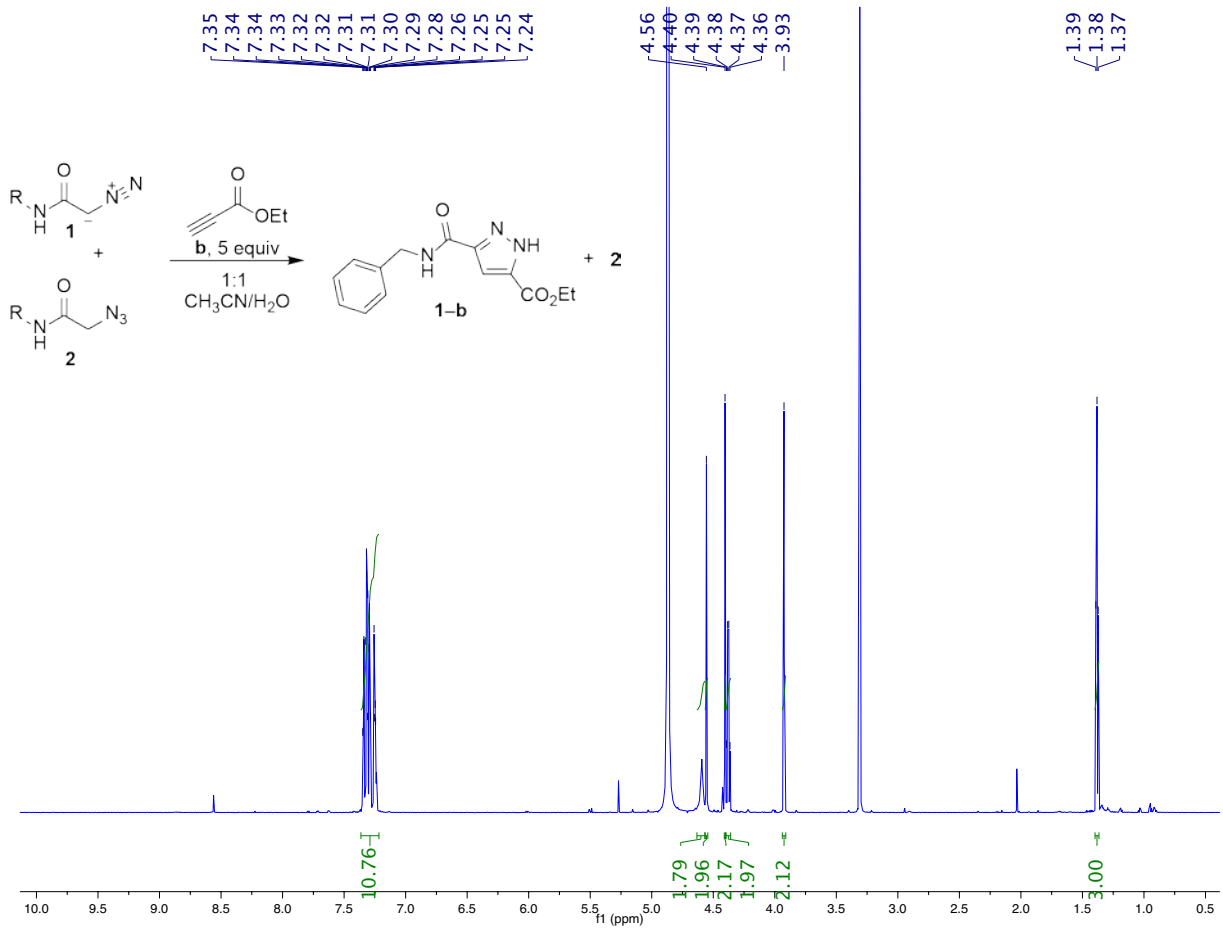


Figure S30. ^{1}H-NMR spectrum (500 MHz) of diazoacetamide **1** (1 equiv) and azidoacetamide **2** (1 equiv) with ethyl propiolate (**b**) (5 equiv) after 24 h in MeOD.

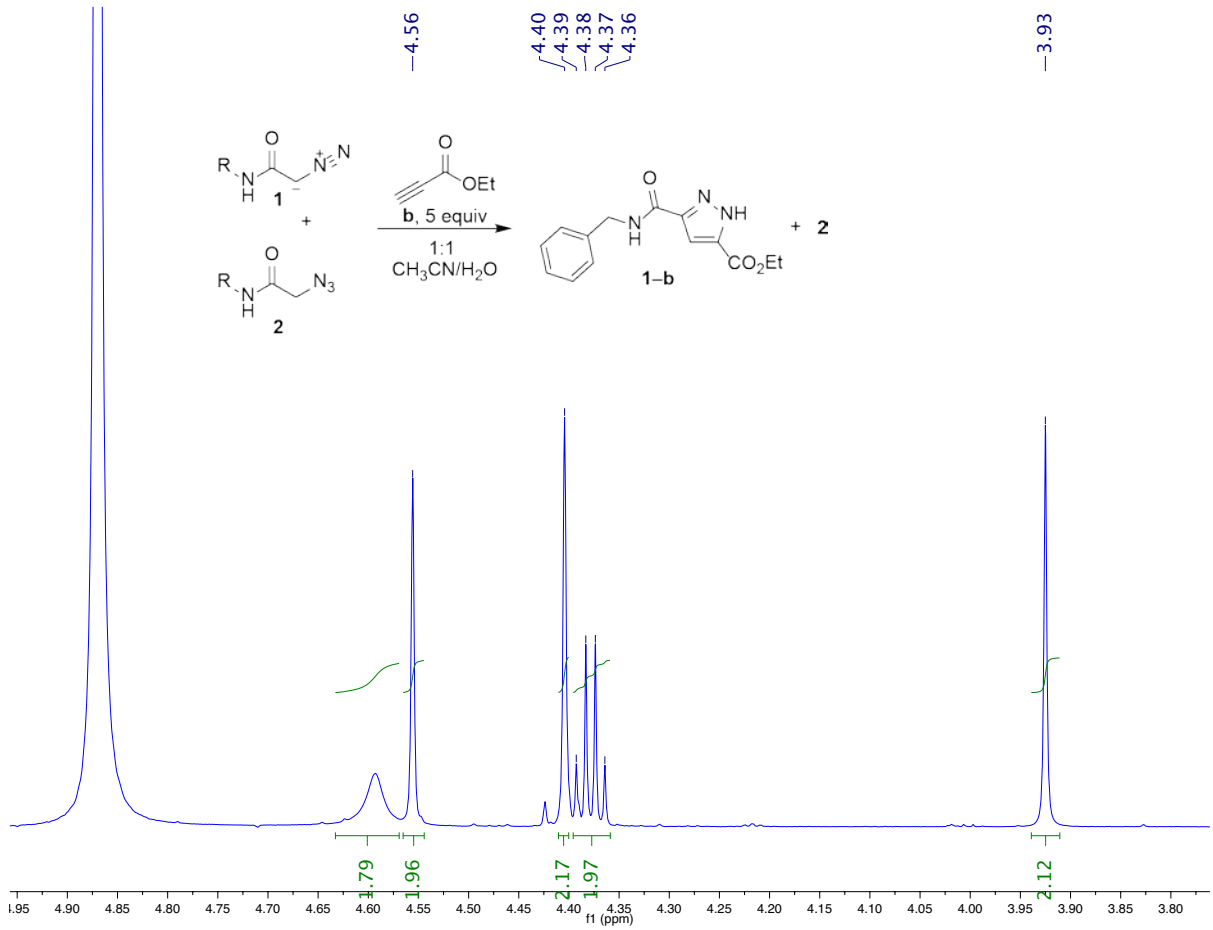


Figure S31. Enlargment of Figure S30. ^{1}H-NMR spectrum (500 MHz) of diazoacetamide **1** (1 equiv) and azidoacetamide **2** (1 equiv) with ethyl propiolate (**b**) (5 equiv) after 24 h in MeOD.

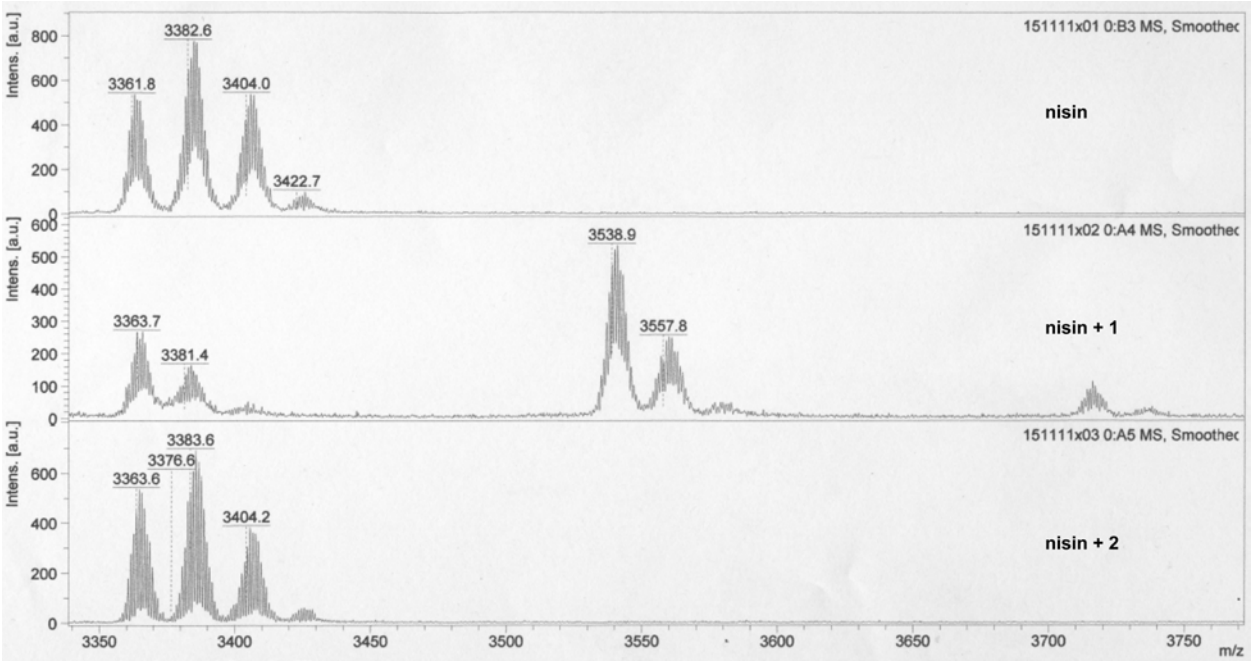


Figure S32. Overlay of MALDI–TOF spectra of enriched nisin, nisin treated with diazoacetamide **1**, and nisin treated with azidoacetamide **2**.

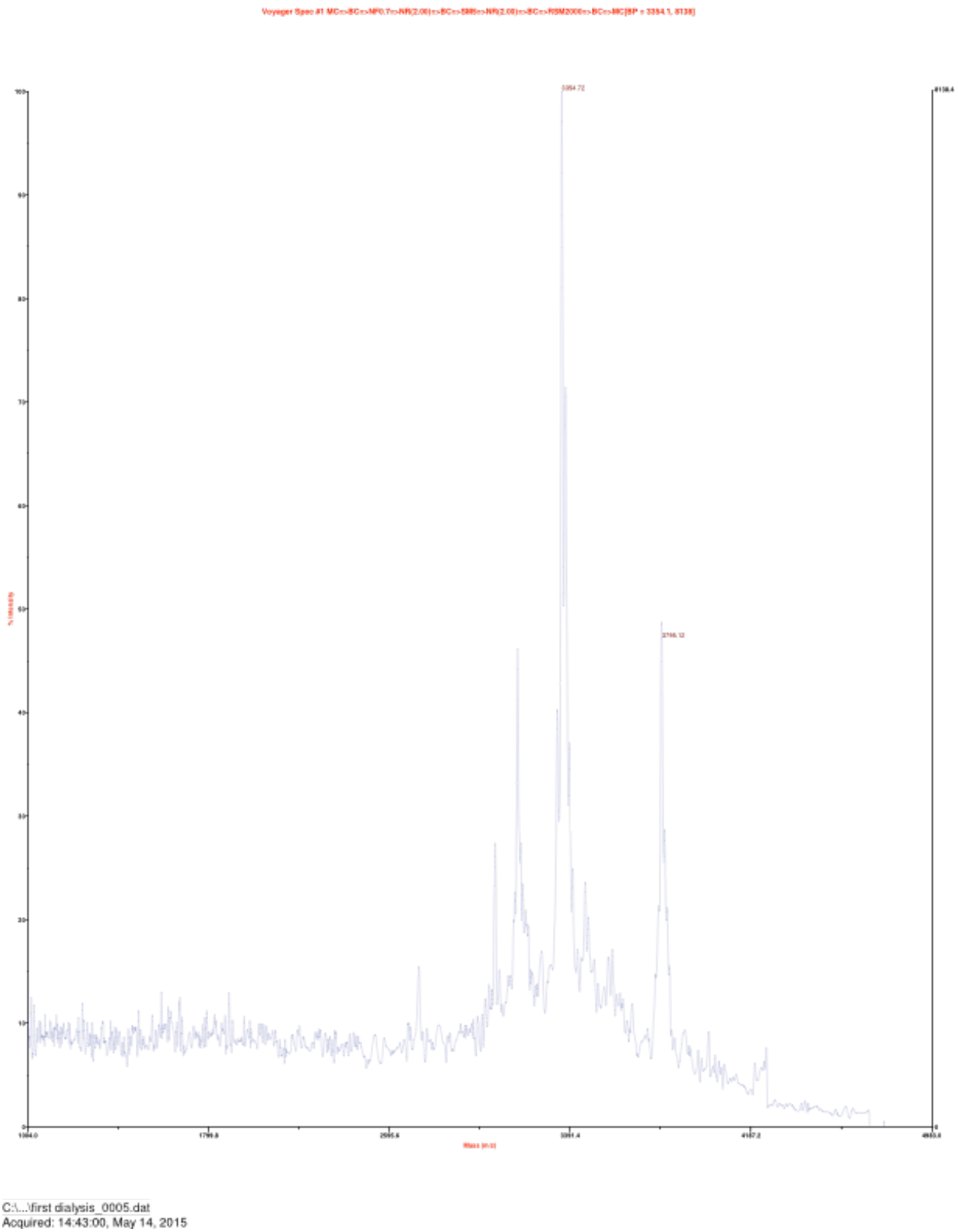
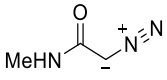


Figure S33. MALDI–TOF mass spectrum of nisin following treatment with diazoacetamide–triglycol–biotin. *m*/*z* calcd. for nisin + diazoacetamide–triglycol–biotin, 3796.6, found 3795.1.

Cartesian coordinates, total energies, and imaginary frequencies (for TSs)

All energies include IEFPCM single-point corrections. TS frequencies are from gas-phase optimized structures.

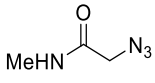
Ground States



(1)

C	0.30852100	0.03905300	-0.02920200
N	-2.02771400	-0.22212300	0.01247700
N	-2.99960900	0.33676500	0.04001300
O	0.22780700	1.25507100	-0.03578400
N	1.50346700	-0.61999200	-0.05770900
H	1.51615300	-1.60579700	0.14568500
C	2.73859300	0.13170600	0.05051200
H	2.86639000	0.56630800	1.04724000
H	3.57565100	-0.53248600	-0.16735100
H	2.72785900	0.94470800	-0.67669500
C	-0.87166200	-0.83196100	-0.01577300
H	-0.89422800	-1.90863500	-0.05928700

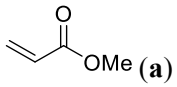
HF: -356.6537399
Sum of electronic and zero-point energies: -356.564577
Sum of electronic and thermal energies: -356.556859
Sum of electronic and thermal enthalpies: -356.555915
Sum of electronic and thermal free energies: -356.596660



(2)

C	0.65675200	0.06180100	0.04343900
N	-2.24704800	-0.12009700	-0.06844100
N	-2.91424700	-0.97514600	0.21976000
O	0.33894400	-1.10332200	-0.07454100
N	-1.62893800	0.87174100	-0.47593200
C	-0.39286000	1.15534100	0.24197900
H	-0.56489900	1.25580900	1.32263900
H	-0.04110500	2.11733000	-0.13372500
N	1.94517100	0.47622300	0.07109500
H	2.14998600	1.46121300	0.06595900
C	3.02736000	-0.48229900	-0.05705700
H	3.03789100	-0.93263300	-1.05359100
H	3.97443500	0.02660800	0.12218300
H	2.90005900	-1.27985100	0.67733000

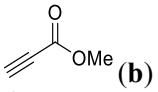
HF: -411.9771915
Sum of electronic and zero-point energies: -411.869824
Sum of electronic and thermal energies: -411.861203
Sum of electronic and thermal enthalpies: -411.860258
Sum of electronic and thermal free energies: -411.904416



(a)

C	-0.03943800	0.10894500	-0.00045300
C	-1.31631500	-0.64908900	0.00001900
H	-1.24516000	-1.73078400	0.00023500
O	0.06165800	1.30836100	-0.00002800
C	-2.47544300	-0.00003800	0.00018800
H	-2.48947600	1.08560000	-0.00002100
H	-3.42123200	-0.52963600	0.00055100
O	1.01362000	-0.72245000	-0.00029400
C	2.28779800	-0.07991200	0.00031900
H	3.02378500	-0.88171200	0.00045600
H	2.39545500	0.54505300	-0.88867200
H	2.39478700	0.54476300	0.88959100

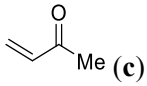
HF: -306.3696751
Sum of electronic and zero-point energies: -306.273754
Sum of electronic and thermal energies: -306.267156
Sum of electronic and thermal enthalpies: -306.266212
Sum of electronic and thermal free energies: -306.304261



(b)

C	-1.46463900	-0.10757700	0.00000500
C	-2.62924200	-0.40058500	0.00019500
H	-3.66319800	-0.66207800	0.00065800
C	-0.06767300	0.30444100	-0.00044200
O	0.29701900	1.44761800	0.00006500
O	0.74638100	-0.75257100	-0.00043500
C	2.14020700	-0.43097400	0.00035500
H	2.39205200	0.14763500	0.89096500
H	2.65937400	-1.38707800	-0.00033500
H	2.39265300	0.14931500	-0.88901500

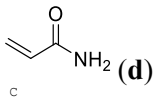
HF: -305.1136683
Sum of electronic and zero-point energies: -305.041527
Sum of electronic and thermal energies: -305.035219
Sum of electronic and thermal enthalpies: -305.034274
Sum of electronic and thermal free energies: -305.071432



(c)

C	-0.80108200	-0.66801300	-0.00027900
C	-2.00425100	-0.10036100	0.00015000
H	-2.91451300	-0.68948500	0.00016300
H	-2.08837200	0.98245800	0.00079000
C	0.44251000	0.16561200	-0.00004600
O	0.39810600	1.37338800	-0.00012500
H	-0.68142700	-1.74810900	-0.00043300
C	1.74873100	-0.59044700	0.00019000
H	1.79885900	-1.23998700	0.88038400
H	1.79939000	-1.23900500	-0.88073500
H	2.58577200	0.10627400	0.00074400

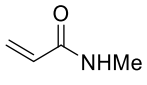
HF: -231.1542877
Sum of electronic and zero-point energies: -231.064587
Sum of electronic and thermal energies: -231.058701
Sum of electronic and thermal enthalpies: -231.057757
Sum of electronic and thermal free energies: -231.093857



(d)

C	-0.79835900	-0.65565100	-0.00646200
C	-1.96711100	-0.02511700	0.00566600
H	-2.90663500	-0.56576400	0.00329100
H	-1.98872100	1.06037600	0.01774900
C	0.47467300	0.12877100	-0.00206500
O	0.50440000	1.34216300	-0.00162200
H	-0.73649000	-1.74056400	-0.02004200
N	1.60873100	-0.62785100	-0.00921900
H	1.58385100	-1.63014400	0.05655100
H	2.49646500	-0.15427000	0.03712800

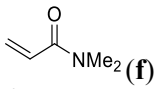
HF: -247.2229011
Sum of electronic and zero-point energies: -247.143545
Sum of electronic and thermal energies: -247.137836
Sum of electronic and thermal enthalpies: -247.136892
Sum of electronic and thermal free energies: -247.172293



(e)

C	-1.34505300	-0.65301600	-0.00007500
C	-2.50493200	-0.00617000	0.00004800
H	-3.45190200	-0.53372000	-0.00004600
H	-2.51113400	1.07953800	0.00023500
C	-0.05962900	0.10929400	0.00008700
O	-0.00670100	1.32568600	0.00000800
C	2.37174700	-0.03750300	0.00003400
H	2.49719100	0.59175800	0.88521400
H	3.13330600	-0.81771100	-0.00114200
H	2.49635000	0.59358100	-0.88394500
H	-1.30094700	-1.73937100	-0.00027900
N	1.06241400	-0.65662300	-0.00011800
H	0.98104800	-1.65882500	0.00015600

HF: -286.512298
Sum of electronic and zero-point energies: -286.404496
Sum of electronic and thermal energies: -286.397281
Sum of electronic and thermal enthalpies: -286.396337
Sum of electronic and thermal free energies: -286.436133



(f)

C	1.42424000	0.62096700	-0.11384200
C	2.67757800	0.21069700	0.05431300
H	3.51307900	0.89671600	-0.02922800
H	2.87885800	-0.83250500	0.27605900
C	0.30567500	-0.37224500	-0.01638700
O	0.53451900	-1.57042300	0.01725400
H	1.20919700	1.65637600	-0.35033400
N	-0.96470800	0.12833900	0.01585800
C	-2.08731400	-0.78880000	-0.03712100
H	-2.66350300	-0.74872800	0.89408900
H	-2.74817000	-0.52210400	-0.86933000
H	-1.70658900	-1.79791700	-0.18041600
C	-1.29000800	1.54171100	0.06736200
H	-0.58761800	2.09116200	0.69460300
H	-1.32043900	1.99919800	-0.92959700
H	-2.27902800	1.64884100	0.51916200

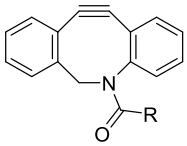
HF: -325.7955373

Sum of electronic and zero-point energies: -325.659014
Sum of electronic and thermal energies: -325.650627
Sum of electronic and thermal enthalpies: -325.649683
Sum of electronic and thermal free energies: -325.692343

(g)

C	-0.60193400	-1.45435800	0.03121100
C	0.60223300	-1.45448400	-0.03118600
C	1.95545600	-0.90990900	-0.12215800
H	2.66833200	-1.43561600	0.51939000
H	2.32135800	-0.99684100	-1.15152000
C	-1.95528300	-0.91015700	0.12213900
H	-2.66797400	-1.43602200	-0.51948500
H	-2.32122700	-0.99721100	1.15147400
C	1.85505800	0.58026800	0.28114400
H	2.80071400	1.06766200	0.01943200
H	1.75991000	0.64211400	1.37136000
C	-1.85521100	0.58006800	-0.28110600
H	-1.76016700	0.64199200	-1.37132600
H	-2.80092800	1.06727900	-0.01928000
C	0.68342700	1.34478600	-0.37273400
H	1.00165200	2.38716400	-0.47471800
H	0.54436000	0.97321100	-1.39596400
C	-0.68365900	1.34476200	0.37270400
H	-1.00199300	2.38711700	0.47458000
H	-0.54456000	0.97329900	1.39597000

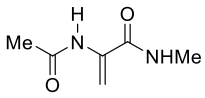
HF: -311.8801675
Sum of electronic and zero-point energies: -311.699679
Sum of electronic and thermal energies: -311.691905
Sum of electronic and thermal enthalpies: -311.690960
Sum of electronic and thermal free energies: -311.731416



(DIBAC)

C	3.04141200	0.71596900	-0.83294700
C	1.88143300	-0.01149700	-0.60016700
C	1.97117500	-1.19372400	0.16949400
C	3.19935700	-1.63757000	0.65752800
C	4.34855200	-0.90379700	0.39296100
C	4.26837100	0.27434000	-0.34442900
H	2.97566200	1.64573900	-1.38870400
H	3.24144000	-2.54718600	1.24535600
H	5.30540500	-1.24541300	0.77146000
H	5.16356200	0.85535400	-0.53666000
C	0.70037500	-1.79509700	0.41222600
C	-0.50902900	-1.84265000	0.37673700
C	-1.78943600	-1.26740200	0.13278800
C	-1.74323700	0.10157300	-0.23034900
C	0.55869900	0.40840800	-1.21683600
H	0.15855200	-0.41593300	-1.81184500
H	0.74033300	1.26035200	-1.87789300
C	-3.01543000	-1.93023300	0.18714700
C	-2.92846200	0.75370500	-0.55559200
C	-4.19154000	-1.25347400	-0.10890800
H	-5.14096500	-1.77414000	-0.05836600
C	-4.14722900	0.08658400	-0.48245400
H	-5.06165900	0.61355100	-0.73026500
H	-3.03253300	-2.97766500	0.46528400
H	-2.88828800	1.79138900	-0.86960700
N	-0.50198100	0.79595500	-0.26320500
C	-0.27089200	1.95788700	0.44077200
O	0.71813200	2.62661900	0.20967800
C	-1.24886300	2.34227600	1.53009700
H	-2.02958000	2.99043200	1.12389900
H	-1.72575200	1.47652800	1.99173400
H	-0.68889700	2.91056800	2.27221700

HF: -785.3126831
Sum of electronic and zero-point energies: -785.056979
Sum of electronic and thermal energies: -785.042088
Sum of electronic and thermal enthalpies: -785.041144
Sum of electronic and thermal free energies: -785.098831



(nisin)

C5

C	0.06441700	0.52576600	-0.07666100
C	0.00664900	1.85898700	-0.16314700
H	-0.93376100	2.38790600	-0.15481900
C	1.35601700	-0.25819900	-0.09319400
O	1.34258800	-1.45915800	-0.31932600
C	3.76487500	-0.29207300	0.17616500
H	3.90784900	-0.82468200	-0.76577900
H	4.56887300	0.43231600	0.30542500
H	3.79456600	-1.02228700	0.99036200
H	0.92055300	2.42715000	-0.28257500
N	-1.01201100	-0.35444800	0.00288600
C	-2.34402600	-0.03331100	0.04092100
H	-0.73613800	-1.32813200	-0.04018600
O	-2.75162100	1.10907900	0.03344200
C	-3.27415900	-1.22314800	0.13509100
H	-2.85336700	-2.12598800	-0.31201500
H	-3.48159500	-1.42130800	1.19045300
H	-4.21219800	-0.96612900	-0.35575500
N	2.49923600	0.41545700	0.15017300
H	2.44426900	1.34658400	0.52549200

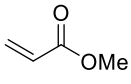
HF: -494.4773965
Sum of electronic and zero-point energies: -494.313830
Sum of electronic and thermal energies: -494.302230
Sum of electronic and thermal enthalpies: -494.301285
Sum of electronic and thermal free energies: -494.353437

C7

C	-0.11585700	1.16054700	0.00040300
C	-0.23285600	2.43863700	0.34757000
H	0.63173500	3.09091100	0.40219000
C	-1.37688900	0.32127200	-0.07887400
O	-2.46462200	0.86890600	-0.12030600
C	-2.41092200	-1.85333100	-0.13909200
H	-3.05090200	-1.57175300	-0.97708000
H	-2.10622100	-2.89418000	-0.25057700
H	-2.99011800	-1.73692700	0.78285600
H	-1.21681000	2.83612300	0.56318300
N	1.14706800	0.65390400	-0.43375500
C	1.84765600	-0.37911300	0.11512400
H	1.63938200	1.23632300	-1.09324800
O	1.38826700	-1.10844600	0.97611100
C	3.25302400	-0.56063400	-0.41128600
H	3.44450300	-1.62804000	-0.52175700
H	3.42718100	-0.05367400	-1.36201200
H	3.95012800	-0.16868500	0.33395500
N	-1.22489700	-1.01927200	-0.13144400
H	-0.35817200	-1.40046500	0.22936600

HF: -494.4711184
Sum of electronic and zero-point energies: 494.307721
Sum of electronic and thermal energies: -494.297130
Sum of electronic and thermal enthalpies: -494.296186
Sum of electronic and thermal free energies: -494.344911

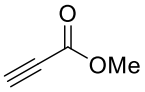
Transition States with Diazoacetamide 1



(1–a)

C	-1.11363000	-0.29192500	0.94871500
C	0.00811400	-1.02448700	0.60594500
H	0.80472000	-1.13049600	1.33572500
H	-0.12466300	-1.84654300	-0.09119500
C	2.41406300	0.32184000	-0.12295500
N	0.28593100	1.19921400	-0.74069500
N	-0.64180300	1.65735400	-0.27764800
O	2.61332000	1.22005900	0.66961600
C	-2.31689100	-0.44910600	0.13202500
O	-2.35069200	-0.99585400	-0.95064800
O	-3.40027700	0.11283600	0.69726800
C	-4.59467600	0.02812400	-0.07387700
H	-4.86394800	-1.01605000	-0.24740200
H	-5.36285700	0.52993600	0.51230100
H	-4.46187800	0.52385300	-1.03803500
H	-1.18878900	0.26022000	1.87552800
N	3.33552500	-0.62536900	-0.42952400
H	3.08120400	-1.38412800	-1.04045700
C	4.60668800	-0.66716100	0.26856400
H	4.49388900	-1.05432500	1.28577700
H	5.29496600	-1.30375100	-0.28762000
H	5.01501100	0.34250200	0.32766000
C	1.08466800	0.11210400	-0.77540200
H	1.02595400	-0.41227100	-1.72518000

HF: -663.0040822
Sum of electronic and zero-point energies: -662.816847
Sum of electronic and thermal energies: -662.803260
Sum of electronic and thermal enthalpies: -662.802316
Sum of electronic and thermal free energies: -662.858483
Frequencies: -511.6685

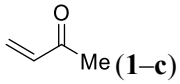


(1–b)

C	1.11022500	-0.22204800	-0.78768600
C	-0.01308300	-0.27621400	-1.29674100
H	-0.68384100	-0.09103700	-2.11269600
C	-2.36657800	-0.00863100	0.32253300
N	-0.46821200	-1.26285800	1.03383500
N	0.61086900	-1.11233700	1.33952300
O	-2.20559100	0.82250900	1.19028100
C	2.51978200	-0.09061800	-0.50914100

O	3.34713100	-0.93236800	-0.75242300
O	2.79550700	1.08262900	0.07949900
C	4.16794500	1.26430800	0.42671200
H	4.79425500	1.23327000	-0.46710600
H	4.22215200	2.24271300	0.90067800
H	4.49086800	0.48236400	1.11706100
N	-3.39403500	0.02450600	-0.56763600
H	-3.56999000	-0.77974900	-1.14741000
C	-4.41596000	1.04887300	-0.45268300
H	-3.93509900	2.02148800	-0.34078800
H	-5.02187100	1.04731600	-1.35876000
H	-5.05745600	0.88012300	0.41763600
C	-1.38076700	-1.10281100	0.06221400
H	-1.70512200	-2.04097600	-0.37877500

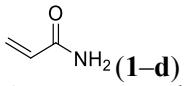
HF: -661.7459307
Sum of electronic and zero-point energies: -661.582624
Sum of electronic and thermal energies: -661.568356
Sum of electronic and thermal enthalpies: -661.567411
Sum of electronic and thermal free energies: -661.625735
Frequencies: -499.7057



(1–c)

C	-1.56270700	-0.29564200	0.94866800
C	-0.40189200	-1.00442700	0.68825800
H	0.37228900	-1.04942400	1.44859800
H	-0.48609500	-1.86601800	0.03177700
C	1.99322400	0.30871600	-0.10351700
N	-0.13282700	1.15343900	-0.76742800
N	-1.06272600	1.65327200	-0.36033000
O	2.19335700	1.24704800	0.64128700
C	-2.70852400	-0.47089300	0.05049900
O	-2.59357800	-1.05136300	-1.01808700
H	-1.67791100	0.29527900	1.84973400
N	2.90912200	-0.66117700	-0.34573600
H	2.72039600	-1.36133200	-1.04383800
C	4.22100600	-0.59892100	0.27061200
H	4.10963700	-0.37701200	1.33319700
H	4.71322000	-1.56412600	0.15145300
H	4.83737400	0.18360800	-0.18145600
C	0.65991900	0.06135400	-0.73526500
H	0.58913900	-0.51874100	-1.65135900
C	-4.02499600	0.13460300	0.48071200
H	-4.35275900	-0.31478000	1.42329700
H	-3.89679200	1.20738100	0.65749200
H	-4.77789400	-0.02779100	-0.28985200

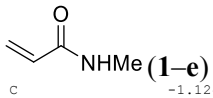
HF: -587.7908713
Sum of electronic and zero-point energies: -587.609498
Sum of electronic and thermal energies: -587.596813
Sum of electronic and thermal enthalpies: -587.595868
Sum of electronic and thermal free energies: -587.649153
Frequencies: -503.8735



(1–d)

C	-1.55865500	-0.24543900	0.94118800
C	-0.42168300	-0.98406000	0.67709900
H	0.36094500	-1.03367500	1.42786300
H	-0.52940100	-1.84388400	0.02277800
C	1.99307200	0.31508600	-0.13163200
N	-0.13237900	1.16898100	-0.78666100
N	-1.06211900	1.64735000	-0.34649100
O	2.20536900	1.25587100	0.60761700
C	-2.73494100	-0.45643200	0.07792900
O	-2.66726600	-1.07081700	-0.97728800
H	-1.65105100	0.34745400	1.84348600
N	2.90608700	-0.65714400	-0.37603600
H	2.66074400	-1.43768700	-0.96214700
C	4.18263400	-0.64637900	0.31292000
H	4.04880500	-0.78470000	1.38953600
H	4.80205900	-1.45139900	-0.08213400
H	4.68405300	0.30969400	0.15033000
C	0.66188300	0.07972700	-0.76771700
H	0.58989400	-0.50015400	-1.68358300
N	-3.91485000	0.07853800	0.52050600
H	-3.91071400	0.76296400	1.25817900
H	-4.67119400	0.11185000	-0.14488000

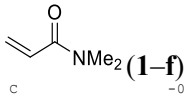
HF: -603.8558177
Sum of electronic and zero-point energies: -603.685076
Sum of electronic and thermal energies: -603.672491
Sum of electronic and thermal enthalpies: -603.671547
Sum of electronic and thermal free energies: -603.724951
Frequencies: -516.3661



(1–e)

C	-1.12405200	-0.20521300	1.01318000
C	0.01058700	-0.95222800	0.76596600
H	0.80397300	-0.97042700	1.50670800
H	-0.09891700	-1.83449500	0.14278000
C	2.42302900	0.30302100	-0.14208500
N	0.28654400	1.15720700	-0.76547800
N	-0.63646300	1.64407200	-0.31806300
O	2.66064500	1.25624300	0.57352300
C	-2.31182900	-0.45157800	0.17176500
O	-2.25002300	-1.08961400	-0.87395700
C	-4.67334800	0.01134300	-0.21979900
H	-4.90647200	-1.03200700	-0.44280800
H	-5.50795600	0.45659200	0.32288900
H	-4.53627300	0.53797600	-1.16956900
H	-1.20879400	0.41744900	1.89639000
N	3.31770200	-0.68893300	-0.37944300
H	3.09811400	-1.40826300	-1.04813700
C	4.64318100	-0.63355200	0.20645300
H	4.56037100	-0.40607000	1.27063400
H	5.12605300	-1.60252500	0.07974800
H	5.25417500	0.14259600	-0.26358100
C	1.07378100	0.06304400	-0.73508700
H	0.96869700	-0.54503500	-1.62937300
N	-3.48387000	0.08889600	0.60156300
H	-3.47344200	0.69346500	1.40538100

HF: -643.14415
Sum of electronic and zero-point energies: -642.944730
Sum of electronic and thermal energies: -642.930692
Sum of electronic and thermal enthalpies: -642.929748
Sum of electronic and thermal free energies: -642.986586
Frequencies: -523.2053



(1–f)

C	-0.90644000	0.17378700	0.95372000
C	0.29766000	-0.48578400	1.12631100
H	1.03667100	-0.05552800	1.79595300
H	0.29390700	-1.56729200	1.03326400
C	2.68125900	0.23044300	-0.28335600
N	0.52566900	0.62124200	-1.23280900
N	-0.42797800	1.22241300	-1.11023600
O	2.91549700	1.41842400	-0.17832900
C	-1.96771800	-0.55493900	0.23021400
O	-1.68795400	-1.57045200	-0.40797300
C	-4.24412800	-0.60750600	-0.62148400
H	-3.85866000	-1.53217500	-1.04613600
H	-5.15838200	-0.81821900	-0.05720100
H	-4.48738200	0.08968900	-1.43339500
H	-1.08058100	1.13649200	1.41111700
N	3.58723300	-0.73382600	0.01527600
H	3.31757600	-1.70250100	-0.03286400
C	4.88247000	-0.37307000	0.55942100
H	4.78299800	0.07690800	1.55133700
H	5.49740200	-1.27034800	0.62738100
H	5.36973200	0.35011100	-0.09738400
C	1.33590100	-0.29463400	-0.66241000
H	1.24085900	-1.26702600	-1.13826500
N	-3.23569200	-0.04560700	0.25487100
C	-3.56384500	1.20234900	0.91547200
H	-4.65108000	1.28264700	0.97834800
H	-3.17290900	1.22483400	1.93451600
H	-3.18608000	2.07520400	0.36668500

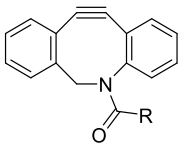
HF: -682.4287447
Sum of electronic and zero-point energies: -682.200512
Sum of electronic and thermal energies: -682.184424
Sum of electronic and thermal enthalpies: -682.183480
Sum of electronic and thermal free energies: -682.246558
Frequencies: -522.129


(1–g)

C	-1.05988500	1.01369600	-0.17732800
C	-0.37390700	0.04177800	-0.51042500
C	2.50939900	0.26172600	0.14583100
N	1.25886600	2.10759200	-0.68256900
N	0.36684100	2.73326800	-0.35283900
O	2.62642800	0.75187100	1.25115300
N	3.08679900	-0.92421000	-0.20337100
H	2.81190100	-1.35587500	-1.07109400
C	3.70916500	-1.74462800	0.81726100
H	2.97116700	-2.15355300	1.51606200
H	4.24695200	-2.56177300	0.33551100
H	4.41340200	-1.13546700	1.38553300
C	1.68384000	0.86822100	-0.93026300
H	1.89512600	0.66641600	-1.97515300
C	-0.24760400	-1.41312400	-0.72581700
H	0.34408800	-1.63596400	-1.62298000
H	0.29218100	-1.85751100	0.12201500
C	-2.29297800	1.66021200	0.29588400
H	-2.06132800	2.50149700	0.95699600
H	-2.82382400	2.08314200	-0.56688200
C	-1.62845800	-2.06895300	-0.85833900
H	-1.47269200	-3.14832200	-0.97017500
H	-2.09473700	-1.72184900	-1.78815000
C	-3.19945200	0.65525200	1.02072800
H	-2.72056700	0.36332400	1.96311100
H	-4.12482700	1.17758100	1.28941800
C	-2.58798300	-1.81711600	0.31912200

H	-3.20655000	-2.71467600	0.42102400
H	-2.00951900	-1.74806900	1.25002300
C	-3.55145700	-0.60803700	0.21748100
H	-4.53116000	-0.94602700	0.57023400
H	-3.69265500	-0.33855200	-0.83807700

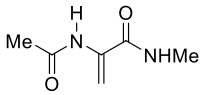
HF: -668.5138707
Sum of electronic and zero-point energies: -668.242174
Sum of electronic and thermal energies: -668.226322
Sum of electronic and thermal enthalpies: -668.225378
Sum of electronic and thermal free energies: -668.286510
Frequencies: -464.2204



(1–DIBAC)

C	-1.93071000	-1.19231300	-0.27869300
C	-2.43568200	-0.02272400	0.33307300
C	-3.72844300	-0.01979100	0.85069600
C	-4.55105000	-1.13130000	0.71420000
C	-4.07088100	-2.27428600	0.08305800
C	-2.76729100	-2.30712800	-0.39235700
H	-4.08450200	0.86839900	1.36194400
H	-5.55938300	-1.10638600	1.11198000
H	-4.70492300	-3.14748200	-0.02127400
H	-2.37653900	-3.20305400	-0.85759300
C	-0.56080700	-1.17876600	-0.71301700
C	0.49856400	-0.55220400	-0.88041600
C	1.21992800	0.68840900	-0.73660600
C	2.28295400	1.07051900	-1.56184200
C	0.81040500	1.53550700	0.31003600
C	2.95742200	2.26295700	-1.33366100
H	2.56765800	0.42700800	-2.38956300
C	1.49681600	2.72650500	0.52571300
C	2.57272600	3.08710500	-0.27772200
H	3.77546900	2.55532500	-1.98328800
H	1.15698600	3.38862400	1.31525100
H	3.09249800	4.02153700	-0.09867400
N	0.10114500	-3.33380900	-0.87142600
N	1.20611100	-3.08077300	-0.95331300
C	2.12138200	-2.11801100	-0.90751700
H	2.75354300	-2.02982600	-1.78332200
C	2.64524200	-1.86131400	0.47142200
O	2.12528300	-2.34109900	1.45806200
N	3.70845900	-1.01371100	0.51011500
H	3.88153200	-0.46090400	-0.31712200
C	4.08723500	-0.41878900	1.78036600
H	5.06030100	0.06027000	1.66869900
H	3.35090600	0.32241000	2.11170500
H	4.15522700	-1.20519400	2.53195300
N	-1.64067300	1.15023500	0.42354000
C	-0.36986100	1.14641200	1.17155200
H	-0.23073000	0.13942400	1.57211900
H	-0.45905900	1.85165400	2.00269200
C	-2.07789600	2.38393500	-0.00755700
C	-3.27574700	2.44129800	-0.93184300
H	-3.40894200	1.52628100	-1.50992800
H	-4.18671200	2.62350800	-0.35623100
H	-3.12004100	3.29304000	-1.59399000
O	-1.47958500	3.39430600	0.31180100

HF: -1141.952745
Sum of electronic and zero-point energies: -1141.605978
Sum of electronic and thermal energies: -1141.584083
Sum of electronic and thermal enthalpies: -1141.583139
Sum of electronic and thermal free energies: -1141.656540
Frequencies: -432.7347



(1–nisin)

C5

C	-1.04218100	0.32611400	-0.53467100
C	0.00020800	-0.34932000	-1.14123600
H	-0.21576800	-1.26961900	-1.66910700
N	0.34585300	-0.80695500	1.41623700
N	-0.48951000	-0.07363200	1.66059600
C	-1.03055900	1.79592000	-0.29240700
O	-2.08303700	2.42301600	-0.25174900
C	1.07105400	-1.32082500	0.40686800
C	0.24570900	3.80240100	0.15059700
H	-0.22106200	4.03617000	1.11305300
H	1.29280000	4.10556100	0.17133900
H	-0.27718700	4.36530900	-0.62501900
H	0.83271200	0.24198600	-1.50732200
H	-3.07260900	0.49103500	-0.41257400
C	-2.62348500	-1.50832600	-0.16565200
O	-1.75271100	-2.35495700	-0.01221300
N	-2.34550600	-0.21336400	-0.45656700
C	-4.08987600	-1.85664100	-0.05267200
H	-4.25619700	-2.32654900	0.91852600
H	-4.74844400	-0.99335900	-0.16028900
H	-4.32988800	-2.59211600	-0.82380200
N	0.18062300	2.38425200	-0.14227800
H	0.98389000	1.80905400	0.08609600
C	2.40978000	-0.68203700	0.26373500
N	3.34750400	-1.44194100	-0.34237400
O	2.59426400	0.48875400	0.56470800
H	0.91784500	-2.38551800	0.26498000
H	3.17692500	-2.42718700	-0.46002500
C	4.65974700	-0.90185600	-0.64538700
H	5.27731900	-0.82617500	0.25421300
H	5.15094900	-1.55064300	-1.37062900
H	4.54546600	0.09644700	-1.06975400

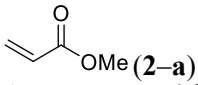
HF: -851.1120152
Sum of electronic and zero-point energies: -850.856236
Sum of electronic and thermal energies: -850.837375
Sum of electronic and thermal enthalpies: -850.836430
Sum of electronic and thermal free energies: -850.903761
Frequencies: -564.8067

C7

C	0.68802800	-0.19772000	-0.41143300
C	-0.33341300	-0.66096000	-1.22233400
H	-1.02869300	0.05877000	-1.64221300
N	-0.92311400	-1.61693100	1.14179500
N	0.08364500	-1.25783100	1.53165300
C	1.92747600	-1.03035400	-0.32015500
O	1.87383700	-2.22434100	-0.59311300
C	-1.74647800	-1.51972800	0.07440900
C	4.28512300	-1.19872800	0.15190000
H	4.60792000	-1.50691400	-0.84851200
H	5.06501900	-0.59302400	0.61498400
H	4.12793100	-2.09968400	0.74731700
H	-0.12778800	-1.55736800	-1.79674500
H	-0.29387200	1.25211500	0.69435300
C	1.30814100	2.20070900	-0.12169400
O	2.30834900	2.16635100	-0.82329400
N	0.55583600	1.10762900	0.16052100
C	0.84701800	3.48773700	0.52628700
H	0.79509700	4.25681900	-0.24622800
H	-0.11956700	3.39917000	1.02531700
H	1.60140200	3.79716600	1.25342800
N	3.05904500	-0.42679500	0.10976800
H	3.12297300	0.57172900	-0.05321600
C	-2.70585000	-0.38140700	0.22819400
N	-3.84445100	-0.48480000	-0.48924400
O	-2.41226500	0.61608500	0.86832500
H	-2.08000800	-2.47227700	-0.32395100
H	-4.08542700	-1.36611900	-0.91134800
C	-4.79566100	0.61151100	-0.52233100
H	-4.28105300	1.53501900	-0.79388800
H	-5.55995400	0.39143500	-1.26722900
H	-5.26637600	0.75313300	0.45407500

HF: -851.1047392
Sum of electronic and zero-point energies: -850.849207
Sum of electronic and thermal energies: -850.830239
Sum of electronic and thermal enthalpies: -850.829294
Sum of electronic and thermal free energies: -850.897804
Frequencies: -560.0924

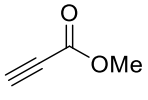
Transition States with Azidoacetamide 2



(2–a)

C	-1.36407200	-0.41681000	-0.72134700
C	-0.50370400	0.49639000	-1.29291300
H	0.36987400	0.13425400	-1.82405200
H	-0.89370800	1.47324800	-1.55775400
C	2.70917500	0.01549600	-0.02742500
N	0.13724200	0.47640000	1.20491700
N	-0.69253400	-0.27683300	1.43688400
O	2.09823700	-1.01970700	-0.19734500
C	-2.72960600	0.01146600	-0.37741700
O	-3.12466100	1.15364300	-0.36634500
O	-3.51042000	-1.03497000	-0.05249900
C	-4.83898700	-0.69616100	0.33187300
H	-5.35048700	-0.17493900	-0.48009600
H	-5.33367100	-1.64066400	0.55323800
H	-4.82689100	-0.05229000	1.21402300
H	-1.15292400	-1.47756200	-0.72303600
N	0.56077200	1.23407000	0.28331300
C	1.99658600	1.36127800	0.14002900
H	2.42721500	1.92202700	0.97769900
H	2.15066700	1.95951200	-0.76287800
N	4.06035600	0.07530000	0.00845000
H	4.51558500	0.95168300	0.20289600
C	4.85541700	-1.12855500	-0.15443700
H	4.60938600	-1.61644700	-1.10021100
H	5.91088200	-0.85712800	-0.15193400
H	4.65911700	-1.83459600	0.65649100

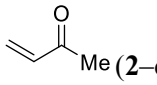
HF: -718.3224768
Sum of electronic and zero-point energies: -718.117403
Sum of electronic and thermal energies: -718.102992
Sum of electronic and thermal enthalpies: -718.102047
Sum of electronic and thermal free energies: -718.160413
Frequencies: -483.2897



(2–b)

C	-1.86861600	0.75346700	-0.14780200
C	-0.91645300	1.44587100	-0.51841400
H	-0.45525200	2.33459000	-0.89594200
C	3.10694800	-0.10873800	0.06597500
N	0.19653100	-0.73755300	0.02535000
N	-0.81850700	-1.18873300	0.28817700
O	2.99317100	-1.31448200	0.08660700
C	-3.19298100	0.34170200	0.26787800
O	-3.63993600	0.49422600	1.37449000
O	-3.85507900	-0.25119500	-0.73476300
C	-5.15884800	-0.72040400	-0.38939800
H	-5.78642400	0.10971100	-0.05915300
H	-5.55803700	-1.16758800	-1.29779900
H	-5.09323400	-1.46088500	0.41020100
N	4.30436300	0.51831800	-0.00249400
H	4.34212800	1.52016100	-0.08390800
C	5.53271500	-0.25409000	-0.04581900
H	5.58517500	-0.84810700	-0.96178200
H	6.38075300	0.42908900	-0.00613800
H	5.57435900	-0.93501000	0.80677900
N	0.72335600	0.28692400	-0.48728400
C	1.89518000	0.81967100	0.18972500
H	1.70421400	0.98641000	1.25835300
H	2.09320600	1.78567400	-0.28039100

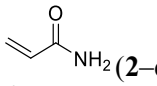
HF: -717.0628467
Sum of electronic and zero-point energies: -716.882230
Sum of electronic and thermal energies: -716.867608
Sum of electronic and thermal enthalpies: -716.866664
Sum of electronic and thermal free energies: -716.926094
Frequencies: -469.5824



(2–c)

C	-1.76218700	-0.53003100	-0.67015900
C	-0.93111800	0.39041200	-1.27457000
H	-0.05259100	0.04377200	-1.80860400
H	-1.35419000	1.34948500	-1.55523900
C	2.31059600	0.05154600	-0.03173300
N	-0.26424300	0.45018800	1.22138400
N	-1.06374300	-0.32116100	1.49327400
O	1.73643500	-1.01386800	-0.12786700
C	-3.13909400	-0.13931000	-0.29215200
O	-3.52295500	1.01117200	-0.35372500
H	-1.49662000	-1.58073700	-0.64378500
N	0.12262600	1.19568100	0.27606600
C	1.55062100	1.37392100	0.11283900
H	1.96947900	1.96745200	0.93371500
H	1.67134100	1.95813400	-0.80411000
N	3.65826400	0.16610300	-0.05664800
H	4.08457300	1.07153000	0.05196000
C	4.49449500	-1.01018700	-0.21462500
H	4.27810400	-1.50805700	-1.16297000
H	5.54028400	-0.70411000	-0.19777000
H	4.31042600	-1.72040400	0.59494900
C	-4.03786500	-1.25172700	0.19730000
H	-4.16376600	-2.00113600	-0.59072300
H	-3.57002800	-1.75111200	1.05162300
H	-5.00786800	-0.84668100	0.48375600

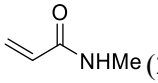
HF: -643.1087358
Sum of electronic and zero-point energies: -642.910155
Sum of electronic and thermal energies: -642.896323
Sum of electronic and thermal enthalpies: -642.895378
Sum of electronic and thermal free energies: -642.952625
Frequencies: -477.4251



(2–d)

C	-1.77229300	-0.55614400	-0.64877900
C	-0.95486800	0.37105600	-1.25435300
H	-0.07144200	0.03457300	-1.78585000
H	-1.38693600	1.32831700	-1.52570300
C	2.30926200	0.06359400	-0.02810200
N	-0.26677800	0.40894800	1.24230400
N	-1.06212900	-0.37748700	1.48831800
O	1.74845300	-1.00759000	-0.13935900
C	-3.16044300	-0.16619800	-0.29625000
O	-3.58208200	0.96982600	-0.41109900
H	-1.50499200	-1.60642300	-0.64227300
N	0.11006000	1.17770000	0.31221800
C	1.53519700	1.37361200	0.14843600
H	1.95228800	1.95285100	0.98052400
H	1.64692300	1.97919300	-0.75579300
N	3.65531700	0.19587300	-0.06221900
H	4.07019200	1.10594700	0.05154900
C	4.50570700	-0.96458300	-0.25585300
H	4.29342600	-1.43936900	-1.21697400
H	5.54758500	-0.64580400	-0.23293300
H	4.33334200	-1.69889300	0.53440500
N	-3.95640000	-1.19127800	0.15021600
H	-3.51867800	-2.02099900	0.51741600
H	-4.82853200	-0.91159500	0.57284900

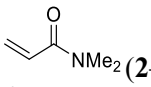
HF: -659.1743234
Sum of electronic and zero-point energies: -658.985777
Sum of electronic and thermal energies: -658.972365
Sum of electronic and thermal enthalpies: -658.971420
Sum of electronic and thermal free energies: -659.027565
Frequencies: -482.1793



(2–e)

C	-1.35600100	-0.37283500	-0.78558200
C	-0.47182400	0.56275400	-1.27264100
H	0.41725900	0.23251600	-1.79882800
H	-0.84706500	1.56144000	-1.46834900
C	2.72995800	0.01506700	0.02570000
N	0.11297400	0.33408700	1.24225400
N	-0.72661500	-0.43501500	1.37179100
O	2.13759900	-1.02679400	-0.16769300
C	-2.73948700	0.05388500	-0.45027900
O	-3.09834100	1.22049700	-0.46847400
H	-1.13965100	-1.43167400	-0.87094700
N	0.56074300	1.17300000	0.40912000
C	1.99706600	1.32671200	0.32419900
H	2.39994900	1.78284900	1.23617900
H	2.17138600	2.03135500	-0.49406300
N	4.07930900	0.11212300	-0.01470900
H	4.52160300	0.99413900	0.18443400
C	4.89504300	-1.05634200	-0.29090500
H	4.62003900	-1.49022700	-1.25502400
H	5.94273600	-0.75730600	-0.31519100
H	4.75239400	-1.81730500	0.48034300
N	-3.59614300	-0.95626400	-0.12229300
H	-3.19538400	-1.85463700	0.09447800
C	-4.91815000	-0.64633800	0.38096500
H	-5.40631300	0.05040200	-0.30207100
H	-5.50403400	-1.56491600	0.43523500
H	-4.87849300	-0.17919100	1.37126400

HF: -698.46284
Sum of electronic and zero-point energies: -698.245843
Sum of electronic and thermal energies: -698.230905
Sum of electronic and thermal enthalpies: -698.229961
Sum of electronic and thermal free energies: -698.289691
Frequencies: -484.9341



(2–f)

C	1.14824300	0.08947600	-0.79245200
C	0.22333800	-0.83289200	-1.22848800
H	-0.63664100	-0.49257500	-1.79523600
H	0.54311000	-1.86282200	-1.34091700
C	-2.96999700	-0.00158000	-0.00236500
N	-0.39583100	-0.38795900	1.25175100
N	0.47897300	0.34465200	1.35292100
O	-2.31728000	0.98160300	-0.28753300
C	2.49829400	-0.40403900	-0.40002400
O	2.75541000	-1.60130000	-0.39505600
H	0.97518800	1.14178200	-0.96914800
N	-0.87284800	-1.25779300	0.46875600
C	-2.31408700	-1.33701800	0.36179400
H	-2.75629000	-1.73942900	1.28092100
H	-2.51067100	-2.06036900	-0.43487300
N	-4.32362300	-0.01165600	0.00026100
H	-4.81344300	-0.83580500	0.30727600
C	-5.07170600	1.18904800	-0.32474500
H	-4.73089800	1.58891900	-1.28168100
H	-6.13013300	0.93825700	-0.39391600
H	-4.92933900	1.95859100	0.43878900
N	3.42443300	0.53611600	-0.04397700
C	4.78438300	0.12352100	0.23728100
H	4.86670600	-0.94770100	0.06436600
H	5.48477400	0.65544700	-0.41730400
H	5.04697200	0.34258400	1.27879100
C	3.14376300	1.95685200	0.03300200
H	3.19135700	2.44535700	-0.94872600
H	2.16755500	2.14290300	0.48293300
H	3.89559400	2.41872600	0.67744200

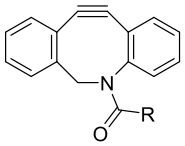
HF: -737.7479698
Sum of electronic and zero-point energies: -737.502516
Sum of electronic and thermal energies: -737.486239
Sum of electronic and thermal enthalpies: -737.485295
Sum of electronic and thermal free energies: -737.548075
Frequencies: -480.0474

(2–g)

C	-1.14805900	1.08081400	0.07925700
C	-0.64713800	0.25849300	-0.68950900

C	2.64952000	-0.15355500	0.18172300
N	1.10377700	2.17355400	-0.52691100
N	0.34202100	2.70259300	0.14324000
O	2.66415500	0.57025000	1.15653900
N	2.81313700	-1.49621100	0.26276500
H	2.71068000	-2.05950500	-0.56419800
C	2.96968500	-2.13701500	1.55464600
H	2.05445600	-2.05004300	2.14734400
H	3.20735600	-3.18983200	1.40211300
H	3.78055100	-1.65809400	2.10683300
C	-0.63732200	-1.01052600	-1.43251400
H	-0.27637900	-0.86364700	-2.45639600
H	0.05667800	-1.71021900	-0.94491100
C	-2.20038600	1.53922100	0.99845300
H	-1.76668500	2.08617100	1.84123100
H	-2.84814500	2.24830800	0.46775300
C	-2.04710400	-1.62198500	-1.45359300
H	-1.97486700	-2.61408800	-1.91367300
H	-2.68186100	-1.01659500	-2.11099200
C	-3.03209700	0.35095300	1.50257200
H	-2.41633600	-0.24881000	2.18360400
H	-3.85902000	0.75129500	2.10015200
C	-2.71795300	-1.74535500	-0.07243900
H	-3.35366000	-2.63585500	-0.10215300
H	-1.94958200	-1.95177200	0.68449200
C	-3.60058500	-0.55983900	0.39925200
H	-4.53627700	-0.98078500	0.78056200
H	-3.88153600	0.05553700	-0.46574000
N	1.23347700	1.20414400	-1.31517000
C	2.45739500	0.41972000	-1.22001500
H	3.33563000	1.02560700	-1.46704200
H	2.36313100	-0.36378600	-1.97575500

HF: -723.8356564
Sum of electronic and zero-point energies: -723.546507
Sum of electronic and thermal energies: -723.530386
Sum of electronic and thermal enthalpies: -723.529442
Sum of electronic and thermal free energies: -723.591089
Frequencies: -452.4287



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C	-2.06784700	-1.15365400	-0.26375900
C	-2.51227900	0.05627200	0.31471700
C	-3.77842200	0.11993400	0.88993100
C	-4.63009500	-0.97774200	0.85114100
C	-4.20592900	-2.16458200	0.26122400
C	-2.92956700	-2.25391500	-0.27710800
H	-4.08974200	1.04091300	1.37157800
H	-5.61730600	-0.90722400	1.29398700
H	-4.86282900	-3.02648500	0.23563200
H	-2.57850500	-3.18040500	-0.71408900
C	-0.72644200	-1.18641900	-0.77621100
C	0.32125700	-0.57134000	-1.02047700
C	1.13013500	0.61187500	-0.91780700
C	2.21692500	0.89630600	-1.75059000
C	0.79190200	1.49491600	0.12569000
C	2.98708200	2.03080900	-1.52862000
H	2.44675300	0.21447400	-2.56325700
C	1.56997700	2.62897600	0.32939200
C	2.67176200	2.89279800	-0.47799700
H	3.82711400	2.25022000	-2.17904300
H	1.28983000	3.32008600	1.11816000
H	3.26637900	3.78346100	-0.30711100
N	-0.08170500	-3.30599800	-0.82800200
N	1.01934400	-3.04349900	-0.98723200
C	2.69739800	-1.46390700	0.88981000
O	1.92334400	-2.07536000	1.60020500
N	3.35007100	-0.34373700	1.28319900
H	3.71585500	0.26454700	0.56354000
C	3.04520700	0.24148000	2.57514900
H	3.20024900	-0.50439300	3.35645200
H	3.70950500	1.08969500	2.74279000
H	2.00474700	0.58147800	2.62492700
N	-1.67410600	1.20281700	0.32155000
C	-0.38098100	1.17836000	1.02645300
H	-0.26245800	0.17730000	1.45141000
H	-0.41799100	1.90952400	1.84016500
C	-2.07684500	2.43430500	-0.14685500
C	-3.30790700	2.50107900	-1.02472200
H	-3.50225400	1.56681500	-1.55231100
H	-4.18514700	2.74919300	-0.42205600
H	-3.14583500	3.31338900	-1.73319000
O	-1.42487500	3.43026700	0.10628800
N	1.80956500	-2.13035400	-1.31577500
C	3.02429100	-1.97040900	-0.51548000
H	3.54613500	-2.92662600	-0.41710800
H	3.66785100	-1.28066000	-1.06188900

HF: -1197.2772796
Sum of electronic and zero-point energies: -1196.912318
Sum of electronic and thermal energies: -1196.889791
Sum of electronic and thermal enthalpies: -1196.888847
Sum of electronic and thermal free energies: -1196.962859
Frequencies: -441.5162

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(2) Slootweg, J. C.; Liskamp, R. M. J.; Rijkers, D. T. S. *J. Pept. Sci.* **2013**, *19*, 692–699.

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