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Rhodium Carbene Routes to Oxazoles and Thiazoles. Catalyst Effects in the Synthesis of Oxazole and Thiazole Carboxylates, Phosphonates, and Sulfones

Baolu Shi,[†] Alexander J. Blake,[†] William Lewis,[†] Ian B. Campbell,[‡] Brian D. Judkins,[‡] and Christopher J. Moody*,[†]

[†]*School of Chemistry, University of Nottingham, University Park, Nottingham NG7 2RD, U.K. and* [‡]*GlaxoSmithKline, Gunnels Wood Road, Stevenage SG1 2NY, U.K.*

c.j.moody@nottingham.ac.uk

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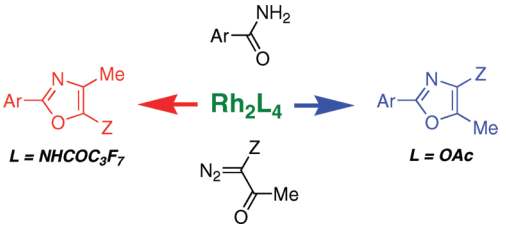

Dirhodium tetraacetate catalyzed reaction of α-diazo-β-keto-carboxylates and -phosphonates with arenecarboxamides gives 2-aryloxazole-4-carboxylates and 4-phosphonates by carbene N−H insertion and cyclodehydration. In stark contrast, dirhodium tetrakis(heptafluorobutyramide) catalysis results in a dramatic change of regioselectivity to give oxazole-5-carboxylates and 5-phosphonates. α-Diazo-β-ketosulfones behave similarly and give 5-sulfonyloxazoles upon dirhodium tetrakis-(heptafluorobutyramide) catalyzed reaction with carboxamides. The analogous reactions of thiocarboxamides give the corresponding thiazole-5-carboxylates, -phosphonates, and -sulfones.

Introduction

The 1,3-azoles—oxazoles, thiazoles, and imidazoles—abound in nature and continue to capture the attention of organic chemists. Thus, while oxazoles and thiazoles occur widely in a range of bioactive natural products, particularly the non-ribosomal peptides,[1−3] the imidazole ring plays a key role in the chemistry of the proteinogenic amino acid histidine. The biological activity of relatively simple synthetic oxazoles and thiazoles as, for example, peptide mimetics[4,5] and enzyme inhibitors,[6−8] and the structural diversity of complex naturally occurring derivatives have combined to ensure that new methods continue to be developed for their synthesis.[9−11]

Of the intermediates available for the synthesis of five-membered heteroaromatic rings, 1,4-dicarbonyl compounds are preeminent. In the field of 1,3-azole synthesis, the cyclodehydration of such a 1,4-dicarbonyl compound (an α-acylaminoketone) is the basis of the Robinson−Gabriel oxazole synthesis.[9] Although this reaction was discovered some time ago, it continues to undergo modification, for example, the preparation of the intermediate α-acylaminoketone by acylation of α-amino-β-ketoesters[4,12] or by

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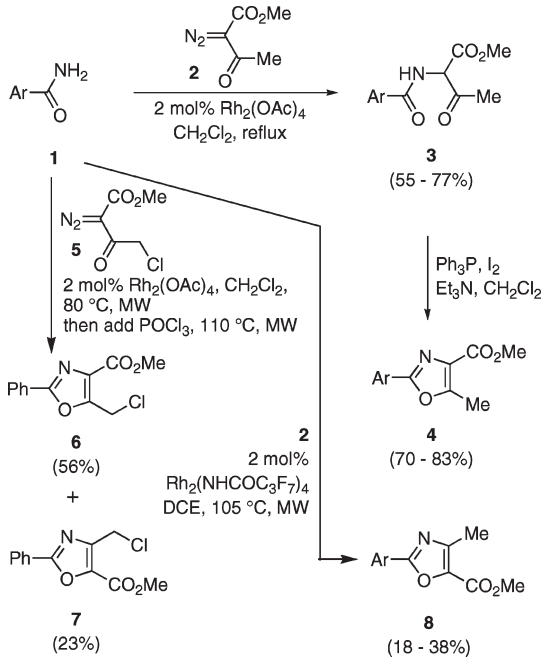
oxidation of β-hydroxyamides.[13] Recently we reported a new variation on the Robinson−Gabriel synthesis in which the key 1,4-dicarbonyl intermediate was obtained by an insertion reaction of a rhodium carbene derived from a diazocarbonyl compound into the N−H bond of a carboxamide,[14] followed by conversion into oxazoles or thiazoles by dehydration or thionation, respectively.[14,15] We originally developed the reaction for the synthesis of the oxazole building blocks of natural products such as nostocyclamide,[16] martefragin,[17] diazonamide A,[18−22] promothiocin A,[23] amythiamicin A,[24] and siphonazole.[25] Other researchers have also used this rhodium carbene N−H insertion protocol in the synthesis of natural products[26] and of oxazole-containing peptide mimetics.[5]

Although oxazoles can be also be obtained by the rhodium-catalyzed reaction of diazocarbonyl compounds with nitriles,[27] this reaction usually requires the use of nitrile as solvent and therefore is only applicable to simple nitriles. Hence the ready availability of carboxamides, combined with the robustness of the rhodium carbene N−H insertion chemistry, renders the methodology highly suitable for the synthesis of a wide range of oxazoles. Indeed Janda and co-workers have developed a solid-phase variant of the reaction and applied it in the synthesis of oxazole arrays.[28,29] In continuation of our own work, we sought to develop a solution-phase, one-pot method that was applicable to a diverse array of substituted 1,3-azoles and have reported some preliminary results on the synthesis of 4- and 5-functionalized oxazoles.[30] We now describe the results of a comprehensive study of the conversion of carboxamides into 4- and 5-substituted oxazole-carboxylates, -phosphonates, and -sulfones, extended to include the corresponding conversion of thiocarboxamides into thiazoles.

Results and Discussion

Initially we investigated the reaction of substituted benzamides **1** with methyl 2-diazo-3-oxobutanaote **2** in dichloromethane using dirhodium tetraacetate as catalyst (Scheme 1). Under these conditions, the intermediate 1,4-dicarbonyl compounds **3** were readily isolated and subsequently dehydrated under the conditions developed by Wipf and Miller[13] to give oxazole-4-carboxylates **4a**−**4c** in reasonable yield (45−54% over two steps).[30] In an attempt to compress the process into a one-pot operation using the reaction of benzamide with the more functionalized diazocarbonyl compound, methyl 4-chloro-2-diazo-3-oxobutanoate **5**, as an example, the first step was carried out using the same catalyst/solvent combination but under microwave irradiation at 80 °C for 5 min, followed by addition of phosphorus oxychloride (2 equiv) and heating to 110 °C for 30 min, again under microwave irradiation. This gave the expected oxazole-4-carboxylate **6** in 56% yield, the structure of which was confirmed by X-ray crystallography (see Supporting Information). Surprisingly, the isomeric oxazole-5-carboxylate **7** was also isolated (23%), and this formation of mixtures of oxazoles somewhat detracted from the one-pot method. Nevertheless the formation of the unexpected oxazole-5-carboxylate was intriguing and is discussed in detail below (q.v.).

SCHEME 1. Synthesis of Oxazole-4- and -5-carboxylates



The failure of the above method to deliver a single oxazole product prompted a search for alternative reaction conditions, and we reasoned that the Lewis acidic nature of dirhodium carboxylates and carboxamidates[31] might be sufficient to mediate the cyclization of the intermediate 1,4-dicarbonyl. This would clearly streamline the procedure further by obviating the need for addition of a second reagent. Therefore we investigated other rhodium catalysts and turned to dirhodium tetrakis(heptafluorobutyramide), a catalyst with fluorinated carboxamide ligands that we had found superior in other reactions of diazocarbonyl compounds.[32,33] The reactions of benzamides **1** with diazocarbonyl

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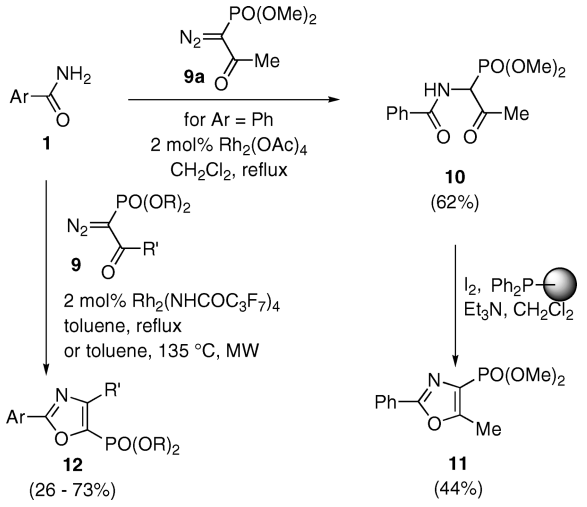
TABLE 1. Complementary Routes to Oxazole-4- and -5-carboxylates 4 and 8 Using Dirhodium Catalysts, Rh_2L_4

entry	Ar	L	3	yield (%)	4	yield (%)	8	yield (%)
1	Ph	OAc	**3a**	60	**4a**	83		
2	4-$MeOC_6H_4$	OAc	**3b**	55	**4b**	81		
3	4-BrC_6H_4	OAc	**3c**	77	**4c**	70		
4	Ph	$NHCOC_3F_7$					**8a**	18
5	4-$MeOC_6H_4$	$NHCOC_3F_7$					**8b**	24
6	4-BrC_6H_4	$NHCOC_3F_7$					**8c**	38

SCHEME 2. Synthesis of Oxazole-4- and -5-phosphonates



compound **2** were carried out with 2 mol % catalyst under more forcing conditions (1,2-dichloroethane, 105 °C, microwave irradiation, 30 min) and gave directly a single oxazole product, albeit in modest yield. However, the products were not the same oxazoles **4** obtained by the dirhodium tetraacetate catalyzed N−H insertion−cyclodehydration route but rather the isomeric oxazole-5-carboxylates **8** (Scheme 1). Although oxazoles **4** and **8** had very similar ^{1}H NMR spectra, their ^{13}C NMR spectra were different, and for final confirmation X-ray crystallography structures were obtained for the 4-methoxyphenyl derivatives **4b** and **8b** as previously described.[30] The results of these complementary routes to oxazole-4- and -5-carboxylates are summarized in Table 1.

The change in catalyst from dirhodium tetraacetate to dirhodium tetrakis(heptafluorobutyramide) evidently causes a dramatic change in reactivity that results in the formation of the isomeric series of oxazoles. Although the yields of the oxazole-5-carboxylates were modest at best, this remarkable catalyst effect clearly merited further investigation using a wider range of carboxamides and diazocarbonyl compounds. The effect of catalyst is not limited to α-diazo-β-keto carboxylate esters **2** since α-diazo-β-ketophosphonates **9** behave similarly. Thus, dirhodium tetraacetate catalyzed reaction of dimethyl 1-diazo-2-oxopropylphosphonate **9a** with benzamide in boiling dichloromethane gave the N−H insertion product **10** in 62% yield.[34−36] Cyclodehydration gave the oxazole-4-phosphonate **11** in modest 44% yield (Scheme 2). In stark contrast, use of the perfluorobutyramide catalyst in boiling toluene gave directly the oxazole-5-phosphonate **12a** in 49% yield, increased to 73% under microwave heating. Likewise heating substituted benzamides with diazophosphonates **9a** or **9b** in toluene (under conventional reflux or microwave heating) gave the oxazoles **12b**−**12i** and **12m** (28−70%). Heterocyclic carboxamides and cinnamamide also participate in the reaction to give oxazole-5-phosphonates **12j**−**12l** and **12n** (Table 2), the location of the phosphonate at C-5 being confirmed by X-ray crystallography in the case of oxazole **12k**.[30] Phosphonic acid derivatives of 1,3-azoles are known, and we and others have previously reported the dirhodium tetraacetate catalyzed reaction of diazocarbonyl phosphonate derivatives with nitriles to give oxazole-4-phosphonates.[37,38] Hence, whereas the 4-phosphonates are accessible by these or other methods,[39] there appear to be no general routes to the 5-phosphonates. The methodology described above now renders a range of oxazole-5-phosphonates readily available.

TABLE 2. Synthesis of Oxazole-5-phosphonates 12

entry	Ar	R	R^1	conditions[a]	12	yield (%)
1	Ph	Me	Me	A	**12a**	49
2	Ph	Me	Me	B	**12a**	73
3	2-BrC_6H_4	Me	Me	B	**12b**	49
4	2-$BnOC_6H_4$	Me	Me	B	**12c**	70
5	4-BrC_6H_4	Me	Me	A	**12d**	46
6	4-$MeOC_6H_4$	Me	Me	A	**12e**	54
7	4-$NO_2C_6H_4$	Me	Me	A	**12f**	35
8	4-$CbzNHC_6H_4$	Me	Me	B	**12g**	28
9	4-PhC_6H_4	Me	Me	A	**12h**	49
10	3,5-$F_2C_6H_3$	Me	Me	A	**12i**	55
11	2-thienyl	Me	Me	A	**12j**	51
12	2-benzothiophenyl	Me	Me	A	**12k**	52
13	PhCH=CH	Me	Me	A	**12l**	26
14	Ph	Et	Ph	A	**12m**	51
15	2-thienyl	Et	Ph	A	**12n**	45

[a]Conditions: (A) 2 mol % $Rh_2(NHCOC_3F_7)_4$, toluene, reflux, ca. 16 h; (B) 2 mol % $Rh_2(NHCOC_3F_7)_4$, toluene, 135 °C, microwave, 30 min.

Next, we investigated the reactions of the α-diazo-β-ketosulfone **13** with carboxamides. Using dirhodium tetrakis(heptafluorobutyramide) as catalyst in 1,2-dichloroethane (reflux or microwave heating), oxazole-5-sulfones **14** were obtained directly from amides **1** (Scheme 3, Table 3). Attempts to prepare oxazole-4-sulfones by the rhodium carbene N−H insertion−cyclodehydration route were not successful. However, oxazole-4-sulfones are accessible by reaction of α-diazo-β-carbonylsulfones with nitriles.[37,40] For example, dirhodium tetraacetate catalyzed reaction of the α-diazo-β-ketosulfone **13** with benzonitrile gave the oxazole-4-sulfone **15** (Scheme 3). The structures of the isomeric oxazole sulfones **14a**[30] and **15** (see Supporting Information) were confirmed by X-ray crystallography. Hence, again, rhodium carbene methodology provides complementary routes to 4- or 5-substituted-oxazoles.

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SCHEME 3. Synthesis of Oxazole-4- and -5-sulfones

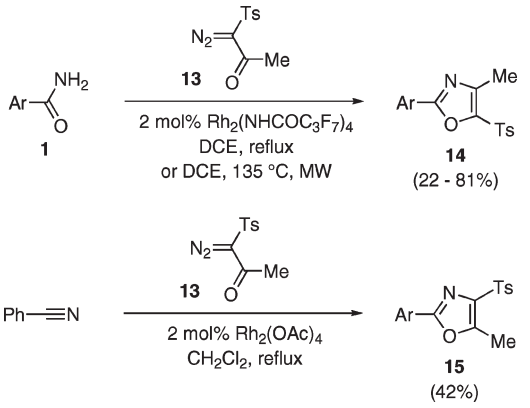

TABLE 3. Synthesis of Oxazole-5-sulfones 14

entry	Ar	conditions[a]	14	yield (%)
1	Ph	A	**14a**	77
2	Ph	B	**14a**	81
3	2-BrC_6H_4	B	**14b**	40
4	2-$BnOC_6H_4$	B	**14c**	79
5	4-BrC_6H_4	A	**14d**	73
6	4-$NO_2C_6H_4$	A	**14e**	22
7	4-$CbzNHC_6H_4$	B	**14f**	47
8	4-PhC_6H_4	A	**14g**	64
9	2-thienyl	A	**14h**	77
10	PhCH=CH	A	**14i**	62

[a]Conditions: (A) 2 mol % $Rh_2(NHCOC_3F_7)_4$, DCE, reflux, ca. 16 h; (B) 2 mol % $Rh_2(NHCOC_3F_7)_4$, DCE, 135 °C, microwave, 30 min.

Although ligand effects in dirhodium(II) catalyzed reactions of diazocarbonyl compounds have been studied, notably by Doyle and co-workers,[41] the changes in regioselectivity described herein are quite dramatic. The role of the dirhodium(II) catalyst, Rh_2L_4 (L = ligand), is thought to be in the generation of a reactive rhodium carbene, Z(COMe)C=Rh_2L_4, by reaction with the diazo compound, Z(COMe)C=N_2 (Z = CO_2Me, $PO(OMe)_2$, Ts), and hence the nature of the ligands L will affect the reactivity of this intermediate.[42] Presumably the 5-substituted oxazoles **5**, **9**, and **11** arise from O−H insertion of the rhodium carbene intermediate into the carboxamide imino tautomer, followed by cyclization, notwithstanding the fact that carboxamide N−H insertion, with formation of a C−N bond, is usually the dominant pathway and a process widely used in synthesis. Although there are a few other examples involving formation of a C−O bond in the reaction of a rhodium carbene with a carboxamide when an N−H bond is also available for insertion,[43−46] all of these involve lactam or imide systems rather than simple primary carboxamides. In the present case, the change in selectivity is presumably electronic in nature, reflecting the changes in electrophilicity of the intermediate rhodium carbene, Z(COMe)C=Rh_2L_4, upon changing ligands L, and provides a selective route to 4- or 5-functionalized oxazoles.

SCHEME 4. Synthesis of Thiazole-5-carboxylates, -phosphonates, and -sulfones

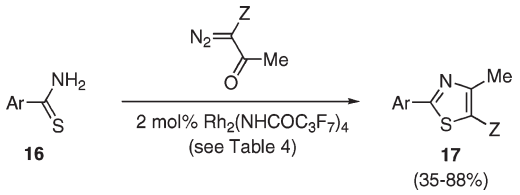

TABLE 4. Synthesis of 5-Functionalized Thiazoles 17

entry	Ar	diazo	Z	conditions[a]	17	yield (%)
1	4-BrC_6H_4	**2**	CO_2Me	A	**17a**	47
2	Ph	**9a**	$PO(OMe)_2$	B	**17b**	75
3	2-$BnOC_6H_4$	**9a**	$PO(OMe)_2$	C	**17c**	59
4	4-BrC_6H_4	**9a**	$PO(OMe)_2$	C	**17d**	35
5	4-$CbzNHC_6H_4$	**9a**	$PO(OMe)_2$	C	**17e**	55
6	Ph	**13**	Ts	D	**17f**	85
7	2-$BnOC_6H_4$	**13**	Ts	E	**17g**	87
8	4-BrC_6H_4	**13**	Ts	E	**17h**	88
9	4-$CbzNHC_6H_4$	**13**	Ts	E	**17i**	83

[a]Conditions: (A) 2 mol % $Rh_2(NHCOC_3F_7)_4$, CH_2Cl_2, 120 °C, microwave, 10 min. (B) 2 mol % $Rh_2(NHCOC_3F_7)_4$, toluene, reflux, ca. 16 h. (C) 2 mol % $Rh_2(NHCOC_3F_7)_4$, toluene, 135 °C, microwave, 30 min. (D) 2 mol % $Rh_2(NHCOC_3F_7)_4$, DCE, reflux, ca. 16 h. (E) 2 mol % $Rh_2(NHCOC_3F_7)_4$, DCE, 105 °C, microwave, 30 min.

In contrast to the reaction of diazocarbonyl compounds with carboxamides, the corresponding reactions with thiocarboxamides are less well-known. The reaction of thiobenzamides with diazoketones is reported to give thiazoles, often in poor yield,[47,48] while the boron trifluoride etherate promoted reaction of diazopyruvate with thioamides gives thiazole-4-carboxylates in good yield.[49] In this instance the diazopyruvate acts as an equivalent to bromopyruvate in the classical Hantzsch route to thiazole-4-carboxylates. More recently, the copper(I) bromide catalyzed reaction of α-diazo-β-ketoesters with thiobenzamides to give thiazole-5-carboxylates has been described.[50] Interestingly, it was reported that dirhodium tetraacetate was an unsatisfactory catalyst for this transformation,[50] and therefore we were keen to see if our optimized conditions using dirhodium tetrakis(heptafluorobutyramide) as catalyst fared any better. In the event, this proved to be the case, and reaction of 4-bromothiobenzamide with methyl 2-diazo-3-oxobutanaote **2** gave the thiazole-5-carboxylate **17a** in reasonable yield (Scheme 4, Table 4), complementing the Hantzsch synthesis of thiazole-4-carboxylates from halopyruvates. The diazophosphonate **9a** and diazosulfone **13** reacted similarly, leading to a range of oxazole-5-phosphonates and -sulfones **17b**−**17i** in modest to excellent yield (Table 4). The structures of the 2-(4-bromophenyl)oxazoles **17a**, **17d**, and **17h** were determined by X-ray crystallography, confirming the locus of the ester, phosphonyl, or sulfonyl substituent

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at the 5-position (see Supporting Information). The mechanism of thiazole formation presumably involves initial S−H insertion of the rhodium carbene into the thiocarboxamide imino tautomer or, more likely, the formation of a thiocarbonyl ylide intermediate by attack of the nucleophilic sulfur on the electrophilic metal carbene. Irrespective of mechanism, the process is a useful route to 5-functionalized thiazoles, not readily accessible by other means.

Experimental Section

General Method for N−H Insertion Reactions. A mixture of the carboxamide (0.64 mmol) and rhodium(II) acetate dimer (7 mg, 16 μmol) in anhydrous 1,2-dichloroethane (5 mL) was stirred under argon and heated under reflux. A solution of methyl 2-diazo-3-oxobutanoate (100 mg, 0.70 mmol) in 1,2-dichloroethane (5 mL) was added dropwise by syringe pump overnight. The solvent was removed in vacuo, and the residue was purified by chromatography.

Methyl 2-Benzoylamino-3-oxobutanoate 3a. Following the general method, benzamide (78 mg, 0.64 mmol) gave, after chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.40), a colorless oil (90 mg, 60%); (lit.,[51] mp 93−94 °C); (found M + Na^+, 258.0742. $C_{12}H_{13}NO_4$ + Na^+ requires 258.0742); ν_{max} ($CHCl_3$)/cm^{-1} 1727, 1606, 1256; δ_H (300 MHz; $CDCl_3$) 7.84−7.80 (2H, m), 7.51−7.40 (4H, m), 5.44 (1H, d, J = 6.3), 3.82 (3H, s), 2.32 (3H, s); δ_C (75 MHz; $CDCl_3$) 198.6, 166.9, 166.8, 133.0, 132.2 (CH), 128.7 (CH), 127.4 (CH), 63.5 (CH), 53.5 (Me), 28.1 (Me).

Methyl 2-(4-Methoxybenzoylamino)-3-oxobutanoate 3b. Following the general method, 4-methoxybenzamide (97 mg, 0.64 mmol) gave, after chromatography (silica, 50% ethyl acetate in petroleum ether; R_f = 0.28), a colorless oil (93 mg, 55%); (found M + Na^+, 288.0833. $C_{13}H_{15}NO_5$ + Na^+ requires 288.0848); ν_{max} ($CHCl_3$)/cm^{-1} 1732, 1606, 1492, 1256; δ_H (300 MHz; $CDCl_3$) 7.81−7.76 (2H, m), 7.25 (1H, d, J = 6.3), 6.93−6.89 (2H, m), 5.41 (1H, d, J = 6.3), 3.83 (3H, s), 3.81 (3H, s), 2.41 (3H, s); δ_C (75 MHz; $CDCl_3$) 198.9, 166.9, 166.3, 162.8, 129.3 (CH), 125.2, 113.9 (CH), 63.4 (CH), 55.5 (Me), 53.4 (Me), 28.1 (Me).

Methyl 2-(4-Bromobenzoylamino)-3-oxobutanoate 3c. Following the general method, 4-bromobenzamide (128 mg, 0.64 mmol) gave, after chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.29), a colorless solid (154 mg, 77%); mp 87−89 °C; (found M + Na^+, 335.9836. $C_{12}H_{12}{}^{79}BrNO_4$ + Na^+ requires 335.9847); ν_{max} ($CHCl_3$)/cm^{-1} 1754, 1728, 1661, 1477, 1216; δ_H (400 MHz; $CDCl_3$) 7.68 (2H, d, J = 8.4), 7.54 (2H, d, J = 8.4), 7.35 (1H, d, J = 6.0), 5.41 (1H, d, J = 6.4), 3.81 (3H, s), 2.41 (3H, s); δ_C (100 MHz; $CDCl_3$) 198.2, 166.4, 165.8, 131.8 (CH), 131.6, 128.8 (CH), 126.8, 63.2 (CH), 53.4 (Me), 28.0 (Me).

Dehydration of NH-Insertion Products To Form Oxazoles. Methyl 5-Methyl-2-phenyloxazole-4-carboxylate 4a. To a dry flask were added triphenylphosphine (178 mg, 0.68 mmol), iodine (173 mg, 0.68 mmol), and anhydrous dichloromethane (17 mL). Once the solids had dissolved completely, triethylamine (194 μL, 1.4 mmol) and a solution of methyl 2-benzoylamino-3-oxobutanoate **3a** (80 mg, 0.34 mmol) in dichloromethane (5 mL) were added. The mixture was allowed to stir under argon overnight and then concentrated in vacuo. The product was purified by chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.62) to give a pale yellow solid (61 mg, 83%); mp 89−91 °C (lit.,[52] mp 88−89 °C); (found M + Na^+, 240.0624. $C_{12}H_{11}NO_3$ + Na^+ requires 240.0637); ν_{max} ($CHCl_3$)/cm^{-1} 1715, 1615, 1440, 1351; δ_H (400 MHz; $CDCl_3$) 8.06−8.03 (2H, m), 7.45−7.41 (3H, m), 3.92 (3H, s), 2.69 (3H, s); δ_C (100 MHz; $CDCl_3$) 162.8, 159.6, 156.3, 130.7, 128.7 (CH), 128.5, 126.5 (CH), 51.9 (Me), 12.0 (Me); one carbon unobserved.

Methyl 2-(4-Methoxyphenyl)-5-methyloxazole-4-carboxylate 4b. To a dry flask were added triphenylphosphine (157 mg, 0.6 mmol), iodine (152 mg, 0.6 mmol), and anhydrous dichloromethane (15 mL). Once the solids had dissolved completely, triethylamine (173 μL, 1.24 mmol) and a solution of methyl 2-(4-methoxybenzoylamino)-3-oxobutanoate **3b** (80 mg, 0.3 mmol) in dichloromethane (5 mL) were added. The mixture was allowed to stir under argon overnight and then concentrated in vacuo. The product was purified by chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.45) to give a colorless solid (60 mg, 81%); mp 108−109 °C (lit.,[52] mp 105−106 °C); (found C, 62.89; H, 5.21; N, 5.44. $C_{13}H_{13}NO_4$ requires C, 63.15; H, 5.30; N, 5.67); (found M + H^+, 248.0915. $C_{13}H_{13}NO_4$ + H^+ requires 248.0923); ν_{max} (solid)/cm^{-1} 1709, 1614, 1501, 1433, 1345, 1254; δ_H (300 MHz; $CDCl_3$) 7.97 (2H, d, J = 9.0), 6.93 (2H, d, J = 9.0), 3.92 (3H, s), 3.83 (3H, s), 2.67 (3H, s); δ_C (75 MHz; $CDCl_3$) 162.9, 161.6, 159.7, 155.8, 128.2 (CH), 119.2, 114.1 (CH), 55.3 (Me), 51.9 (Me), 12.2 (Me); one carbon unobserved.

Methyl 2-(4-Bromophenyl)-5-methyloxazole-4-carboxylate 4c. To a dry flask were added triphenylphosphine (167 mg, 0.64 mmol), iodine (162 mg, 0.64 mmol), and anhydrous dichloromethane (30 mL). Once the solids had dissolved completely, triethylamine (182 μL, 1.3 mmol) and a solution of methyl 2-(4-bromobenzoylamino)-3-oxobutanoate **3c** (100 mg, 0.32 mmol) in dichloromethane (10 mL) were added. The mixture was allowed to stir under argon overnight and then concentrated in vacuo. The product was purified by chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.61) to give a yellow solid (66 mg, 70%); mp 125−127 °C; (found M + Na^+, 317.9722. $C_{12}H_{10}{}^{79}BrNO_3$ + Na^+ requires 317.9712); ν_{max} ($CHCl_3$)/cm^{-1} 1715, 1614, 1482, 1350, 1240; δ_H (400 MHz; $CDCl_3$) 7.89 (2H, d, J = 8.8), 7.55 (2H, d, J = 8.8), 3.92 (3H, s), 2.67 (3H, s); δ_C (100 MHz; $CDCl_3$) 162.7, 158.9, 156.7, 132.1 (CH), 128.8, 128.1 (CH), 125.5, 125.4, 52.2 (Me), 12.2 (Me).

Methyl 5-Chloromethyl-2-phenyloxazole-4-carboxylate 6. To a microwave tube were added benzamide (500 mg, 4.13 mmol), rhodium acetate dimer (36.5 mg, 0.083 mmol), and methyl 4-chloro-2-diazo-3-oxobutanoate (784 mg, 4.44 mmol) in dichloromethane (5 mL). The mixture was subjected to microwave irradiation at 80 °C for 5 min. Phosphorus oxychloride (770 μL, 11.9 mmol) was added, and the mixture was subjected to microwave irradiation at 110 °C for 30 min. After cooling, the crude product was purified by chromatography (silica, 0 to 50% EtOAc in cyclohexane over 40 min; R_f = 0.58) to give a colorless solid (586 mg, 56%), mp 74−75 °C; (found C, 57.44; H, 3.95; N, 5.44. $C_{12}H_{10}ClNO_3$ requires C, 57.27; H, 4.00; N, 5.57); (found M + H^+, 252.0426. $C_{12}H_{10}{}^{35}ClNO_3$ + H^+ requires 252.0427); ν_{max} (solid)/cm^{-1} 1713, 1446, 1358, 1330, 1244, 1214, 1154; δ_H (400 MHz; $CDCl_3$) 8.10−8.08 (2H, m), 7.49−7.43 (3H, m), 5.00 (2H, s), 3.97 (3H, s); δ_C (100 MHz; $CDCl_3$) 161.7, 161.4, 152.6, 131.4, 130.4, 128.8, 126.9, 125.8, 52.4 (Me), 33.8 (CH_2).

Also formed was methyl 4-chloromethyl-2-phenyl-oxazole-5-carboxylate **7**, isolated by chromatography (R_f = 0.62) as a colorless solid (236 mg, 23%), mp 97−98 °C (lit.,[53] no data given); (found C, 57.31; H, 3.98; N, 5.38. $C_{12}H_{10}ClNO_3$ requires C, 57.27; H, 4.00; N, 5.57); (found M + H^+, 252.0430. $C_{12}H_{10}{}^{35}ClNO_3$ + H^+ requires 252.0427); ν_{max} (solid)/cm^{-1}

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1729, 1604, 1545, 1480, 1442, 1373, 1202, 1158; δ_H (400 MHz; $CDCl_3$) 8.14−8.12 (2H, m), 7.52−7.45 (3H, m), 4.85 (2H, s), 3.97 (3H, s); δ_C (100 MHz; $CDCl_3$) 163.0, 158.1, 145.4, 137.7, 131.9, 128.8, 127.3, 125.8, 52.4 (Me), 36.2 (CH_2).

General Method for Microwave-Assisted Synthesis of Methyl Oxazole-5-carboxylates. To a dry microwave tube flushed with argon were added aryl carboxamide (0.32 mmol), rhodium(II) heptafluorobutyramide dimer (8.4 mg, 8 μmol) ,and methyl 2-diazo-3-oxobutanoate (50 mg, 0.35 mmol) in anhydrous 1,2-dichloroethane (6 mL). The mixture was then subjected to microwave irradiation at 105 °C for 30 min. The solvent was removed in vacuo, and the residue was purified by column chromatography on silica gel with the eluants specified.

Methyl 4-Methyl-2-phenyloxazole-5-carboxylate 8a. Following the general method, benzamide (39 mg, 0.32 mmol) gave, after chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.62), a colorless solid (40 mg, 18%); mp 54−55 °C (lit.,[54] mp 45−47 °C); (found M + H^+, 218.0894. $C_{12}H_{11}NO_3$ + H^+ requires 218.0817); ν_{max} ($CHCl_3$)/cm^{-1} 1713, 1542; δ_H (400 MHz; $CDCl_3$) 8.13−8.11 (2H, m), 7.50−7.47 (3H, m), 3.94 (3H, s), 2.55 (3H, s); δ_C (100 MHz; $CDCl_3$) 162.5, 159.4, 147.5, 137.4, 131.7 (CH), 129.0 (CH), 127.4 (CH), 126.5, 52.1 (Me), 13.6 (Me).

Methyl 2-(4-Methoxyphenyl)-4-methyloxazole-5-carboxylate 8b. Following the general method, 4-methoxybenzamide (48 mg, 0.32 mmol) gave, after chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.57), a colorless solid (19 mg, 24%); mp 68−70 °C (lit.,[55] white solid, mp not given); (found M + H^+, 248.0913. $C_{13}H_{13}NO_4$ + H^+ requires 248.0923); ν_{max} (solid)/cm^{-1} 1707, 1608, 1254, 1108; δ_H (400 MHz; $CDCl_3$) 8.05 (2H, d, J = 8.0), 6.97 (2H, d, J = 8.0), 3.93 (3H, s), 3.86 (3H, s), 2.52 (3H, s); δ_C (100 MHz; $CDCl_3$) 162.7, 162.5, 159.6, 147.5, 136.9, 129.2 (CH), 119.1, 114.5 (CH), 55.6 (Me), 52.0 (Me), 13.6 (Me).

Methyl 2-(4-Bromophenyl)-4-methyloxazole-5-carboxylate 8c. Following the general method, 4-bromobenzamide (64 mg, 0.32 mmol) gave, after chromatography (silica, 50% ethyl acetate in light petroleum; R_f = 0.66), a pink solid (36 mg, 38%); mp 109−111 °C; (found M + H^+, 295.9919. $C_{12}H_{10}{}^{79}BrNO_3$ + H^+ requires 295.9922); ν_{max} (solid)/cm^{-1} 1714, 1610, 1599, 1436, 1100; δ_H (400 MHz; $CDCl_3$) 7.97 (2H, d, J = 8.4), 7.61 (2H, d, J = 8.4), 3.94 (3H, s), 2.53 (3H, s); δ_C (100 MHz; $CDCl_3$) 161.6, 159.3, 147.5, 137.6, 132.2, 128.8, 126.5 (CH), 125.4 (CH), 52.2 (Me), 13.5 (Me).

Dimethyl (1-Benzoylamino-2-oxopropyl)phosphonate 10. Diazophosphonate **9a** (100 mg, 0.52 mmol), benzamide (57 mg, 0.47 mmol), and rhodium(II) acetate dimer (5.6 mg, 11.8 μmol) were heated under reflux in dichloromethane (8 mL) overnight. The solvent was evaporated, and the residue was purified by chromatography (silica, ethyl acetate; R_f = 0.34) to give the title compound as a colorless solid (83 mg, 62%); mp 64−66 °C; (found C, 50.18; H, 5.54; N, 4.73. $C_{12}H_{16}NO_5P$ requires C, 50.53; H, 5.65; N, 4.91); (found M + Na^+, 308.0657. $C_{12}H_{16}NO_5P$ + Na^+ requires 308.0664); ν_{max} ($CHCl_3$)/cm^{-1} 3606, 3425, 1723, 1665, 1509, 1482, 1264, 1037; δ_H (400 MHz; $CDCl_3$) 7.82 (2H, d, J = 8.2), 7.51 (1H, t, J = 8.2), 7.43 (2H, t, J = 8.2), 7.21 (1H, br d, J = 7.6), 5.54 (1H, dd, J = 24.0, 7.6), 3.85 (3H, d, J = 11.0), 3.76 (3H, d, J = 11.0), 2.47 (3H, d, J = 0.8); δ_C (100 MHz; $CDCl_3$) 199.8 (d, J = 2.0), 166.8 (d, J = 4.0), 133.2, 132.2 (CH), 128.8 (CH), 127.3 (CH), 57.9 (CH, d, J = 141.0), 54.3 (Me, d, J = 5.0), 53.9 (Me, d, J = 7.0), 29.1 (Me).

Dimethyl 5-Methyl-2-phenyloxazole-4-phosphonate 11. To a suspension of solid-phase bound triphenylphosphine (182 mg, 0.58 mmol) in anhydrous dichloromethane (5 mL) were added iodine (148 mg, 0.58 mmol) and triethylamine (166 μL, 1.19 mmol) in dichloromethane (5 mL). The mixture was stirred for 5 min under argon before a solution of **10** (83 mg, 0.29 mmol) in dichloromethane (5 mL) was added. The mixture was allowed to stir under argon at room temperature for 18 h. The product was purified by chromatography (silica, 20% light petroleum in ethyl acetate; R_f = 0.34) to give a pale yellow solid (34 mg, 44%); mp 39−40 °C; (found M + Na^+, 290.0549. $C_{12}H_{14}NO_4P$ + Na^+ requires 290.0558); ν_{max} ($CHCl_3$)/cm^{-1} 1246, 1036; δ_H (500 MHz; $CDCl_3$) 8.03 (2H, m), 7.44 (3H, m), 3.84 (6H, d, J = 11.5), 2.66 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 161.4 (d, J = 21.0), 159.2 (d, J = 38.0), 130.9 (CH), 128.9 (CH), 126.7 (CH), 124.3 (d, J = 242.0), 53.2 (Me, d, J = 5.0), 11.7 (Me); one carbon unobserved.

General Method for One-Pot Synthesis of Oxazole-5-phosphonates (Table 2, Conditions A). To an anhydrous toluene solution (8 mL) of diazophosphonate **9** (100 mg, 0.52 mmol) were added the carboxamide (0.47 mmol) and rhodium(II) heptafluorobutyramide dimer (12.5 mg, 11.8 μmol). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated, and the residue was purified by chromatography.

Dimethyl 4-Methyl-2-phenyloxazole-5-phosphonate 12a. Following the general method, benzamide (57 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate; R_f = 0.33), a colorless solid (61 mg, 49%); mp 29−30 °C; (found C, 53.99; H, 5.30; N, 5.05. $C_{12}H_{14}NO_4P$ requires C, 53.94; H, 5.28; N, 5.24); (found M + H^+, 268.0716. $C_{12}H_{14}NO_4P$ + H^+ requires 268.0739); ν_{max} ($CHCl_3$)/cm^{-1} 1260, 1034; δ_H (500 MHz; $CDCl_3$) 8.07 (2H, m), 7.51−7.45 (3H, m), 3.83 (6H, d, J = 11.5), 2.49 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 164.6 (d, J = 14.0), 151.3 (d, J = 28.0), 134.3 (d, J = 240.0), 131.5 (CH), 129.0 (CH), 127.2 (CH), 126.5, 53.3 (Me, d, J = 5.0), 12.9 (Me).

Dimethyl 2-(4-Bromophenyl)-4-methyloxazole-5-phosphonate 12d. Following the general method, 4-bromobenzamide (95 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.44, followed by a second column using 4% methanol in dichloromethane), a colorless solid (75 mg, 46%); mp 74−75 °C; (found C, 41.34; H, 3.72; N, 3.74. $C_{12}H_{13}BrNO_4P$ requires C, 41.64; H, 3.79; N, 4.05); (found M + Na^+, 369.9634. $C_{12}H_{13}{}^{79}BrNO_4P$ + Na^+ requires 369.9663); ν_{max} ($CHCl_3$)/cm^{-1} 1261, 1035; δ_H (500 MHz; $CDCl_3$) 7.94 (2H, d, J = 8.5), 7.61 (2H, d, J = 8.5), 3.85 (6H, d, J = 11.5), 2.48 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 163.7 (d, J = 14.0), 151.4 (d, J = 28.0), 134.8 (d, J = 240.0), 132.3, 128.7, 126.3 (CH), 125.5 (CH), 53.3 (Me, d, J = 6.0), 12.9 (Me).

Dimethyl 2-(4-Methoxyphenyl)-4-methyloxazole-5-phosphonate 12e. Following the general method, 4-methoxybenzamide (72 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.38, followed by a second column using 10% methanol in dichloromethane), a pale yellow solid (75 mg, 54%); mp 70−72 °C; (found M + Na^+, 320.0650. $C_{13}H_{16}NO_5P$ + Na^+ requires 320.0664); ν_{max} ($CHCl_3$)/cm^{-1} 1258, 1032; δ_H (400 MHz; $CDCl_3$) 7.99 (2H, d, J = 8.8), 6.94 (2H, d, J = 8.8), 3.84 (3H, s), 3.80 (6H, d, J = 11.6), 2.45 (3H, d, J = 2.4); δ_C (100 MHz; $CDCl_3$) 164.7 (d, J = 15.0), 162.3, 151.4 (d, J = 27.0), 133.6 (d, J = 242.0), 129.0 (CH), 119.2, 114.4 (CH), 55.5 (Me), 53.2 (Me, d, J = 6.0), 12.9 (Me).

Dimethyl 4-Methyl-2-(4-nitrophenyl)oxazole-5-phosphonate 12f. Following the general method, 4-nitrobenzamide (78 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.44, followed by a second column using methanol in dichloromethane), a yellow solid (52 mg, 35%); mp 119−120 °C; (found C, 45.82; H, 4.03; N, 8.47. $C_{12}H_{13}N_2O_6P$ requires C, 46.16; H, 4.20; N, 8.97); (found M + Na^+, 335.0392.

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$C_{12}H_{13}N_2O_6P + Na^+$ requires 335.0409); ν_{max} ($CHCl_3$)/cm^{-1} 1602, 1526, 1354, 1261, 1036; δ_H (500 MHz; $CDCl_3$) 8.32 (2H, d, J = 9.5), 8.24 (2H, d, J = 9.5), 3.85 (6H, d, J = 11.5), 2.49 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 162.2 (d, J = 14.0), 151.5 (d, J = 26.0), 149.4, 136.3 (d, J = 239.0), 131.9, 128.1 (CH), 124.3 (CH), 53.4 (Me, d, J = 6.0), 12.9 (Me).

Dimethyl 2-(4-Biphenyl)-4-methyloxazole-5-phosphonate 12h. Following the general method, 4-biphenylcarboxamide (93 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.41, followed by a second column using 4% methanol in dichloromethane), a colorless solid (79 mg, 49%); mp 78−80 °C; (found C, 62.67; H, 5.37; N, 3.85. $C_{18}H_{18}NO_4P$ requires C, 62.97; H, 5.28; N, 4.08); (found M + Na^+, 366.0881. $C_{18}H_{18}NO_4P + Na^+$ requires 366.0871); ν_{max} ($CHCl_3$)/cm^{-1} 1602, 1261, 1035; δ_H (500 MHz; $CDCl_3$) 8.15 (2H, m), 7.70 (2H, m), 7.63 (2H, d, J = 7.5), 7.47 (2H, d, J = 7.5), 7.39 (1H, m), 3.85 (6H, d, J = 11.5), 2.51 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 164.5 (d, J = 14.0), 151.5 (d, J = 26.0), 144.3, 140.0, 134.4 (d, J = 241.0), 129.1 (CH), 128.2 (CH), 127.8 (CH), 127.6 (CH), 127.3 (CH), 125.3, 53.3 (Me, d, J = 5.0), 12.9 (Me).

Dimethyl 2-(3,5-Difluorophenyl)-4-methyloxazole-5-phosphonate 12i. Following the general method, 3,5-difluorobenzamide (74 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.48, followed by a second column using 3% methanol in dichloromethane), a colorless solid (70 mg, 55%), further purified by LCMS (reverse phase C_{18}, 10% to 95% acetonitrile in water); mp 46−47 °C; (found C, 47.39; H, 3.95; N, 4.75. $C_{12}H_{12}F_2NO_4P$ requires C, 47.54; H, 3.99; N, 4.62); (found M + H^+, 304.0546. $C_{12}H_{12}F_2NO_4P + H^+$ requires 304.0550); ν_{max} (solid)/cm^{-1} 1580, 1264, 1021; δ_H (400 MHz; $CDCl_3$) 7.59 (2H, m), 6.94 (1H, m), 3.84 (6H, d, J = 11.5), 2.47 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 163.2 (dd, J = 250.0, 13.0), 151.2 (d, J = 28.0), 135.4 (d, J = 241.0), 131.6, 129.1 (CH, d, J = 11.0), 110.2 (dd, J = 20.0, 8.0), 106.8 (CH, t, J = 25.0), 53.3 (Me, d, J = 5.0), 12.7 (Me).

Dimethyl 4-Methyl-2-(2-thienyl)oxazol-5-phosphonate 12j. Following the general method, thiophene-2-carboxamide (60 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate; R_f = 0.32), a colorless solid (66 mg, 51%); mp 67−68 °C; (found C, 43.95; H, 4.43; N, 4.86. $C_{10}H_{12}NO_4PS$ requires C, 43.96; H, 4.43; N, 5.13%); (found M + H^+, 274.0312. $C_{10}H_{12}NO_4PS$ + H^+ requires 274.0303); ν_{max} ($CHCl_3$)/cm^{-1} 1591, 1259, 1033; δ_H (400 MHz; $CDCl_3$) 7.74 (1H, dd, J = 4.5, 1.5), 7.48 (1H, dd, J = 6.5, 1.5), 7.11 (1H, dd, J = 6.5, 4.5), 3.81 (6H, d, J = 14.0), 2.44 (3H, d, J = 3.0); δ_C (100 MHz; $CDCl_3$) 160.6 (d, J = 15.0), 151.4 (d, J = 27.0), 133.8 (d, J = 241.0), 130.1 (CH), 129.7 (CH), 128.8, 128.3 (CH), 53.3 (Me, d, J = 5.0), 12.8 (Me).

Dimethyl 2-(Benzo[*b*]thiophen-2-yl)-4-methyloxazole-5-phosphonate 12k. Following the general method, benzothiophene-2-carboxamide (83 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.44, followed by a second column using 4% MeOH in dichloromethane), a colorless solid (77 mg, 52%); mp 144−145 °C; (found C, 51.73; H, 4.31; N, 4.04. $C_{14}H_{14}NO_4PS$ requires C, 52.01; H, 4.36; N, 4.33); (found M + Na^+, 346.0276. $C_{14}H_{14}NO_4PS + Na^+$ requires 346.0279); ν_{max} ($CHCl_3$)/cm^{-1} 1596, 1261, 1036; δ_H (500 MHz; $CDCl_3$) 8.01 (1H, s), 7.86 (2H, m), 7.42 (2H, m), 3.85 (6H, d, J = 11.5), 2.50 (3H, d, J = 2.5); δ_C (125 MHz; $CDCl_3$) 160.6 (d, J = 15.0), 151.6 (d, J = 26.0), 141.1, 139.4, 134.7 (d, J = 240.0), 128.4, 126.6 (CH), 126.5 (CH), 125.3 (CH), 125.0 (CH), 122.7 (CH), 53.5 (Me, d, J = 5.0), 12.9 (Me).

Dimethyl 4-Methyl-2-styryloxazole-5-phosphonate 12l. Following the general method, cinnamamide (70 mg, 0.47 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.44, followed by a second column using 4% methanol in dichloromethane), a yellow oil (36 mg, 26%); (found M + H^+, 294.0883. $C_{14}H_{16}NO_4P + H^+$ requires 294.0895); ν_{max} ($CHCl_3$)/cm^{-1} 1260, 1027; δ_H (500 MHz; $CDCl_3$) 7.64 (1H, d, J = 16.5), 7.53−7.51 (2H, m), 7.40−7.35 (3H, m), 6.91 (1H, dd, J = 16.5, 0.5), 3.82 (6H, d, J = 11.5), 2.44 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 164.4 (d, J = 14.0), 151.2 (d, J = 26.0), 139.2 (CH), 135.0, 133.9 (d, J = 240.0), 129.9 (CH), 129.1 (CH), 127.6 (CH), 112.9 (CH), 53.3 (Me, d, J = 5,0), 12.8 (Me).

Diethyl 2,4-Diphenyloxazole-5-phosphonate 12m. To a solution of diazophosphonate **9b** (100 mg, 0.35 mmol) in anhydrous toluene (6 mL) were added benzamide (39 mg, 0.32 mmol) and rhodium(II) heptafluorobutyramide dimer (8.5 mg, 8 μmol). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated, and the residue was purified by chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.56) to give a yellow oil (58 mg, 51%); (found M + H^+, 358.1209. $C_{19}H_{20}NO_4P + H^+$ requires 358.1208); ν_{max} ($CHCl_3$)/cm^{-1} 1558, 1257, 1017; δ_H (400 MHz; $CDCl_3$) 8.18 (2H, d, J = 7.4), 8.06 (2H, d, J = 6.4), 7.52−7.26 (6H, m), 4.26−4.11 (4H, m), 1.29 (6H, t, J = 7.2); δ_C (100 MHz; $CDCl_3$) 164.1 (d, J = 13.0), 150.9 (d, J = 22.0), 135.5 (d, J = 240.0), 131.5 (CH), 130.3, 129.5 (CH), 129.0 (CH), 128.9 (CH), 128.4 (CH), 127.4 (CH), 126.6, 63.3 (CH_2, d, J = 5.0), 16.2 (Me, d, J = 7.0).

Diethyl 4-Phenyl-2-(2-thienyl)oxazole-5-phosphonate 12n. To a solution of diazophosphonate **9b** (100 mg, 0.35 mmol) in anhydrous toluene (6 mL) were added thiophene-2-carboxamide (41 mg, 0.32 mmol) and rhodium(II) heptafluorobutyramide dimer (8.5 mg, 8 μmol). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated and the residue was purified by chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.53) to give a yellow oil (52 mg, 45%); (found M + H^+, 364.0788. $C_{17}H_{18}NO_4PS + H^+$ requires 364.0772); ν_{max} ($CHCl_3$)/cm^{-1} 1587, 1255, 1017; δ_H (500 MHz; $CDCl_3$) 8.02 (2H, m), 7.83 (2H, dd, J = 4.0, 1.5), 7.51 (2H, dd, J = 5.0, 1.5), 7.46−7.38 (3H, m), 7.14 (2H, dd, J = 5.0, 4.0), 4.24−4.08 (4H, m), 1.28 (6H, td, J = 7.0, 0.5); δ_C (125 MHz; $CDCl_3$) 160.1 (d, J = 15.0), 150.9 (d, J = 24.0), 134.9 (d, J = 238.0), 130.1, 130.0, 129.8 (CH), 129.6 (CH), 128.9 (CH), 128.5 (CH), 128.4 (CH), 128.3 (CH), 63.4 (CH_2, d, J = 5.0), 16.2 (Me, d, J = 6.0).

General Method for Microwave-Aided Synthesis of Oxazole-5-phosphonates (Table 2, Conditions B). To a dry microwave tube flushed with argon were added carboxamide (0.24 mmol), rhodium(II) heptafluorobutyramide dimer (6 mg, 5.9 μmol), and diazophosphonate **9a** (50 mg, 0.26 mmol) in anhydrous toluene (4 mL). The mixture was then subjected to microwave irradiation at 135 °C for 30 min. The solvent was removed in vacuo, and the residue was purified by chromatography.

Dimethyl 4-Methyl-2-phenyloxazole-5-phosphonate 12a. Following the general method, benzamide (29 mg, 0.24 mmol) gave a colorless solid (46 mg, 73%); data as above.

Dimethyl 2-(2-Bromophenyl)-4-methyloxazole-5-phosphonate 12b. Following the general method, 2-bromobenzamide (47 mg, 0.24 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.35), a colorless oil (40 mg, 49%); (found M + Na^+, 367.9658. $C_{12}H_{13}{}^{79}BrNO_4P + Na^+$ requires 367.9663); ν_{max} ($CHCl_3$)/cm^{-1} 1583, 1260, 1026; δ_H (500 MHz; $CDCl_3$) 7.93 (1H, m), 7.70 (1H, m), 7.40 (1H, m), 7.32 (1H, m), 3.85 (6H, d, J = 11.5), 2.51 (3H, d, J = 2.0); δ_C (125 MHz; $CDCl_3$) 163.1 (d, J = 14.0), 150.9 (d, J = 26.0), 135.1 (d, J = 239.0), 134.7 (CH), 132.2 (CH), 131.9 (CH), 127.7, 127.6 (CH), 121.5, 53.5 (Me, d, J = 5.0), 12.9 (Me).

Dimethyl 2-(2-Benzyloxyphenyl)-4-methyloxazole-5-phosphonate 12c. Following the general method, 2-benzyloxybenzamide (54 mg, 0.24 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.50), a colorless solid (62 mg, 70%); mp 103−105 °C; (found M + Na^+, 396.0966. $C_{19}H_{20}NO_5P + Na^+$ requires 396.0977); ν_{max} ($CHCl_3$)/cm^{-1} 1589, 1262, 1023; δ_H (500 MHz; $CDCl_3$) 8.04 (1H, m), 7.55 (2H, m), 7.46 (1H, m), 7.39 (2H, m), 7.33 (1H, m), 5.19 (2H, s), 3.70 (6H, d, J = 11.5), 2.52

(3H, d, J = 1.5); δ_C (125 MHz; $CDCl_3$) 163.8 (d, J = 14.0), 157.2, 151.1 (d, J = 28.0), 136.6, 134.2 (d, J = 239.0), 132.9 (CH), 131.4 (CH), 128.6 (CH), 128.0 (CH), 127.4 (CH), 121.2 (CH), 116.3, 113.4 (CH), 70.7 (CH_2), 53.2 (Me, d, J = 5.0), 12.9 (Me).

Dimethyl 2-(4-Benzyloxycarbonylaminophenyl)-4-methyloxazole-5-phosphonate 12g. Following the general method, 4-(benzyloxycarbonylamino)benzamide (64 mg, 0.24 mmol) in 1,2-dichloroethane gave, after chromatography (silica, ethyl acetate, R_f = 0.39, followed by a second column using 10% methanol in dichloromethane, R_f = 0.50), a colorless solid (28 mg, 28%); mp 38−39 °C; (found M + H^+, 417.1217. $C_{20}H_{21}N_2O_6P$ + H^+ requires 417.1216); ν_{max} ($CHCl_3$)/cm^{-1} 1735, 1528, 1216; δ_H (400 MHz; $CDCl_3$) 8.01 (2H, d, J = 8.8), 7.54 (2H, d, J = 8.8), 7.41−7.32 (5H, m), 7.22 (1H, br s), 5.21 (2H, s), 3.82 (6H, d, J = 11.6), 2.47 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 164.4 (d, J = 14.0), 153.1, 151.4 (d, J = 27.0), 141.1, 135.9, 133.9 (d, J = 241.0), 128.8 (CH), 128.6 (CH), 128.5 (CH), 128.4 (CH), 121.4, 118.4 (CH), 67.4 (CH_2), 53.3 (Me, d, J = 5.0), 12.9 (Me).

General Method for One-Pot Synthesis of Oxazole-5-sulfones (Table 3, Conditions A). To a dry flask were added diazosulfone **13** (100 mg, 0.42 mmol), the carboxamide (0.38 mmol), rhodium(II) heptafluorobutyramide dimer (10 mg, 9.5 μmol), and anhydrous 1,2-dichloroethane (7 mL). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated, and the residue was purified by chromatography.

4-Methyl-2-phenyl-5-(toluene-4-sulfonyl)oxazole 14a. Following the general method, benzamide (46 mg, 0.38 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.53), a colorless solid (91 mg, 77%); mp 146−148 °C; (found C, 65.05; H, 4.75; N, 4.42. $C_{17}H_{15}NO_3S$ requires C, 65.16; H, 4.82; N, 4.47); (found M + H^+, 314.0849. $C_{17}H_{15}NO_3S$ + H^+ requires 314.0851); ν_{max} ($CHCl_3$)/cm^{-1} 1580, 1338, 1147; δ_H (400 MHz; $CDCl_3$) 8.00 (2H, m), 7.92 (2H, d, J = 8.4), 7.51−7.42 (3H, m), 7.36 (2H, d, J = 8.4), 2.58 (3H, s), 2.43 (3H, s); δ_C (100 MHz; $CDCl_3$) 162.8, 145.3, 144.9, 142.2, 137.7, 132.0 (CH), 130.2 (CH), 129.0 (CH), 127.7 (CH), 127.3 (CH), 125.9, 21.8 (Me), 13.0 (Me).

2-(4-Bromophenyl)-4-methyl-5-(toluene-4-sulfonyl)oxazole 14d. Following the general method, 4-bromobenzamide (76 mg, 0.38 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.35), a colorless solid (109 mg, 73%); mp 175−176 °C; (found C, 51.91; H, 3.47; N, 3.44. $C_{17}H_{14}BrNO_3S$ requires C, 52.05; H, 3.60; N, 3.57); (found M + H^+, 391.9947. $C_{17}H_{14}{}^{79}BrNO_3S$ + H^+ requires 391.9956); ν_{max} ($CHCl_3$)/cm^{-1} 1601, 1336, 1148; δ_H (500 MHz; $CDCl_3$) 7.91 (2H, d, J = 9.0), 7.85 (2H, d, J = 8.0), 7.57 (2H, dt, J = 9.0), 7.36 (2H, d, J = 8.0), 2.56 (3H, s), 2.42 (3H, s); δ_C (125 MHz; $CDCl_3$) 161.9, 145.4, 145.0, 142.5, 137.6, 132.4 (CH), 130.3 (CH), 128.7 (CH), 127.8 (CH), 126.8, 124.8, 21.8 (Me), 13.0 (Me).

4-Methyl-2-(4-nitrophenyl)-5-(toluene-4-sulfonyl)oxazole 14e. Following the general method, 4-nitrobenzamide (64 mg, 0.38 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.25), a colorless solid (30 mg, 22%); mp 184−185 °C; (found C, 56.97; H, 3.85; N, 7.61. $C_{17}H_{14}N_2O_5S$ requires C, 56.98; H, 3.94; N, 7.82); (found M + Na^+, 381.0513. $C_{17}H_{14}N_2O_5S$ + Na^+ requires 381.0521); ν_{max} ($CHCl_3$)/cm^{-1} 1548, 1340, 1148; δ_H (500 MHz; $CDCl_3$) 8.31 (2H, d, J = 9.0), 8.18 (2H, d, J = 9.0), 7.93 (2H, d, J = 8.5), 7.39 (2H, d, J = 8.5), 2.60 (3H, s), 2.45 (3H, s); δ_C (125 MHz; $CDCl_3$) 160.4, 149.7, 145.8, 145.2, 143.8, 137.3, 131.4, 130.4 (CH), 128.2 (CH), 127.9 (CH), 124.4 (CH), 21.9 (Me), 13.0 (Me).

2-(4-Biphenyl)-4-methyl-5-(toluene-4-sulfonyl)oxazole 14g. Following the general method, 4-biphenylcarboxamide (75 mg, 0.38 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.24), a colorless solid (95 mg, 64%); mp 174−176 °C; (found C, 70.33; H, 4.85; N, 3.55. $C_{23}H_{19}NO_3S$ requires C, 70.93; H, 4.92; N, 3.60); (found M + H^+, 390.1156. $C_{23}H_{19}NO_3S$ + H^+ requires 390.1164); ν_{max} ($CHCl_3$)/cm^{-1} 1336, 1178; δ_H (500 MHz; $CDCl_3$) 8.07 (2H, d, J = 8.5), 7.94 (2H, d, J = 7.5), 7.67 (2H, d, J = 8.5), 7.61 (2H, d, J = 7.5), 7.46 (2H, m), 7.38 (3H, m), 2.60 (3H, s), 2.43 (3H, s); δ_C (125 MHz; $CDCl_3$) 162.6, 145.1, 144.9, 144.5, 142.1, 139.6, 137.6, 130.1 (CH), 128.9 (CH), 128.2 (CH), 127.6 (2 × CH), 127.5 (CH), 127.1 (CH), 124.5, 21.6 (Me), 12.8 (Me).

4-Methyl-2-(2-thienyl)-5-(toluene-4-sulfonyl)oxazole 14h. Following the general method, thiophene-2-carboxamide (49 mg, 0.38 mmol) gave, after chromatography (silica, 40% ethyl acetate in light petroleum; R_f = 0.49), a colorless solid (94 mg, 77%); mp 158−159 °C; (found C, 56.45; H, 4.07; N, 4.22. $C_{15}H_{13}NO_3S_2$ requires C, 56.41; H, 4.10; N, 4.39); (found M + Na^+, 342.0214. $C_{15}H_{13}NO_3S_2$ + Na^+ requires 342.0234); ν_{max} ($CHCl_3$)/cm^{-1} 1587, 1337, 1145; δ_H (500 MHz; $CDCl_3$) 7.89 (2H, d, J = 8.0), 7.71 (1H, dd, J = 4.0, 1.5), 7.49 (1H, dd, J = 5.0, 1.5), 7.35 (2H, d, J = 8.0), 7.10 (1H, dd, J = 5.0, 4.0), 2.54 (3H, s), 2.42 (3H, s); δ_C (125 MHz; $CDCl_3$) 158.9, 145.3, 145.1, 141.6, 137.6, 130.8 (CH), 130.3 (CH), 130.2 (CH), 128.4 (CH), 128.2, 127.7 (CH), 21.8 (Me), 12.9 (Me).

4-Methyl-2-styryl-5-(toluene-4-sulfonyl)oxazole 14i. Following the general method, cinnamamide (56 mg, 0.38 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.26), a colorless solid (80 mg, 62%); mp 119−120 °C; (found C, 67.08; H, 5.03; N, 4.02. $C_{19}H_{17}NO_3S$ requires C, 67.24; H, 5.05; N, 4.13); (found M + Na^+, 362.0811. $C_{19}H_{17}NO_3S$ + Na^+ requires 362.0827); ν_{max} ($CHCl_3$)/cm^{-1} 1337, 1145; δ_H (500 MHz; $CDCl_3$) 7.91 (2H, d, J = 8.5), 7.61 (1H, d, J = 16.5), 7.52−7.50 (2H, m), 7.40−7.36 (5H, m), 6.81 (1H, d, J = 16.5), 2.54 (3H, s), 2.44 (3H, s); δ_C (125 MHz; $CDCl_3$) 162.7, 145.3, 145.0, 141.7, 140.2 (CH), 137.7, 134.8, 130.2 (CH), 129.1 (CH), 127.7 (2 × CH), 112.4 (CH), 21.8 (Me), 12.9 (Me); one carbon unobserved.

General Method for Microwave-Assisted Synthesis of Oxazole-5-sulfones (Table 3, Conditions B). To a dry microwave tube flushed with argon were added diazosulfone **13** (50 mg, 0.21 mmol), carboxamide (0.19 mmol), rhodium(II) heptafluorobutyramide dimer (5.0 mg, 4.77 μmol), and dry 1,2-dichloroethane (3.5 mL). The mixture was subject to microwave irradiation at 105 °C for 30 min. The solvent was then removed in vacuo, and the residue was purified by chromatography.

4-Methyl-2-phenyl-5-(toluene-4-sulfonyl)oxazole 14a. Following the general method, benzamide (23 mg, 0.19 mmol) gave a colorless solid (48 mg, 81%); data as above.

2-(2-Bromophenyl)-4-methyl-5-(toluene-4-sulfonyl)oxazole 14b. Following the general method, 2-bromobenzamide (38 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum, R_f = 0.38, followed by a second column using dichloromethane), a colorless solid (30 mg, 40%); mp 88−90 °C; (found C, 52.02; H, 3.64; N, 3.41. $C_{17}H_{14}BrNO_3S$ requires C, 52.05; H, 3.60; N, 3.57); (found M + Na^+, 413.9773. $C_{17}H_{14}{}^{79}BrNO_3S$ + Na^+ requires 413.9775); ν_{max} ($CHCl_3$)/cm^{-1} 1583, 1333, 1149; δ_H (500 MHz; $CDCl_3$) 7.94 (2H, m), 7.90 (1H, d, J = 8.0), 7.68 (1H, dd, J = 8.0, 1.0), 7.41−7.30 (4H, m), 2.60 (3H, s), 2.43 (3H, s); δ_C (125 MHz; $CDCl_3$) 161.3, 145.4, 144.2, 142.9, 137.5, 134.8 (CH), 132.5 (CH), 132.0 (CH), 130.2 (CH), 128.0 (CH), 127.6 (CH), 127.0, 121.5, 21.8 (Me), 13.0 (Me).

2-(2-Benzyloxyphenyl)-4-methyl-5-(toluene-4-sulfonyl)oxazole 14c. Following the general method, 2-benzyloxybenzamide (43 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.24), a colorless solid (63 mg, 79%); mp 104−106 °C; (found C, 68.58; H, 4.94; N, 3.21. $C_{24}H_{21}NO_4S$ requires C, 68.72; H, 5.05; N, 3.34); (found

M + Na^+, 442.1078. $C_{24}H_{21}NO_4S + Na^+$ requires 442.1089); ν_{max} (solid)/cm^{-1} 1590, 1336, 1144; δ_H (500 MHz; $CDCl_3$) 8.01 (1H, m), 7.75 (2H, m), 7.59 (2H, d, J = 8.0), 7.48−7.42 (3H, m), 7.36 (1H, t, J = 7.5), 7.21 (2H, d, J = 8.0), 7.07 (1H, d, J = 8.5), 7.03 (1H, t, J = 7.5), 5.20 (2H, s), 2.58 (3H, s), 2.37 (3H, s); δ_C (125 MHz; $CDCl_3$) 162.0, 157.2, 144.9, 144.3, 142.0, 137.8, 136.5, 133.3 (CH), 131.2 (CH), 130.0 (CH), 128.8 (CH), 128.1 (CH), 127.7 (CH), 127.3 (CH), 121.1 (CH), 115.5, 113.6 (CH), 70.6 (CH_2), 21.7 (Me), 12.9 (Me).

2-[4-(Benzyloxycarbonylamino)phenyl]-4-methyl-5-(toluene-4-sulfonyl)oxazole 14f. Following the general method, 4-(benzyloxycarbonylamino)benzamide (52 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.14), a colorless solid (41 mg, 47%); mp 174−175 °C; (found M + Na^+, 485.1136. $C_{25}H_{22}N_2O_5S + Na^+$ requires 485.1147); ν_{max} ($CHCl_3$)/cm^{-1} 1738, 1518, 1336, 1147; δ_H (500 MHz; $CDCl_3$) 7.94 (2H, d, J = 8.5), 7.91 (2H, m), 7.48 (2H, d, J = 8.5), 7.41−7.36 (7H, m), 6.89 (1H, s), 5.21 (2H, s), 2.56 (3H, s), 2.43 (3H, s); δ_C (125 MHz; $CDCl_3$) 162.6, 152.9, 145.2, 145.1, 141.8, 141.3, 137.8, 135.8, 130.2, 128.8 (CH), 128.7 (CH), 128.6 (CH), 128.5 (CH), 127.7 (CH), 120.8 (CH), 118.4 (CH), 67.6 (CH_2), 21.8 (Me), 13.0 (Me).

5-Methyl-2-phenyl-4-(toluene-4-sulfonyl)oxazole 15. To a dry two-neck flask were added diazosulfone **13** (100 mg, 0.42 mmol), rhodium(II) acetate dimer (4 mg, 9.5 μmol), and a dichloromethane solution (7 mL) of benzonitrile (39 mg, 0.38 mmol) under argon. The mixture was heated under reflux and stirred under argon for 1 h. After cooling, the solvent was removed in vacuo, and the residue was purified by chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.25) to give a colorless solid (50 mg, 42%); mp 137−139 °C; (found M + H^+, 314.0843. $C_{17}H_{15}NO_3S + H^+$ requires 314.0851); ν_{max} (solid)/cm^{-1} 1593, 1316, 1152; δ_H (400 MHz; $CDCl_3$) 7.98−7.95 (4H, m), 7.45−7.39 (3H, m), 7.34 (2H, d, J = 8.0), 2.75 (3H, s), 2.42 (3H, s); δ_C (100 MHz; $CDCl_3$) 160.3, 153.2, 144.7, 137.8, 136.9, 131.2 (CH), 129.9 (CH), 128.9 (CH), 128.1 (CH), 126.8 (CH), 126.2, 21.8 (Me), 11.8 (Me).

Methyl 2-(4-Bromophenyl)-4-methylthiazole-5-carboxylate 17a. To a microwave tube were added 4-bromothiobenzamide (65 mg, 0.301 mmol), rhodium heptafluorobutyrate dimer (6.3 mg, 6.02 μmol), and methyl 2-diazo-3-oxobutanoate **2** (50 mg, 0.352 mmol) in dichloromethane (1 mL). The mixture was immediately subjected to microwave at 120 °C for 10 min. After cooling, the solvent was evaporated, and the residue was purified by chromatography (silica, 0 to 50% EtOAc in cyclohexane over 20 min; R_f = 0.71) to give a colorless solid (44 mg, 47%), mp 139−140 °C; (found M + H^+, 311.9686. $C_{12}H_{10}{}^{79}BrNO_2S + H^+$ requires 311.9694); (found C, 46.16; H, 3.09; N, 4.23. $C_{12}H_{10}BrNO_2S$ requires C, 46.17; H, 3.23; N, 4.49); ν_{max} (solid)/cm^{-1} 1715, 1520, 1428, 1369, 1319, 1260, 1194; δ_H (400 MHz; $CDCl_3$) 7.82 (2 H, d, J = 8.5), 7.57 (2 H, d, J = 8.5), 3.89 (3 H, s), 2.77 (3 H, s); δ_C (100 MHz; $CDCl_3$) 168.5, 162.5, 161.4, 132.2 (CH), 131.8, 128.1 (CH), 125.4, 121.7, 52.2 (Me), 17.5 (Me).

Dimethyl 4-Methyl-2-phenylthiazole-5-phosphonate 17b. To a solution of diazophosphonate **9a** (50 mg, 0.26 mmol) in anhydrous toluene (4 mL) were added thiobenzamide (33 mg, 0.24 mmol) and rhodium(II) heptafluorobutyramide dimer (6.2 mg, 5.9 μmol). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated, and the residue was purified by chromatography (silica, ethyl acetate; R_f = 0.34) to give a yellow oil (50 mg, 75%); (found M + H^+, 284.0506. $C_{12}H_{14}NO_3PS + H^+$ requires 284.0510); ν_{max} ($CHCl_3$)/cm^{-1} 1253, 1034; δ_H (400 MHz; $CDCl_3$) 7.94−7.92 (2H, m), 7.46−7.42 (3H, m), 3.81 (6H, d, J = 11.6), 2.68 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 172.7 (d, J = 12.0), 162.6 (d, J = 14.0), 132.7, 131.1 (CH), 129.2 (CH), 127.0 (CH), 114.6 (d, J = 207.0), 53.1 (Me, d, J = 5.0), 17.4 (Me).

4-Methyl-2-phenyl-5-(toluene-4-sulfonyl)thiazole 17f. To a solution of diazosulfone **13** (100 mg, 0.42 mmol) in anhydrous 1,2-dichloroethane (7 mL) were added thiobenzamide (52 mg, 0.38 mmol) and rhodium(II) heptafluorobutyramide dimer (10.0 mg, 9.5 μmol). The mixture was allowed to stir under argon and heated to reflux overnight. The solvent was evaporated, and the residue was purified by chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.26) to give a colorless solid (106 mg, 85%); mp 109−110 °C; (found C, 61.97; H, 4.50; N, 4.12. $C_{17}H_{15}NO_2S_2$ requires C, 61.98; H, 4.59; N, 4.25); (found M + H^+, 330.0609. $C_{17}H_{15}NO_2S_2 + H^+$ requires 330.0622); ν_{max} ($CHCl_3$)/cm^{-1} 1326, 1154; δ_H (500 MHz; $CDCl_3$) 7.89−7.86 (4H, m), 7.45−7.40 (3H, m), 7.33 (2H, d, J = 8.0), 2.66 (3H, s), 2.41 (3H, s); δ_C (125 MHz; $CDCl_3$) 171.1, 157.8, 144.8, 138.9, 132.3, 132.1, 131.5 (CH), 130.1 (CH), 129.2 (CH), 127.4 (CH), 126.8 (CH), 21.7 (Me), 16.5 (Me).

General Method for Microwave-Aided Synthesis of Thiazole-5-phosphonates (Table 4, Conditions C). To a dry microwave tube flushed with argon were added thiocarboxamide (0.24 mmol), rhodium(II) heptafluorobutyramide dimer (6 mg, 5.9 μmol), and diazophosphonate **9a** (50 mg, 0.26 mmol) in anhydrous toluene (4 mL). The mixture was then subjected to microwave irradiation at 135 °C for 30 min. The solvent was removed in vacuo, and the residue was purified by chromatography.

Dimethyl 2-(2-Benzyloxyphenyl)-4-methylthiazole-5-phosphonate 17c. Following the general method, 2-benzyloxythiobenzamide (57 mg, 0.24 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.44), a yellow oil (54 mg, 59%); (found M + Na^+, 412.0732. $C_{19}H_{20}NO_4PS + Na^+$ requires 412.0748); ν_{max} ($CHCl_3$)/cm^{-1} 1598, 1247, 1020; δ_H (400 MHz; $CDCl_3$) 8.43 (1H, m), 7.46 (2H, m), 7.40−7.33 (4H, m), 7.07 (1H, m), 7.03 (1H, m), 5.35 (2H, s), 3.76 (6H, d, J = 11.6), 2.70 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 166.7 (d, J = 13.0), 160.6 (d, J = 14.0), 155.9, 136.1, 131.7 (CH), 129.0 (CH), 128.7 (CH), 128.4 (CH), 127.7 (CH), 121.9, 121.4 (CH), 114.9 (d, J = 205.0), 112.8 (CH), 70.9 (CH_2), 53.0 (Me, d, J = 6.0), 17.3 (Me).

Dimethyl 2-(4-Bromophenyl)-4-methylthiazole-5-phosphonate 17d. Following the general method, 4-bromothiobenzamide (51 mg, 0.24 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.32), a colorless solid (30 mg, 35%); mp 85−86 °C; (found C, 39.70; H, 3.42; N, 3.63. $C_{12}H_{13}BrNO_3PS$ requires C, 39.80; H, 3.62; N, 3.87); (found M + H^+, 361.9600. $C_{12}H_{13}{}^{79}BrNO_3PS + H^+$ requires 361.9615); ν_{max} ($CHCl_3$)/cm^{-1} 1252, 1028; δ_H (400 MHz; $CDCl_3$) 7.81 (2H, d, J = 8.8), 7.58 (2H, d, J = 8.8), 3.81 (6H, d, J = 11.6), 2.68 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 171.3 (d, J = 11.0), 162.7 (d, J = 14.0), 132.5, 131.7, 128.4 (CH), 125.6 (CH), 115.3 (d, J = 207.0), 53.1 (Me, d, J = 6.0), 17.4 (Me).

Dimethyl 2-(4-Benzyloxycarbonylaminophenyl)-4-methylthiazole-5-phosphonate 17e. Following the general method, 4-(benzyloxycarbonylamino)thiobenzamide (68 mg, 0.24 mmol) gave, after chromatography (silica, ethyl acetate, R_f = 0.35), a yellow solid (56 mg, 55%); mp 39−40 °C; (found M + Na^+, 455.0796. $C_{20}H_{21}N_2O_5PS + Na^+$ requires 455.0806); ν_{max} ($CHCl_3$)/cm^{-1} 1715, 1536, 1216, 1028; δ_H (400 MHz; $CDCl_3$) 7.87 (2H, d, J = 8.4), 7.52 (2H, d, J = 8.4), 7.42 (1H, br s), 7.39−7.33 (5H, m), 5.20 (2H, s), 3.78 (6H, d, J = 11.6), 2.66 (3H, d, J = 2.0); δ_C (100 MHz; $CDCl_3$) 172.3 (d, J = 12.0), 162.6 (d, J = 14.0), 153.2, 140.9, 135.9, 128.7 (CH), 128.6 (CH), 128.5 (CH), 127.9 (CH), 127.7, 118.7 (CH), 113.7 (d, J = 208.0), 67.3 (CH_2), 53.1 (d, J = 5.0), 17.4 (Me).

General Method for Microwave-Assisted Synthesis of Thiazole-5-sulfones (Table 4, Conditions E). To a dry microwave tube flushed with argon were added diazosulfone **13** (50 mg, 0.21 mmol), thiocarboxamide (0.19 mmol), rhodium(II) heptafluorobutyramide dimer (5.0 mg, 4.77 μmol), and dry 1,2-dichloroethane (3.5 mL). The mixture was subjected to microwave

irradiation at 105 °C for 30 min. The solvent was then removed in vacuo, and the residue was purified by chromatography.

2-(2-Benzyloxyphenyl)-4-methyl-5-(toluene-4-sulfonyl)thiazole 17g. Following the general method, 2-benzyloxythiobenzamide (46 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.20), a colorless solid (72 mg, 87%); mp 138−139 °C; (found C, 66.14; H, 4.75; N, 3.05. $C_{24}H_{21}NO_3S_2$ requires C, 66.18; H, 4.86; N, 3.22); (found M + H^+, 436.1038. $C_{24}H_{21}NO_3S_2 + H^+$ requires 436.1041); ν_{max} (solid)/cm^{-1} 1597, 1320, 1150; δ_H (400 MHz; $CDCl_3$) 8.36 (1H, dd, J = 8.0, 1.6), 7.82 (2H, d, J = 8.4), 7.48−7.34 (6H, m), 7.30 (2H, d, J = 8.4), 7.07−7.02 (2H, m), 5.36 (2H, s), 2.67 (3H, s), 2.41 (3H, s); δ_C (100 MHz; $CDCl_3$) 165.2, 156.0, 144.4, 139.5, 138.2, 135.8, 132.2, 132.1 (CH), 130.0 (CH), 128.8 (CH), 128.7 (CH), 128.6 (CH), 127.8 (CH), 127.3 (CH), 121.6, 121.4 (CH), 112.8 (CH), 71.1 (CH_2), 21.7 (Me), 16.5 (Me).

2-(4-Bromophenyl)-4-methyl-5-(toluene-4-sulfonyl)thiazole 17h. Following the general method, 4-bromothiobenzamide (41 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.34), a colorless solid (68 mg, 88%); mp 171−173 °C; (found M + H^+, 407.9732. $C_{17}H_{14}{}^{79}BrNO_2S_2 + H^+$ requires 407.9728); ν_{max} ($CHCl_3$)/cm^{-1} 1589, 1326, 1154; δ_H (400 MHz; $CDCl_3$) 7.87 (2H, d, J = 8.4), 7.75 (2H, d, J = 8.4), 7.57 (2H, d, J = 8.8), 7.35 (2H, d, J = 8.8), 2.65 (3H, s), 2.43 (3H, s); δ_C (100 MHz; $CDCl_3$) 169.8, 158.0, 145.0, 138.8, 132.6, 132.5 (CH), 131.3, 130.2 (CH), 128.3 (CH), 127.5 (CH), 126.1, 21.8 (Me), 16.6 (Me).

2-[4-(Benzyloxycarbonylamino)phenyl]-4-methyl-5-(toluene-4-sulfonyl)thiazole 17i. Following the general method, 4-(benzyloxycarbonylamino)thiobenzamide (54 mg, 0.19 mmol) gave, after chromatography (silica, 20% ethyl acetate in light petroleum; R_f = 0.10), a colorless solid (75 mg, 83%); mp 169−171 °C; (found C, 62.59; H, 4.52; N, 5.48. $C_{25}H_{22}N_2O_4S_2$ requires C, 62.74; H, 4.63; N, 5.85); (found M + Na^+, 501.0900. $C_{25}H_{22}N_2O_4S_2 + Na^+$ requires 501.0919); ν_{max} (solid)/cm^{-1} 1728, 1526, 1517, 1315, 1148; δ_H (400 MHz; $CDCl_3$) 7.87 (2H, d, J = 8.4), 7.81 (2H, d, J = 8.8), 7.47 (2H, d, J = 8.4), 7.40−7.32 (7H, m), 7.03 (1H, s), 5.20 (2H, s), 2.63 (3H, s), 2.42 (3H, s); δ_C (100 MHz; $CDCl_3$) 170.6, 157.7, 152.9, 144.6, 140.9, 138.8, 135.6, 131.2, 130.0 (CH), 128.6 (CH), 128.4 (CH), 128.3 (CH), 127.8 (CH), 127.2 (CH + C), 118.5 (CH), 67.3 (CH_2), 21.6 (Me), 16.4 (Me).

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Supporting Information Available: General experimental details, experimental procedures for preparation of diazo compounds **2**, **5**, **9**, and **13**, X-ray crystal structures of compounds **6**, **15**, **17a**, **17d**, and **17h**, copies of ^1H and ^{13}C NMR spectra, and CIF files for compounds **6**, **15**, **17a**, **17d**, and **17h**. This material is available free of charge via the Internet at http://pubs.acs.org.