

Stereocontrol in a Combined Allylic Azide Rearrangement and Intramolecular Schmidt Reaction

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Computational study

All stationary points were calculated using B3LYP^{S1} with the 6-31G (d,p) basis set (SDD was used for Sn) in DCM (CPCM; UA0) as implemented in GAUSSIAN09.^{S2} As shown in **Figure S1-1**, the relative energies for the carbon alkyl migration/N₂ leaving show that all transition state structures with a vinyl group occupying an axial position are 5-8 kcal/mol higher in energy than the corresponding transition state structures with a vinyl group at an equatorial position. Although the vinyl group has an A value around 1.6-2, the much larger energy difference is attributed to severe A^{1,3} diaxial strain between the vinyl group and the O-LA group/hydrocarbon chain. Therefore, fused lactam **2a** arises predominately from **TS-A-eq**, although **TS-C-eq** certainly contributes, and **2b** arises from **TS-B-eq**. For this system, the transition state structure leading to the bridged lactam is too high in energy and is not expected to produce any significant product. Note: the overall barrier from the lowest energy reactant (complexed to SnCl₄) to the lowest energy transition state structure (**TS-A-eq**) is 28.7 kcal/mol, which is much higher than that calculated for the allylic azide rearrangement (ca. 22 kcal/mol)^{S3} and therefore the overall regio- and diastereoselectivity is controlled by the alkyl migration/N₂ loss transition state structures. Although not observed in this study, transition states leading to bridged isomers **2e** and **2f** were also calculated for completeness.

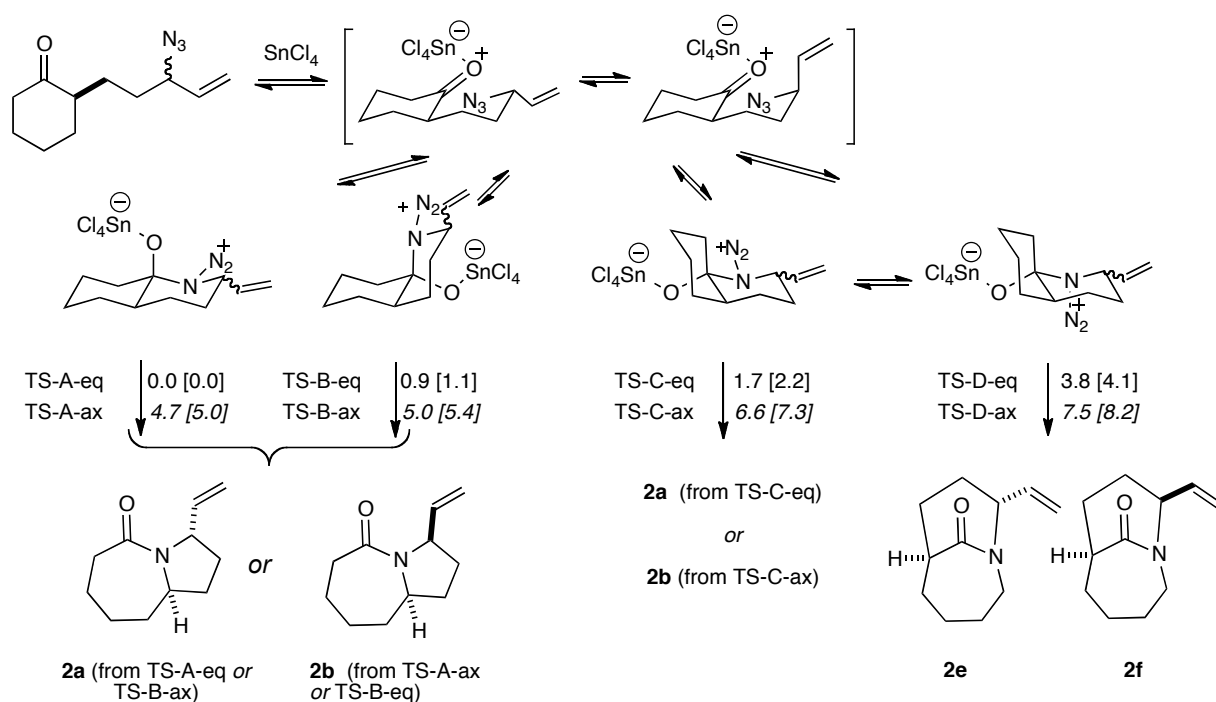


Figure SI-1. Relative enthalpies (free energies in brackets; 298.15 K) of transition state structures calculated using B3LYP/6-31G (d,p)-[SDD for Sn] in DCM (CPCM;UA0).

TS-A-eq

Zero-point correction=	0.277218 (Hartree/Particle)
Thermal correction to Energy=	0.301004
Thermal correction to Enthalpy=	0.301948
Thermal correction to Gibbs Free Energy=	0.220929
Sum of electronic and zero-point Energies=	-2512.825778
Sum of electronic and thermal Energies=	-2512.801992
Sum of electronic and thermal Enthalpies=	-2512.801048
Sum of electronic and thermal Free Energies=	-2512.882067

C	1.66787300	3.59179600	-0.36189700
C	2.03703200	2.55410200	-1.42708700
C	2.95041800	1.44758300	-0.87688000
C	2.18475500	0.73176800	0.35194800
C	1.82501900	1.78579300	1.41320900
C	0.97874500	2.92856900	0.83623700
H	1.13181500	2.09654800	-1.84032400
H	2.57280800	3.03212600	-2.25575300
H	2.57534300	4.11148400	-0.02576700
H	1.01038600	4.35277800	-0.79534400
H	1.28355100	1.29287900	2.23007900
H	2.75663500	2.18411600	1.82964900
H	0.00058300	2.54475000	0.52899400
H	0.79592400	3.65925400	1.63058300
H	3.85402000	1.90856100	-0.46175100
C	3.34064500	0.39076400	-1.91063400
H	3.88262200	0.87546900	-2.72994100
H	2.43648000	-0.05516300	-2.33462900
C	3.60132100	-1.30017700	0.01425600
N	3.30870900	-0.10239100	0.81620600
C	4.22740800	-0.68550400	-1.28718200
H	4.38419700	-1.52858000	-1.96569200
H	5.20922800	-0.27417400	-1.03097300
N	3.29528500	-0.48680100	3.45597900
N	3.07026300	-0.60358200	2.37411400
O	1.12225800	0.03728900	-0.18373900
Sn	-0.63128900	-0.71120900	0.49155400
Cl	-1.79200600	0.21690800	2.39385100
Cl	0.58466500	-2.28146500	1.99766600
Cl	-1.79378800	0.82634000	-1.04245400
Cl	-1.48637700	-2.59892000	-0.72928600
H	2.67997700	-1.83083800	-0.23739400
C	4.58264800	-2.19244100	0.71512500
H	5.51656600	-1.72887400	1.02842600
C	4.35711900	-3.49078600	0.92286000
H	3.43272800	-3.96864400	0.61004100
H	5.09416500	-4.11784300	1.41455700

TS-A-ax

Zero-point correction=	0.277569 (Hartree/Particle)
Thermal correction to Energy=	0.301264
Thermal correction to Enthalpy=	0.302208
Thermal correction to Gibbs Free Energy=	0.221705
Sum of electronic and zero-point Energies=	-2512.818218
Sum of electronic and thermal Energies=	-2512.794523
Sum of electronic and thermal Enthalpies=	-2512.793579
Sum of electronic and thermal Free Energies=	-2512.874083

C	1.25873000	3.65716600	0.46386600
C	1.59092500	2.92156400	-0.83888500
C	2.39173700	1.63359700	-0.59314900
C	1.49305200	0.67270400	0.35305200
C	1.20206400	1.42163000	1.66683800
C	0.47900200	2.75374600	1.42714800
H	0.67494500	2.67439300	-1.38602300
H	2.20104100	3.55921200	-1.48956800
H	2.18973600	3.98756000	0.94354700
H	0.67806000	4.55960800	0.24555600
H	0.60267300	0.77103200	2.31316600
H	2.15680800	1.60245300	2.17139800
H	-0.52407700	2.56959900	1.02676400
H	0.33463300	3.24963900	2.39222600
H	3.29402300	1.88410700	-0.02365600
C	2.78830000	0.88249700	-1.86330000
H	3.38171300	1.54772700	-2.49993500
H	1.89265900	0.60875300	-2.42824900
C	2.89464000	-1.29962700	-0.49431400
N	2.49795700	-0.36209400	0.58319000
C	3.62106500	-0.34614200	-1.51033900
H	3.84624000	-0.96220300	-2.38557300
H	4.57155200	-0.03992300	-1.06315300
N	2.35807100	-1.81625700	2.82670700
N	2.08586900	-1.32289500	1.87043900
H	3.66139000	-1.93984800	-0.05009100
C	1.83002200	-2.16173600	-1.12015200
C	1.82548100	-3.48630700	-0.96475400
H	1.08351900	-1.66961600	-1.73247900
H	1.06989200	-4.10575400	-1.43765900
H	2.57149000	-3.99850800	-0.36142400
O	0.39406900	0.28185200	-0.38181100
Sn	-1.55600100	-0.17151600	-0.06388200
Cl	-3.17088400	1.16507700	1.14023900
Cl	-1.06761400	-1.42942500	2.02244300
Cl	-1.98084300	1.11887700	-2.11757800
Cl	-2.31489100	-2.19610700	-1.12141700

TS-B-eq

Zero-point correction=	0.277503 (Hartree/Particle)
Thermal correction to Energy=	0.301268
Thermal correction to Enthalpy=	0.302212
Thermal correction to Gibbs Free Energy=	0.221388
Sum of electronic and zero-point Energies=	-2512.824265
Sum of electronic and thermal Energies=	-2512.800500
Sum of electronic and thermal Enthalpies=	-2512.799556
Sum of electronic and thermal Free Energies=	-2512.880379

C	3.08786300	0.81524200	-1.84656800
C	2.41620700	-0.46641900	-2.33891200
C	2.13514700	-1.43990300	-1.18883500
C	1.23363500	-0.69812400	-0.07177600
C	2.28220900	1.48666900	-0.67859400
H	3.06057500	-0.95798700	-3.07605900
H	1.47694400	-0.22075300	-2.84046100
H	3.14115500	1.57009100	-2.63584500
H	4.10868000	0.62634700	-1.50199200
H	1.43326800	-2.21066700	-1.52876400
C	3.37943000	-2.12676400	-0.60588100
H	3.84267200	-2.70777000	-1.41185700
H	4.11785300	-1.38196500	-0.28971000
C	2.27400100	-2.29500100	1.66837000
C	3.04184900	-3.04695100	0.57522800
H	3.96202400	-3.47449000	0.98699800
H	2.43291500	-3.88843100	0.21915400
H	1.99512000	-2.97520000	2.47955100
O	0.09016100	-0.25725500	-0.70084900
Sn	-1.81906600	-0.02218500	-0.06034000
Cl	-1.15808400	2.23098200	0.77763400
Cl	-3.22814900	0.94492300	-1.73691900
Cl	-2.74877700	-0.53412800	2.11319700
Cl	-2.30150100	-2.31652800	-0.83250400
N	2.15637200	0.39121400	0.29471600
N	1.67115000	1.08960400	1.72033200
N	1.76167800	1.20638200	2.82095400
H	2.91824700	-1.52663100	2.11290200
C	0.99725300	-1.65968400	1.10366400
H	0.33495700	-2.44066900	0.71651800
H	0.43463500	-1.13754200	1.88768000
C	3.03787000	2.63987800	-0.08889700
H	4.01609100	2.41267100	0.33132800
C	2.56495300	3.88767800	-0.09341200
H	3.13865900	4.70818600	0.32588500
H	1.59283500	4.12964600	-0.51442200
H	1.29717200	1.78893400	-1.04243900

TS-B-ax

Zero-point correction=	0.277988 (Hartree/Particle)
Thermal correction to Energy=	0.301623
Thermal correction to Enthalpy=	0.302567
Thermal correction to Gibbs Free Energy=	0.222175
Sum of electronic and zero-point Energies=	-2512.817725
Sum of electronic and thermal Energies=	-2512.794090
Sum of electronic and thermal Enthalpies=	-2512.793146
Sum of electronic and thermal Free Energies=	-2512.873537

C	3.30408400	0.79297500	-1.65205700
C	2.25743900	-0.20279100	-2.14210300
C	1.91370200	-1.22684100	-1.05394800
C	1.34663900	-0.46553600	0.24493700
C	2.86473500	1.52482100	-0.33181000
H	2.64225800	-0.73225400	-3.02047500
H	1.35067700	0.31941700	-2.45971700
H	3.48631100	1.58930700	-2.37875100
H	4.25945300	0.29660100	-1.46571300
H	1.03304300	-1.80265300	-1.35727500
C	3.05107500	-2.21243800	-0.73339000
H	3.25320700	-2.78643600	-1.64524300
C	3.97297600	-1.67300800	-0.49075600
H	2.31068600	-2.38507300	1.67938000
C	2.71068500	-3.16426100	0.42131700
H	3.57029900	-3.80926300	0.63191900
H	1.88482100	-3.82344400	0.12360300
H	2.03511500	-3.07248900	2.48602200
O	0.22847400	0.30829400	-0.03608600
Sn	-1.74821000	-0.02396700	-0.30411200
Cl	-2.01029000	2.33667500	0.35440800
Cl	-2.64994400	0.47181000	-2.48914200
Cl	-3.15648200	-0.71184600	1.53642200
Cl	-1.52115000	-2.40651400	-0.98573500
N	2.47329900	0.40155500	0.55445000
N	2.13038300	1.14866200	2.00886800
N	2.38647800	1.55136400	3.00935900
H	3.16348400	-1.79889400	2.04267700
C	1.11826700	-1.46731100	1.39063100
H	0.25667600	-2.07511600	1.10093300
H	0.81298800	-0.89818700	2.27798600
C	1.86944800	2.63408900	-0.54715100
H	0.92768200	2.38458800	-1.02018500
C	2.14734200	3.88643200	-0.18064400
H	3.08581400	4.15212200	0.30086200
H	1.44063400	4.69246000	-0.35203700
H	3.76968600	1.94027100	0.12006900

TS-C-eq				TS-C-ax			
Zero-point correction=		0.277627	(Hartree/Particle)	Zero-point correction=		0.277920	(Hartree/Particle)
Thermal correction to Energy=		0.301317		Thermal correction to Energy=		0.301485	
Thermal correction to Enthalpy=		0.302261		Thermal correction to Enthalpy=		0.302429	
Thermal correction to Gibbs Free Energy=		0.221929		Thermal correction to Gibbs Free Energy=		0.222546	
Sum of electronic and zero-point Energies=		-2512.822905		Sum of electronic and zero-point Energies=		-2512.814981	
Sum of electronic and thermal Energies=		-2512.799216		Sum of electronic and thermal Energies=		-2512.791417	
Sum of electronic and thermal Enthalpies=		-2512.798271		Sum of electronic and thermal Enthalpies=		-2512.790472	
Sum of electronic and thermal Free Energies=		-2512.878603		Sum of electronic and thermal Free Energies=		-2512.870355	
C	-1.86060800	3.50906400	0.81689000	C	-2.11836500	3.07900800	1.30883500
C	-1.20683000	2.94824400	-0.45207100	C	-1.33659300	2.85448600	0.00922200
C	-1.61749600	1.49766700	-0.78461300	C	-1.61047500	1.49886700	-0.67434300
C	-1.29519100	0.59323100	0.49326300	C	-1.32582100	0.34024800	0.40178100
C	-1.99012100	1.16324700	1.75396400	C	-2.14423600	0.58566600	1.69411100
C	-1.57371200	2.61179200	2.02906200	C	-1.84214100	1.95235400	2.31428200
H	-1.46255000	3.56256900	-1.32314900	H	-1.57175300	3.63379900	-0.72510800
H	-0.11781800	2.99375100	-0.34954000	H	-0.26433600	2.93300100	0.21548400
H	-1.48167600	4.51972100	1.00170200	H	-1.83388700	4.04503100	1.73889200
H	-2.94441100	3.60636300	0.67601800	H	-3.19474300	3.13613500	1.10203100
H	-3.07651600	1.10818200	1.63615400	H	-3.21034600	0.51159000	1.47607200
H	-1.71125600	0.50844700	2.58807500	H	-1.88810300	-0.22962800	2.38123200
H	-2.11254200	2.97468800	2.91054900	H	-2.46020800	2.07802600	3.20951400
H	-0.50577900	2.63764900	2.26845400	H	-0.79588800	1.98304200	2.63454700
H	-0.97457600	1.12210800	-1.58490300	H	-0.87193100	1.35050600	-1.46575100
C	-3.07238400	1.34504700	-1.24119100	C	-2.99888500	1.36021600	-1.30569300
H	-3.19811500	1.90000300	-2.17710900	H	-3.10727100	2.14038800	-2.06707500
H	-3.76840600	1.78589500	-0.52040000	H	-3.79695200	1.53018700	-0.57621900
C	-3.18868800	-0.97378300	-0.18055300	C	-2.95716600	-1.17693400	-0.94483500
N	-1.76662700	-0.74072000	0.10335800	N	-1.64739000	-0.87408800	-0.33040700
C	-3.41925500	-0.12076200	-1.47554600	C	-3.14121600	-0.00495300	-1.96975500
H	-4.47402300	-0.25911700	-1.72814200	H	-4.13082300	-0.15331100	-2.41104300
H	-2.81872800	-0.54272400	-2.28692400	H	-2.39814800	-0.11922900	-2.76351900
N	-0.81185500	-2.64891200	1.74255400	N	-0.84174500	-3.13391100	0.91018800
N	-1.33020200	-1.74315900	1.36355700	N	-1.30711600	-2.14304800	0.72496900
O	0.05452000	0.52195900	0.78094200	H	-2.79097300	-2.09658600	-1.51185500
Sn	1.75929800	0.13084200	-0.25202900	C	-4.15282500	-1.37254200	-0.04420900
Cl	2.87192300	1.15597500	1.69316200	C	-4.67835500	-2.58027800	0.16496300
Cl	2.72382100	1.80088600	-1.71077500	H	-4.61726300	-0.49547000	0.39580800
Cl	2.88148300	-1.96154100	0.19370100	H	-5.55373000	-2.71147300	0.79329200
Cl	0.66205700	-0.91693800	-2.22076900	H	-4.25791000	-3.47727400	-0.28333000
H	-3.83719200	-0.58535300	0.61107600	O	0.00041800	0.28767500	0.79190600
C	-3.44770800	-2.43262500	-0.42523000	O	1.79809900	0.12013300	-0.14059700
H	-2.81503600	-2.91033600	-1.17078300	Cl	2.71063800	0.64731200	2.08698100
C	-4.40897300	-3.10876300	0.20381700	Cl	2.86071600	2.08722300	-1.06324900
H	-5.04829200	-2.63897800	0.94710000	Cl	2.90017100	-2.03107500	-0.09295800
H	-4.59128500	-4.15730000	-0.00873200	Cl	0.91860800	-0.42384000	-2.40233100

TS-D-eq

Zero-point correction=	0.276931 (Hartree/Particle)
Thermal correction to Energy=	0.300613
Thermal correction to Enthalpy=	0.301557
Thermal correction to Gibbs Free Energy=	0.220934
Sum of electronic and zero-point Energies=	-2512.819565
Sum of electronic and thermal Energies=	-2512.795884
Sum of electronic and thermal Enthalpies=	-2512.794940
Sum of electronic and thermal Free Energies=	-2512.875563

C	-1.46354900	3.60211700	0.44219800
C	-1.58094500	2.99311800	-0.96466700
C	-2.14598200	1.56109600	-0.95348700
C	-1.30815500	0.65579000	0.00292700
C	-1.26726700	1.27294700	1.45053500
C	-0.66810100	2.68640200	1.37962200
H	-2.21945500	3.61798000	-1.59916700
H	-0.59112300	2.97028200	-1.43126500
H	-0.97527400	4.57999400	0.37577600
H	-2.45984200	3.78201800	0.86555700
H	-2.28077700	1.32975100	1.85573600
H	-0.68549200	0.61527000	2.09861800
H	-0.65832000	3.08915700	2.39851600
H	0.37526000	2.63022700	1.05313500
H	-1.99070700	1.11900300	-1.94790200
C	-3.64943500	1.50237900	-0.62531300
H	-4.18972100	2.03648200	-1.41401800
H	-3.86597700	2.03579500	0.30632300
C	-3.33019700	-0.80349500	0.40310300
N	-1.89602200	-0.68508100	0.15942200
C	-4.18395900	0.07177000	-0.53264200
H	-5.21657000	0.06212400	-0.17333500
H	-4.18401200	-0.40699900	-1.52090100
N	-1.45250000	-2.37209600	-1.86707000
N	-1.64132100	-1.40733500	-1.34816100
O	-0.05202500	0.51404500	-0.55533000
Sn	1.74236900	-0.24524600	0.04100400
Cl	2.64729800	1.14791000	-1.77651700
Cl	2.52392600	-2.24026300	-1.06957500
Cl	3.11458600	0.92062300	1.65458500
Cl	0.82348500	-1.65059100	1.87204100
H	-3.37003100	-0.37079800	1.42116100
C	-3.78589900	-2.23947800	0.51648100
H	-4.83953400	-2.39056900	0.29507400
C	-3.01411100	-3.26606900	0.87837800
H	-1.96527500	-3.14027500	1.13411000
H	-3.42042200	-4.27044500	0.93575900

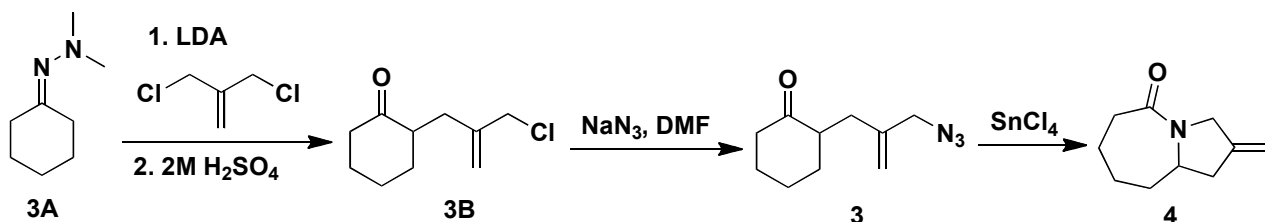
TS-D-ax

Zero-point correction=	0.277834 (Hartree/Particle)
Thermal correction to Energy=	0.301354
Thermal correction to Enthalpy=	0.302298
Thermal correction to Gibbs Free Energy=	0.222303
Sum of electronic and zero-point Energies=	-2512.813530
Sum of electronic and thermal Energies=	-2512.790011
Sum of electronic and thermal Enthalpies=	-2512.789066
Sum of electronic and thermal Free Energies=	-2512.869061

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Experimental Details

Scheme S1. Preparation of azide **3** and lactam **4**.

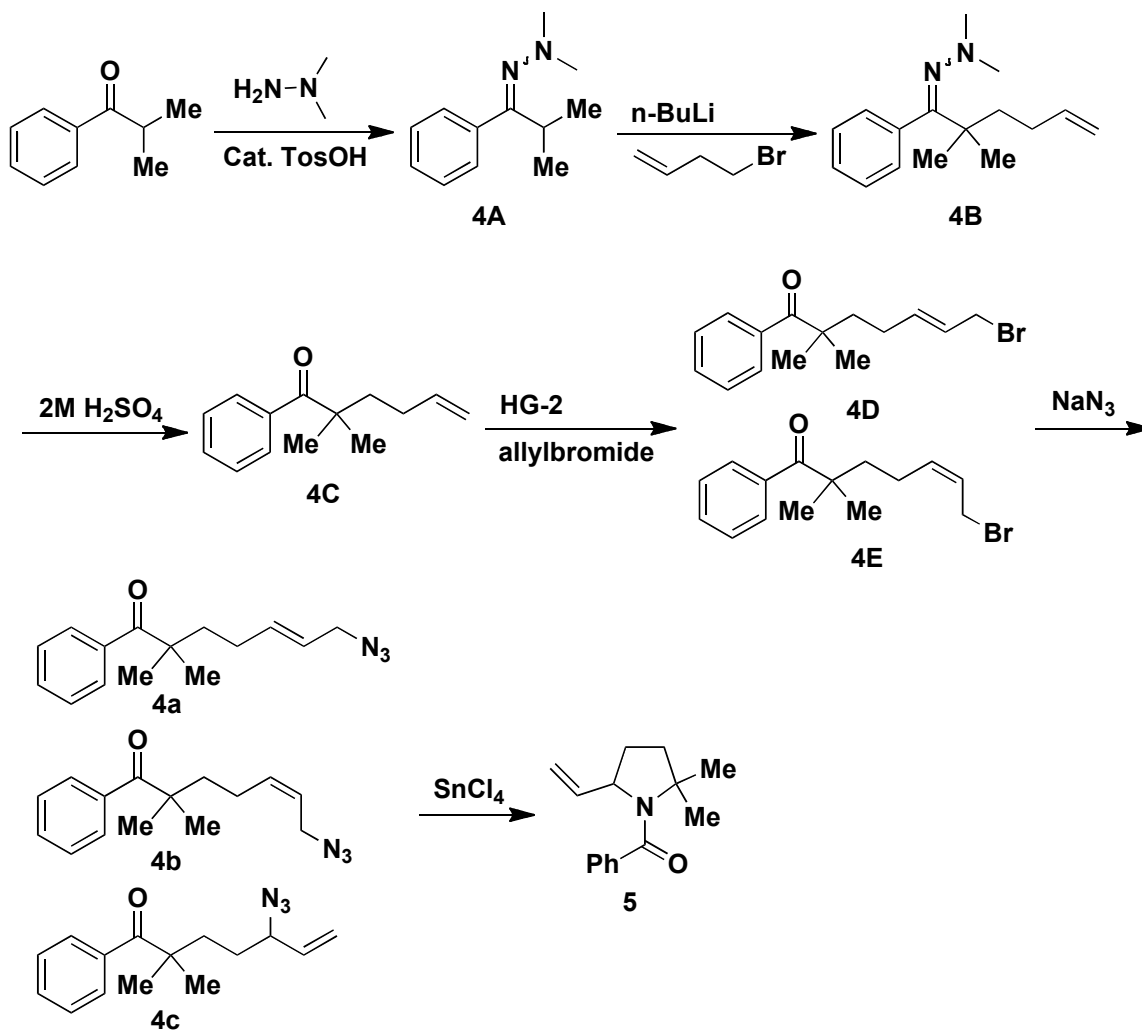


2-(2-(Chloromethyl)allyl)cyclohexanone (3B). From literature precedent of Milligan et al.^{S4} To a solution of diisopropylamine (4.33 g, 42.8 mmol) in anhydrous THF (50 mL) under N₂ atmosphere at 0 °C was slowly added *n*-BuLi (16.4 mL, 2.4 M in hexane, 39.3 mmol). The ice bath was removed after 10 min and the reaction stirred for another 20 min. The reaction mixture was cooled to 0 °C and cyclohexanone dimethylhydrazone (5.00 g, 35.7 mmol) was slowly added. After the addition, the ice bath was removed and the reaction stirred for another 3 h. The reaction mixture was cooled to 0 °C, 3-chloro-2-chloromethyl-1-propene (5.35 g, 42.8 mmol) was slowly added, and the resulting mixture was stirred overnight. The solution was poured into a mixture of iced 2M H₂SO₄ (80 mL) and diethyl ether (80 mL), and was vigorously stirred for 1 h. After separation, the aqueous layer was extracted twice with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by chromatography (1-30% EtOAc/hexanes) to afford **3B** (1.10 g, 17%) as a colorless oil. Ketone **3B**: *R*_f = 0.35 (20% EtOAc/hexanes); IR (neat) 2937, 1710, 1148, 1129 cm⁻¹; ¹H NMR (400 MHz, CDCl₃) δ 1.34-1.43 (m, 1H), 1.65-1.75 (m, 2H), 1.86-1.93 (m, 1H), 2.03-2.20 (m, 3H), 2.31-2.38 (m, 1H), 2.41-2.48 (m, 1H), 2.53-2.62 (m, 1H), 2.75 (dd, *J* = 5.6 Hz, 14.8 Hz, 1H), 4.05 (s, 2H), 4.95 (q, *J* = 1.2 Hz, 1H), 5.20 (s, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 25.0 (CH₂), 28.1 (CH₂), 33.2 (CH₂), 33.9 (CH₂), 42.1 (CH₂), 48.4 (CH₂), 48.8 (CH), 116.1 (CH₂), 143.0 (C), 212.2 (C).

2-(2-(Azidomethyl)allyl)cyclohexanone (3). A suspension of **3B** (1.10 g, 5.90 mmol), sodium azide (1.15 g, 17.7 mmol), and sodium iodide (44 mg, 0.30 mmol) in DMF (10 mL) was stirred overnight at room temperature. Diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by chromatography (0.5-8% EtOAc/hexanes) to afford **3** (1.0 g, 89%) as a colorless oil. Azide **3**: *R*_f = 0.5 (20% EtOAc/hexanes); IR (neat) 2937, 2100, 1710 cm⁻¹; HRMS (ESI) *m/z* calculated for

($C_{10}H_{15}N_3O+Na$)⁺ 216.1113, found: 216.1148; ¹H NMR (400 MHz, CDCl₃) δ 1.31-1.41 (m, 1H), 1.63-1.75 (m, 2H), 1.84-1.93 (m, 1H), 2.06 (dd, *J* = 7.6 Hz, 14.8 Hz, 1H), 2.04-2.18 (m, 2H), 2.30-2.39 (m, 1H), 2.40-2.47 (m, 1H), 2.49-2.56 (m, 1H), 2.65 (dd, *J* = 6.0 Hz, 14.8 Hz, 1H), 3.47 (dd, *J* = 14.0 Hz, 18.4 Hz, 2H), 4.97 (s, 1H), 5.10 (s, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 25.0 (CH₂), 28.0 (CH₂), 33.7 (CH₂), 33.9 (CH₂), 42.1 (CH₂), 48.8 (CH), 56.2 (CH₂), 115.1 (CH), 141.3 (C), 212.0 (C).

2-Methylene-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (4). To a refluxing solution of azide **3** (0.11 g, 0.57 mmol) in anhydrous dichloromethane (8 mL) under N₂ atmosphere was added tin tetrachloride (0.86 mL, 1M in dichloromethane, 0.86 mmol). After refluxing for 15 h, saturated aqueous ammonium chloride was added to the cooled reaction mixture. After separation, the aqueous layer was washed with dichloromethane. The aqueous layer was neutralized by saturated aqueous sodium bicarbonate, and washed twice with dichloromethane. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (1-75% EtOAc/hexanes) to afford lactam **4** (78 mg, 83%) as a colorless oil. Lactam **4**: *R*_f = 0.40 (100% EtOAc/hexanes); IR (neat) 2930, 1626, 1445 cm⁻¹; HRMS (ESI) *m/z* calculated for ($C_{10}H_{16}NO+H$)⁺ 166.1232, found: 166.1227; ¹H NMR (400 MHz, CDCl₃) δ 1.45-1.58 (m, 3H), 1.76-1.97 (m, 3H), 2.35 (dd, *J* = 3.6 Hz, 15.6 Hz, 1H), 2.43 (dd, *J* = 11.6 Hz, 12.8 Hz, 1H), 2.54 (dd, *J* = 6.8 Hz, 14.0 Hz, 1H), 2.93 (dd, *J* = 8.8 Hz, 14.4 Hz, 1H), 3.88 (sextet, *J* = 5.6 Hz, 1H), 4.10 (dd, *J* = 16.0 Hz, 38.8 Hz, 2H), 4.96 (q, *J* = 1.6 Hz, 2H); ¹³C NMR (100 MHz, CDCl₃) δ 23.3 (CH₂), 29.6 (CH₂), 35.9 (CH₂), 37.8 (CH₂), 40.8 (CH₂), 51.5 (CH₂), 59.0 (CH), 107.1 (CH₂), 143.0 (C), 174.2 (C).

Scheme S2. Preparation of azides **4a**, **4b**, **4c**, and lactam **5**.

1,1-Dimethyl-2-(2-methyl-1-phenylpropylidene)hydrazine (4A).^{S5} To a solution of isobutyrophenone (22.6 mL, 0.150 mol) and 1,1-dimethylhydrazine (34.2 mL, 0.450 mol) in 40 mL toluene was added *p*-toluenesulfonic acid monohydrate (0.29 g, 1.5 mmol). The reaction mixture was heated to reflux using a Dean-Stark apparatus for one day before the additional addition of 1,1-dimethylhydrazine (34 mL, 0.45 mol). The reaction mixture was allowed to reflux for 5 days. The reaction mixture was concentrated under reduced pressure and the residue was distilled under reduced pressure to afford hydrazone **4A**^{S5} (27.3 g, 100%, *E/Z*: 8:1). *E* isomer: ^1H NMR (400 MHz, CDCl_3) δ 1.10 (d, $J = 6.8$ Hz, 6H), 2.36 (s, 6H), 2.79 (septet, $J = 6.8$ Hz, 1H), 7.20-7.22 (m, 2H), 7.32-7.38 (m, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 20.6 (CH_3), 37.1 (CH), 47.3 (CH_3), 127.1 (CH), 127.6 (CH), 128.0 (CH), 137.9 (C), 169.1 (C). *Z* isomer (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) δ 1.16 (d, $J = 6.8$ Hz, 6H), 2.57 (s, 6H), 3.88 (septet, $J = 6.8$

Hz, 1H), 7.20-7.22 (m, 2H), 7.32-7.38 (m, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 20.4 (CH_3), 29.1 (CH), 48.1 (CH_3), 132.8 (C), 175.8 (C).

2-(2,2-Dimethyl-1-phenylhex-5-enylidene)-1,1-dimethylhydrazine (4B). To a solution of hydrazone **4A** (11.4 g, 60.0 mmol) in THF (100 mL) under N_2 atmosphere at 0 °C was added *n*-BuLi (30 mL, 2.5 M in hexane, 75 mmol). After stirring for 2 h, 4-bromo-1-butene (10.1 g, 75.0 mmol) was added dropwise at 0 °C. The reaction mixture was allowed naturally to warm to rt and stirred overnight. The reaction mixture was quenched with saturated NH_4Cl . After the separation, the aqueous layer was washed with diethyl ether three times. The combined organic layers were washed with brine, dried over anhydrous magnesium sulfate. After the filtration and concentration, the residue was purified by chromatography (0.5-5% EtOAc/hexanes) to afford hydrazone **4B** (9.5 g, 65%) as a colorless oil. Hydrazone **4B**: R_f = 0.40 (20% EtOAc/hexanes); IR (neat) 2965, 1640, 1467 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{16}\text{H}_{24}\text{N}_2+\text{H})^+$ 245.2018, found: 245.2010; ^1H NMR (400 MHz, CDCl_3) δ 1.13 (s, 6H), 1.58-1.62 (m, 2H), 2.14-2.20 (m, 2H), 2.35 (s, 6H), 4.96-5.09 (m, 2H), 5.82-5.92 (m, 1H), 7.06-7.09 (m, 2H), 7.32-7.38 (m, 3H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.9 (CH_3), 29.3 (CH_2), 39.7 (CH_2), 41.4 (C), 47.4 (CH_3), 114.0 (CH_2), 127.2 (CH), 127.3 (CH), 127.8 (CH), 137.9 (C), 139.3 (CH), 170.7 (C).

2,2-Dimethyl-1-phenylhex-5-en-1-one (4C). A solution of hydrazone **4B** (3.9 g, 16 mmol) in a mixed solvent of CCl_4 (35 mL) and 2M aqueous H_2SO_4 (35 mL) was heated to reflux for 10 h. After cooling to room temperature, the aqueous layer was separated from organic layer and washed twice with dichloromethane. The combined organic layers were washed with brine and dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.5-1.5% EtOAc/hexanes) to afford ketone **4C** (3.0 g, 93%). Ketone **4C**: R_f = 0.50 (20% EtOAc/hexanes); IR (neat) 2973, 1674, 699 cm^{-1} ; ^1H NMR (400 MHz, CDCl_3) δ 1.35 (s, 6H), 1.84-1.89 (m, 2H), 2.00-2.06 (m, 2H), 4.92-5.01 (m, 2H), 5.72-5.82 (m, 1H), 7.39-7.49 (m, 3H), 7.67-7.69 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.1 (2 CH_3), 29.2 (CH_2), 40.1 (CH_2), 47.7 (C), 114.6 (CH_2), 127.5 (2CH), 128.1 (2CH), 130.8 (CH), 138.4 (CH), 139.1 (C), 209.0 (C).

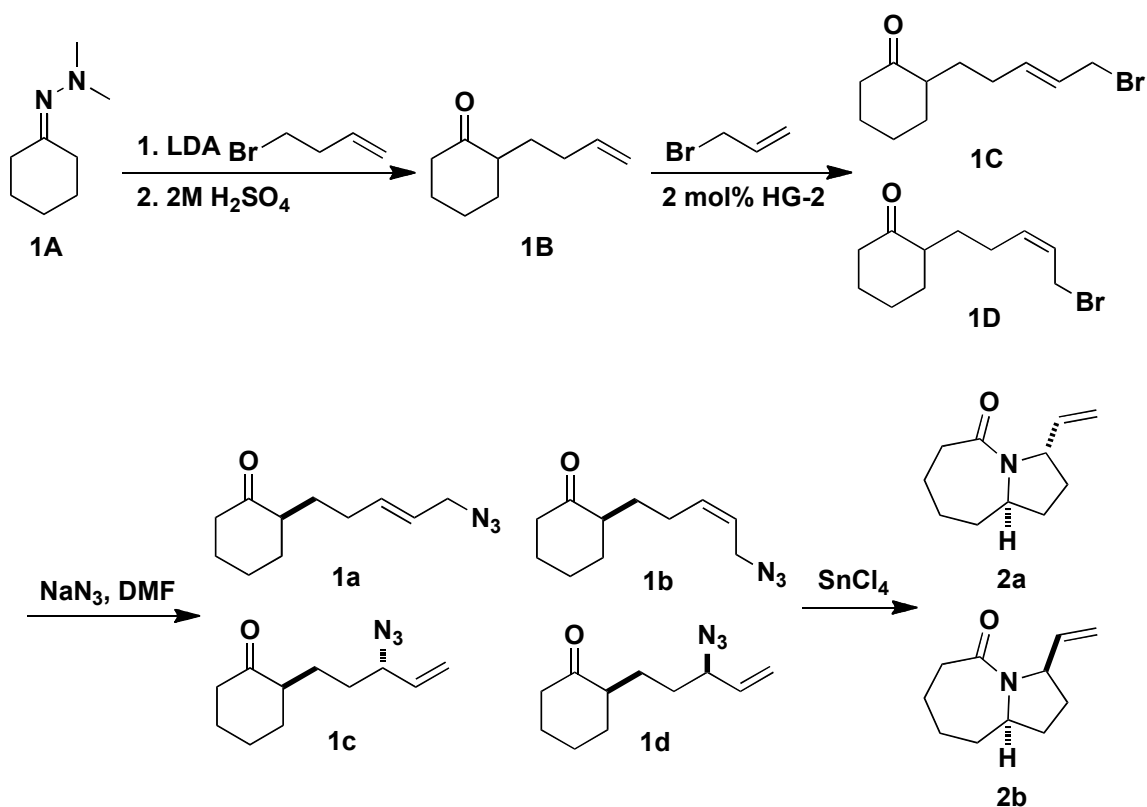
(E)-7-Bromo-2,2-dimethyl-1-phenylhept-5-en-1-one (4D) and (Z)-7-bromo-2,2-dimethyl-1-phenylhept-5-en-1-one (4E). Following the procedure of Bandini et al.,^{S7} to a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (125 mg, 0.20 mmol, 2 mol%) in dichloromethane (15 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **4C** (2.03 g, 10.0 mmol) and allyl bromide (2.54 mL, 30.0 mmol) in dichloromethane (5 mL). The resulting reaction mixture was stirred overnight. The solvent was concentrated and the

residue was purified by chromatography (0.5-1.5% EtOAc/hexanes) to afford a mixture of bromides **4D** and **4E** (2.44 g, 83%, 5:1 ratio) as a colorless oil. Bromides **4D** and **4E**: $R_f = 0.35$ (5% EtOAc/hexanes); IR (neat) 2968, 1672, 1203, 965, 718, 699 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{19}\text{BrO}+\text{NH}_4)^+$ 312.0963, found: 312.0968. Bromide **4D**: ^1H NMR (400 MHz, CDCl_3) δ 1.34 (s, 3H), 1.82-1.88 (m, 2H), 2.01-2.07 (m, 2H), 3.91 (d, $J = 6.8$ Hz, 1H), 5.61-5.78 (m, 2H), 7.39-7.48 (m, 3H), 7.66-7.73 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.1 (2CH_3), 27.6 (CH_2), 33.3 (CH_2), 39.9 (CH_2), 47.7 (C), 126.6 (CH), 127.6 (CH), 128.2 (CH), 131.0 (CH), 135.8 (CH), 138.9 (C), 208.6 (C). Bromide **4E** (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) δ 1.37 (s, 3H), 3.85 (d, $J = 8.4$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 125.8 (CH), 135.0 (CH), 208.9 (C).

(E)-7-Azido-2,2-dimethyl-1-phenylhept-5-en-1-one (4a), **(Z)-7-azido-2,2-dimethyl-1-phenylhept-5-en-1-one (4b)**, and **5-azido-2,2-dimethyl-1-phenylhept-6-en-1-one (4c)**. A suspension of bromides **4D** and **4E** (2.44 g, 8.30 mmol) and sodium azide (1.63 g, 25.0 mmol) in DMF (15 mL) at room temperature was stirred overnight. Diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine and dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.25-1.5% EtOAc/hexanes) afforded a mixture of azides **4a**, **4b** and **4c** (1.5 g, 71%, 53:11:36 ratio) as colorless oil. Azides **4a**, **4b** and **4c**: $R_f = 0.45$ (10% EtOAc/hexanes); IR (neat) 2968, 2094, 1671, 962 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{30}\text{H}_{38}\text{N}_4\text{O}_2+\text{H})^+$ 487.3073 (corresponding to $(2\text{M}-\text{N}_2+\text{H})^+$), found: 487.3087. Azide **4a**: ^1H NMR (400 MHz, CDCl_3) δ 1.34 (s, 3H), 1.82-1.89 (m, 2H), 2.01-2.08 (m, 2H), 3.67 (d, $J = 6.8$ Hz, 1H), 5.44-5.51 (m, 1H), 5.61-5.74 (m, 1H), 7.39-7.50 (m, 3H), 7.66-7.69 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.1 (2CH_3), 27.8 (CH_2), 40.4 (CH_2), 47.6 (C), 52.7 (CH_2), 123.1 (CH), 127.6 (CH), 128.2 (CH), 131.0 (CH), 136.3 (CH), 138.9 (C), 208.66 (C). Azide **4b** (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) δ 1.36 (s, 3H), 3.64 (d, $J = 11.6$ Hz, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 23.1 (CH_2), 26.2 (CH_3), 40.9 (CH_2), 47.0 (C), 52.1 (CH_2), 122.5 (CH), 127.7 (CH), 131.1 (CH), 135.3 (CH), 208.39 (C). Azide **4c** (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) δ 1.33 (s, 3H), 1.45-1.52 (m, 2H), 1.72-1.89 (m, 2H), 3.76 (q, $J = 7.2$ Hz, 1H), 5.22-5.27 (m, 2H), 5.61-5.74 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.2 (CH_3), 29.7 (CH_2), 36.9 (CH_2), 47.4 (C), 65.3 (CH), 118.4 (CH_2), 127.6 (CH), 131.0 (CH), 135.4 (CH), 138.8 (C), 208.47 (C).

(2,2-Dimethyl-5-vinylpyrrolidin-1-yl)phenylmethanone (5). According to the procedure described for lactams **2a** and **2b**, azides **4a**, **4b**, and **4c** (86 mg, 0.33 mmol) afforded after chromatography (1-8% EtOAc/hexanes) lactam **5** (41 mg, 54%) as a colorless oil. Lactam **5**: $R_f =$

0.20 (20% EtOAc/hexanes); IR (neat) 2965, 1627, 1388 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{19}\text{NO}+\text{Na})^+$ 252.1364, found: 252.1343; ^1H NMR (400 MHz, CDCl_3) δ 1.58 (br s, 3H), 1.58-1.70 (m, 1H), 1.70 (br s, 3H), 1.78-1.83 (m, 1H), 1.90-1.97 (m, 1H), 2.06-2.15 (m, 1H), 4.35 (br s, 3H), 4.76 (d, $J = 16.4$ Hz, 3H), 4.92 (d, $J = 10.0$ Hz, 3H), 5.58 (br s, 1H), 7.32 (s, 5H); ^{13}C NMR (100 MHz, CDCl_3) δ 25.4 (CH_3), 27.2 (CH_3), 29.3 (CH_2), 39.7 (CH_2), 63.0 (C), 63.5 (CH), 115.0 (CH_2), 126.2 (CH), 127.9 (CH), 128.7 (CH), 139.1 (CH), 170.7 (C).

Scheme S3. Preparation of azides **1a**, **1b**, **1c**, **1d**, and lactams **2a**, **2b**.

2-(But-3-enyl)cyclohexanone (1B).^{S6} According to the procedure described for ketone **3B**, the reaction of hydrazone **1A** (5.0 g, 36 mmol) afforded ketone **1B** (5.2 g, 96%) as a colorless oil. Ketone **1B**: $R_f = 0.70$ (20% EtOAc/hexanes); IR (neat) 2935, 1710, 1449 cm^{-1} ; HRMS (EI) m/z calculated for $(\text{C}_{10}\text{H}_{16}\text{O})^+$ 152.1201, found: 152.1189; ^1H NMR (400 MHz, CDCl_3) δ 1.23-1.32 (m, 1H), 1.34-1.44 (m, 1H), 1.62-1.73 (m, 2H), 1.82-1.97 (m, 2H), 2.03-2.14 (m, 4H), 2.28-2.33 (m, 2H), 2.37-2.42 (m, 1H), 4.94-5.04 (m, 2H), 5.74-5.84 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 25.0 (CH_2), 28.0 (CH_2), 28.5 (CH_2), 31.2 (CH_2), 33.9 (CH_2), 42.1 (CH_2), 49.8 (CH), 114.7 (CH_2), 138.5 (CH), 213.2 (C).

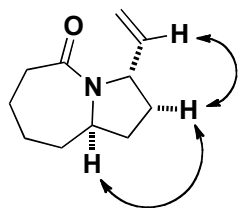
(E)-2-(5-Bromopent-3-enyl)cyclohexanone (1C) and **(Z)-2-(5-bromopent-3-enyl)cyclohexanone (1D)**. To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (50 mg, 0.080 Ommol, 2 mol%) in dichloromethane (4 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **1B** (0.61 g, 4.0 mmol) and allyl bromide (0.68 mL, 8.0 mmol) in dichloromethane (2 mL). The resulting reaction mixture was stirred overnight. The solvent was concentrated in vacuum and the residue was purified by chromatography (3% EtOAc/hexanes) to afford a mixture of bromides **1C** and **1D** (320 mg, 33%, 5:1 ratio) as colorless oil. Bromides **1C**

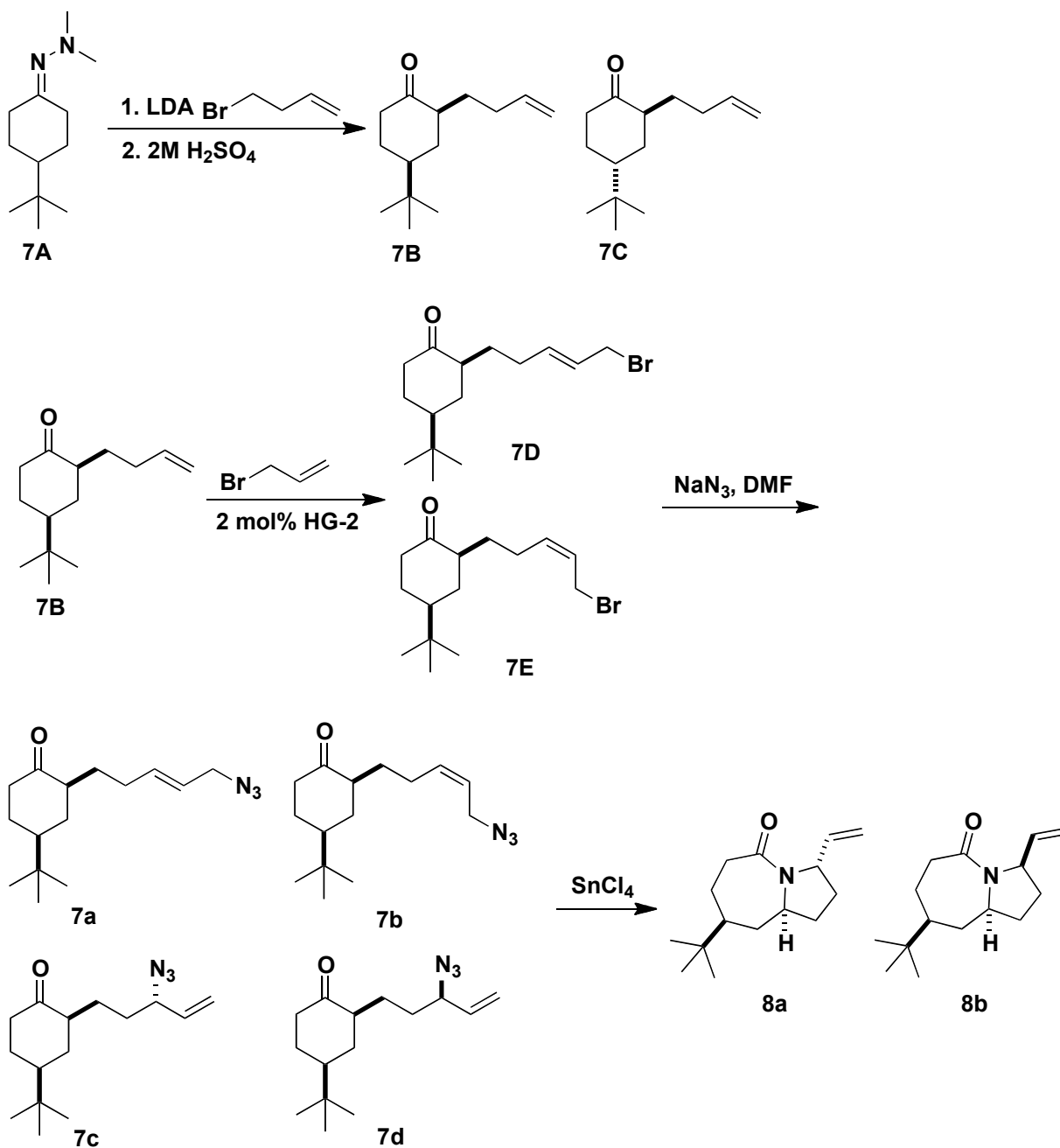
and **1D**: $R_f = 0.50$ (20% EtOAc/hexanes); IR (neat) 2934, 1709, 1448 cm^{-1} . Bromide **1C**: ^1H NMR (400 MHz, CDCl_3) δ 1.25-1.32 (m, 1H), 1.34-1.43 (m, 1H), 1.64-1.72 (m, 2H), 1.85-1.96 (m, 2H), 2.04-2.14 (m, 4H), 2.26-2.42 (m, 3H), 3.96 (d, $J = 6.4$ Hz, 2H), 5.68-5.78 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 25.0 (CH_2), 28.0 (CH_2), 28.4 (CH_2), 29.6 (CH_2), 33.4 (CH_2), 34.0 (CH_2), 42.1 (CH_2), 49.8 (CH), 126.7 (CH), 136.1 (CH), 213.0 (C). Bromide **1D** (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) 4.00 (d, $J = 8.4$ Hz, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 25.0 (CH_2), 28.1 (CH_2), 34.2 (CH_2), 125.9 (CH), 135.4 (CH), 213.1 (C).

(2R*,E)-2-(5-Azidopent-3-enyl)cyclohexanone (1a), **(2R*,Z)-2-(5-azidopent-3-enyl)cyclohexanone (1b)**, **(2R*)-2-(3'S*)-3-azidopent-4-enylcyclohexanone (1c)**, and **(2R*)-2-(3'R*)-3-azidopent-4-enylcyclohexanone (1d)**. A suspension of bromides **1C** and **1D** (0.27 g, 1.1 mmol) and sodium azide (0.22 g, 3.3 mmol) in DMF (6 mL) at room temperature was stirred overnight. Diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (1-5% EtOAc/hexanes) to afford a mixture of azides **1a**, **1b**, **1c**, and **1d** (225 mg, 99%, 62:8:15:15 ratio) as a colorless oil. Azides **1a**, **1b**, **1c**, and **1d**: $R_f = 0.50$ (20% EtOAc/hexanes); IR (neat) 2935, 2098, 1709, 1239 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{22}\text{H}_{34}\text{N}_4\text{O}_2+\text{H})^+$ 387.2760 (corresponding to $(2\text{M}-\text{N}_2+\text{H})^+$), found: 387.2719. Azide **1a**: ^1H NMR (400 MHz, acetone) δ 1.19-1.30 (m, 1H), 1.30-1.41 (m, 1H), 1.53-1.78 (m, 3H), 1.82-1.90 (m, 2H), 2.03-2.16 (m, 3H), 2.25-2.28 (m, 1H), 2.31-2.42 (m, 2H), 3.77 (d, $J = 6.4$ Hz, 2H), 5.55-5.62 (m, 1H), 5.76-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 24.8 (CH_2), 27.8 (CH_2), 28.8 (CH_2), 29.6 (CH_2), 33.8 (CH_2), 41.6 (CH_2), 49.3 (CH), 52.3 (CH_2), 123.33 (CH), 136.5 (CH), 210.9 (C). Azide **1b** (diagnostic peaks only): ^1H NMR (400 MHz, acetone) δ 3.89 (d, $J = 7.2$ Hz, 2H); ^{13}C NMR (100 MHz, acetone) δ 49.4 (CH), 122.5 (CH), 135.7 (CH), 211.0 (C). Azides **1c** and **1d** (diagnostic peaks only): ^1H NMR (400 MHz, acetone) δ 3.97 (q, $J = 7.2$ Hz, 1H), 5.27-5.36 (m, 2H), 5.76-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 25.7 (CH_2), 25.8 (CH_2), 31.6 (CH_2), 31.7 (CH_2), 49.7 (CH), 49.7 (CH), 65.0 (CH), 65.1 (CH), 117.49 (CH_2), 117.51 (CH_2), 136.12 (CH), 136.16 (CH), 210.82 (C), 210.84 (C).

(3S*,9aR*)-3-Vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (2a) and **(3R*,9aR*)-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (2b)**. To a refluxing solution of azides **1a**, **1b**, **1c**, and **1d** (500 mg, 2.41 mmol) in anhydrous dichloromethane (40 mL) under N_2 atmosphere was added tin tetrachloride (3.8 mL, 1M in dichloromethane, 3.8 mmol). After being allowed to reflux for 15 h, the reaction was cooled and saturated aqueous ammonium chloride was

added. After separation, the aqueous layer was washed with dichloromethane. The aqueous layer was neutralized by saturated aqueous sodium bicarbonate and washed twice with dichloromethane. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, and dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (10-100% EtOAc/hexanes) to afford lactam **2a** (161 mg, 37%) as a colorless oil and **2b** (134 mg, 31%) as a colorless oil. Lactam **2a**: $R_f = 0.7$ (100% EtOAc, twice); IR (neat) 2928, 1635, 1447, 1415 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{11}\text{H}_{17}\text{NO}+\text{H})^+$ 180.1388, found: 180.1380; ^1H NMR (400 MHz, CDCl_3) δ 1.45-1.68 (m, 6H), 1.79-1.83 (m, 1H), 1.92-1.97 (m, 1H), 1.97-2.04 (m, 1H), 2.19-2.24 (m, 1H), 2.47-2.50 (m, 2H), 3.83 (t, $J = 9.2$ Hz, 1H), 4.66 (dd, $J = 5.6$ Hz, 6.8 Hz, 1H), 4.95-5.05 (m, 2H), 5.69-5.77 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 23.4 (CH_2), 28.3 (CH_2), 29.8 (CH_2), 31.8 (CH_2), 35.9 (CH_2), 38.5 (CH_2), 59.2 (CH), 59.6 (CH), 113.6 (CH_2), 137.2 (CH), 173.7 (C). Lactam **2b**: $R_f = 0.65$ (100% EtOAc, twice); IR (neat) 2927, 1636, 1446 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{11}\text{H}_{17}\text{NO}+\text{H})^+$ 180.1388, found: 180.1376; ^1H NMR (400 MHz, CDCl_3) δ 1.35-1.46 (m, 1H), 1.47-1.55 (m, 2H), 1.68-1.75 (m, 2H), 1.79-1.97 (m, 4H), 2.08-2.13 (m, 1H), 2.41 (dd, $J = 12.0$ Hz, 14.0 Hz, 1H), 2.59 (dd, $J = 7.2$ Hz, 14.4 Hz, 1H), 3.69 (dd, $J = 9.2$ Hz, 16.4 Hz, 1H), 4.75 (t, $J = 6.0$ Hz, 1H), 5.08-5.16 (m, 2H), 5.75-5.81 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 23.5 (CH_2), 29.0 (CH_2), 29.8 (CH_2), 32.6 (CH_2), 36.0 (CH_2), 38.4 (CH_2), 59.6 (CH), 59.9 (CH), 114.2 (CH_2), 137.9 (CH), 174.3 (C). The following NOE correlations were used to assign lactam **2a**.



Scheme S4. Preparation of azides **7a**, **7b**, **7c**, **7d**, and lactams **8a**, **8b**.

(2*S**,4*S**)-2-(But-3-enyl)-4-*tert*-butylcyclohexanone (**7B**) and (2*S**,4*R**)-2-(but-3-enyl)-4-*tert*-butylcyclohexanone (**7C**).^{S8} According to the procedure described for ketone **3B**, the reaction of hydrazone **7A** (7.85 g, 40.0 mmol) afforded ketone **7B** (3.6 g, 43%) as a colorless oil and ketone **7C** (3.5 g, 42%) as a colorless oil. Ketone **7B**: *R*_f = 0.45 (10% EtOAc/hexanes); ¹H NMR (400 MHz, CDCl₃) δ 0.91 (s, 9H), 1.08-1.26 (m, 2H), 1.43 (dq, *J* = 4.8 Hz, 12.8 Hz, 1H), 1.58 (tt, *J* = 3.0 Hz, 12.0 Hz, 1H), 1.88-1.97 (m, 1H), 2.07-2.15 (m, 4H), 2.26-2.40 (m, 3H), 4.93-

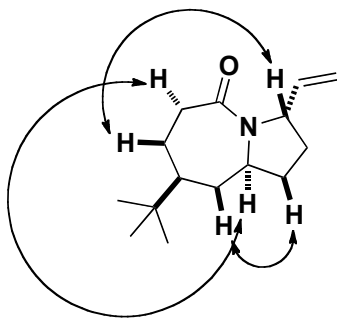
5.02 (m, 2H), 5.74-5.81 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 27.6 (3 CH_3), 28.4 (CH_2), 28.8 (CH_2), 31.3 (CH_2), 32.4 (C), 35.1 (CH_2), 41.7 (CH_2), 47.1 (CH), 48.8 (CH), 114.6 (CH_2), 138.6 (CH), 213.3 (C). Ketone **7C**: $R_f = 0.4$ (10% EtOAc/hexanes); ^1H NMR (400 MHz, CDCl_3) δ 0.90 (s, 9H), 1.40-1.68 (m, 4H), 1.77-1.86 (m, 2H), 1.94-2.12 (m, 3H), 2.26-2.32 (m, 1H), 2.36-2.45 (m, 2H), 4.96-5.04 (m, 2H), 5.73-5.83 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 26.9 (CH_2), 27.4 (3 CH_3), 30.6 (CH_2), 31.3 (CH_2), 31.4 (CH_2), 32.4 (C), 38.4 (CH_2), 41.3 (CH_2), 48.5 (CH_2), 115.2 (CH_2), 137.8 (CH), 215.6 (C).

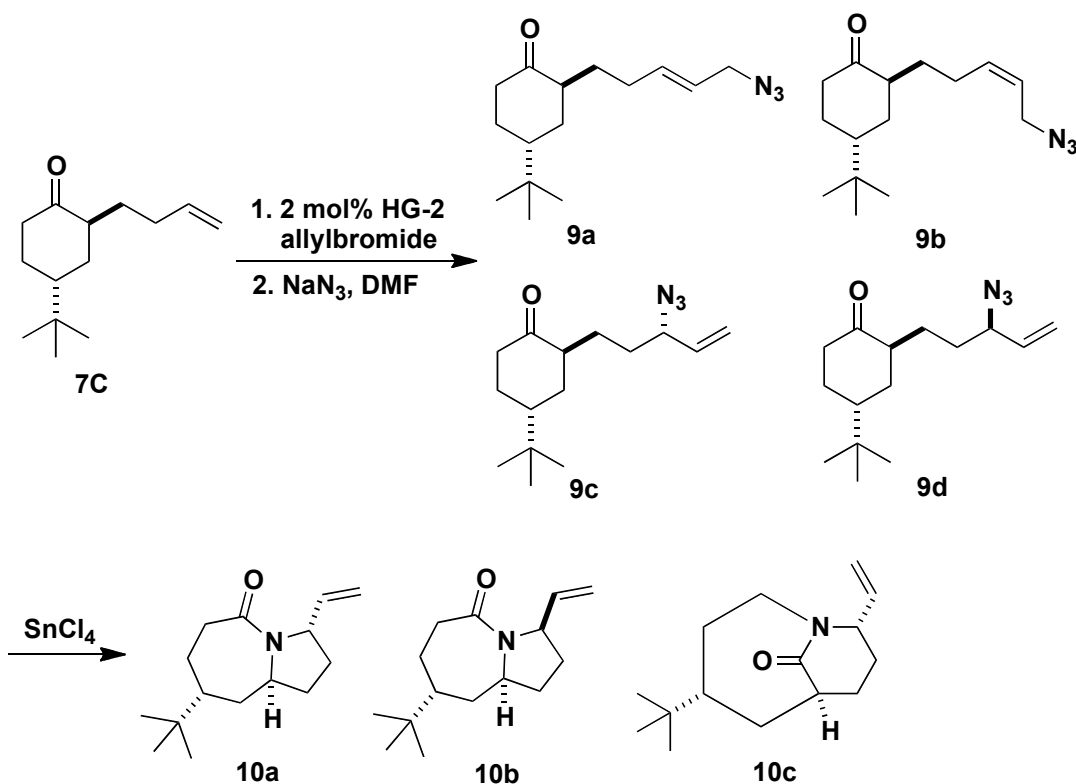
(2S*,4S*,E)-2-(5-Bromopent-3-enyl)-4-tert-butylcyclohexanone (7D) and **(2S*,4S*,Z)-2-(5-bromopent-3-enyl)-4-tert-butylcyclohexanone (7E)**. According to the procedure described for bromides **1C** and **1D**, ketone **7B** (2.38 g, 11.4 mmol) afforded a mixture of bromides **7D** and **7E** (1.3 g, 38%, 10:1 ratio) as a colorless oil. Bromides **7D** and **7E**: $R_f = 0.30$ (10% EtOAc/hexanes); IR (neat) 2954, 2868, 1712, 1366 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{30}\text{H}_{49}\text{BrO}_2+\text{Na})^+$ 543.2814 (corresponding to $(2\text{M-HBr}+\text{Na})^+$), found: 543.2808. Bromide **7D**: ^1H NMR (400 MHz, CDCl_3) δ 0.93 (s, 9H), 1.08-1.29 (m, 2H), 1.45 (dq, $J = 4.8$ Hz, 12.4 Hz, 1H), 1.60 (tt, $J = 2.8$ Hz, 12.0 Hz, 1H), 1.88-1.98 (m, 1H), 2.07-2.18 (m, 4H), 2.26-2.43 (m, 3H), 3.96 (d, $J = 6.6$ Hz, 1H), 5.66-5.80 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 27.7 (3 CH_3), 28.4 (CH_2), 28.8 (CH_2), 29.6 (CH_2), 32.5 (C), 33.5 (CH_2), 35.1 (CH_2), 41.7 (CH_2), 47.1 (CH), 48.8 (CH), 126.7 (CH), 136.2 (CH), 213.2 (C). Bromide **7E** (diagnostic peaks only): ^1H NMR (400 MHz, CDCl_3) 4.00-4.03 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) 27.4 (3 CH_3).

(2S*,4S*,E)-2-(5-Azidopent-3-enyl)-4-tert-butylcyclohexanone (7a), **(2S*,4S*,Z)-2-(5-azido-pent-3-enyl)-4-tert-butylcyclohexanone (7b)**, **(2S*,4S*)-2-((S*)-3-azidopent-4-enyl)-4-tert-butylcyclohexanone (7c)**, and **(2S*,4S*)-2-((R*)-3-azidopent-4-enyl)-4-tert-butylcyclohexanone (7d)**. According to the procedure described for azides **1a**, **1b**, **1c** and **1d**, the mixture of bromides **7D** and **7E** (1.23 g, 4.10 mmol) afforded after chromatography (0.25-1.2% EtOAc/hexanes) a mixture of azides **7a**, **7b**, **7c**, and **7d** (0.90 g, 84%, 67:7:13:13 ratio) as a colorless oil. Azides **7a**, **7b**, **7c**, and **7d**: $R_f = 0.45$ (10% EtOAc/hexanes); IR (neat) 2953, 2093, 1711 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{30}\text{H}_{50}\text{N}_6\text{O}_2+\text{Na})^+$ 549.3893 (corresponding to $(2\text{M}+\text{Na})^+$), found: 549.3894. Azide **7a**: ^1H NMR (400 MHz, acetone) δ 0.94 (s, 9H), 1.11-1.32 (m, 3H), 1.36-1.45 (m, 1H), 1.65-1.73 (m, 1H), 1.85-1.93 (m, 1H), 2.05-2.28 (m, 4H), 2.36-2.45 (m, 2H), 3.77 (d, $J = 6.4$ Hz, 2H), 5.54-5.62 (m, 1H), 5.77-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 27.1 (3 CH_3), 28.5 (CH_2), 28.8 (CH_2), 29.6 (CH_2), 32.1 (C), 34.9 (CH_2), 41.2 (CH_2), 46.9 (CH), 48.3 (CH), 52.3 (CH_2), 123.3 (CH), 136.6 (CH), 211.05 (C). Azide **7b** (diagnostic peaks only): ^1H

NMR (400 MHz, acetone) δ 3.90 (d, $J = 7.2$ Hz, 2H); ^{13}C NMR (100 MHz, acetone) δ 122.5 (CH), 135.8 (CH), 211.17 (C). Azides **7c** and **7d** (diagnostic peaks only): ^1H NMR (400 MHz, acetone) δ 3.96 (q, $J = 7.2$ Hz, 1H), 5.28-5.36 (m, 2H), 5.79-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 48.8 (CH), 48.9 (CH), 65.1 (CH), 65.2 (CH), 117.4 (CH_2), 117.5 (CH_2), 136.2 (CH), 136.2 (CH), 210.97 (C), 211.00 (C).

(3R*,8S*,9aS*)-8-tert-Butyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (8a) and **(3S*,8S*,9aS*)-8-tert-butyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (8b)**. According to the procedure described for lactams **2a** and **2b**, azides **7a**, **7b**, **7c**, and **7d** (86 mg, 0.33 mmol) afforded after chromatography (10-100% EtOAc/hexanes) lactam **8a** (39 mg, 51%) as a colorless oil and lactam **8b** (13 mg, 17%) as a colorless oil. Lactam **8a**: $R_f = 0.55$ (100% EtOAc); IR (neat) 2951, 1637, 1416 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{25}\text{NO}+\text{H})^+$ 236.2014, found: 236.2002; ^1H NMR (400 MHz, CDCl_3) δ 0.88 (s, 9H), 1.23-1.37 (m, 3H), 1.63-1.71 (m, 2H), 1.74-1.82 (m, 1H), 1.95-2.02 (m, 1H), 2.03-2.13 (m, 1H), 2.25-2.35 (m, 1H), 2.42-2.48 (m, 1H), 2.53-2.59 (m, 1H), 3.83 (t, $J = 8.8$ Hz, 1H), 4.70 (t, $J = 6.0$ Hz, 1H), 4.99-5.10 (m, 2H), 5.74-5.82 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 24.2 (CH_2), 27.7 (3 CH_3), 28.5 (CH_2), 32.5 (CH_2), 33.2 (C), 37.4 (CH_2), 37.7 (CH_2), 51.7 (CH), 58.6 (CH), 59.5 (CH), 113.7 (CH_2), 137.2 (CH), 173.6 (C). Lactam **8b**: $R_f = 0.65$ (100% EtOAc); IR (neat) 2960, 1637, 1416 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{25}\text{NO}+\text{H})^+$ 236.2014, found: 236.2006; ^1H NMR (400 MHz, CDCl_3) δ 0.90 (s, 9H), 1.13-1.36 (m, 3H), 1.70-1.79 (m, 2H), 1.81-1.90 (m, 1H), 1.98-2.05 (m, 2H), 2.11-2.19 (m, 1H), 2.40 (dd, $J = 12.0$ Hz, 14.0 Hz, 1H), 2.64 (dd, $J = 8.0$ Hz, 14.0 Hz, 1H), 3.65-3.71 (m, 1H), 4.77 (t, $J = 6.0$ Hz, 1H), 5.10-5.17 (m, 2H), 5.78-5.86 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 24.3 (CH_2), 27.6 (3 CH_3), 29.1 (CH_2), 33.09 (CH_2), 33.11 (C), 37.2 (CH_2), 37.6 (CH_2), 51.5 (CH), 59.1 (CH), 59.7 (CH), 114.3 (CH_2), 137.9 (CH), 174.4 (C). The following NOE correlations were used to assign lactam **8a**.

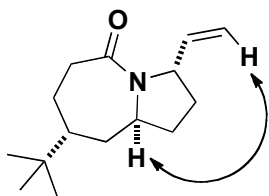


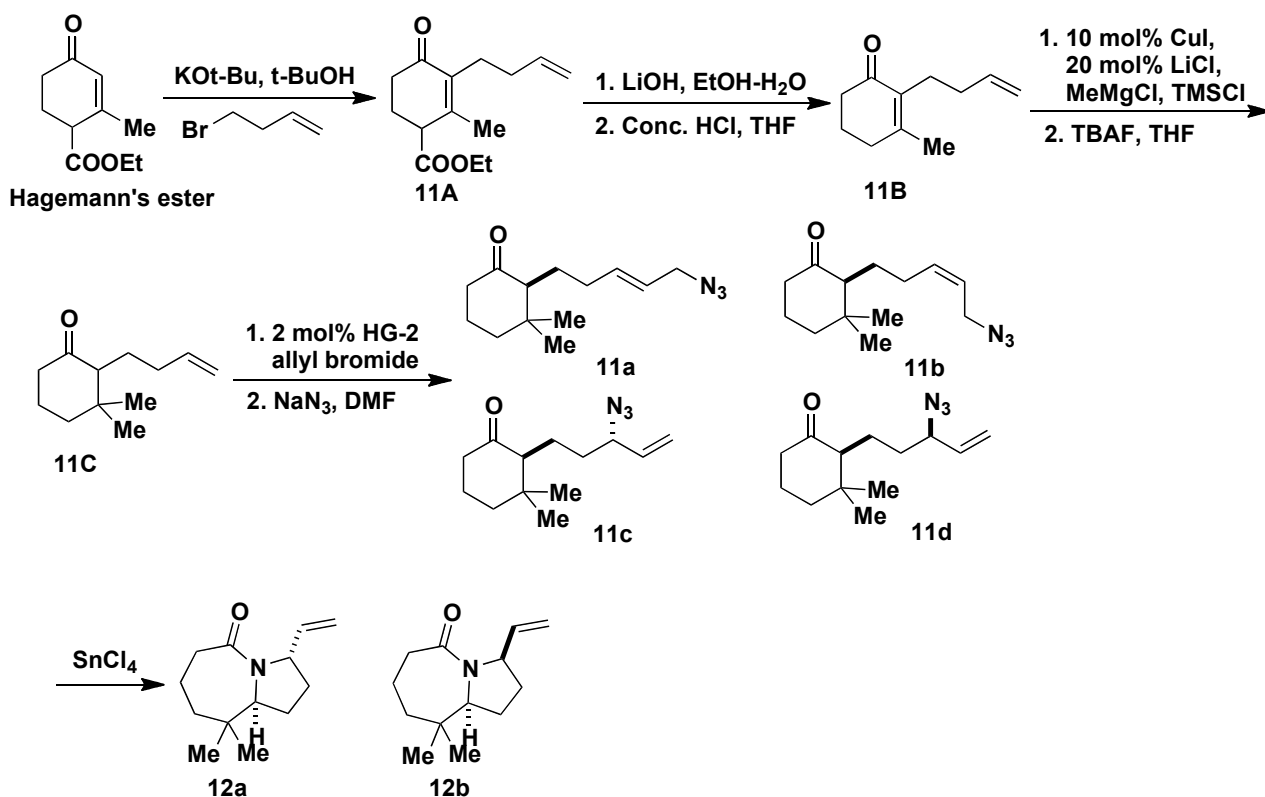
Scheme S5. Preparation of azides **9a**, **9b**, **9c**, **9d**, and lactams **10a**, **10b**.

($2S^*$, $4R^*$, E)-2-(5-Azidopent-3-enyl)-4-*tert*-butylcyclohexanone (**9a**), ($2S^*$, $4R^*$, Z)-2-(5-azido-pent-3-enyl)-4-*tert*-butylcyclohexanone (**9b**), ($2S^*$, $4R^*$)-2-((S^*)-3-azidopent-4-enyl)-4-*tert*-butylcyclohexanone (**9c**), and ($2S^*$, $4R^*$)-2-((R^*)-3-azidopent-4-enyl)-4-*tert*-butylcyclohexanone (**9d**). To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (11 mg, 0.020 mmol) in dichloromethane (5 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **7C** (63 mg, 0.30 mmol) and allyl bromide (125 mg, 1.03 mmol) in dichloromethane (2 mL). The resulting reaction mixture was stirred for 1.5 h. The solvent was concentrated in vacuum and the residue was dissolved in DMSO (2 mL), followed by the addition of sodium azide (0.20 g, 3.0 mmol) at room temperature. After stirring for 1 h, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.3-1.6% EtOAc/hexanes) to afford a mixture of azides **9a**, **9b**, **9c**, and **9d** (53 mg, 67%, 63:9:14:14 ratio) as a colorless oil. Azides **9a**, **9b**, **9c**, and **9d**: R_f = 0.25 (10% EtOAc/hexanes); IR (neat) 2952, 2095, 1709 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{30}\text{H}_{50}\text{N}_6\text{O}_2+\text{Na})^+$ 549.3893 (corresponding to $(2\text{M}+\text{Na})^+$), found: 549.3893. Azide **9a**: ^1H NMR (400 MHz, acetone) δ 0.94 (s, 9H), 1.46-1.62 (m, 2H), 1.66-1.75 (m, 2H), 1.80-1.90 (m, 2H), 1.95-

2.13 (m, 3H), 2.15-2.25 (m, 1H), 2.36-2.50 (m, 2H), 3.78 (d, $J = 6.4$ Hz, 2H), 5.58-5.65 (m, 1H), 5.79-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 26.4 (CH_2), 26.8 (3CH_3), 29.6 (CH_2), 30.5 (CH_2), 31.1 (CH_2), 32.0 (C), 38.0 (CH_2), 41.2 (CH), 47.9 (CH), 52.3 (CH_2), 123.9 (CH), 135.7 (CH), 212.9 (C). Azide **9b** (diagnostic peaks only): ^1H NMR (400 MHz, acetone) δ 3.91 (d, $J = 7.2$ Hz, 2H); ^{13}C NMR (100 MHz, acetone) δ 122.9 (CH), 135.0 (CH), 212.97 (C). Azides **9c** and **9d** (diagnostic peaks only): ^1H NMR (400 MHz, acetone) δ 3.97-4.04 (m, 1H), 5.28-5.36 (m, 2H), 5.79-5.86 (m, 1H); ^{13}C NMR (100 MHz, acetone) δ 48.26 (CH), 48.32 (CH), 64.54 (CH), 64.63 (CH), 117.7 (CH_2), 136.0 (CH), 212.87 (C), 212.90 (C).

(3*S,8*R**,9*aS**)-8-*tert*-Butyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (10a)**, **(3*R**,8*R**,9*aS**)-8-*tert*-butyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (10b)**, and **(4*S**,6*S**,9*S**)-4-*tert*-butyl-9-vinyl-1-azabicyclo[4.3.1]decan-10-one (10c)**. According to the procedure described for lactams **2a** and **2b**, the mixture of azides **9a**, **9b**, **9c**, and **9d** (48 mg, 0.18 mmol) afforded after chromatography (1/4-3/1 EtOAc/hexanes) lactam **10a** (24 mg, 56%) as a colorless oil and a mixture of lactams **10a**, **10b**, and **10c** (3 mg, 7%, 1:1:1 ratio) as a colorless oil. Lactam **10a**: $R_f = 0.50$ (100% EtOAc); IR (neat) 2950, 1632, 1408 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{25}\text{NO}+\text{H})^+$ 236.2014, found: 236.1981; ^1H NMR (500 MHz, CDCl_3) δ 0.79 (s, 9H), 1.23-1.27 (m, 1H), 1.32-1.40 (m, 1H), 1.41-1.48 (m, 1H), 1.50-1.62 (m, 3H), 1.70-1.78 (m, 1H), 1.96-2.08 (m, 2H), 2.37-2.44 (m, 1H), 2.62-2.68 (m, 1H), 3.92-3.97 (m, 1H), 4.54-4.63 (m, 1H), 4.94-5.02 (m, 2H), 5.67-5.74 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 22.0 (CH_2), 27.2 (3CH_3), 28.2 (CH_2), 31.4 (CH_2), 33.0 (C), 34.0 (CH_2), 35.5 (CH_2), 43.2 (CH), 55.5 (CH), 59.4 (CH), 113.7 (CH_2), 137.7 (CH), 171.0 (C). Lactams **10b** and **10c**: $R_f = 0.45$ (100% EtOAc); IR (neat): 2925, 1635, 1413 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{15}\text{H}_{25}\text{NO}+\text{Na})^+$ 258.1834, found: 258.1811; ^1H NMR (500 MHz, CDCl_3) (diagnostic peaks only) δ 0.80 (s, 9H), 0.82 (s, 9H), 3.55-3.63 (m, 1H), 3.85-3.91 (m, 1H), 4.54-4.63 (m, 1H), 4.67-4.73 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 22.5 (CH_2), 24.3 (CH_2), 27.2 (3CH_3), 27.6 (3CH_3), 29.1 (CH_2), 29.7 (CH_2), 32.4 (CH_2), 33.0 (C), 33.09 (CH_2), 33.12 (C), 34.3 (CH_2), 35.5 (CH_2), 37.2 (CH_2), 37.6 (CH_2), 43.5 (CH), 51.5 (CH), 55.9 (CH), 59.1 (CH), 59.7 (CH), 59.8 (CH), 114.3 (CH_2), 114.5 (CH_2), 137.9 (CH), 138.4 (CH), 171.4 (C), 174.4 (C). The following NOE correlation was used to assign lactam **10a**.



Scheme S6. Preparation of azides **11a**, **11b**, **11c**, **11d**, and lactams **12a**, **12b**.

Ethyl 3-(but-3-en-1-yl)-2-methyl-4-oxocyclohex-2-enecarboxylate (11A). Following the procedure of Segupta et al.,^{S9} Hagemann's ester (90% purity, 20.4 g, 0.100 mol) was rapidly added to a stirred solution of potassium *tert*-butoxide (12.1 g, 0.110 mol) in dry *tert*-butanol (60 mL). The red solution so formed turned into a straw-yellow suspension a few minutes after the addition. The mixture was stirred for 15 min before 4-bromo-1-butene (14.6 g, 0.110 mol) was added in a single portion. The mixture was allowed to reflux overnight. The mixture was allowed to cool to room temperature then was partitioned between 0.5 M aqueous HCl and dichloromethane. The combined organic layer was dried over anhydrous sodium sulfate and concentrated to afford ester **11A** (24.5 g, 104%), which was used without further purification. Ester **11A**: ¹H NMR (400 MHz, CDCl₃) δ 1.28 (t, *J* = 7.2 Hz, 3H), 1.96-2.10 (m, 2H), 1.99 (s, 3H), 2.15-2.30 (m, 2H), 2.32-2.42 (m, 3H), 2.52-2.65 (m, 1H), 3.29 (t, *J* = 4.8 Hz, 1H), 4.20 (q, *J* = 7.2 Hz, 2H), 4.91-5.02 (m, 2H), 5.76-5.86 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 14.2 (CH), 20.5 (CH), 24.9 (CH₂), 25.6 (CH₂), 32.9 (CH₂), 34.7 (CH₂), 47.7 (CH), 61.2 (CH₂), 114.7 (CH₂), 136.9 (C), 138.2 (CH), 150.3 (C), 172.2 (C), 197.4 (C).

2-(But-3-enyl)-3-methylcyclohex-2-enone (11B). Ester **11A** (8.1g, 34 mmol) was dissolved in a 1/1 mixture of ethanol and water (40 mL) and LiOH•H₂O (2.86 g, 68.0 mmol) was added as a powder. The mixture was stirred overnight, concentrated, and the residue partitioned between water and diethyl ether. The aqueous phase was acidified with 6M aqueous HCl and extracted with dichloromethane. The organic extracts were dried over anhydrous sodium sulfate and concentrated. The residue was dissolved in a mixture of concentrated HCl (3 mL) in THF (50 mL) and heated for 24 h at 90 °C. The mixture was concentrated. The residue was partitioned between water and dichloromethane. The combined organic layer was dried over anhydrous sodium sulfate and concentrated. The residue was chromatographed (2.5-5% EtOAc/hexanes) to yield ketone **11B** as a dark-yellow oil (3.08 g, 50% two steps). Ketone **11B**: *R_f* = 0.40 (20% EtOAc/hexanes); IR (neat) 2927, 1660, 1379 cm⁻¹; HRMS (ESI) *m/z* calculated for (C₁₁H₁₆O+H)⁺ 165.1279, found: 165.1270; ¹H NMR (400 MHz, CDCl₃) δ 1.94 (s, 3H), 1.90-1.96 (m, 2H), 2.04-2.10 (m, 2H), 2.33-2.41 (m, 6H), 4.91-5.02 (m, 2H), 5.77-5.87 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 21.3 (CH₃), 22.3 (CH₂), 24.7 (CH₂), 32.9 (CH₂), 33.2 (CH₂), 37.9 (CH₂), 114.5 (CH₂), 135.0 (C), 138.5 (CH), 155.6 (C), 198.7 (C).

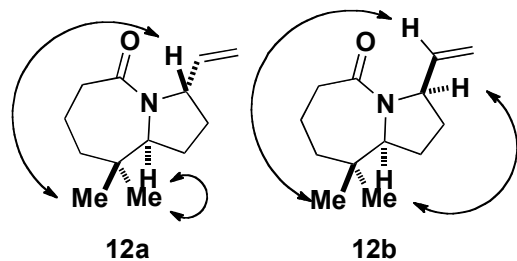
2-(But-3-enyl)-3,3-dimethylcyclohexanone (11C). Following a procedure by Reetz and Kindler,^{S10} lithium chloride (158 mg, 37.5 mmol, flame-dried) and copper(I) iodide were dissolved in anhydrous THF (120 mL) under argon at rt. The resulting solution was cooled to -40 °C using a dry ice/acetonitrile bath, ketone **11B** (3.08 g, 18.8 mmol) and chlorotrimethylsilane (2.24 g, 20.6 mmol) were added, and the solution stirred for 10 min. MeMgCl (3M in THF, 9.4 mL, 28.1 mmol) was added dropwise and left stirring at -40 °C for 1.5 h. The reaction mixture was then poured into 150 mL of saturated aqueous ammonium chloride and 150 mL of diethyl ether, and the aqueous layer was extracted with diethyl ether. The combined organic extracts were dried with anhydrous sodium sulfate, filtered, and concentrated under reduced pressure to afford (2-(but-3-enyl)-3,3-dimethylcyclohex-1-enyloxy)trimethylsilane (4.42 g), which was used without further purification: IR (neat) 2934, 1252, 1196 cm⁻¹; HRMS (ESI) *m/z* calculated for (C₁₅H₂₈OSi+H)⁺ 253.1988, found: 253.1913; ¹H NMR (400 MHz, CDCl₃) δ 0.20 (s, 9H), 1.02 (s, 6H), 1.39-1.42 (m, 2H), 1.63-1.69 (m, 2H), 1.99-2.06 (m, 4H), 2.14-2.20 (m, 2H), 4.92-5.06 (m, 2H), 5.83-5.93 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 0.8 (CH₂), 19.4 (CH₂), 26.2 (CH₂), 28.5 (2CH₃), 30.8 (CH₂), 33.9 (CH₂), 34.5 (C), 39.2 (CH₂), 113.5 (CH₂), 123.1 (C), 139.9 (CH), 144.3 (C). The silyl enol ether was dissolved in THF (40 mL) and stirred with TBAF (1M in THF, 28.1 mL, 28.1 mmol) at rt for 30 min under N₂ atmosphere. The mixture was poured into water and diethyl ether, and the

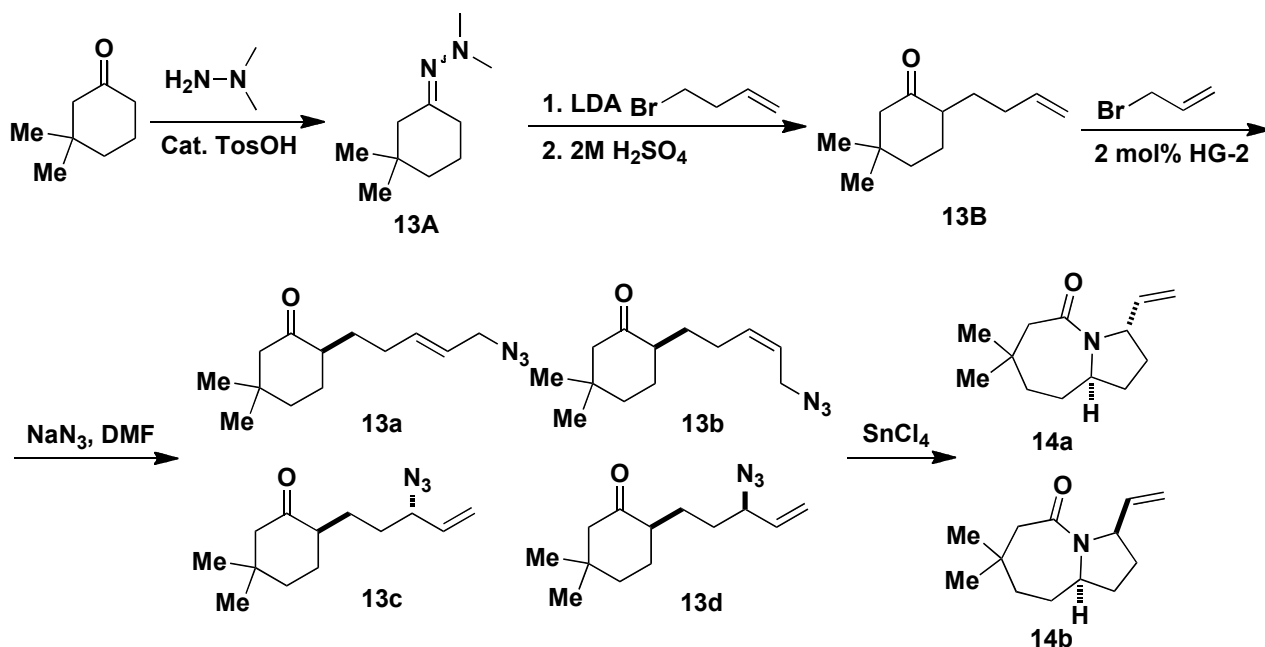
aqueous layer extracted with diethyl ether. The combined organic extracts were dried with anhydrous sodium sulfate, filtered, and concentrated to yield a residue, which was purified by chromatography (1.5% EtOAc/hexanes) to afford ketone **11C** (2.60 g, 77% for two steps). Ketone **11C**: R_f = 0.30 (5% EtOAc/hexanes); IR (neat) 2962, 1708 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{24}\text{H}_{40}\text{O}_2+\text{Na})^+$ 383.2926 (corresponding to $(2\text{M}+\text{Na})^+$), found: 383.2923; ^1H NMR (400 MHz, CDCl_3) δ 0.78 (s, 3H), 1.05 (s, 3H), 1.34-1.42 (m, 1H), 1.58-1.69 (m, 2H), 1.77-1.94 (m, 4H), 2.06-2.15 (m, 2H), 2.23-2.38 (m, 2H), 4.94-5.01 (m, 2H), 5.72-5.83 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 22.1 (CH_3), 23.2 (CH_2), 29.4 (CH_3), 32.8 (CH_2), 39.2 (CH_2), 39.7 (C), 41.3 (CH_2), 60.1 (CH), 114.7 (CH_2), 138.7 (CH), 213.3 (C).

(*S^,*E*)-2-(5-Azidopent-3-enyl)-3,3-dimethylcyclohexanone (11a)**, **(*S^**,*Z*)-2-(5-azidopent-3-enyl)-3,3-dimethylcyclohexanone (11b)**, **(*R^**)-2-((*S^**)-3-azidopent-4-enyl)-3,3-dimethylcyclohexanone (11c)**, and **(*R^**)-2-((*R^**)-3-azidopent-4-enyl)-3,3-dimethylcyclohexanone (11d)**. To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (179 mg, 0.450 mmol) in dichloromethane (20 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **11C** (1.6 g, 8.9 mmol) and allyl bromide (3.8 mL, 45 mmol) in dichloromethane (10 mL). The resulting reaction mixture was stirred overnight. The solvent was concentrated in vacuum and the residue was dissolved in DMSO (10 mL) and DMF (20 mL), followed by the addition of sodium azide (3.25 g, 50.0 mmol) at room temperature. After being allowed to stir overnight, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.6-4.0% EtOAc/hexanes) to afford a mixture of azides **11a**, **11b**, **11c**, and **11d** (1.60 g, 77%, 67:9:12:12 ratio) as a colorless oil. Azides **11a**, **11b**, **11c**, and **11d**: R_f = 0.15 (5% EtOAc/hexanes); IR (neat) 2954, 2094, 1706, 1236 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{26}\text{H}_{42}\text{N}_6\text{O}_2+\text{H})^+$ 471.3447 (corresponding to $(2\text{M}+\text{H})^+$), found: 471.3417. Azide **11a**: ^1H NMR (500 MHz, CDCl_3) δ 0.76 (s, 3H), 1.04 (s, 3H), 1.22-1.38 (m, 1H), 1.55-1.68 (m, 2H), 1.76-1.93 (m, 4H), 2.07-2.18 (m, 2H), 2.23-2.35 (m, 2H), 3.67-3.72 (m, 2H), 5.46-5.54 (m, 1H), 5.68-5.76 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 21.9 (CH_3), 23.16 (CH_2), 23.18 (CH_2), 29.5 (CH_3), 31.3 (CH_2), 39.3 (CH_2), 39.8 (C), 41.4 (CH_2), 52.8 (CH_2), 59.8 (CH), 123.3 (CH), 136.7 (CH), 213.09 (C); ^1H NMR (500 MHz, acetone) δ 0.76 (s, 3H), 1.06 (s, 3H), 1.28-1.43 (m, 1H), 1.55-1.62 (m, 1H), 1.69-1.95 (m, 5H), 2.08-2.18 (m, 1H), 2.21-2.28 (m, 2H), 2.29-2.39 (m, 1H), 3.76 (m, 2H), 5.54-5.58 (m, 1H), 5.79-5.86 (m, 1H); ^{13}C NMR (125 MHz, acetone) δ 26.3 (CH_3), 28.1 (CH_2), 28.2 (CH_2), 34.2 (CH_3), 36.4 (CH_2), 44.4 (CH_2), 44.5 (C), 46.2

(CH₂), 57.6 (CH₂), 64.5 (CH), 128.6 (CH), 141.7 (CH), 216.2 (C). Azide **11b** (diagnostic peaks only): ¹H NMR (500 MHz, CDCl₃) δ 0.767 (s, 3H), 1.055 (s, 3H), 3.65-3.75 (m, 2H); ¹³C NMR (125 MHz, CDCl₃) δ 122.7 (CH), 135.7 (CH), 213.07 (C); ¹H NMR (500 MHz, acetone) δ 3.83-3.88 (m, 2H); ¹³C NMR (125 MHz, acetone) δ 64.7 (CH), 127.8 (CH), 140.9 (CH). Azides **11c** and **11d** (diagnostic peaks only): ¹H NMR (500 MHz, CDCl₃) δ 0.753 (s, 3H), 1.04 (s, 3H), 3.77-3.84 (m, 1H); 5.25-5.29 (m, 2H), 5.68-5.76 (m, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 64.8 (CH), 65.4 (CH), 118.1 (CH₂), 118.2 (CH₂), 135.6 (CH), 135.7 (CH), 212.91 (C), 212.94 (C); ¹H NMR (500 MHz, acetone) δ 3.92-4.00 (m, 1H), 5.25-5.38 (m, 2H), 5.79-5.86 (m, 1H); ¹³C NMR (125 MHz, acetone) δ 67.0 (CH), 70.4 (CH), 122.6 (CH₂), 122.8 (CH₂), 141.3 (CH), 141.4 (CH).

(3*S**,9*aR**)-9,9-Dimethyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (**12a**) and (3*S**,9*aR**)-9,9-dimethyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (**12b**). According to the procedure described for lactams **2a** and **2b**, azides **11a**, **11b**, **11c**, and **11d** (130 mg, 0.550 mmol) afforded after chromatography (15-25% EtOAc/hexanes) a mixture of lactams **12a** and **12b** (65 mg, 57%, 30:1 ratio) as a colorless oil. Lactams **12a** and **12b**: *R*_f = 0.35 (100% EtOAc/hexanes); IR (neat) 2966, 2927, 1634, 1408 cm⁻¹; HRMS (ESI) *m/z* calculated for (C₁₃H₂₁NO+Na)⁺ 230.1521, found: 230.1449. Lactam **12a**: ¹H NMR (400 MHz, CDCl₃) δ 0.84 (s, 3H), 0.94 (s, 3H), 1.42-1.70 (m, 5H), 1.91-2.08 (m, 3H), 2.35-2.42 (m, 1H), 2.48-2.53 (m, 1H), 3.73 (dd, *J* = 2.4, 8.0 Hz, 1H), 4.60 (t, *J* = 5.2 Hz, 1H), 4.94-5.05 (m, 2H), 5.72-5.81 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 19.7 (CH₂), 20.3 (CH₃), 26.1 (CH₂), 29.5 (CH₂), 29.8 (CH₃), 36.0 (C), 38.6 (CH₂), 46.5 (CH₂), 60.5 (CH), 66.2 (CH), 113.0 (CH₂), 138.1 (CH), 173.7 (C). Lactam **12b** (diagnostic peaks only): ¹H NMR (400 MHz, CDCl₃) δ 0.79 (s, 3H), 0.87 (s, 3H), 3.58 (dd, *J* = 6.4 Hz, 9.6 Hz, 1H), 4.79 (t, *J* = 6.2 Hz, 1H), 5.05-5.21 (m, 2H), 5.72-5.82 (m, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 19.0 (CH₃), 19.5 (CH₂), 27.9 (CH₂), 28.0 (CH₂), 28.7 (CH₃), 34.6 (C), 38.2 (CH₂), 46.0 (CH₂), 60.0 (CH), 66.9 (CH), 115.0 (CH₂), 138.1 (CH), 174.5 (C). The following NOE correlations were used to assign lactams **12a** and **12b**.



Scheme S7. Preparation of azides **13a**, **13b**, **13c**, **13d**, and lactams **14a**, **14b**.

2-(3,3-Dimethylcyclohexylidene)-1,1-dimethylhydrazine (13A). A solution of 3,3-dimethylcyclohexanone (10.0 g, 79.2 mmol), 1,1-dimethylhydrazine (18.3 mL, 240 mmol), and *p*-toluenesulfonic acid monohydrate (0.38 g, 2.0 mmol) in benzene (100 mL) was heated using a Dean-Stark apparatus for 20 h. The reaction was cooled to rt, and the solvent was removed in vacuum. Diethyl ether and saturated aqueous sodium bicarbonate were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, dried over anhydrous sodium sulfate. The concentration afforded hydrazone **13A** (12.3 g, 92%, 1:1 ratio), which was used directly in the next step without further purification. Hydrazone **13A**: ¹H NMR (400 MHz, CDCl₃) δ 0.93 (s, 3H), 0.94 (s, 3H), 1.42-1.47 (m, 2H), 1.63-1.75 (m, 2H), 2.03 (s, 1H), 2.19 (t, *J* = 6.4 Hz, 1H), 2.35 (s, 1H), 2.40 (s, 3H), 2.45 (s, 3H), 2.45 (t, *J* = 6.4 Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 22.1 (CH₂), 22.8 (CH₂), 27.8 (CH₂), 28.2 (CH₃), 28.6 (CH₃), 33.2 (C), 34.2 (C), 35.2 (CH₂), 39.0 (CH₂), 39.2 (CH₂), 41.2 (CH₂), 47.4 (CH₃), 47.7 (CH₃), 48.6 (CH₂), 169.4 (C), 170.3 (C).

2-(But-3-enyl)-5,5-dimethylcyclohexanone (13B). According to the procedure described for ketone **3B**, hydrazone **13A** (5.05 g, 30.0 mmol) afforded after chromatography (0.5-2.5% EtOAc/hexanes) ketone **13B** (3.91 g, 72%) as a colorless oil. Ketone **13B**: *R*_f = 0.50 (10% EtOAc/hexanes); IR (neat) 2954, 1710 cm⁻¹; HRMS (ESI) *m/z* calculated for (C₁₂H₂₀O+H)⁺ 181.1592, found: 181.1606; ¹H NMR (400 MHz, CDCl₃) δ 0.88 (s, 3H), 1.05 (s, 3H), 1.24-1.33 (m,

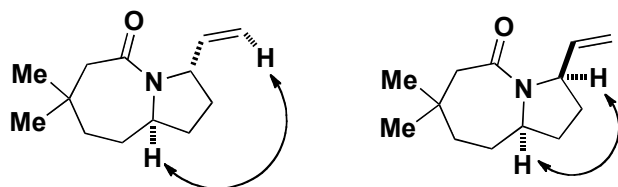
1H), 1.45-1.55 (m, 1H), 1.56-1.70 (m, 2H), 1.86-1.95 (m, 1H), 1.98-2.15 (m, 4H), 2.18-2.27 (m, 2H), 4.94-5.04 (m, 2H), 5.74-5.84 (m, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 25.7 (CH₃), 28.3 (CH₂), 29.4 (CH₂), 31.2 (CH₂), 31.3 (CH₃), 37.0 (C), 38.0 (CH₂), 48.7 (CH), 54.9 (CH₂), 114.7 (CH₂), 138.5 (CH), 212.8 (C).

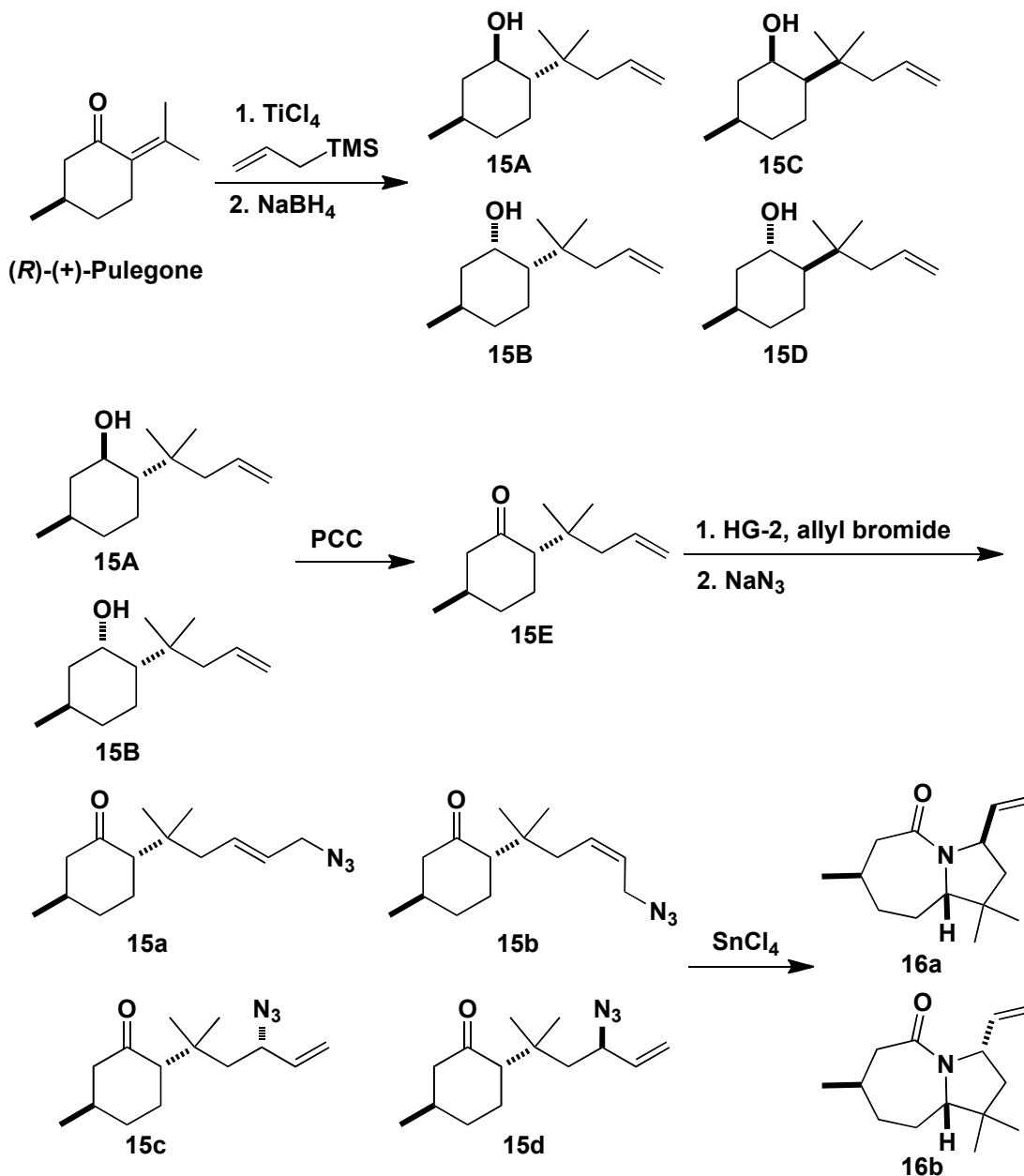
(*S,*E*)-2-(5-Azidopent-3-enyl)-5,5-dimethylcyclohexanone (13a)**, **(*S**,*Z*)-2-(5-azido pent-3-enyl)-5,5-dimethylcyclohexanone (13b)**, **(*R**)-2-((*S**)-3-azidopent-4-enyl)-5,5-dimethyl cyclohexanone (13c)**, and **(*R**)-2-((*R**)-3-azidopent-4-enyl)-5,5-dimethylcyclo hexanone (13d)**.

To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (89 mg, 0.14 mmol) in dichloromethane (15 mL) under N₂ atmosphere at room temperature was slowly added a solution of ketone **13B** (1.28 g, 7.10 mmol) and allyl boromide (1.80 mL, 21.3 mmol) in dichloromethane (5 mL). The resulting reaction mixture was stirred for 5 h. The solvent was concentrated in vacuum and the residue was dissolved in DMF (20 mL), followed by the addition of sodium azide (2.75 g, 42.3 mmol) at room temperature. After stirring for 10 h, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.1-1.6% EtOAc/hexanes) to afford a mixture of azides **13a**, **13b**, **13c**, and **13d** (872 mg, 52%, 63:7:15:15 ratio) as colorless oil. Azides **13a**, **13b**, **13c**, and **13d**: *R*_f = 0.30 (10% EtOAc/hexanes); IR (neat) 2952, 2093, 1708, 1236 cm⁻¹; HRMS (ESI) *m/z* calculated (C₂₆H₄₂N₆O₂+H)⁺ 471.3447 (corresponding to (2M+H)⁺), found: 471.3432. Azide **13a**: ¹H NMR (400 MHz, acetone) δ 0.85 (s, 3H), 1.05 (s, 3H), 1.22-1.31 (m, 1H), 1.42-1.62 (m, 3H), 1.69-1.79 (m, 1H), 1.81-1.92 (m, 1H), 1.99-2.08 (m, 2H), 2.09-2.19 (m, 1H), 2.28-2.36 (m, 2H), 3.77 (d, *J* = 6.4 Hz, 2H), 5.55-5.62 (m, 1H), 5.77-5.86 (m, 1H); ¹³C NMR (100 MHz, acetone) δ 24.9 (CH₂), 28.6 (CH₃), 29.3 (CH₂), 29.6 (CH₂), 30.8 (CH₃), 36.4 (C), 37.7 (CH₂), 48.1 (CH), 52.3 (CH₂), 54.5 (CH₂), 123.3 (CH), 136.5 (CH), 210.65 (C). Azide **13b** (diagnostic peaks only): ¹H NMR (400 MHz, acetone) δ 3.90 (d, *J* = 7.2 Hz, 2H); ¹³C NMR (100 MHz, acetone) δ 122.6 (CH), 135.7 (CH), 210.75 (C). Azides **13c** and **13d** (diagnostic peaks only): ¹H NMR (400 MHz, acetone) δ 3.97 (q, *J* = 7.0 Hz, 1H); 5.28-5.36 (m, 2H), 5.77-5.86 (m, 1H); ¹³C NMR (100 MHz, acetone) δ 48.55 (CH₂), 48.62 (CH₂), 65.0 (CH), 65.1 (CH), 117.52 (CH₂), 117.54 (CH₂), 136.12 (CH), 136.16 (CH), 210.58 (C).

(3*S,9*aR**)-7,7-Dimethyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (14a)** and **(3*S**,9*aR**)-7,7-dimethyl-3-vinyl-hexahydro-1*H*-pyrrolo[1,2-*a*]azepin-5(6*H*)-one (14b)**. According to the procedure described for lactams **2a** and **2b**, azides **13a**, **13b**, **13c**, and **13d** (125

mg, 0.530 mmol) afforded after chromatography (10-50% EtOAc/hexanes) lactam **14a** (53 mg, 48%) as a colorless oil and lactam **14b** (7 mg, 6%) as a colorless oil. Lactam **14a**: $R_f = 0.60$ (100% EtOAc); IR (neat) 2956, 1631, 1414 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{13}\text{H}_{21}\text{NO}+\text{H})^+$ 208.1701, found: 208.1701; ^1H NMR (400 MHz, CDCl_3) δ 1.00 (s, 6H), 1.53-1.70 (m, 5H), 1.71-1.82 (m, 1H), 1.98-2.10 (m, 1H), 2.20-2.31 (m, 1H), 2.24 (d, $J = 13.2$ Hz, 1H), 2.62 (d, $J = 13.2$ Hz, 1H), 3.81 (t, $J = 9.6$ Hz, 1H), 4.71 (t, $J = 6.0$ Hz, 1H), 4.99-5.08 (m, 2H), 5.71-5.80 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 23.7 (CH_3), 28.5 (CH_2), 30.3 (C), 31.8 (CH_2), 32.3 (CH_2), 33.6 (CH_3), 43.6 (CH_2), 50.7 (CH_2), 59.0 (CH), 59.5 (CH), 113.8 (CH_2), 137.3 (CH), 171.3 (C). Lactam **14b**: $R_f = 0.52$ (100% EtOAc); IR (neat) 2956, 2925, 1635, 1415 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{13}\text{H}_{21}\text{NO}+\text{H})^+$ 208.1701, found: 208.1712; ^1H NMR (500 MHz, CDCl_3) δ 0.93 (s, 3H), 0.97 (s, 3H), 1.41 (dt, $J = 4.0$ Hz, 13.5 Hz, 1H), 1.51-1.28 (m, 2H), 1.65-1.80 (m, 4H), 2.01-2.07 (m, 1H), 2.22 (dd, $J = 2.0$ Hz, 13.5 Hz, 1H), 2.46 (d, $J = 13.5$ Hz, 1H), 3.55 (dd, $J = 9.0$ Hz, 16.0 Hz, 1H), 4.65 (t, $J = 6.0$ Hz, 1H), 5.02-5.16 (m, 2H), 5.72-5.80 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 22.6 (CH_3), 27.9 (CH_2), 29.5 (C), 31.43 (CH_2), 31.47 (CH_2), 32.8 (CH_3), 42.2 (CH_2), 49.5 (CH_2), 58.4 (CH), 59.0 (CH), 113.5 (CH_2), 137.0 (CH), 170.9 (C). The following NOE correlations were used to assign lactams **14a** and **14b**.



Scheme S8. Preparation of azides **15a**, **15b**, **15c**, **15d** and lactams **16a**, **16b**.

(1R,2S,5R)-5-Methyl-2-(2-methylpent-4-en-2-yl)cyclohexanol (15A), **(1S,2S,5R)-5-methyl-2-(2-methylpent-4-en-2-yl)cyclohexanol (15B)**, **(1R,2R,5R)-5-methyl-2-(2-methylpent-4-en-2-yl)cyclohexanol (15C)** and **(1S,2R,5R)-5-methyl-2-(2-methylpent-4-en-2-yl)cyclohexanol (15D)**. Following the procedure of Miles et al.,^{S11} a solution of (R)-(+)-pulegone (85% purity, 12.5 g, 70.0 mmol) in dichloromethane (150 mL) was stirred at -78°C as titanium tetrachloride (neat, 8.4 mL, 77 mmol) was added dropwise over 5 min to form a red solution. After stirring 10 min, a solution of allyltrimethylsilane (10.4 g, 91.0 mmol) in dichloromethane (30 mL) was added dropwise over 5 min. The resulting purple solution was stirred at -78°C for 10 min and

at 0 °C for an additional 10 min. A solution of triethylamine (70 mL) and methanol (22 mL) was added dropwise over 5 min, forming a white heterogeneous mixture that was diluted with diethyl ether (300 mL) and filtered. The mixture was washed with 10% HCl, saturated aqueous sodium bicarbonate, and brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a crude product, which was purified by chromatography (0.6-5% EtOAc/hexanes) to afford a mixture of ketones **15E** and **17A** (15.3 g, 96%, 1.3:1 ratio) as a colorless oil. To a solution of ketones **15E** and **17A** (11.5 g, 59.0 mmol) in methanol (110 mL) at 0 °C was added portionwise sodium borohydride (3.37 g, 88.7 mmol). After being allowed to stir overnight, water was added slowly to quench the reaction. Diethyl ether was used to extract the product, and the aqueous layer was washed with diethyl ether three times. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by chromatography (0.6-5% EtOAc/hexanes) to afford a mixture of alcohols **15A** and **15B** (2.50 g, 22%, 2:5 ratio) as a colorless oil, a mixture of alcohols **15A**, **15B**, **15C**, and **15D** (3.80 g, 33%) as a colorless oil, and alcohols **15C** and **15D** (3.68 g, 32%, 25:1 ratio) as a colorless oil. Alcohol **15A** and **15B** (2:5 ratio): $R_f = 0.25$ (10% EtOAc/hexanes); IR (neat) 3424, 2916, 1638, 1455 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{13}\text{H}_{24}\text{ONa}$ ($\text{M}+\text{Na}$)⁺ 219.1725, found: 219.1772; Alcohol **15B**: ¹H NMR (400 MHz, CDCl_3) δ 0.89 (d, $J = 6.2$ Hz, 3H), 0.95 (s, 3H), 0.98 (s, 3H), 0.88-1.02 (m, 1H), 1.07-1.20 (m, 2H), 1.47-1.60 (m, 2H), 1.71-1.82 (m, 3H), 2.03-2.15 (m, 2H), 4.25 (br, 1H), 5.00-5.06 (m, 2H), 5.80-5.90 (m, 1H); ¹³C NMR (100 MHz, CDCl_3) δ 20.9 (CH_2), 22.3 (CH_3), 25.4 (CH_3), 25.98 (CH_3), 26.2 (CH), 35.4 (C), 35.6 (CH_2), 44.0 (CH_2), 45.8 (CH_2), 48.6 (CH), 68.3 (CH), 116.8 (CH_2), 136.0 (CH). Alcohol **15A** (diagnostic peaks only): ¹H NMR (400 MHz, CDCl_3) δ 0.91 (d, $J = 6.4$ Hz, 3H), 0.97 (s, 3H), 1.03 (s, 3H), 1.37-1.45 (m, 1H), 1.63-1.68 (m, 1H), 1.89-1.96 (m, 1H), 2.15-2.30 (m, 2H), 3.58 (dt, $J = 4.0, 10.4$ Hz, 1H); ¹³C NMR (100 MHz, CDCl_3) δ 22.0 (CH_3), 26.04 (CH_2), 26.4 (CH_3), 26.6 (CH_3), 31.7 (CH), 34.9 (CH_2), 35.7 (CH_2), 46.7 (CH_2), 46.9 (CH_2), 50.9 (CH), 73.1 (CH), 116.5 (CH_2), 136.5 (CH). Alcohol **15C** and **15D** (25:1 ratio): $R_f = 0.30$ (10% EtOAc/hexanes); IR (neat) 3506, 2910, 1638 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{13}\text{H}_{24}\text{ONa}$ ($\text{M}+\text{Na}$)⁺ 219.1725, found: 219.1728; Alcohol **15C**: ¹H NMR (400 MHz, CDCl_3) δ 0.96 (s, 3H), 0.98 (s, 3H), 1.08-1.18 (m, 2H), 1.19 (d, $J = 7.4$ Hz, 3H), 1.27-1.33 (m, 1H), 1.37-1.44 (m, 1H), 1.51-1.60 (m, 1H), 1.62-1.77 (m, 2H), 1.89-1.97 (m, 1H), 2.03-2.17 (m, 2H), 4.26 (br, 1H), 5.00-5.06 (m, 2H), 5.80-5.90 (m, 1H); ¹³C NMR (100 MHz, CDCl_3) δ 15.9 (CH_2), 21.3 (CH or CH_3), 25.2 (CH or CH_3), 25.9 (CH or CH_3), 26.5 (CH or CH_3), 32.6 (CH_2),

35.6 (C), 40.7 (CH₂), 45.7 (CH₂), 49.1 (CH), 69.2 (CH), 116.7 (CH₂), 136.1 (CH). Alcohol **15D** (diagnostic peaks only): ¹H NMR (400 MHz, CDCl₃) δ 1.00 (s, 3H), 3.83 (br, 1H).

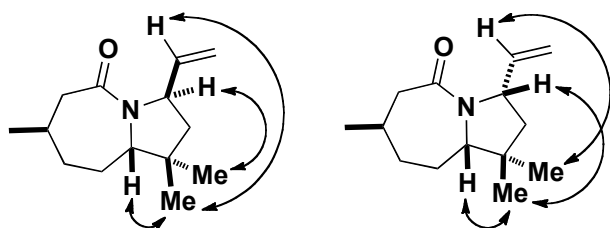
(2S,5R)-5-Methyl-2-(2-methylpent-4-en-2-yl)cyclohexanone (15E). To a solution of alcohols **15A** and **15B** (2.50 g, 12.7 mmol) in dichloromethane (40 mL) at room temperature was added silica gel (7.50 g) and pyridinium chlorochromate (PCC, 5.50 g, 25.5 mmol) slowly. After being allowed to stir overnight, the reaction mixture was concentrated, purified by chromatography (0.6-3% EtOAc/hexanes) to afford ketone **15E** (2.20 g, 88%) as a colorless oil. Its spectral data matched with reported data.^{S11}

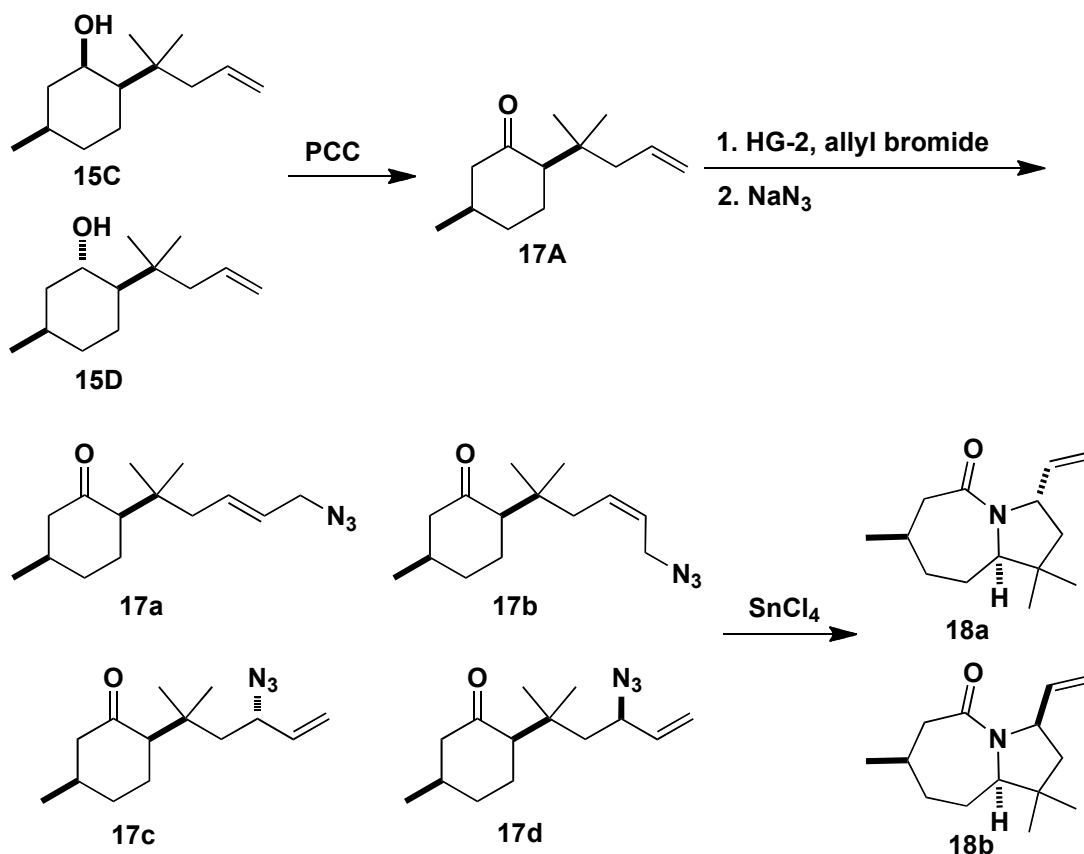
(2S,5R,E)-2-(6-Azido-2-methylhex-4-en-2-yl)-5-methylcyclohexanone (15a), **(2S,5R,Z)-2-(6-Azido-2-methylhex-4-en-2-yl)-5-methylcyclohexanone (15b)**, **(2S,5R)-2-((S)-4-azido-2-methylhex-5-en-2-yl)-5-methylcyclohexanone (15c)**, and **(2S,5R)-2-((R)-4-azido-2-methylhex-5-en-2-yl)-5-methylcyclohexanone (15d)**. To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (250 mg, 0.400 mmol) in dichloromethane (20 mL) under N₂ atmosphere at room temperature was slowly added a solution of ketone **15E** (1.55 g, 8.0 mmol) and allyl bromide (2.0 mL, 24 mmol) in dichloromethane (10 mL). The resulting reaction mixture was stirred overnight. The solvent was concentrated in vacuum and the residue was dissolved in DMSO (15 mL) and DMF (15 mL), followed by the addition of sodium azide (2.60 g, 40.0 mmol) at room temperature. After being allowed to stir overnight, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.6-4.0% EtOAc/hexanes) to afford a mixture of azides **15a**, **15b**, **15c**, and **15d** (1.41 g, 71%, 90:8.4:0.8:0.8 ratio) as a colorless oil. Azides **15a**, **15b**, **15c**, and **15d**: *R_f* = 0.35 (5% EtOAc/hexanes); IR (neat) 2954, 2094, 1708 cm⁻¹; HRMS (ESI) *m/z* calculated for C₂₈H₄₇N₄O₂ (2M-N₂+H)⁺ 471.3699, found: 471.3673. Azide **15a**: ¹H NMR (500 MHz, CDCl₃) δ 0.89 (s, 3H), 0.93 (dd, *J* = 1.0, 6.2 Hz, 3H), 0.95 (s, 3H), 1.22-1.32 (m, 1H), 1.35-1.45 (m, 1H), 1.76-1.86 (m, 2H), 1.94 (t, *J* = 12.5 Hz, 1H), 1.96-2.04 (m, 2H), 2.11 (dd, *J* = 4.7, 13.0 Hz, 1H), 2.18 (td, *J* = 2.0, 10.0 Hz, 1H), 2.33 (dd, *J* = 8.5, 13.5 Hz, 1H), 3.63 (d, *J* = 6.5 Hz, 2H), 5.40-5.47 (m, 1H), 5.62-5.68 (m, 1H); ¹H NMR (500 MHz, acetone) δ 0.91 (s, 3H), 0.93 (d, *J* = 6.5 Hz, 3H), 0.97 (s, 3H), 1.28-1.43 (m, 2H), 1.73-1.81 (m, 1H), 1.82-1.87 (m, 1H), 1.96-2.04 (m, 1H), 2.05-2.12 (m, 3H), 2.18 (ddd, *J* = 1.0, 4.5, 13.0 Hz, 1H), 2.33 (dd, *J* = 7.5, 13.5 Hz, 1H), 3.72 (d, *J* = 6.7 Hz, 2H), 5.46-5.52 (m, 1H), 5.76-5.80 (m, 1H); ¹³C NMR (125 MHz, CDCl₃) δ 22.3 (CH₃), 24.2 (CH₃), 25.4 (CH₃), 28.2 (CH₂), 34.5 (C), 34.62 (CH₂), 36.4 (CH), 43.1 (CH₂), 52.4 (CH₂), 52.9 (CH₂),

56.7 (CH), 125.4 (CH), 133.6 (CH), 212.1 (C); ^{13}C NMR (125 MHz, acetone) δ 22.6 (CH₃), 24.5 (CH₃), 25.5 (CH₃), 28.8 (CH₂), 35.1 (C), 35.3 (CH₂), 37.1 (CH), 43.8 (CH₂), 52.7 (CH₂), 53.3 (CH₂), 57.1 (CH), 126.6 (CH₂), 134.3 (CH), 211.6 (C). Azide **15b** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl₃) δ 2.43 (dd, $J = 8.7, 14.0$ Hz, 1H), 3.70-3.78 (m, 2H); ^1H NMR (500 MHz, acetone) δ 2.43 (dd, $J = 8.7, 14.0$ Hz, 1H), 3.81-3.87 (m, 2H); ^{13}C NMR (125 MHz, CDCl₃) δ 124.4 (CH), 132.1 (CH), 211.98 (C); ^{13}C NMR (125 MHz, acetone) δ 125.3 (CH), 132.9 (CH), 211.8 (C). Azides **15c** and **15d** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl₃) δ 3.70-3.78 (m, 1H); ^1H NMR (500 MHz, acetone) δ 3.85-3.88 (m, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ 61.97 (CH), 62.03 (CH), 117.1 (CH₂), 117.2, (CH₂) 136.7 (CH), 136.9 (CH); ^{13}C NMR (125 MHz, acetone) δ 62.60 (CH), 62.74 (CH), 117.42 (CH₂), 117.57 (CH₂), 138.14 (CH), 138.21 (CH).

(3R,7R,9aS)-1,1,7-Trimethyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (16a) and **(3S,7R,9aS)-1,1,7-trimethyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (16b)**. To a refluxing solution of azides **15a**, **15b**, **15c**, and **15d** (63 mg, 0.25 mmol) in anhydrous 1,2-dichloroethane (12 mL) under N₂ atmosphere was added tin tetrachloride (0.38 mL, 1M in dichloromethane, 0.38 mmol). After being allowed to reflux for 15 h, the reaction was cooled and saturated aqueous ammonium chloride was added. After separation, the aqueous layer was washed with dichloromethane. The aqueous layer was neutralized by saturated aqueous sodium bicarbonate and washed twice with dichloromethane. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, and dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (10-18% EtOAc/hexanes) to afford lactam **16a** (17 mg, 30%) as a colorless oil and **16b** (11 mg, 20%) as a colorless oil. Lactam **16a**: $R_f = 0.5$ (100% EtOAc/hexanes); $[\alpha]_{546}^{25} -48.0$ (c 3.75, dichloromethane); IR (neat) 2954, 1638, 1408 cm⁻¹; HRMS (ESI) m/z calculated for C₁₄H₂₃NONa (M+Na)⁺ 244.1677, found: 244.1708; ^1H NMR (500 MHz, CDCl₃) δ 0.93 (s, 3H), 0.96 (d, $J = 6.5$ Hz, 3H), 1.07 (s, 3H), 1.13-1.27 (m, 2H), 1.54 (dd, $J = 6.0, 12.5$ Hz, 1H), 1.68-1.75 (m, 1H), 1.77-1.82 (m, 1H), 1.87 (dd, $J = 8.0, 12.5$ Hz, 1H), 1.90-1.95 (m, 1H), 2.27-2.37 (m, 2H), 3.31 (d, $J = 10.0$ Hz, 1H), 4.45 (dd, $J = 6.5, 14.0$ Hz, 1H), 5.03 (td, $J = 1.0, 9.0$ Hz, 1H), 5.08 (td, $J = 1.0, 17.0$ Hz, 1H), 5.79-5.86 (m, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ 23.7 (CH₃), 24.2 (CH₃), 28.5 (CH₃), 29.9 (CH), 30.1 (CH₂), 38.5 (CH₂), 41.2 (C), 45.0 (CH₂), 46.8 (CH₂), 59.6 (CH), 69.0 (CH), 113.7 (CH₂), 140.5 (CH), 173.4 (C). Lactam **16b**: $R_f = 0.4$ (100% EtOAc/hexanes); $[\alpha]_{546}^{25} -25.6$ (c 2.35, dichloromethane); IR (neat) 2954, 1638, 1406 cm⁻¹; HRMS (ESI) m/z calculated for C₁₄H₂₃NONa (M+Na)⁺ 244.1677, found: 244.1676; ^1H NMR (500 MHz, CDCl₃) δ 0.92 (d, $J = 6.5$ Hz, 3H), 0.94 (s, 3H), 1.03 (s, 3H), 1.13-1.32 (m, 2H), 1.55

(dd, $J = 6.5, 12.5$ Hz, 1H), 1.68-1.75 (m, 1H), 1.77-1.82 (m, 2H), 1.88-1.94 (m, 1H), 2.26-2.35 (m, 2H), 3.22 (d, $J = 10.5$ Hz, 1H), 4.39-4.45 (m, 1H), 5.00 (td, $J = 1.3, 10.0$ Hz, 1H), 5.06 (td, $J = 1.3, 17.0$ Hz, 1H), 5.73-5.81 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 24.0 (CH_3), 24.6 (CH_3), 29.0 (CH_3), 30.23 (CH_2), 30.26 (CH), 39.0 (CH_2), 41.3 (C), 44.4 (CH_2), 46.6 (CH_2), 59.0 (CH), 69.2 (CH), 113.8 (CH_2), 140.0 (CH), 174.0 (C). The following NOE correlations were used to assign lactams **16a** and **16b**.



Scheme S9. Preparation of azides **17a**, **17b**, **17c**, **17d** and lactams **18a**, **18b**.

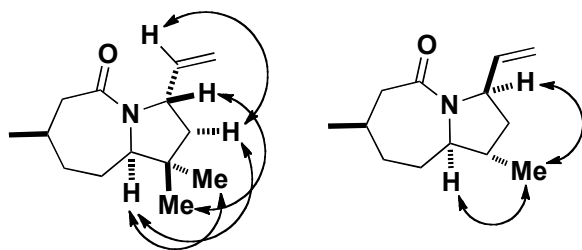
(2*R*,5*R*)-5-Methyl-2-(2-methylpent-4-en-2-yl)cyclohexanone (17A). To a solution of alcohols **15C** and **15D** (3.68 g, 18.8 mmol) in dichloromethane (40 mL) at room temperature was added silica gel (10 g) and pyridinium chlorochromate (PCC, 8.08 g, 37.5 mmol) slowly. After stirring overnight, the reaction mixture was concentrated, purified by chromatography (0.6-3% EtOAc/hexanes) to afford ketone **17A** (2.23 g, 61%) as a colorless oil. Its spectral data matched with reported data.^{S11}

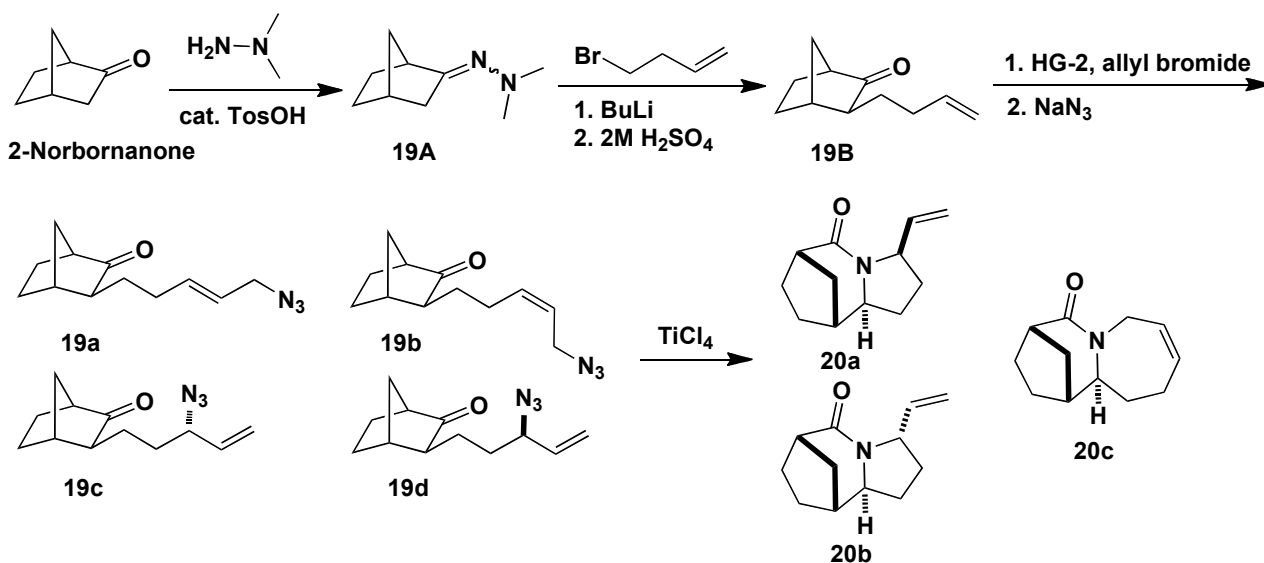
(2*R*,5*R*,*E*)-2-(6-Azido-2-methylhex-4-en-2-yl)-5-methylcyclohexanone (17a), **(2*R*,5*R*,*Z*)-2-(6-Azido-2-methylhex-4-en-2-yl)-5-methylcyclohexanone (17b)**, **(2*R*,5*R*)-2-((*S*)-4-azido-2-methylhex-5-en-2-yl)-5-methylcyclohexanone (17c)**, and **(2*R*,5*R*)-2-((*R*)-4-azido-2-methylhex-5-en-2-yl)-5-methylcyclohexanone (17d)**. To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (360 mg, 0.570 mmol) in dichloromethane (20 mL) under N₂ atmosphere at room temperature was slowly added a solution of ketone **17A** (2.23 g, 11.5 mmol) and allyl bromide (2.0 mL, 24 mmol) in dichloromethane (10 mL). The resulting reaction mixture was stirred for 1h. The solvent was concentrated in vacuum and the residue was dissolved in DMSO (15 mL) and DMF

(35 mL), followed by the addition of sodium azide (2.60 g, 40.0 mmol) at room temperature. After being allowed to stir for 2h, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.6-4.0% EtOAc/hexanes) to afford a mixture of azides **17a**, **17b**, **17c**, and **17d** (1.97 g, 69%, 94:5:0.5:0.5 ratio) as a colorless oil. Azides **17a**, **17b**, **17c**, and **17d**: $R_f = 0.5$ (5% EtOAc/hexanes); IR (neat) 2957, 2094, 1707 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{28}\text{H}_{47}\text{N}_6\text{O}_2$ (2M +H)⁺ 499.3760, found: 499.3738. Azide **17a**: ^1H NMR (500 MHz, CDCl_3) δ 0.95 (d, $J = 7.0$ Hz, 3H), 0.98 (s, 3H), 1.03 (s, 3H), 1.58-1.65 (m, 1H), 1.76 (dq, $J = 3.5, 12.0$ Hz, 1H), 1.82-1.90 (m, 1H), 1.93-1.98 (m, 1H), 2.03-2.12 (m, 2H), 2.22 (dd, $J = 5.5, 11.5$ Hz, 1H), 2.33-2.39 (m, 2H), 2.50 (dd, $J = 5.5, 12.8$ Hz, 1H), 3.71 (d, $J = 6.6$ Hz, 2H), 5.49-5.57 (m, 1H), 5.72-5.78 (m, 1H); ^1H NMR (500 MHz, acetone) δ 0.91 (d, $J = 7.1$ Hz, 3H), 0.97 (s, 3H), 1.02 (s, 3H), 1.58-1.45 (m, 1H), 1.67-1.78 (m, 1H), 1.88-1.97 (m, 3H), 2.10 (dd, $J = 7.5, 13.5$ Hz, 1H), 2.28-2.38 (m, 3H), 2.55 (dd, $J = 6.8, 12.5$ Hz, 1H), 3.76 (d, $J = 6.6$ Hz, 2H), 5.51-5.57 (m, 1H), 5.70-5.86 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 19.1 (CH or CH_3), 24.0 (CH_2), 24.5 (CH or CH_3), 25.4 (CH or CH_3), 31.4 (CH_2), 32.3 (CH or CH_3), 34.9 (C), 43.3 (CH_2), 50.3 (CH_2), 52.9 (CH_2), 57.0 (CH), 125.5 (CH), 133.6 (CH), 212.8 (CH_2); ^{13}C NMR (125 MHz, acetone) δ 19.1 (CH or CH_3), 24.6 (CH_2), 24.72 (CH or CH_3), 25.5 (CH or CH_3), 32.0 (CH_2), 33.0 (CH or CH_3), 35.4 (C), 43.9 (CH_2), 50.8 (CH_2), 53.3 (CH_2), 57.5 (CH), 126.6 (CH), 134.2 (CH), 212.06 (C). Azide **17b** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl_3) δ 3.79-3.84 (m, 2H); ^1H NMR (500 MHz, acetone) δ 2.45 (dd, $J = 8.7, 14.0$ Hz, 1H), 3.83-3.91 (m, 2H); ^{13}C NMR (125 MHz, CDCl_3) δ 57.2 (CH), 124.5 (CH_2), 132.0 (CH_2), 212.7 (CH_2); ^{13}C NMR (125 MHz, acetone) δ 57.7 (CH), 125.3 (CH), 132.8 (CH), 212.28 (C). Azides **17c** and **17d** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl_3) δ 3.79-3.84 (m, 1H); ^1H NMR (500 MHz, acetone) δ 3.83-3.91 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 62.02 (CH), 62.05 (CH), 117.13 (CH_2), 117.19 (CH_2), 136.77 (CH), 136.91 (CH), 212.12 (C), 212.42 (C); ^{13}C NMR (125 MHz, acetone) δ 62.63 (CH), 62.73 (CH), 117.43 (CH_2), 117.53 (CH_2), 138.16 (CH), 138.22 (CH), 211.8 (C), 212.14 (C).

(3S,7R,9aR)-1,1,7-Trimethyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (18a) and **(3R,7R,9aR)-1,1,7-trimethyl-3-vinyl-hexahydro-1H-pyrrolo[1,2-a]azepin-5(6H)-one (18b)**. According to the procedure described for lactams **16a** and **16b**, azides **17a**, **17b**, **17c**, and **17d** (50 mg, 0.20 mmol) afforded after chromatography (11-25% EtOAc/hexanes) lactam **18a** (19 mg, 43%) as a colorless oil and **18b** (2 mg, 5%) as a colorless oil. Lactam **18a**: $R_f = 0.5$ (100%

EtOAc/hexanes); $[\alpha]_{546}^{25} +12.7$ (c 0.75, dichloromethane); IR (neat) 2955, 1629, 1410 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{14}\text{H}_{23}\text{NONa}$ ($\text{M}+\text{Na}$) $^{+}$ 244.1677, found: 244.1632; ^1H NMR (500 MHz, CDCl_3) δ 0.78 (s, 3H), 0.94 (d, $J = 6.8$ Hz, 3H), 0.98 (s, 3H), 1.31-1.37 (m, 2H), 1.41 (dd, $J = 9.8, 12.5$ Hz, 1H), 1.48-1.55 (m, 1H), 1.65-1.73 (m, 2H), 1.85 (dd, $J = 7.5, 12.5$ Hz, 1H), 2.03-2.10 (m, 1H), 2.34-2.45 (m, 2H), 3.21 (d, $J = 10.5$ Hz, 1H), 4.49 (dd, $J = 7.2, 16.0$ Hz, 1H), 5.03 (td, $J = 1.0, 10.0$ Hz, 1H), 5.09 (td, $J = 1.0, 17.0$ Hz, 1H), 5.71-5.78 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 21.0 (CH_3), 21.6 (CH_3), 25.2 (CH_2), 25.4 (CH_3), 27.0 (CH), 34.0 (CH_2), 41.1 (C), 43.2 (CH_2), 45.1 (CH_2), 58.7 (CH), 67.4 (CH), 113.9 (CH_2), 139.5 (CH), 172.7 (C). Lactam **18b**: $R_f = 0.35$ (100% EtOAc/hexanes); $[\alpha]_{546}^{25} +20.8$ (c 0.75, dichloromethane); IR (neat) 2959, 1644, 1412 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{14}\text{H}_{23}\text{NONa}$ ($\text{M}+\text{Na}$) $^{+}$ 244.1677, found: 244.1641; ^1H NMR (500 MHz, CDCl_3) δ 0.98 (s, 3H), 1.01 (s, 3H), 1.02 (d, $J = 7.0$ Hz, 3H), 1.43-1.53 (m, 1H), 1.58-1.70 (m, 3H), 1.75-1.82 (m, 2H), 2.03-2.12 (m, 1H), 2.39 (ddd, $J = 1.0, 6.5, 14.5$ Hz, 1H), 2.69 (dd, $J = 2.5, 14.5$ Hz, 1H), 3.25 (d, $J = 11.5$ Hz, 1H), 4.45 (dd, $J = 6.5, 14.0$ Hz, 1H), 5.05 (td, $J = 1.3, 10.5$ Hz, 1H), 5.13 (td, $J = 1.3, 17.0$ Hz, 1H), 5.79-5.86 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 17.2 (CH_3), 23.9 (CH_3), 25.4 (CH_2), 27.1 (CH), 28.8 (CH_3), 35.5 (CH_2), 41.0 (C), 44.1 (CH_2), 44.3 (CH_2), 59.3 (CH), 69.4 (CH), 114.3 (CH_2), 140.2 (CH), 173.0 (C). The following NOE correlations were used to assign lactams **18a** and **18b**.



Scheme S10. Preparation of azides **19a**, **19b**, **19c**, **19d** and lactams **20a**, **20b**.

2-(Bicyclo[2.2.1]heptan-2-ylidene)-1,1-dimethylhydrazine (19A).^{S12} To a solution of 2-norbornanone (6.6 g, 60 mmol) and 1,1-dimethylhydrazine (12 g, 0.18 mol) in 40 mL benzene was added *p*-toluenesulfonic acid monohydrate (0.38 g, 2.0 mmol). The reaction mixture was heated to reflux using a Dean-Stark apparatus for two days. The reaction mixture was concentrated under reduced pressure, and diethyl ether and saturated aqueous sodium bicarbonate were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentration affords hydrazone **19A**, (27.3 g, 100%, *E/Z*: 4:1), which was used without any purification. Hydrazone **19A**: IR (neat) 2952, 1669, 1466 cm⁻¹; HRMS (ESI) *m/z* calculated for C₉H₁₇N₂ (M+H)⁺ 153.1392, found: 153.1382. Major isomer: ¹H NMR (400 MHz, CDCl₃) δ 1.25-1.50 (m, 4H), 1.62-1.78 (m, 2H), 2.05 (dd, *J* = 3.0, 17.2 Hz, 1H), 2.25 (d, *J* = 17.2 Hz, 1H), 2.44 (s, 6H), 2.47-2.50 (m, 1H), 2.78 (br, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 26.9 (CH₂), 27.73 (CH₂), 35.7 (CH), 36.9 (CH₂), 38.2 (CH₂), 44.9 (CH), 47.1 (CH₃), 176.5 (C). Minor isomer (diagnostic peaks only): ¹H NMR (400 MHz, CDCl₃) δ 1.94 (dd, *J* = 3.0, 16.4 Hz, 1H), 3.36 (br, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 26.2 (CH₂), 27.67 (CH₂), 34.9 (CH), 38.4 (CH₂), 39.5 (CH₂), 40.8 (CH), 48.0 (CH₃), 176.1 (C).

(1*S,3*S**,4*R**)-3-(But-3-enyl)bicyclo[2.2.1]heptan-2-one (19B).** To a solution of hydrazone **19A** (4.56 g, 30.0 mmol) in THF (60 mL) under N₂ atmosphere at 0 °C was added *n*-BuLi (12 mL, 2.5 M in hexane, 30 mmol). After stirring for 1.2 h, 4-bromo-1-butene (4.5 g, 33 mmol) was added dropwise at 0 °C. The reaction mixture was allowed naturally to warm to rt and stirred overnight. The reaction mixture was poured into a mixture of iced 2M H₂SO₄ (30 mL) and

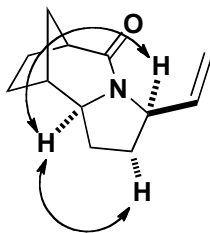
diethyl ether (80 mL), and was vigorously stirred for 1 h. After separation, the aqueous layer was extracted twice with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by chromatography (0.6-11% EtOAc/hexanes) to afford **19B** (3.68 g, 75%) as a colorless oil. Ketone **19B**: R_f = 0.60 (10% EtOAc/hexanes); IR (neat) 2958, 1740, 1033 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{11}\text{H}_{17}\text{O}$ ($\text{M}+\text{H}$)⁺ 165.1279, found: 165.1242; ¹H NMR (400 MHz, CDCl_3) δ 1.28-1.38 (m, 1H), 1.38-1.53 (m, 3H), 1.60-1.68 (m, 1H), 1.68-1.75 (m, 1H), 1.78-1.87 (m, 3H), 2.08-2.25 (m, 2H), 2.42 (br, 1H), 2.53 (br, 1H), 4.97 (td, J = 0.8, 10.0 Hz, 1H), 5.03 (qd, J = 1.6, 17.2 Hz, 1H), 5.78 (tdd, J = 6.6, 10.4, 17.2 Hz, 1H); ¹³C NMR (100 MHz, CDCl_3) δ 24.0 (CH_2), 27.9 (CH_2), 28.3 (CH_2), 32.2 (CH_2), 34.8 (CH_2), 39.1 (CH), 49.6 (CH), 53.2 (CH), 115.2 (CH_2), 137.9 (CH), 220.2 (C).

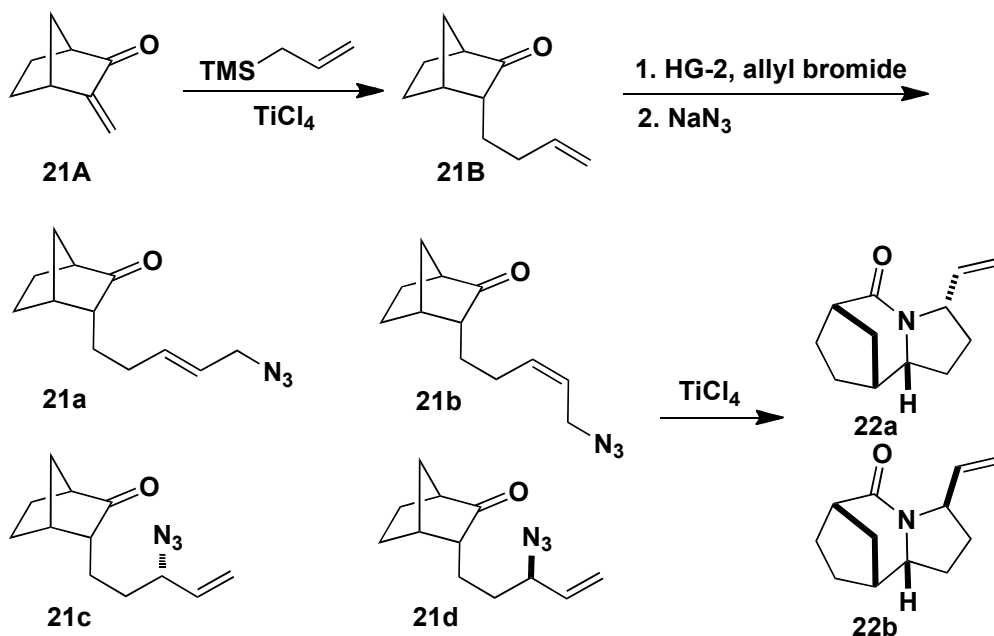
(1S*,3S*,4R*,E)-3-(5-Azidopent-3-enyl)bicyclo[2.2.1]heptan-2-one (19a), **(1S*,3S*,4R*,Z)-3-(5-azidopent-3-enyl)bicyclo[2.2.1]heptan-2-one (19b)**, **(1S*,3S*,4R*)-3-((S*)-3-azidopent-4-enyl)bicyclo[2.2.1]heptan-2-one (19c)** and **(1S*,3S*,4R*)-3-((R*)-3-azidopent-4-enyl)bicyclo[2.2.1]heptan-2-one (19d)**. To a solution of Hoveyda-Grubbs 2nd generation catalyst (HG-2) (285 mg, 0.450 mmol) in dichloromethane (15 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **19B** (1.50 g, 9.10 mmol) and allyl bromide (3.9 mL, 45.5 mmol) in dichloromethane (10 mL). The resulting reaction mixture was stirred for 2 h. The solvent was concentrated in vacuum and the residue was dissolved in DMSO (10 mL) and NMF (30 mL), followed by the addition of sodium azide (3.3 g, 50 mmol) at room temperature. After stirring for 2 h, diethyl ether and water were added and the aqueous layer was washed three times with diethyl ether. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (0.6-6% EtOAc/hexanes) to afford a mixture of azides **19a**, **19b**, **19c**, and **19d** (1.77 g, 84%, 64:8:14:14 ratio) as a colorless oil. Azides **19a**, **19b**, **19c**, and **19d**: R_f = 0.25 (10% EtOAc/hexanes); IR (neat) 2959, 2093, 1739, 1239 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{12}\text{H}_{17}\text{N}_3\text{ONa}$ ($\text{M}+\text{Na}$)⁺ 242.1269, found: 242.1295. Azide **19a**: ¹H NMR (500 MHz, CDCl_3) δ 1.27-1.35 (m, 1H), 1.37-1.43 (m, 1H), 1.52-1.63 (m, 3H), 1.67 (dd, J = 1.0, 10.0 Hz, 1H), 1.75-1.85 (m, 2H), 1.95-2.05 (m, 1H), 2.08-2.23 (m, 2H), 2.60 (br, 2H), 3.70 (d, J = 6.5 Hz, 2H), 5.53-5.59 (m, 1H), 5.69-5.76 (m, 1H); ¹H NMR (500 MHz, acetone) δ 1.23-1.32 (m, 2H), 1.53-1.60 (m, 4H), 1.62-1.72 (m, 2H), 1.75-1.82 (m, 1H), 1.97-2.03 (m, 1H), 2.08-2.22 (m, 1H), 2.43 (d, J = 5.0 Hz, 1H), 2.59 (br, 1H), 3.73 (d, J = 5.5 Hz, 2H), 5.56-5.62 (m, 1H), 5.73-5.83 (m, 1H); ¹³C NMR (125 MHz, CDCl_3) δ 21.1 (CH_2), 25.3 (CH_2), 25.6 (CH_2), 30.5 (CH_2), 37.0 (CH_2), 38.2 (CH), 50.5 (CH), 52.69 (CH), 52.74 (CH_2),

123.7 (CH), 135.9 (CH), 219.8 (C); ^{13}C NMR (125 MHz, acetone) δ 21.7 (CH₂), 25.9 (CH₂), 26.7 (CH₂), 31.2 (CH₂), 37.4 (CH₂), 39.0 (CH), 51.1 (CH), 53.17 (CH₂), 53.20 (CH), 124.7 (CH), 136.83 (CH), 218.3 (C). Azide **19b** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl₃) δ 3.79-3.86 (m, 2H); ^1H NMR (500 MHz, acetone) δ 3.88 (d, $J = 7.5$ Hz, 2H), 5.50-5.56 (m, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ 123.0 (CH), 135.2 (CH), 219.6 (C); ^{13}C NMR (125 MHz, acetone) δ 123.8 (CH), 136.1 (CH). Azides **19c** and **19d** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl₃) δ 3.79-3.86 (m, 1H), 5.26-5.29 (m, 2H), 5.70-5.77 (m, 1H); ^1H NMR (500 MHz, acetone) δ 3.96-4.01 (m, 1H), 5.25 (ddd, $J = 0.7, 1.3, 11.0$ Hz, 1H), 5.31 (td, $J = 1.1, 17.0$ Hz, 1H), 5.72-5.82 (m, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ 64.9 (CH), 65.0 (CH), 118.4 (CH₂), 118.7 (CH₂), 135.3 (CH), 135.5 (CH), 219.26 (C), 219.35 (C); ^{13}C NMR (125 MHz, acetone) δ 65.65 (CH), 65.70 (CH), 118.55 (CH₂), 118.69 (CH₂), 136.85 (CH), 136.99 (CH), 218.00 (C), 218.05 (C).

(1S*,2R*,5S*,8S*)-5-Vinyl-6-azatricyclo[6.1.2.0^{2,6}]undecan-7-one (20a), **(1S*,2R*,10S*)-8-aza-tricyclo[8.1.2.0^{2,8}]-5-tridecen-9-one (20c)** and **(1S*,2R*,5R*,8S*)-5-vinyl-6-azatricyclo[6.1.2.0^{2,6}]undecan-7-one (20b)**. To a refluxing solution of azides **19a**, **19b**, **19c**, and **19d** (98 mg, 0.45 mmol) in anhydrous 1,2-dichloroethane (18 mL) under N₂ atmosphere was added titanium tetrachloride (0.67 mL, 1M in dichloromethane, 0.67 mmol). After being allowed to reflux for 15 h, the reaction was cooled and saturated aqueous ammonium chloride was added. After separation, the aqueous layer was washed with dichloromethane. The aqueous layer was neutralized by saturated aqueous sodium bicarbonate and washed twice with dichloromethane. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, and dried over anhydrous sodium sulfate. The concentrated residue was purified by chromatography (2-30% EtOAc/hexanes) to afford lactam **20a** (53 mg, 62%) as a colorless oil and a mixture of lactams **20b** and **20c** (5 mg, 6%, 1:7 ratio) as a colorless oil. Lactam **20a**: $R_f = 0.2$ (100% EtOAc/hexanes); IR (neat) 2946, 1649, 1415 cm⁻¹; HRMS (ESI) m/z calculated for C₁₂H₁₇NONa (M+Na)⁺ 214.1208, found: 214.1204; ^1H NMR (500 MHz, CDCl₃) δ 1.41-1.47 (m, 1H), 1.48-1.59 (m, 2H), 1.62 (d, $J = 11.5$ Hz, 1H), 1.69-1.82 (m, 4H), 1.91-1.99 (m, 1H), 2.01-2.11 (m, 1H), 2.37 (br, 1H), 2.70 (t, $J = 4.0$ Hz, 1H), 3.11 (td, $J = 2.0, 12.0$ Hz, 1H), 4.19 (t, $J = 8.5$ Hz, 1H), 5.05 (td, $J = 0.8, 10.0$ Hz, 1H), 5.13 (td, $J = 0.8, 17.0$ Hz, 1H), 5.73-5.80 (m, 1H); ^{13}C NMR (125 MHz, CDCl₃) δ 27.2 (CH₂), 29.5 (CH₂), 30.1 (CH₂), 31.6 (CH₂), 33.2 (CH₂), 36.5 (CH), 43.8 (CH), 57.8 (CH), 66.2 (CH), 114.3 (CH₂), 138.9 (CH), 175.6 (C). Mixture of lactams **20b** and **20c**: $R_f = 0.25$ (100% EtOAc/hexanes); IR (neat) 2941, 1639, 1450 cm⁻¹; HRMS (ESI) m/z calculated for C₁₂H₁₇NONa (M+Na)⁺ 214.1208, found: 214.1218. Lactam **20c**: ^1H NMR (500 MHz, CDCl₃) δ 1.38-1.43 (m, 1H), 1.49-1.59 (m,

2H), 1.65-1.78 (m, 2H), 1.82-1.92 (m, 2H), 1.98 (d, $J = 11.5$ Hz, 1H), 2.19 (t, $J = 6.0$ Hz, 1H), 2.23-2.26 (m, 2H), 2.65 (t, $J = 5.0$ Hz, 1H), 3.00-3.04 (m, 1H), 3.18 (d, $J = 9.5$ Hz, 1H), 4.60 (dd, $J = 7.0, 15.0$ Hz, 1H), 5.84-5.89 (m, 1H), 5.90-5.95 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 26.4 (CH_2), 29.3 (CH_2), 29.7 (CH_2), 30.8 (CH_2), 34.5 (CH_2), 40.6 (CH), 43.7 (CH_2), 43.8 (CH), 69.5 (CH), 129.8 (CH), 134.0 (CH), 175.3 (C). Lactam **20b** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl_3) δ 2.10 (dtd, $J = 1.0, 8.5, 13.0$ Hz, 1H), 2.36 (t, $J = 4.5$ Hz, 1H), 2.68-2.71 (m, 1H), 3.13 (dd, $J = 4.5, 11.5$ Hz, 1H), 4.55-4.60 (m, 1H), 4.95 (td, $J = 1.5, 10.5$ Hz, 1H), 4.99 (td, $J = 1.5, 17.0$ Hz, 1H), 5.72 (ddd, $J = 5.0, 10.5, 17.0$ Hz, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 28.4 (CH_2), 29.19 (CH_2), 29.24 (CH_2), 30.7 (CH_2), 31.8 (CH_2), 36.2 (CH), 43.5 (CH), 56.3 (CH), 64.8 (CH), 112.8 (CH_2), 138.7 (CH), 175.0 (C). The following NOE correlations were used to assign lactam **20a**.



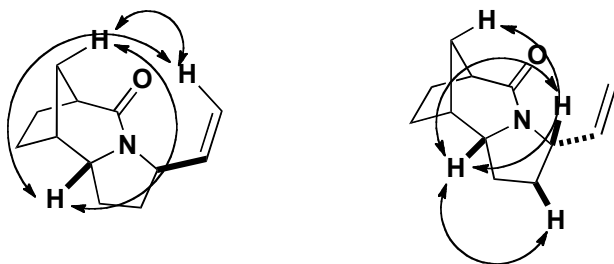
Scheme S11. Preparation of azides **21a**, **21b**, **21c**, **21d** and lactams **22a**, **22b**.

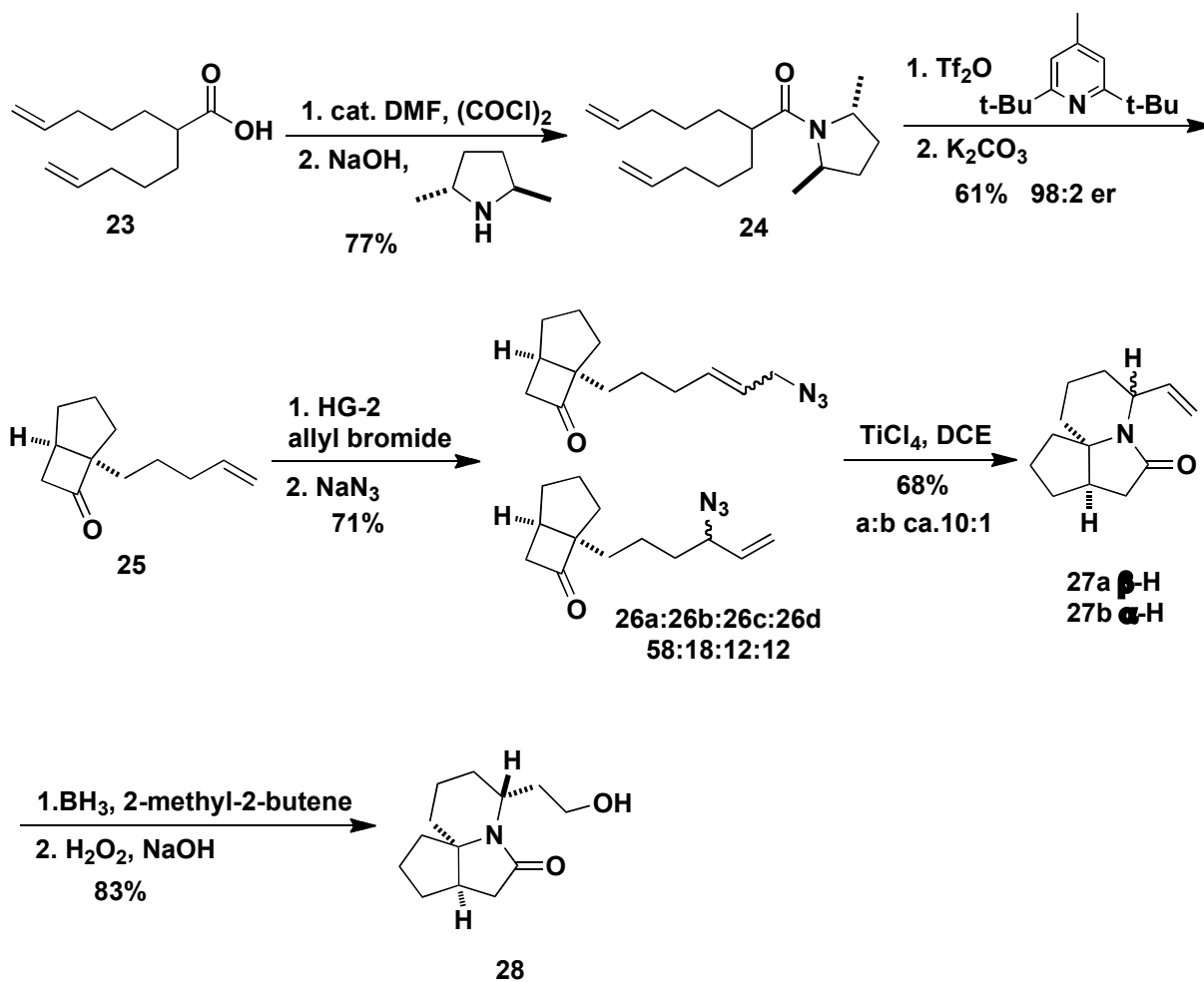
(1*S,3*R**,4*R**)-3-(But-3-enyl)bicyclo[2.2.1]heptan-2-one (21B).** Following the procedure of Miles et al.,^{S11} a solution of 3-methylene-2-norbornanone (**21A**, 2.45 g, 20.0 mmol) in dichloromethane (60 mL) was stirred at -78 °C as titanium tetrachloride (neat, 20 mL, 1M in dichloromethane, 20 mmol) was added dropwise over 5 min to form a gray solution. After stirring 40 min, a solution of allyltrimethylsilane (2.97 g, 26.0 mmol) in dichloromethane (30 mL) was added dropwise over 5 min. The resulting purple solution was stirred at -78 °C for 30 min and at 0 °C for an additional 20 min. A solution of triethylamine (15 mL) and methanol (5 mL) was added dropwise over 5 min, forming a white heterogeneous mixture that was diluted with diethyl ether (100 mL) and filtered. The mixture was washed with 10% HCl, saturated aqueous sodium bicarbonate, and brine, dried over anhydrous sodium sulfate, and concentrated under reduced pressure to give a crude product, which was purified by chromatography (0.6-5% EtOAc/hexanes) to afford ketone **21B** (1.20 g, 36%) as a colorless oil. Ketone **21B**: $R_f = 0.3$ (10% EtOAc/hexanes); IR (neat) 2961, 1740, 1033 cm⁻¹; HRMS (ESI) m/z calculated for C₁₁H₁₆ONa (M+Na)⁺ 187.1099, found: 187.1122; ¹H NMR (400 MHz, CDCl₃) δ 1.25-1.35 (m, 1H), 1.36-1.45 (m, 1H), 1.57-1.62 (m, 3H), 1.67 (d, $J = 10.0$ Hz, 1H), 1.75-1.87 (m, 2H), 2.00-2.21 (m, 3H), 2.60 (br, 2H), 4.98 (td, $J = 0.8, 10.4$ Hz, 1H), 5.04 (qd, $J = 1.6, 17.2$ Hz, 1H), 5.79 (tdd, $J = 6.6, 10.4, 17.2$ Hz, 1H); ¹³C NMR (100 MHz, CDCl₃) δ 21.1 (CH₂), 25.3 (CH₂), 25.5 (CH₂), 32.0 (CH₂), 37.0 (CH₂), 38.1 (CH), 50.5 (CH), 52.8 (CH), 115.1 (CH₂), 137.9 (CH), 219.9 (C).

(1S*,3R*,4R*,E)-3-(5-Azidopent-3-enyl)bicyclo[2.2.1]heptan-2-one (21a), **(1S*,3R*,4R*,Z)-3-(5-azidopent-3-enyl)bicyclo[2.2.1]heptan-2-one (21c)**, **(1S*,3R*,4R*)-3-((S*)-3-azidopent-4-enyl)bicyclo[2.2.1]heptan-2-one (21c)** and **(1S*,3R*,4R*)-3-((R*)-3-azidopent-4-enyl)bicyclo[2.2.1]heptan-2-one (21d)**. According to the procedure described for azides **19a**, **19b**, **19c**, and **19d**, ketone **21B** (1.10 g, 6.70 mmol) afforded after chromatography (0.6-5% EtOAc/hexanes) azides **21a**, **21b**, **21c**, and **21d** (1.30 g, 89%, 64:8:14:14 ratio) as a colorless oil. Azides **21a**, **21b**, **21c**, and **21d**: $R_f = 0.3$ (10% EtOAc/hexanes); IR (neat) 2957, 2093, 1739, 1239 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{12}\text{H}_{17}\text{N}_3\text{ONa}(\text{M} + \text{Na})^+$ 242.1269, found: 242.1299. Azide **21a**: ^1H NMR (500 MHz, CDCl_3) δ 1.28-1.49 (m, 5H), 1.52-1.68 (m, 2H), 1.70-1.80 (m, 3H), 2.10-2.22 (m, 1H), 2.34 (br, 1H), 2.47 (br, 1H), 3.63 (d, $J = 6.5$ Hz, 2H), 5.46-5.52 (m, 1H), 5.64-5.70 (m, 1H); ^1H NMR (500 MHz, acetone) δ 1.28-1.47 (m, 3H), 1.49 (d, $J = 11.5$ Hz, 1H), 1.55-1.65 (m, 1H), 1.67-1.73 (m, 2H), 1.77-1.88 (m, 3H), 2.18-2.32 (m, 1H), 2.42 (br, 1H), 2.46 (br, 1H), 3.78 (d, $J = 6.5$ Hz, 2H), 5.59-5.65 (m, 1H), 5.78-5.86 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 24.0 (CH_2), 27.9 (CH_2), 28.5 (CH_2), 30.7 (CH_2), 34.84 (CH_2), 39.2 (CH), 49.6 (CH), 52.7 (CH_2), 53.0 (CH), 123.8 (CH), 135.8 (CH), 220.1 (C); ^{13}C NMR (125 MHz, acetone) δ 24.5 (CH_2), 28.6 (CH_2), 29.4 (CH_2), 31.3 (CH_2), 35.19 (CH_2), 40.0 (CH), 50.15 (CH), 53.2 (CH_2), 53.5 (CH), 124.8 (CH), 136.7 (CH), 218.6 (C). Azide **21b** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl_3) δ 3.71-3.82 (m, 2H); ^1H NMR (500 MHz, acetone) δ 3.88-3.97 (m, 2H); ^{13}C NMR (125 MHz, CDCl_3) δ 123.1 (CH), 135.0 (CH), 219.9 (C); ^{13}C NMR (125 MHz, acetone) δ 124.0 (CH), 136.0 (CH). Azides **21c** and **21d** (diagnostic peaks only): ^1H NMR (500 MHz, CDCl_3) δ 3.71-3.82 (m, 1H), 5.18-5.23 (m, 2H), 5.64-5.70 (m, 1H); ^1H NMR (500 MHz, acetone) δ 4.01 (d, $J = 7.0$ Hz, 1H), 5.30 (d, $J = 10.0$ Hz, 1H), 5.34 (d, $J = 17.0$ Hz, 1H), 5.74-5.85 (m, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 64.8 (CH), 65.0 (CH), 118.4 (CH_2), 118.5 (CH_2), 135.3 (CH), 135.5 (CH), 219.56 (C), 219.64 (C); ^{13}C NMR (125 MHz, acetone) δ 65.60 (CH), 65.63 (CH), 118.58 (CH_2), 118.63 (CH_2), 136.85 (CH), 136.93 (CH), 218.33 (C), 218.30 (C).

(1S*,2S*,5R*,8S*)-5-Vinyl-6-azatricyclo[6.1.2.0^{2,6}]undecan-7-one (22a) and **(1S*,2S*,5S*,8S*)-5-vinyl-6-azatricyclo[6.1.2.0^{2,6}]undecan-7-one (22b)**. According to the procedure described for lactams **20a** and **20b**, azides **21a**, **21b**, **21c**, and **21d** (130 mg, 0.593 mmol) afforded after chromatography (11-35% EtOAc/hexanes) lactam **22a** (69 mg, 61%) as a colorless oil and **22b** (5 mg, 4%) as a colorless oil. Lactam **22a**: $R_f = 0.15$ (100% EtOAc/hexanes); IR (neat) 2946, 1644, 1418 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{12}\text{H}_{17}\text{NONa}(\text{M} + \text{Na})^+$ 214.1208, found: 214.1232; ^1H NMR (500 MHz, CDCl_3) δ 1.55-1.65 (m, 4H), 1.67-1.73 (m, 2H), 1.73-1.83 (m, 2H),

1.87-1.93 (m, 1H), 1.95 (dd, $J = 1.0, 11.5$ Hz, 1H), 2.38 (br, 1H), 2.54 (dt, $J = 0.8, 4.5$ Hz, 1H), 3.52-3.56 (m, 1H), 4.27 (t, $J = 7.5$ Hz, 1H), 5.00 (td, $J = 1.0, 10.5$ Hz, 1H), 5.05 (td, $J = 1.0, 17.0$ Hz, 1H), 5.65 (ddd, $J = 6.5, 10.5, 17.0$ Hz, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 21.4 (CH_2), 26.5 (CH_2), 30.4 (CH_2), 32.0 (CH_2), 35.4 (CH_2), 36.0 (CH), 43.3 (CH), 56.9 (CH), 65.9 (CH), 114.3 (CH_2), 138.0 (CH), 172.8 (C). Lactam **22b**: $R_f = 0.2$ (100% EtOAc/hexanes); IR (neat) 2950, 1645, 1428 cm^{-1} ; HRMS (ESI) m/z calculated for $\text{C}_{12}\text{H}_{17}\text{NONa}$ ($\text{M}+\text{Na}$) $^+$ 214.1208, found: 214.1233; ^1H NMR (500 MHz, CDCl_3) δ 1.45-1.62 (m, 4H), 1.65-1.71 (m, 2H), 1.72-1.85 (m, 2H), 1.95 (d, $J = 11.5$ Hz, 1H), 2.07-2.11 (m, 1H), 2.39 (br, 1H), 2.61 (t, $J = 4.5$ Hz, 1H), 3.57-3.62 (m, 1H), 4.38 (dd, $J = 6.5, 13.5$ Hz, 1H), 5.00 (td, $J = 1.5, 10.0$ Hz, 1H), 5.05 (td, $J = 1.3, 17.0$ Hz, 1H), 5.73 (ddd, $J = 5.5, 10.5, 17.0$ Hz, 1H); ^{13}C NMR (125 MHz, CDCl_3) δ 21.1 (CH_2), 27.7 (CH_2), 29.7 (CH_2), 31.5 (CH_2), 34.9 (CH_2), 35.8 (CH), 42.9 (CH), 57.2 (CH), 63.1 (CH), 113.7 (CH_2), 138.4 (CH), 173.3 (C). The following NOE correlations were used to assign lactams **22a** and **22b**.



Scheme S12. Preparation of lactam **28**.

1-((2*R*,5*R*)-2,5-Dimethylpyrrolidin-1-yl)-2-(pent-4-enyl)hept-6-en-1-one (**24**). To a stirred solution of 2-(pent-4-enyl)hept-6-enoic acid^{S13} (108 mg, 0.550 mmol) and one drop of DMF in dichloromethane (5 mL) at 0 °C was slowly added oxalyl chloride (0.47 mL, 5.5 mmol). The resulting reaction mixture was allowed to warm to room temperature and was stirred for 5 h. To a stirred solution of (2*R*,5*R*)-2,5-dimethylpyrrolidine (50 mg, 0.50 mmol) and 2.5 M aqueous NaOH (2 mL, 5 mmol) in dichloromethane (6 mL) at 0 °C was slowly added a solution of the above residue in dichloromethane (5 mL). The resulting reaction mixture was allowed naturally to warm to room temperature and was stirred overnight. Saturated aqueous NH₄Cl was used to quench the reaction. The aqueous layer was extracted three times with dichloromethane, washed with brine, dried over Na₂SO₄, filtered, and concentrated. The resulting residue was purified by silica gel chromatography (4-7% EtOAc/hexanes) to afford amide **24** (105 mg, 77%) as a colorless oil.

Amide **24**: $[\alpha]_{546}^{25} +17.0$ (*c* 3.5, dichloromethane); $R_f = 0.35$ (20% EtOAc/hexanes); IR (neat) 2967, 2930, 1635, 1418 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{18}\text{H}_{31}\text{NO}+\text{H})^+$ 278.2484, found: 278.2484; ^1H NMR (400 MHz, CDCl_3) δ 1.15 (d, $J = 3.2$ Hz, 3H), 1.16 (d, $J = 3.2$ Hz, 3H), 1.36-1.43 (m, 5H), 1.45-1.54 (m, 3H), 1.57-1.62 (m, 1H), 1.65-1.70 (m, 1H), 2.01-2.23 (m, 6H), 2.39-2.45 (m, 1H), 4.03 (quintet, $J = 6.4$ Hz, 1H), 4.24 (quintet, $J = 6.4$ Hz, 1H), 4.91-5.00 (m, 4H), 5.72-5.84 (m, 2H); ^{13}C NMR (100 MHz, CDCl_3) δ 18.9 (CH_3), 22.5 (CH_3), 26.4 (CH_2), 27.2 (CH_2), 29.0 (CH_2), 30.9 (CH_2), 31.9 (CH_2), 33.3 (CH_2), 33.9 (CH_2), 34.1 (CH_2), 43.4 (CH), 53.0 (CH), 53.2 (CH), 114.4 (CH_2), 114.5 (CH_2), 138.6 (CH), 138.7 (CH), 174.6 (C).

(1R,5R)-5-(Pent-4-enyl)bicyclo[3.2.0]heptan-6-one (25) and **(1S,5R)-1-(pent-4-enyl)bicyclo[3.1.1]heptan-6-one (29)**. To a refluxing solution of amide **24** (87 mg, 0.31 mmol) and 2,6-di-*tert*-butyl-4-methylpyridine (81 mg, 0.39 mmol) in 1,2-dichloroethane (5 mL) was added a solution of triflic anhydride (97 mg, 0.35 mmol) in 1,2-dichloroethane (2 mL) over 12 h using a syringe pump. The solution was allowed to reflux for another 5 h, after which the reaction was cooled to room temperature and concentrated. To the residue in a mixed solvent of acetone (4 mL) and water (4 mL) was added potassium carbonate (217 mg, 1.57 mmol). The resulting mixture was heated to reflux for 3 h. After the reaction was cooled to room temperature, 1 M HCl was used to adjust the pH to 2-3. The aqueous layer was extracted three times with diethyl ether, washed with brine, dried over anhydrous sodium sulfate, filtered, and concentrated. The resulting residue was purified by silica gel chromatography (0.1% EtOAc/hexanes) to afford ketone **25** (34 mg, 61%) as a colorless oil and ketone **29** (5 mg, 9%). Ketone **25**: $[\alpha]_{546}^{25} -100.0$ (*c* 1.35, dichloromethane); $t_R = 32.03$ min (chiral GC column: Astec ChiralDEXTM B-DM; 45-190 °C at 3 °C/min); $R_f = 0.65$ (10% EtOAc/hexanes); spectral data matched with reported data.^{S13} Ketone **29**: $t_R = 33.62$ (chiral GC column: Astec ChiralDEXTM B-DM; 45-190 °C at 3 °C/min); $R_f = 0.60$ (10% EtOAc/hexanes); IR (neat) 2931, 1771, 1117 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{12}\text{H}_{18}\text{O}+\text{H})^+$ 179.1436, found: 179.1443; ^1H NMR (400 MHz, CDCl_3) δ 1.36-1.47 (m, 3H), 1.48-1.58 (m, 1H), 1.62-1.69 (m, 2H), 1.77-1.87 (m, 2H), 2.00-2.09 (m, 3H), 2.21-2.28 (m, 3H), 2.98-3.03 (m, 1H), 4.95-5.05 (m, 2H), 5.75-5.86 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 18.1 (CH_2), 23.8 (CH_2), 28.9 (CH_2), 32.0 (CH_2), 33.1 (CH_2), 34.2 (CH_2), 38.9 (CH_2), 54.9 (CH), 66.2 (C), 114.7 (CH_2), 138.6 (CH), 214.6 (C).

(1R,5S)-5-(6-Bromohex-4-enyl)bicyclo[3.2.0]heptan-6-one. To a stirred solution of Hoveyda-Grubbs 2nd generation catalyst (32 mg, 0.050 mmol, 5 mol%) in dichloromethane (2 mL) under N_2 atmosphere at room temperature was slowly added a solution of ketone **25** (154 mg,

0.860 mmol) and allyl bromide (0.25 mL, 3.0 mmol) in dichloromethane (2 mL). The reaction mixture was stirred overnight, then concentrated and the residue was purified by silica gel chromatography (0.05%-0.5% EtOAc/hexanes) to afford the title compound as an oil (173 mg, 74% (or 82% brsm), *E/Z* 8:1) and ketone **25** (15 mg). Bromide: $[\alpha]_{546}^{25} -68.0$ (*c* 4.7, dichloromethane); $R_f = 0.40$ (10% EtOAc/hexanes); IR (neat) 2938, 1766, 1205, 1066 cm^{-1} . *E* isomer: $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 1.34-1.44 (m, 2H), 1.53-1.71 (m, 4H), 1.78-1.85 (m, 3H), 1.98-2.09 (m, 3H), 2.45 (dd, $J = 4.4$ Hz, 18.4 Hz, 1H), 2.55-2.59 (m, 1H), 3.11 (dd, $J = 9.6$ Hz, 18.4 Hz, 1H), 3.95 (d, $J = 6.4$ Hz, 2H), 5.67-5.75 (m, 2H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 24.9 (CH_2), 25.0 (CH_2), 32.4 (CH_2), 32.68 (CH_2), 32.77 (CH_2), 33.4 (CH_2), 34.0 (CH), 35.4 (CH_2), 49.3 (CH_2), 75.7 (C), 126.8 (CH), 135.8 (CH), 217.96 (C). *Z* isomer (diagnostic peaks only): $^1\text{H NMR}$ (400 MHz, CDCl_3) δ 4.01 (d, $J = 8.4$ Hz, 2H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 25.2 (CH_2), 27.17 (CH_2), 27.26 (CH_2), 32.8 (CH_2), 75.6 (C), 125.7 (CH), 135.2 (CH), 217.89 (C).

(1*R*,5*S*,*E*)-5-(6-Azidohex-4-enyl)bicyclo[3.2.0]heptan-6-one (26a), **(1*R*,5*S*,*Z*)-5-(6-azidohex-4-enyl)bicyclo[3.2.0]heptan-6-one (26b)**, **(1*R*,5*S*)-5-(*R*)-4-azidohex-5-enyl)bicyclo[3.2.0]heptan-6-one (26c)**, and **(1*R*,5*S*)-5-(*R*)-4-azidohex-5-enyl)bicyclo[3.2.0]heptan-6-one (26d)**. A suspension of (1*R*,5*S*)-5-(6-bromohex-4-enyl)bicyclo[3.2.0]heptan-6-one (145 mg, 0.540 mmol) and sodium azide (210 mg, 3.20 mmol) in DMF (3 mL) at room temperature was allowed to stir overnight. Diethyl ether and water were added and the aqueous layer was washed with diethyl ether three times. The combined organic layers were washed with brine, dried over anhydrous sodium sulfate, and concentrated. The resulting residue was purified by silica gel chromatography (0.2%→1% EtOAc/hexanes) to afford a mixture of azides **26a**, **26b**, **26c**, and **26d** as a colorless oil (110 mg, 88%, 58:18:12:12 ratio). Azides **26a**, **26b**, **26c**, and **26d**: $[\alpha]_{546}^{25} -78.8$ (*c* 4.4, dichloromethane); $R_f = 0.40$ (10% EtOAc/hexanes); IR (neat) 2942, 2098, 1771, 1247 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{26}\text{H}_{38}\text{N}_4\text{O}_2+\text{H})^+$ 439.3073 (corresponding to $(2\text{M}-\text{N}_2+\text{H})^+$), found: 439.3075. Azide **26a**: $^1\text{H NMR}$ (400 MHz, acetone) δ 1.36-1.44 (m, 2H), 1.53-1.71 (m, 5H), 1.78-1.85 (m, 3H), 1.88-1.96 (m, 1H), 2.08-2.18 (m, 1H), 2.43 (dd, $J = 4.4$ Hz, 18.4 Hz, 1H), 2.54-2.64 (m, 1H), 3.13 (dd, $J = 9.6$ Hz, 18.4 Hz, 1H), 3.77 (d, $J = 6.4$ Hz, 2H), 5.55-5.63 (m, 1H), 5.79-5.86 (m, 1H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 24.98 (CH_2), 25.03 (CH_2), 32.55 (CH_2), 32.58 (CH_2), 32.68 (CH_2), 34.1 (CH), 35.3 (CH_2), 49.3 (CH_2), 52.8 (CH_2), 75.7 (C), 123.4 (CH), 136.3 (CH), 217.8 (C). Azide **26b** (diagnostic peaks only): $^1\text{H NMR}$ (400 MHz, acetone) δ 3.90 (d, $J = 7.2$ Hz, 2H); $^{13}\text{C NMR}$ (100 MHz, CDCl_3) δ 122.52, 136.14. Azides **26c** and **26d** (diagnostic peaks

only): ^1H NMR (400 MHz, acetone) δ 4.00 (q, $J = 6.8$ Hz, 1H), 5.27-5.36 (m, 2H), 5.79-5.86 (m, 1H). Azides **26b**, **26c** and **26d** (diagnostic peaks only): ^{13}C NMR (100 MHz, CDCl_3) δ 64.81 (CH), 64.84 (CH_2), 118.2 (CH_2), 135.6 (CH).

(4R,7aR,10aS)-4-Vinyl-octahydrocyclopenta[*i*]indolizin-6(7H)-one (27a) and **(4S,7aR,10aS)-4-vinyl-octahydrocyclopenta[*i*]indolizin-6(7H)-one (27b)**. To a refluxing solution of azides **26a**, **26b**, **26c**, and **26d** (110 mg, 0.470 mmol) in anhydrous 1,2-dichloroethane (24 mL) under N_2 atmosphere was added titanium tetrachloride (0.71 mL, 1M in dichloromethane, 0.71 mmol). After being allowed to reflux for 15 h, saturated aqueous ammonium chloride was added to the cooled reaction mixture, which was allowed to stir overnight. The aqueous layer was washed twice with dichloromethane. The aqueous layer was neutralized by saturated aqueous sodium bicarbonate and extracted twice with dichloromethane. The combined organic layers were washed with saturated aqueous sodium bicarbonate, brine, and were dried over anhydrous sodium sulfate. The concentrated residue was purified by silica gel chromatography (10% EtOAc/hexanes) to afford **27a** as a colorless oil (60 mg, 62%) and **27b** as a colorless oil (6 mg, 6%). Lactam **27a**: $[\alpha]_{546}^{25} +21.6$ (c 2.0, dichloromethane); $R_f = 0.50$ (100% EtOAc/hexanes, twice); IR (neat) 2937, 1683, 1401, 1316 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{13}\text{H}_{19}\text{NO}+\text{H})^+$ 206.1545, found: 206.1522; ^1H NMR (400 MHz, CDCl_3) δ 1.42-1.55 (m, 3H), 1.58-1.77 (m, 6H), 1.78-1.85 (m, 1H), 1.85-1.95 (m, 2H), 2.08 (ddd, $J = 1.2$ Hz, 4.0 Hz, 17.6 Hz, 1H), 2.15-2.23 (m, 1H), 2.64 (dd, $J = 10.4$ Hz, 17.6 Hz, 1H), 3.66 (t, $J = 8.8$ Hz, 1H), 5.06-5.13 (m, 2H), 6.58-6.67 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 21.9 (CH_2), 24.9 (CH_2), 32.3 (CH_2), 33.6 (CH_2), 35.3 (CH_2), 36.9 (CH_2), 38.2 (CH_2), 42.3 (CH), 58.2 (CH), 72.7 (C), 113.1 (CH_2), 138.3 (CH), 173.1 (C). Lactam **27b**: $R_f = 0.55$ (100% EtOAc/hexanes, twice); IR (neat) 2937, 1698, 1388, 1310 cm^{-1} ; HRMS (ESI) m/z calculated for $(\text{C}_{13}\text{H}_{19}\text{NO}+\text{H})^+$ 206.1545, found: 206.1515; ^1H NMR (400 MHz, CDCl_3) δ 1.19-1.27 (m, 1H), 1.36-1.47 (m, 4H), 1.58-1.75 (m, 6H), 1.84-1.87 (m, 2H), 2.05-2.09 (m, 1H), 2.45 (t, $J = 5.2$ Hz, 1H), 3.67-3.72 (m, 1H), 5.05-5.12 (m, 2H), 6.25-6.33 (m, 1H); ^{13}C NMR (100 MHz, CDCl_3) δ 18.85 (CH_2), 18.89 (CH_2), 26.2 (CH_2), 28.9 (CH_2), 33.3 (CH_2), 35.2 (CH_2), 41.5 (CH), 44.7 (CH_2), 54.9 (CH), 60.7 (C), 112.0 (CH_2), 140.3 (CH), 177.8 (C).

(4R,7aR,10aS)-4-(2-Hydroxyethyl)-octahydrocyclopenta[*i*]indolizin-6(7H)-one (28). To an oven-dried flask at 0 $^\circ\text{C}$ under nitrogen atmosphere was added $\text{BH}_3 \cdot \text{THF}$ complex (1M in THF, 1.25 mL, 1.25 mmol), followed by the addition of 2-methyl-2-butene (2M in THF, 1.25 mL, 2.50 mmol). After stirring at 0 $^\circ\text{C}$ for 2 h, the above solution was added to lactam **27a** (40 mg, 0.20 mmol) in THF (2 mL) at 0 $^\circ\text{C}$. The resulting reaction mixture was allowed to rise to room

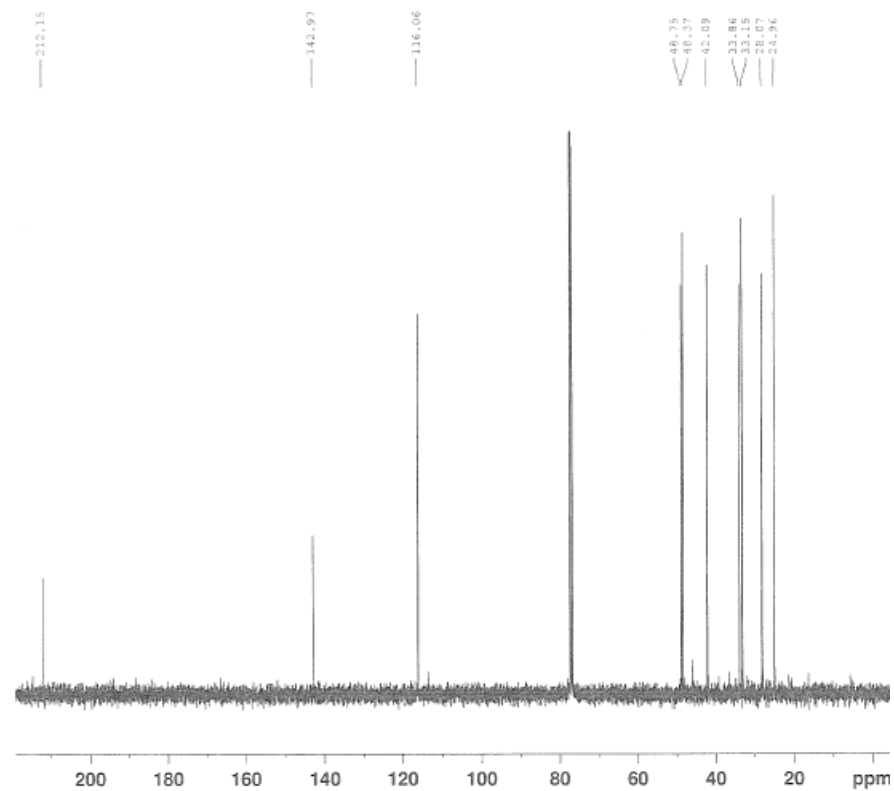
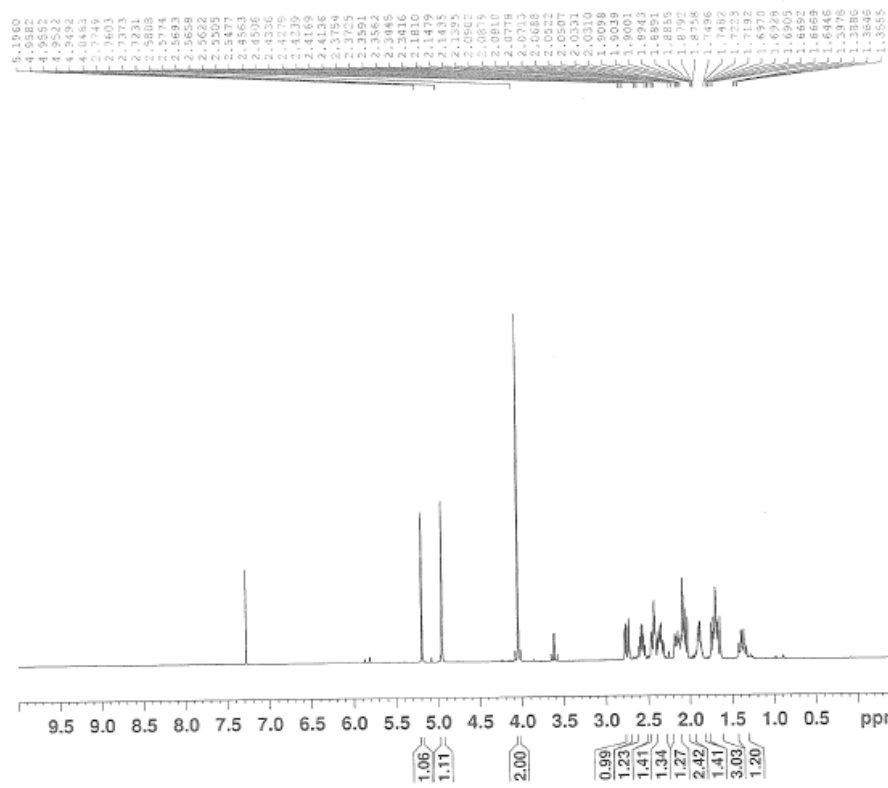
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temperature and stir overnight. The resulting mixture was cooled to 0 °C, followed by the addition of 3M aqueous NaOH (2.1 mL) and H₂O₂ (30% w/w in H₂O, 1 mL). The resulting reaction mixture was allowed to rise to room temperature over 2 h. Ethyl acetate was used to extract the product. The aqueous layer was extracted three times with ethyl acetate and the combined organic layers were washed with brine, dried over anhydrous sodium sulfate, filtered, and concentrated. The resulting residue was purified by silica gel chromatography (0.8%-2% MeOH/dichloromethane) to afford lactam **28** (35 mg, 83%) as an oil. $[\alpha]_{546}^{25} -22.6$ (*c* 0.9, dichloromethane). $R_f = 0.35$ (5% MeOH/DCM); Spectral data matched with reported data.^{S14}

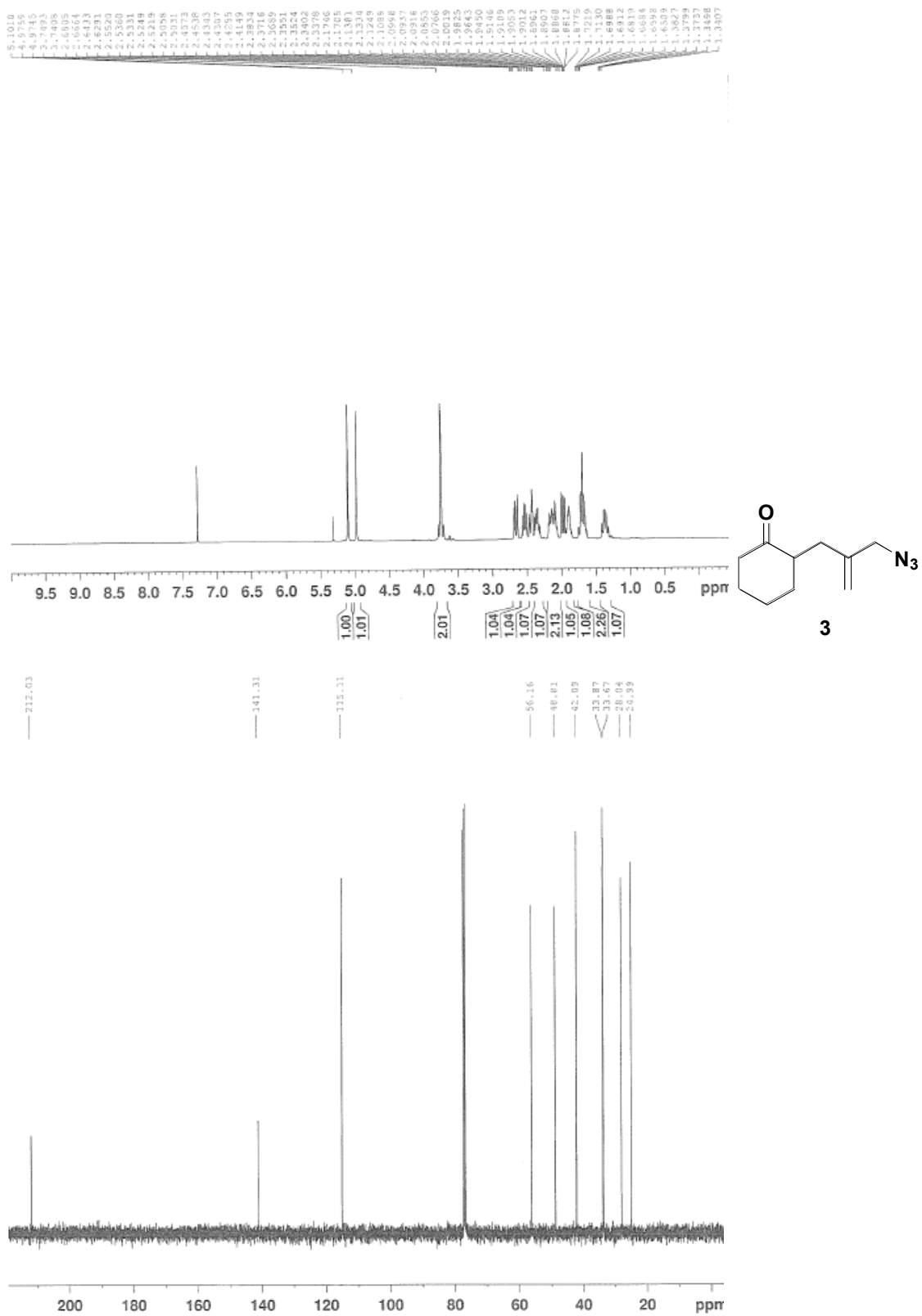
Comparison of Data for Compound 28 with Literature Values

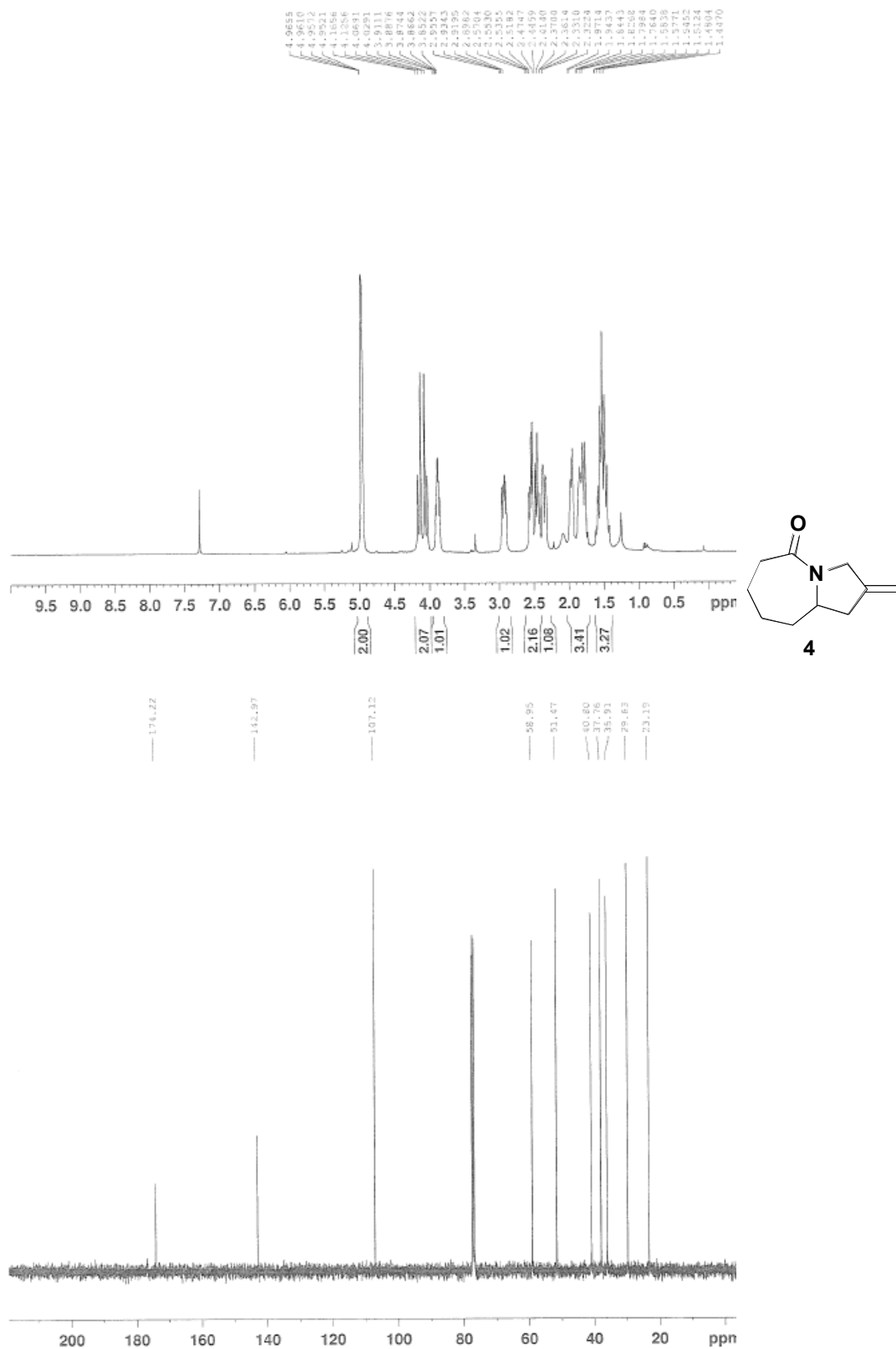
¹ H NMR (400 MHz, CDCl ₃)	
Found	Reference ^{S14}
3.72-3.79 (m, 2H)	3.65-3.75 (m, 2H)
3.29-3.34 (m, 1H)	3.24-3.30 (br m, 1H)
3.00 (br s, 1H)	3.13 (br s, 1H)
2.84-2.93 (m, 1H)	2.79-2.88 (m, 1H)
2.65 (dd, <i>J</i> = 18.0 Hz, 10.4 Hz, 1H)	2.60 (dd, <i>J</i> = 18.0 Hz, 10.3 Hz, 1H)
2.07-2.17 (m, 2H)	2.02-2.11 (m, 2H)
1.79-2.00 (m, 4H)	1.74-1.94 (m, 4H)
1.69-1.77 (m, 1H)	1.63-1.72 (m, 1H)
1.57-1.67 (m, 5H)	1.56-1.64 (m, 5H)
1.35-1.57 (m, 3H)	1.38-1.57 (m, 2H)
	1.30-1.39 (m, 1H)
¹³ C NMR (100 MHz, CDCl ₃)	
Found	Reference ^{S14}
174.28 (C)	174.13
74.09 (C)	73.99
60.97 (CH ₂)	60.76
53.74 (CH)	53.56
42.04 (CH)	41.99
38.48 (CH ₂)	38.40
36.49 (CH ₂)	36.46
35.45 (CH ₂)	35.37
34.92 (CH ₂)	34.90
33.65 (CH ₂)	33.62
32.15 (CH ₂)	32.04
25.21 (CH ₂)	25.16
22.50 (CH ₂)	22.49

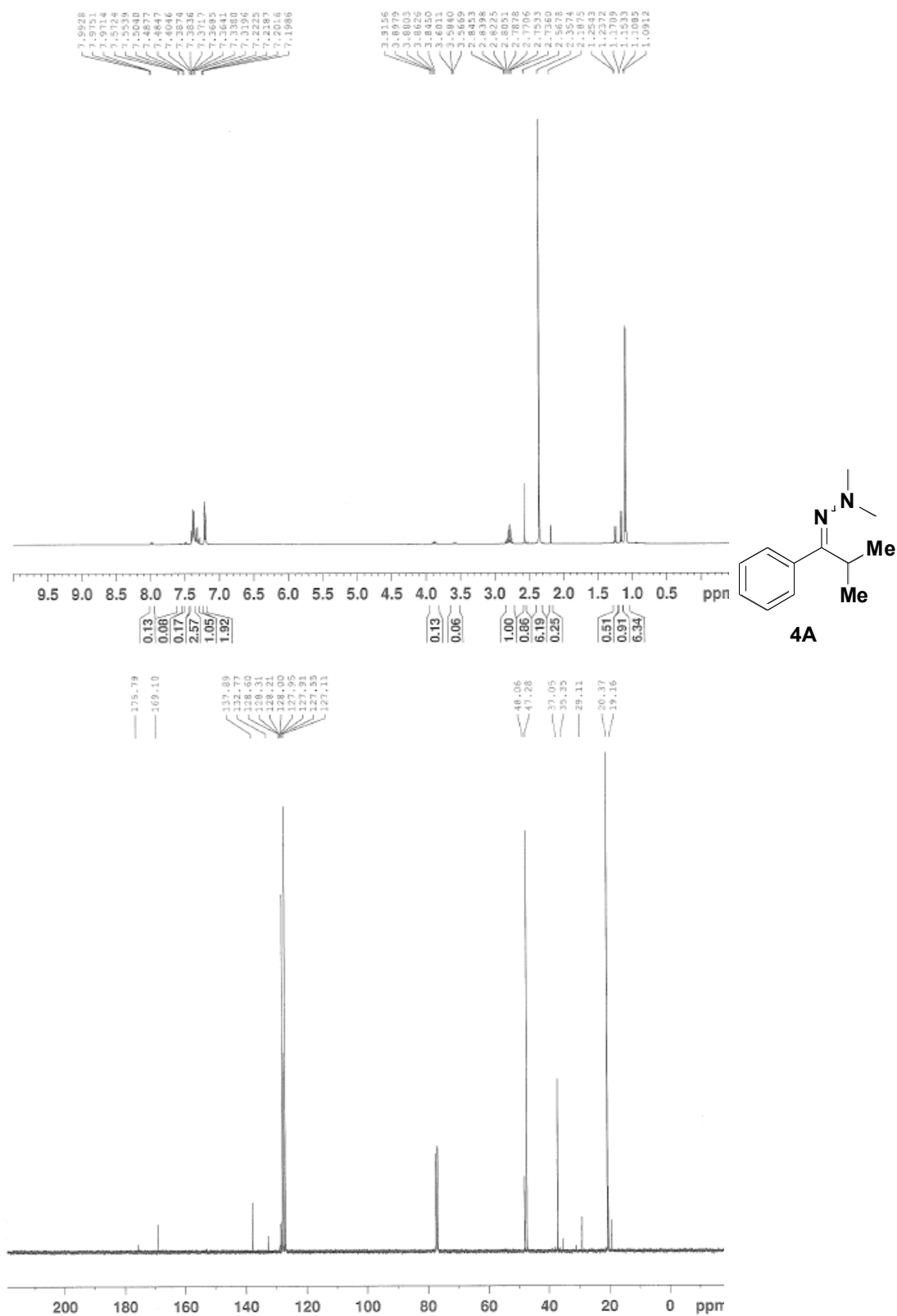
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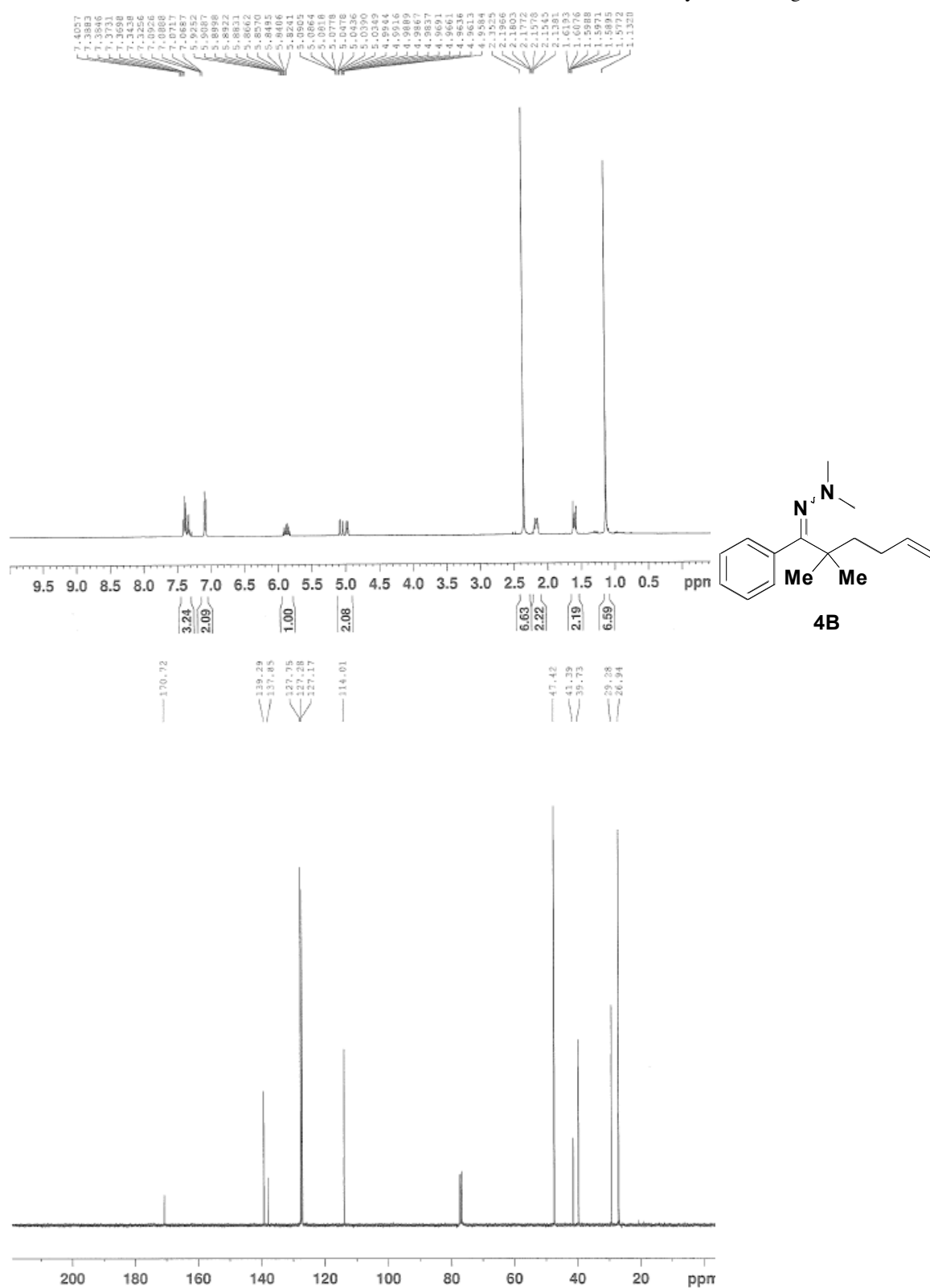
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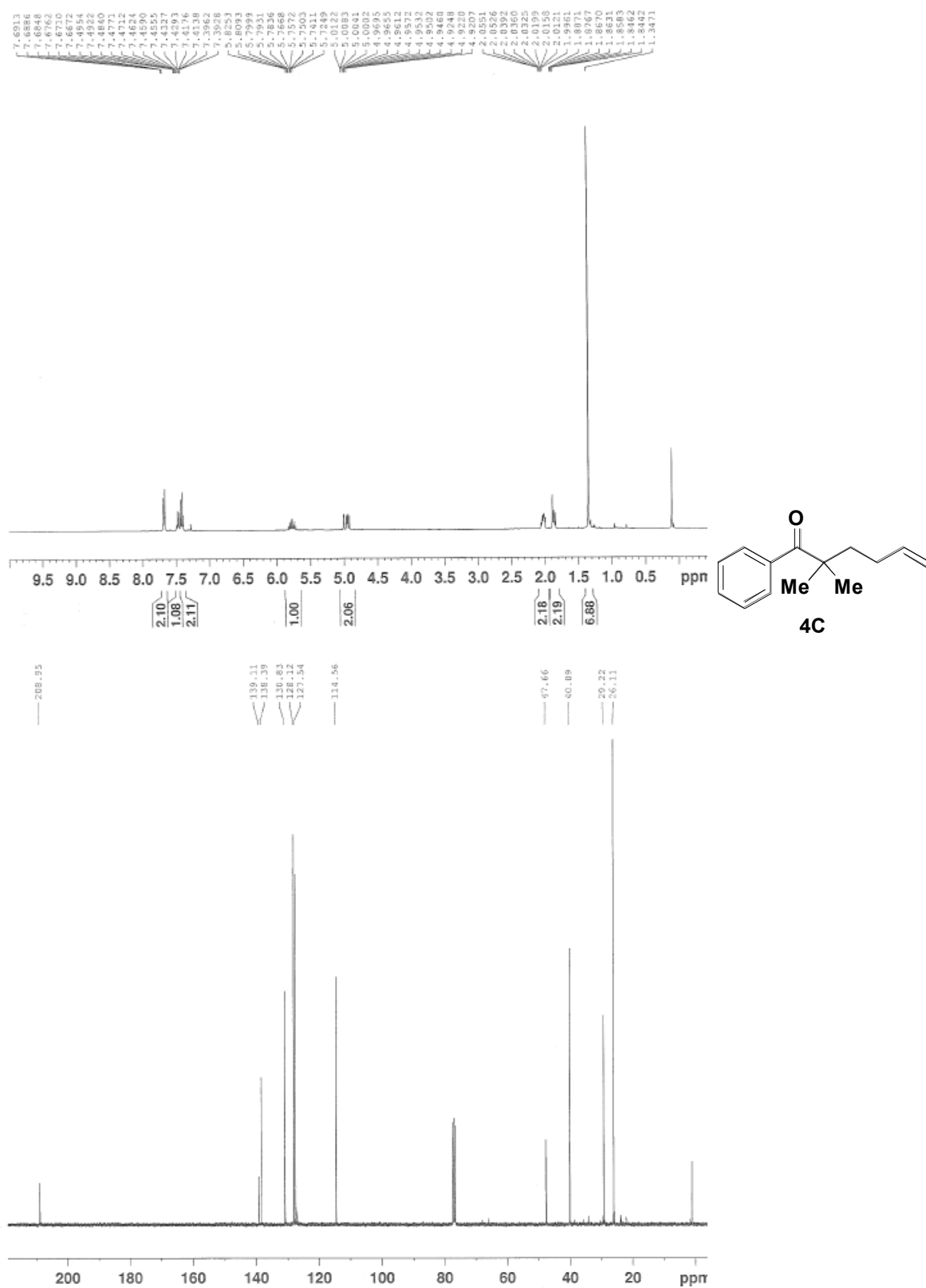


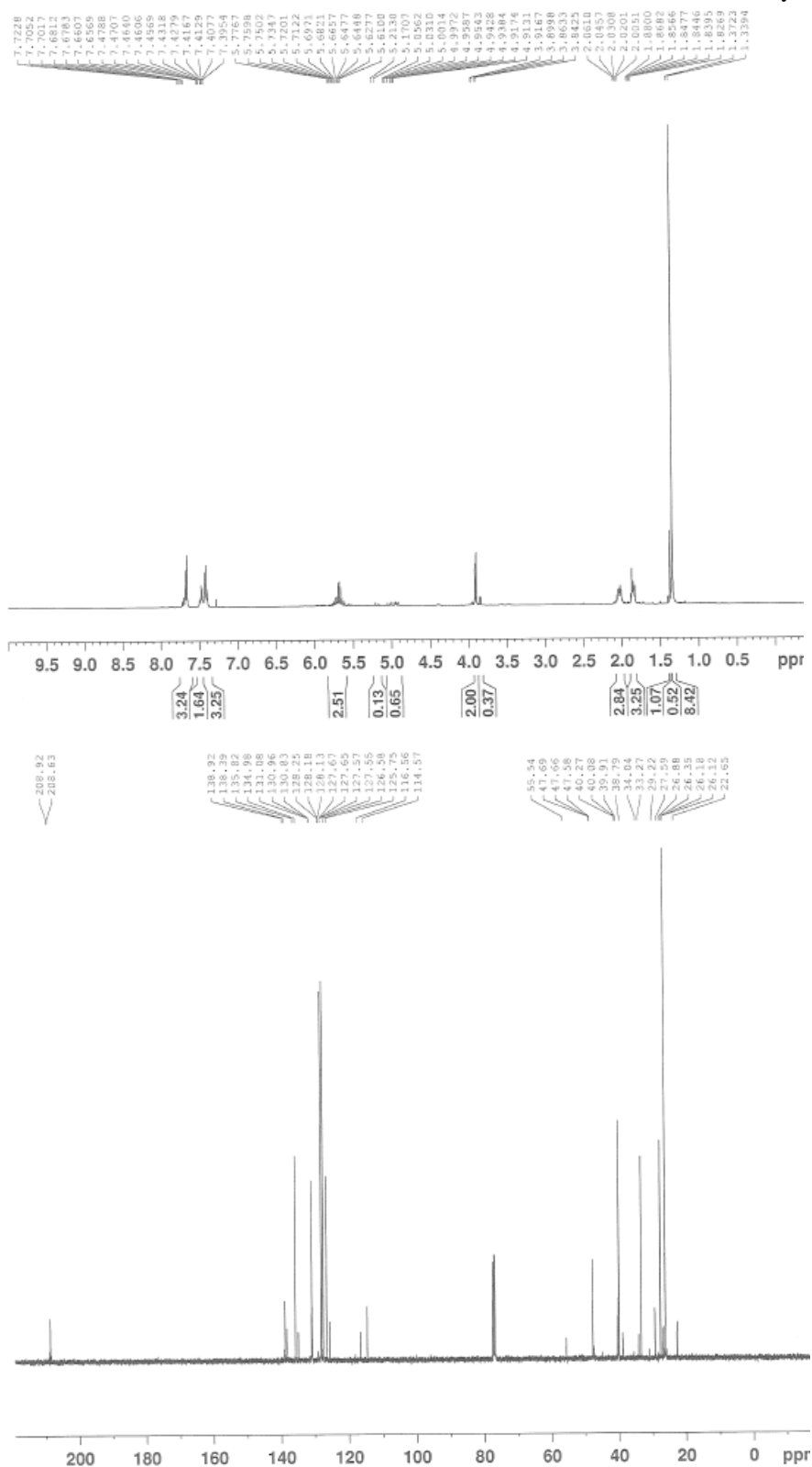


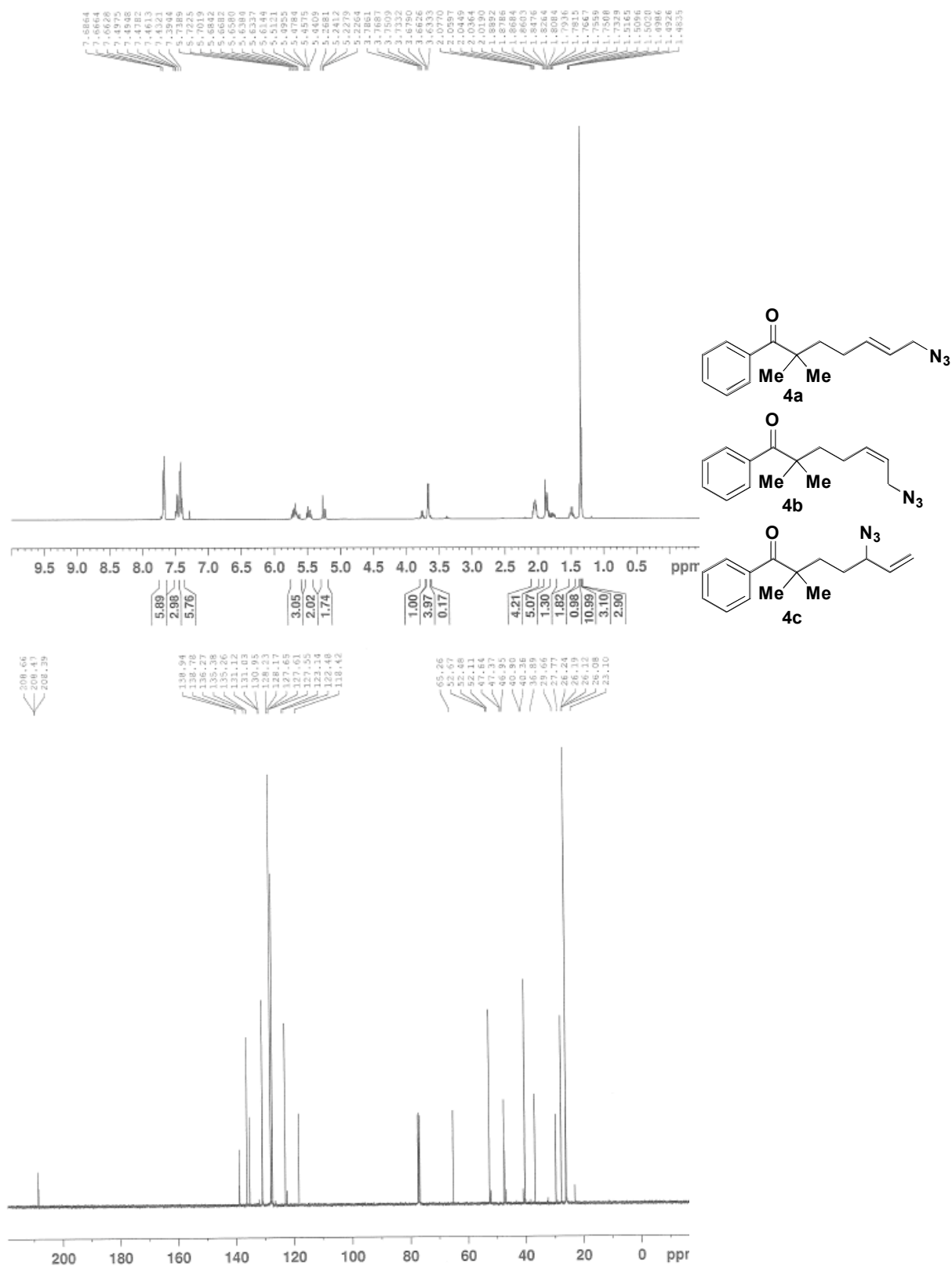


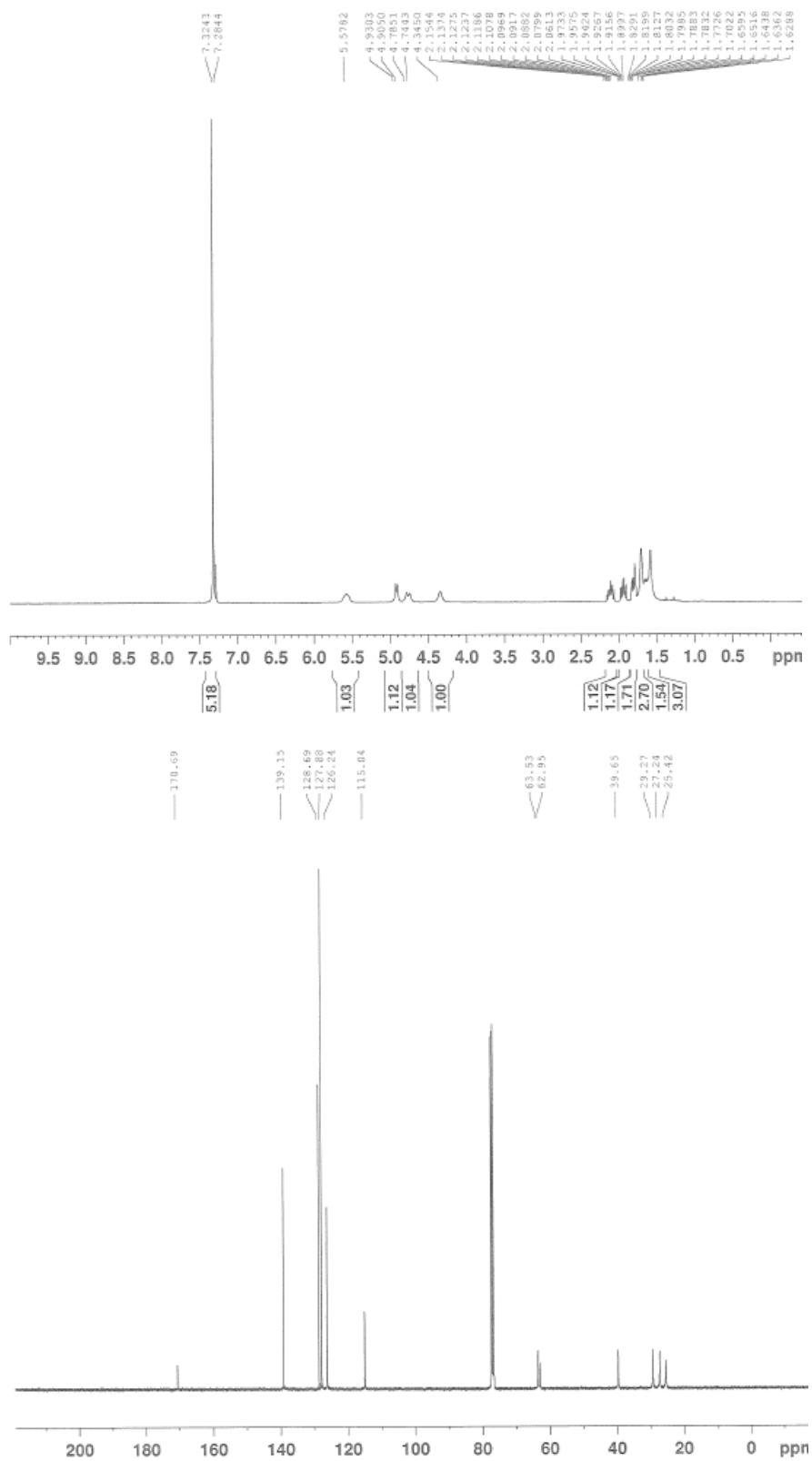


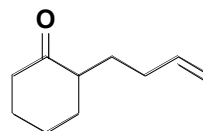
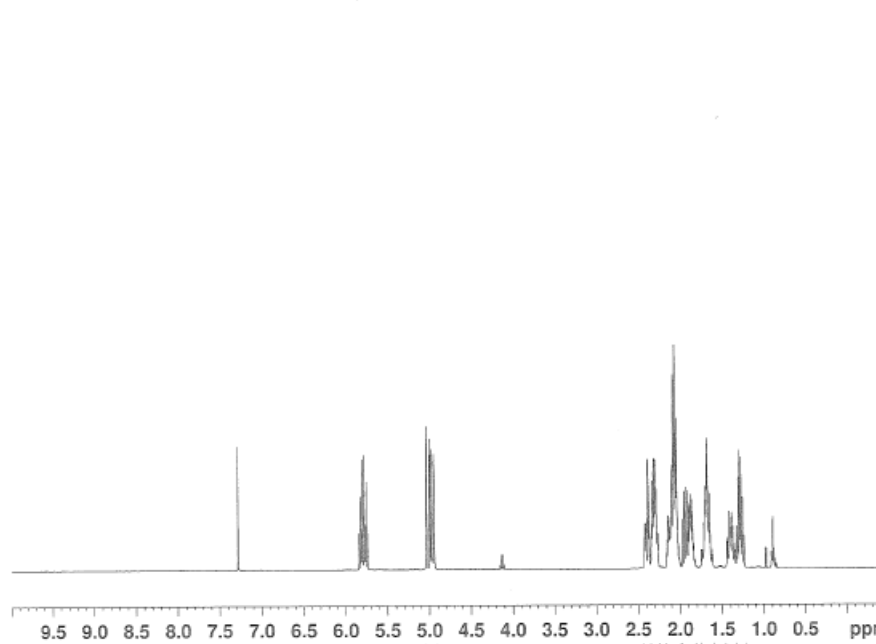


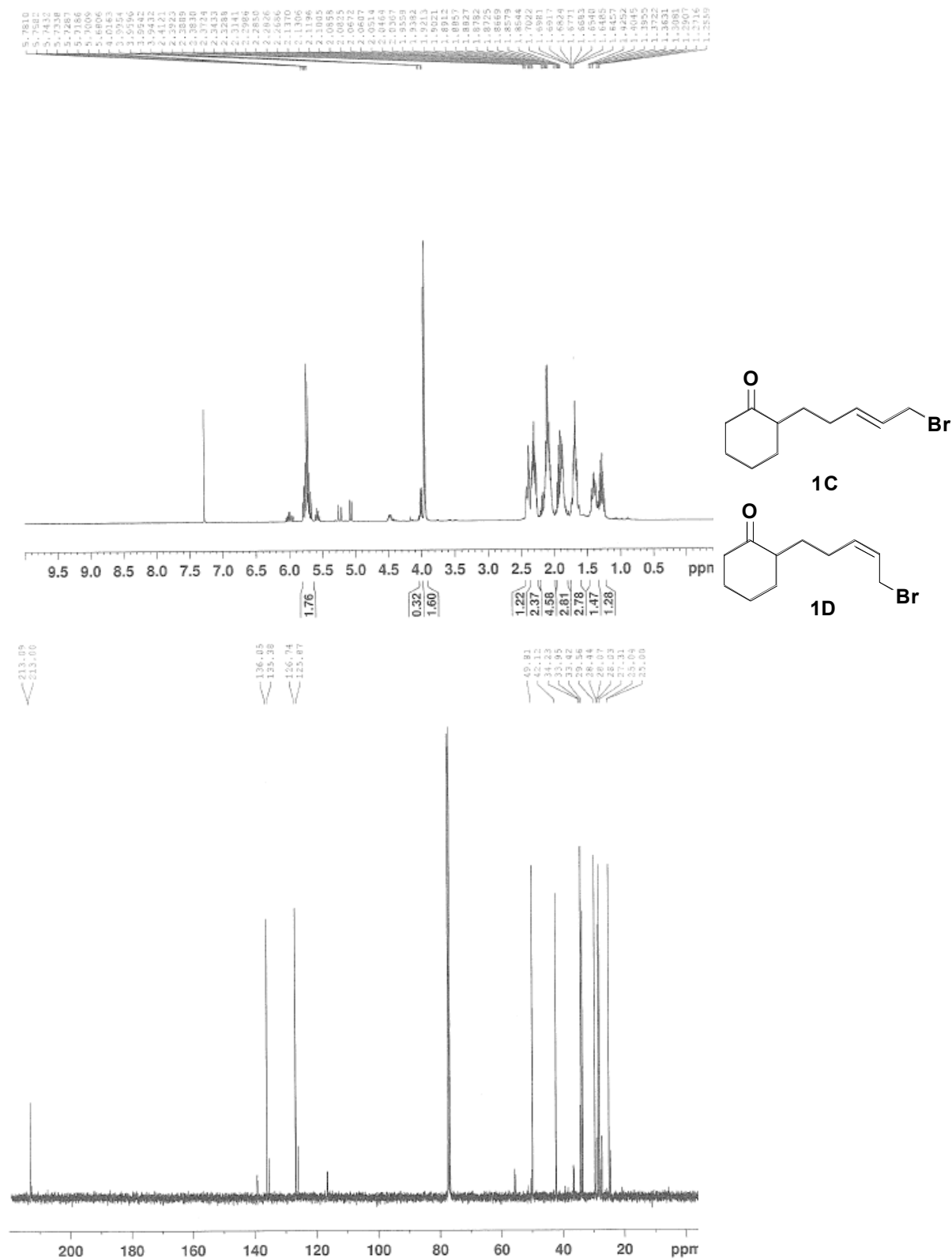


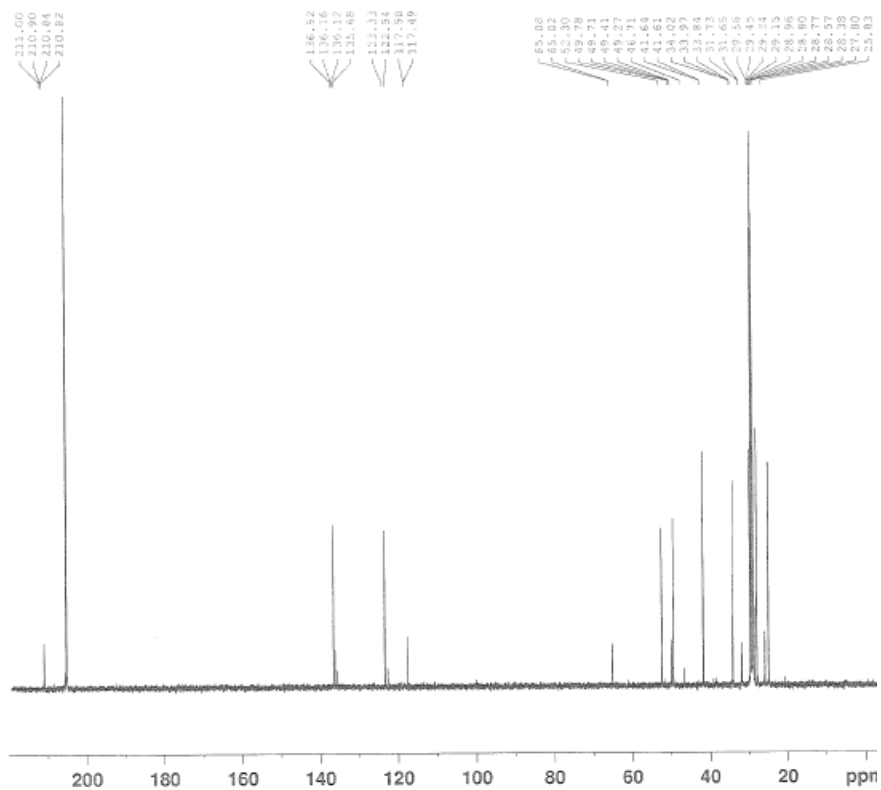
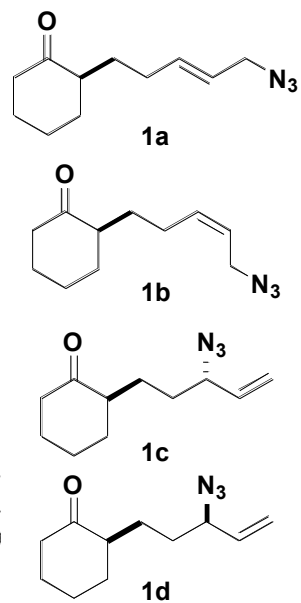
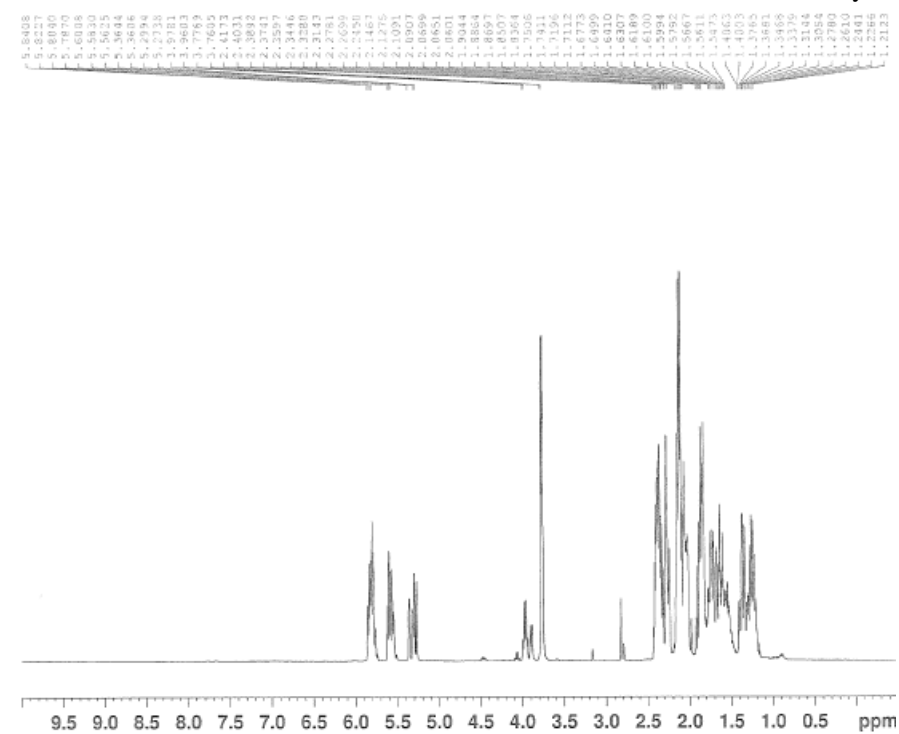


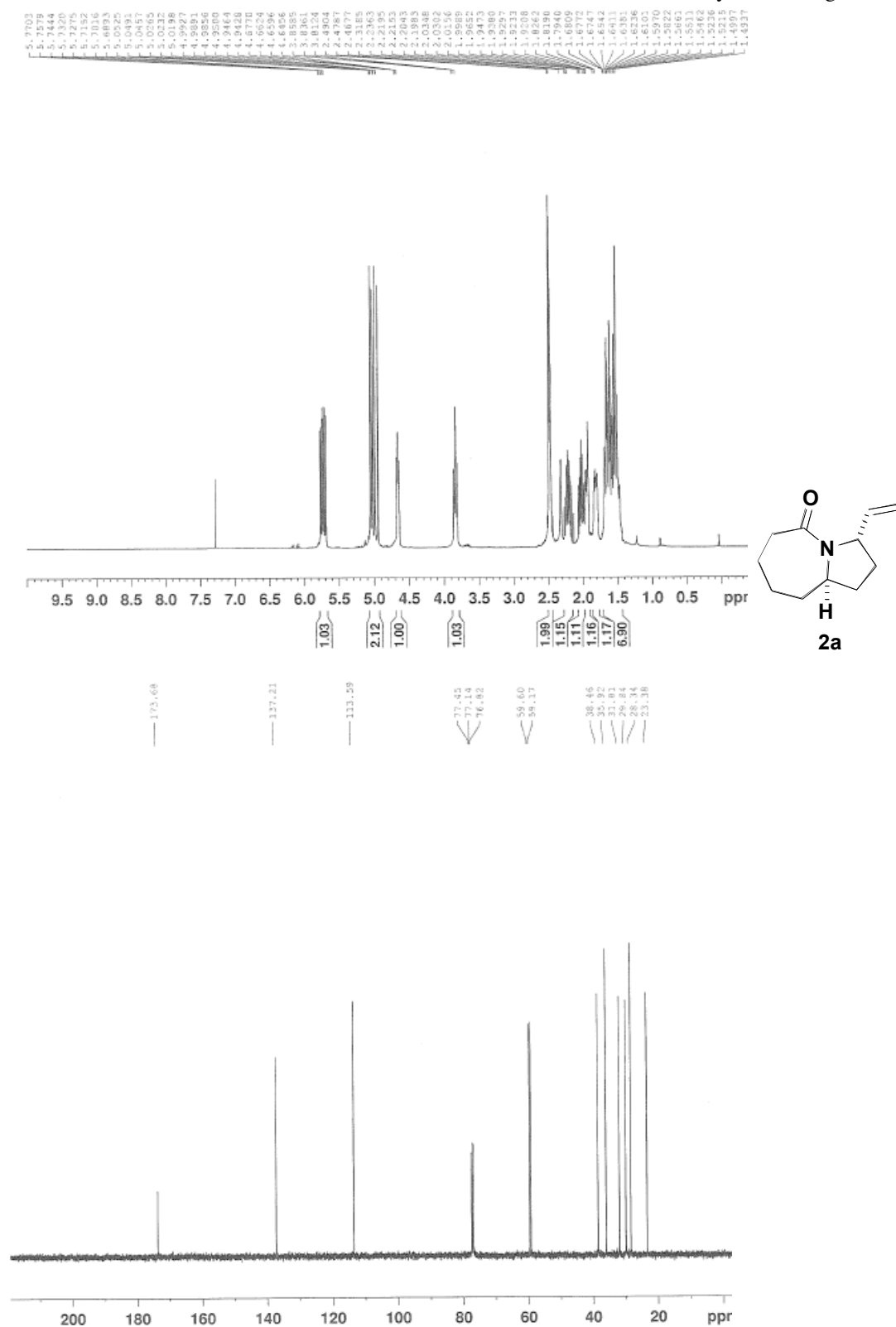


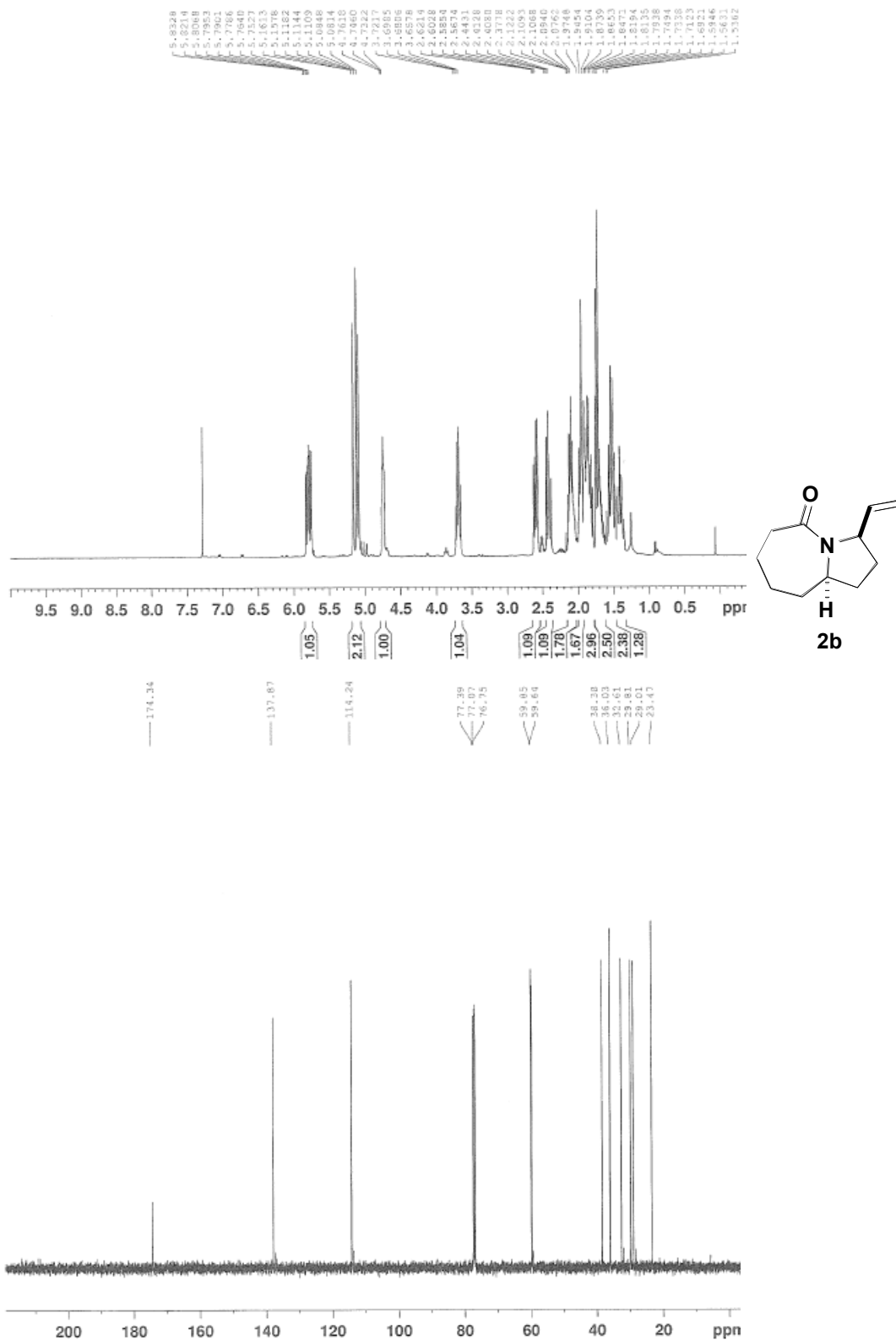


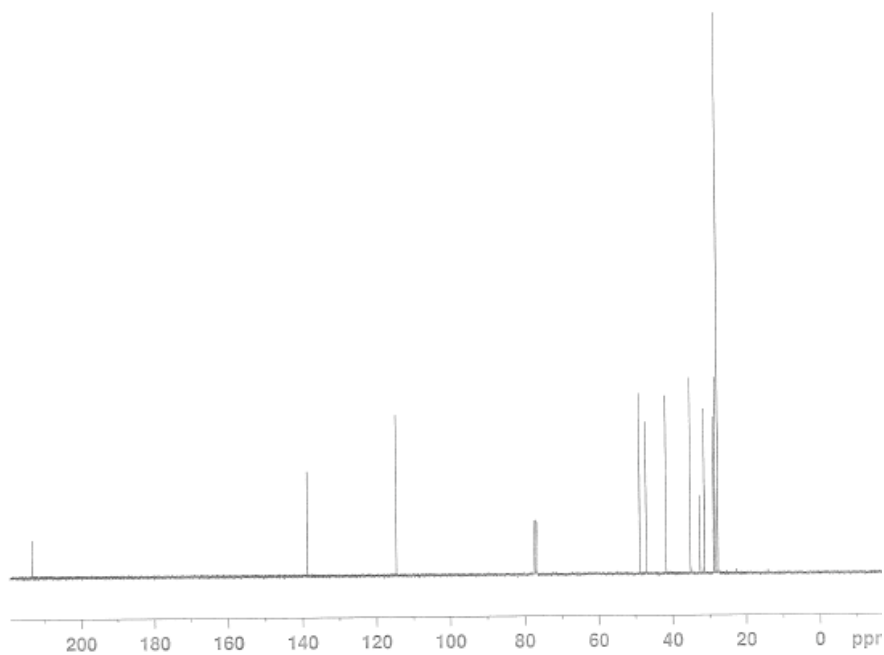
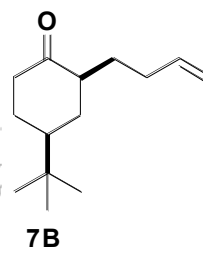
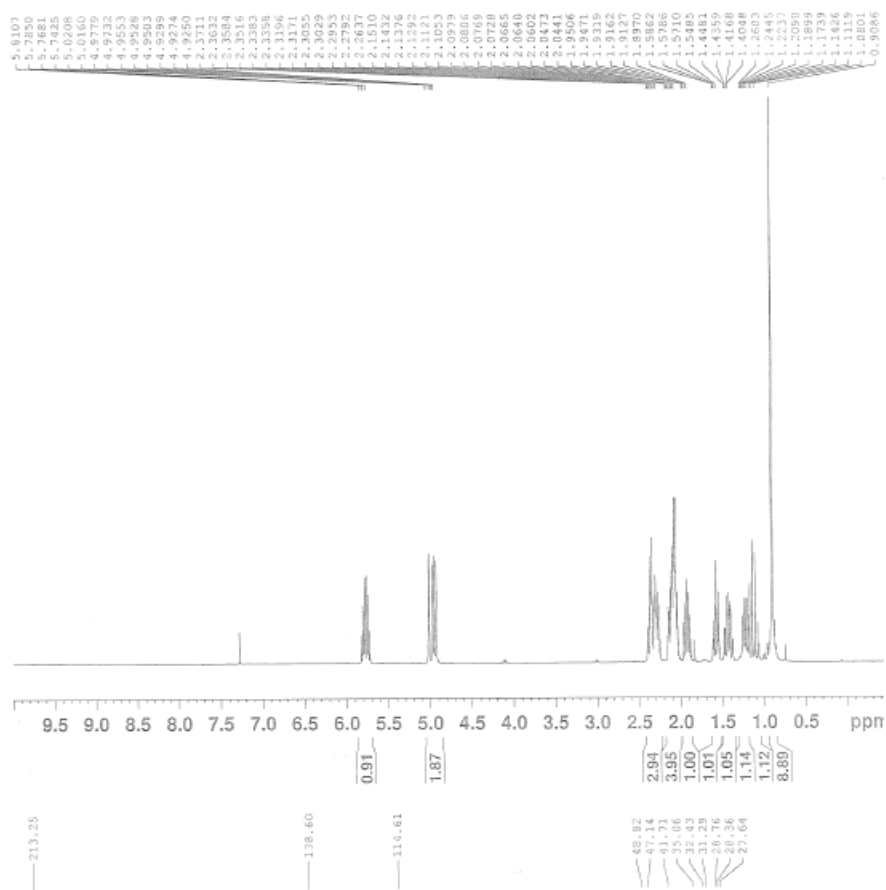
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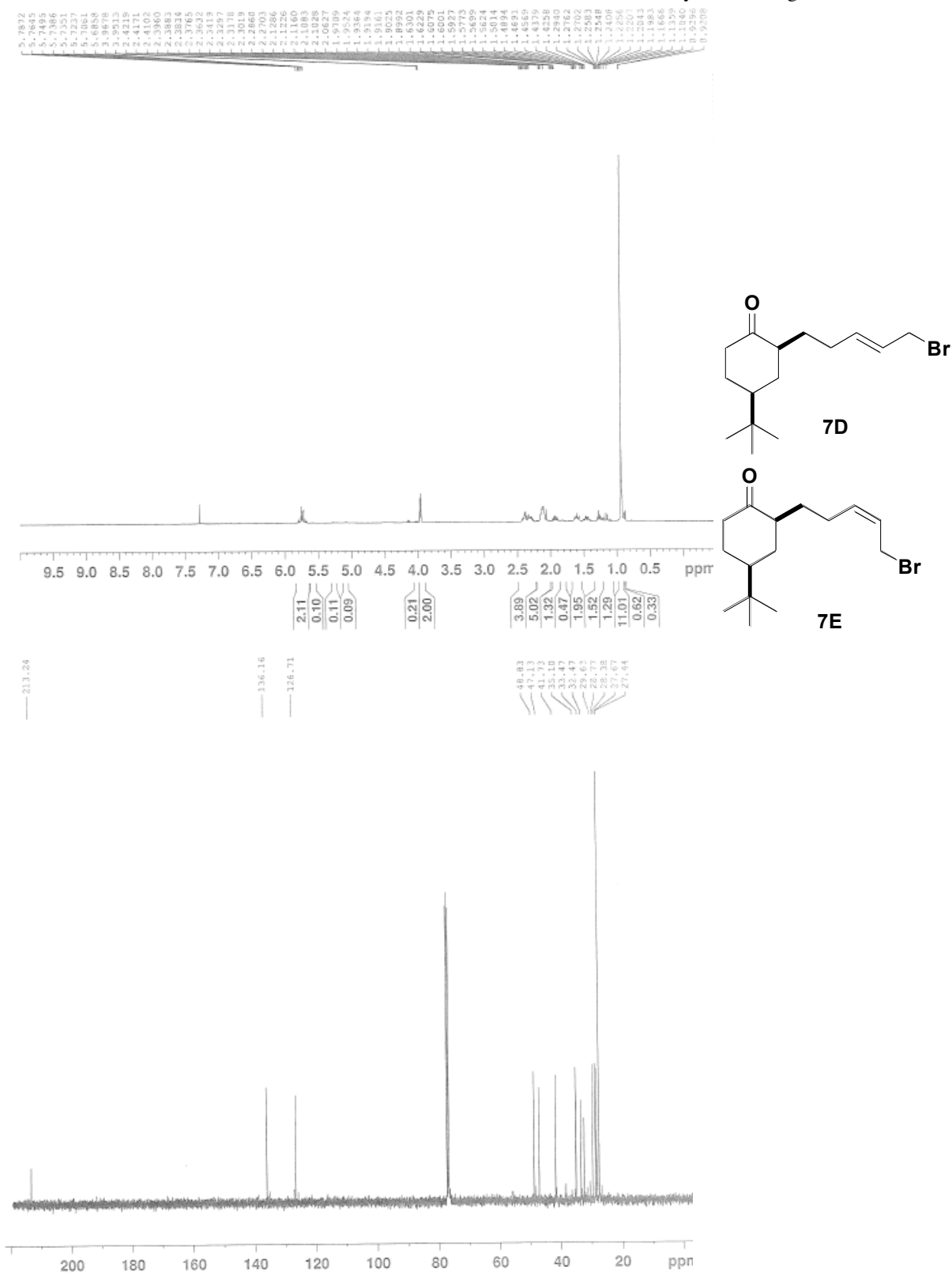


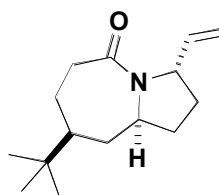
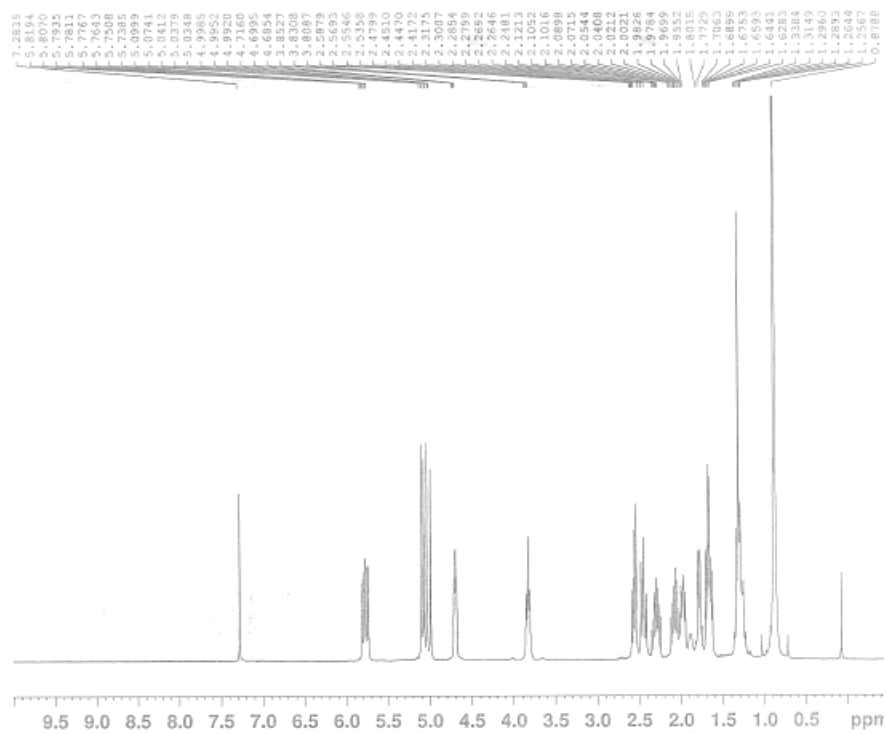
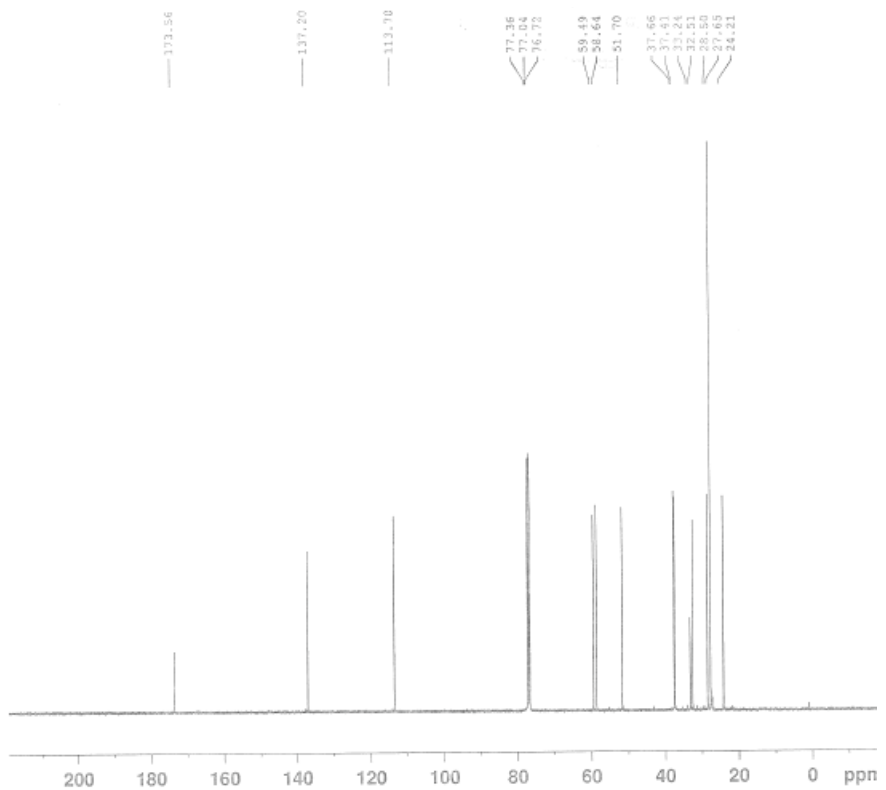


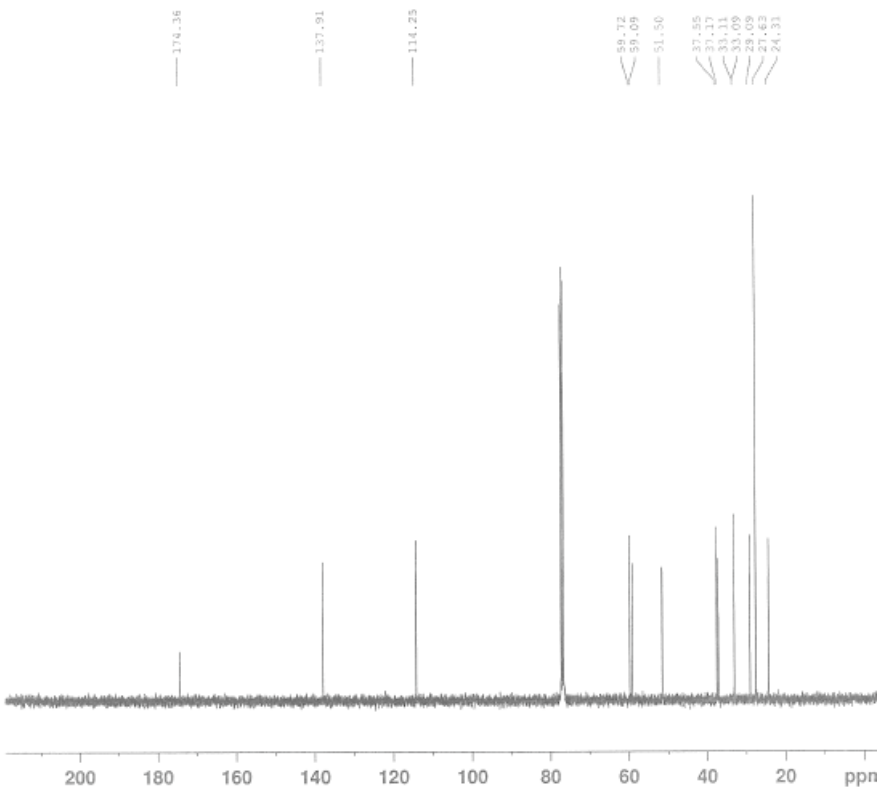
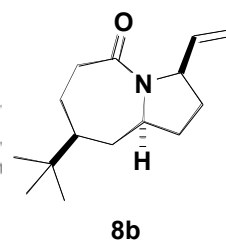
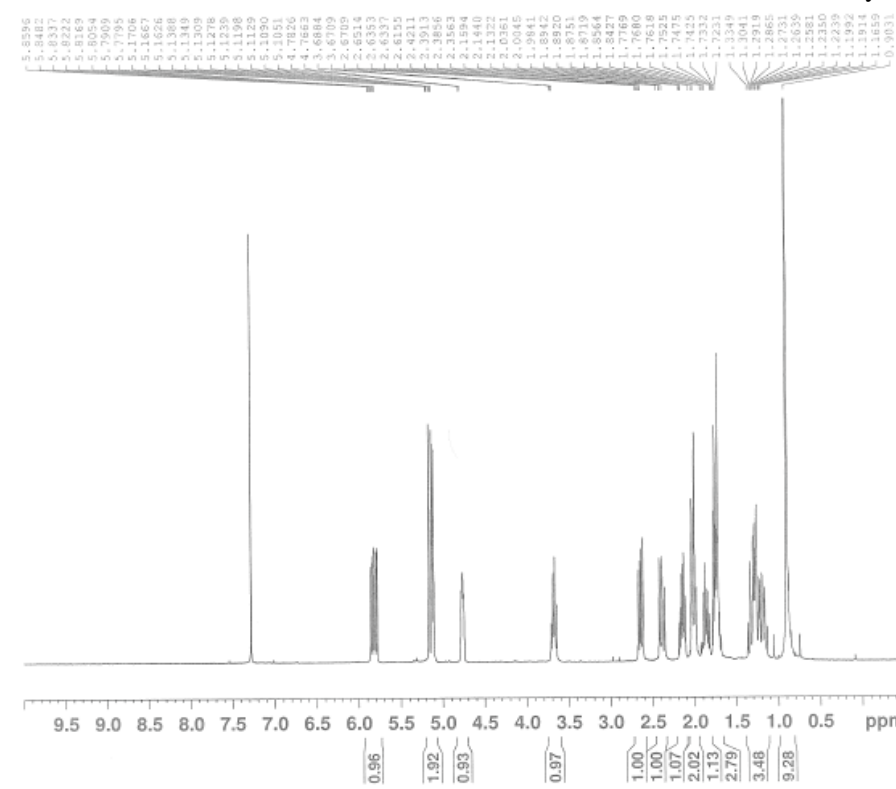


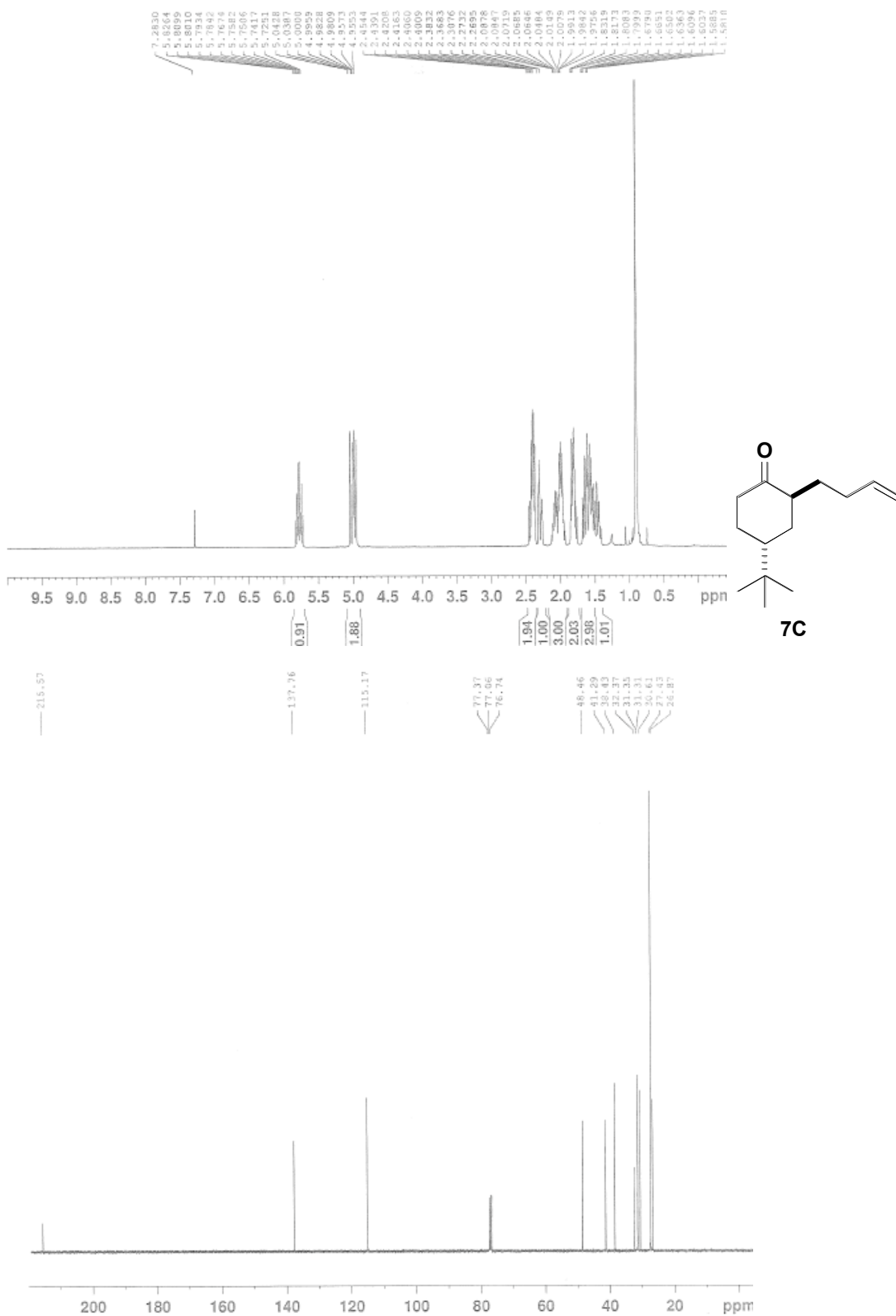


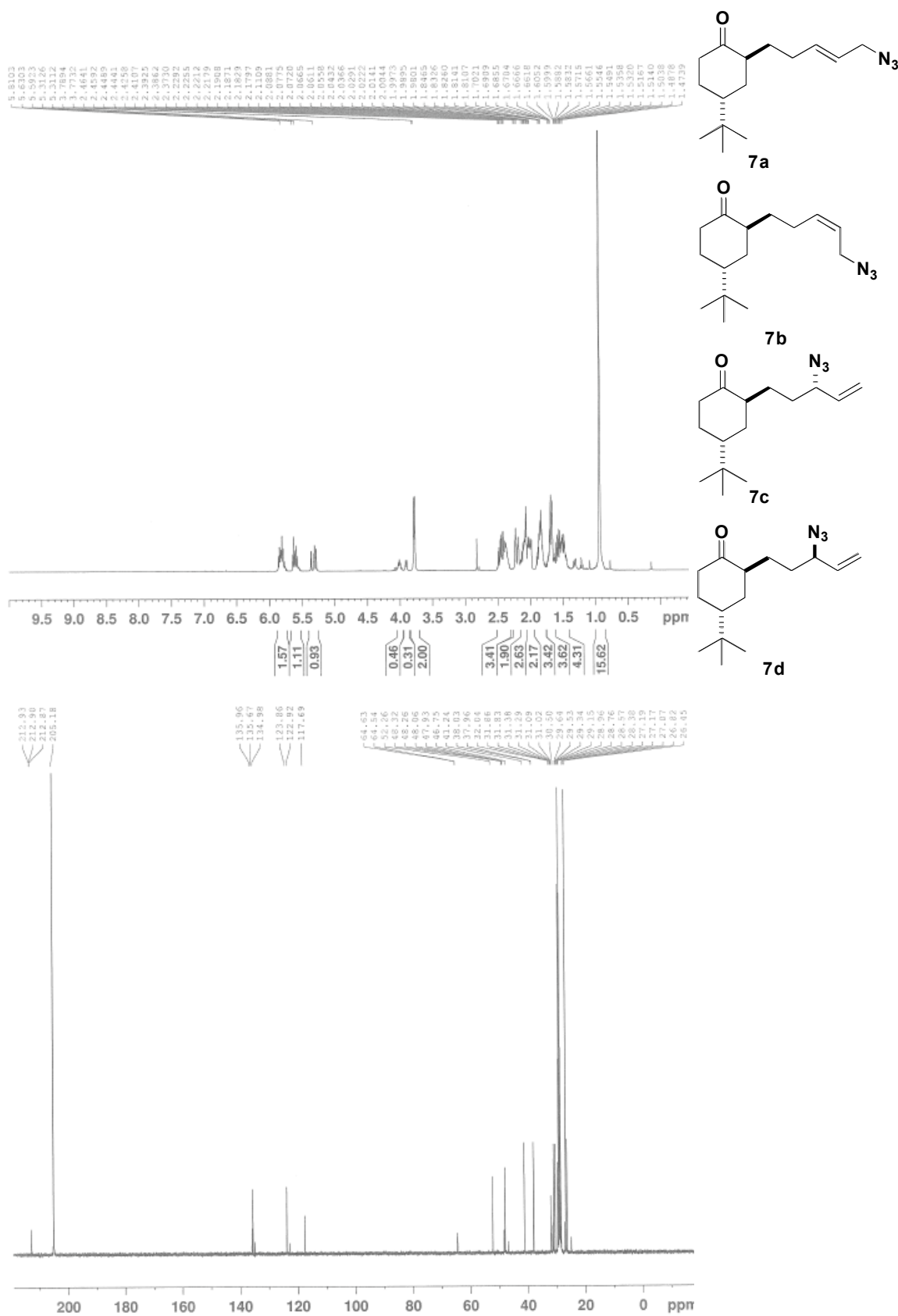


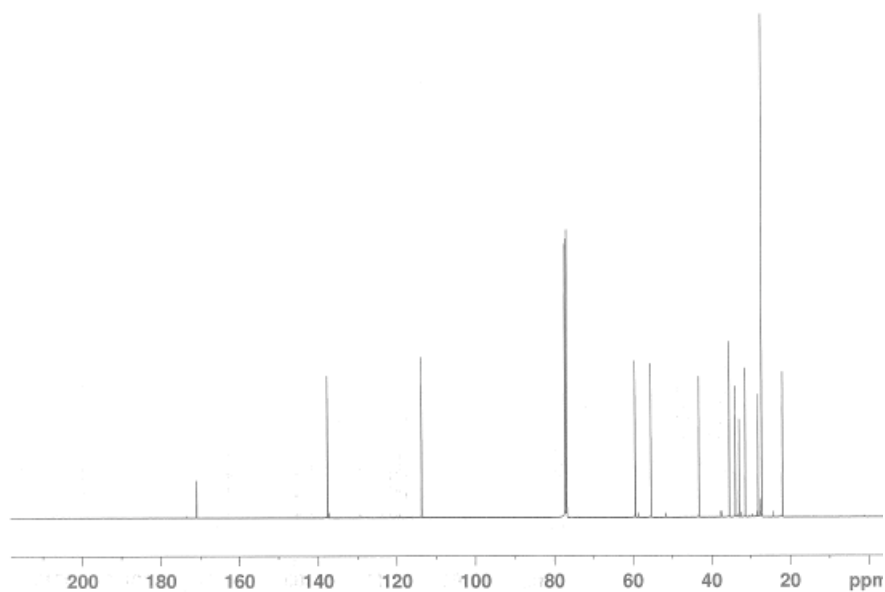
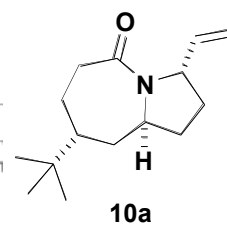
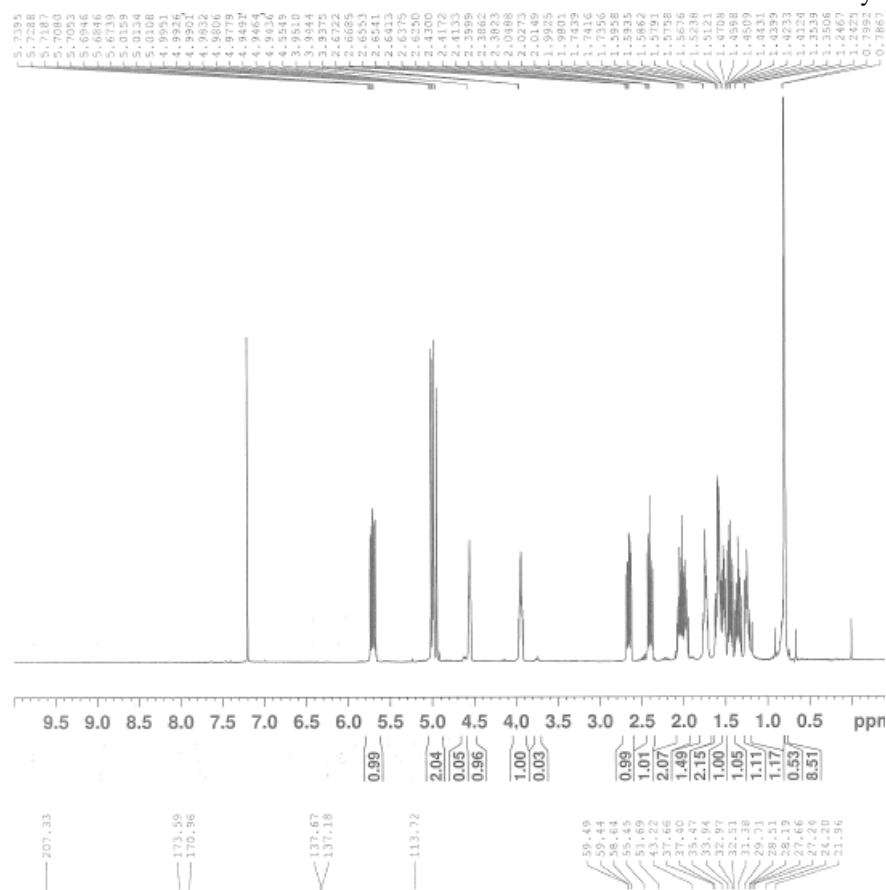


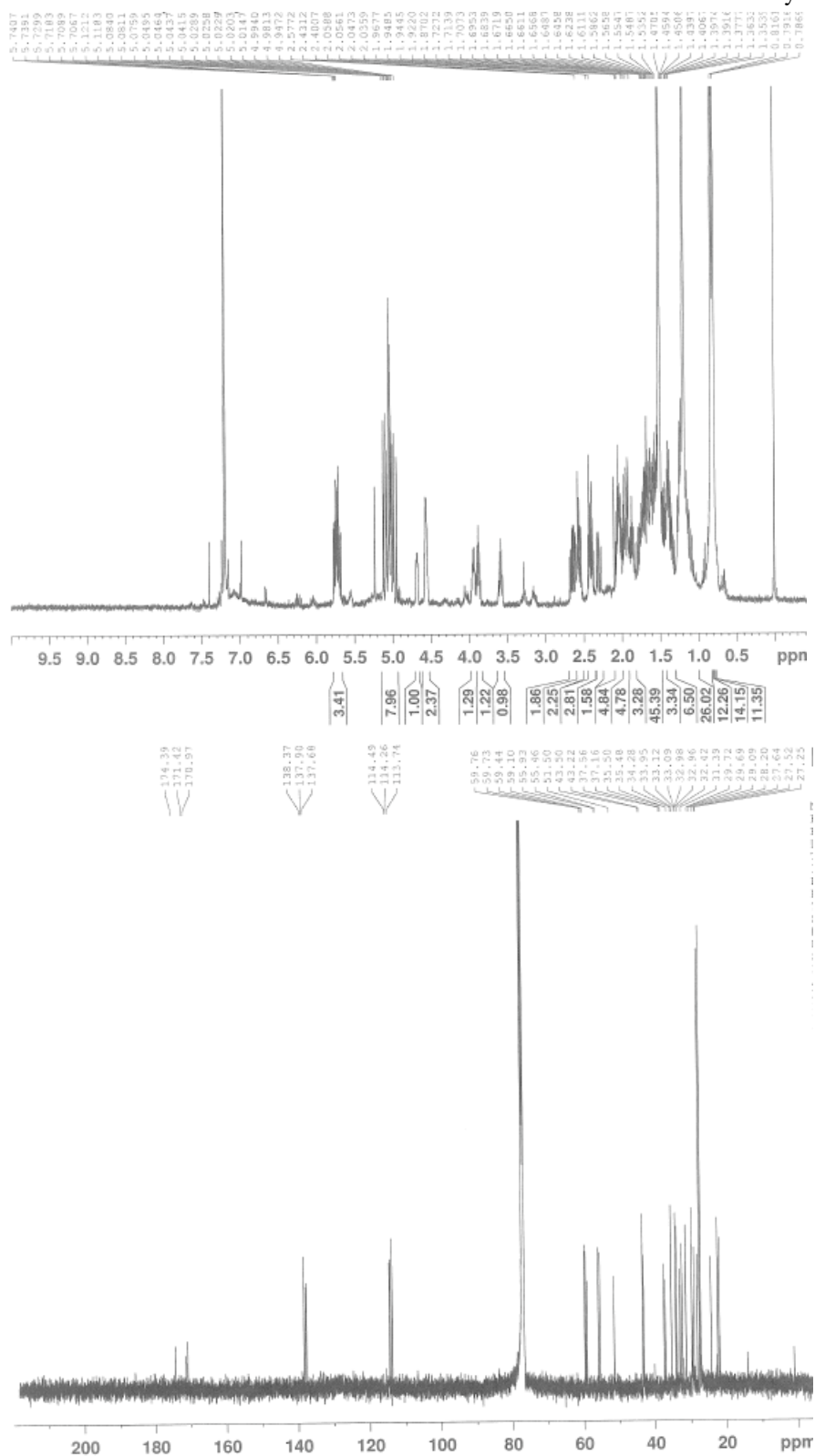
**8a**



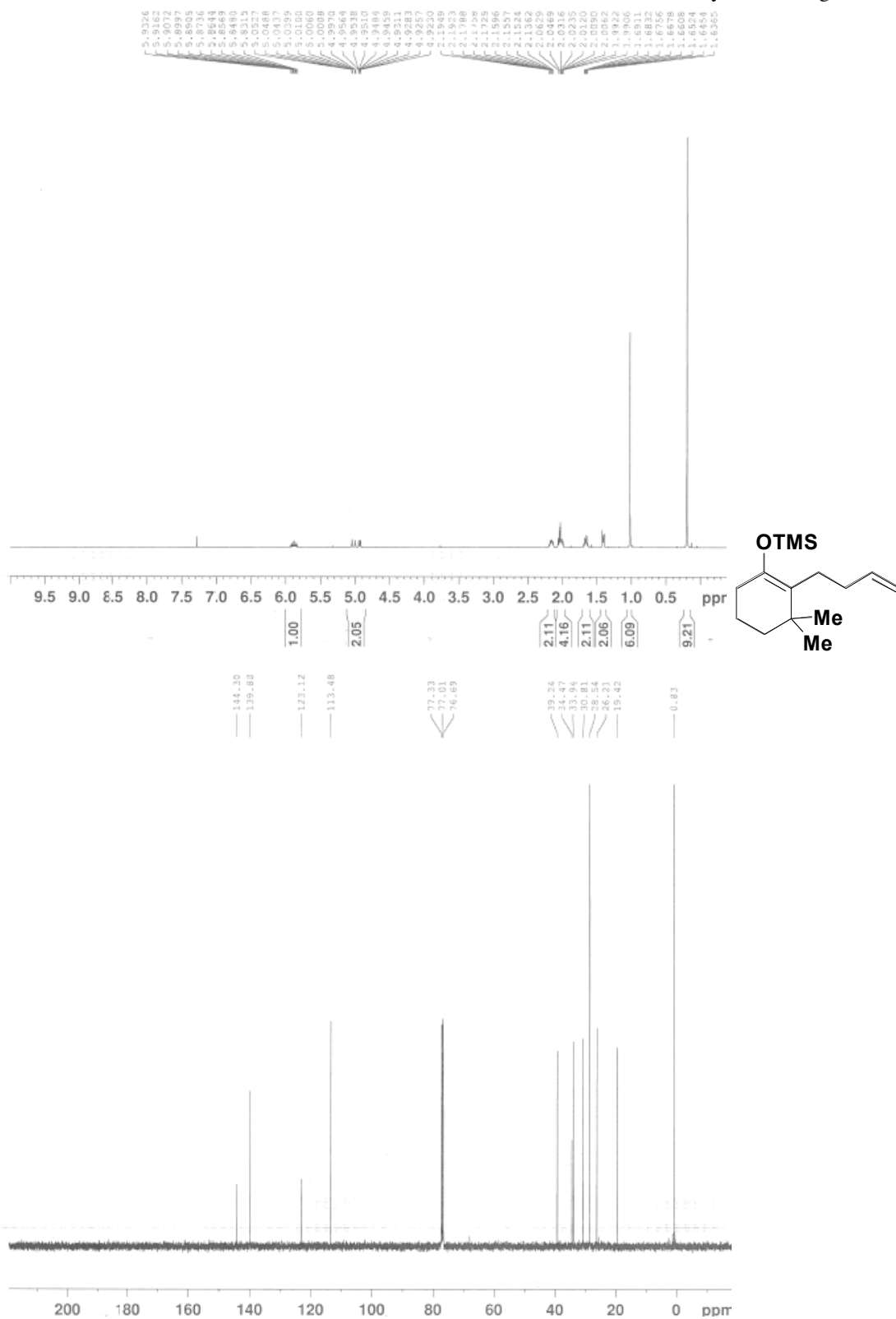


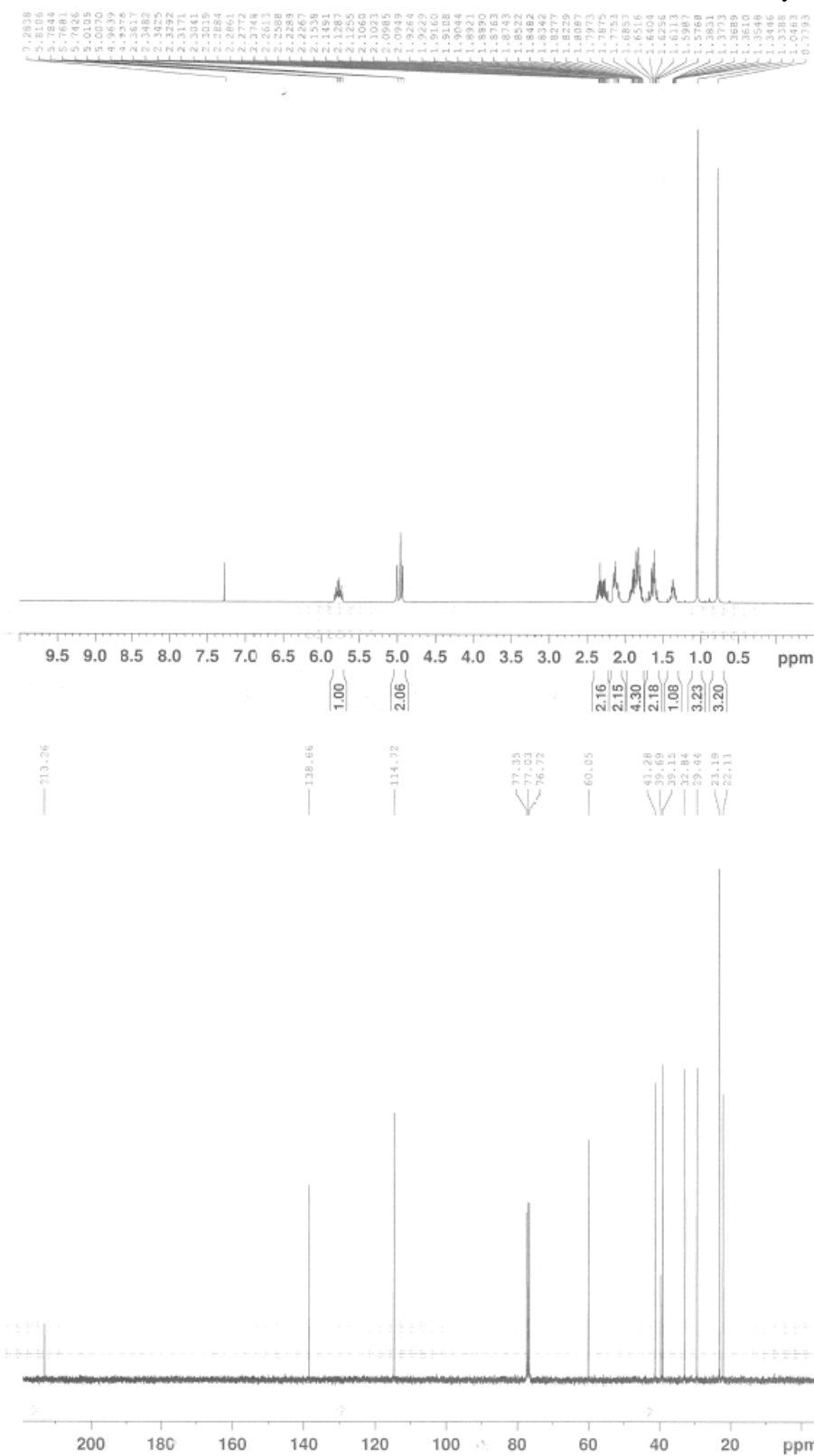


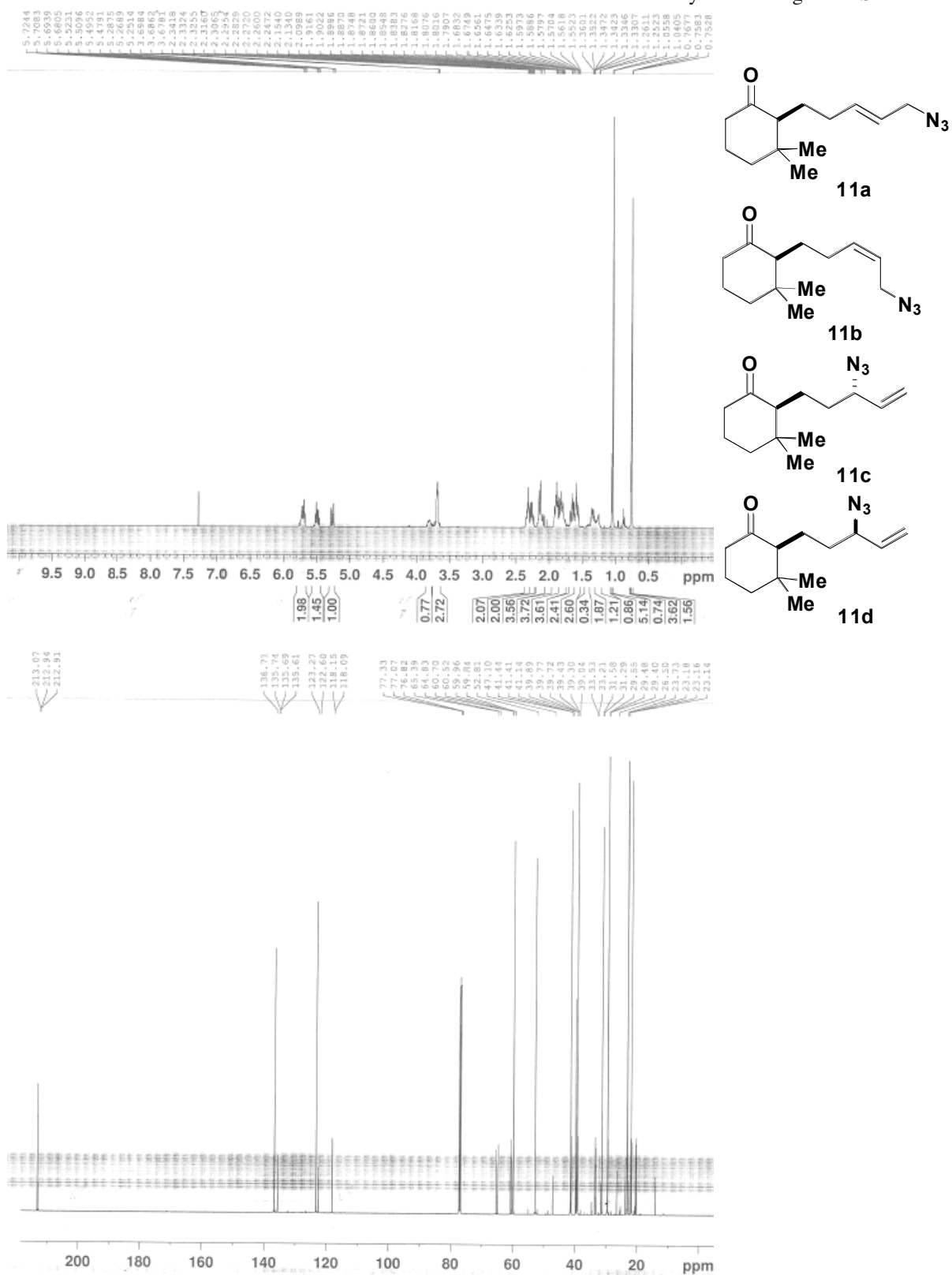


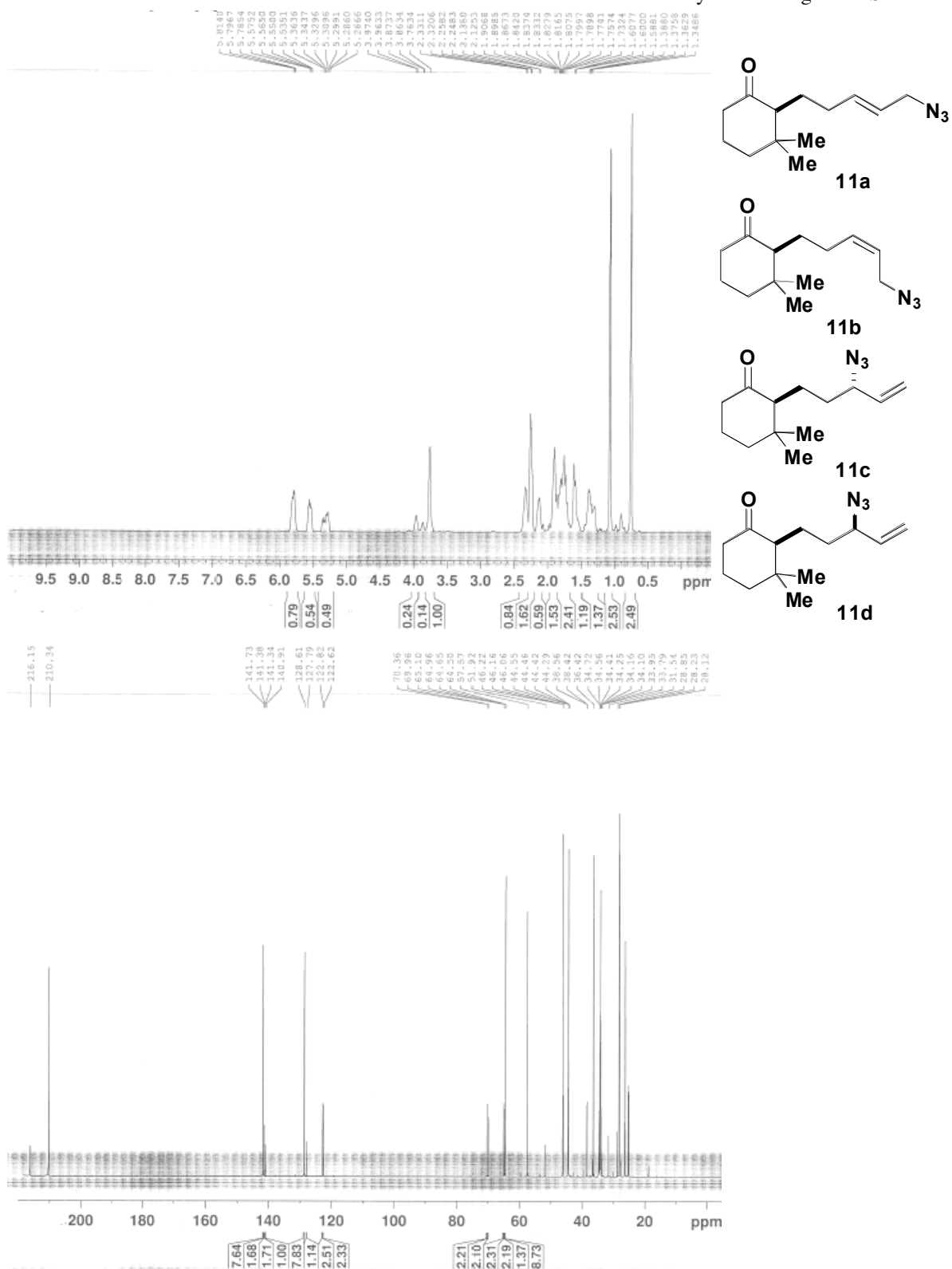


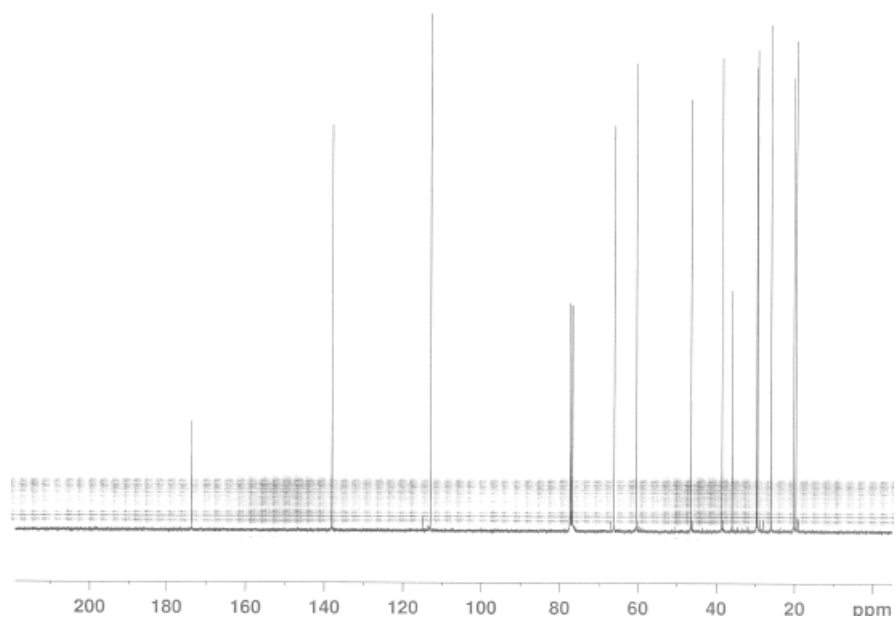
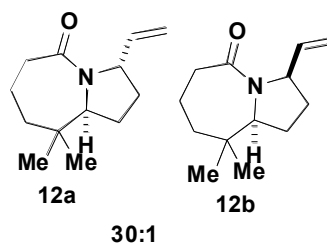
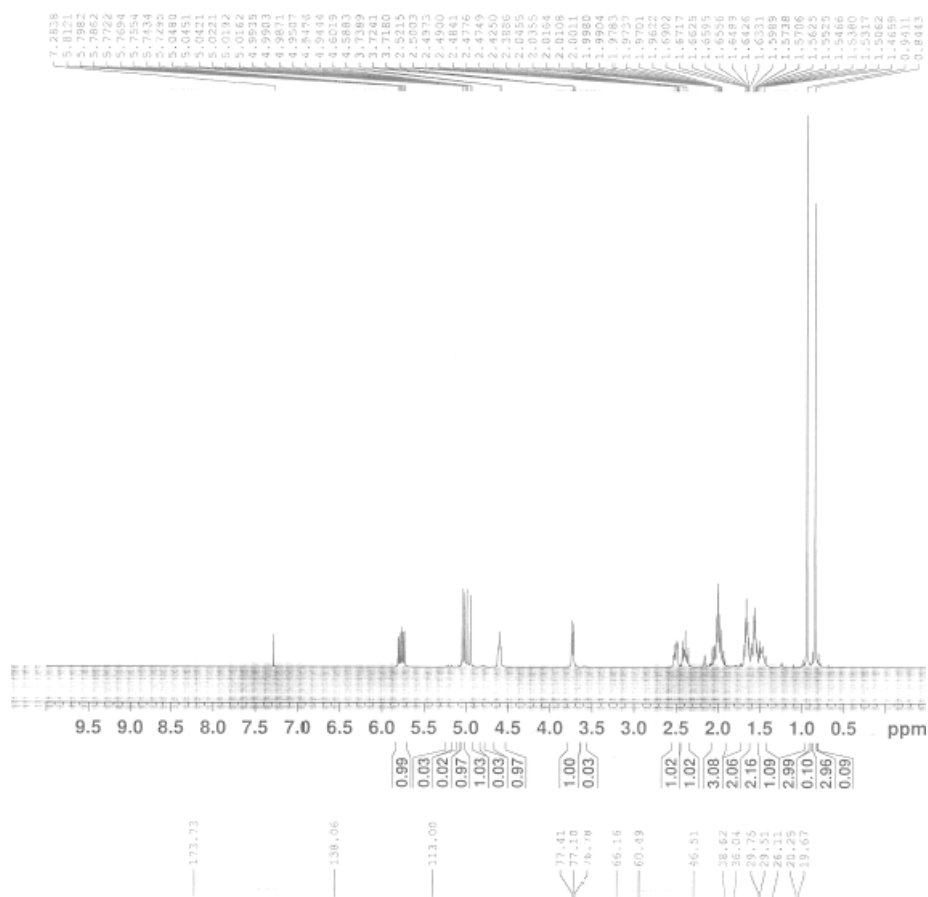


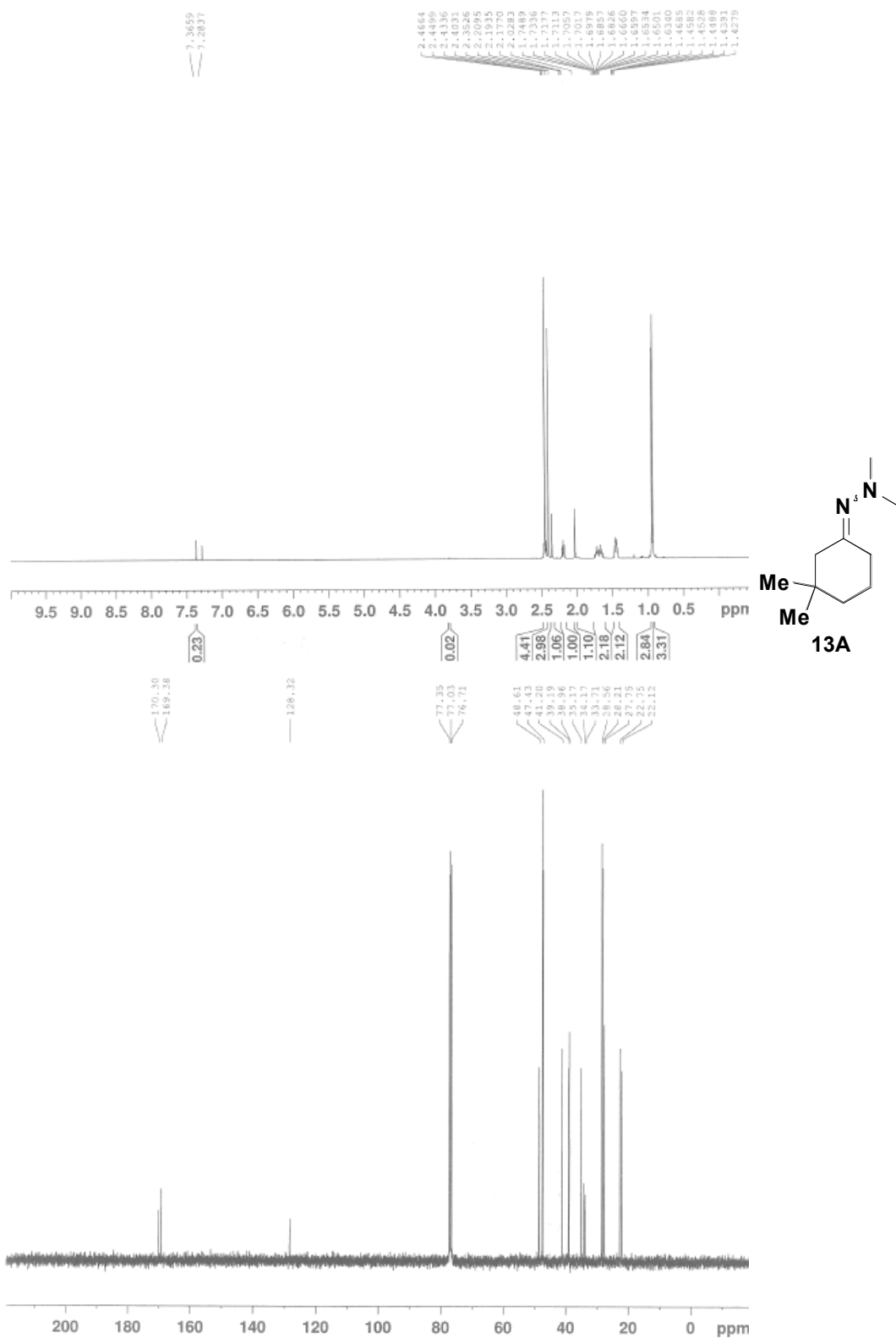


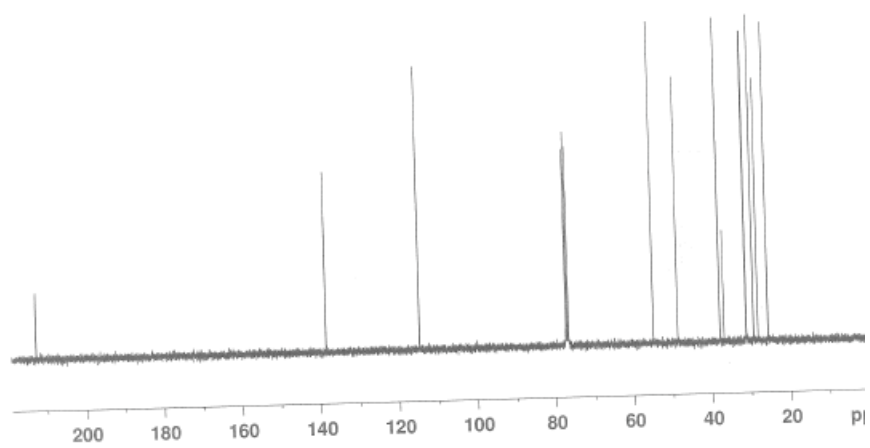
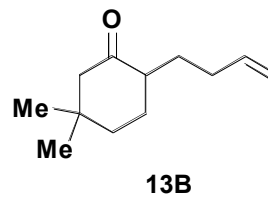
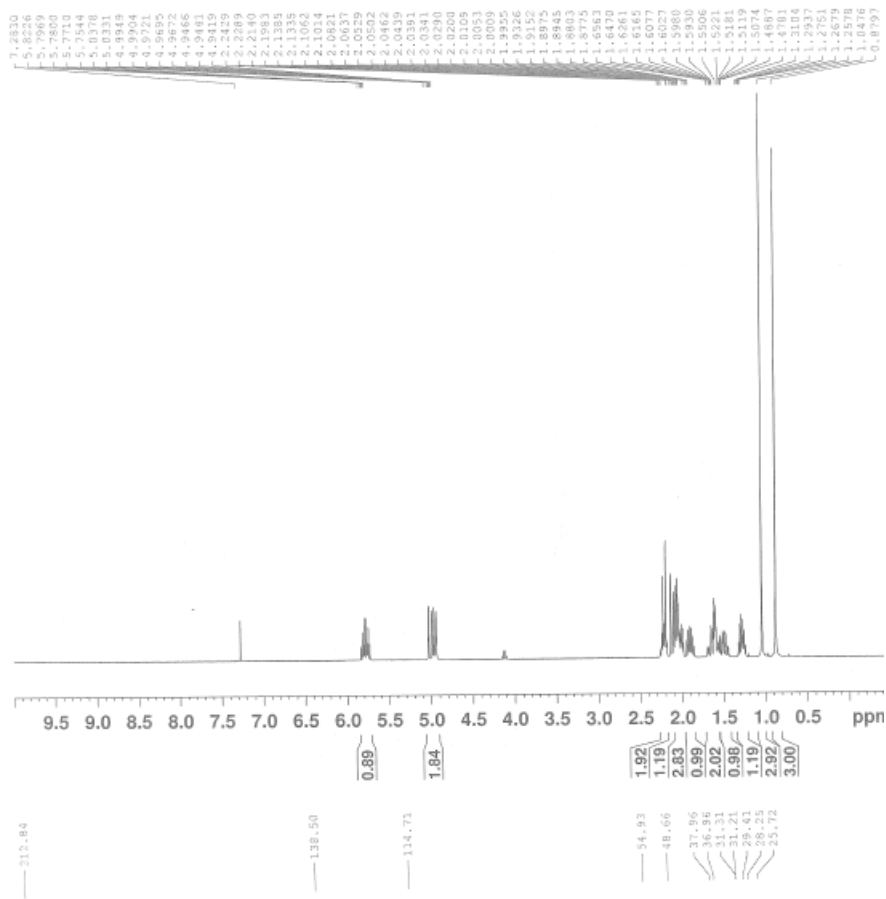


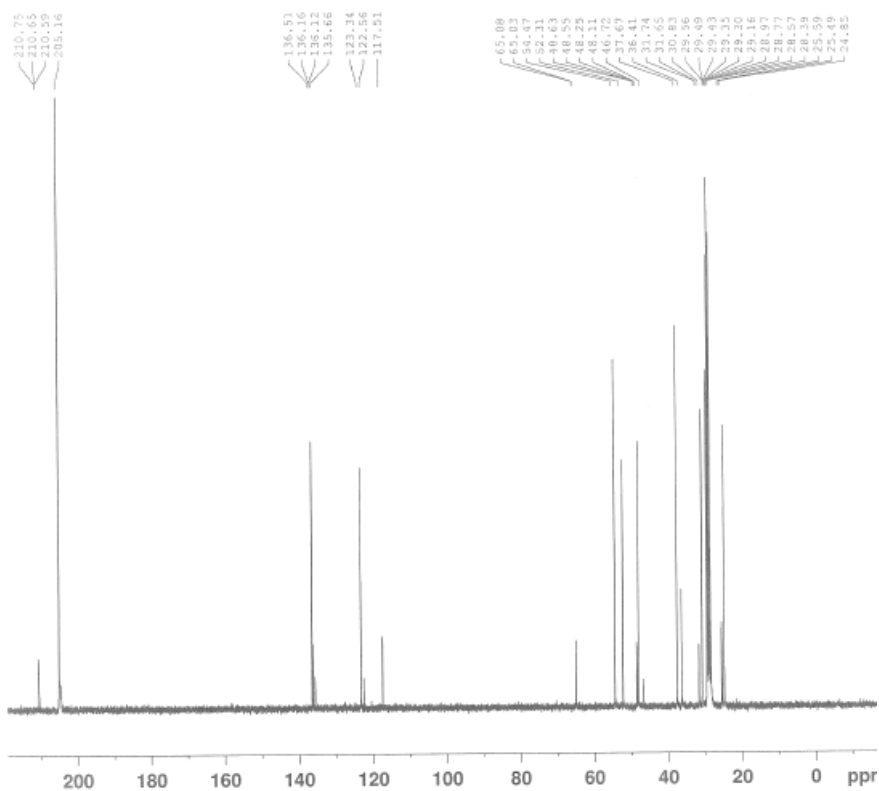
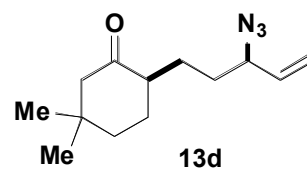
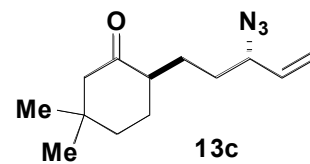
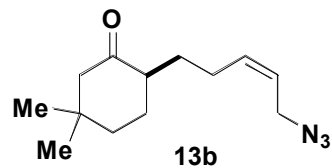
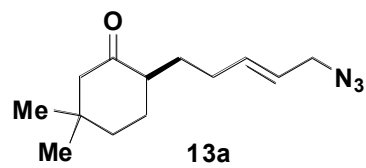
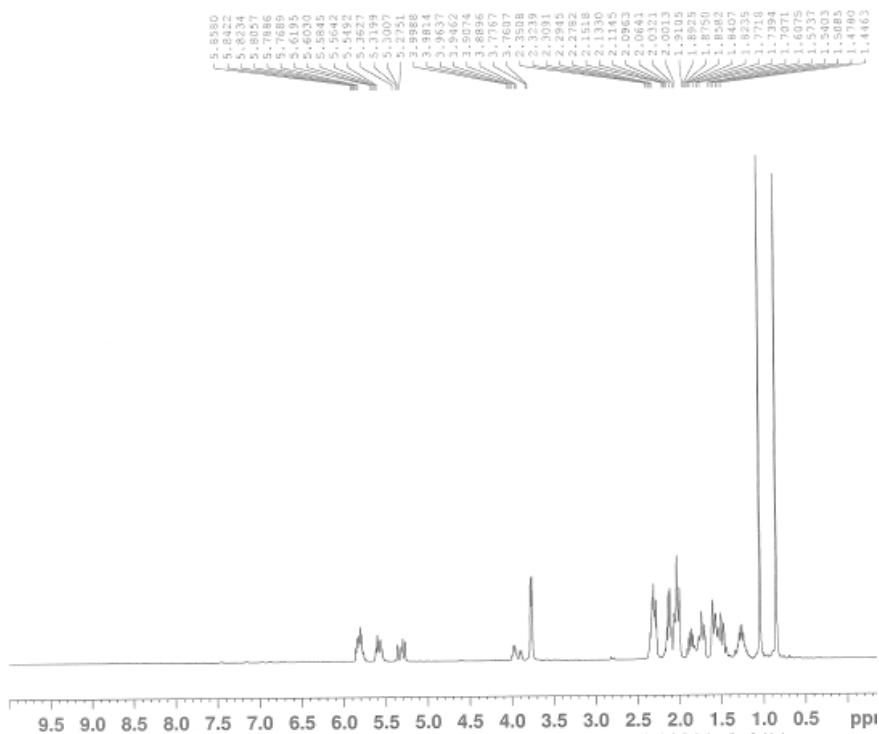


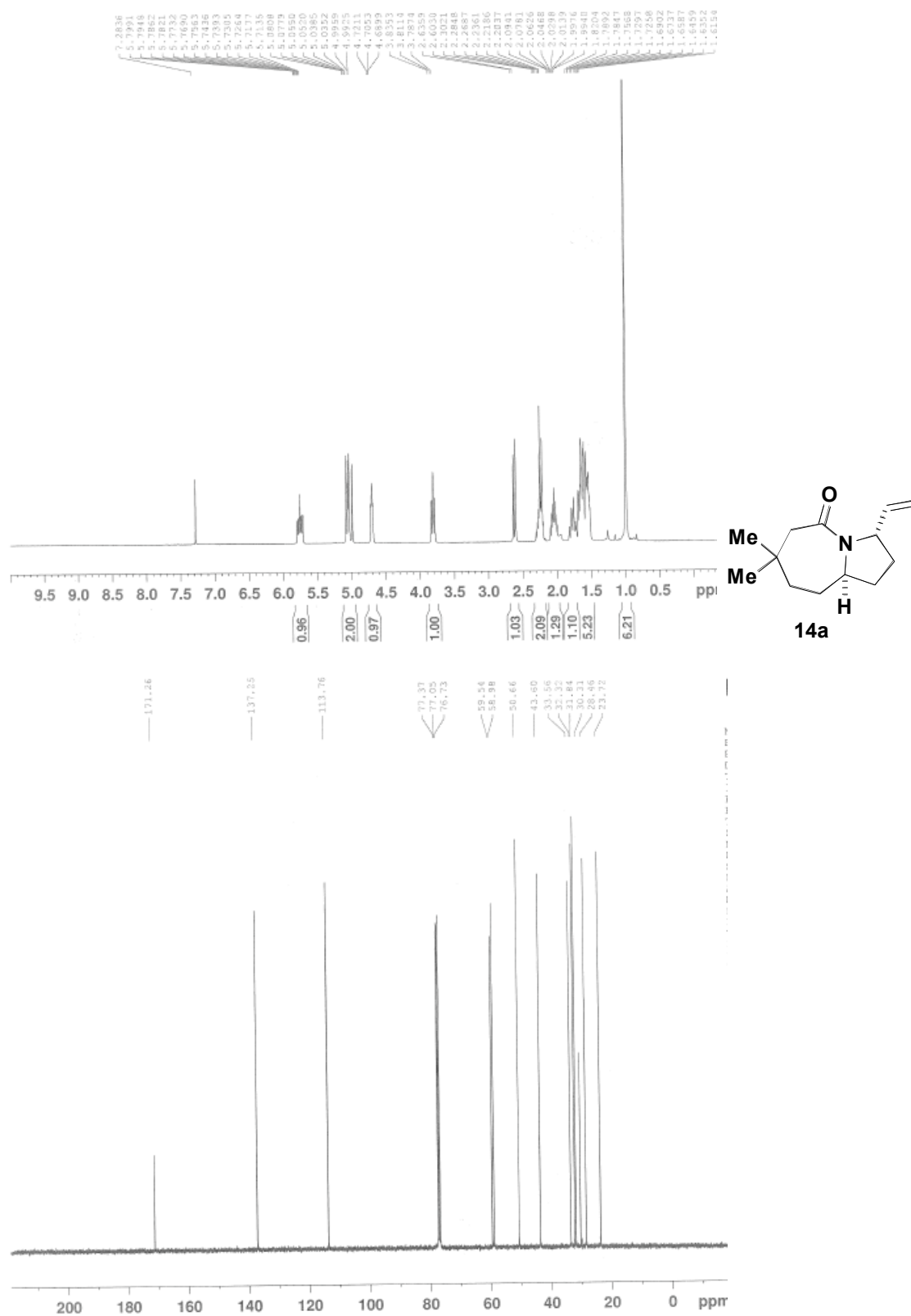


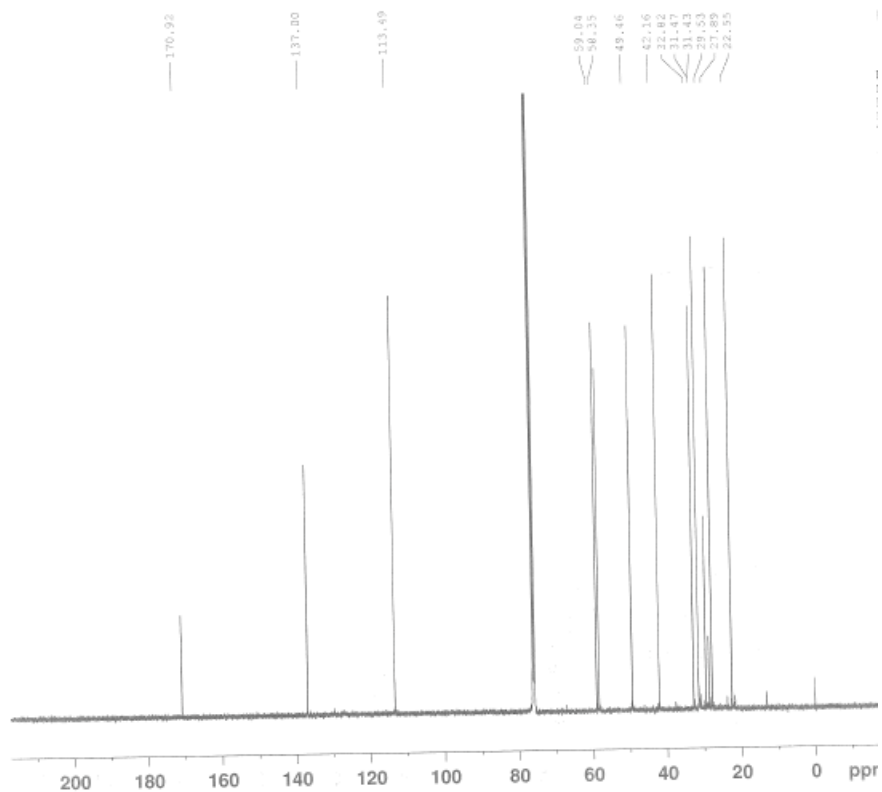
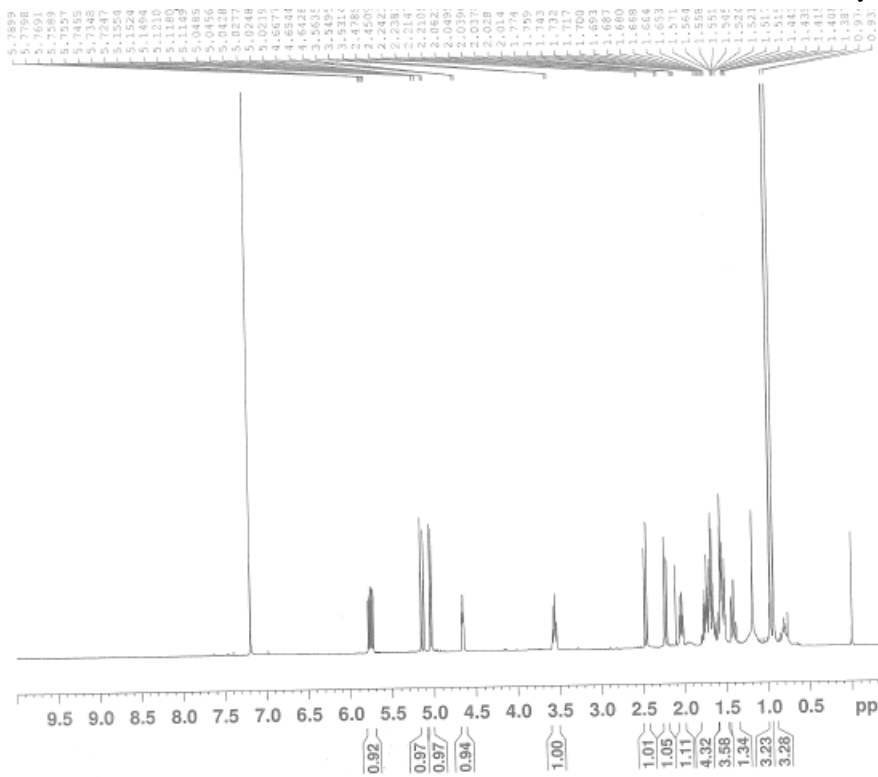


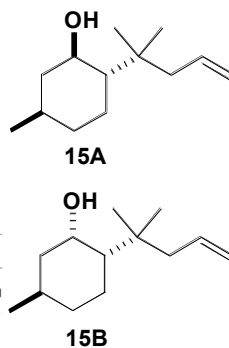
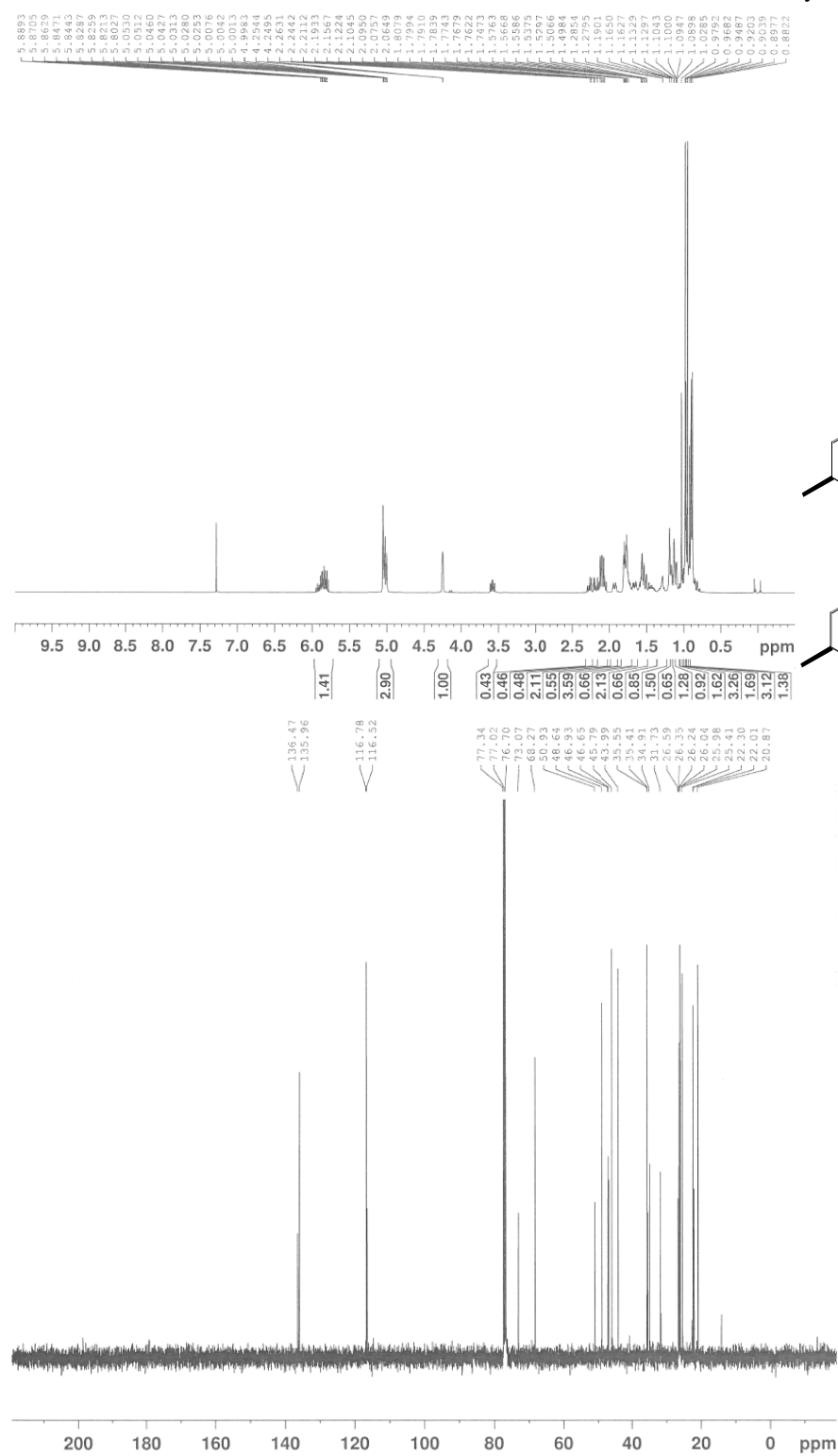


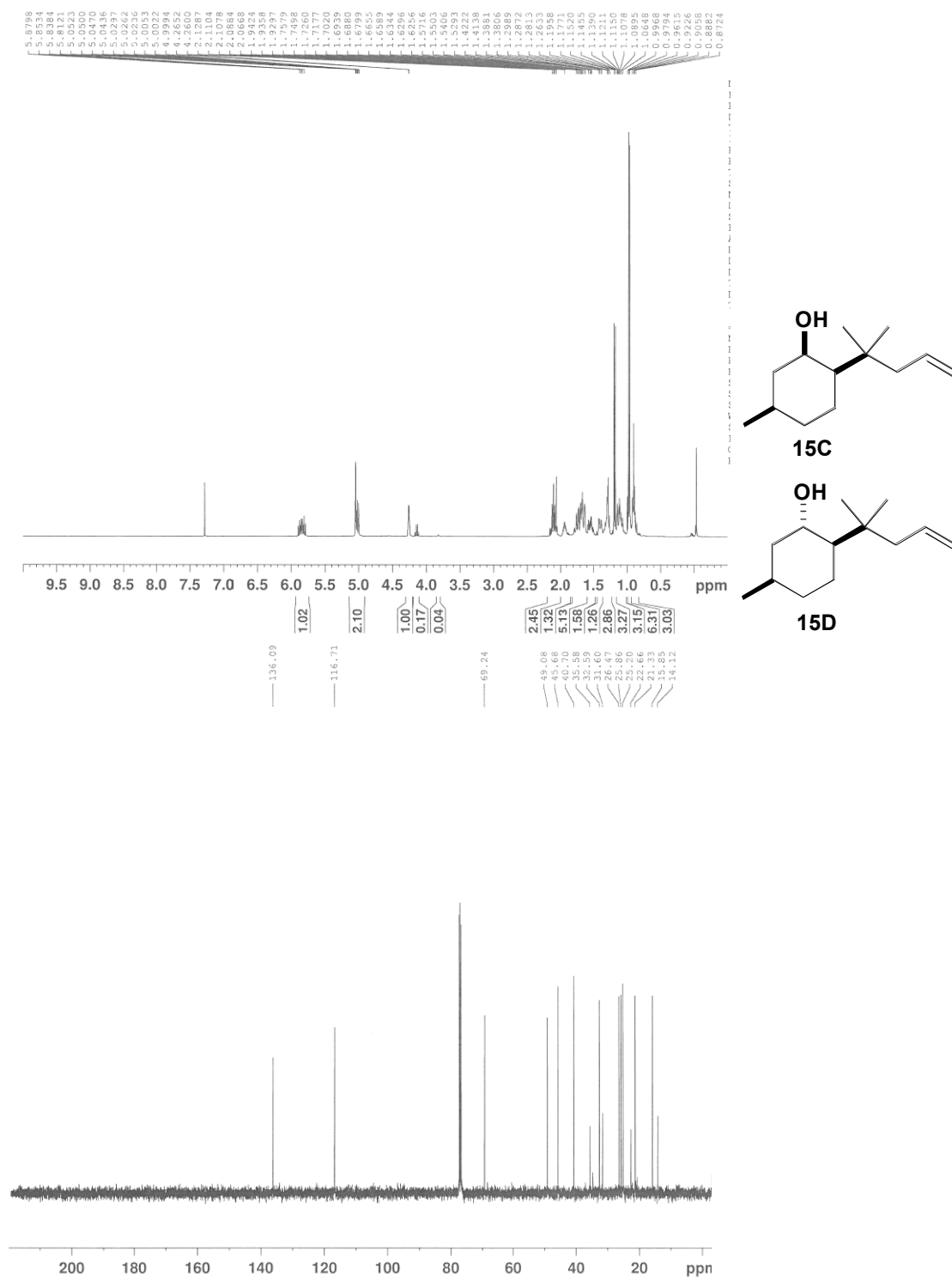


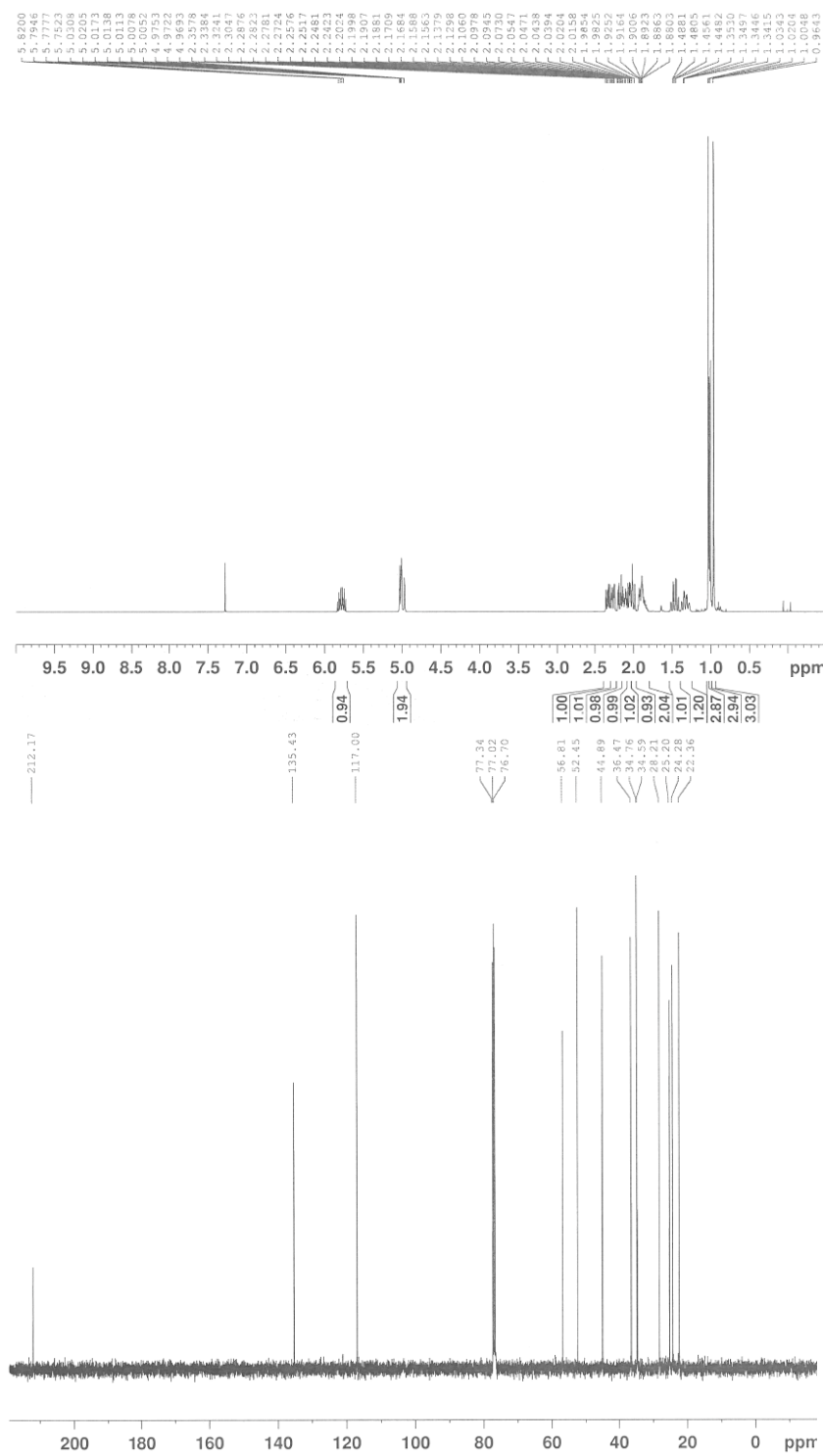


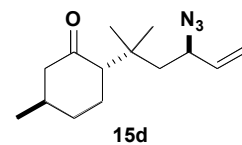
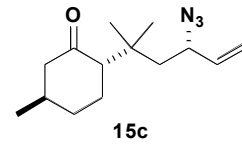
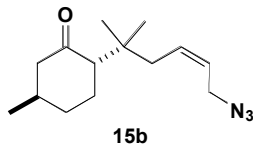
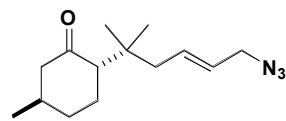
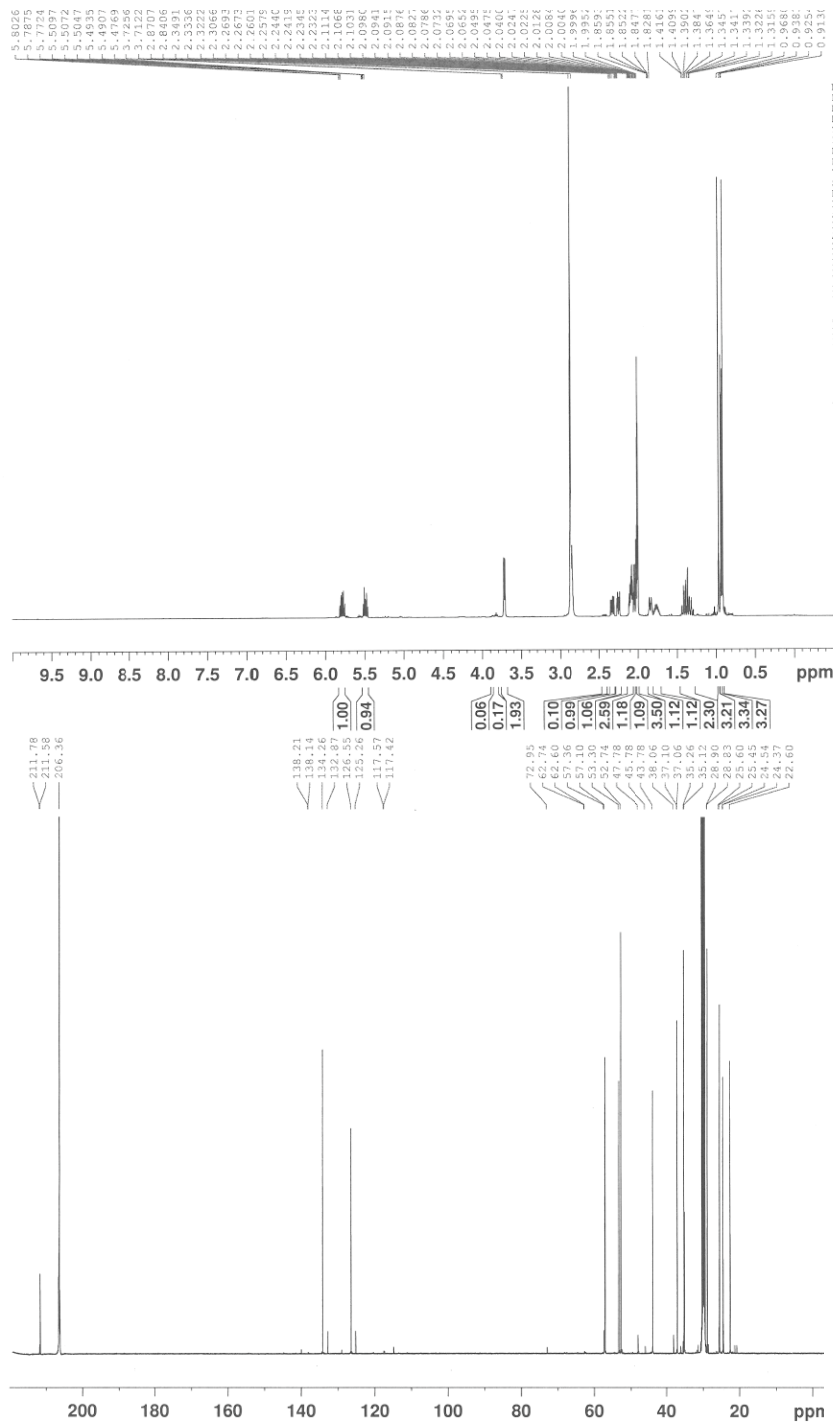


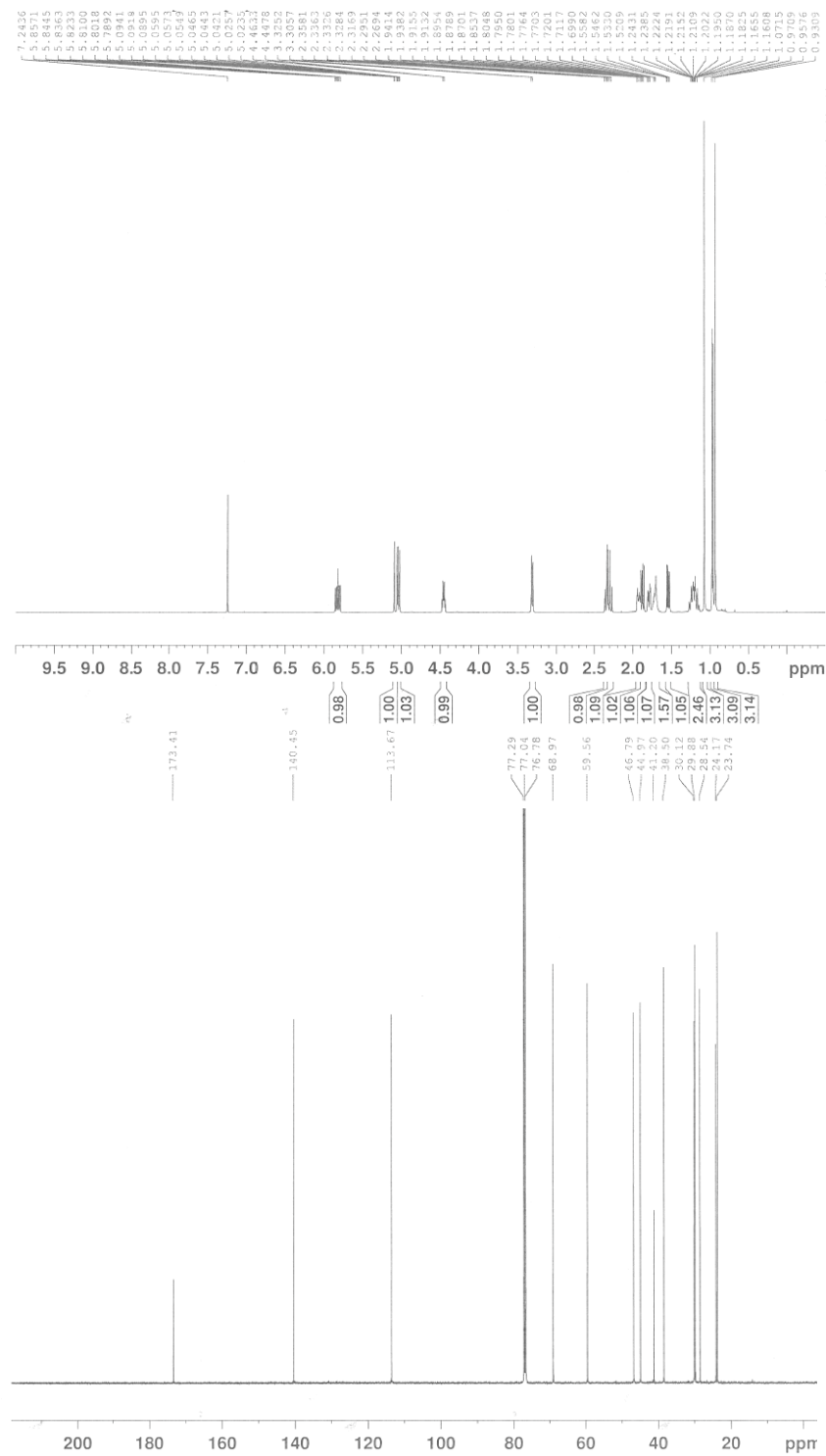


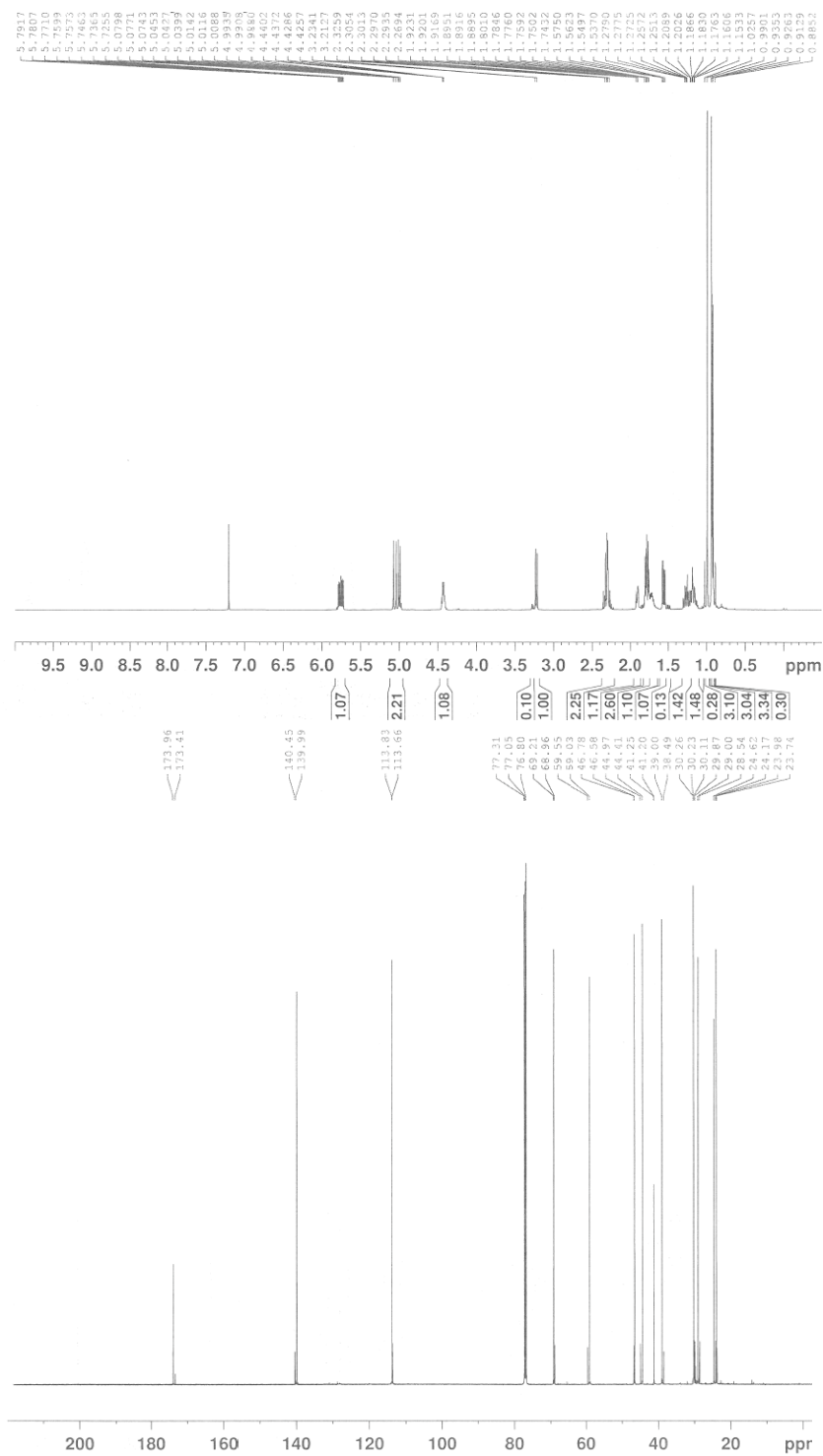


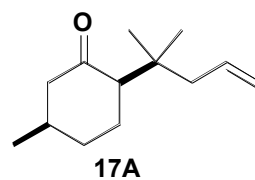
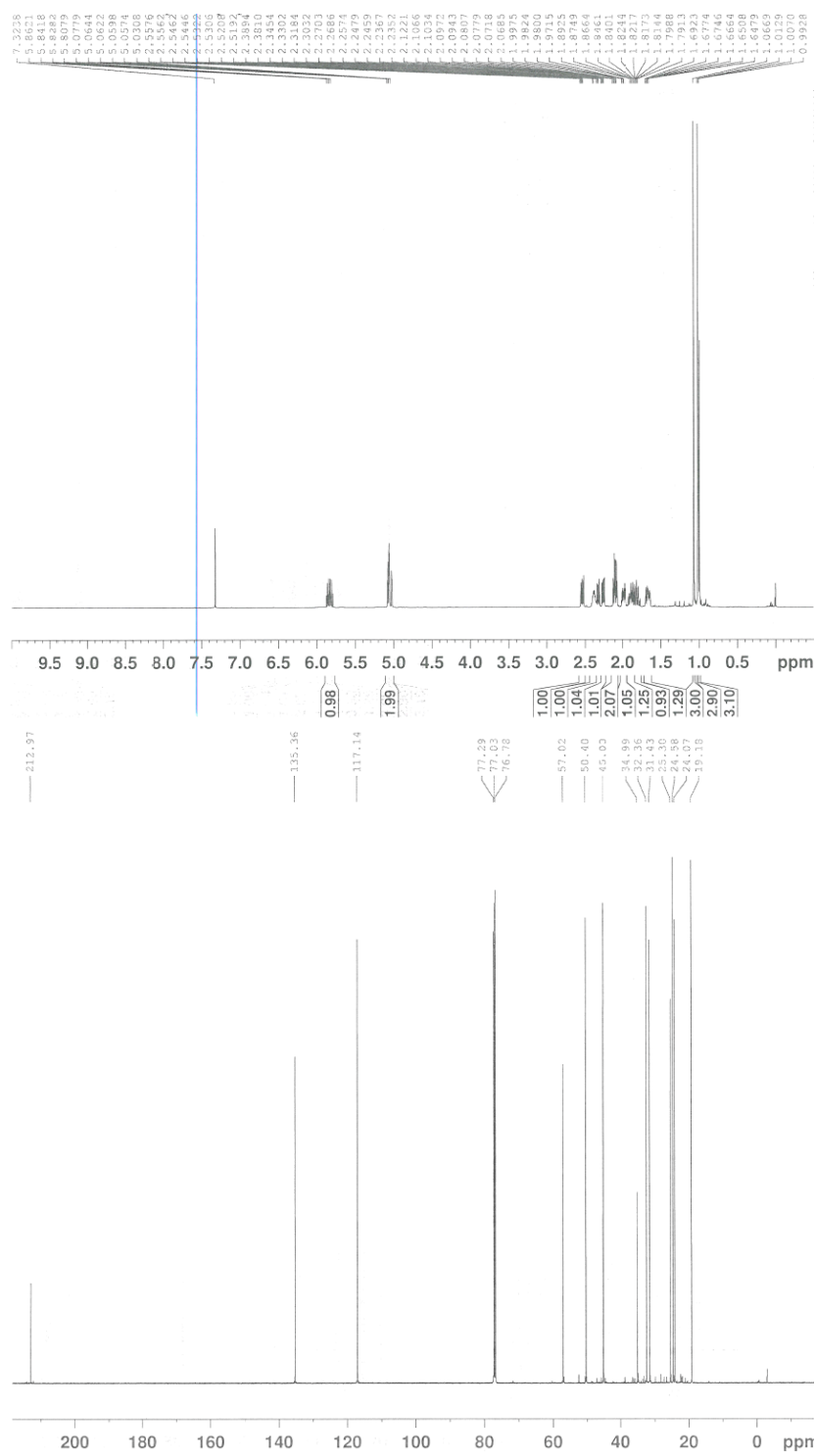


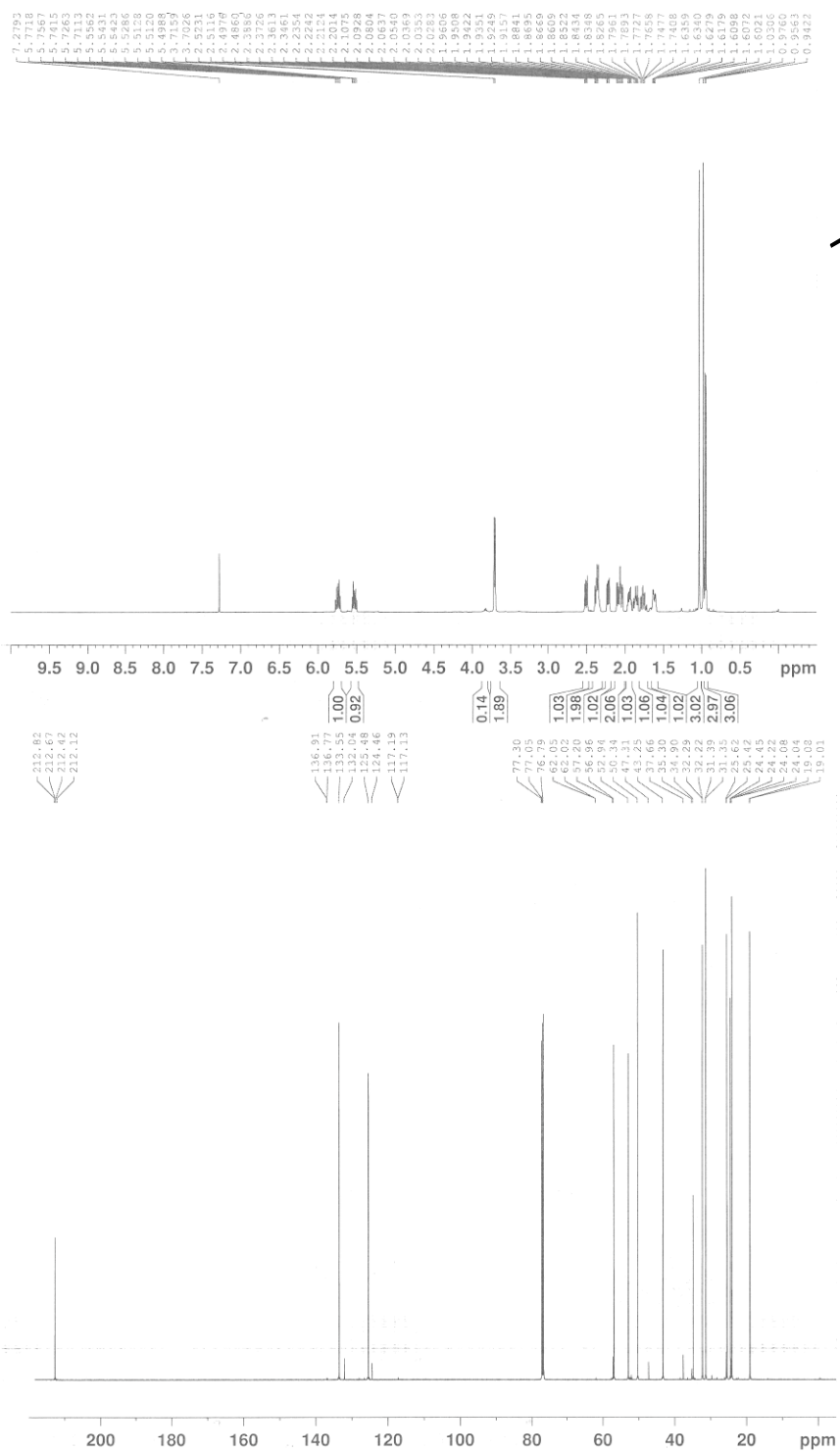


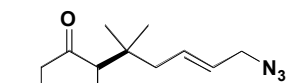
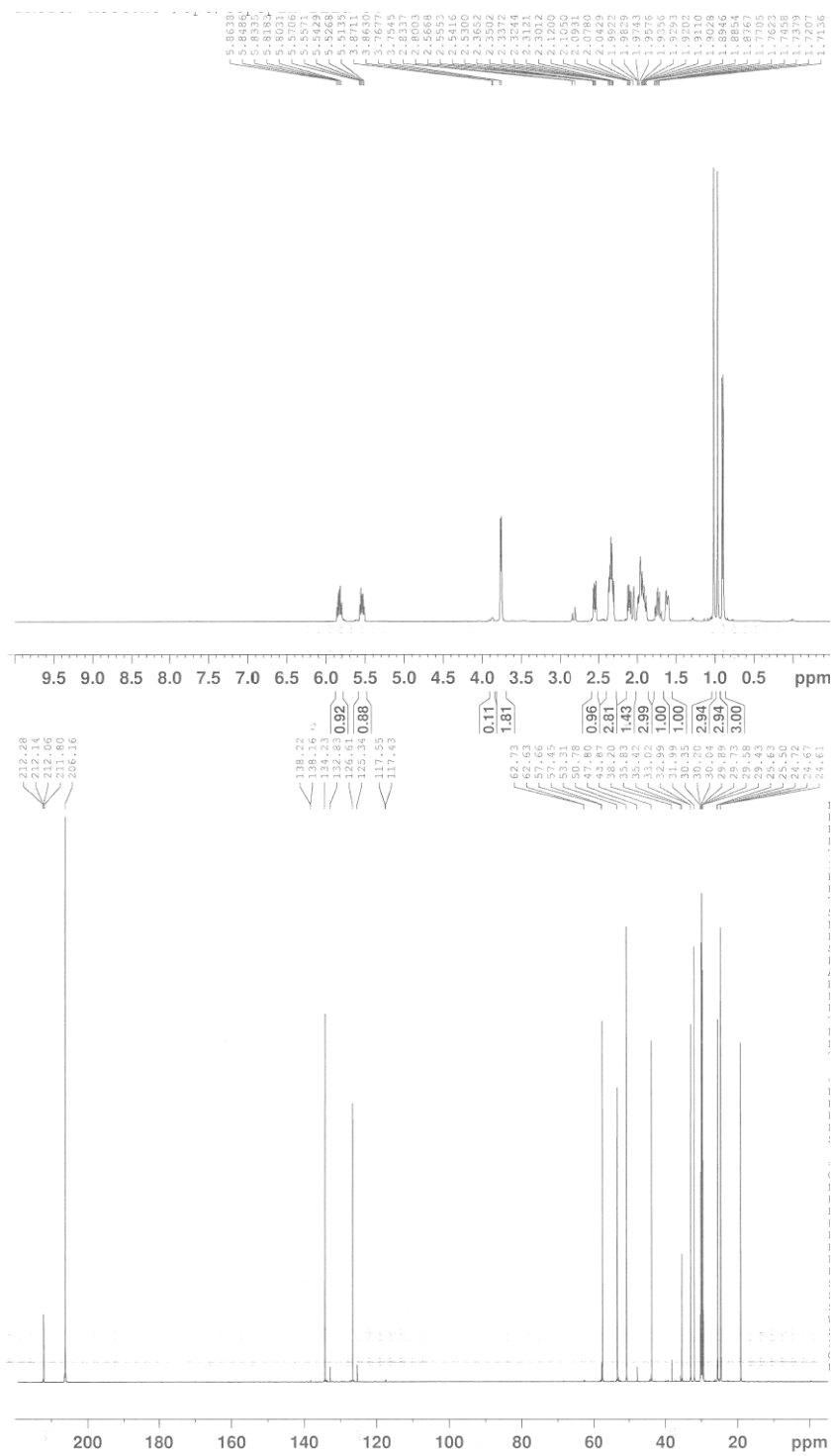




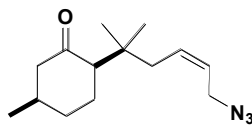




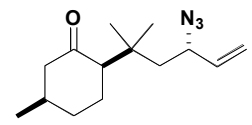




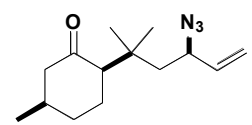
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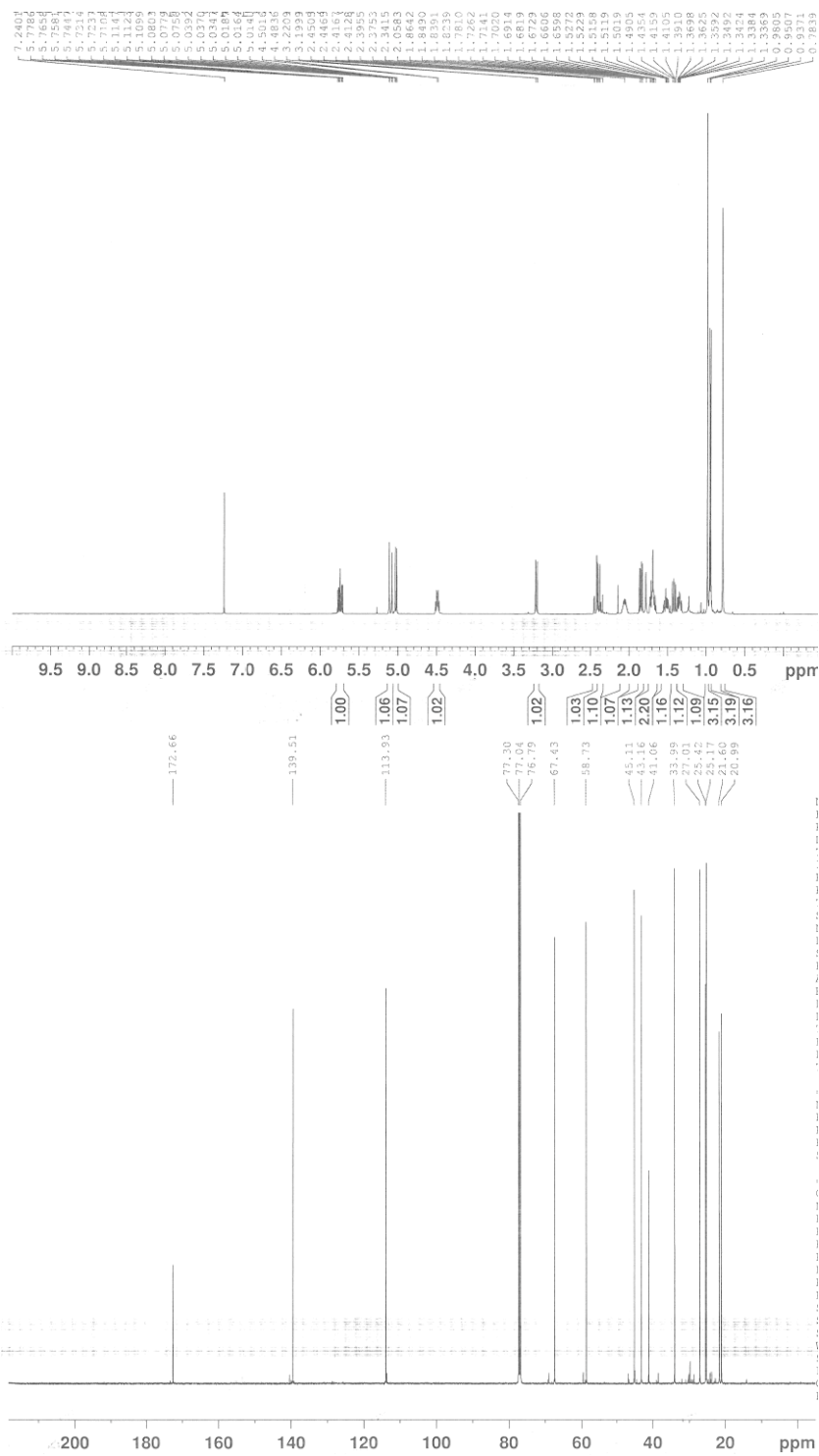
17b

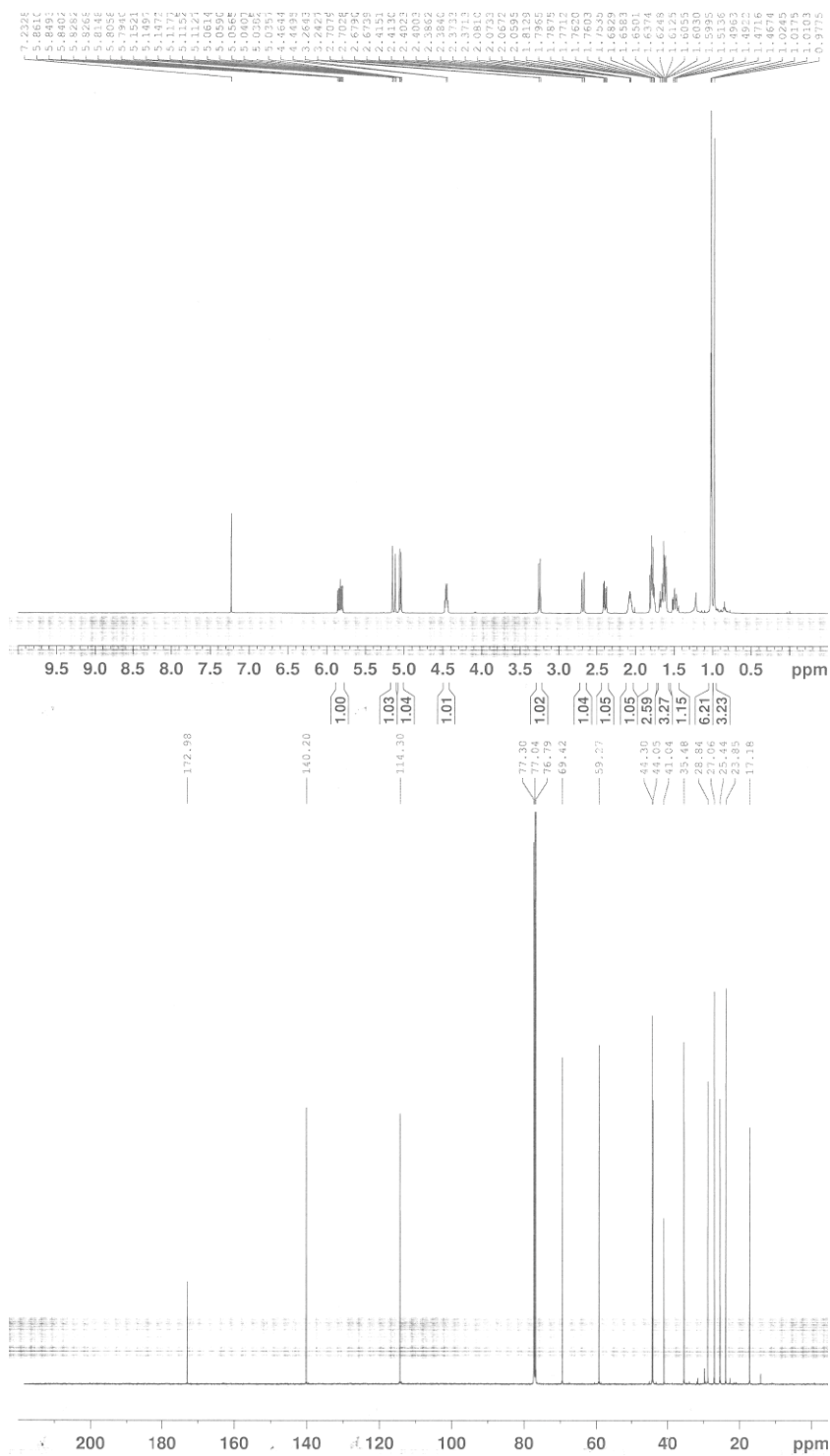


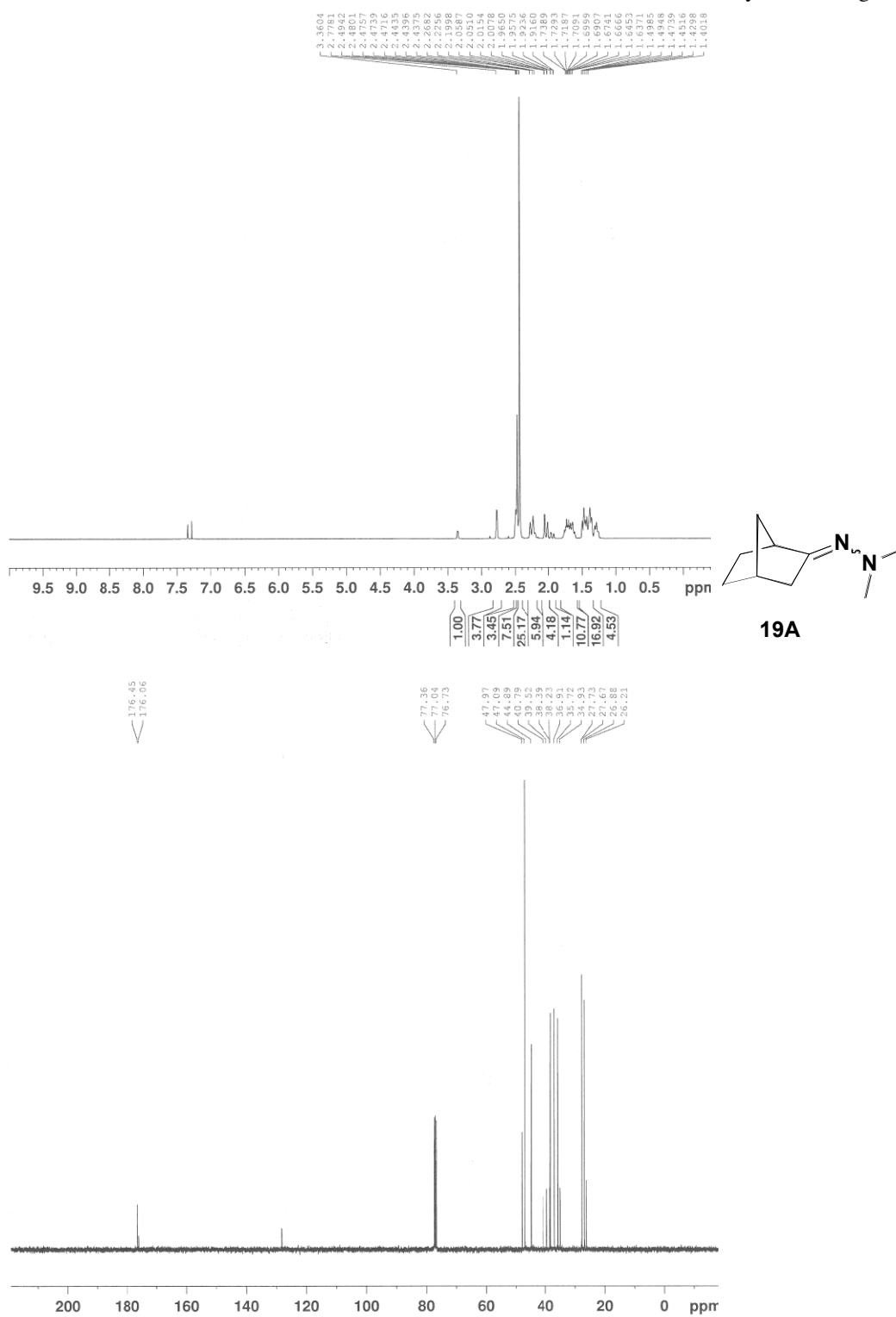
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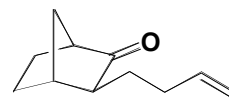
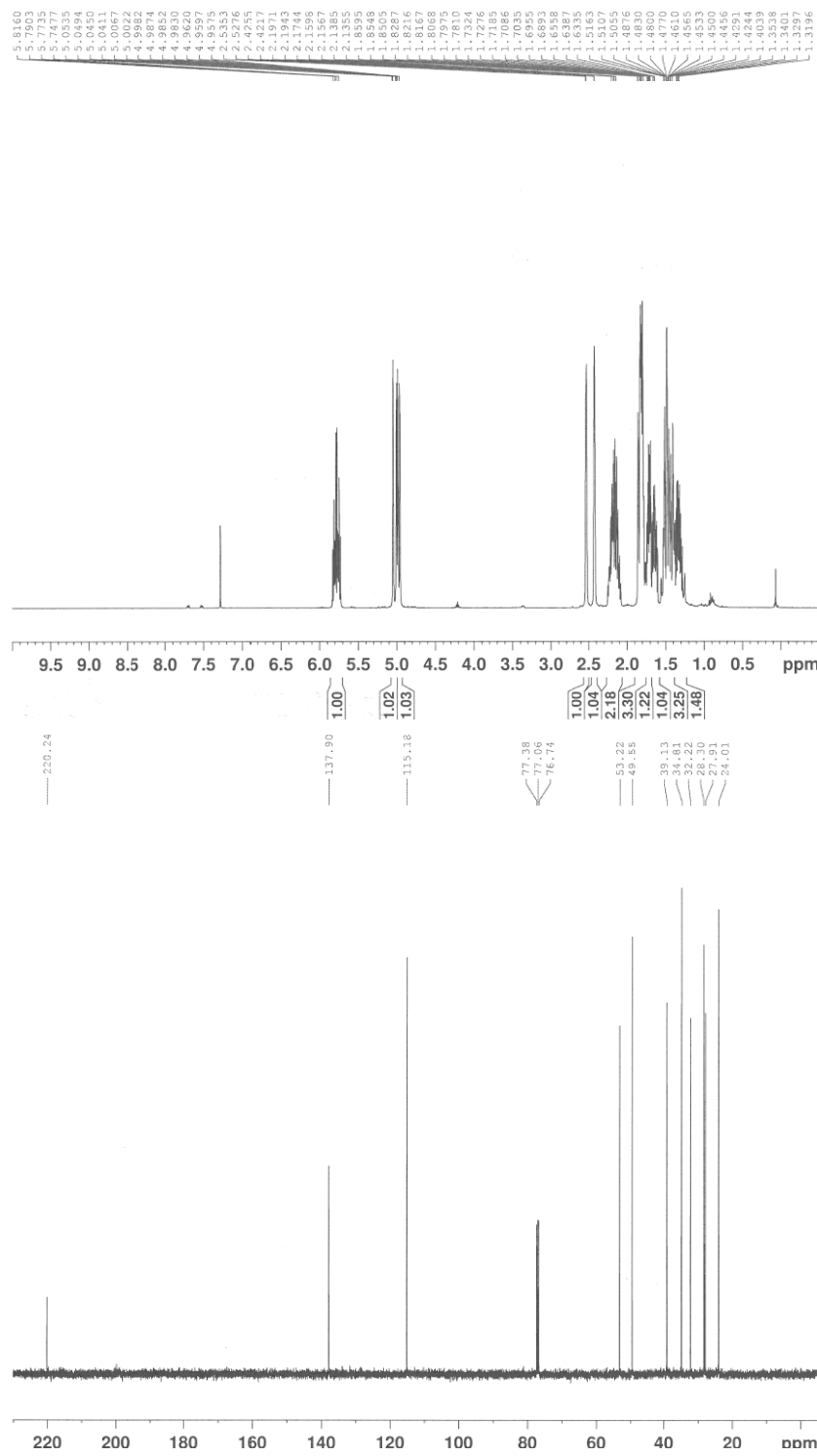


17d







**19B**

