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Highly Chemo- and Stereoselective Intermolecular Coupling of Diazoacetates To Give *cis*-Olefins by Using Grubbs Second-Generation Catalyst

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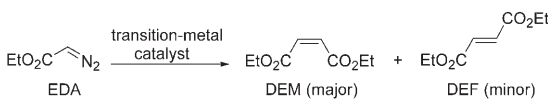
Abstract: Highly stereoselective formation of *cis*-2-ene-1,4-diesters by homo- and heterocoupling of α-diazoacetates in the presence of Grubbs second-generation catalyst is demonstrated. The dual reactivity of the catalyst in alkene metathesis and diazocoupling has been exploited in the synthesis of 12–26-membered macrocyclic dienyl dilactones by one-pot carbene dimerisation/ring-closing metathesis.

Keywords: diazo compounds · dimerisation · Grubbs catalyst · macrocycles · metathesis

Introduction

α-Diazocarbonyl compounds, when treated with transition-metal catalysts, form transient metallocarbenes that undergo a number of synthetically useful reactions, such as inter-/intramolecular cyclopropanation, X–H insertion (X = C, O, N) and ylide generation.[1] These processes have been extensively developed into important stereo- and enantioselective transformations.[1,2] Transition-metal catalysed dimerisation of α-diazocarbonyl compounds is the "simplest" carbene-based reaction pathway, and has often been noted as an unwanted side reaction during the above processes. More recently, however, catalysts for the stereoselective decomposition of α-diazoacetates to generate *cis*-olefins with high stereoselectivity have been developed (Scheme 1),[3] and the process has seen application in target-oriented synthesis.[3,4]



Scheme 1. Transition-metal-catalysed homocoupling of ethyl diazoacetate.

Porphyrin- or phosphine-based Ru and Os catalysts have been investigated for the stereoselective generation of *cis*-olefins from diazo compounds. Woo and Smith demonstrated the use of Os porphyrin complexes, such as $[(TTP)Os]_2$ and $[(TTP)Os(py)_2]$ (TTP = 5,10,15,20-tetra-*p*-tolyl porphyrin), in the stereoselective decomposition of ethyl diazoacetate (EDA), giving diethyl maleate (DEM) and diethyl fumarate (DEF) with ≈26:1 selectivity.[5] The diazo coupling was shown to proceed by way of a metallo–ester carbene, $[(TTP)Os{=}CHCO_2Et]$, which, when prepared independently and treated with an excess of EDA, gave similar olefin stereoselectivity ($Z/E \approx 25{:}1$). Subsequently, Collman showed that [Ru(TMP)] (TMP = 5,10,15,20-tetramesityl porphyrin) also reacts with EDA to give DEM and DEF in a 15:1 ratio (91% overall yield).[6] However, a similar rhodium(III)-based complex, [Rh(TTP)I], gave DEM in poor yield (36%). The half-sandwich ruthenium(II) complex $[RuCl(\eta^5\text{-}C_5H_5)(PPh_3)_2]$ was also found to dimerise EDA to DEM quantitatively and with complete stereoselectivity ($Z/E > 99{:}1$);[7] this latter catalyst is also known to catalyse the intermolecular cyclopropanation of styrenes with EDA.[8] A simple ruthenium(II) phosphine complex, $[RuCl_2(PPh_3)_3]$, has also been used in the carbene dimerisation, though the Z/E selectivity with this catalyst was found to be dependent on the reaction conditions employed (concentration, catalyst/diazo substrate, solvent).[9] More recently, $[Ru(2,6\text{-}Cl_2TPP)CO]$ (TTP = 5,10,15,20-tetraphenyl porphyrin) complex has been used in the coupling of diazoacetates to give coupling products in 61–93% yields and with complete *cis* selectivity.[4a] Aside from these catalysts, transition-metal complexes of nickel,[10] copper,[11] iridium,[12] tantalum,[13] chromium[14] and rhenium[15] have also been shown to effect the coupling of α-diazocarbonyl compounds.

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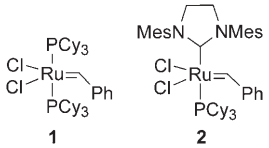
Another powerful olefin bond-forming reaction proceeding via metallocarbenes is olefin metathesis.[16] The process has become synthetically significant after the development of highly active (pre)catalysts, particularly Grubbs first- and second-generation ruthenium carbenes, **1**[17] and **2**,[18] respectively, which allow the chemistry to proceed under mild conditions with high stereoselectivity, and which also exhibit wide-ranging functional-group compatibility. We were interested in determining whether such catalysts (which can be synthesised from α-diazo compounds),[17,19] would be able to dimerise diazo compounds in a stereoselective manner and, if so, whether the propensity to catalyse alkene metathesis would be retained. Here we detail our studies on the ability of the Ru-carbene complex **2** to fulfil such a dual catalytic role in carbene dimerisation and olefin metathesis in a one-pot process.[20]



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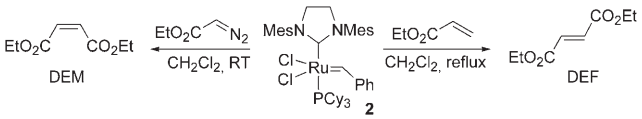
Results and Discussion

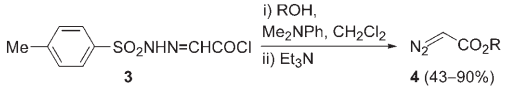
Initially, Grubbs catalyst **2** (0.5 mol%) was found to catalyse the homocoupling of EDA under mild conditions to give mainly DEM.[20] In stark contrast, *trans*-2-ene-1,4-dicarbonyl compounds are known to be generated from α,β-unsaturated carbonyl compounds by olefin metathesis in the presence of catalyst **2** (5 mol%) (Scheme 2).[21]



Scheme 2. Diazo coupling and olefin metathesis[21] in the presence of catalyst **2**.

On comparing catalysts **1** and **2**, the second-generation catalyst **2** (0.5 mol%, 12–14 h, room temperature) was observed to be superior for the diazo coupling, with high control over stereoselectivity (95% isolated yield of DEM obtained, 98:2 *Z*/*E* stereoselectivity determined by GCMS of the crude reaction mixture). In comparison, the first-generation catalyst **1** (0.5 mol%, room temperature), although highly active (EDA was consumed within 1.5 h), gave only a 73% isolated yield of DEM, with poor stereoselectivity (*Z*/*E* 83:17). With reduced or higher loadings of catalyst **2** (0.1 or 5 mol%) the stereoselectivity during the carbene dimerisation was unaffected, but the latter reaction now took 72 h to reach completion (and the former had not completed by that time).

To examine the scope of catalyst **2** in the homocoupling of diazoacetates to give *cis*-olefins, a range of diazoacetates **4** were studied (Scheme 3). The diazoacetates **4** were straightforwardly prepared by esterification of glyoxylic acid

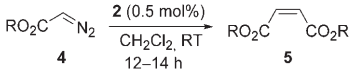


Scheme 3. Synthesis of α-diazoacetates **4**.

chloride tosylhydrazone (**3**)[22] with various alcohols in the presence of *N,N*-dimethylaniline, followed by base-induced diazo-group generation.[23]

With α-diazoacetates **4** in hand we tested the generality of the dimerisation ability of catalyst **2**. Pleasingly, conversion to olefins **5** always occurred in high yields and with high stereoselectivity for *cis*-olefins, which were isolated as single *Z* isomers after chromatography (Table 1). Typically the unsaturated diesters **5** were formed with ≥94:6 *Z*/*E* stereoselectivity, although *n*-butyl diazoacetate reproducibly gave an anomalously low stereoselectivity (entry 3). Given the stereoselectivity observed for *n*-propyl and *n*-hexyl diazoacetates (95:5 and 94:6, respectively, entries 2 and 4), there is no obvious explanation for the reduced stereocontrol with *n*-butyl diazoacetate. No significant stereochemical dependence on ester group size was apparent, although the most hindered ester examined (*tert*-butyl diazoacetate) intriguingly gave the highest level of *cis* selectivity (>99:1, entry 10).

Table 1. Maleates **5** from α-diazoacetates **4** in the presence of catalyst **2**.



Entry	R		Yield [%]		*Z*/*E*[a]
1	ethyl	**4a**	95	**5a**	98:2
2	*n*-propyl	**4b**	84	**5b**	95:5
3	*n*-butyl	**4c**	74	**5c**	86:14
4	*n*-hexyl	**4d**	98[b]	**5d**	94:6
5	benzyl	**4e**	79	**5e**	97:3
6	neopentyl	**4f**	79	**5f**	97:3
7	isopropyl	**4g**	95	**5g**	97:3
8	cyclohexyl	**4h**	82	**5h**	95.5:4.5
9	adamantan-2-yl	**4i**	75	**5i**	95:5
10	*tert*-butyl	**4j**	quant.	**5j**	>99:1

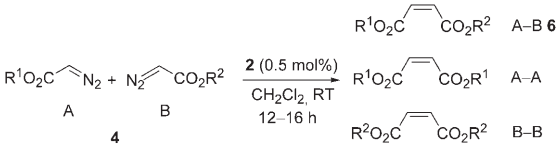
[a] Determined by GCMS on the crude product. [b] Chromatographically inseparable isomeric mixture.

Unsymmetrical maleates are of interest as they have been used to modify poly(vinyl chloride) to induce freeze-resistance properties[24] and they exhibit sex pheromone activity comparable to that of disparlure,[25] whilst chiral, unsymmetrical maleates can induce high asymmetric induction in Diels–Alder reactions.[26] In addition, they have found use in synthetic lubricating oils.[27] Therefore, after having established the ability of catalyst **2** to catalyse the homocoupling of diazoacetates, we were intrigued to see whether the catalyst would be able to induce heterocoupling between two different α-diazoacetates to generate such unsymmetrical *cis*-2-ene-1,4-diesters.[28] In connection with this concept, the formation of unsymmetrical *cis*-2-ene-1,4-diones by heterocoupling of two different α-diazoketones had previously been examined by Del Zotto et al.;[29] symmetrical and un-

symmetrical *cis*-enediones were formed in ratios close to those expected statistically (1:1:2).

A solution of α-diazoacetates (in a 1:1 molar ratio) in CH_2Cl_2 was treated with catalyst **2** (0.5 mol%) at room temperature (Table 2). After 12–16 h, the starting diazoacetates had been completely consumed and the only products observed were symmetrical (A–A/B–B) and unsymmetrical (A–B) maleates **6** arising from homo- and heterocoupling, respectively. The heterocoupling proceeded highly stereoselectively to give predominantly maleates, with the proportion of fumarates never comprising more than 3% of the *Z*/*E* mixture. Because of the high reactivity of α-diazoacetates towards catalyst **2**, symmetrical (A–A/B–B) and unsymmetrical (A–B) maleates **6** were in most cases formed in molar ratios close to the statistically expected 1:1:2 (entries 6–12), although unsymmetrical maleates were formed in higher than statistical ratios during heterocoupling between diazoacetates bearing significantly sterically different alkyl groups (entries 1–4). In several cases, the unsymmetrical maleates **6** were cleanly isolated from the mixtures (of symmetrical and unsymmetrical maleates) by column chromatography (entries 2–6 and 9), thus providing a synthetic route to such compounds.

Table 2. Unsymmetrical maleates **6** from α-diazoacetates in the presence of catalyst **2**.

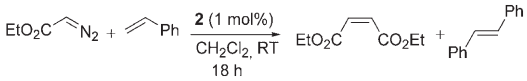


Entry	R^1	R^1	A–B [%][a]		Z/E[b]
1	ethyl	benzyl	63	**6a**	98:2
2	ethyl	isopropyl	53[c]	**6b**	98:2
3	ethyl	cyclohexyl	67[d]	**6c**	99:1
4	ethyl	*tert*-butyl	55[e]	**6d**	>99:1
5	ethyl	adamantan-2-yl	46[f]	**6e**	>99:1
6	cyclohexyl	benzyl	52[g]	**6f**	>99:1
7	cyclohexyl	isopropyl	52	**6g**	>99:1
8	cyclohexyl	adamantan-2-yl	48	**6h**	>99:1
9	*tert*-butyl	benzyl	50[h]	**6i**	97:3
10	*tert*-butyl	isopropyl	50	**6j**	>99:1
11	*tert*-butyl	cyclohexyl	50	**6k**	>99:1
12	*tert*-butyl	adamantan-2-yl	50	**6l**	97:3

[a] Determined by ^{1}H NMR spectroscopy and GCMS of the crude product. [b] Determined by GCMS of the crude product. [c] 42% isolated. [d] 57% isolated. [e] 42% isolated. [f] 44% isolated. [g] 50% isolated. [h] 45% isolated.

The more substituted α-diazoester ethyl 2-diazopropanoate[30] was found to be stable to catalyst **2** at room temperature (12 h), but decomposed to unidentified products at reflux (CH_2Cl_2, 12 h). However, the dicarbonyl-stabilised ethyl 2-diazoacetoacetate[31] was stable to catalyst **2**, even under typical metathesis conditions (5 mol% **2**, CH_2Cl_2, reflux, 14–18 h). We have exploited this finding elsewhere to carry out chemoselective cross-metathesis in the presence of such stabilised diazo functionalities.[32]

Having determined the ability of catalyst **2** to couple α-diazoacetates efficiently, it was of interest to study whether the catalyst could catalyse carbene transfer from α-diazoesters to olefins. A 1:1 mixture of EDA and styrene (190 mM in CH_2Cl_2) was treated with catalyst **2** (1 mol%) at room temperature. After 18 h, the only products observed were DEM (98%, with traces of DEF, 2%) and *trans*-stilbene (≈33%) arising from homocoupling of EDA and homo-metathesis of styrene, respectively (Scheme 4). When the reaction mixture was concentrated at ≈50 °C prior to chromatography, the remaining styrene was also converted into *trans*-stilbene (isolated in quantitative yield, along with 95% of DEM). The above studies suggest that a source of metathetically active catalyst was still present in the reaction mixture, catalysing the homo-metathesis of styrene. This was intriguing, implying that the catalyst is capable of catalysing two different carbene transformations in the same flask, without any crossover.[33] Interestingly, no products arising from the cyclopropanation of styrene by EDA were observed. With use either of slow (syringe pump) addition of EDA or of an increased amount of styrene (2 equiv), again no cyclopropanation was observed. Upon ^{1}H NMR spectroscopic monitoring of the reaction over 18 h, EDA was found to react relatively rapidly (50% consumed in 1 h; Figure 1a) to give mainly DEM (95% isolated yield, *Z*/*E* 98:2), whereas the metathesis of styrene to give *trans*-stilbene proceeded more gradually (Figure 1b; in the absence of EDA, catalyst **2** (0.5 mol%) converts styrene quantitatively into *trans*-stilbene within 18 h at room temperature, Figure 1c).



Scheme 4. Homocoupling of EDA and styrene by using catalyst **2**.

In order to examine further the ability of catalyst **2** to catalyse both carbene dimerisation and alkene metathesis, we considered how the catalyst might behave if both diazo and olefin functionalities were present in the same substrate. Representative unsaturated α-diazoacetates **7** were prepared by the procedure described above for the synthesis of α-diazoacetates **4**, but with use of unsaturated alcohol components (Scheme 5).

With unsaturated α-diazoacetates **7**, the catalyst **2** might potentially induce: i) intra- or intermolecular cyclopropana-

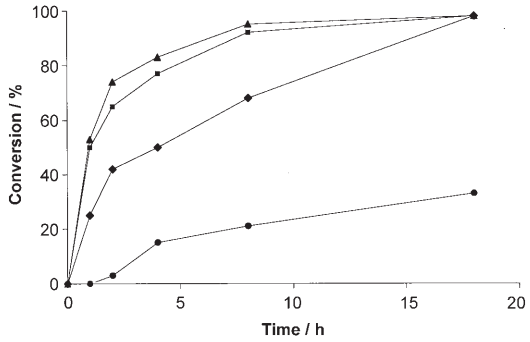
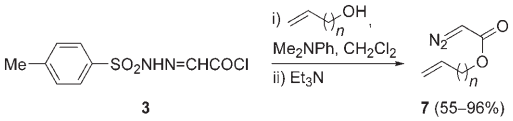
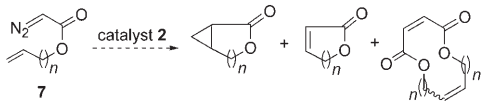


Figure 1. Conversion rates for homocoupling of EDA (1 equiv) and styrene (1 equiv) in the presence of **2**: a) ▲ homocoupling of EDA in the presence of styrene on treatment with **2** (1 mol%), b) ● metathesis of styrene in the presence of EDA on treatment with **2** (1 mol%), c) ◆ homo-metathesis of styrene in the absence of EDA on treatment with **2** (0.5 mol%), and d) ■ homocoupling of EDA in the absence of styrene on treatment with **2** (0.5 mol%).



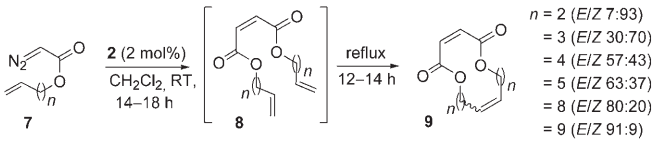
Scheme 5. Synthesis of unsaturated α-diazoacetates **7** ($n=2$–9).

tion[34] to give medium-sized cyclopropane-fused lactones and/or ii) heterocoupling between the diazo and olefin functionalities[35] to give medium-sized unsaturated lactones and/or iii) two independent carbene transformations in the same flask to give macrocyclic dilactones (Scheme 6).



Scheme 6. Possible carbene transformations of unsaturated diazoacetates **7**.

In the event, on mixing the unsaturated diazoacetates **7** with catalyst **2** (1 mol%) at room temperature, we observed that formation of the maleate **8** was complete after 14–18 h in all cases and that ring-closing metathesis to generate macrocyclic dilactones **9** had proceeded to variable extents depending on the ring size (**8**/**9** = 52:48 for the 12-membered ring, 91:9 for the 14-membered ring, 29:71 for the 16-membered ring, and **9** not detected for 18–26-membered rings after this time). To expedite ring-closing metathesis, an additional 1 mol% of catalyst **2** was added and the reaction mixture was heated to reflux to give macrocyclic dienyl dilactones **9** (Scheme 7). As was to be expected from our above studies, only *Z* stereochemistry was seen in the 2-ene-1,4-dicarbonyl fragment, whereas *Z*/*E* mixtures (the ratios varied with the ring size, Scheme 7) were obtained during the ring-closing metathesis step. *cis*-Alkenes were preferentially



Scheme 7. Macrocyclic dilactones **9** from head-to-head carbene dimerisation.

formed in the cases of 12- and 14-membered dilactones, whereas the *trans* stereochemistry was favoured for larger (16–26-membered) rings. No products arising from heterocoupling of the diazo and olefin functionality were observed.

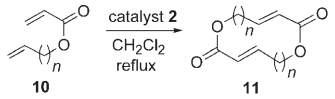
At an initial substrate concentration of 60–70 mM, macrocycle formation to form 12- and 14-membered rings was most effective (45–55%, Table 3, entries 1 and 2) in relation to larger rings (20–38%, entries 3–6). Reducing the initial concentration (to 30 mM) resulted in significant improvements only for 16- and 24-membered rings (entries 7 and 9) in relation to 18- and 26-membered rings (entries 8 and 10). We then attempted the intermolecular carbene dimerisation under the initial concentration conditions (70 mM), but the (majority of the) intramolecular ring-closing metathesis under more dilute conditions (5 mM, based on **7**). On decreasing the concentration for the metathesis step, we observed efficient macrocycle formation for 12-, 16-, 18- and 26-membered rings (entries 11, 13, 14 and 16) in relation to the 14- and 24-membered ring (entries 12 and 15).

Table 3. Formation of macrocycles **9** from head-to-head carbene dimerisation.

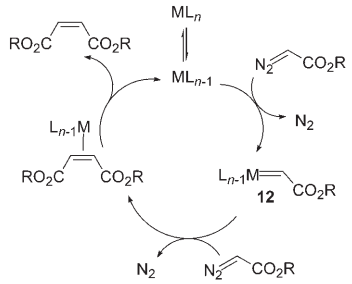
Entry	n		Concn [mM]	Yield [%]	
1	2	**7a**	60–70	45	**9a**
2	3	**7b**	60–70	53	**9b**
3	4	**7c**	60–70	22	**9c**
4	5	**7d**	60–70	25	**9d**
5	8	**7e**	60–70	24	**9e**
6	9	**7f**	60–70	38	**9f**
7	4	**7c**	30	42	**9c**
8	5	**7d**	30	27	**9d**
9	8	**7e**	30	48	**9e**
10	9	**7f**	30	25	**9f**
11	2	**7a**	70→5	49	**9a**
12	3	**7b**	70→5	38	**9b**
13	4	**7c**	70→5	43	**9c**
14	5	**7d**	70→5	42	**9d**
15	8	**7e**	70→5	26	**9e**
16	9	**7f**	70→5	55	**9f**

The above studies can be contrasted with those of Fürstner and of Grubbs, who had previously obtained homo-dimeric lactones **11** by 'head-to-tail' dimerisation of unsaturated acrylates **10** (Scheme 8).[36]

The generally accepted reaction pathway for transition-metal catalysed carbene dimerisation of diazoacetates invokes initial attack of the diazoacetate at the metal centre to generate an ester carbene **12** (Scheme 9). Nucleophilic



Scheme 8. Head-to-tail dimerisation of unsaturated acrylates **10**.



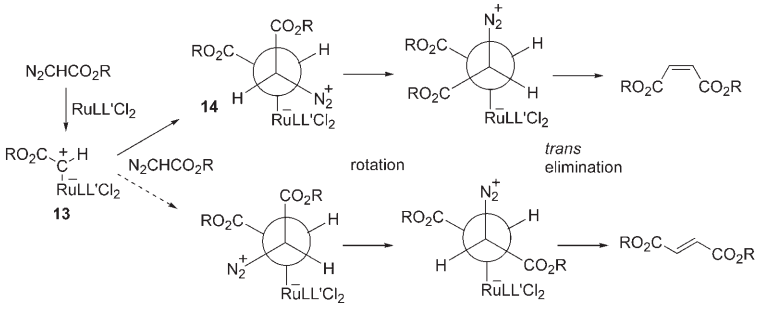
Scheme 9. An outline reaction pathway for the metal-catalysed homocoupling of diazoacetates.

attack on the ester carbene by diazoacetate, followed by dissociation of maleate from the metal complex, completes the catalytic cycle.[1]

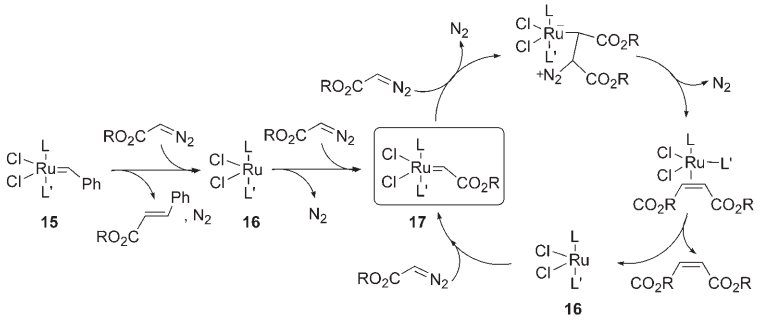
The origin of *cis* selectivity during the (copper-catalysed) coupling of α-diazo compounds has been interpreted by Nagai[11] and Wulfman.[37] on the basis of steric and electronic effects. In analogy with these suggestions, nucleophilic attack of diazoacetate on the metallocarbene **13** could preferentially proceed via an intermediate conformer **14** (Scheme 10), in which steric repulsions are minimised (H rather than N_2^+ placed in the most crowded position between ester and catalyst moieties), whilst the opposite charges (at diazonium and metal) stabilise each other. Rotation and subsequent *trans* elimination gives a *cis*-olefin.

We decided to probe the reaction pathway of dimerisation of EDA with Grubbs' catalysts in more detail. When EDA was treated with PCy_3 (0.5 mol%), no DEM or DEF was observed. However, when catalyst **2** was subsequently added to this reaction mixture, carbene dimerisation started, but rather slowly (even after 40 h, 35% of unreacted EDA was still present) in relation to the situation when no additional phosphine was added (Figure 1d). These observations suggest that phosphine dissociation is an important step in the carbene dimerisation pathway,[7,29] as it is in metathesis.[16] During our initial studies, we did not observe any formation of ethyl cinnamate in the reaction of EDA in the presence of Grubbs' catalyst **2**, implying that the diazo coupling might proceed via a biscarbene.[20] However, when a solution of EDA (1.1 equiv) in $CDCl_3$ was added slowly to a solution of catalyst **1**[38] (1 equiv) in $CDCl_3$, formation of ethyl cinnamate[39] along with a phosphine complex was observed on following the reaction by ^{1}H NMR spectroscopy. On treatment of this mixture with excess EDA, instant evolution of nitrogen and formation of DEM and DEF ($Z/E \approx 83{:}17$, determined by ^{1}H NMR spectroscopy) was observed in the same ratio as that obtained with catalyst **1**, when used catalytically. When the dimerisation of EDA in the presence of catalyst **1** (Ru=CH; $\delta_H = 19.76$ ppm in $CDCl_3$) was studied at low temperature (−55 °C) in $CDCl_3$, the reaction was found to proceed via a new carbene (Ru=CH; $\delta_H = 19.56$ ppm in $CDCl_3$). From the above observations, we propose a catalytic cycle modified from that outlined earlier[20] to account for the observations concerning diazo coupling and metathesis in the one-pot approach (Scheme 11).

Initial attack of diazoacetate on the benzylidene (pre)catalyst **15** generates carbene-free Ru^{II} complex **16** with the evolution of nitrogen and cinnamate. Further attack of diazoacetate on **16** generates an ester carbene **17**, which is suggested as the key intermediate catalysing the diazo coupling, similarly to other ester carbenes proposed for this type of process in the literature.[4,5,6,7b,29,40] Ru–ester carbenes (of the type $[Cl_2(PR_3)_2Ru{=}CHCO_2R']$) are known to be unstable species (the stabilities of which vary with the alkyl groups), but they are reported to be very active initiators during olefin metathesis,[19,41] thus explaining the ability



Scheme 10. Origin of *cis* selectivity in dimerisation of α-diazoacetates.



Scheme 11. Proposed catalytic cycle for diazo coupling in the presence of Ru carbenes **1** and **2**.

of carbene-based Grubbs catalysts to catalyse diazo coupling and metathesis in the same flask.[42]

Conclusion

In summary, our results demonstrate the ability of Grubbs second-generation Ru carbene complex to catalyse the coupling of diazoacetates with high stereoselectivity to give *cis*-olefins under mild conditions (room temperature, low catalyst loading). This study, together with those reported earlier by Grubbs and by Fürstner, highlight the versatility of the catalyst for the synthesis of olefins with both *cis* and *trans* geometries through diazo coupling and cross-metathesis, respectively. In the presence of additional alkene functionality, inter-/intramolecular cyclopropanation is not observed but rather metathetical activity is retained, and has been exploited with unsaturated diazoacetates to generate dienyl dilactones by head-to-head diazo coupling followed by ring-closing metathesis.

Experimental Section

General remarks: All reactions were performed under argon in flame-dried glassware. CH_2Cl_2 was degassed and dried over alumina under argon.[43] Reactions were monitored by TLC on commercially available aluminium plates precoated with silica (0.25 mm, Merck 60 F_{254}), which were developed by standard visualising techniques: UV fluorescence (254 nm) and/or potassium permanganate solution, followed by heating. Flash chromatography was performed on Kieselgel 60 (40–63 μm). Petrol refers to petroleum spirit (b.p. 30–40 °C). ^{1}H and ^{13}C NMR spectra were recorded in $CDCl_3$ with Bruker DPX 200 (200 MHz), AV 400 (400 MHz) or AV 500 (500 MHz) spectrometers. Chemical shifts (δ) are reported in ppm relative to residual $CHCl_3$ (^{1}H NMR spectroscopy: $\delta = 7.26$ ppm), or $CDCl_3$ (^{13}C NMR spectroscopy $\delta = 77.4$ ppm). The multiplicity of each signal is designated by the following abbreviations: s, singlet; d, doublet; dd, doublet of doublets; t, triplet. Coupling constants (J) are reported in Hz. For ^{13}C NMR spectra, because of long relaxation times, N_2CHCO_2 and N_2CH were observed as broad signals only in concentrated samples. IR were recorded as thin films on NaCl plates or KBr discs, on a Bruker Tensor 27 FTIR spectrophotometer; peaks are quoted as ν_{max} in cm^{-1}. Bands are characterised as broad (br), strong (s), medium (m) or weak (w). Mass spectra were obtained by the EPSRC National Mass Spectrometry Service at the University of Swansea, on a Micromass Quattro II low-resolution triple quadrupole mass spectrometer by CI. GCMS were obtained on a Micromass GCT by CI.

Synthesis of diazoacetates

General procedure: ***n*-propyl diazoacetate (4b)**: A solution of glyoxylic acid chloride *p*-toluenesulfonylhydrazone (**3**)[22] (2.20 g, 8.46 mmol) in CH_2Cl_2 (10 mL) was added to an ice-cooled solution of *n*-propanol (450 μL, 6.03 mmol) in CH_2Cl_2 (10 mL). *N*,*N*-Dimethylaniline (1.60 mL, 12.6 mmol) was added and the mixture was stirred for 30 min at 0 °C, followed by the addition of freshly distilled Et_3N (4.50 mL, 32.3 mmol). The resulting mixture was stirred for 30 min at 0 °C and 1 h at room temperature, followed by the addition of water (15 mL). The mixture was concentrated under reduced pressure. Saturated aqueous citric acid (25 mL) was added and the aqueous layer was extracted with EtOAc in hexane (10%, 3×30 mL). The combined organics were washed with saturated aqueous citric acid (3×30 mL), dried (Na_2SO_4), concentrated under reduced pressure and purified by flash chromatography (5% Et_2O in petrol) to afford the diazoacetate **4b** (524 mg, 68%) as a yellow oil. $R_f = 0.51$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 4.74$ (br s, 1H; CHN_2), 4.13 (t, ^3J(H,H) = 6.7 Hz, 2H; OCH_2), 1.72–1.63 (m, 2H; OCH_2CH_2), 0.95 ppm (t, ^3J(H,H) = 7.4 Hz, 3H; CH_3); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.9$ (CO_2), 66.4 (OCH_2), 46.1 (CHN_2), 22.2 (OCH_2CH_2), 10.3 ppm (CH_3); IR (neat): $\tilde{\nu} = 2972$ (s), 2113 (C=N$_2$, s), 1694 (C=O, s), 1462 (m), 1401 (s), 1361 cm^{-1} (s); MS (FI): *m*/*z* (%): 128 $[M]^+$ (100), 129 $[M+H]^+$ (5), 198 (75); HRMS: *m*/*z*: calcd for $C_5H_8N_2O_2$: 128.0586 $[M]^+$; found: 128.0581.

***n*-Butyl diazoacetate (4c)**: This compound was prepared by the general procedure with use of *n*-butanol (440 μL, 4.81 mmol). The residue was purified by flash chromatography (10% Et_2O in petrol) to afford the diazoacetate **4c** (611 mg, 89%) as a yellow oil. $R_f = 0.47$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 4.74$ (br s, 1H; CHN_2), 4.16 (t, ^3J(H,H) = 6.7 Hz, 2H; OCH_2), 1.66–1.59 (m, 2H; OCH_2CH_2), 1.43–1.34 (m, 2H; CH_3CH_2), 0.94 ppm (t, ^3J(H,H) = 7.4 Hz, 3H; CH_3); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.9$ (CO_2), 64.7 (OCH_2), 46.2 (CHN_2), 30.8 (OCH_2CH_2), 19.1 (CH_3CH_2), 13.7 ppm (CH_3); IR (neat): $\tilde{\nu} = 2962$ (m), 2112 (C=N$_2$, s), 1694 (C=O, s), 1398 (m), 1364 cm^{-1} (m); MS (FI): *m*/*z* (%): 142 $[M]^+$ (100), 143 $[M+H]^+$ (3); HRMS: *m*/*z*: calcd for $C_6H_{10}N_2O_2$: 142.0742 $[M]^+$; found: 142.0737.

***n*-Hexyl diazoacetate (4d)**: This compound was prepared by the general procedure with use of *n*-hexanol (0.80 mL, 6.37 mmol). The residue was purified by flash chromatography (5% Et_2O in petrol) to afford the diazoacetate **4d** (830 mg, 77%) as a yellow oil. $R_f = 0.52$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 4.74$ (br s, 1H; CHN_2), 4.16 (t, ^3J(H,H) = 6.7 Hz, 2H; OCH_2), 1.67–1.59 (m, 2H; OCH_2CH_2), 1.38–1.25 (m, 6H; 3×CH_2), 0.91–0.88 ppm (m, 3H; CH_3); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.9$ (CO_2), 65.0 (OCH_2), 46.1 (CHN_2), 31.4, 28.7, 25.5 + 22.5 (4×CH_2), 13.9 ppm (CH_3); IR (neat): $\tilde{\nu} = 2958$ (s), 2111 (C=N$_2$, s), 1698 (C=O, s), 1468 (m), 1398 (s), 1361 cm^{-1} (s); MS (FI): *m*/*z* (%): 170 $[M]^+$ (100), 171 $[M+H]^+$ (15); HRMS: *m*/*z*: calcd for $C_8H_{14}N_2O_2$: 170.1055 $[M]^+$; found: 170.1053.

Benzyl diazoacetate (4e): This compound was prepared by the general procedure with use of benzyl alcohol (0.65 mL, 6.29 mmol). The residue was purified by flash chromatography (10% Et_2O in petrol) to afford the diazoacetate **4e** (1.00 g, 90%) as a yellow oil. $R_f = 0.45$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 7.42$–7.30 (m, 5H; Ar), 5.22 (s, 2H; CH_2), 4.80 ppm (br s, 1H; CHN_2); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.7$ (CO_2), 135.8 (Ar, quart.), 128.6, 128.3 + 128.2 (3×Ar), 66.5 (CH_2), 46.4 ppm (CHN_2); IR (neat): $\tilde{\nu} = 2113$ (C=N$_2$, s), 1694 (C=O, s), 1498 (w), 1391 cm^{-1} (s); MS (FI): *m*/*z* (%): 131 (15), 176 $[M]^+$ (100), 177 $[M+H]^+$ (12); HRMS: *m*/*z*: calcd for $C_9H_8N_2O_2$: 176.0586 $[M]^+$; found: 176.0591.

Neopentyl diazoacetate (4f): This compound was prepared by the general procedure with use of neopentanol (1.00 mL, 9.29 mmol). The residue was purified by flash chromatography (5% Et_2O in petrol) to afford the diazoester **4f** (1.10 g, 76%) as a yellow oil. $R_f = 0.48$ (20% ether in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 4.76$ (br s, 1H; CHN_2), 3.87 (s, 2H; CH_2), 0.95 ppm (s, 9H; CMe_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 73.9$ (CH_2), 46.1 (CHN_2), 31.5 (CMe_3), 26.4 ppm (CMe_3); IR (neat): $\tilde{\nu} = 3125$ (w), 2113 (C=N$_2$, s), 1699 (C=O, s), 1384 (s), 1248 cm^{-1} (s); MS (FI): *m*/*z* (%): 156 $[M]^+$ (100), 157 $[M+H]^+$ (12); HRMS: *m*/*z*: calcd for $C_7H_{12}N_2O_2$: 156.0899 $[M]^+$; found: 156.0900.

Isopropyl diazoacetate (4g): This compound was prepared by the general procedure with use of isopropanol (450 μL, 5.95 mmol). The residue was purified by flash chromatography (5% Et_2O in petrol) to afford the diazoacetate **4g** (325 mg, 43%) as a yellow oil. $R_f = 0.47$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.09$ (heptet, ^3J(H,H) = 6.3 Hz, 1H; OCH), 4.71 (br s, 1H; CHN_2), 1.26 ppm (d, ^3J(H,H) = 6.3 Hz, 6H; 2×CH_3); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.5$ (CO_2), 68.4 (OCH), 46.3 (CHN_2), 22.0 ppm (2×CH_3); IR (neat): $\tilde{\nu} = 2110$ (C=N$_2$, s), 1652 (C=O, s), 1379 (m), 1329 cm^{-1} (m); MS (FI): *m*/*z* (%): 128 $[M]^+$ (100), 129 $[M+H]^+$ (5); HRMS: *m*/*z*: calcd for $C_5H_8N_2O_2$: 128.0586 $[M]^+$; found: 128.0584.

Cyclohexyl diazoacetate (4h): This compound was prepared by the general procedure with use of cyclohexanol (0.50 mL, 4.73 mmol). The residue was purified by flash chromatography (5% Et_2O in petrol) to afford the diazoacetate **4h** (673 mg, 84%) as a yellow oil. $R_f = 0.57$ (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 4.90$–4.78 (m, 1H;

OCH), 4.74 (brs, 1H; CHN_2), 1.98–1.20 ppm (m, 10H; $5\times CH_2$); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.4$ (CO_2), 73.2 (OCH), 46.3 (CHN_2), 31.8, 25.3 + 23.7 ppm ($3\times CH_2$); IR (neat): $\tilde{\nu} = 2939$ (s), 2110 (C=N_2, s), 1690 (C=O, s), 1451 (m), 1378 cm^{-1} (s); MS (FI): *m/z* (%): 168 $[M]^+$ (100), 169 $[M+H]^+$ (15); HRMS: calcd for $C_8H_{12}N_2O_2$: 168.0899 $[M]^+$; found: 168.0901.

Adamantan-2-yl diazoacetate (4i): This compound was prepared by the general procedure with use of adamantan-2-ol (1.20 g, 7.88 mmol). The residue was purified by flash chromatography (10% Et_2O in petrol) to afford the diazoacetate **4i** (1.33 g, 77%) as a yellow oil. $R_f = 0.57$ (30% Et_2O in petrol); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.10$ (t, $^3J(H,H) = 3.3$ Hz, 1H; OCH), 4.74 (brs, 1H; CHN_2), 2.03–1.96 (m, 4H; $2\times CH_2$), 1.87–1.74 (m, 8H; $2\times$CH, $3\times CH_2$), 1.61–1.54 ppm (m, 2H; $2\times$CH); ^{13}C NMR (125 MHz, $CDCl_3$, 25 °C): $\delta = 166.2$ (CO_2), 77.5 (OCH), 46.3 (CHN_2), 37.3, 2×36.3 + 2×31.7 ($5\times CH_2$), 2×32.0, 27.2 + 26.9 ppm ($4\times$CH); IR (neat): $\tilde{\nu} = 2977$ (w), 2910 (s), 2858 (s), 2112 (C=N_2, s), 1692 (C=O, s), 1452 (s), 1375 (s), 1333 (s), 1248 (s), 1190 cm^{-1} (s); MS (FI): *m/z* (%): 220 (M, 100), 221 $[M+H]^+$ (18); HRMS: *m/z*: calcd for $C_{12}H_{16}N_2O_2$: 220.1212 $[M]^+$; found: 220.1204.

But-3-enyl diazoacetate (7a): This compound was prepared by the general procedure with use of but-3-en-1-ol (0.25 mL, 2.91 mmol). The residue was purified by flash chromatography (5% EtOAc in hexane) to afford the diazoester **7a** (223 mg, 55%) as a yellow oil. Data as lit.[44]

Pent-4-enyl diazoacetate (7b): This compound was prepared by the general procedure with use of pent-4-en-1-ol (1.10 mL, 10.7 mmol). The residue was purified by flash chromatography (5% EtOAc in hexane) to afford the diazoester **7b** (1.04 g, 63%) as a yellow oil. $R_f = 0.14$ (10% EtOAc in hexane); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.88$–5.74 (m, 1H; =CH), 5.08–4.96 (m, 2H; $=CH_2$), 5.74 (brs, 1H; CHN_2), 4.16 (t, $^3J(H,H) = 6.6$ Hz, 2H; OCH_2), 2.18–2.06 (m, 2H; CH_2), 1.80–1.68 ppm (m, 2H; CH_2); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 137.4$ (=CH), 115.3 ($=CH_2$), 64.3 (OCH_2), 46.1 (CHN_2), 29.9 + 27.9 ppm ($2\times CH_2$); IR (neat): $\tilde{\nu} = 2956$ (s), 2113 (C=N_2, s), 1697 (C=O, s), 1450 (s), 1398 (s), 1242 (s), 1187 cm^{-1} (s); MS (FI): *m/z* (%): 154 $[M]^+$ (52), 155 $[M+H]^+$ (50), 170 (100); HRMS: *m/z*: calcd for $C_7H_{10}N_2O_2$: 154.0742 $[M]^+$; found: 154.0742.

Hex-5-enyl diazoacetate (7c): This compound was prepared by the general procedure with use of hex-5-en-1-ol (0.95 mL, 7.92 mmol). The residue was purified by flash chromatography (5% EtOAc in hexane) to afford the diazoacetate **7c** (1.20 g, 90%) as a yellow oil. $R_f = 0.34$ (10% EtOAc in hexane); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.82$–5.68 (m, 1H; =CH), 5.06–4.90 (m, 2H; $=CH_2$), 4.74 (brs, 1H; CHN_2), 4.16 (t, $^3J(H,H) = 6.7$ Hz, 2H; OCH_2), 2.16–1.96 (m, 2H; $=CHCH_2$), 1.76–1.56 (m, 2H; OCH_2CH_2), 1.56–1.36 ppm (m, 2H; $OCH_2CH_2CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 138.3$ (=CH), 114.8 ($=CH_2$), 64.7 (OCH_2), 46.1 (CHN_2), 33.2, 28.2 + 25.1 ppm ($3\times CH_2$); IR (neat): $\tilde{\nu} = 2938$ (s), 2111 (C=N_2, s), 1696 (C=O, s), 1243 (s), 1186 cm^{-1} (s); MS (FI): *m/z* (%): 168 $[M]^+$ (25%), 169 $[M+H]^+$ (100); HRMS: *m/z*: calcd for $C_8H_{13}N_2O_2$: 169.0977 $[M+H]^+$; found: 169.0973.

Hept-6-enyl diazoacetate (7d): This compound was prepared by the general procedure with use of hept-6-en-1-ol (1.27 g, 11.1 mmol). The residue was purified by flash chromatography (5% EtOAc in hexane) to afford the diazoester **7d** (1.90 g, 94%) as a yellow oil. $R_f = 0.34$ (20% EtOAc in hexane); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.88$–5.72 (m, 1H; =CH), 4.90–5.06 (m, 2H; $=CH_2$), 4.73 (brs, 1H; CHN_2), 4.16 (t, $^3J(H,H) = 6.7$ Hz, 2H; OCH_2), 2.06 (q, $^3J(H,H) = 7.0$ Hz, 2H; $=CHCH_2$), 1.69–1.62 (m, 2H; OCH_2CH_2), 1.48–1.30 ppm (m, 4H; $2\times CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 138.6$ (=CH), 114.5 ($=CH_2$), 64.9 (OCH_2), 46.1 (CHN_2), 33.5 ($=CHCH_2$), 28.6, 28.4 + 25.3 ppm ($3\times CH_2$); IR (neat): $\tilde{\nu} = 2933$ (s), 2111 (C=N_2, s), 1696 (C=O, s), 1398 (s), 1359 (s), 1241 (s), 1185 cm^{-1} (s); MS (FI): *m/z* (%): 121 (100), 170 (40), 169 $[M+H]^+$ (50); HRMS: *m/z*: calcd for $C_9H_{15}N_2O_2$: 183.1134 $[M+H]^+$; found: 183.1132.

Dec-9-enyl diazoacetate (7e): This compound was prepared by the general procedure with use of dec-9-en-1-ol (0.75 mL, 4.21 mmol). The residue was purified by flash chromatography (5% EtOAc in hexane) to afford the diazoester **7e** (911 mg, 96%) as a yellow oil. $R_f = 0.67$ (30% EtOAc in hexane); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.36$–5.22 (m, 1H; =CH), 5.04–4.90 (m, 2H; $=CH_2$), 4.74 (brs, 1H; CHN_2), 4.14 (t, $^3J(H,H) = 6.7$ Hz, 2H; OCH_2), 2.04 (q, $^3J(H,H) = 6.8$ Hz, 2H; $=CHCH_2$), 1.68–1.61 (m, 2H; OCH_2CH_2), 1.24–1.44 ppm (m, 10H; $5\times CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 139.2$ (=CH), 114.2 ($=CH_2$), 65.1 (OCH_2), 46.2 (CHN_2), 33.8, 29.3, 29.2, 29.0, 28.8, 28.7 + 25.8 ppm ($7\times CH_2$); IR (neat): $\tilde{\nu} = 2928$ (s), 2110 (C=N_2, s), 1697 (C=O, s), 1242 (s), 1186 cm^{-1} (s); MS (FI): *m/z* (%): 224 $[M]^+$ (8), 225 $[M+H]^+$ (100), 226 (40); HRMS: calcd for $C_{12}H_{21}N_2O_2$: 225.1603 $[M+H]^+$; found: 225.1604.

Undec-10-enyl diazoacetate (7f): This compound was prepared by the general procedure with use of undec-10-en-1-ol (1.90 mL, 9.50 mmol). The residue was purified by flash chromatography (5% EtOAc in petrol) to afford the diazoester **7f** (2.05 g, 91%) as a yellow oil. $R_f = 0.30$ (10% EtOAc in hexane); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 5.82$–5.72 (m, 2H; =CH), 4.98–4.88 (m, 2H; $=CH_2$), 4.71 (brs, 1H; CHN_2), 4.12 (t, $^3J(H,H) = 6.8$ Hz, 2H; OCH_2), 2.04–1.98 (m, 2H; $=CHCH_2$), 1.64–1.57 (m, 2H; OCH_2CH_2), 1.40–1.16 ppm (m, 12H; $6\times CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 139.0$ (=CH), 114.1 ($=CH_2$), 64.9 (OCH_2), 46.0 (CHN_2), 33.7, 29.4, 29.3, 29.2, 29.0, 28.8, 28.7 + 25.7 ppm ($8\times CH_2$); IR (neat): $\tilde{\nu} = 2927$ (s), 2110 (C=N_2, s), 1698 (C=O, s), 1241 (s), 1186 cm^{-1} (s); MS (FI): *m/z* (%): 238 $[M]^+$ (8), 239 $[M+H]^+$ (100), 308 (100); HRMS: *m/z*: calcd for $C_{13}H_{23}N_2O_2$: 239.1760 $[M+H]^+$; found: 239.1764.

Homocoupling of diazoacetates

General procedure: Grubbs second-generation catalyst **2** (0.005 equiv, 0.5 mol%) was added to a solution of the α-diazoacetate (1.0 equiv) in CH_2Cl_2. The mixture was stirred at room temperature for 12–14 h, concentrated under reduced pressure and purified by flash chromatography.[45]

Diethyl maleate (5a): This compound was prepared by the general procedure, from ethyl diazoacetate (**4a**, 0.10 mL, 0.952 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 98:2 as determined by GCMS) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **5a** (78.0 mg, 95%) as a pale-yellow liquid. Data as commercial sample.

Di-*n*-propyl maleate (5b): This compound was prepared by the general procedure, from *n*-propyl diazoacetate (**4b**, 52.0 mg, 0.406 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 95:5, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5b** (34.0 mg, 84%) as a yellow liquid. Data as commercial sample.

Di-*n*-butyl maleate (5c): This compound was prepared by the general procedure, from *n*-butyl diazoacetate (**4c**, 96.0 mg, 0.676 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 86:14, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5c** (57.0 mg, 74%) as a yellow liquid. Data as commercial sample.

Di-*n*-hexyl maleate (5d): This compound was prepared by the general procedure, from *n*-hexyl diazoacetate (**4d**, 90.0 mg, 0.529 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 94:6, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford an inseparable mixture of the *Z* and *E* isomers of **5d** (74.0 mg, 98%) as a yellow liquid. Data as commercial sample.

Dibenzyl maleate (5e): This compound was prepared by the general procedure, from benzyl diazoacetate (**4e**, 80.0 mg, 0.454 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 97:3, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5e** (53.0 mg, 79%) as a yellow liquid. $R_f = 0.31$ (30% Et_2O in petrol); ^1H NMR (400 MHz, $CDCl_3$, 25 °C): $\delta = 7.30$–7.42 (m, 10H; Ar), 6.30 (s, 2H; 2×=CH), 5.64 ppm (s, 4H; $2\times CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): $\delta = 164.9$ ($2\times CO_2$), 135.1 (2×Ar, quart.), 129.8 (2×=CH), 2× 128.6 and 128.5 (6×Ar), 67.1 ppm ($2\times CH_2$); IR (neat): $\tilde{\nu} = 1725$ (C=O, s), 1644 (C=C, s), 1498 (w), 1401 (w), 1364 cm^{-1} (w); MS (%): *m/z* (%): 297 ($[M+H]^+$,15), 314 $[M+NH_4]^+$ (100), 316 (40); HRMS: *m/z*: calcd for $C_{18}H_{20}O_4N$: 314.1387 $[M+NH_4]^+$; found: 314.1386.

Dineopentyl maleate (5f): This compound was prepared by the general procedure, from neopentyl diazoacetate (**4f**, 100 mg, 0.641 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 97:3, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5f** (65.0 mg, 79%) as a yellow oil. $R_f = 0.48$ (20% Et_2O in

petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.27 (s, 2H; 2×=CH), 3.88 (s, 4H; 2×CH_2), 0.95 ppm (s, 18H; 2×CMe_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.4 (2×CO_2), 129.7 (2×=CH), 74.6 (2×CH_2), 31.3 (2×*C*Me$_3$), 26.4 ppm (2×C*Me*$_3$); IR (neat): $\tilde{\nu}$ = 2962 (s), 1729 (C=O, s), 1646 (C=C, m), 1479 (s), 1410 (s), 1393 (s), 1368 (s), 1217 (s), 1165 cm^{-1} (s); MS (CI): *m*/*z* (%): 187 (10), 257 $[M+H]^+$ (10), 274 $[M+NH_4]^+$ (100); HRMS: *m*/*z*: calcd for $C_{14}H_{25}O_4$: 257.1753 $[M+H]^+$; found: 257.1751.

Diisopropyl maleate (5g): This compound was prepared by the general procedure, from isopropyl diazoacetate (**4g**, 54.0 mg, 0.422 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 97:3, as determeined by GCMS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **5g** (40.0 mg, 95%) as a yellow liquid. Data as lit.[46]

Dicyclohexyl maleate (5h): This compound was prepared by the general procedure, from cyclohexyl diazoacetate (**4h**, 70.0 mg, 0.417 mmol) in CH_2Cl_2 (3 mL). The residue (*Z*/*E* 95.5:4.5, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5h** (48.0 mg, 82%) as a colourless oil. Data as commercial sample.

Diadamantan-2-yl maleate (5i): This compound was prepared by the general procedure, starting from adamantan-2-yl diazoacetate (**4i**, 95.0 mg, 0.432 mmol) in CH_2Cl_2 (3 mL). The residue (*Z*/*E* 95:5, as determined by GCMS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **5i** (62.0 mg, 75%) as a yellow liquid. R_f = 0.54 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.26 (s, 2H; 2×=CH), 5.05 (t, ^3J(H,H) = 3.5 Hz, 2H; 2×OCH), 2.06–1.99 (m, 8H; 4×CH_2), 1.87–1.74 (m, 16H; 6×CH and 5×CH_2), 1.61–1.54 ppm (m, 4H; 2×CH and CH_2); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 164.8 (2×CO_2), 129.9 (2×=CH), 78.2 (2×OCH), 37.3, 2×36.3 + 2×31.6 (10×CH_2), 2×31.7, 27.2 + 26.9 ppm (8×CH); IR (neat): $\tilde{\nu}$ = 2912 (s), 2858 (s), 1719 (C=O, s), 1642 (C=C, w), 1453 (s), 1402 (s), 1382 (m), 1365 (w), 1215 (s), 1169 (s), 1101 cm^{-1} (s); MS (CI): *m*/*z* (%): 135 (40), 152 (38), 385 $[M+H]^+$ (100), 402 $[M+NH_4]^+$ (10); HRMS: *m*/*z*: calcd for $C_{24}H_{33}O_4$: 385.2379 $[M+H]^+$; found: 385.2384.

Di-*tert*-butyl maleate (5j): This compound was prepared by the general procedure, from *tert*-butyl diazoacetate (**4j**, 0.10 mL, 0.722 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* > 99:1, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **5j** (82.0 mg, quant.) as a yellow oil. R_f = 0.44 (20% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.06 (s, 2H; 2×=CH), 1.54 ppm (s, 18H; 2×CMe_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 164.5 (2×CO_2), 130.1 (2×=CH), 81.8 (2×*C*Me$_3$), 28.0 ppm (2×C*Me*$_3$); IR (neat): $\tilde{\nu}$ = 2935 (s), 1721 (C=O, s), 1642 (C=C, m), 1478 (m), 1395 (s), 1370 (s), 1217 (s), 1144 cm^{-1} (s); MS (CI): *m*/*z* (%): 190 (100), 192 (70), 229 $[M+H]^+$ (15); HRMS: *m*/*z*: calcd for $C_{12}H_{21}O_4$: 229.1434 $[M+H]^+$; found: 229.1437.

Heterocoupling of diazoacetates

General procedure: Grubbs second-generation catalyst **2** (0.005 equiv, 0.5 mol%) was added to a solution of mixture of diazoacetates (1.0 equiv each) in CH_2Cl_2. The reaction mixture was stirred at room temperature for 12–16 h, concentrated under reduced pressure and purified by flash chromatography.[45]

Ethyl isopropyl maleate (6b): This compound was prepared by the general procedure, from ethyl diazoacetate (**4a**, 36.5 mg, 0.320 mmol) and isopropyl diazoacetate (**4g**, 41.0 mg, 0.320 mmol) in CH_2Cl_2 (4.5 mL). The residue (*Z*/*E* 98:2, as determined by GCMS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **6b** (25.0 mg, 42%) as a colourless liquid. R_f = 0.44 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.22 (s, 2H; 2×=CH), 5.13 (heptet, ^3J(H,H) = 6.3 Hz, 1H; C*H*Me$_2$), 4.25 (q, ^3J(H,H) = 7.2 Hz, 2H; OCH_2), 1.36–1.26 ppm (m, 9H; 3×CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.3 + 164.8 (2×CO_2), 130.2 + 129.4 (2×=CH), 68.9 (CH), 61.2 (OCH_2), 21.7 (C*Me*$_2$), 14.0 ppm (CH_2CH_3); IR (neat): $\tilde{\nu}$ = 2980 (s), 1708 (C=O, s), 1646 (C=C, s), 1450 (m), 1390 (s), 1210 (s), 1141 cm^{-1} (s); MS (CI): *m*/*z* (%): 70 (40), 87 (38), 131 (65), 187 $[M+H]^+$ (100), 204 $[M+NH_4]^+$ (15); HRMS: *m*/*z*: calcd for $C_9H_{15}O_4$: 187.0970 $[M+H]^+$; found: 187.0977.

Ethyl cyclohexyl maleate (6c): This compound was prepared by the general procedure, from ethyl diazoacetate (**4a**, 15.0 mg, 0.131 mmol) and cyclohexyl diazoacetate (**4h**, 22.0 mg, 0.131 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* > 99:1, as determined by GCMS analysis) was purified by flash chromatography (5→10% Et_2O in petrol) to afford the maleate **6c** (17.0 mg, 57%) as a yellow liquid. R_f = 0.46 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.22 (s, 2H; 2×=CH), 4.91–4.84 (m, 1H; OCH), 4.25 (q, ^3J(H,H) = 7.1 Hz, 2H; OCH_2), 1.94–1.90 (m, 2H; CH_2 cyclohexyl), 1.77–1.72 (m, 2H; CH_2 cyclohexyl), 1.62–1.54 (m, 2H; CH_2 cyclohexyl), 1.32 (t, ^3J(H,H) = 7.1 Hz, 3H; CH_3), 1.50–1.21 ppm (m, 4H; 2×CH_2 cyclohexyl); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.3 + 164.8 (2×CO_2), 130.2 + 129.4 (2×=CH), 73.9 (OCH), 61.2 (OCH_2), 31.4, 25.3 + 23.7 (3×CH_2 cyclohexyl), 14.0 ppm (CH_3); IR (neat): $\tilde{\nu}$ = 2900 (s), 2846 (m), 1725 (C=O, s), 1640 (C=C, s), 1457 (m), 1403 (m), 1210 (s), 1164 cm^{-1} (s); MS (CI): *m*/*z* (%): 145 (53), 162 (25), 227 $[M+H]^+$ (100), 244 $[M+NH_4]^+$ (10); HRMS: *m*/*z*: calcd for $C_{12}H_{22}NO_4$: 244.1549 $[M+NH_4]^+$; found: 244.1545.

***tert*-Butyl ethyl maleate (6d)**: This compound was prepared by the general procedure, from ethyl diazoacetate (**4a**, 76.0 μL, 0.722 mmol) and *tert*-butyl diazoacetate (**4j**, 100 μL, 0.722 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* > 99:1, as determined by GCMS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **6d** (61.0 mg, 42%) as a yellow liquid. R_f = 0.35 (20% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.13 (d, ^3J(H,H) = 3.6 Hz, 2H; 2×=CH), 4.25 (q, ^3J(H,H) = 7.1 Hz, 2H; OCH_2), 1.51 (s, 9H; CMe_3), 1.31 ppm (t, ^3J(H,H) = 7.1 Hz, 3H; CH_2CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.3 + 164.4 (2×CO_2), 131.4 + 128.3 (2×=CH), 82.2 (*C*Me$_3$), 61.0 (OCH_2), 27.9 (C*Me*$_3$), 14.1 ppm (CH_2CH_3); IR (neat): $\tilde{\nu}$ = 2982 (s), 1728 (C=O, s), 1640 (C=C, s), 1458 (m), 1397 (s), 1369 (s), 1218 (s), 1151 cm^{-1} (s); MS (CI): *m*/*z* (%): 104 (30), 162 (100), 164 (85), 201 $[M+H]^+$ (35), 203 (15), 220 $[M+NH_4]^+$ (55); HRMS: *m*/*z*: calcd for $C_{10}H_{17}O_4$: 201.1121 $[M+H]^+$; found: 201.1122.

Adamantan-2-yl ethyl maleate (6e): This compound was prepared by the general procedure, from ethyl diazoacetate (**4a**, 13.0 μL, 0.123 mmol) and adamantan-2-yl diazoacetate (**4i**, 27.0 mg, 0.123 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* > 99:1, as determined by GC-MS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **6e** (15.0 mg, 44%) as a yellow liquid. R_f = 0.48 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 6.25 (d, ^3J(H,H) = 8.1 Hz, 2H; 2×=CH), 5.06 (t, ^3J(H,H) = 3.2 Hz, 1H; OCH), 4.25 (q, ^3J(H,H) = 7.1 Hz, 2H; OCH_2), 2.07–1.99 (m, 4H; 2×CH_2), 1.90–1.74 (m, 6H; 2×CH and 2×CH_2), 1.60–1.56 (m, 4H; 2×CH and CH_2), 1.31 ppm (t, ^3J(H,H) = 7.1 Hz, 3H; CH_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.4 + 164.7 (2×CO_2), 130.2 + 129.5 (2×=CH), 78.3 (OCH), 61.2 (OCH_2), 37.3, 2×36.3 + 2×31.7 (5×CH_2 adamantyl), 2×31.6, 27.1 + 26.9 (4×CH adamantyl), 14.0 ppm (CH_3); IR (neat): $\tilde{\nu}$ = 2908 (s), 2856 (m), 1728 (C=O, s), 1642 (C=C, s), 1453 (m), 1403 (m), 1209 (s), 1164 (s), 1101 cm^{-1} (w); MS (CI): *m*/*z* (%): 148 (80), 152 (20), 279 $[M+H]^+$ (100), 296 $[M+NH_4]^+$ (10); HRMS: *m*/*z*: calcd for $C_{16}H_{23}O_4$: 279.1596 $[M+H]^+$; found: 279.1592.

Benzyl cyclohexyl maleate (6f): This compound was prepared by the general procedure, from benzyl diazoacetate (**4e**, 29.4 mg, 0.167 mmol) and cyclohexyl diazoacetate (**4h**, 28.0 mg, 0.167 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* > 99:1, as determined by GCMS analysis) was purified by flash chromatography (10% Et_2O in petrol) to afford the maleate **6f** (24.0 mg, 50%) as a yellow liquid. R_f = 0.47 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 7.40–7.30 (m, 5H; Ar), 6.25 (d, ^3J-(H,H) = 6.0 Hz, 2H; 2×=CH), 5.22 (s, 2H; CH_2Ar), 4.89–4.77 (m, 1H; CH cyclohexyl), 1.91–1.83 (m, 2H; CH_2 cyclohexyl), 1.78–1.68 (m, 2H; CH_2 cyclohexyl), 1.59–1.49 (m, 2H; CH_2 cyclohexyl), 1.44–1.18 ppm (m, 4H; 2×CH_2 cyclohexyl); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.1 + 164.7 (2×CO_2), 135.2 (Ar, quart.), 131.0 (=CH), 128.7, 128.6, 128.5 + 128.4 (3×Ar, =CH), 74.1 (OCH), 67.1 (OCH_2), 31.4, 25.3 + 23.8 ppm (3×CH_2 cyclohexyl); IR (neat): $\tilde{\nu}$ = 2939 (s), 2869 (s), 1728 (C=O, s), 1643 (C=C, m), 1598 (s), 1454 (s), 1401 (m), 1365 (m), 1214 (s), 1164 (s), 1037 cm^{-1} (m); MS (CI): *m*/*z* (%): 148 (75), 289 $[M+H]^+$ (35), 306 $[M+NH_4]^+$ (100); HRMS: *m*/*z*: calcd for $C_{17}H_{24}NO_4$: 306.1705 $[M+NH_4]^+$; found: 306.1703.

Benzyl *tert*-butyl maleate (6i): This compound was prepared by the general procedure, from benzyl diazoacetate (**4e**, 60.0 mg, 0.341 mmol) and *tert*-butyl diazoacetate (**4j**, 47.0 μL, 0.341 mmol) in CH_2Cl_2 (5 mL). The residue (*Z*/*E* 97:3, as determined by GCMS analysis) was purified by flash chromatography (5% Et_2O in petrol) to afford the maleate **6i** (40.0 mg, 45%) as a yellow liquid. R_f = 0.69 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): δ = 7.40–7.30 (m, 5H; Ar), 6.19 (d, ^3J(H,H) = 2.7 Hz, 2H; 2×=CH), 5.23 (s, 2H; OCH_2), 1.49 ppm (s, 9H; CMe_3); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): δ = 165.1 + 164.3 (2×CO_2), 135.3 (Ar, quart.), 135.0 + 127.8 (2×=CH), 128.6, 128.5 + 127.4 (3× Ar), 82.3 (CMe_3), 66.8 (OCH_2), 27.9 ppm (CMe_3); IR (neat): $\tilde{\nu}$ = 2980 (s), 1727 (C=O, s), 1641 (C=C, m), 1498 (m), 1456 (s), 1397 (s), 1213 (s), 1149 cm^{-1} (s); MS (CI): *m*/*z* (%): 224 (100), 226 (20), 263 [*M*+H]$^+$ (15), 280 [*M*+NH_4]$^+$ (15); HRMS: *m*/*z*: calcd for $C_{15}H_{19}O_4$: 263.1278 [*M*+H]$^+$; found: 263.1280.

Macrocyclic dilactones from unsaturated diazoesters

General procedure: Grubbs second-generation catalyst **2** (0.01 equiv, 1 mol%) was added to a solution of diazoacetate (1.0 equiv) in CH_2Cl_2 and the mixture was stirred at room temperature for 14–18 h. Further catalyst **2** (0.01 equiv, 1 mol%) and (in some cases) CH_2Cl_2 was added, and the reaction mixture was then heated at reflux for 12–14 h. The mixture was concentrated under reduced pressure and purified by flash chromatography.[45,47]

1,6-Dioxacyclododeca-3,9-diene-2,5-dione (9a): This compound was prepared by the general procedure, from but-3-enyl diazoacetate (**7a**, 50.0 mg, 0.357 mmol) in CH_2Cl_2 (5+66 mL). The residue was purified by flash chromatography (5→10% Et_2O in petrol) to afford the dilactone **9a** (17.0 mg, 49%, *E*/*Z* 7:93, as determined by GCMS analysis) as a yellow liquid. R_f = 0.22 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): *Z* isomer: δ = 6.18 (s, 2H; 2×=CHCO), 5.62–5.54 (m, 2H; 2×=C*H*CH_2), 4.28–4.25 (m, 4H; 2×OCH_2), 2.54–2.49 (m, 4H; 2×=CHCH_2); discernible data for the *E* isomer: δ = 6.16 (s, 2H; 2×=CHCO), 5.42–5.39 (m, 2H; 2×=C*H*CH_2), 2.44–2.40 ppm (m, 4H; 2×=CHCH_2); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): *Z* isomer: δ = 165.1 (2×CO_2), 128.7 + 128.6 (4×=CH), 64.8 (2×OCH_2), 26.4 (2×=C*H*CH_2); discernible data for *E* isomer: δ = 129.2 (2×=CH), 63.3 (2×OCH_2), 32.5 ppm (2×=C*H*CH_2); IR (neat): $\tilde{\nu}$ = 2962 (w), 2254 (s), 1794 (C=O, s), 1382 (w), 1261 (m), 1100 cm^{-1} (s); MS (CI): *m*/*z* (%): 197 [*M*+H]$^+$ (30), 214 [*M*+NH_4]$^+$ (100), 215 (10); HRMS: *m*/*z*: calcd for $C_{10}H_{13}O_4$: 197.0814 [*M*+H]$^+$; found: 197.0816.

1,6-Dioxacyclotetradeca-3,10-diene-2,5-dione (9b): This compound was prepared by the general procedure, from pent-4-enyl diazoacetate (**7b**, 53.0 mg, 0.344 mmol) in CH_2Cl_2 (5 mL). The residue was purified by flash chromatography (5→10% EtOAc in hexane) to afford dilactone **9b** (20.0 mg, 53%, *E*/*Z* 30:70, as determined by GCMS analysis) as a yellow liquid. R_f = 0.45 (50% EtOAc in hexane); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): *Z* isomer: δ = 6.24 (s, 2H; 2×=CHCO), 5.48–5.38 (m, 2H; 2×=C*H*CH_2), 4.18–4.15 (m, 4H; 2×OCH_2), 2.16–2.26 (m, 4H; 2 ×=CHCH_2), 1.70–1.76 (m, 4H; 2×=$CHCH_2CH_2$); discernible data for the *E* isomer: δ = 6.24 (s, 2H; 2×=CH), 4.23–4.21 (m, 4H; 2×OCH_2), 1.76–1.84 ppm (m, 4H; 2×=$CHCH_2CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): *Z* isomer: δ = 165.3 (2×CO_2), 129.6 (2×=CH), 129.4 (2×=CH), 63.9 (2×OCH_2), 27.7 (2×=CHCH_2), 22.8 (2×OCH_2CH_2); discernible data for the *E* isomer: δ = 165.2 (2×CO_2), 130.3 + 129.6 (4×=CH), 64.9 (2×OCH_2), 30.2 (2×=$CHCH_2$), 27.2 ppm (2×OCH_2CH_2); IR (neat): $\tilde{\nu}$ = 2401 (s), 1725 (C=O, s), 1297 (m), 1216 cm^{-1} (s); MS (CI): *m*/*z* (%): 93 (15), 109 (15), 225 [*M*+H]$^+$ (100), 242 [*M*+NH_4]$^+$ (25); HRMS: *m*/*z*: calcd for $C_{12}H_{17}O_4$: 225.1127 [*M*+H]$^+$; found: 225.1129.

1,6-Dioxacyclohexadeca-3,11-diene-2,5-dione (9c): This compound was prepared by the general procedure, from hex-5-enyl diazoacetate (**7c**, 50.0 mg, 0.297 mmol) in CH_2Cl_2 (4+55 mL). The residue was purified by flash chromatography (15% Et_2O in petrol) to afford dilactone **9c** (16.0 mg, 43%, *E*/*Z* 57:43, as determined by GCMS analysis) as a pale-yellow liquid. R_f = 0.35 (30% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 6.22 (s, 2H; 2×=CHCO), 5.38–5.35 (m, 2H; 2×=C*H*CH_2), 4.17 (t, ^3J(H,H) = 7.4 Hz, 4H; 2×OCH_2), 2.02–2.14 (m, 4H; 2×=$CHCH_2$), 1.70–1.64 (m, 4H; 2×OCH_2CH_2), 1.48–1.38 (m, 4H; 2×=$CHCH_2CH_2$); discernible data for the *Z* isomer: δ = 6.23 (s, 2H; 2×=CHCO), 5.43–5.34 (m, 2H; 2×=C*H*CH_2), 4.19 (t, ^3J(H,H) = 6.7 Hz, 4H; 2×OCH_2), 1.76–1.71 ppm (m, 4H; 2×OCH_2CH_2); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 165.2 (2×CO_2), 131.1 + 129.5 (4×=CH), 65.2 (2×OCH_2), 31.4 (2×=$CHCH_2$), 26.8 (2×OCH_2CH_2), 24.2 (2×=$CHCH_2CH_2$); discernible data for the *Z* isomer: δ = 165.3 (2×CO_2), 129.8 + 129.5 (4×=CH), 64.7 (2×OCH_2), 27.4 (2×=$CHCH_2$), 26.2 + 25.2 ppm (4×CH_2); IR (neat): $\tilde{\nu}$ = 2400 (w), 1724 (C=O, s), 1216 cm^{-1} (s); MS (CI): *m*/*z* (%): 137 (15), 253 [*M*+H]$^+$ (100), 270 [*M*+NH_4]$^+$ (15); HRMS: *m*/*z*: calcd for $C_{14}H_{21}O_4$: 253.1440 [*M*+H]$^+$; found: 253.1448.

1,6-Dioxacyclooctadeca-3,12-diene-2,5-dione (9d): This compound was prepared by the general procedure, from hept-6-enyl diazoacetate (**7d**, 50.0 mg, 0.275 mmol) in CH_2Cl_2 (4+51 mL). The residue was purified by flash chromatography (10% Et_2O in petrol) to afford the dilactone **9d** (16.0 mg, 42%, *E*/*Z* 63:37, as determined by GCMS analysis) as a pale-yellow liquid. R_f = 0.40 (20% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 6.23 (s, 2H; 2×=CHCO), 5.34 (t, ^3J(H,H) = 4.1 Hz, 2H; 2×=C*H*CH_2), 4.10–4.26 (m, 4H; 2×OCH_2), 2.10–1.96 (m, 4H; 2×=$CHCH_2$), 1.72–1.58 (m, 4H; 2×OCH_2CH_2), 1.50–1.22 ppm (m, 8H; 2×=$CHCH_2CH_2CH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 165.4 (2×CO_2), 130.8 + 129.6 (4×=CH), 65.5 (2×OCH_2), 32.1 (2×=$CHCH_2$), 28.6, 28.4 + 25.0 (6×CH_2); discernible data for the *Z* isomer: δ = 165.3 (2×CO_2), 129.9 (2×=CH), 65.3 (2×OCH_2), 28.7, 28.2, 25.6 + 24.8 ppm (8×CH_2); IR (neat): $\tilde{\nu}$ = 2920 (s), 2254 (m), 1720 (C=O, s), 1450 (w), 1216 cm^{-1} (s); MS (CI): *m*/*z* (%): 95 (10), 281 [*M*+H]$^+$ (100), 298 [*M*+NH_4]$^+$ (25); HRMS: *m*/*z*: calcd for $C_{16}H_{25}O_4$: 281.1753 [*M*+H]$^+$; found: 281.1758.

1,6-Dioxacyclotetracosa-3,15-diene-2,5-dione (9e): This compound was prepared by the general procedure, from dec-9-enyl diazoacetate (**7e**, 174 mg, 0.777 mmol) in CH_2Cl_2 (25 mL). The residue was purified by flash chromatography (5→10% EtOAc in hexane) to afford the dilactone **9e** (68.0 mg, 48%, *E*/*Z* 80:20, as determined by GCMS analysis) as a pale-yellow liquid. R_f = 0.52 (30% EtOAc in hexane); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 6.23 (s, 2H; 2×=CHCO), 5.32–5.30 (m, 2H; 2×=C*H*CH_2), 4.15 (t, ^3J(H,H) = 7.2 Hz, 4H; 2×OCH_2), 1.92–2.02 (m, 4H; 2×=$CHCH_2$), 1.60–1.72 (m, 4H; 2×OCH_2CH_2), 1.20–1.44 (m, 20H; 10×CH_2); discernible data for the *Z* isomer: δ = 6.28 (s, 2H; 2×=CHCO), 5.38–5.34 ppm (m, 2H; 2×=C*H*CH_2); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C): *E* isomer: δ = 165.3 (2×CO_2), 130.9 + 129.5 (4×=CH), 65.4 (2×OCH_2), 32.1 (2×=$CHCH_2$), 29.4, 29.2, 28.8, 28.5, 28.1 + 25.5 (12×CH_2); discernible data for the *Z* isomer: δ = 129.9 + 125.2 (4×=CH), 65.5 (2×OCH_2), 29.4, 29.3, 29.1, 26.8 + 25.7 ppm (10×CH_2); IR (neat): $\tilde{\nu}$ = 2929 (s), 2857 (s), 2254 (m), 1724 (C=O, s), 1466 (w), 1216 cm^{-1} (s); MS (CI): *m*/*z* (%): 70 (48), 148 (48), 365 [*M*+H]$^+$ (100), 382 [*M*+NH_4]$^+$ (50); HRMS: *m*/*z*: calcd for $C_{22}H_{37}O_4$: 365.2692 [*M*+H]$^+$; found: 365.2697.

1,6-Dioxacyclohexacosa-3,16-diene-2,5-dione (9f): This compound was prepared by the general procedure, from undec-10-enyl diazoacetate (**7f**, 46.0 mg, 0.193 mmol) in CH_2Cl_2 (3+35 mL). The residue was purified by flash chromatography (10% Et_2O in petrol) to afford the dilactone **9f** (21.0 mg, 55%, *E*/*Z* 91:9, as determined by GCMS analysis) as a yellow liquid. R_f = 0.38 (20% Et_2O in petrol); ^{1}H NMR (400 MHz, $CDCl_3$, 25 °C); *E* isomer: δ = 6.23 (s, 2H; 2×=CHCO), 5.36–5.40 (m, 2H; 2×=C*H*CH_2), 4.18 (t, ^3J(H,H) = 6.8 Hz, 4H; 2×OCH_2), 2.00–1.86 (m, 4H; 2×=$CHCH_2$), 1.60–1.72 (m, 4H; 2×OCH_2CH_2), 1.20–1.32 (m, 24H; 12×CH_2); discernible data for the *Z* isomer: δ = 5.35 (t, ^3J(H,H) = 5.3 Hz, 2H; 2×=C*H*CH_2), 4.14–4.08 (t, ^3J(H,H) = 4.8 Hz, 4H; 2×OCH_2), 2.06–2.01 ppm (m, 4H; 2×=$CHCH_2$); ^{13}C NMR (100 MHz, $CDCl_3$, 25 °C); *E* isomer: δ = 165.4 (2×CO_2), 130.2 + 129.8 (4×=CH), 65.5 (2×OCH_2), 32.6 (2×=$CHCH_2$), 29.7, 29.5, 29.4, 29.2, 29.1, 28.4 + 25.8 (14×CH_2); discernible data for the *Z* isomer: δ = 129.8 (2×=CH), 27.2 ppm (2×CH_2); IR (neat): $\tilde{\nu}$ = 2929 (s), 2254 (s), 1723 (C=O, s), 1468 (w), 1216 cm^{-1} (s); MS (CI): *m*/*z* (%): 70 (15), 393 [*M*+H]$^+$ (100); HRMS: *m*/*z*: calcd for $C_{24}H_{41}O_4$: 393.3005 [*M*+H]$^+$; found: 393.3007.

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