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Intermolecular rhodium catalyzed hydroacylation of allenes: the regioselective synthesis of β,γ-unsaturated ketones

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ABSTRACT

A variety of β-*S*-substituted aldehydes undergo efficient and regioselective rhodium catalyzed hydroacylation reactions with 1,3-disubstituted and 1,1,3-trisubstituted allenes, to deliver β,γ-unsaturated ketone products. Regioselectivites are controlled primarily by steric factors. The reactions are catalyzed by the complex [Rh(dppe)]ClO_4.

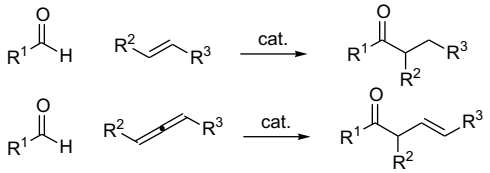
1. Introduction

Transition metal catalyzed alkene hydroacylation, in which the elements of an aldehyde are added across an alkene, is an attractive, atom-economic, method for the preparation of ketone containing products. The process was originally reported as an intramolecular reaction,[1] and it is in the preparation of cyclic ketones that the reaction has received most attention.[2] Competing metal catalyzed decarbonylation limited early examples to the preparation of cyclopentanone derivatives, although more recently methods for the synthesis of larger ring systems have also been described.[3] Enantioselective intramolecular reactions have also been developed.[4] Intermolecular hydroacylation is similarly complicated by decarbonylation processes; a number of strategies have been developed to overcome this, including the use of elevated temperatures and/or pressures of CO or ethene.[5] Brookhart has shown that Rh- and Co-cyclopentadienyl complexes can generate effective catalysts,[6] and recently a number of oxidative protocols have been described.[7] The Jun group has focused on the in situ generation of picolyl-imines to achieve efficient hydroacylation reactions.[8] The use of substrates able to provide chelation-stabilization of the key acyl-metal species, and thus limit decarbonylation, has also been shown to deliver successful reactions.[9] In spite of these advances, a general limitation of intermolecular reactions is the relatively narrow scope of the alkene components that can be employed, which consequently limits the structures accessible using hydroacylation chemistry. Although alkenes bearing a variety of functional groups have been employed in hydroacylation reactions, the number of examples of di- or trisubstituted alkenes being employed is small.

Allenes have emerged as useful C=C components in a variety of transition metal catalyzed processes, often providing reactivity contrasting to simple alkenes or alkynes.[10] A number of asymmetric processes based on selective additions to achiral allenes, or exploiting the axially chiral nature of certain allenes, have also been documented.[11] Despite this proven utility, the use of allenes in hydroacylation reactions is virtually unknown, with only a single report describing the use of mono- and 1,1-disubstituted allenes in combination with salicylaldehydes.[12] In this manuscript we establish that di- and trisubstituted allenes are effective substrates in Rh-catalyzed hydroacylation reactions, providing access to synthetically useful substituted β,γ-unsaturated ketone products in good yields and with high regioselectivities (Scheme 1).[13]

2. Results and discussion

We have recently shown that when combined with cationic Rh(I) catalysts, β-*S*-substituted aldehydes generate chelation stabilized acylrhodium hydride intermediates, and are effective substrates in intermolecular alkene and alkyne hydroacylation reactions.[14,15] To determine the compatibility of di- and trisubstituted allenes in intermolecular hydroacylation chemistry we



Scheme 1. Alkene and allene hydroacylation.

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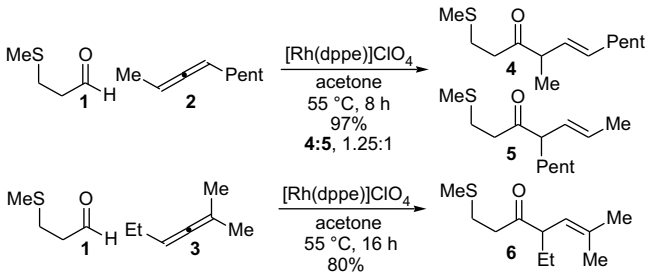


Scheme 2. Hydroacylation of allenes **2** and **3**.

first examined the reactions between β-MeS-propanal (**1**) and both 1,3-disubstituted allene **2**, and 1,1,3-trisubstituted allene **3** (Scheme 2). The reactions were performed in acetone at 55 °C, using [Rh(dppe)]ClO_4 as the catalyst, and pleasingly, both combinations provided good yields of the hydroacylation products. The reaction employing the Me-,Pent-disubstituted allene (**2**) delivered a mixture of the two regioisomeric adducts **4** and **5** in a 1.25:1 ratio, with a slight preference for the smaller Me-substituent next to the carbonyl. The transformation employing the trisubstituted allene (**3**) took a longer time to reach completion (16 h vs 8 h), but provided a single product (**6**), resulting from addition across the less-hindered C=C bond of the allene.

Having established the feasibility of intermolecular hydroacylation reactions between allenes and β-*S*-substituted aldehydes, we moved on to explore the scope of the process with respect to the allene. Given the mixture of products obtained from the combination of aldehyde **1** and Me-,Pent-disubstituted allene (**2**), we were particularly keen to probe the effect of the allene substituents on the regioselectivity of the reactions (Table 1). β-MeS-propanal (**1**) and *o*-MeS-benzaldehyde (**7**) were selected as the standard aldehydes and used in combination with [Rh(dppe)]ClO_4 as the catalyst. The first 16 entries employ aldehyde **1**. Entries 1–14 demonstrate the effective coupling of aldehyde **1** with a variety of mono-, di- and trisubstituted allenes, delivering the hydroacylation adducts in good to excellent yields. For dialkyl-substituted allenes, provided that there is a reasonable difference in the steric requirements of the two substituents, reaction takes place across the least hindered C=C bond with good regioselectivity. For example, in entry 4 the Pent-,*i*-Pr-allene delivers the hydroacylation adducts with 15:1 selectivity favouring addition across the pentyl-substituted C=C bond. For aryl-,alkyl-disubstituted allenes, reaction occurs exclusively across the alkyl-substituted C=C bond; for example, in entry 5 the Ph-,Pent-allene delivers the expected adduct with >20:1 regioselectivity. When trisubstituted allenes are employed addition again takes place exclusively across the least hindered C=C bond; for example, in entry 10 1,1-dimethyl-3-Ph-allene undergoes reaction selectively across the Ph–C=C bond. Entries 15 and 16 feature ethyl ester substituted allenes; as shown in entry 15 the Me-,CO_2Et-substituted allene delivered a single compound in 96% yield. Although the adduct results from addition across the least hindered Me-substituted C=C bond, the final product has the alkene conjugated with the ketone carbonyl and not the ester carbonyl. This is attributed to isomerization after the initial addition. Reaction with the H-,CO_2Et-substituted allene resulted in a 1:1 mixture of products, both originating from addition across the more accessible C=C of the allene, but differing in the position of the conjugated alkene (entry 16).

Entries 17–27 all employ aromatic aldehyde **7**, and generally confirm the same trends established using alkyl aldehyde **1**. For example, entry 17 again illustrates the selectivity of the process for addition across the least hindered C=C bond in a 1,3-dialkyl-substituted allene (Pent vs *i*-Pr). Entries 18–23 show the good yields and regioselectivities obtained when aldehyde **7** is combined with a series of di- and trisubstituted allenes. Entries 24 and 25 demonstrate that simple hetero-aromatic aldehydes can also be employed, with the adducts from the hexy,furyl- and hexyl,thienyl-disubstituted allenes being isolated in excellent yields as single regioisomers. The final two entries explore the effect of electronically differentiated 1,3-diaryl-substituted allenes; reaction with the Ph,(4-CF_3-Ph)-disubstituted allene resulted in a slight preference for addition next to the more electron-poor arene (1.8:1). When the Ph,(4-OMe-Ph)-disubstituted allene was employed, addition across the PhC=C was favoured, albeit with similarly low selectivity (1.6:1) and with only modest efficiency (32%).

Scheme 3 illustrates the use of two further β-*S*-substituted aldehydes in efficient, regioselective allene hydroacylation reactions. β-Dithiane-substituted propanal (**8**) underwent smooth reaction with the Pent,*i*-Pr-disubstituted allene, with addition proceeding across the Pent-substituted C=C bond. The second reaction features the addition of 1-deuterated *o*-MeS-benzaldehyde (*d*-**7**) to the Pent,Ph-disubstituted allene. Ketone **9** was obtained in good yield, as a single regioisomer, and only featured deuterium incorporation at the position β to the carbonyl. Deuterium incorporation at this single position indicates that reversible addition of the acylrhodium deuteride in the opposite regioselective sense, i.e., formation of an intermediate corresponding to structure **10**, is *not* occurring, and that the reaction most likely proceeds through an intermediate such as **11**.

3. Conclusion

We have demonstrated that β-*S*-substituted aldehydes undergo high yielding, highly regioselective hydroacylation reactions with both 1,3-disubstituted and 1,1,3-trisubstituted allenes. For di- or trialkylsubstituted allenes the regioselectivity is controlled by steric factors, however, for aryl,alkyl-disubstituted allenes, the low reactivity of the aryl-substituted alkene results in addition across the alkyl-substituted C=C bond. For allenes substituted with only alkyl- or aryl-substituents, or combinations of the two, only non-conjugated enone products are obtained; the corresponding conjugated enones are not observed. The described methodology represents a significant addition to the substitution patterns that can be accessed using hydroacylation chemistry, and provides a direct and efficient route to synthetically challenging β,γ-unsaturated ketones. Importantly, the majority of products obtained from di- or trisubstituted allene hydroacylation reactions feature a stereogenic centre, therefore presenting the possibility of enantioselective catalysis.[13,20]

4. Experimental section

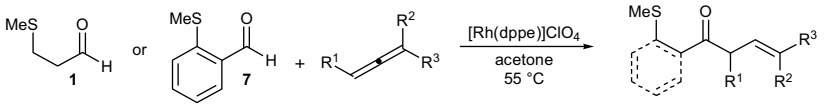
4.1. General information

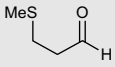
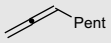
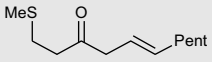
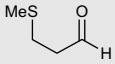
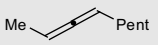
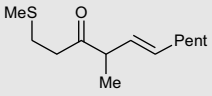
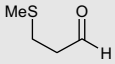
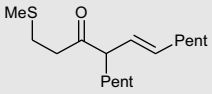
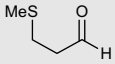
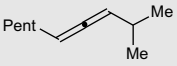
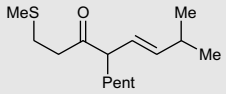
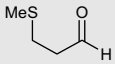
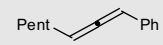
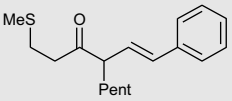
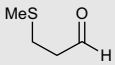
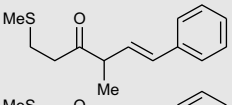
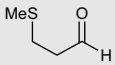
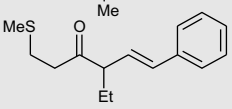
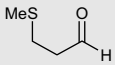
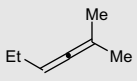
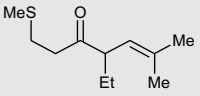
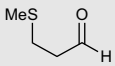
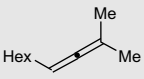
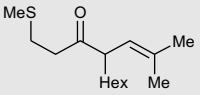
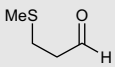
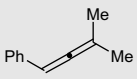
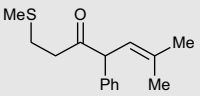
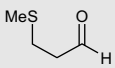
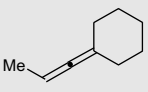
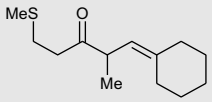
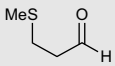
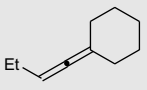
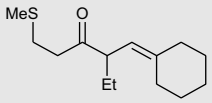
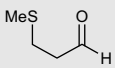
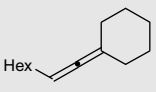
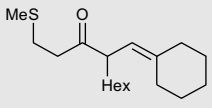
All reactions were performed under an inert atmosphere of nitrogen, in oven or flame dried glassware. Aldehydes **1** and **7** were purchased from Aldrich Chemical Company and distilled under reduced pressure before use. The rhodium catalyst,[16] allenes[17] and aldehydes **8**[18] and **9**[19] were prepared according to literature procedures.

4.2. General procedure for the hydroacylation of allenes using β-thio-substituted aldehydes

Acetone (2.0 mL) was added to pre-catalyst [Rh(nbd)(dppe)]ClO_4 (10 mg, 0.015 mmol) under nitrogen. The catalyst was activated in

Table 1
Variation of allene structure in combination with aldehydes **1** and **7**[a]



Entry	Aldehyde	Allene	Time (h)	Product	Regioselectivity[b]	Yield[c] (%)
1			8		>20:1	87
2			8		1.25:1	97
3			8		—	70
4			8		15:1	92
5			8		>20:1	89
6			8		>20:1	97
7			8		>20:1	89
8			16		>20:1	80
9			16		>20:1	74
10			16		>20:1	70
11			16		>20:1	78
12			16		>20:1	81
13			16		>20:1	89
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15			16		>20:1	96
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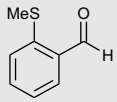
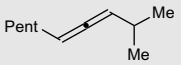
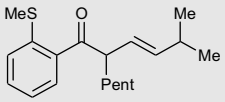
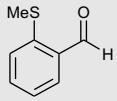
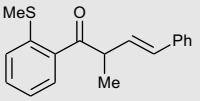
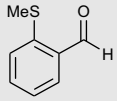
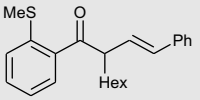
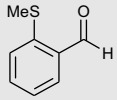
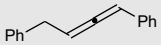
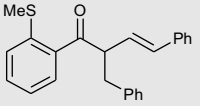
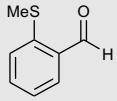
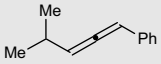
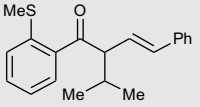
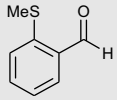
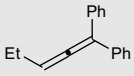
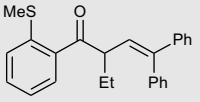
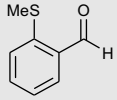
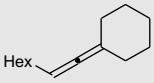
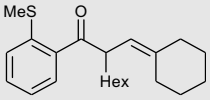
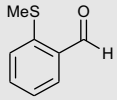
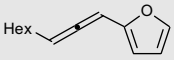
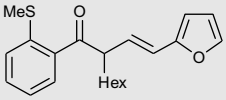
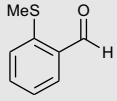
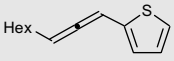
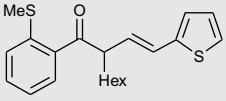
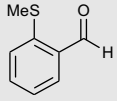
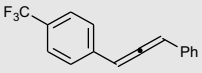
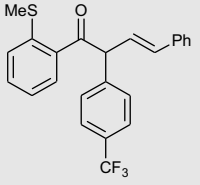
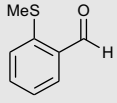
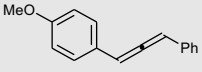
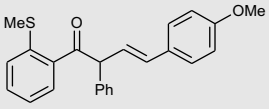
Table 1 (*continued*)

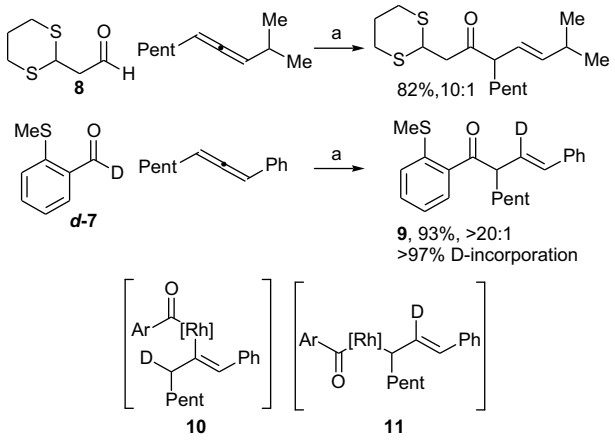
Entry	Aldehyde	Allene	Time (h)	Product	Regioselectivity[b]	Yield[c] (%)
17			8		>20:1	98
18			8		>20:1	82
19			8		>20:1	94
20			8		>20:1	99
21			8		12:1	99
22			16		>20:1	96
23			16		>20:1	99
24			8		>20:1	99
25			8		>20:1	99
26			16		1.8:1	97
27			16		1.6:1	32

[a] Reaction conditions: aldehyde (1.0 equiv), allene (2.0 equiv), [Rh(dppe)]ClO_4 (10 mol %), acetone, 55 °C. Catalyst generated in situ from [Rh(nbd)(dppe)]ClO_4 and H_2.
[b] Determined by ^1H NMR spectroscopy.
[c] Isolated yields.

situ by passing H_2 through the solution for 2 min or until a colour change from orange to light yellow was observed. After this time the hydrogen atmosphere was purged by passing nitrogen through the solution for 0.5 min. To this was added the thio-aldehyde (0.15 mmol) followed by the appropriate allene (0.3 mmol). The resulting mixture was stirred and heated at 55 °C for 8–16 h. After this time the solution was filtered through a silica plug, reduced in vacuo and purified by flash chromatography.

4.3. (*E*)-1-(Methylthio)undec-5-en-3-one (Table 1, entry 1)

Flash chromatography (9:1 hexane/EtOAc) yielded the title compound as a pale yellow oil (26 mg, 87%); ν_{max} (film)/cm^{-1} 2955, 2927, 2858, 1715; δ_H (300 MHz, $CDCl_3$) 5.65–5.45 (2H, m), 3.11 (2H, d, *J* 5.2), 2.73 (4H, t, *J* 6.8), 2.12 (3H, s), 2.02 (2H, q, *J* 6.7), 1.40–1.20 (6H, m), 0.88 (3H, t, *J* 6.7); δ_C (75 MHz, $CDCl_3$) 208.1, 134.6, 120.8, 47.4, 42.1, 32.9, 31.7, 29.2, 28.2, 22.9, 16.1, 14.4; *m*/*z* (CI^+, NH_3) 232



Scheme 3. Allene hydroacylations employing aldehydes **8** and ***d*-7**. (a) $[Rh(dppe)]ClO_4$ (10 mol %), acetone, 55 °C.

(100%, $[M+NH_4]^+$), 215 (20%, $[M+H]^+$), 200 (30%, $[M-CH_2]^+$), 184 (70%, $[M-CH_3CH_3]^+$); found $[M+NH_4]^+$ 232.1730, $C_{12}H_{26}NOS$ requires 232.1730.

4.4. (*E*)-4-Methyl-1-(methylthio)undec-5-en-3-one (5) and (*E*)-1-(methylthio)-4-(prop-1-enyl)nonan-3-one (4) (Table 1, entry 2)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compounds **4** and **5** (1:1.25) as a pale yellow oil (1:1.25, **5**/**4**, 33 mg, 97%); ν_{max} (film)/cm^{-1} 3049, 1647, 1421, 1262; δ_H (300 MHz, $CDCl_3$) (**4**) 5.58–5.46 (1H, m), 5.28 (1H, ddt, *J* 16.5, 8.3, 1.4), 3.12–3.03 (1H, m), 2.79–2.56 (4H, m), 2.16–1.92 (3H, m), 1.36–1.13 (8H, m), 1.08 (3H, d, *J* 6.9), 0.83–0.78 (3H, m); δ_H (300 MHz, $CDCl_3$) (**5**) 5.58–5.46 (1H, m), 5.25 (1H, ddq, *J* 16.5, 9.0, 1.5), 3.12–3.03 (1H, m), 2.79–2.56 (4H, m), 2.16–1.92 (3H, m), 1.62 (3H, dd, *J* 6.4, 1.5), 1.36–1.13 (8H, m), 0.83–0.78 (3H, m); δ_C (75 MHz, $CDCl_3$) (both) 207.2, 206.3, 134.4, 129.5, 129.3, 129.1, 57.2, 51.0, 41.3, 40.6, 32.9, 32.1, 32.0, 29.6, 29.5, 29.2, 28.4, 27.5, 23.1, 23.0, 18.4, 16.5, 16.3, 16.2, 14.5, 14.4; *m*/*z* (EI^+) 228 (20%, $[M]^+$), 102 (75%, $[M-CH_3CHCHCHCH_2CH_2CH_2CH_2CH_3]^+$), 75 (100%, $[M-CH_3CHCHCHCH_2CH_2CH_2CH_2CH_3CO]^+$); found $[M+H]^+$ 229.1621, $C_{13}H_{25}OS$ requires 229.1621.

4.5. (*E*)-1-(Methylthio)-4-pentylundec-5-en-3-one (Table 1, entry 3)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (30 mg, 70%); ν_{max} (film)/cm^{-1} 2926, 1699, 1457, 898, 718; δ_H (300 MHz, $CDCl_3$) 5.58 (1H, dt, *J* 15.4, 6.8), 5.26 (1H, ddt, *J* 15.4, 9.1, 1.6), 3.01 (1H, dt, *J* 9.1, 7.0), 2.85–2.64 (4H, m), 2.10 (3H, s), 2.06–1.97 (2H, m), 1.78–1.62 (2H, m), 1.43–1.19 (12H, m), 0.94–0.83 (6H, m); δ_C (75 MHz, $CDCl_3$) 210.2, 134.9, 127.7, 56.9, 40.9, 32.5, 31.7, 31.6, 31.3, 30.9, 28.9, 28.0, 26.8, 22.5, 15.8, 14.1, 14.0; *m*/*z* (EI^+) 284 (3%, $[M]^+$), 103 (100%, $[M-PentCHCHCHPent]^+$); found $[M+H]^+$ 285.2247, $C_{17}H_{33}OS$ requires 285.2247.

4.6. (*E*)-4-((3-Methylbut-1-enyl)-1-methylthio)nonan-3-one (Table 1, entry 4)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (35 mg, 92%); ν_{max} (film)/cm^{-1} 2916, 1704, 1463, 903; δ_H (300 MHz, $CDCl_3$) 5.48 (1H, dd, *J* 15.4, 6.7), 5.15 (1H, ddd, *J* 15.4, 9.0, 1.2), 2.92 (1H, m), 2.77–2.55 (4H, m), 2.29–2.16 (1H, m), 2.03 (3H, s), 1.70–1.56 (1H, m), 1.41–1.30 (1H, m), 1.27–1.09 (6H, m), 0.92 (3H, d, *J* 1.2), 0.90 (3H, d, *J* 1.2), 0.82–0.77 (3H, m); δ_C (75 MHz, $CDCl_3$) 210.6, 142.1, 125.2, 57.2, 41.3, 32.1, 32.0, 31.6, 31.3, 28.4, 27.2, 22.9, 22.7, 16.2, 14.4; *m*/*z* (EI^+) 256 (10%, $[M]^+$), 103 (60%, $[M-(CH_3)_2CHCHCH(CH_2)_4CH_3]^+$), 75 (100%, $[M-(CH_3)_2CHCHCH-(CH_2)_4CH_3CO]^+$); found $[M+H]^+$ 257.1931, $C_{15}H_{29}S$ requires 257.1934.

4.7. (*E*)-1-(Methylthio)-4-styrylnonan-3-one (Table 1, entry 5)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (39 mg, 89%); ν_{max} (film)/cm^{-1} 2926, 1709, 1457, 908; δ_H (300 MHz, $CDCl_3$) 7.32–7.14 (5H, m), 6.43 (1H, d, *J* 15.8), 6.0 (1H, dd, *J* 15.8, 9.3), 3.17 (1H, dt, *J* 9.3, 6.8), 2.83–2.62 (4H, m), 2.02 (3H, s), 1.78–1.68 (1H, m), 1.55–1.45 (1H, m), 1.27–1.16 (6H, m), 0.82–0.67 (3H, m); δ_C (75 MHz, $CDCl_3$) 209.8, 137.1, 133.6, 129.0, 128.1, 128.0, 126.7, 57.6, 41.8, 32.1, 31.6, 28.4, 27.3, 22.9, 16.2, 14.4; *m*/*z* (EI^+) 290 (20%, $[M]^+$), 187 (40%, $[M-CH_3SCH_2CH_2CO]^+$), 116 (100%, $[M-PhCHCHCH_2CH_2CH_2CH_2CH_3]^+$); found $[M+H]^+$ 291.1783, $C_{18}H_{27}OS$ requires 291.1777.

4.8. (*E*)-4-Methyl-1-(methylthio)-6-phenylhex-5-en-3-one (Table 1, entry 6)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (34 mg, 97%); ν_{max} (film)/cm^{-1} 2972, 1709, 1447, 898; δ_H (300 MHz, $CDCl_3$) 7.31–7.14 (5H, m), 6.42 (1H, d, *J* 15.8), 6.08 (1H, dd, *J* 15.8, 8.3), 3.36–3.25 (1H, m), 2.87–2.63 (4H, m), 2.02 (3H, s), 1.21 (3H, d, *J* 6.8); δ_C (75 MHz, $CDCl_3$) 209.9, 137.1, 132.8, 129.0, 128.9, 128.2, 126.6, 51.3, 41.0, 28.4, 16.5, 16.2; *m*/*z* (EI^+) 234 (30%, $[M]^+$), 130 (10%, $[M-CH_3SCH_2CH_2COH]^+$), 91 (80%, $[M-PhCHCHCH\ CH_3O]^+$); found $[M+H]^+$ 235.1152, $C_{14}H_{19}OS$ requires 235.1151.

4.9. (*E*)-4-Ethyl-1-(methylthio)-6-phenylhex-5-en-3-one (Table 1, entry 7)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (33 mg, 89%); ν_{max} (film)/cm^{-1} 2989, 1723, 1406, 917; δ_H (300 MHz, $CDCl_3$) 7.31–7.12 (5H, m), 6.44 (1H, d, *J* 15.8), 6.00 (1H, dd, *J* 15.8, 9.3), 3.13–3.05 (1H, m), 2.83–2.56 (4H, m), 2.03 (3H, s), 1.87–1.73 (1H, m), 1.60–1.46 (1H, m), 0.84 (3H, t, *J* 7.4); δ_C (75 MHz, $CDCl_3$) 209.7, 137.1, 133.8, 129.0, 128.1, 127.8, 126.7, 59.2, 41.8, 28.3, 24.8, 16.2, 12.2; *m*/*z* (EI^+) 248 (20%, $[M]^+$), 145 (100%, $[M-CH_3SCH_2CH_2CO]^+$); found $[M+H]^+$ 249.1309, $C_{15}H_{21}OS$ requires 249.1309.

4.10. 4-Ethyl-6-methyl-1-(methylthio)hept-5-en-3-one (6) (Table 1, entry 8)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (24 mg, 80%); ν_{max} (film)/cm^{-1} 3020, 1747, 1457, 1142; δ_H (300 MHz, $CDCl_3$) 4.91–4.82 (1H, m), 3.23–3.15 (1H, m), 2.71–2.57 (4H, m), 2.03 (3H, s), 1.68 (3H, d, *J* 1.3), 1.64 (3H, d, *J* 1.2), 1.32–1.05 (2H, m), 0.80 (3H, t, *J* 6.7); δ_C (75 MHz, $CDCl_3$) 210.6, 136.1, 123.2, 53.1, 41.1, 32.1, 26.3, 23.0, 22.6, 18.8, 14.5; *m*/*z* (EI^+) 200 (2%, $[M]^+$) 97 (30%, $[M-CH_3SCH_2CH_2CO]^+$), 55 (100%, $[M-CH_3SCH_2CH_2COCHCH_2CH_3]^+$); found $[M+H]^+$ 201.1306, $C_{11}H_{21}OS$ requires 201.1308.

4.11. 4-(2-Methylprop-1-enyl)-1-(methylthio)decan-3-one (Table 1, entry 9)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (28 mg, 74%); ν_{max} (film)/cm^{-1} 2936, 1699, 1452, 913; δ_H (300 MHz, $CDCl_3$) 4.96 (1H, br d, *J* 9.8), 3.26 (1H, ddd, *J* 9.8, 8.0, 6.2), 2.78–2.62 (4H, m), 2.10 (3H, s), 1.74 (3H, d, *J* 1.2), 1.69 (3H, d, *J* 1.3), 1.46–1.15 (10H, m), 0.87 (3H, t, *J* 6.7); δ_C (75 MHz, $CDCl_3$) 210.2, 135.7, 122.8, 52.7, 40.8, 31.7, 31.5, 29.3, 28.1, 27.1, 25.9,

22.6, 18.4, 15.8, 14.1; *m*/*z* (EI$^+$) 256 (60%, [M]$^+$), 208 (50%, [M−CH_3SH]$^+$), 153 (100%, [M−$CH_3SCH_2CH_2CO$]$^+$); found [M+H]$^+$ 257.1938, $C_{15}H_{29}OS$ requires 257.1934.

4.12. 6-Methyl-1-(methylthio)-4-phenylhept-5-en-3-one (Table 1, entry 10)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (27 mg, 70%); ν_{max} (film)/cm^{-1} 3049, 2680, 1709, 1416, 1262; δ_H (300 MHz, $CDCl_3$) 7.32–7.16 (5H, m), 5.59–5.54 (1H, m), 4.49 (1H, d, *J* 9.4), 2.75–2.54 (4H, m), 1.95 (3H, s), 1.71 (3H, d, *J* 1.2), 1.61 (3H, d, *J* 1.3); δ_C (75 MHz, $CDCl_3$) 207.8, 139.3, 136.0, 129.3, 128.5, 127.5, 121.7, 58.7, 41.1, 28.6, 26.4, 18.7, 16.1; *m*/*z* (EI$^+$) 248 (10%, [M]$^+$), 145 (100%, [M−$MeSCH_2CH_2CO$]$^+$), 103 (20%, [M−$Me_2CCHCHPh$]$^+$); found [M+H]$^+$ 249.1308, $C_{15}H_{21}OS$ requires 249.1308.

4.13. 1-Cyclohexylidene-2-methyl-5-(methylthio)pentan-3-one (Table 1, entry 11)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (26 mg, 78%); ν_{max} (film)/cm^{-1} 3055, 1704, 1416, 1257; δ_H (300 MHz, $CDCl_3$) 4.87 (1H, d, *J* 9.7), 3.36 (1H, dq, *J* 9.7, 6.8), 2.76–2.54 (4H, m), 2.16–2.14 (2H, m), 2.05–1.98 (2H, m), 2.03 (3H, s), 1.62–1.44 (6H, m), 1.05 (3H, d, *J* 6.8); δ_C (75 MHz, $CDCl_3$) 210.9, 143.3, 120.9, 46.1, 40.5, 37.6, 29.7, 28.8, 28.6, 28.2, 27.1, 16.9, 16.2; *m*/*z* (EI$^+$) 226 (5%, [M]$^+$), 123 (75%, [M−$CH_3SCH_2CH_2$-CO]$^+$), 82 (100%, [M−Cy]$^+$); found [M+H]$^+$ 227.1464, $C_{13}H_{23}OS$ requires 227.1462.

4.14. 4-(Cyclohexylidenemethyl)-1-(methylthio)hexan-3-one (Table 1, entry 12)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (29 mg, 81%); ν_{max} (film)/cm^{-1} 2972, 1653, 1473, 1365, 1160; δ_H (300 MHz, $CDCl_3$) 4.81 (1H, d, *J* 9.8), 3.71 (1H, ddd, *J* 9.8, 8.2, 6.0), 2.73–2.55 (4H, m), 2.19–2.12 (2H, m), 2.08–2.04 (2H, m), 2.03 (3H, s), 1.74–1.60 (1H, m), 1.53–1.46 (6H, m), 1.43–1.28 (1H, m), 0.78 (3H, t, *J* 7.4); δ_C (75 MHz, $CDCl_3$) 210.7, 144.5, 119.5, 53.7, 41.1, 37.7, 29.8, 29.0, 28.5, 28.2, 27.1, 24.8, 16.2, 12.1; *m*/*z* (EI$^+$) 240 (5%, [M]$^+$), 137 (55%, [M−$CH_3SCH_2CH_2CO$]$^+$), 95 (100%, [M−$CH_3SCH_2CH_2COCHCH_2CH_3$]$^+$); found [M+H]$^+$ 241.1621, $C_{14}H_{25}OS$ requires 241.1621.

4.15. 4-(Cyclohexylidenemethyl)-1-(methylthio)decan-3-one (Table 1, entry 13)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (40 mg, 89%); ν_{max} (film)/cm^{-1} 2936, 1709, 1468, 903; δ_H (300 MHz, $CDCl_3$) 4.82 (1H, d, *J* 9.8), 3.24 (1H, ddd, *J* 9.8, 8.2, 5.9), 2.74–2.55 (4H, m), 2.18–2.12 (2H, m), 2.07–2.05 (2H, m), 2.03 (3H, s), 1.68–1.58 (1H, m), 1.52–1.48 (6H, m), 1.39–1.28 (1H, m), 1.24–1.08 (8H, m), 0.80 (3H, t, *J* 6.7); δ_C (75 MHz, $CDCl_3$) 210.7, 144.2, 119.8, 52.0, 41.1, 37.7, 32.1, 31.7, 29.8, 29.6, 29.0, 28.9, 28.5, 27.5, 27.1, 23.0, 16.2, 14.5; *m*/*z* (EI) 296 (5%, [M]$^+$), 193 (40%, [M−$CH_3SCH_2CH_2CO$]$^+$), 109 (100%, [M−$CH_3(CH_2)_5C_2$]$^+$); found [M+H]$^+$ 296.2169, $C_{18}H_{33}OS$ requires 296.2168.

4.16. 1-Cyclohexylidene-5-(methylthio)-2-phenylpentan-3-one (Table 1, entry 14)

Flash chromatography (1:9, Et_2O/hexane) yielded the title compound as a yellow oil (27 mg, 62%); ν_{max} (film)/cm^{-1} 3044, 1714, 1427, 1263; δ_H (300 MHz, $CDCl_3$) 7.31–7.15 (5H, m), 5.49 (1H, dt, *J* 9.3, 1.0), 4.58 (1H, d, *J* 9.3), 2.71–2.54 (4H, m), 2.14–1.94 (7H, m), 1.51–1.36 (6H, m); δ_C (75 MHz, $CDCl_3$) 207.9, 144.0, 139.6, 129.2, 128.5, 127.4, 118.3, 57.7, 37.7, 29.8, 28.8, 27.9, 27.0, 23.1; *m*/*z* (EI$^+$) 288 (10%, [M]$^+$), 185 (90%, [M−$CH_3SCH_2CH_2CO$]$^+$), 117 (100%, [M−CyCCPh]$^+$); found [M+H]$^+$ 289.1622, $C_{18}H_{25}OS$ requires 289.1621.

4.17. (*E*)-Ethyl 4-methyl-7-(methylthio)-5-oxohept-3-enoate (Table 1, entry 15)

Flash chromatography (1:8, Et_2O/hexane) yielded the title compound as a yellow oil (31 mg, 96%); ν_{max} (film)/cm^{-1} 2978, 1735, 1663, 1365, 913; δ_H (300 MHz, $CDCl_3$) 6.78–6.72 (1H, m), 4.13 (2H, q, *J* 7.2), 3.22 (2H, d, *J* 6.8), 2.95 (2H, t, *J* 7.3), 2.71 (2H, t, *J* 7.3), 2.06 (3H, s), 1.73 (3H, d, *J* 1.1), 1.22 (3H, t, *J* 7.2); δ_C (75 MHz, $CDCl_3$) 199.9, 175.5, 139.7, 133.8, 61.6, 37.7, 34.8, 29.3, 16.2, 14.8, 12.1; *m*/*z* (ES$^+$) 230 (100%, [M]$^+$), 182 (80%, [M−CH_3SH]$^+$); found [M+H]$^+$ 231.1048, $C_{11}H_{19}O_3S$ requires 231.1049.

4.18. (*E*)-Ethyl 7-(methylthio)-5-oxohept-2-enoate and (*E*)-ethyl 7-(methylthio)-5-oxohept-3-enoate (Table 1, entry 16)

Flash chromatography (1:8, Et_2O/hexane) yielded the title compounds **16a** and **16b** as an inseparable mixture (1:1) as a yellow oil (26 mg, 81%); ν_{max} (film)/cm^{-1} 2983, 1791, 1719, 1440, 1375, 1160; δ_H (300 MHz, $CDCl_3$) ((*E*)-ethyl 7-(methylthio)-5-oxohept-2-enoate) 6.96 (1H, dt, *J* 15.7, 7.2), 5.84 (1H, dt, *J* 15.7, 1.5), 4.17–4.08 (2H, m), 3.31–3.28 (2H, m), 2.74–2.65 (4H, m), 2.05 (3H, s), 1.22 (3H, t, *J* 6.0); δ_H (300 MHz, $CDCl_3$) ((*E*)-ethyl 7-(methylthio)-5-oxohept-3-enoate) 6.85 (1H, dt, *J* 16.1, 7.1), 6.13 (1H, dt, *J* 16.1, 1.5), 4.17–4.08 (2H, m), 3.19 (2H, dd, *J* 7.1 1.5), 2.83 (2H, t, *J* 8.5), 2.74–2.65 (2H, m), 2.06 (3H, s), 1.23 (3H, t, *J* 5.9); δ_C (75 MHz, $CDCl_3$) (both) 205.2, 198.4, 170.2, 166.1, 139.8, 138.8, 135.0, 125.6, 61.7, 60.9, 46.2, 42.9, 40.2, 38.1, 30.1, 28.5, 28.1, 16.2, 14.6, 14.5; *m*/*z* (FI$^+$) found [M]$^+$ 216.0830, $C_{10}H_{16}O_3S$ requires 216.0820.

4.19. (*E*)-2-(3-Methylbut-1-enyl)-1-(2-(methylthio)-phenyl)heptan-1-one (Table 1, entry 17)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound (10:1) as a colourless oil (45 mg, 98%); ν_{max} (film)/cm^{-1} 2957, 1672, 1585, 1434, 1270, 973, 740; δ_H (400 MHz, $CDCl_3$); 7.78 (1H, dd, *J* 4.6, 1.3), 7.47–7.28 (2H, m), 7.25–7.13 (1H, m), 5.51 (1H, dd, *J* 15.9, 6.3), 5.41 (1H, d, *J* 15.9, 8.6), 3.90–3.82 (1H, m), 2.42 (3H, s, SCH_3), 2.33–2.16 (1H, m), 1.93–1.77 (1H, m), 1.63–1.49 (1H, m), 1.45–1.13 (6H, m), 1.04–0.77 (9H, m); δ_C (100 MHz, $CDCl_3$) 203.4, 141.9, 141.0, 135.7, 131.7, 129.8, 125.8, 125.6, 123.6, 52.7, 32.5, 31.8, 31.3, 27.0, 22.6, 22.4, 16.4, 14.2; *m*/*z* (FI$^+$) found [M]$^+$ 304.1871, $C_{19}H_{28}OS$ requires 304.1861.

4.20. (*E*)-2-Methyl-1-(2-(methylthio)phenyl)-4-phenylbut-3-en-1-one (Table 1, entry 18)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound as a colourless oil (34 mg, 82%); ν_{max} (film)/cm^{-1} 2976, 2972, 1669, 1586, 1433, 972, 741, 694; δ_H (400 MHz, $CDCl_3$) 7.84 (1H, dd, *J* 7.8, 1.5), 7.51–7.41 (1H, m), 7.38–7.18 (7H, m), 6.51 (1H, d, *J* 16.0), 6.29 (1H, dd, *J* 16.0, 8.3), 4.30–4.23 (1H, m), 2.45 (3H, s), 1.44 (3H, d); δ_C (100 MHz, $CDCl_3$) 202.6, 142.0, 136.9, 135.0, 131.8, 131.6, 129.8, 129.6, 128.5, 127.4, 126.2, 125.7, 123.7, 46.7, 17.6, 16.3; *m*/*z* (ESI$^+$) found [M+Na]$^+$ 305.0971, $C_{18}H_{18}OSNa$ requires 305.0976.

4.21. (*E*)-1-(2-(Methylthio)phenyl)-2-styryloctan-1-one (Table 1, entry 19)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound as a colourless oil (49 mg, 94%); ν_{max} (film)/cm^{-1} 3026, 2926, 2855, 1668, 1460, 1433, 969, 742; δ_H (400 MHz, $CDCl_3$) 7.83 (1H, dd, *J* 7.8, 1.3), 7.48–7.44 (1H, m), 7.37–7.20 (7H, m), 6.49 (1H, d, *J*

15.9), 6.30 (1H, dd, *J* 15.9, 8.8), 4.15–4.09 (1H, m), 2.44 (3H, s), 2.01–1.95 (1H, m), 1.74–1.69 (1H, m), 1.43–1.22 (8H, br m), 0.92–0.83 (3H, m); δ_C (100 MHz, $CDCl_3$) 202.4, 142.2, 137.0, 135.3, 132.3, 131.9, 129.3, 128.8, 128.5, 127.4, 126.3, 125.6, 123.6, 52.8, 32.7, 31.7, 29.2, 27.3, 22.6, 16.2, 14.0; *m*/*z* (ESI^+) found $[M+H]^+$ 353.1934, $C_{23}H_{29}OS$ requires 353.1939.

4.22. (*E*)-2-Benzyl-1-(2-(methylthio)phenyl)-4-phenylbut-3-en-1-one (Table 1, entry 20)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound as a colourless oil (52 mg, 99%); ν_{max} (film)/cm^{-1} 3026, 2921, 1668, 1586, 1558, 1495, 1433, 1269, 1075, 968, 743, 697; δ_H (400 MHz, $CDCl_3$) 7.73 (1H, dd, *J* 7.8, 1.5), 7.52–7.38 (1H, m), 7.35–7.02 (12H, m), 6.38 (1H, d, *J* 15.9), 6.30 (1H, dd, *J* 15.9, 8.1), 4.52–4.05 (1H, m), 3.40 (1H, dd, *J* 13.6, 6.8), 3.02 (1H, dd, *J* 13.6, 7.6), 2.43 (3H, s); δ_C (100 MHz, $CDCl_3$) 201.0, 142.0, 139.0, 136.5, 134.7, 132.8, 131.6, 129.5, 129.0, 128.1, 127.9, 127.4, 127.2, 125.9, 125.9, 125.2, 123.2, 54.3, 38.3, 15.9; *m*/*z* (ESI^+) found $[M+Na]^+$ 381.1284, $C_{24}H_{22}OSNa$ requires 381.1289.

4.23. (*E*)-2-Isopropyl-1-(2-(methylthio)phenyl)-4-phenylbut-3-en-1-one (Table 1, entry 21)

Flash chromatography (1:10, EtOAc/hexane) yielded the title compound (12:1) as a colourless oil (47 mg, 99%); ν_{max} (film)/cm^{-1} 2959, 1669, 1433, 970, 742, 691; δ_H (400 MHz, $CDCl_3$) 7.88 (1H, dd, *J* 7.8, 1.3), 7.49–7.43 (1H, m), 7.41–7.17 (7H, m), 6.51 (1H, d, *J* 15.9), 6.33 (1H, dd, *J* 15.9, 9.4), 3.90–3.75 (1H, m), 2.42 (3H, s), 2.40–2.30 (1H, m), 0.99 (6H, t, *J* 7.0); δ_C (100 MHz, $CDCl_3$) 202.6, 142.4, 137.0, 135.5, 133.2, 132.0, 129.8, 128.3, 128.0, 127.5, 126.4, 125.4, 123.5, 60.2, 31.5, 21.5, 20.1, 16.1; *m*/*z* (FI^+) found $[M]^+$ 310.1391, $C_{20}H_{22}OS$ requires 310.1404.

4.24. 2-Ethyl-1-(2-(methylthio)phenyl)-4,4-diphenylbut-3-en-1-one (Table 1, entry 22)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound as a colourless oil (54 mg, 96%); ν_{max} (film)/cm^{-1} 3058, 2963, 2855, 1668, 1586, 1494, 1434, 1202, 1074, 895, 764, 702; δ_H (400 MHz, $CDCl_3$) 7.54–7.14 (11H, m), 7.13–6.90 (3H, m), 6.15 (1H, d, *J* 10.4), 4.13 (1H, dt, *J* 10.4, 8.0), 2.39 (3H, s), 2.09–1.92 (1H, m), 1.87–1.70 (1H, m), 0.95 (3H, t, *J* 7.3); δ_C (100 MHz, $CDCl_3$) 203.1, 144.1, 141.6, 141.4, 139.7, 135.8, 131.6, 129.7, 129.5, 128.3, 128.1, 127.7, 127.4, 127.3, 127.2, 125.6, 123.5, 51.1, 26.1, 16.2, 12.0; *m*/*z* (ESI+) found $[M+Na]^+$ 395.1440, $C_{25}H_{24}NaOS$ requires 395.1440.

4.25. 2-(Cyclohexylidenemethyl)-1-(2-(methylthio)-phenyl)octan-1-one (Table 1, entry 23)

Flash chromatography (1:20, EtOAc/hexane) yielded the title compound as a colourless oil (52 mg, 99%); ν_{max} (film)/cm^{-1} 2927, 2854, 1675, 1587, 1434, 1212, 1078, 979, 852, 738; δ_H (400 MHz, $CDCl_3$) 7.68 (1H, dd, *J* 7.7, 1.9), 7.46–7.38 (1H, m), 7.35–7.29 (1H, m), 7.20–7.13 (1H, m), 5.04 (1H, d, *J* 9.9), 4.16 (1H, ddd, *J* 9.9, 8.1, 5.9), 2.43 (3H, s), 2.22–2.00 (4H, m), 1.94–1.77 (1H, m), 1.62–1.18 (15H, m), 0.94–0.81 (3H, m); δ_C (100 MHz, $CDCl_3$) 203.8, 162.4, 141.1, 136.3, 131.3, 129.3, 125.7, 123.6, 120.2, 48.1, 37.2, 32.2, 31.7, 29.5, 29.3, 28.4, 27.5, 27.1, 26.7, 22.6, 16.3, 14.1; *m*/*z* (ESI^+) found $[M+H]^+$ 345.2251, $C_{22}H_{33}OS$ requires 345.2252.

4.26. (*E*)-2-(2-(Furan-2-yl)vinyl)-1-(2-(methylthio)-phenyl)octan-1-one (Table 1, entry 24)

Flash chromatography (1:10, EtOAc/hexane) yielded the title compound as a colourless oil (51 mg, 99%); ν_{max} (film)/cm^{-1} 2928, 2857, 1781, 1669, 1587, 1435, 1245, 993, 751; δ_H (400 MHz, $CDCl_3$) 7.82 (1H, dd, *J* 7.8, 1.0), 7.49–7.41 (1H, m), 7.33 (2H, t, *J* 8.2), 7.20 (1H, t, *J* 7.5), 6.40–6.10 (4H, m), 4.06 (1H, q, *J* 7.8), 2.43 (3H, s), 2.04–1.86 (1H, m), 1.46–1.12 (1H, m), 0.98–0.78 (8H, m), 0.97–0.75 (3H, m); δ_C (100 MHz, $CDCl_3$) 202.2, 152.6, 142.4, 141.9, 135.3, 132.0, 129.9, 127.6, 125.7, 123.7, 120.9, 111.3, 107.6, 52.4, 32.7, 31.8, 29.4, 27.5, 22.7, 16.3, 14.2; *m*/*z* (ESI^+) found $[M+H]^+$ 343.1731, $C_{21}H_{27}O_2S$ requires 343.1732.

4.27. (*E*)-1-(2-(Methylthio)phenyl)-2-(2-(thiophen-2-yl)vinyl)octan-1-one (Table 1, entry 25)

Flash chromatography (1:10, Et_2O/hexane) yielded the title compound as a colourless oil (54 mg, 99%); ν_{max} (film)/cm^{-1} 2925, 2855, 1667, 1586, 1460, 1433, 1269, 1217, 1078, 957, 740, 696; δ_H (400 MHz, $CDCl_3$) 7.90–7.75 (1H, m), 7.50–7.42 (1H, m), 7.35 (1H, d, *J* 8.1), 7.20 (1H, t, *J* 7.5), 7.12 (1H, d *J* 4.8), 6.97–6.88 (2H, m), 6.62 (1H, d, *J* 15.7), 6.14 (1H, dd, *J* 15.7, 8.9), 4.16–3.97 (1H, m), 2.44 (3H, s), 2.08–1.87 (1H, m), 1.80–1.59 (1H, m), 1.50–1.15 (8H, m), 0.97–0.75 (3H, m); δ_C (75 MHz, $CDCl_3$) 202.1, 142.2, 142.1, 135.1, 131.9, 129.7, 128.3, 127.2, 125.6, 125.4, 125.3, 124.0, 123.6, 52.5, 32.6, 31.6, 29.2, 27.3, 22.5, 16.2, 14.0; *m*/*z* (ESI^+) found $[M+H]^+$ 359.1505, $C_{21}H_{27}OS_2$ requires 359.1498.

4.28. (*E*)-1-(2-(Methylthio)phenyl)-2-phenyl-4-(4-(trifluoromethyl)phenyl)but-3-en-1-one and (*E*)-1-(2-(methylthio)phenyl)-2-phenyl-4-(4-(trifluoromethyl)-phenyl)but-3-en-1-one (Table 1, entry 26)

Flash chromatography (1:5, EtOAc/hexane) yielded the title compounds as an inseparable mixture (1.8:1) as a colourless oil (60 mg, 97%); ν_{max} (film)/cm^{-1} 3061, 2977, 2923, 1666, 1616, 1587, 1434, 1325, 1122, 733, 698; δ_H (400 MHz, $CDCl_3$) 7.88–7.81 (1H, m), 7.65–7.58 (1H, m), 7.57–7.08 (11H, m), 6.93 (0.36H, dd, *J* 15.9, 7.8), 6.74 (0.64H, dd, *J* 15.9, 8.1), 6.51 (0.64H, d, *J* 15.9), 6.48 (0.36H, d, *J* 15.9), 5.53 (0.64H, d, *J* 8.1), 5.45 (0.36H, d, *J* 7.8), 2.44 (3H, s) δ_C (100 MHz, $CDCl_3$) 199.3, 199.0, 143.1, 142.8, 136.5, 134.1, 133.1, 132.4, 132.2, 131.8, 130.6, 130.5, 129.2, 128.9, 128.6, 128.4, 127.9, 127.7, 127.5, 126.6, 126.5, 125.9, 125.7, 125.6, 125.4, 123.7, 123.6, 114.2, 58.5, 58.1, 16.2; *m*/*z* (FI^+) found $[M]^+$ 412.1106, $C_{24}H_{19}F_3OS$ requires 412.1106.

4.29. (*E*)-4-(4-Methoxyphenyl)-1-(2-(methylthio)phenyl)-2-phenylbut-3-en-1-one and (*E*)-2-(4-methoxyphenyl)-1-(2-(methylthio)phenyl)-4-phenylbut-3-en-1-one (Table 1, entry 27)

Flash chromatography (1:5, EtOAc/hexane) yielded the title compounds as an inseparable mixture (1.6:1) as a colourless oil (18 mg, 32%); ν_{max} (film)/cm^{-1} 2926, 2855, 1668, 1607,1511, 1461, 1433, 1250, 1175, 1035, 741; δ_H (400 MHz, $CDCl_3$) 7.88–7.78 (1H, m), 7.51–7.15 (10H, m), 7.13 (2H, t, *J* 7.6), 6.87 (0.38H, d, *J* 8.8), 6.83 (0.62H, d, *J* 8.8), 6.76 (0.38H, dd, *J* 15.9, 8.0), 6.63 (0.62H, dd, *J* 15.9, 8.1), 6.43 (0.38H, d, *J* 15.9), 6.40 (0.62H, d, *J* 15.9), 5.39 (0.62H, d, *J* 8.1), 5.36 (0.38H, d, *J* 8.0), 3.80 (1.86H, s), 3.78 (1.14H, s), 2.43 (3H, s); δ_C (100 MHz, $CDCl_3$) 200.0, 142.8, 139.4, 132.0, 131.8, 131.5, 130.8, 130.4, 129.7, 129.5, 129.1, 129.0, 128.5, 128.4, 127.7, 127.5, 127.2, 126.6, 126.5, 125.6, 125.4, 123.6, 114.4, 113.9, 58.6, 57.7, 55.3, 54.8, 16.3; *m*/*z* (FI^+) found $[M]^+$ 374.1344, $C_{24}H_{22}O_2S$ requires 374.1341.

4.30. (*E*)-1-(1,3-Dithian-2-yl)-3-(3-methylbut-1-enyl)-octan-2-one (Scheme 3)

Flash chromatography (1:4, Et_2O/hexane) yielded the title compound (10:1) as a yellow oil (39 mg, 82%); ν_{max} (film)/cm^{-1} 3060, 1714, 1416, 1267; δ_H (300 MHz, $CDCl_3$) 5.50 (1H, ddd, *J* 15.4,

6.7, 0.5), 5.12 (1H, ddd, *J* 15.4, 9.0, 1.2), 4.45 (1H, t, *J* 6.8), 2.97–2.82 (4H, m), 2.79–2.70 (4H, m), 2.27–2.16 and 2.09–1.99 (2H, m), 1.84–1.57 (2H, m), 1.41–1.11 (6H, m), 0.91 (6H, d, *J* 6.8), 0.80 (3H, t, *J* 6.5); δ_C (75 MHz, $CDCl_3$) 207.3, 142.7, 124.6, 57.5, 46.5, 41.6, 32.0, 31.6, 31.0, 30.8, 27.1, 25.7, 22.9, 22.7, 14.4; *m*/*z* (EI^+) (both) 314 (10%, $[M]^+$), 271 (20%, $[M-CH(CH_2)_3]^+$), 119 (100%, $[M-CH_2COCH(Pent)-CHCHCH(CH_3)_2]^+$); found $[M+H]^+$ 315.1813, $C_{17}H_{31}OS_2$ requires 315.1811.

4.31. (*E*)-1-(2-(Methylthio)phenyl)-2-(1-D-styryl)heptan-1-one (9, Scheme 3)

Flash chromatography (1:9 Et_2O/hexane) yielded the title compound as a yellow oil (47 mg, 93%); ν_{max} (film)/cm^{-1} 2911, 1678, 1463, 1365; δ_H (200 MHz, $CDCl_3$) 7.78 (1H, dd, *J* 7.9, 1.4), 7.41–7.10 (8H, m), 6.41 (1H, br s), 4.11 (1H, t, *J* 7.0), 2.36 (3H, s), 1.95–1.84 (1H, m), 1.69–1.54 (1H, m), 1.39–1.89 (6H, m), 0.79 (3H, t, *J* 7.0); δ_D (77 MHz, $CHCl_3$) 6.34 (br s); δ_C (125 MHz, $CDCl_3$) 202.5, 142.1, 137.0, 135.3, 132.3, 131.9, 129.7, 128.5, 127.4, 126.3, 125.6, 123.6, 52.8, 32.6, 31.8, 27.0, 22.5, 16.2, 14.0; *m*/*z* (FI^+) 339; found $[M]^+$ 339.1769, $C_{22}H_{25}DOS$ requires 339.1767.

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