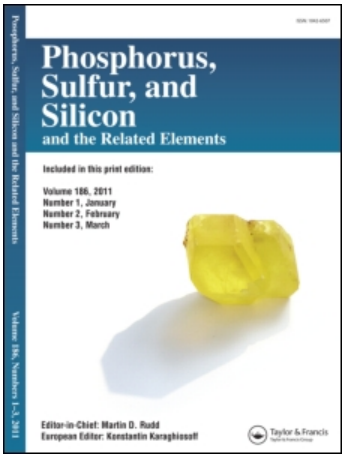


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# Studies on Phosphonium Ylides XXV: The Behavior of Active Phosphacumulene and Stabilized Alkylidenephosphoranes Towards 5-(4*H*)-Oxazolones

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# Studies on Phosphonium Ylides XXV: The Behavior of Active Phosphacumulene and Stabilized Alkylidenephosphoranes Towards 5-(4*H*)-Oxazolones

**Leila S. Boulos, Mona H. N. Arsanious, and Ewies F. Ewies**
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*The reaction of 2-phenyl-5-(4*H*)-oxazolone 1 and its 4-benzylidene derivative 2 with oxovinylidenetriphenylphosphorane 3 afforded 2-phenylfuro [3,2-d] [1,3]oxazol-5-(6*H*)-one 6 and 2,7-diphenyl-5*H*-pyrano[3,2-d][1,3]oxazol-5-one 7 along with triphenylphosphine. Alternatively, when 2-phenyl-5-(4H)-oxazolone 1 reacts with phosphorus ylides 4a–f the corresponding new phosphorane, the cyclic and/or the olefinic adducts were obtained. Moreover, oxazolone reacts with N-(triphenylphosphoranylidene)aniline 5 to give the new imino product 14 together with triphenylphosphine oxide. Possible reaction mechanisms are considered and the structural assignments are based on analytical and spectroscopic results. Biological evaluations of the new products are also studied.*

**Keywords** 5-(4*H*)-Oxazolones; oxovinylidenetriphenylphosphorane; *N*-(triphenylphosphoranylidene) aniline; ylides



## INTRODUCTION

Oxazolones constitute a class of small heterocycles, which are important intermediates in the synthesis of several small molecules, including amino acids, peptides, antimicrobial or antitumor compounds,[1,2] and heterocyclic precursors,[3,4] as well as biosensor coupling and/or photosensitive composition devices for proteins.[5]

Some oxazolones have shown a wide range of pharmaceutical properties.[6] As part of our continuous interest in organophosphorus chemistry,[7–11] the present study deals with the reaction of active phosphacumulene ylides, namely 2-oxovinylidenetriphenylphosphorane **3** with 5-(4*H*)-oxazolone **1** and its 4-benzylidene derivative **2**, and a comparison of the reactivity of the active phosphacumulene **3** with the

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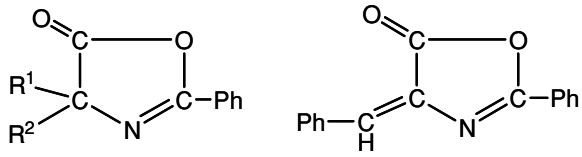
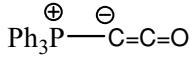


**1**, $R^1=R^2=H$ **2**



**3**

$Ph_3P=C\ R^1R^2$

**4**

a, $R^1$= H; $R^2$= $COOC_2H_5$

b, $R^1$= H; $R^2$= $COOCH_3$

c, $R^1$= H; $R^2$= CH-CHO

d, $R^1$= H; $R^2$= CN

e, $R^1$= H; $R^2$= $COCH_3$

f, $R^1+R^2$= 9-fluorenylidene

$Ph_3P=N\text{-}Ph$

**5**

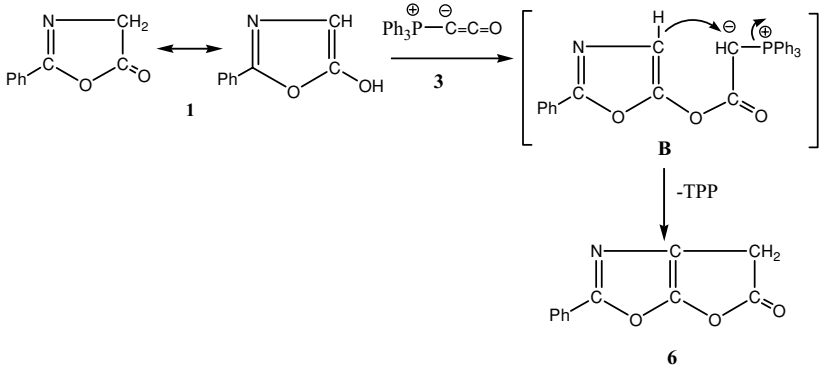
**FIGURE 1**

reactivity of stabilized phosphorus ylides (**4a–4f**) and iminophosphorane (**5**) towards the above mentioned oxazolone **1** and **2** (Figure 1).

## RESULTS AND DISCUSSION

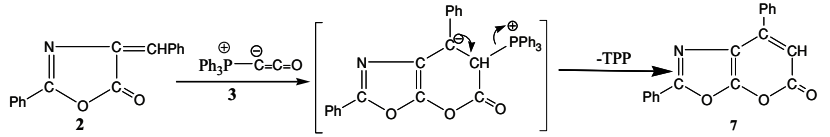
We have found that 2-phenyl-5-(4*H*)-oxazolone **1** reacts with 1 mol equivalent of 2-oxovinylidenetriphenylphosphorane **3** in dry tetrahedrofuran, at room temperature for 9 h to give colorless crystalline product assigned structure **6**. Triphenylphosphine was also isolated from the reaction medium and identified (Scheme 1).

Structural support for 2-phenylfuro [3,2-*d*][1,3]oxazol-5-(6*H*)-one **6** was based upon correct elemental and spectroscopic data (IR, $^1$H,



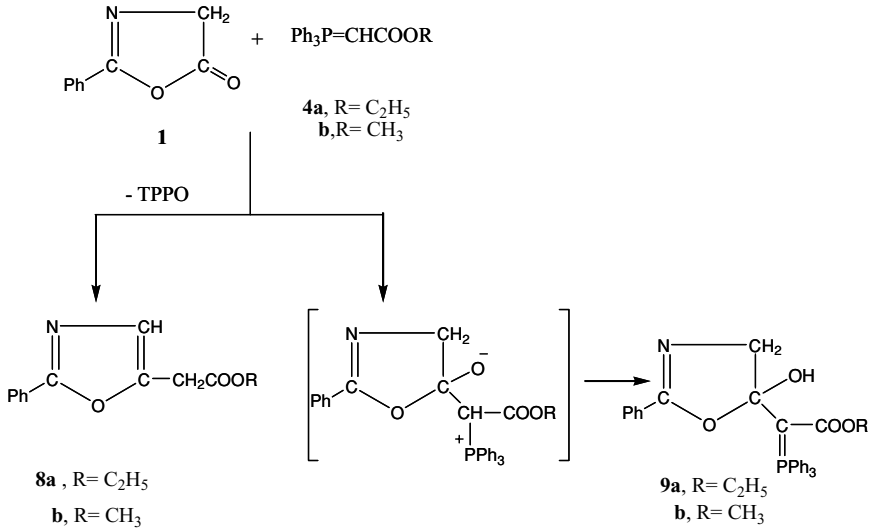
**SCHEME 1**

$^{13}$C NMR, and mass spectrum). Elemental analyses and molecular weight determination (MS) of compound **6** support the molecular formula $C_{11}H_7NO_3$; accordingly, ms: $m/z = 201(M^+, 100)$. Its IR spectrum, in KBr, exhibits an intense band at 1726 $cm^{-1}$for the lacton carbonyl band. $^1$H NMR of compound **6** showed a singlet at 3.66 ppm for the methylene protons (s, 2H, $CH_2$). The aromatic protons appeared as multiplet at 7.84–7.43 ppm (5H). $^{13}$C NMR of product **6** exhibits signals at 173.44 ppm (C=O, lacton), 165.46 (C=N), 134.75, 127.0 ppm (C=C), 40.60 ($CH_2$), 129.43, 128.22, 127.33, 126.30 (C-CH, Ar). A possible explanation for the course of the reaction of 2-oxovinylidenetriphenylphosphorane **3** with **1** is shown in Scheme 1. Formation of product **6** can be explained in terms of protonation with the hydrogen proton of compound **1** on the carbon-ion center of the accumulated ylide **3** to give the intermediate **B**. Since triphenylphosphine is a good leaving group,[12,13] Hoffmann elimination[14] of triphenylphosphine afforded the final product **6**. In addition, we studied the behavior of 4-benzylidene-2-phenyl-5-(4*H*)-oxazolone **2** with 2-oxovinylidenetriphenylphosphorane **3**. Treatment of **2** with 1 mol equivalent of **3** in tetrahedrofuran leads to the formation of the new cyclic product **7**. Triphenylphosphine was also isolated from the reaction medium (Scheme 2). The structure of product **7** is deduced from its elemental analysis, IR, $^1$H, $^{13}$C NMR, and mass spectral data (*cf.* experimental, Scheme 2).[14]



**SCHEME 2**

Furthermore, the reaction of 2-phenyl-5-(4*H*)-oxazolone **1** with resonance stabilized ylidenetriphenylphosphoranes **4a–4f** and iminophosphorane **5** has also been investigated (Figure 1). 2-Phenyl-5-(4*H*)-oxazolone **1** reacted with 1 mol equivalent of carbethoxymethylen-etriphenynphosphorane **4a**, in refluxing toluene for 6 h, to give two crystalline compounds that were assigned structures **8a** and **9a**. Triphenylphosphine oxide was also isolated from the reaction mixture and identified (Scheme 3). The first product was obtained as yellow crystals in 45% yield and was formulated as the known[15] ethyl(2-phenyl-1,3-oxazol-5-yl)acetate **8a** based on elemental analysis, IR, $^1$H, $^{13}$C NMR, and mass spectral data (*cf*. Experimental).




**SCHEME 3**

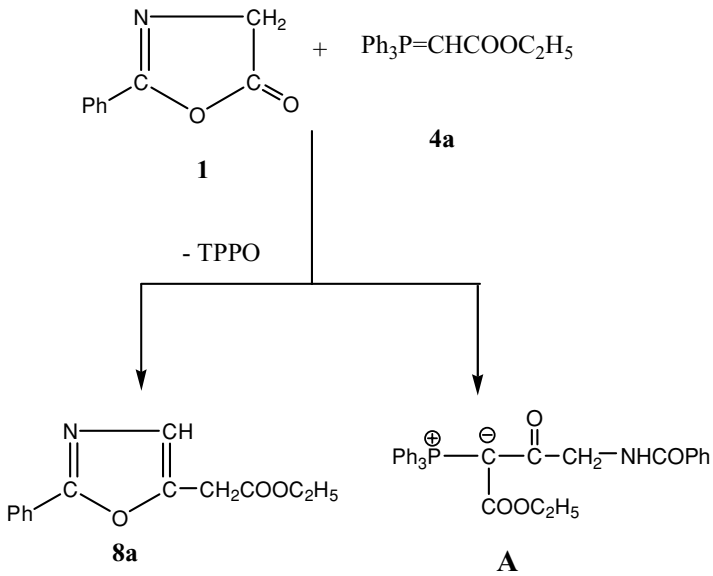
The structure of the other isolated compound **9a** (colorless crystalline compound m.p. 120°C, yield 40%) was deduced from its elemental analysis, IR, $^1$H, $^{13}$C, $^{31}$P NMR, and mass spectral data. Elemental and mass spectroscopic analysis for compound **9a** corresponded to an empirical formula $C_{31}H_{28}NO_4P$. Its IR spectrum (in KBr) revealed the presence of strong absorption bands at 1733 (C=O, ester), 1644, 1590cm$^{-1}$ (C=P), 1439, 969cm$^{-1}$(P-C, Phenyl), 3293cm$^{-1}$ (OH).$^1$H NMR spectrum of compound **9a** showed signals at 0.82 (t, 3H, $J$ = 8Hz, $CH_3$), 3.84 (q, 2H, $J$ = 8Hz, $CH_2$), 2.21 (s, 1H, OH, exchangeable with $D_2O$), 7.32–7.96 (m, 20H, Ar). Moreover, the structure of product **9a** is identified mainly from its $^1$H NMR which reveals the presence of doublet of doublets for the unsymmetrical methylene

protons at 4.805, 4.801–4.791, 4.787 ppm with ($J_{HH}$ = 1.2 Hz, $J_{HP}$ = 4.2 Hz). This is due to the mutual coupling of the unsymmetrical methylene protons and the long range coupling with the phosphorus atom.[16] $^{13}$C NMR of ethyl(5-hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)(triphenyl-$\lambda^5$-phosphoranylidene) acetate **9a** indicates signals at 166.91 ppm (d, $^2J_{cp}$ = 13.25 Hz, $\underline{CO}OC_2H_5$), 163.34 ppm (C=N), 125.31 ppm (d,$^1J_{cp}$ = 93.2 Hz, P=C)[17] 96.30 (d,$^2J_{cp}$ = 15 Hz, C-OH), 68.53 ppm (d,$^3J_{cp}$ = 8.5 Hz, $CH_2$), 57.78 ppm (ethoxy –$CH_2$), 13.43 ppm (ethoxy –$CH_3$). The $^{31}$P NMR shift recorded for adduct **9a** was 18.50. The molecular weight determination (MS) of **9a** supports the molecular formula.

Similarly, carbmethoxymethylenetriphenylphosphorane **4b** reacted with **1** to give two products, **8b** and **9b**, along with triphenylphosphine oxide. The structures of **8b** and **9b** were deduced from their analysis, IR, $^1$H, $^{13}$C NMR, and mass spectral data (*cf.* Scheme 3 and Experimental).

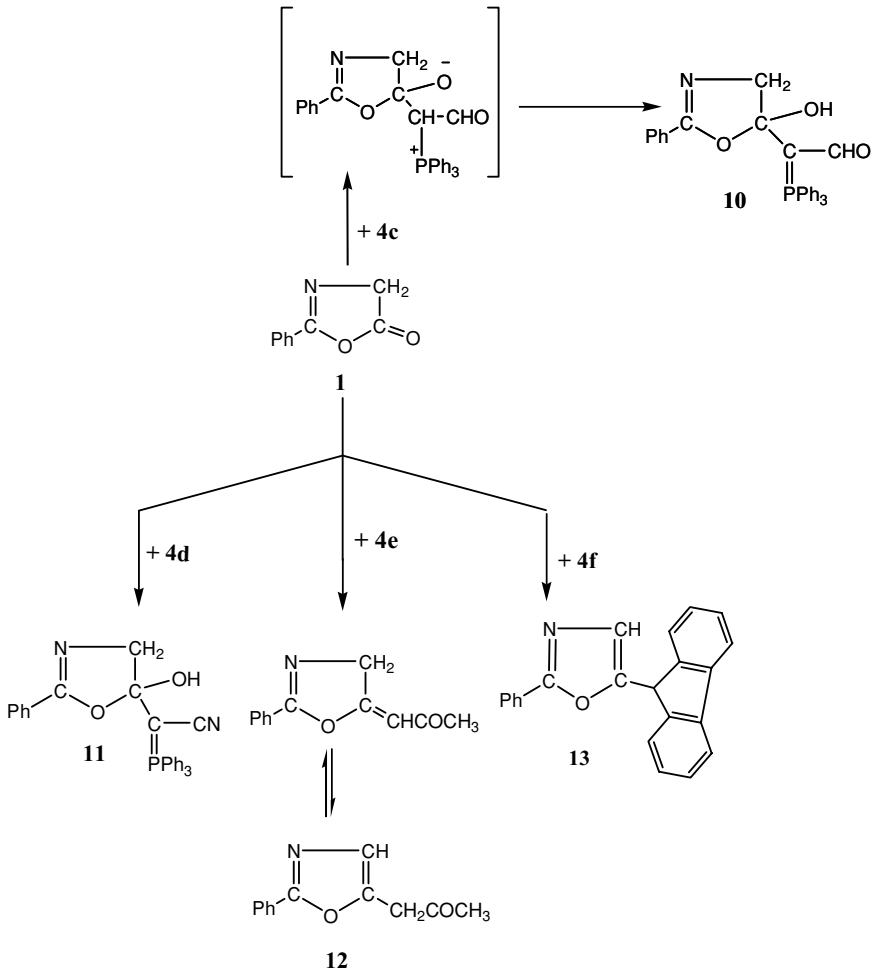
Formation of adducts **9a** and **9b** can be explained in terms of initial attack of the ylidic carbon in **4** on the carbonyl carbon of lacton C(5)=O followed by migration of the $\alpha$-proton of the first formed phosphonium betain to the electron rich center (Scheme 3).

The forgoing results confirm the assigned structure **9** and rule out the alternative open-chain structure **A** since the methylene protons in its $^1$H NMR appeared as singlet at 4.82 ppm as previously reported (Scheme 4).[15,18–20]

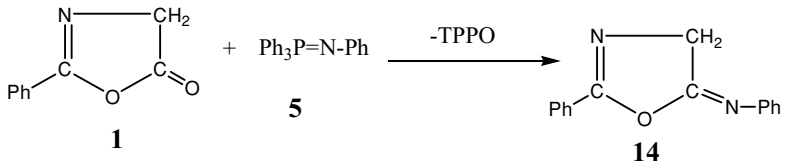



**SCHEME 4**

The reaction of 2-phenyl-5-(4*H*)-oxazolone **1** with formylmethylenetriphenylphosphorane **4c** was also investigated. We have found that the reaction of **1** with one mol equivalent of **4c**, in dry toluene, proceeds at reflux temperature to give a chromatographically pure compound formulated as (5-hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)triphenyl-$\lambda^5$-phosph- oranylidene)acetaldehyde **10** (Scheme 5). The structure of product **10** is deduced from its elemental analysis, IR, $^1$H, $^{13}$C, $^{31}$P NMR, and mass spectral data (*cf*. Experimental). Triphenylphosphine




**SCHEME 5**




**SCHEME 6**

and/or triphenylphosphine oxide are neither isolated nor detected in the reaction medium.

Moreover, the reaction products of **1** with cyanomethylenetriphenylphosphorane **4d**, 1-triphenylphosphoranylidene-2-propanone **4e**, and fluorenylidenetriphenylphosphorane **4f** were assigned structures **11**, **12**, and **13**, respectively on the basis of spectroscopic arguments (*cf*. Scheme 5, Experimental section).

The reaction of **1** with *N*-(triphenylphosphoranylidene) aniline **5** was also investigated.

We found that 2-phenyl-5-(4*H*)-oxazolone **1** reacts with 1 mol equivalent of *N*-(triphenylphosphoranylidene) aniline **5** in refluxing toluene to give the corresponding imino derivative **14** (Scheme 6). Triphenylphosphine oxide is also isolated from the reaction medium. Structure elucidation of compound **14** is based on analytical and spectral data (*cf*. Experimental).



## CONCLUSION

Based on the results of the present investigation, it could be inferred that phosphacumulene and stabilized phosphorus ylides behave differently towards 2-phenyl-5-(4*H*)-oxazolones **1, 2**. While the reaction of active phosphacumulene ylide **3** with oxazolones **1**,**2** resulted in the formation of the cyclic 2-phenylfuro[3,2-*d*][1,3]oxazol-5-(6*H*)-one **6** and 2,7-diphenyl-5*H*-pyrano[3,2-*d*][1,3]oxazol-5-one **7**, a different behavior was observed in the reaction of **1** with stabilized ylides **4** and the iminophosphorane **5**, depending on the stability of the addition products. Moreover, we have found that 2-phenyl-5(4*H*)-oxazolone**1** reacted with ethyl(triphenylphosphoranylidene)acetate **4a** to give ethyl(5-hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl(triphenyl-$\lambda^5$-phosphoranyli dene) acetate **9a** and not the open chain phosphorane adduct **A** as previously reported.[15,18–20]

## BIOLOGICAL EVALUATION OF THE TESTED COMPOUNDS

### Materials

Adult worms of *Schistosoma mansoni* (Egyptian strain) are obtained by infecting Syrian golden hamsters (*Mesocricetus auratus*) by percutaneous infection of 350 cercariae/animal, freshly shed from an infected *Biomphalaria alexandrina* snail.[21] The animal experiments have been carried out according to the internationally valid guidelines in an institution complying with biological ethics (Theodor Bilharz Research Institute).[22] Worms are obtained by porto-mesenteric perfusion, 45 days post-infection using citrated saline (7.5 g Na citrate + 8.59Na chloride/l).

The worms are washed in a small sterilized sieve three times by phosphate buffer (pH 7.4) then 3 other times by RPMI-1640 medium with L glutamine containing antibiotics (300 $\mu$g streptomycin, 300 units penicillin, and 160 $\mu$g gentamycin) + 20% foetal calf serum, inside a sterilization laminar flow. Then the worms are poured into a small Petri dish. Compound samples are kept at $-20^{\circ}$C in the dark.



### Chemicals

The tested compounds are organophosphorus and olefinic compounds derived from the reaction of oxazolone derivatives and organophosphorus reagents; they were prepared as mentioned in the text.

It is well known that organophosphorus compounds are the most important group of pesticides due to their rapid metabolism.[23] On the other hand, oxazolone derivatives have a wide range of pharmaceutical and biological purposes,[6] and they also possess insecticidal properties.[24] Therefore, this work aims to prepare some oxazolone derivatives and test them for antischistosomal activity in vitro on *Schistosoma mansoni* worms. The organophosphorus and olefinic compounds were tested in 10 $\mu$g/mL for in vitro bioactivity on viable *Schistosoma mansoni* mature worms in culture medium (RPMI 1640). Three replicates were used for each compound and three pairs of worms, males and females equally represented, were placed in each vial containing the medium and the compound. The worms were considered dead when they did not show motility for 1 min. Viability ratio of worms was determined by calculating the number of dead worms relative to the total number of worms. The results were compared with negative (DMSO) and positive (praziquantel) controls. Praziquantel (PZQ) is the mainstay of schistosomiasis control programs worldwide; in other words an

enormous investment in terms of money, manpower, and training rests on the efficacy of a single synthetic compound.

The results revealed that 2,7-diphenyl-5*H*-pyrano[3,2-*d*][1,3] oxazol-5-one **7** possessed in vitro antischistosomal activity (100% mortality). Compounds showed various degrees of lethal effect 8.3–41.7% mortality) on worms at 10 $\mu$g/ml of the compounds after 4 days of exposure (Table I). 2,7-Diphenyl-5*H*-pyrano[3,2-*d*][1,3]oxazol-5-one **7** was further subjected to determination of its $IC_{50}$ and $IC_{90}$ values (Table II). The results clarified that 2,7-diphenyl-5*H*-pyrano[3,2-*d*][1,3]oxazol-5-one **7,** which possesses the strongest antischistosomal activity ($IC_{50}$ values equal to or less than 10$\mu$g/ml) (Table II), and 2,7-diphenyl-5*H*-pyrano[3,2-*d*][1,3]oxazol-5-one **7** were considered promising bioactive compounds and deserving of further investigation. Therefore, the present study is a trial to throw light on some new chemotherapeutic antischistosomal drugs.



## EXPERIMENTAL

Melting points were measured by means of electrothermal apparatus. Phosphoranes **4a–4f** and 5-(4*H*)-oxazolone **1, 2** were prepared.[25–29,30,31] The IR spectra were measured in KBr pellets with a Perkin-Elmer infrared spectrophotometer model 157.The $^{1}H$ and $^{13}C$ NMR spectra were recoded in $CDCl_3$ with a varian spectrometer at 270 and 67.5 MHz using TMS as internal reference. The $^{31}P$ NMR spectra were taken with a Varian CFT-20 (vs. external 85% $H_3PO_4$ standard).The mass spectra were recoded at 70 eV with a Kratos MS equipment or Varian MAT 311 A spectrometer. Elemental analyses were preformed using the Elmentar Varu EL Germany Instrument. Their values agreed favorably with the calculated ones.

### Reaction of Phosphacumulene Ylide (3) with 2-Phenyl-5-(4*H*)-Oxazolone (1)

A mixture of **3** (0.30 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 30 $cm^3$ THF was stirred at room temperature 10 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **6** 2-phenylfuro[3,2-*d*][1,3]oxazol-5-(6*H*)-one (**6**, $C_{11}H_7NO_3$).

Eluent: petroleum ether/acetone (90/10, v/v) product **6** was separated as yellow crystals, yield 75% and m.p. 120°C. IR (KBr): $\upsilon = 1726$ (C=O, lacton), 1630 (C=N)$cm^{-1}$; $^{1}H$ NMR (270 MHz, $CDCl_3$): $\delta = 3.66$ (s, 2H, $CH_2$), 7.43–7.84 ppm (m, 5H, Ar); $^{13}C$ NMR (270 MHz, $CDCl_3$): $\delta =$

**TABLE I In Vitro Evaluation of Compounds for Schistosomicidal Activity at 10 $\mu$g/mL**

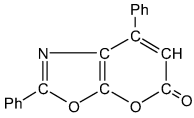
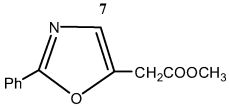
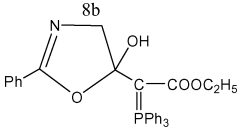
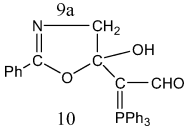
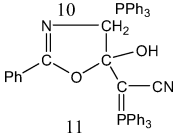
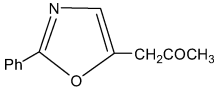
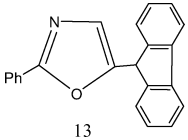
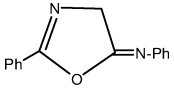
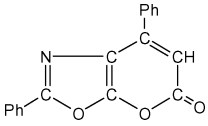
| Code Number of compound | 1st. day No. of worms (12) | | 2nd Day No. of worms (12) | | 3rd day No. of worms (12) | | 4th Day No. of worms (12) | |
|---|---|---|---|---|---|---|---|---|
| | Dead | Mortality% | Dead | Mortality% | Dead | Mortality% | Dead | Mortality% |
|  | 0 | 0 | 0 | 0 | 7 | 66.7 | 12 | 100* |
| 7  | 0 | 0 | 0 | 0 | 2 | 16.7 | 5 | 41.7 |
| 8b  | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 33.3 |
| 9a  | 0 | 0 | 0 | 0 | 1 | 8.3 | 3 | 25 |
| 10  | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8.3 |
| 11  | 0 | 0 | 0 | 0 | 2 | 16.7 | 4 | 33.3 |
| 12  | 0 | 0 | 0 | 0 | 1 | 8.3 | 5 | 41.7 |
| 13  | 0 | 0 | 0 | 0 | 1 | 8.3 | 1 | 8.3 |
| 14 | | | | | | | | |
| PZQ (+ve) control | 12 | 100 | 12 | 100 | 12 | 12 | 12 | 100 |
| DMSO (-ve) control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**TABLE II In Vitro Antischistosomal Effect ($IC_{50}$ & $IC_{90}$) of Compound 7 Compared to PZQ**

| Code Number of compound | $IC_{50}$ | $IC_{90}$ |
|---|---|---|
|  7 | 6.62 | 9,02 |
| PZQ(+ve) control | 0.4 | 0.64 |

173.44 (C=O, lacton), 165.46 (C=N), 134,0 127.0 (C=C), 40.60 ($CH_2$), 129.43, 128.2, 127.3, 126.3 (C-CH, Ar); MS (EI): $m/z$ (%) = 201 ($M^+$, 100). Triphenylphosphine was also separated and identified (mix. m.p., ms).



## Reaction of Phosphacumulene Ylide (3) with 4-Benzylidene-2-phenyl-5-oxazolone (2)

A mixture of **3** (0.30 g, 0.001 mol) and **2** (0.25 g, 0.001 mol) in 30 $cm^3$ THF was stirred at room temperature for 12 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **7** 2,7-diphenyl-5*H*-pyrano[3,2-*d*][1,3]oxazol-5-one (**7**, $C_{18}H_{11}NO_3$).

Eluent: petroleum ether/acetone (85/15, v/v) product **7** was separated as pale yellow crystals, yield 80% m.p. 150°C. IR (KBr): $\upsilon$ = 1720 (C=O, lacton), 1651 (C=N); $^1$H NMR (270 MHz, $CDCl_3$): $\delta$ = 6.32 (s, 1H, C=CH), 7.44–7.70 (m, 10H, Ar) ppm; $^{13}$C NMR (270 MHz, $CDCl_3$): $\delta$ = 174.55 (C=O, lacton), 165.81 (C=N), 133.36, 126.53 (C=C), 132.08, 121.9 (C=CH), 128.92–125.03 (C-CH, Ar); MS (EI): $m/z$ (%) = 289($M^+$, 99). Triphenylphosphine was also separated and identified (mix. m.p., ms).

## General Procedures for the Reaction of Phosphonium Ylides (4a) and (4b) with Oxazolone (1)

A mixture of 0.001 mol **4a** and **4b** and 0.001mol oxazolone **1** in 30 $cm^3$ dry toluene was refluxed for 6 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give products **8a**, **9a**, **8b**, and **9b**.

### *Ethyl (2-Phenyl-1,3-oxazol-5-yl)Acetate (8a, $C_{13}H_{13}NO_3$)*[15]

Eluent: petroleum ether/acetone (95/5, v/v) product **8a** was separated as yellow crystals, yield 45% m.p. 46°C. IR (KBr): $\upsilon = 1740$ ($\underline{CO}OC_2H_5$); $^1$H NMR (270 MHz, $CDCl_3$): $\delta = 1.2$ (t, $J = 8$Hz, 3H, $CH_3$), 3.7 (s, 2H, $CH_2$), 4.2 (q, $J = 8$Hz, 2H, $CH_2$), 7.06 CH (s, 1H, H-4), 7.2–8.2 (m, 5H, Aryl H); MS (EI): $m/z$ (%) 231($M^+$, 100).

### *Ethyl(5-hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)(triphenyl-$\lambda^5$-phosphoranylidene) Acetate (9a, $C_{31}H_{28}NO_4P$)*

Eluent: petroleum ether/acetone (85/15, v/v) product **9a** was separated as colorless crystals, yield 40% m.p. 120°C. IR (KBr): $\upsilon = 1733$ (C=O, ester), 1644, 1590 $cm^{-1}$(C=P); 1439, 969 $cm^{-1}$(P-C, phenyl), 3293 $cm^{-1}$(OH); $^1$H NMR (270 MHz, $CDCl_3$): $\delta = 0.82$ (t, 3H, $J =$ 8Hz, 3H, $CH_3$), 3.84 (q, $J = 8$Hz, $CH_2$), 2.21 (s, 1H, OH, exchangeable with $D_2O$), 7.32–7.96 (m, 20H, Ar). Doublet of doublets at 4.805, 4.801–4.791, 4.787 with $J_{HH} = 1.2$ Hz, $J_{HP} = 4.2$ Hz) for the unsymmetrical methylene protons. $^{13}$C NMR of **9a** $\delta = 166.91$ppm (d, $^2J_{cp} =$ 13.25 Hz, $\underline{CO}OC_2H_5$), 163.34 (C=N), 125.31 (d, $^1J_{cp} = 93.2$ Hz, P=C) [15], 96.30 (d, $^2J_{cp} = 15$ Hz, C-OH), 68.53 ppm (d, $^3J_{cp} = 8.5$ Hz, $CH_2$), 57.78 (ethoxy-$CH_2$), 13.43 ppm (ethoxy-$CH_3$), MS $m/z$ ( $M^+$, rel. int. %):509($M^+$, 10), 479($M^+$-$C_2H_5$, 20), 463($M^+$-$OC_2H_5$), 347([$Ph_3P$=C-$COOC_2H_5$]$^+$,25), 105([$C_6H_5CO$]$^+$,45), 77([$C_6H_5$]$^+$, 100);$^{31}$P NMR 18.5 ppm.

### *Methyl (2-Phenyl-1,3-oxazol-5-yl)Acetate (8b, $C_{12}H_{11}NO_3$)*

Eluent: petroleum ether/acetone (95/5, v/v) product **8b** was separated as yellow crystals, yield 42% m.p. 47°C. IR (KBr): $\upsilon = 1735$ $cm^{-1}$(C=O, ester); $^1$H NMR (270 MHz, $CDCl_3$): $\delta = 3.32$(s, 3H, COO$\underline{CH_3}$), 3.75(s, 2H, $CH_2$), 7.2–8.15 (m, 5H, aryl H); MS (EI):$m/z$ (%) =217 ($M^+$, 100). Triphenylphosphine oxide was also isolated and identified (mix. m.p.; ms).

### *Methyl(5-hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)(triphenyl-$\lambda^5$-phosphoranylidene) Acetate (9b, $C_{30}H_{26}NO_4P$)*

Eluent: petroleum ether/acetone (80/20, v/v) product **9b** was separated as colorless crystals, yield 45% m.p. 108°C. IR (KBr):$\upsilon = 1740$ (C=O, ester), 1640, 1595 $cm^{-1}$(C=P), 1430, 970 $cm^{-1}$(C-P, phenyl), 3300 $cm^{-1}$ (OH);$^1$H NMR (270 MHz, $CDCl_3$): $\delta = 3.32$ (s, 3H, COO$\underline{CH_3}$), 2.01 (s, 1H, OH), 7.32–7.69 (m, 20H, Ar), dd centered at 4.80 and 4.79 ppm ($CH_2$,$J_{HH} = 1.2$ Hz, $J_{HP} = 4.2$ Hz, unsymmetrical methylene protons);

$^{13}$C NMR of **9b** $\delta = 165.80$ ppm (d, $^{2}J_{cp} = 13.7$ Hz, C=O), 164.53 (C=N), 124.53 (d, $^{1}J_{cp} = 100$ Hz, P=C), 89.43 ppm (d, $^{2}J_{cp} = 15.6$ Hz), 64.35 ppm (d, $^{3}J_{cp} = 8.5$ Hz, $CH_2$), 52.21 ($COO\underline{C}H_3$), 133.19, 132.07, 132.03, 130.9, 128.7, 128.6, 128.17, 127.14 (Ar-C-H); $^{31}$P NMR $\delta = 18.9$ ppm, MS *m/z* ( $M^+$, rel.int. %):497($M^+$, 10), 482 ($M^+$-$CH_3$, 20), 466($M^+$-$OCH_3$), 333($[Ph_3P{=}C\text{-}COOCH_3]^+$,25), 105($[C_6H_5CO]^+$,45), 77($[C_6H_5]^+$, 100).

## Reaction of Formylmethylenetriphenyphosphorane (4c) with 2-Phenyl-5-(4H)-oxazolone (1)

A mixture of **4c** (0.30 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 50 $cm^3$ dry toluene was refluxed for 10 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **10**.



### *(5-Hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)(triphenyl-λ$^5$-phosphoranylidene) Acetaldehyde (10, $C_{29}H_{24}NO_3P$)*

Eluent: petroleum ether/acetone (93/7, v/v) product **10** was separated as pale yellow crystals, yield 75% m.p. 116°C. IR (KBr): $\upsilon = 1690$ (C=O, aldehyde), 1630 (C=N) $cm^{-1}$, 3300 (OH), 1582 $cm^{-1}$(C=P), 1430, 968 $cm^{-1}$(C-P, phenyl), 2925 (C-H, aldehyde); $^{1}$H NMR (270 MHz, $CDCl_3$): $\delta = 2.15$ (s, 1H, OH, exchangeable with $D_2O$), 8.20 (d, 1H, $^{3}J_{HP} = 6.8$ Hz CHO), doublet of doublets centered at 4.20, 4.31 for the unsymmetrical methylene protons with $J_{HH} = 1.8$ Hz, $^{4}J_{HP} = 4.65$Hz, 7.20–7.81 (m, 20H, Ar); $^{31}$P NMR of **10** $\delta = 19.05$ ppm; MS (EI): *m/z*(%)=469 ($M^+$, 12), 440 ($M^+$-CHO, 35), 162 ($M^+$- $[Ph_3P{=}C\text{-}CHO]^{\cdot}$, 40),105($[C_6H_5CO]^+$,90), 77($[C_6H_5]^+$, 100).

Triphenylphosphine and/or triphenylphosphine oxide are neither isolated nor detected in the reaction medium.

## Reaction of Cyanomethylenetriphenyphosphorane (4d) with 2-Phenyl-5-(4*H*)-oxazolone (1)

A mixture of **4d** (0.30 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 50 $cm^3$ dry toluene was refluxed for 10 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **11**.

### *(5-Hydroxy-2-phenyl-4,5-dihydro-1,3-oxazol-5-yl)(triphenyl-$\lambda^5$-phosphoranylidene) acetonitrile (11, $C_{29}H_{23}N_2O_2P$)*

Eluent: petroleum ether/acetone (75/25, v/v) product **11** was separated as colorless crystals, yield 72% m.p. 170°C. IR (KBr): $\nu = 1625$ (C=N), 3300 (OH), 1580 (C=P), 1435, 960 $cm^{-1}$, (P-C, phenyl), 2210 (C≡N) $cm^{-1}$; $^1H$ NMR (270 MHz, $CDCl_3$): $\delta = 6.75–7.48$ (m, 20H, Aryl), 1.33 (s, 1H, OH, exchangeable with $D_2O$), doublet of doublets centered at 4.31–4.32 for the methylene protons with $J_{HH} = 1.8$ Hz, $^4J_{Hp} = 4.70$ Hz; $^{31}P$ NMR $\delta = 18.78$ ppm, MS (EI): *m/z* (%)= 463 ($M^+$, 10), 435 ($M^+$-CN, 20), 162 ($M^+$-[$Ph_3P$=C-CN, 30]$^\cdot$, 105 ($[C_6H_5CO]^+$,77), 77 ($[C_6H_5]^+$, 100). Triphenylphosphine and/or triphenylphosphine oxide are neither isolated nor detected in the reaction medium.



## Reaction of 1-Triphenylphosphoranylidene-2-propanone (4e) with 2-Phenyl-5(4*H*)-oxazolone (1)

A mixture of **4e** (0.31 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 50 $cm^3$ dry toluene was refluxed for 8 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **12**.

### *1-(5-Hydroxy-2-phenyl-1,3-oxazol-4-yl)propan-2-one (12, $C_{12}H_{11}NO_3$)*

Eluent: petroleum ether/acetone (80/20, v/v) product **12** was separated as yellow crystals, yield 75% m.p. 103°C. IR (KBr): $\nu = 1671$ (C=O, $\underline{CO}CH_3$), 1602 (C=C), 3340 (OH) $cm^{-1}$. $^1H$ NMR (270 MHz, $CDCl_3$): $\delta =$ 1.42 (s, 3H, $CH_3$), 2.29 (s, 2H, $CH_2$), 9.17 (s, 1H, OH, exchangeable with $D_2O$), 7.01–8.01 (m, 5H, Aryl); MS (EI): *m/z* (%) = 217 ($M^+$, 25), 202($M^+$-$CH_3$, 10), 173($M^+$-$COCH_3$, 20), 144($M^+$-$CH_2COCH_3$, 30), 105 ($[C_6H_5CO]^+$,77), 77 ($[C_6H_5]^+$, 100).

Triphenylphosphine was also isolated from the reaction medium and identified (mix. m.p.; ms).

## Reaction of Fluorenylidenetriphenylphosphorane (4F) with 2-Phenyl-5-(4*H*)-Oxazolone (1)

A mixture of **4f** (0.42 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 50 $cm^3$ dry toluene was refluxed for 12 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **13**.

### *5-(9H-Fluoren-9-yl)-2-phenyl-1,3-oxazole (13, $C_{22}H_{15}NO$)*

Eluent: petroleum ether/acetone (95/5, v/v) product **13** was separated as colorless crystals, yield 80% m.p. 105°C. IR (KBr): $\nu = 1630$ (C=N); $^1$H NMR (270 MHz, $CDCl_3$): $\delta = 6.90$ (s, 1H, =CH), 5.35 ppm (s, 1H, CH-fluorene), 7.25–7.90 (m, 13H, Aryl). MS (EI): $m/z$ (%) = 309 ($M^+$, 30), 144($M^+$-[$C_{13}H_9$], 100).

Triphenylphosphine oxide was also separated and identified (mix. m.p.; ms).

## Reaction of *N*-(Triphenylphosphoranylidene)Aniline (5) with 2-Phenyl-5-(4*H*)-oxazolone (1)

A mixture of **5** (0.35 g, 0.001 mol) and **1** (0.16 g, 0.001 mol) in 50 $cm^3$ dry toluene was refluxed for 5 h. The volatile materials were evaporated under reduced pressure. The residue was subjected to silica gel column chromatography to give **14**.

### *N-(2-Phenyl-1,3-oxazol-5-(4H)-ylidene)Aniline (14, $C_{15}H_{12}N_2O$)*

Eluent: petroleum ether/acetone (90/10, v/v) product **15** was separated as colorless crystals, yield 55% m.p. 198–200°C. IR (KBr): $\nu$ = 1637.65 (C=N-Ph), 1310 (C-O), 1682 (C=N); $^1$H NMR (270 MHz, $CDCl_3$): $\delta = 4.34$ (s, 2H, $CH_2$), 7.24–7.82 (m, 10H, Aryl). $^{13}$C NMR (270 MHz, $CDCl_3$), $\delta$ =168.31 (C=N-Ph), 167.22 (C=N, ring), 133.19-124.50 (Aryl), 45.08 ($CH_2$); MS (EI): $m/z$ (%) = 236 ($M^+$, 10), 159($M^+$-$C_6H_5$, 25), 105 ([$C_6H_5CO$]$^+$, 80), 77 ([$C_6H_5$]$^+$, 100).

Triphenylphosphine oxide was also separated and identified (mix. m.p.; ms).

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