One-Pot Ring-Closing Metathesis-Alkene Cross Metathesis Reactions of Sulfamide-Linked Enynes

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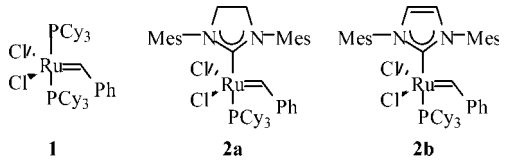
Ring-closing metathesis (RCM) of sulfamide-linked enynes **7**, **11** and **12** containing disubstituted alkynes afforded a series of novel 7-membered cyclic sulfamides **13**–**15** in good yield. Substrates **5**, **9** and **10** containing mono-substituted alkynes gave either simple RCM products **18a**–**c** or those arising from combinations of enyne RCM and olefin cross metathesis **16/17a**–**c** depending on the reaction conditions. Notably, in the presence of two equivalents of styrene or ethyl acrylate, substrates **5**, **9** and **10** containing terminal alkynes underwent selective enyne-RCM-olefin-cross metathesis to provide cyclic sulfamides **17a**–**c** and **19b**,**c** in yields of 54–83%.

Introduction

Ruthenium-catalysed enyne metathesis reactions are of considerable current interest,[1−5] and a growing number of applications in target synthesis are emerging.[2] The discovery of robust ruthenium carbene complexes such as **1** and **2a/b**, with good activities and functional group tolerance has played a key role in the recent development of the reaction.[6−8]



1 **2a** **2b**

Figure 1. Ruthenium carbene metathesis pre-catalysts

An attraction of enyne metathesis is the formation of 1,3-diene products, which are suitable substrates for a variety of further useful synthetic transformations such as cycloaddition reactions.[2] A number of different sub-classes of enyne metathesis reactions have now been reported, including: cross-metathesis (CM, process A), ring-closing metathesis (RCM, process B), and domino sequences involving combinations of ring-opening metathesis (ROM), enyne RCM, olefin RCM and olefin CM (process C) (Figure 2).[9] Recently the first examples have appeared where the product of a simple enyne RCM reaction (process B, Figure 2) has directly undergone selective CM with an olefin other than ethylene (process D).[10,11] Here we report RCM reactions of sulfamide-linked enynes to give a series of novel cyclic sulfamides, which in certain cases undergo selective in situ CM with olefins to provide enyne RCM-CM products.

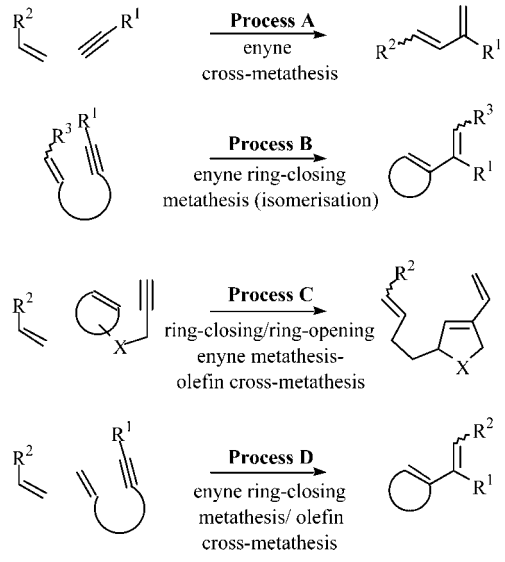


Figure 2. Various processes involving enyne metathesis

Results and Discussion

As part of our ongoing studies on the synthesis of cyclic sulfonamides and sulfamides we considered the possibility of using enyne RCM to produce cyclic 1,3-dienes, which would be useful intermediates for further elaboration to a

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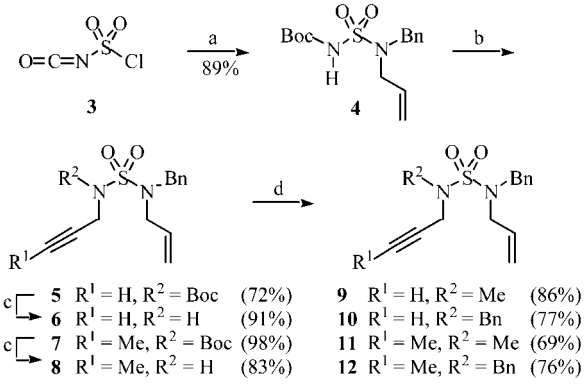
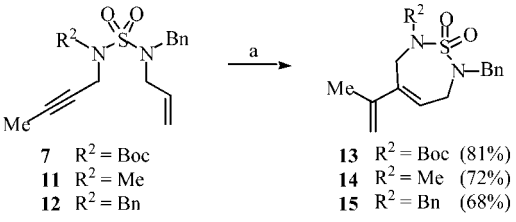
variety of interesting and novel heterocyclic scaffolds.[12−18] To investigate the idea, a number of acyclic sulfamide substrates were prepared from chlorosulfonyl isocyanate (**3**) (Scheme 1).[15,19] Treatment of **3** with *tert*-butanol then benzylallylamine gave **4**, which underwent *N*-propargylation under basic conditions to afford Boc-protected sulfamides **5** and **7**. Deprotection and *N*-alkylation then returned *N*,*N*′-dialkyl sulfamides **9** −**12** in good to excellent yields.



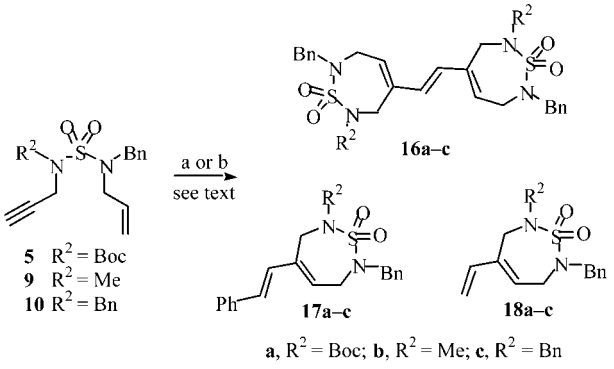
Scheme 1. Reagents: (a) *t*BuOH, CH_2Cl_2, Et_3N, then allylbenzylamine; (b) *t*BuOK, 18-crown-6, THF, propargyl bromide or 1-bromo-2-butyne; (c) TFA, CH_2Cl_2; (d) *t*BuOK, 18-crown-6, THF, MeI or BnBr

With a range of enyne substrates in hand, their metathesis reactions were investigated using 3−20 mol% of the ruthenium alkylidene complex **2a** in CH_2Cl_2 (Schemes 2−4). RCM of internal alkyne substrates was found to occur sluggishly at room temperature, but proceeded rapidly in a sealed system under microwave irradiation at 100 °C to give the seven-membered cyclic sulfamides **13**−**15** in high yields (Scheme 2).[20] Similar results could be obtained by heating the reactants in sealed crimped cap vials immersed in a pre-heated oil bath at 100 °C.



Scheme 2. Reagents: (a) **2a** (3 mol%), CH_2Cl_2, microwave irradiation (100 °C)

Metathesis reactions of the terminal alkynes **5, 9** and **10** require further discussion as different products predominated depending on the reaction conditions (Scheme 3, Table 1). Heating enynes **5, 9** and **10** in the presence of 6−20 mol% of the ruthenium complex **2a** led to the isolation of three main components; the expected enyne-RCM products **18a**−**c**, RCM-CM products **16a**−**c** and **17a**−**c**.[21] Using lower amounts of pre-catalyst **2a** favoured the formation of the simple enyne-RCM products for the *N*-alkylated enynes **9** and **10** (Entries 2,3,5 and 6, Table 1), whereas the *N*-Boc protected enyne afforded mainly RCM-homo-CM product **16a** (Entry 1, Table 1). The reactions of the enynes **9** and **10** could also be made to favour the formation of RCM-homo-CM products by using increased amounts of **2a** (Entries 4 and 7, Table 1). By-products present in all of the reactions were the CM adducts **17a**−**c** that had incorporated the benzylidene group from the pre-catalyst **2a**. Formation of the CM products **17a**−**c** was a very efficient process based on the amount of **2a**.



Scheme 3. Reagents: (a) **2a** (6−20 mol%), CH_2Cl_2, reflux, 24 h; (b) **2a** (6 mol%), CH_2Cl_2, microwave irradiation (100 °C), 1 h.

Table 1. Enyne RCM reactions of substrates **5**, **9** and **10** containing terminal alkynes (see Scheme 3).

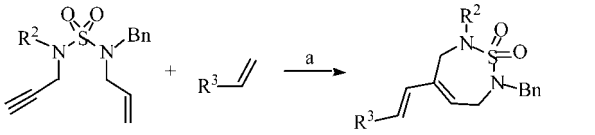
Entry	Enyne (R)	**2a** (mol%)[a] Conditions	Yields (%)[b] **16a**−**c**	**17a**−**c**	**18a**−**c**
1	**5** (Boc)	(6 mol%), A	61%	6%	8%
2	**9** (Me)	(6 mol%), B	10%	6%	60%
3	**9** (Me)	(10 mol%), A	12%	7%	49%
4	**9** (Me)	(20 mol%), A	66%	18%	2%
5	**10** (Bn)	(6 mol%), B	8%	4%	63%
6	**10** (Bn)	(10 mol%), A	21%	8%	56%
7	**10** (Bn)	(20 mol%), A	80%	16%	0%

[a] Reactions were conducted on a 20−100 mg scale at a concentration of 0.05 M with respect to the enyne substrate. Conditions A: Reaction mixtures in CH_2Cl_2 were heated at reflux with the specified amount of **2a** for 24 h. Conditions B: Reaction mixtures in CH_2Cl_2 were heated in sealed tubes using microwave irradiation at 100 °C for 1 hour with the specified amount of **2a**. A SmithSynthesizer™ was used for these experiments. [b] Isolated yields of purified material.

The precise sequence of events taking place along the reaction pathway remains unclear, although monitoring the reaction of enyne **5** by TLC and NMR showed initial formation of the simple RCM product **18a** and gradual conversion into the CM product **16a** implying enyne RCM followed by CM as a significant manifold. Alternative sequences involving initial olefin CM, intermolecular enyne CM followed by RCM, and product equilibration may also be occurring.

Intrigued by the formation of cross-metathesis products **17a**−**c**, the possibility of a one-pot RCM-CM reaction was investigated using three terminal alkyne substrates **5**, **9** and **10** in the presence of 2−3 equivalents of either styrene or

methyl acrylate (Scheme 4). As anticipated, the desired enyne RCM-CM products **17a−c** and **19b**,**c** were produced selectively in good yields with the expected *E*-isomer predominant (15:1 or greater by ^{1}H NMR).



5 R^2 = Boc
9 R^2 = Me
10 R^2 = Bn

17a R^2 = Boc R^3 = Ph (54%)
17b R^2 = Me R^3 = Ph (62%)
17c R^2 = Bn R^3 = Ph (79%)
19b R^2 = Me R^3 = CO_2Me (83%)
19c R^2 = Bn R^3 = CO_2Me (54%)

Scheme 4. Reagents: (a) **2a** (6 mol%), CH_2Cl_2, microwave irradiation (100 °C)

Conclusion

In conclusion, enyne RCM reactions of sulfamide-linked internal and terminal alkynes provided a new route to various novel seven-membered cyclic sulfamides. The substrates bearing terminal alkynes were shown to undergo selective one-pot RCM-CM reactions with styrene and methyl acrylate. Future studies will explore the scope of enyne RCM-CM reactions and further elaboration of the resulting 1,3-diene products.

Experimental Section

General Remarks: ^{1}H NMR and ^{13}C NMR were recorded with a 300 or 400 MHz spectrometer (300 or 400 MHz, ^{1}H NMR respectively and 75 or 100 MHz, ^{13}C NMR respectively) in deuteriochloroform ($CDCl_3$) with chloroform (δ = 7.26 ppm ^{1}H, δ = 77.00 ppm ^{13}C) as the internal standard. Infrared (IR) spectra are reported in wavenumbers (cm^{-1}). Melting points were obtained in open capillary tubes and are uncorrected. All reactions were carried out under an inert atmosphere, in oven-dried glassware. The following solvents were distilled before use: THF (from Na/benzophenone) and CH_2Cl_2 (from CaH_2) and where appropriate, other reagents and solvents were purified by standard techniques. TLC was performed on glass-backed plates coated with silica gel 60 with an F254 indicator; the chromatograms were visualised under UV light and/or by staining with $KMnO_4$ (aq.). Flash column chromatography was performed with 40−63 μm silica gel (Merck). [Dichloro{1,3-bis(2,4,6-trimethylphenyl)-2-imidazolidinylidene}-(phenylmethylene)(tricyclohexylphosphane)ruthenium] (**2a**) was purchased from either Strem or Aldrich and used without further purification. All microwave-assisted reactions were carried out in a SmithSynthesizer™. The reactions were carried out in sealed vessels and run at a fixed temperature and time as defined by the user, the power being adapted by the instrument to reach and maintain the set temperature. The maximum power for this instrument is 300 W.

***N*-Allyl-*N*-benzyl-(*N*′-*tert*-butoxycarbonyl)sulfamide (4):** To a stirring solution of chlorosulfonylisocyanate (290 μL, 3.40 mmol) in CH_2Cl_2 (8 mL) at 0 °C was added *t*BuOH (0.25 g, 3.40 mmol). The mixture was stirred at 0 °C for 10 min then Et_3N (460 μL, 3.40 mmol) was added followed by *N*-allyl-*N*-benzylamine (0.5 g, 3.40 mmol). The mixture was stirred for 12 h at room temp. CH_2Cl_2 (5 mL) was added and the solution was washed with 1 M HCl (3 × 5 mL) and H_2O (2 × 5 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting yellow oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to provide the title compound **4** as a colourless oil (0.98 g, 3.02 mmol, 89%). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.50 (s, 9 H, CH_3), 3.88 (d, *J* = 6.4 Hz, 2 H, CH_2), 4.56 (s, 2 H, $PhCH_2$), 5.21−5.25 (m, 2 H, =CH_2), 5.77 (tdd, *J* = 6.4, 10.1, 16.7 Hz, 1 H, =CH), 7.10 (s, 1 H, NH), 7.30−7.33 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 28.6 (CH_3), 50.2 (CH_2), 51.6 (CH_2), 83.7 (C), 119.8 (CH_2), 128.0 (CH), 128.5 (CH), 128.8 (CH), 132.0 (CH), 135.9 (C), 150.2 (C=O) ppm. IR: $\tilde{\nu}_{max}$/cm^{-1}: 3285 (NH), 2973, 2931, 1734, 1360 (SO_2), 1147 (SO_2), 925, 821. LRMS (ES^+, CH_3CN): *m*/*z* (relative intensity, %) = 349 $[M + Na]^+$ (40), 675 $[2M + Na]^+$(100).

***N*-Allyl-*N*-benzyl-(*N*′-*tert*-butoxycarbonyl-*N*′-(2-propynyl))-sulfamide (5):** To a stirring solution of sulfamide **4** (1.0 g, 3.07 mmol) in THF (50 mL) was added *t*BuOK (364 mg, 3.07 mmol), 18-crown-6 (810 mg, 3.07 mmol), and propargyl bromide (467 μL of an 80% solution in toluene, 3.07 mmol). The mixture was stirred at room temp. for 24 h, then quenched by the addition of water (50 mL). The product was extracted with Et_2O (3 × 30 mL), the combined Et_2O layers were washed with brine (2 × 25 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting colourless oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish compound **5** as a colourless oil (0.81 mg, 2.21 mmol, 72%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.55 (s, 9 H, CH_3), 2.25 (t, *J* = 2.3 Hz, 1 H, HC≡C), 3.86 (d, *J* = 6.5 Hz, 2 H, CH_2), 4.47 (d, *J* = 2.3 Hz, 2 H, CH_2), 4.55 (s, 2 H, $PhCH_2$), 5.13 (dd, *J* = 17.0, 1.0 Hz, 1 H, CH_2), 5.20 (dd, *J* = 10.0, 1.0 Hz, 1 H, CH_2), 5.74 (ddt, *J* = 17.0, 10.0, 6.5 Hz, 1 H, CH), 7.26−7.35 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 28.3 (CH_3), 38.2, (CH_2), 50.0 (CH_2), 51.7 (CH_2), 72.0 (CH), 79.3 (C), 84.5 (C), 119.7 (CH_2), 127.9 (CH), 128.5 (CH), 128.6 (CH), 132.2 (CH), 136.1(C), 151.0 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 2983, 2935, 2121, 1734 (C=O), 1493, 1412, 1455, 1384 (SO_2), 1304, 1284, 1265, 1143 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m*/*z* (relative intensity, %) = 387 (100) $[M + Na]^+$.

***N*-Allyl-*N*-benzyl-*N*′-(2-propynyl)sulfamide (6):** To a solution of sulfamide **5** (500 mg, 1.37 mmol) in CH_2Cl_2 (50 mL) was added TFA (10 mL). The mixture was stirred for 2 h at room temp., before being quenched by the addition of a saturated solution of $NaHCO_3$ (aq) (50 mL). The product was extracted with CH_2Cl_2 (3 × 30 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting colourless oil was purified by column chromatography, eluting with Et_2O/hexane (2:8) to furnish compound **6** as a colourless oil (330 mg, 1.25 mmol, 91%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.45 (t, *J* = 2.5 Hz, 1 H, C≡H), 3.76 (d, *J* = 6.6 Hz, 2 H, CH_2), 3.84 (dd, *J* = 6.0, 2.5 Hz, 2 H, CH_2), 4.40 (s, 2 H, $PhCH_2$), 4.54 (t, *J* = 6.0 Hz, 1 H, NH), 5.20 (dd, *J* = 17.0, 1.5 Hz, 1 H, CH), 5.25 (dd, *J* = 10.0, 1.5 Hz, 1 H, CH_2), 5.87 (ddt, *J* = 17.0, 10.0, 6.6 Hz, 1 H, CH), 7.39−7.36 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 33.1 (CH_2) 50.0 (CH_2), 50.8 (CH_2), 73.0 (CH), 79.1 (C), 119.7 (CH_2), 128.0 (CH), 128.8 (CH × 2), 132.8 (CH), 136.2 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3285 (NH), 3077, 3025, 2921, 2850, 1332 (SO_2), 1143 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m*/*z* (relative intensity, %) = 551 (100) $[2M + Na]^+$.

***N*-Allyl-*N*-benzyl-(*N*′-*tert*-butoxycarbonyl-*N*′-(2-butynyl))sulfamide (7):** To a stirring solution of sulfamide **4** (2.0 g, 6.12 mmol) in THF (70 mL) was added *t*BuOK (685 mg, 6.12 mmol), 18-crown-6

(1.61 g, 6.12 mmol) and 1-bromo-2-butyne (531 μL, 6.12 mmol). The mixture was stirred for 12 h, then quenched with H_2O (50 mL) and extracted with Et_2O (3 × 50 mL). The combined Et_2O layers were washed with brine (2 × 50 mL), dried (Na_2SO_4) and concentrated under reduced pressure. The resulting colourless oil was purified by column chromatography, eluting with Et_2O/hexane (4:2) to provide the title compound **7** as a colourless oil (2.25 g, 6.0 mmol, 98%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.51 (s, 9 H, CH_3), 1.70 (s, 3 H, CH_3), 3.80 (d, *J* = 6.5 Hz, 2 H, CH_2), 4.39 (q, *J* = 2.3 Hz, 2 H, CH_2), 4.52 (s, 2 H, $PhCH_2$), 5.09 (tdd, *J* = 1.2, 1.4, 17.0 Hz, 1 H, CH_2), 5.13 (tdd, *J* = 1.2, 1.4, 10.3 Hz, 1 H, CH_2), 5.71 (ddt, *J* = 17.0, 10.3, 6.5 Hz,, 1 H, CH), 7.23−7.32 (m, 5 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 4.0 (CH_3), 29.0 (CH_3), 39.2 (CH_2), 50.2 (CH_2), 52.0 (CH_2), 75.3 (C), 80.4 (C), 84.7 (C), 120.0 (CH_2), 128.4 (CH), 129.0 (CH), 129.2 (CH), 132.8 (CH), 136.7 (C), 151.7 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 2801, 1724 (C=O), 1365 (SO_2), 1128 (SO_2) cm^{-1}. LRMS (ES+, CH_3CN): *m*/*z* (relative intensity, %) = 401 (50) [M + Na]$^+$, 779 (100) [2M + Na]$^+$. HRMS (ES$^+$): Calcd. for $C_{19}H_{26}N_2O_4SNa$: 401.1505, found 401.1504.

***N*-Allyl-*N*-benzyl-(*N*′-(2-butynyl))sulfamide (8):** To a solution of sulfamide **7** (1.0 g, 2.64 mmol) in CH_2Cl_2 (50 mL) was added TFA (10 mL). The mixture was stirred for 2 h at room temp., then quenched by the addition of a saturated solution of $NaHCO_3$ (aq) (50 mL). The product was extracted with CH_2Cl_2 (3 × 30 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting colourless oil was purified by column chromatography, eluting with Et_2O/hexane (2:8) to furnish compound **8** as a colourless oil (609 mg, 2.19 mmol, 83%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.45 (t, *J* = 2.5 Hz, 1 H, CH_3), 3.75 (d, *J* = 6.8 Hz, 2 H, CH_2), 3.79 (dq, *J* = 6.0, 2.5 Hz, 2 H, CH_2), 4.39 (s, 2 H, $PhCH_2$), 4.49 (br. s, 1 H, NH), 5.17 (dd, *J* = 17.0, 1.0 Hz, 1 H, CH), 5.23 (dd, *J* = 10.1, 1.0 Hz, 1 H, CH_2), 5.89 (1 H, ddt, *J* = 17.0, 10.1, 6.8 Hz, CH), 7.26−7.36 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 3.6 (CH_3), 33.5 (CH_2), 50.0 (CH_2), 50.8 (CH_2), 74.3 (C), 80.9 (C), 119.6 (CH_2), 127.9 (CH), 128.7 (CH × 2), 132.9 (CH), 136.3 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3295 (NH), 3077, 3025, 2916, 2855, 1341 (SO_2), 1151 (SO_2) cm^{-1}. LRMS (ES+, CH_3CN): *m*/*z* (relative intensity, %) = 579 (100) [2M + Na]. HRMS (ES$^+$): Calcd. for $C_{28}H_{36}N_4O_4S_2Na$: 579.2070, found 579.2070.

***N*-Allyl-*N*-benzyl-(*N*′-(2-propynyl))sulfamide (9):** To a stirring solution of sulfamide **6** (100 mg, 0.380 mmol) in THF (5 mL) was added *t*BuOK (43 mg, 0.380 mmol), 18-crown-6 (100 mg, 0.380 mmol), and MeI (23 μL, 0.380 mmol). The mixture was stirred for 12 h at room temp., then quenched by the addition of water (5 mL). The product was extracted with Et_2O (3 × 5 mL), the combined Et_2O layers were washed with brine (10 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting yellow oil was purified by column chromatography, eluting with Et_2O/hexane (1:3) to furnish compound **9** as a colourless oil (91 mg, 0.326 mmol, 86%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.26 (t, *J* = 2.5 Hz, 1 H, HC≡C), 2.72 (s, 3 H, CH_3), 3.68 (d, *J* = 6.5 Hz, 2 H, CH_2), 3.90 (d, *J* = 2.5 Hz, 2 H, CH_2), 4.29 (s, 2 H, $PhCH_2$), 5.06 (d, *J* = 17.1 Hz, 1 H, CH_2), 5.14 (d, *J* = 10.3 Hz, 1 H, CH_2), 5.74 (ddt, *J* = 17.1, 10.3, 6.5 Hz, 1 H, CH), 7.18−7.28 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 35.1 (CH_3), 40.6 (CH_2), 50.1 (CH_2), 51.0 (CH_2), 74.1 (CH), 78.3 (C), 119.9 (CH_2), 128.6 (CH), 129.1 (CH × 2), 133.1 (CH), 136.5 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3271, 3077, 2916, 1322 (SO_2), 1143 (SO_2) cm^{-1}. LRMS (ES$^+$, CH_3CN): *m*/*z* (relative intensity, %) = 279 (100) [M + H]$^+$.

***N*-Allyl-*N*,*N*′-dibenzyl-*N*′-(2-propynyl)sulfamide (10):** To a stirring solution of sulfamide **6** (100 mg, 0.380 mmol) in THF (5 mL) was added *t*BuOK (43 mg, 0.380 mmol), 18-crown-6 (100 mg, 0.380 mmol), and benzyl bromide (44.5 μL, 0.380 mmol). The mixture was stirred for 12 h at room temp., then quenched by the addition of water (5 mL). The product was extracted with Et_2O (3 × 10 mL), the combined Et_2O layers were washed with brine (10 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting colourless oil was purified by column chromatography, eluting with Et_2O/hexane (2:8) to furnish compound **10** as a colourless oil (103 mg, 0.292 mmol, 77%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 2.39 (t, *J* = 2.5 Hz, 1 H, HC≡C), 3.80 (d, *J* = 6.5 Hz, 2 H, CH_2), 3.90 (d, *J* = 2.5 Hz, 2 H, CH_2), 4.46 (s, 2 H, $PhCH_2$), 4.53 (s, 2 H, $PhCH_2$), 5.17 (dd, *J* = 17.0, 1.5 Hz, 1 H, CH_2), 5.25 (dd, *J* = 10.0, 1.5 Hz, 1 H, CH_2), 5.90 (ddt, *J* = 17.0, 10.3, 6.5 Hz, 1 H, CH), 7.31−7.41 (m, 10 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 36.2 (CH_2), 50.0 (CH_2), 50.6 (CH_2), 50.8 (CH_2), 74.0 (CH), 78.1 (C), 119.7 (CH_2), 127.9 (CH), 128.2 (CH), 128.7 (CH), 128.8 (CH), 128.9 (CH × 2), 132.7 (CH), 135.5 (C) 136.3 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3054, 3025, 2921, 2855, 1318 (SO_2), 1143 (SO_2) cm^{-1}. LRMS (ES+, CH_3CN): *m*/*z* (relative intensity, %) = 355 (50) [M + H]$^+$, 731 (100) [2M + Na]$^+$. HRMS (ES$^+$): Calcd. for $C_{20}H_{22}N_2O_2SNa$: 377.1294, found 377.1291.

***N*-Allyl-*N*-benzyl-*N*′-(2-butynyl)-*N*′-methylsulfamide (11):** To a stirring solution of sulfamide **8** (250 mg, 0.90 mmol) in THF (10 mL) was added *t*BuOK (153 mg, 0.90 mmol), 18-crown-6 (237 mg, 0.90 mmol), and MeI (56 μL, 0.90 mmol). The mixture was stirred at room temp. for 12 h, then quenched by the addition of water (10 mL). The product was extracted with Et_2O (3 × 10 mL), the combined Et_2O layers were washed with brine (10 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting yellow oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish compound **11** as a colourless oil (181 mg, 0.62 mmol, 69%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.8 (t, *J* = 2.2 Hz, 3 H, CH_3), 2.80 (s, 3 H, CH_3), 3.70 (d, *J* = 6.6 Hz, 2 H, CH_2), 3.95 (q, *J* = 2.2 Hz, 2 H, CH_2), 4.37 (s, 2 H, $PhCH_2$), 5.13 (dd, *J* = 17.0, 1.5 Hz, 1 H, CH), 5.23 (dd, *J* = 10.2, 1.5 Hz, 1 H, CH_2), 5.83 (ddt, *J* = 17.0, 10.2, 6.6 Hz, 1 H, CH), 7.29−7.35 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 4.1 (CH_3), 35.2 (CH_3), 41.2 (CH_2), 50.2 (CH_2), 51.1 (CH_2), 73.8 (C), 82.1 (C), 120.1 (CH_2), 128.4 (CH), 129.2 (CH), 129.3 (CH), 133.5 (CH), 136.9 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 2922, 1454, 1326 (SO_2), 1143 (SO_2) cm^{-1}. LRMS (ES$^+$, CH_3CN): *m*/*z* (relative intensity, %) = 315 (10) [M + Na]$^+$, 603 (100) [2M + Na]$^+$.

***N*-Allyl-*N*,*N*′-dibenzyl-*N*′-(2-butynyl)sulfamide (12):** To a stirring solution of sulfamide **8** (250 mg, 0.90 mmol) in THF (10 mL) was added *t*BuOK (153 mg, 0.90 mmol), 18-crown-6 (237 mg, 0.90 mmol), and benzyl bromide (106 mg, 0.90 mmol). The mixture was stirred for 12 h at room temp., then quenched by the addition of water (10 mL). The product was extracted with Et_2O (3 × 10 mL), the combined Et_2O layers were washed with brine (10 mL), dried ($MgSO_4$) and the solvent removed in vacuo. The resulting yellow oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish compound **12** as a colourless oil (251 mg, 0.68 mmol, 76%). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.71 (t, *J* = 2.0 Hz, 3 H, CH_3), 3.66 (t, *J* = 6.8 Hz, 2 H, CH_2), 3.74 (q, *J* = 2.0 Hz, 2 H, CH_2), 4.33 (s, 2 H, $PhCH_2$), 4.40 (s, 2 H, $PhCH_2$), 5.05 (dd, *J* = 17.0, 1.5 Hz, 1 H, CH_2), 5.12 (dd, *J* = 10.3, 1.5 Hz, 1 H, CH_2), 5.77 (ddt, *J* = 17.0, 10.3, 6.8 Hz, 1 H, CH), 7.18−7.30 (m, 10 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 3.9 (CH_3), 37.1 (CH_2), 50.2 (CH_2), 51.0 (CH_2), 51.2 (CH_2), 73.7 (C), 82.1 (C), 119.8 (CH), 128.8 (CH), 129.0 (CH), 129.1 (CH), 129.2 (CH), 129.4 (CH), 129.7 (CH), 133.4 (CH), 136.7 (C), 138.2 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3068, 3039, 2992, 2912, 1502, 1445, 1360, 1332 (SO_2), 1152 (SO_2) cm^{-1}. LRMS (ES$^+$, CH_3CN): *m*/*z* (relative intensity, %) =

369 (40) $[M + H]^+$, 759 (100) $[2M + Na]^+$. HRMS (ES^+): Calcd. for $C_{21}H_{24}N_2O_2SNa$: 391.1450, found 391.1450.

Enyne-RCM Procedures

7-Benzyl-2-*tert*-butoxycarbonyl-4-isopropenyl-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (13): To a solution of sulfamide **7** (60 mg, 0.16 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (4.0 mg, 4.8 μmol), the mixture was sealed in a crimped-cap vessel under an atmosphere of argon and heated with microwaves at 100 °C for 30 minutes. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:2) to furnish compound **13** as a colourless oil (49 mg, 0.13 mmol, 81%). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.54 (s, 9 H, CH_3), 1.95 (s, 3 H, CH_3), 3.96 (d, J = 5.0 Hz, 2H CH_2), 4.50 (s, 2 H, CH_2), 4.52 (s, 2 H, CH_2), 5.10 (s, 1 H, CH_2), 5.27 (s, 1 H, CH_2), 5.62 (t, J = 5.0 Hz, 1 H, CH), 7.30−7.35 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.7 (CH_3), 28.4 (CH_3), 43.7 (CH_2), 45.0 (CH_2), 52.8 (CH_2), 84.2 (C), 113.9 (CH_2), 121.8 (CH), 128.5 (CH), 128.9 (CH × 2), 135.6 (C), 140.5 (C), 142.0 (C), 151.7 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 3025, 2983, 2916, 1725 (C=O), 1322 (SO_2), 1176, 1147 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 401 (25) $[M + Na]^+$, 779(100) $[2M + Na]^+$. HRMS (ES^+): Calcd. for $C_{38}H_{52}N_4O_8S_2Na$: 779.3118, found 779.3102.

7-Benzyl-4-isopropenyl-2-methyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (14): To a solution of sulfamide **11** (60 mg, 0.21 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (5.3 mg, 6.3μmol). The mixture was sealed in a crimped-cap vessel under argon and heated with microwaves at 100 °C for 30 minutes. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:2) to furnish compound 14 as a colourless oil (44 mg, 0.15 mmol, 72%). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.95 (s, 3 H, CH_3), 2.93 (s, 3 H, CH_3) 3.73 (d, J = 6.0 Hz, 2 H, CH_2), 4.17 (s, 2 H, CH_2), 4.40 (s, 2 H, $PhCH_2$), 5.10 (s, 1 H, CH_2), 5.13 (s, 1 H, CH_2), 5.92 (t, J = 6.0 Hz, 1 H, CH), 7.29−7.38 (m, 5 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.5 (CH_3), 36.2 (CH_3), 43.4 (CH_2), 48.0 (CH_2), 52.5 (CH_2), 113.9 (CH_2), 124.6 (CH), 128.0 (CH), 128.4 (CH), 128.8 (CH), 136.4 (C), 142.4 (C), 142.9 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3082, 3063, 3016, 2945, 1583, 1497, 1441, 1360 (SO_2), 1332, 1157 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 293 (40) $[M + H]^+$, 585 (100) [2M + Na]. HRMS (ES^+): Calcd. for $C_{30}H_{40}N_4O_4S_2Na$: 607.2382, found 607.2388.

2,7-Dibenzyl-4-isopropenyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (15): To a solution of sulfamide **12** (60 mg, 0.16 mmol) in CH_2Cl_2 (5 mL) was added the ruthenium complex **2a** (4.1 mg, 4.8 μmol). The mixture was sealed in a crimped-cap vessel under argon and irradiated with microwaves at 100 °C for 50 minutes. The solvent was removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:2) to furnish compound **15** as a white solid (40 mg, 0.11 mmol, 68%). M.p. 95−97 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.90 (s, 3 H, CH_3), 3.80 (d, J = 5.5 Hz, 2 H, CH_2), 4.02 (s, 2 H, CH_2), 4.42 (s, 2 H, $PhCH_2$), 4.45 (s, 2 H, $PhCH_2$), 4.77 (s, 1 H, CH_2), 4.69 (s, 1 H, CH_2), 5.84 (t, J = 5.5 Hz, 1 H, CH), 7.36−7.39 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.5 (CH_3), 43.7 (CH_2), 44.4 (CH_2), 52.2 (CH_2 × 2), 114.0 (CH_2), 124.2 (CH), 128.0 (CH), 128.1 (CH), 128.3 (CH), 128.5 (CH), 128.7 (CH), 128.8 (CH), 136.2 (C), 136.7 (C), 142.0 (C), 142.5 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3062, 3031, 2952, 2928, 1337 (SO_2), 1156 (SO_2), 1122 cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 407 (15) $[M + K]^+$, 759 (100) $[2M + Na]^+$.

***tert*-Butyl 7-Benzyl-4-{(*E*)-2-[7-benzyl-2-(*tert*-butoxycarbonyl)-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepin-4-yl]-1-ethenyl}-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-2-carboxylate (16a):** To a solution of sulfamide **5** (100 mg, 0.27 mmol) in CH_2Cl_2 (7.5 mL) was added ruthenium complex **2a** (13.8 mg, 16.3 μmol). The mixture was stirred at reflux for 24 h. The solvent was removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to give **16a** as a white solid (59.1 mg, 0.084 mmol, 61%), **17a** as a white solid (7 mg, 0.016 mmol, 6%), and **18a** as a colourless oil (8.1 mg, 0.022 mmol, 8%). **Data for 16a:** M.p. 158−160 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.5 (s, 18 H, CH_3), 4.0 (d, J = 4.2 Hz, 4 H, CH_2), 4.48 (s, 4 H, CH_2), 4.51 (s, 4 H, CH_2), 5.75 (t, J = 4.2 Hz, 2 H, CH), 6.50 (s, 2 H, CH), 7.38−7.43 (m, 10 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 28.3 (CH_3), 42.5 (CH_2), 45.1 (CH_2), 52.8 (CH_2), 84.5 (C), 127.4 (CH), 128.4 (CH), 128.5 (CH), 129.1 (CH), 129.4 (CH), 135.4 (C), 138.5 (C), 151.8 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 2968, 2926, 1734 (C=O), 1327 (SO_2), 1174 (SO_2), 1138 cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 723.4 (100) $[M + Na]^+$, 1423 (10) $[2M + Na]^+$. The structure of **16a** was unambiguously established by X-ray crystallography.

7-Benzyl-2-*tert*-butoxycarbonyl-1,1-dioxo-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (17a): M.p. 155−156 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 1.5 (s, 9 H, CH_3), 3.98 (d, J = 4.7 Hz, 2 H, CH_2), 4.52 (s, 2 H, CH_2), 4.62 (s, 2 H, CH_2), 5.73 (t, J = 4.7 Hz, 1 H, CH), 6.78 (s, 2 H, CH), 7.30−7.47 (m, 10 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 26.5 (CH_3), 41.1 (CH_2), 43.2 (CH_2), 50.9 (CH_2), 82.5 (C), 124.4 (CH), 125.0 (CH), 126.4 (CH), 126.6 (CH), 126.7 (CH), 127.1 (CH), 127.2 (CH), 127.7 (CH), 133.7 (C), 135.1 (C), 137.3 (C), 149.9 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 3054, 2997, 2926, 1717 (C=O), 1368 (SO_2), 1272, 1173 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 441 (20) $[M + H]^+$, 441 (50) $[M + Na]^+$, 903 (100) $[2M + Na]^+$.

2-*tert*-Butoxycarbonyl-7-benzyl-1,1-dioxo-4-vinyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (18a): ^1H NMR (400 MHz, $CDCl_3$): δ = 1.54 (s, 9 H, CH_3), 3.92 (d, J = 4.3 Hz, 2 H, CH_2), 4.47 (s, 4 H, CH_2), 5.18 (d, J = 11.0 Hz, 1 H, CH_2), 5.43 (d, J = 17.6 Hz, 1 H, CH_2), 5.58 (t, J = 4.3 Hz, 1 H, CH), 6.34 (dd, J = 11.0, 17.6 Hz, 1 H, CH), 7.32−7.38 (m, 5 H, CH) ppm ^{13}C NMR (75 MHz, $CDCl_3$): δ = 26.9 (CH_3), 40.7 (CH_2), 43.6 (CH_2), 51.5 (CH_2), 83.0 (C), 112.8 (CH_2), 124.9 (CH), 127.1 (CH × 2), 127.7 (CH), 134.2 (C), 136.2 (C), 137.6 (C), 150.4 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 2992, 2940, 1720 (C=O), 1587, 1367 (SO_2), 1328, 1258, 1176 (SO_2), 1146 cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 403 (50) $[M + K]^+$, 751 (100) $[2M + Na]^+$. HRMS (ES^+): Calcd. for $C_{18}H_{24}N_2O_4S_1Na$: 387.1349, found 384.1359.

7-Benzyl-2-methyl-1,1-dioxo-4-vinyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (18b): To a solution of the sulfamide **9** (74 mg, 0.27 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (13.8 mg, 16.2 μmol). The mixture was sealed in a crimped-cap vessel under argon and heated with microwaves at 100 °C for 60 minutes. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish **18b** as a colourless oil (45 mg, 0.16 mmol, 60%), **16b** as a white solid (14 mg, 0.027 mmol, 10%), and **17b** as a white solid (5.5 mg, 0.015 mmol, 6%). **Data for 18b:** ^1H NMR (400 MHz, $CDCl_3$): δ = 2.90 (s, 3 H, CH_3), 3.70 (d, J = 5.5 Hz, 2 H, CH_2), 4.10 (s, 2 H, CH_2), 4.40 (s, 2 H, $PhCH_2$), 5.16 (d, J = 10.6 Hz, 1 H, CH_2), 5.29 (d, J = 17.6 Hz, 1 H, CH_2), 5.86 (t, J = 5.5 Hz, 1 H, CH), 6.41 (dd, J = 10.6, 17.6 Hz, 1 H, CH), 7.26−7.35 (m, 5 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 36.6 (CH_3), 43.6 (CH_2), 46.6 (CH_2), 53.0 (CH_2), 114.4 (CH_2), 128.4 (CH), 128.8

(CH), 129.1 (CH), 129.2 (CH), 129.4 (CH), 136.7 (C), 138.9 (C), 140.9 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 2921, 2897, 1359 (SO_2), 1331, 1158 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 301 (100) $[M + Na]^+$, 579 (50) $[2M + Na]^+$.

7-Benzyl-4-[(*E*)-2-(7-benzyl-2-methyl-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepin-4-yl)-1-ethenyl]-2-methyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (16b): M.p. 170−172 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.9 (s, 3 H, CH_3), 3.74 (d, *J* = 6.0 Hz, 4 H, CH_2), 4.13 (s, 4 H, CH_2), 4.41 (s, 4 H, CH_2), 5.95 (t, *J* = 5.8 Hz, 2 H, CH), 6.31 (s, 2 H, CH), 7.30−7.36 (m, 5 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 36.7 (CH_3), 43.8 (CH_2), 47.2 (CH_2), 53.0 (CH_2), 128.5 (CH), 128.7 (CH), 129.2 (CH), 130.6 (CH), 130.5 (CH), 136.5 (C), 140.0 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 1354 (SO_2), 1357, 1153 (SO_2), 1110 cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 1095 (100) $[2M + K]^+$.

7-Benzyl-2-methyl-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (17b): M.p. 153−155 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.97 (s, 3 H, CH_3), 3.76 (d, *J* = 6.0 Hz, 2 H, CH_2), 4.26 (s, 2 H, CH_2), 4.45 (s, 2 H, CH_2), 6.01 (t, *J* = 6.0 Hz, 1 H, CH), 6.65 (d, *J* = 16.5 Hz 1 H, CH), 6.85 (d, *J* = 16.5 Hz, 1 H, CH), 7.30−7.47 (m, 10 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 36.1 (CH_3), 43.2 (CH_2), 46.7 (CH_2), 52.3 (CH_2), 126.6 (CH), 127.9 (CH), 128.2 (CH), 128.3 (CH), 128.6 (CH), 128.7 (CH), 128.8 (CH), 128.9 (CH), 130.4 (CH), 136.1 (C), 136.5 (C), 140.5 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3625, 1494, 1450, 1360 (SO_2), 1332, 1157 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 355 (60) $[M + H]^+$, 394 (85) $[M + CH_3CN]^+$, 730 (100) $[2M + Na]^+$.

***2*,7-Dibenzyl-1,1-dioxo-4-vinyl-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (18c):** To a solution of sulfamide **10** (95 mg, 0.27 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (13.8 mg, 16 μmol). The mixture was sealed in a crimped-cap vessel under argon and heated with microwaves at 100 °C for 60 minutes. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish **18c** as a colourless oil (60 mg, 0.17 mmol, 63%), **16c** as a white solid (15 mg, 0.022 mmol, 8%) and **17c** as a white solid (4.5 mg, 0.010 mmol, 4%). **Data for 18c:** ^1H NMR (400 MHz, $CDCl_3$): δ = 3.76 (d, *J* = 5.7 Hz, 2 H, CH_2), 3.92 (s, 2 H, CH_2), 4.44 (s, 4 H, $PhCH_2$), 4.88 (d, *J* = 17.5 Hz, 1 H, CH_2), 5.03 (d, *J* = 11.1 Hz, 1 H, CH_2), 5.82 (t, *J* = 5.7 Hz, 1 H, CH), 6.34 (dd, *J* = 17.5, 11.1 Hz, 1 H, CH), 7.33−7.37 (m, 10 H, CH) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 42.7 (CH_2), 43.8 (CH_2), 52.5 (CH_2), 52.6 (CH_2), 114.6 (CH_2), 128.8 (CH), 128.9 (CH), 129.1 (CH), 129.2 (CH), 136.5 (CH), 136.9 (C), 138.5 (C), 140.9 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3087, 3030, 1360 (SO_2), 1332, 1158 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 731 (100) $[2M + Na]^+$. HRMS (ES^+): Calcd. for $C_{20}H_{22}N_2O_2SNa$: 377.1294, found 377.1293.

2,7-Dibenzyl-4-[(*E*)-2-(2,7-dibenzyl-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepin-4-yl)-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (16 c): M.p. 180−182 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.92 (s, 4 H, CH_2), 3.74 (d, *J* = 5.8 Hz, 4 H, CH_2), 4.14 (s, 4 H, CH_2), 4.41 (s, 4 H, CH_2), 5.95 (t, *J* = 5.8 Hz, 2 H, CH), 6.34 (s, 2 H, CH), 7.33−7.38 (m, 10 H, CH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 43.3 (CH_2), 44.2 (CH_2), 52.5 (CH_2), 52.8 (CH_2), 128.7 (CH), 128.9 (CH), 129.0 (CH), 129.1 (CH), 129.4 (CH), 129.6 (CH), 130.7 (CH), 130.9 (CH), 136.5 (C), 137.0 (C), 140.9 (C) ppm. $\tilde{\nu}_{max.}$ = 3030, 1359 (SO_2), 1333, 1120 (SO_2) cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) = 1384 (100) $[2M + Na]^+$.

2,7-Dibenzyl-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (17c): M.p. 110−112 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 3.84 (d, *J* = 6.1 Hz, 2 H, CH_2) 4.10 (s, 2 H, CH_2), 4.46 (s, 2 H, CH_2), 4.48 (s, 2 H, CH_2), 6.01 (t, *J* = 6.1 Hz, 1 H, CH), 6.16 (d, *J* = 16.5 Hz, 1 H, CH), 6.80 (d, *J* = 16.5 Hz, 1 H, CH), 7.29−7.38 (m, 15 H, CH) ppm. ^{13}C NMR (90 MHz, $CDCl_3$): δ = 42.9 (CH_2), 43.7(CH_2), 52.0 (CH_2), 52.1 (CH_2), 126.7 (CH), 128.2 (CH), 128.3 (CH), 128.6 (CH), 128.7 (CH), 128.8 (CH), 128.9 (CH × 2), 129.1 (CH), 129.2 (CH), 130.0 (C), 136.5 (C), 136.6 (C), 141.3 (C) ppm. IR: $\tilde{\nu}_{max.}$ = 3063, 3030, 2916, 2860, 1351 (SO_2), 1318, 1152 (SO_2), 1114 cm^{-1}. LRMS (ES^+, CH_3CN): *m/z* (relative intensity, %) 431 (10) $[M + H]^+$, 883 (100) $[2M + Na]^+$. The structure of **17c** was unambiguously established by X-ray crystallography.

Enyne RCM−CM Procedures

7-Benzyl-2-*tert*-butoxycarbonyl-1,1-dioxo-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine (17a): To a solution of sulfamide **5** (100 mg, 0.27 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (13.8 mg, 16.3 μmol) and styrene (62 μL, 0.54 mmol). The mixture was sealed in a crimped-cap vessel under an atmosphere of argon and heated with microwaves at 100 °C for 2 h. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (2:3) to furnish compound **17a** as a white solid (54 mg, 0.15 mmol, 55%). Analytical data were identical to those reported above.

7-Benzyl-2-methyl-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione (17b): To a solution of sulfamide **9** (100 mg, 0.36 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (18.3 mg, 21.6 μmol) and styrene (82.5 μL, 0.72 mmol). The mixture was sealed in a crimped-cap vessel under argon and heated with microwaves at 100 °C for 2 h. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:4) to furnish compound **17b** as a white solid (79 mg, 0.22 mmol, 62%). Analytical data were identical to those reported above.

2,7-Dibenzyl-4-[(*E*)-2-phenyl-1-ethenyl]-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepine-1,1-dione(17c): To a solution of sulfamide **10** (150 mg, 0.42 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (21.6 mg, 25 μmol) and styrene (96 μL, 0.84 mmol). The mixture was sealed in a crimped-cap vessel under an atmosphere of argon and heated with microwaves at 100 °C for 2 h. The solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:9) to furnish compound **17c** as a white solid (142 mg, 0.33 mmol, 79%). Analytical data were identical to those reported above.

Methyl (*E*)-3-(7-Benzyl-2-methyl-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ⁶,2,7-thiadiazepin-4-yl)-2-propenoate (19b): To a solution of sulfamide **9** (100 mg, 0.36 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (18.3 mg, 21.6 μmol) and methyl acrylate (64 μL, 0.72 mmol). The mixture was stirred for 1 h at 100 °C in the microwave, the solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:1) to furnish compound **19b** as a white solid (100 mg, 0.30 mmol, 83%). M.p. 114−115 °C (EtOAc/hexane). ^1H NMR (400 MHz, $CDCl_3$): δ = 2.80 (s, 3 H, CH_3), 3.75 (d, *J* = 4.1 Hz, 2 H, CH_2), 3.77 (s, 3 H, CH_3), 4.10 (s, 2 H, CH_2), 4.39 (s, 2 H, $PhCH_2$), 5.93 (d, *J* = 11.0 Hz, 1 H, CH), 6.20 (t, *J* = 4.1 Hz, 1 H, CH), 7.35−7.28 (m, 6 H, CH) ppm. ^{13}C NMR (90 MHz, $CDCl_3$): δ = 36.7 (CH_3), 43.8 (CH_2), 47.1 (CH_2), 52.3 (CH_2), 53.2 (CH_3), 118.4 (CH), 128.5 (CH), 128.7 (CH), 129.2 (CH), 136.2 (C), 137.3

(CH), 138.8 (C), 146.1 (CH), 167.3 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 3063, 3030, 2945, 2860, 1706 (C=O), 1620, 1356, 1313, 1147 cm^{-1}. LRMS (ES^+, CH_3CN): *m*/*z* (relative intensity, %) = 711 (100) [2M + K]$^+$. The structure of **19b** was unambiguously established by X-ray crystallography.

Methyl (*E*)-3-(2,7-Dibenzyl-1,1-dioxo-2,3,6,7-tetrahydro-1*H*-1λ^6,2,7-thiadiazepin-4-yl)-2-propenoate (19c): To a solution of sulfamide **10** (100 mg, 0.28 mmol) in CH_2Cl_2 (5 mL) was added ruthenium complex **2a** (14.2 mg, 16.8 μmol) and methyl acrylate (50 μL, 0.56 mmol). The mixture was stirred for 1 h at 100 °C in the microwave, the solvent removed in vacuo and the resulting brown oil was purified by column chromatography, eluting with Et_2O/hexane (1:2) to furnish compound **19c** as a white solid (62 mg, 0.15 mmol, 54%). M.p. 120−122 °C (EtOAc/hexane). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 3.70 (s, 3 H, CH_3), 3.83 (d, *J* = 5.5 Hz, 2 H, CH_2), 3.93 (s, 2 H, CH_2), 4.41 (s, 2 H, $PhCH_2$), 4.42 (s, 2 H, CH_2), 5.52 (d, *J* = 16.1 Hz, 1 H, CH), 6.12 (t, *J* = 5.5 Hz, 1 H, CH), 7.22−7.36 (m, 11 H, CH) ppm. ^{13}C NMR (90 MHz, $CDCl_3$): δ = 43.3 (CH_2), 44.2 (CH_2), 52.4 (CH_2), 52.9 (CH_2), 53.1 (CH_3), 118.5 (CH), 128.6 (CH), 128.7 (CH), 128.9 (CH), 129.3 (CH × 2), 129.4 (CH), 136.3 (C), 136.4 (C), 138.7 (C), 145.7 (CH), 167.5 (C=O) ppm. IR: $\tilde{\nu}_{max.}$ = 3052, 3030, 2948, 1718 (C=O), 1625, 1585, 1495, 1361, 1285, 1149 cm^{-1}. LRMS (ES^+, CH_3CN): *m*/*z* (relative intensity, %) = 435 (100) [M + Na]$^+$.

CCDC-222239 (**16a**), -222240 (**17c**), -222241 (**19b**) contain the supplementary crystallographic data for this paper. These data can be obtained free of charge at www.ccdc.cam.ac.uk/conts/retrieving.html [or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; Fax: (internat.) + 44-1223-336-033; E-mail: deposit@ccdc.cam.ac.uk].

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