

Initiated pseudo-[3+2] cycloaddition of mixed phosphonium-iodonium ylides to acetonitrile*

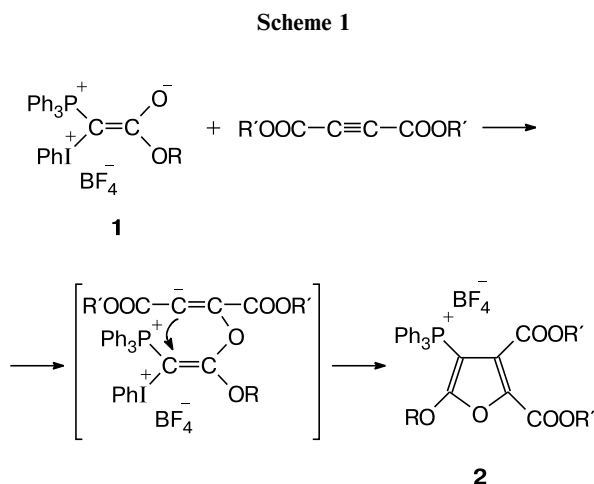
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The oxazole fragment is involved as a structural unit in some biologically active compounds. A large number of oxazole-containing compounds were isolated from various natural sources, particularly, of the sea origin. Many of these compounds exhibit different activities, for example, antiviral, antifungal, and antibacterial activities.^{1,2}

An analysis of the published data shows that there are no general approaches to the synthesis of 2,4- and 2,4,5-substituted oxazoles.^{3–5} Iodonium ylides hold promise as reagents for the synthesis of oxazoles.^{6,7}

Recently, we have found that mixed phosphonium-iodonium ylides **1** have different reactivities associated primarily with the existence of the enolate resonance form.^{8–10} An analysis of the structural features of ylide suggests that this compound can be used as a 1,3-dipole in the synthesis of furans **2** according to Scheme 1.

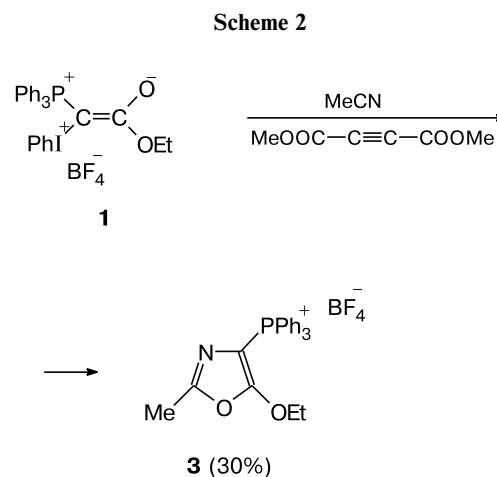


In the 20–60 °C temperature range, the reaction of phosphonium-iodonium ylides **1** with dimethyl acetylenedicarboxylate (DMAD) serving as the solvent does not proceed. At 70 °C, the strong resinification of the reaction mixture occurs. The ³¹P NMR spectrum of the

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reaction mixture consisting of mixed ylide **1** and DMAD in CDCl₃ shows, in addition to the signal of the starting ylide at δ 30, two new signals at δ 44. Hence, we studied the reactions of ylide **1** with DMAD in more detail.

We found that the reaction of ylide **1** with DMAD in boiling acetonitrile unexpectedly afforded the addition product of mixed ylide **1** at the C–N triple bond of acetonitrile. We isolated 2,4,5-substituted oxazole **3** as the major reaction product in 30% yield (Scheme 2). In addition to oxazole **3**, ethoxycarbonylmethylenetriphenylphosphonium tetrafluoroborate (30%) and triphenylphosphine oxide (30%) were isolated from the reaction mixture by chromatography.



The structure of compound **3** was established by X-ray diffraction (Fig. 1). The structural characteristics are given in Table 1.

It should be emphasized that the discovered reaction has a paradoxical feature. Thus, special experiments showed that the reaction of mixed ylide in acetonitrile in the absence of DMAD does not proceed upon heating. Therefore, DMAD serves apparently as a promoter for the addition of ylide **1** to acetonitrile. We plan to extend the range of dienophiles and ylides in this unusual reaction and to elucidate the role of DMAD.

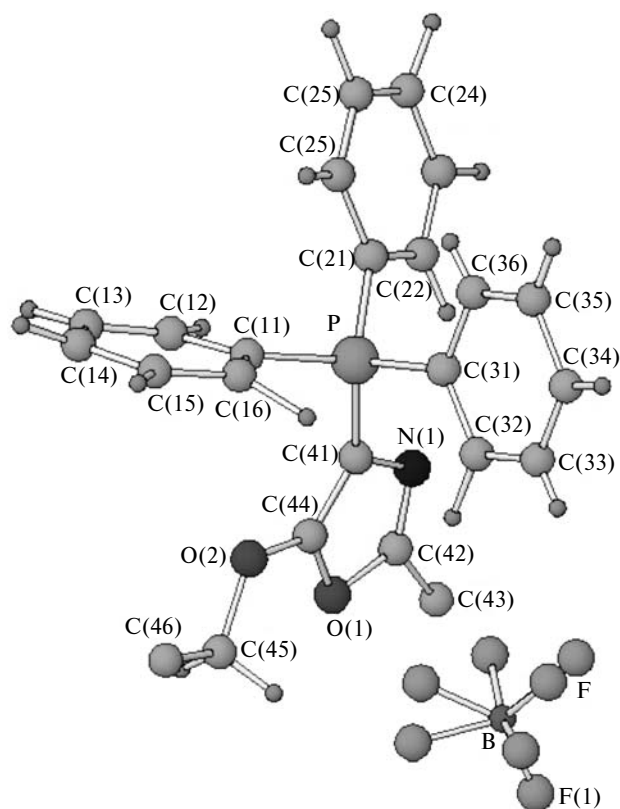


Fig. 1. Structure of compound **3** (hydrogen atoms of the methyl groups are omitted).

The ^1H , ^{31}P , and ^{13}C NMR spectra were recorded on a Bruker Avance 400 instrument operating at 400 MHz in CDCl_3 with Me_4Si as the internal standard. The IR spectra were measured on a UR-20 instrument in CCl_4 . The elemental analysis was carried out on a Vario-II CHN analyzer.

X-ray diffraction study. X-ray diffraction data were collected from transparent plate-like crystals of $\text{C}_{24}\text{H}_{23}\text{BF}_4\text{NO}_2\text{P}$ (**3**). The unit cell parameters were refined based on 23 reflections. The absorption correction was applied based on the crystal shape. The structure was solved by direct methods (SIR2002).¹¹ All nonhydrogen atoms were located in sequential Fourier and difference Fourier maps and refined first isotropically and then with anisotropic atomic displacement parameters using the JANA2000 program package.¹² The hydrogen atoms (except for the H atoms of the methyl groups) were positioned geometri-

Table 1. Interatomic distances (d) in compound **3**

Distance	$d/\text{\AA}$	Distance	$d/\text{\AA}$
P—C(11)	1.795(6)	N(41)—C(42)	1.273(9)
P—C(21)	1.804(7)	C(42)—O(41)	1.365(8)
P—C(31)	1.799(7)	C(42)—C(43)	1.497(10)
P—C(41)	1.760(6)	O(41)—C(44)	1.350(7)
C(41)—N(41)	1.412(7)	C(44)—O(42)	1.319(8)
C(41)—C(44)	1.340(9)	O(42)—C(45)	1.343(10)
C—H	0.73(9)—1.14(8)	C(45)—C(46)	1.438(12)
B—F	1.31(2)—1.430(17)		

Table 2. Crystallographic characteristics and the X-ray data collection and refinement statistics for compound **3**

Parameter	Characteristics
Molecular formula	$\text{C}_{24}\text{H}_{23}\text{BF}_4\text{NO}_2\text{P}$
Molecular weight	475.23
Crystal system	Monoclinic
Space group	$\text{P}2_1/a$
Unit cell parameters	
$a/\text{\AA}$	12.711(4)
$b/\text{\AA}$	14.5739(16)
$c/\text{\AA}$	13.031(3)
β/deg	103.291(24)
Z	4
$d_{\text{calc}}/\text{g cm}^{-3}$	1.343
Radiation	Mo-K α
$\lambda/\text{\AA}$	0.71069
T/K	293
Crystal shape	Plates
Crystal dimensions/mm	0.32×0.81×0.04
Diffractometer	CAD-4
Scanning mode	ω
Absorption correction	Analytical (based on the crystal shape)
Number of measured/independent reflections	5793/2599
Number of observed reflections with $I > 3\sigma(I)$	2060
θ -Scan range/deg	2–26
h, k, l ranges	$0 \leq h \leq 15,$ $-2 \leq k \leq 17$ $-16 \leq l \leq 15$
R_{int}	0.025
R/R_w ($I > 3\sigma(I)$)	0.074/0.105
Goodness-of-fit	1.60
Number of refined parameters	339
Weighting scheme	$w = (\sigma^2(F) + (0.055F)^2)^{-1}$
$\Delta\rho_{\text{max}}/e \text{\AA}^{-3}$	+0.39/−0.55

cally and refined first with fixed bond lengths and bond angles and then independently (except for the H(41) and H(42) atoms; the independent refinement led to inadequate results, and these C—H distances were restrained ($d = 1.0$) in the refinement). Their atomic displacement parameters were taken equal to $1.2U_{\text{iso}}$ of the parent carbon atoms. The positions of the hydrogen atoms of the methyl groups were refined using a riding model. Only one atom per group was taken if the fragment has a local threefold axis (*i.e.*, the other hydrogen atoms were generated by the corresponding symmetry operations). The C—H interatomic distances (0.99(4) Å) and the C—C—H bond angles (112°(2)) are indicative of the reliability of the results. The X-ray data collection and refinement statistics are given in Table 2.

(5-Ethoxy-2-methyl-1,3-oxazol-4-yl)(triphenyl)phosphonium tetrafluoroborate (3). Dimethyl acetylenedicarboxylate (0.077 mL, 0.628 mol) was added to a solution of ylide **1** (0.2 g, 0.314 mmol) in anhydrous acetonitrile (3 mL). The reaction mixture was heated under argon for 1 h. The completion of the reaction was determined from the disappearance of ylide **1** (TLC monitoring). The reaction mixture was concentrated *in vacuo*.

The residue was chromatographed on a column using benzene, dichloromethane, and then a CH₂Cl₂/MeOH mixture in a gradient from 100 : 1 to 20 : 1 as the eluents. The yield of compound **3** was 0.05 g (30%). ¹H NMR (CDCl₃), δ: 0.99 (t, 3 H, CH₃, *J* = 7.1 Hz); 2.49 (s, 3 H, CH₃), 4.32 (q, 2 H, CH₂, *J* = 7.1 Hz); 7.65–7.80 (m, 15 H, arom.). ¹³C NMR (CDCl₃), δ: 14.15 (s, CH₃); 14.22 (s, CH₃); 70.63 (s, OCH₂); 118.21 (d, C_{ipso} arom., ¹*J*_{C,P} = 95.3 Hz), 130.19 (d, C_m arom., ³*J*_{C,P} = 13.9 Hz), 134.19 (d, C_o arom., ²*J*_{C,P} = 11.0 Hz), 135.21 (s, C_p arom.), 155.47 (s, C–O), 167.01 (s, C–CH₃). ³¹P NMR (CDCl₃), δ: 8.64. IR, ν/cm⁻¹: 1590, 1630 (ring), 1730 (C=O). Found (%): C, 59.86; H, 4.82; N, 3.08. C₂₄H₂₃BF₄NO₂P. Calculated (%): C, 60.63; H, 4.84; N, 2.95.

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