a white, crystalline solid: mp 183.0–183.5 °C; ^{1}H NMR ($CDCl_3$) δ 4.98 (d, 2 H, $^2J_{HP}$ = 14 Hz), 6.98 (d, 2 H), 7.11 (t, 2 H), 7.22 (t, 1 H), 7.63 (m, 12 H), 7.76 (m, 3 H); ^{13}C NMR ($CDCl_3$) δ 30.2 (d, $^1J_{CP}$ = 48 Hz), 117.4 (CF_3, $^1J_{CF}$ = 86 Hz), 127.0, 128.5, 128.8, 130.2, 131.3, 134.0, 135.1, 160.6 (C=O, $^2J_{CF}$ = 33 Hz); ^{19}F NMR ($CDCl_3$) δ −73.9; ^{31}P NMR ($CDCl_3$) δ 23.1. Anal. Calcd for $C_{27}H_{22}PO_2F_3$: C, 69.53; H, 4.75. Found: C, 69.60; H, 4.79.

Acknowledgment. I thank M. Dahl (Monsanto) for obtaining the mass spectra and Drs. G. Srouji and L. H. Brannigan for useful discussions.

Supplementary Material Available: Experimental and spectral data for compounds **1b–d**, **1f–i**, **1k**, **1m,n**, and **3f** (5 pages). Ordering information is given on any current masthead page.

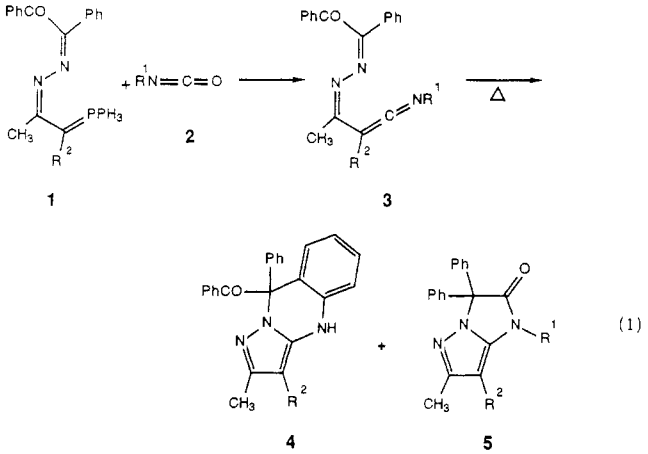
Reactions of Azines. 13. Thermal Rearrangements of 1,5,6-Triaza-1,2,4,6-heptatetraenes to 4,9-Dihydropyrazolo[5,1-*b*]quinazolines and *N*-α-Styryl-5-(phenylamino)pyrazoles

Edward E. Schweizer* and John E. Hayes

Department of Chemistry and Biochemistry, University of Delaware, Newark, Delaware 19716

Received April 15, 1988

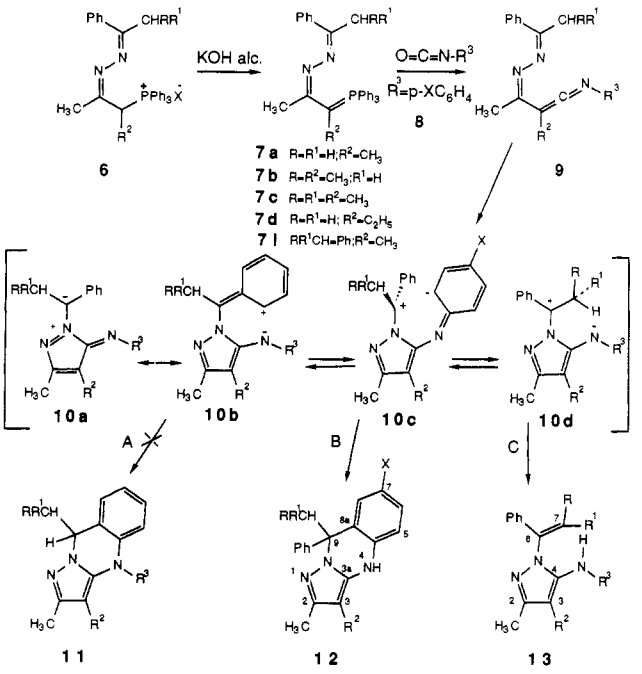
The thermal rearrangements of unsaturated azines **3** with cumulated double bonds in conjugation with the azine moiety have been shown[1-8] to provide excellent syntheses for a variety of pyrazolo fused heterocyclic compounds such as pyrazolo[5,1-*c*]oxazines and 4,9-dihydropyrazolo[1,5-*b*]isoquinolines,[1,2] 4*H*-pyrazolo[1,5-*c*][1,3,5]oxadiazines,[4] 4,5-dihydro- and 6,7-dihydropyrazolo[1,5-*a*]pyridines.[5] For example, the reaction of keto azine phosphoranes **1** with isocyanates **2** gave 4,9-dihydropyrazolo[5,1-*b*]quinazolines **4** and 2,3-dihydro-1*H*-imidazo[1,2-*b*]pyrazol-2-ones **5** as shown in eq 1.[6]



(1)

We anticipated on the basis of the previous work that the thermal electrocyclic reactions of azine ketimines **9**, obtained from **7** and an isocyanate **8** (Scheme I), could give 4,9-dihydropyrazolo[5,1-*b*]quinazolines **11** and **12** and the *N*-α-styryl-5-(phenylamino)pyrazoles **13** via the resonance stabilized zwitterionic intermediates **10a–d**.

Scheme I



Results and Discussion

Trippet and Walker showed[9] that the reactions of isocyanates with phosphoranes with α-protons give betamines, which do not decompose to ketimines but transfer a proton to give stable phosphorane amides. Staudinger and Meyer had previously demonstrated[10] that phosphoranes without α-protons underwent normal carbonyl olefination reactions with isocyanates to yield ketimines. It was therefore necessary to use the α-alkylated phosphoranes **6** to prepare the desired ketimines **9**.

The phosphonium ylides **7** were prepared as previously reported[11] from the corresponding phosphonium salts **6** and ethanolic KOH. The phosphoranes **7** decomposed on standing; therefore, they were used immediately after their preparation.

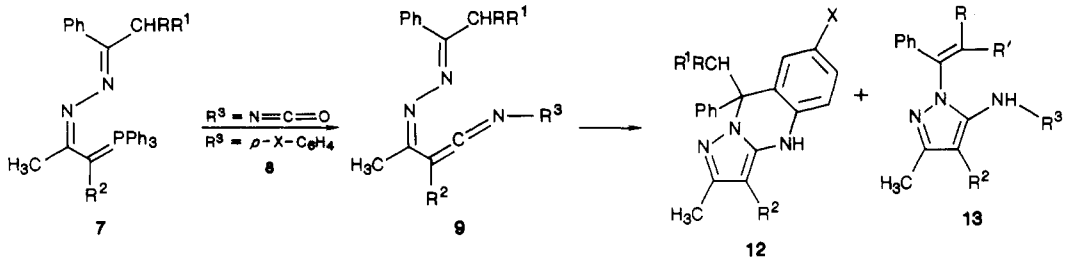
The reactions of phosphoranes **7a–d,i** with aromatic isocyanates **8** in refluxing toluene led to the formation of two products along with triphenylphosphine oxide, as indicated by TLC. The presumed intermediate azine ketimines **9** were too unstable to isolate, so the thermolyses were carried out directly by briefly heating the reaction mixtures. The products were separated by column chromatography.[12]

The less polar products were isolated as orange oils and assigned as the *N*-α-styryl-5-(phenylamino)pyrazoles **13** on the basis of the following spectral data. A pyrazole ring was indicated by peaks[13] at δ 137–140 (C2), 107–111 (C3), and 143–146 (C4) in the ^{13}C NMR spectrum. There were

(1) Schweizer, E. E.; Evans, S. *J. Org. Chem.* **1978**, *43*, 4328.
(2) Schweizer, E. E.; Lee, K. J. *J. Org. Chem.* **1984**, *49*, 1959.
(3) Schweizer, E. E.; Hsueh, W.; Rheingold, A. L.; Durney, R. L. *J. Org. Chem.* **1983**, *48*, 3889.
(4) Schweizer, E. E.; Lee, K. J. *J. Org. Chem.* **1987**, *52*, 3681.
(5) Schweizer, E. E.; Hayes, J. E.; Hirwe, S. N.; Rheingold, A. L. *J. Org. Chem.* **1987**, *52*, 1319.
(6) Schweizer, E. E.; Lee, K. J. *J. Org. Chem.* **1984**, *49*, 1964.
(7) Schweizer, E. E.; Hayes, J. F.; Lee, K. J.; Rheingold, A. L. *J. Org. Chem.* **1987**, *52*, 1324.
(8) Schweizer, E. E.; Hayes, J. E.; Rheingold, A. L.; Wei, X. *J. Org. Chem.* **1987**, *52*, 1810.
(9) Trippett, S.; Walker, D. M. *J. Chem. Soc.* **1959**, 3874.
(10) Staudinger, H.; Meyer, J. *Chem. Ber.* **1910**, *53*, 72.
(11) (a) Hayes, J. E. Ph.D. Thesis, University of Delaware, Newark, DE, June 1986. (b) Boring, J. C. Masters Thesis, University of Delaware, Newark, DE, June 1984. (c) Schweizer, E. E.; Lee, K. J. *J. Org. Chem.* **1982**, *47*, 2768. (d) Schweizer, E. E.; De Voe-Goff, S.; Murray, W. P. *j. Org. Chem.* **1987**, *42*, 200.
(12) Chromatographic technique was that of Taber, D. F. *J. Org. Chem.* **1982**, *47*, 1351.
(13) The numbering schemes used in the following discussions for the 4,9-dihydropyrazolo[5,1-*b*]quinazolines **12** and the *N*-α-styryl-5-(phenylamino)pyrazoles **13** are as shown in Tables II and III, respectively.

0022-3263/88/1953-5562$01.50/0

Table I. Reactions of Phosphoranes 7 with Isocyanates 8. Isolated Yields and Ratios of 4,9-Dihydropyrazolo[5,1-*b*]quinazolines 12 to *N*-α-Styryl-5-(phenylamino)pyrazoles 13



entry	R	R^1	R^2	X in 12	yield,[a] %	ratio[b] 12/13	mp,[c] °C for 12
a	H	H	CH_3	H	72	58/42	228–9
b	CH_3	H	CH_3	H	68	70/30	209–10
c	CH_3	CH_3	CH_3	H	65	79/21	227–8
d	H	H	CH_3CH_2	H	60	76/24	219–20
e	H	H	CH_3	OCH_3	74	48/52	241–2
f	H	H	CH_3	CH_3	69	53/47	234–6
g	H	H	CH_3	Cl	66	64/36	146–7
h	H	H	CH_3	CF_3	67	69/31	244–5
i	*d*		CH_3	H	68	100/0	249–50

[a] Isolated by column chromatography. [b] Ratios based on isolated yields. [c] Recrystallized from diethyl ether. Pyrazoles **13** were obtained as oils. [d] $CHRR^1$=Ph.

also *C*-methyl absorptions at δ 12.0–12.5 (C2-CH_3) and 7.2–7.8 (C3-CH_3), as well as peaks at δ 109.5–122.6 for the β-styryl carbon (C7).

The more polar products were isolated as white solids and were found to be the 4,9-dihydropyrazolo[5,1-*b*]-quinazolines **12**. The ^{13}C NMR showed peaks at δ 137–140 (C2), 90–98.8 (C3), and 143–146 (C3a) assignable to the pyrazole ring and at δ 62–70.5 (C9) for the dihydroquinazoline ring in addition to the aromatic and alkyl peaks.

The proposed mechanism for formation of pyrazoles **12** and **13** is shown in Scheme I. The intramolecular cycloaddition reactions of azine ketimines **9** would give the resonance stabilized zwitterionic intermediates **10a–d**. Proton abstraction by the exocyclic nitrogen anion in zwitterionic intermediate **10d** would produce **13**, while addition of the anion in the ortho position to the carbocation in zwitterionic intermediate **10c** and rearomatization by 1,3-hydride shift to the nitrogen atom would yield **12**.

In an attempt to alter the ratios of **12** to **13** and possibly obtain compound **11**, substituents were placed in the para position of the phenyl isocyanate and C5 of the phosphoranes. Compound **11** was, however, not obtained. Slight changes in the ratio of **12** to **13** were observed and are shown in Table I and are discussed below.

Examination of Table I shows the following: (1) As the bulk of R and R^1 increases in intermediates **10c** and **10d** the ratio of **12** to **13** increases (entries a–c). This may be the result of increasing steric interactions between the $CHRR^1$ group and the exocyclic nitrogen anion or a decrease in acidity of the proton being eliminated.

(2) As R^2 increases from methyl to ethyl the ratio of **12** to **13** increases (entries a, d). This increase in formation of 4,9-dihydropyrazolo[5,1-*b*]quinazolines **4** with increasing bulk of the C3 substituent (R^2) was previously observed[4] in the thermolysis of keto azine ketimine **3** (R′ = Ar) (eq 1). It was suggested[4] that increasing steric interactions between the C3 substituent on the pyrazole and the *N*-aryl group forces the *N*-aryl group into a cisoid position relative to the group attached to the nitrogen of the pyrazole, therefore diminishing the contribution of the form **10d** and allowing form **10c** to be more operative (see Scheme I).

(3) On changing the para subsituents on the phenyl isocyanate in the order CH_3O, CH_3, H, Cl, CF_3 (i.e., in order of increasing σρ value), the ratio of **12** to **13** increased [entries e, f, a, g, h]. Possibly, electron-withdrawing substituents can stabilize the anion on the ortho position of the phenyl ring to a greater extent than on the exocyclic nitrogen anion through inductive effects, therefore increasing the contribution of resonance form **10c**. Likewise, electron-donating substituents destabilize the anion in the ortho position to a greater extent, allowing form **10d** to be more operative.

Reaction of phosphorane **7i** with phenyl isocyanate produced only the 4,9-dihydropyrazolo[5,1-*b*]quinazoline **12i** [in 68% yield] as expected since there is no proton available for elimination.

In conclusion we have shown that quinazolines **12** and pyrazoles **13** may be produced in relatively high yields (60–74%). The ratios of **12** to 13, varying from 48/52 to 79/21, are influenced slightly by steric and electronic factors.

Experimental Section

General Methods. Dry nitrogen was routinely used as the reaction atmosphere in all reactions. All glassware was baked at 100–120°C for a minimum of 2 h before being used. Melting points are uncorrected. Acetonitrile was dried over calcium hydride, followed by its distillation over P_2O_5. Toluene was distilled from sodium metal. Eastman Chromatogram (silica gel with a fluorescent indicator on polyethylene) precoated sheets were employed in thin-layer chromatographic (TLC) operations. Baker silica gel (50–200 mesh) and EM7747 silica gel for column chromatography was used throughout for product separation.[12]

The phosphonium salts **6** and phosphoranes **7** were prepared by known methods.[11] Isocyanates **8** were purchased from the Aldrich Chemical Co. and were purified by distillation prior to use.

Spectral Information. The ^1H and ^{13}C NMR spectra of approximately 10% (w/v) solutions in $CDCl_3$ (DMSO-d_6 for compounds **12**) were obtained on a Bruker Spectrospin Model WM250 or AM250 instrument. The numbering systems employed are shown in Scheme I and in Tables II–V (see supplementary material).

Tables II and III list the ^1H NMR parameters for compounds **12** and **13**, respectively. The ranges for the ^1H NMR parameters for compounds **12** were δ 1.84–1.99 (C3-CH_3), 1.98–2.05 (C2-CH_3), 2.24–2.29 (C9-CH_3), 9.27–9.53 (NH), 6.35–7.40 (Ar H). In **12b** C9-CH_2CH_3 appears at δ 1.08 (J = 6.9), C9-CH_2CH_3 at δ 2.63. The C9-$CH(CH_3)_2$ appear at δ 0.75 (J = 6.7) plus 0.99 (J = 6.6) and

the C9-C*H*$(CH_3)_2$ multiplet is centered at δ 2.81 in **12c**. The C7-OCH_3 resonances appear at δ 3.54 and C7-CH_3 at 2.15 in **12e** and **12f**, respectively. Peaks at δ 1.81-1.86 (C3-CH_3), 2.18-2.27 (C2-CH_3), 4.70-4.95 (NH), 5.28-5.42 (C7-H_2), and 6.35-7.90 (Ar H) characterize the ^1H NMR parameters for pyrazoles **13**. In **13b**, C7-CH_3 (1.63); in **13c** the C7-CH_3's are at 1.69 and 1.78, whereas in **13d** C3-CH_2CH_3 (1.10) and C3-CH_2CH_3 (2.41, J = 7.6). The aromatic OCH_3 in **13e** and CH_3 in **13f** appear at δ 3.68 and 2.24, respectively.

Tables IV and V (supplementary material) list the ^{13}C NMR parameters for compounds **12** and **13**, respectively. The ranges for the ^{13}C NMR parameters for **12** (Table IV) are as follows: C3-CH_3 at δ 6.4-6.7, C2-CH_3 at δ 11.8-12.2, C9-CHRR^1 at δ 26.6-27.3 (**12b** and **12c** at 30.8 and 36.9, respectively), C9 at δ 62.7-63.6 (**12b**, **12c**, and **12i** at 67.0, 69.9, and 70.5, respectively), C3 at δ 90.1-92.6 (**12d** at 98.5), C2 at δ 143.5-146.5, C3a at δ 145.0-148.0. The ranges for the ^{13}C NMR parameters for **13** (Table V) are as follows: C3-CH_3 at δ 7.5-7.9, C2-CH_3 at δ 12.1-12.7, C3 at δ 107.7-110.0 (**13d** at 114.9), C7 δ 109.5-110.2 (**13b** and **13c** at 119.0 and 122.6, respectively).

Precise mass spectra were recorded using a Du Pont 21-492B instrument with a resolution of 3300 or 5000. Table VI (supplementary material) lists the mass spectral data for compounds **12** and **13**. All precise mass found were within 0.003 mass units of the calculated values. The major fragment ions and in many cases the base peaks for compounds **12** were $M^+ - 77$ (Ph) and M^+ - (C9-CHRR^1). Pyrazoles **13** had peaks for $M^+ - 1$ and (Ph - CRR^1)$^+$ in their mass spectra.

Reactions of Phosphoranes 7 with Isocyanates 8: Preparations of 4,9-Dihydropyrazolo[5,1-*b*]quinazolines 12 and *N*-α-Styryl-5-(phenylamino)pyrazoles 13. General Method. A solution of the freshly distilled isocyanate **14** (2.5 mmol) in 10 mL of dry toluene was added dropwise with stirring at room temperature to a solution of the phosphorane **7**[11] (2.0 mmol) in 35 mL of dry toluene. After all of the isocyanate was added, the mixture was heated under reflux for 16 h. The solvent was removed in vacuo, and the mixture were chromatographed, eluting with petroleum ether/ethyl acetate (increasing polarity from 90/10 to 80/20). This procedure cleanly separated the following in order of elution:

(a) *N*-α-Styryl-5-(phenylamino)pyrazoles **13** were obtained as orange oils, which resisted recrystallization; the samples were determined to be pure by TLC and NMR (>97%) analyses. Precise mass analyses were shown to be within 0.002 of that calculated (see Table VI in supplementary material).

(b) 4,9-Dihydropyrazolo[5,1-*b*]quinazolines **12** were obtained as off-white solids, which were recrystallized to a constant melting point from diethyl ether; the samples were determined to be pure by TLC and NMR (>97%) analyses. Precise mass analyses were shown to be within 0.002 of that calculated (see Table VI in supplementary material).

(c) Triphenylphosphine oxide.

Supplementary Material Available: ^1H NMR, ^{13}C NMR, and mass spectral data for 4,9-dihydropyrazolo[5,1-*b*]quinazolines **12** and *N*-α-styryl-5-(phenylamino)pyrazoles **13** (Tables II-VI) (5 pages). Ordering information is given on any current masthead page.

Synthesis of 1,3,5-Tri-*n*-alkylbenzene Compounds

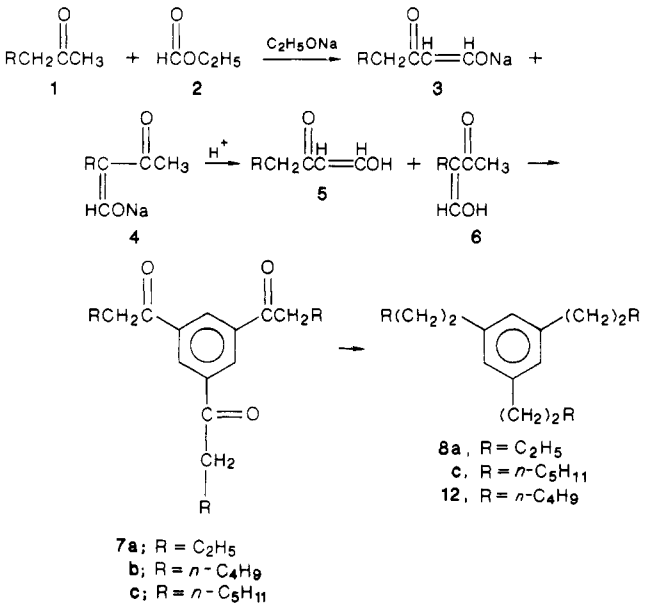
Kalathil C. Eapen[1a] and Christ Tamborski*[,1b]

Air Force Wright Aeronautical Laboratories, Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433-6533

Received May 31, 1988

Our previous study[2] was concerned with the formation of carbon-carbon σ bonds by $NiCl_2$(dppe)[3]-catalyzed cross-coupling of Grignard reagents and polychlorobenzenes. By this method we were able to prepare pure tri- and tetraalkylated benzene compounds, which were required for related studies concerned with chemical structure versus physical property correlation of high temperature stable fluids.[4] In our continuing studies we have examined an alternate synthesis of 1,3,5-trialkylbenzenes by reduction of 1,3,5-triacylbenzenes. We have also extended our original study of synthesizing pure 1,3,5-trialkylated benzenes to the synthesis of mixtures of trialkylated benzenes. Such mixtures should provide improved rheologic properties to the resulting fluid materials for wide liquid range fluid applications.

Chart I



Reduction of Triacylbenzene Compounds. We have synthesized 1,3,5-trialkylbenzene compounds by the reduction of 1,3,5-triacylbenzenes. The triacylbenzenes were synthesized by a method previously reported for the preparation of hydroxymethylene ketones,[5-8] where the former were byproducts. For the present study, experimental conditions were chosen to facilitate the cyclization reaction leading to triacylbenzenes. The method involves base-catalyzed condensation of methyl ketones with ethyl formate, which provides a mixture of sodium salts of hydroxymethylene ketones (**3** and **4**) (see Chart I). Decomposition of these salts with acid leads to self-condensation of one of the components to a symmetrical triacylbenzene as shown in Chart I.

The hydrolysis product of **3** yielded **5**, which spontaneously cyclized to **7**; however, the hydrolysis product of **4** yielded **6**, which is not capable of trimerization. The ratio of **3** to **4** may depend on the type of methyl ketone and the base used. In our studies with sodium ethoxide and longer chain methyl ketones (**1**, R = C_2H_5, *n*-C_4H_9, and *n*-C_5H_{11}), the **3** isomer predominated since yields of ~ 60-70% of **7** were obtained. With the methyl ketones we

(1) (a) University of Dayton Research Institute, 300 College Park Avenue, Dayton, OH 45469. (b) Present address: Fluidics Inc., P.O. Box 291886, Dayton, OH 45429.

(2) Eapen, K. C.; Tamborski, C. *J. Org. Chem.* **1984**, *49*, 478.
(3) The ligand dppe refers to $Ph_2P(CH_2)_2PPh_2$.
(4) Eapen, K. C.; Snyder, C. E., Jr.; Gschwender, L.; Tamborski, C. *Prepr.-Am. Chem. Soc., Div. Pet. Chem.* **1984**, *29*(4), 1053.
(5) Mariella, R. P.; Godar, E. *J. Org. Chem.* **1957**, *22*, 566.
(6) Benary, E.; et al. *Ber.* **1926**, *59*, 2198.
(7) Kaushal, R.; Sorani, S.; Deshpande, S. S. *J. Ind. Chem. Soc.* **1942**, *19*, 107.
(8) Chelintsev, G. V. *J. Gen. Chem. USSR* **1944**, *14*, 1070.

0022-3263/88/1953-5564$01.50/0