A NEW ROUTE TO 1-AZAAZULENE RING SYSTEM BY THE REACTION OF 1-(DIPHENYLPHOSPHINYL)AZAALLYL ANIONS WITH TROPONE DERIVATIVES[1]

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Abstract--The reaction of 1-(diphenylphosphinyl)azaallyl anions, derived from the corresponding imines, with tropones underwent enamine-type alkylation and mainly followed by aza-Wittig reaction to give 1-azaazulene derivatives, in addition to a trace amount of 4H-4-oxocyclohepta[b]pyrroles.

Previously, we have demonstrated the simple preparation of (vinylimino)phosphoranes (1), which were found to react with α-bromo ketones,[2] α,β-unsaturated ketones,[3] tropones,[4] and their vinylogues[5] in an enamine-type alkylation followed by intramolecular aza-Wittig reaction to provide novel routes to pyrroles, pyridines, 1-azaazulenes, and their vinylogues, respectively. Although bis(trimethylsilyl)vinylamines, equivalents of (vinylimino)phosphoranes, have been known to react with α,β-unsaturated ketones to give pyridines,[6] Kobayashi et al. have recently reported an alternative reaction of 1-(diphenylphosphinyl)azaallyl anions (2) with α,β-unsaturated ketones to give phenyl-substituted pyridines[7] via similar mechanistic pathways to those of 1. The 1-Azaallyl anions are conveniently derived from base-treatment of the corresponding imines,[7,8] which are obtained by the reaction of easily available oximes with chlorodiphenylphosphine,[9] and are considered as a synthetic equivalent of 1. In search for an alternative convenient way for the prepara-

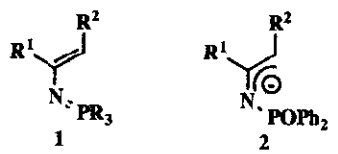
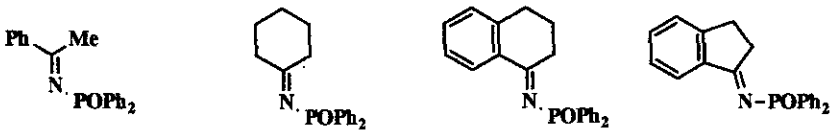


Figure 1.

tion of 1-azaazulenes, we have investigated the reaction of 2 with tropone derivatives. We wish to describe herein the results.



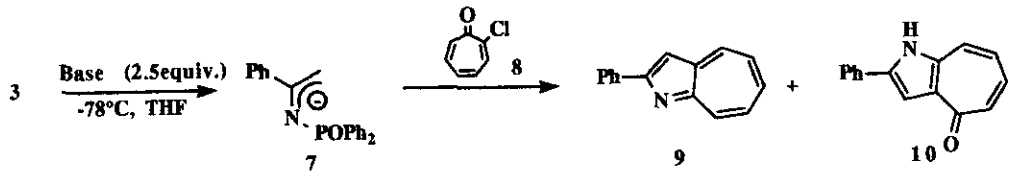
3 4 5 6

Figure 2.

According to the reported procedures,[7,9,10] the precursory imines (3),[9] (4),[10] (5), and (6) were prepared by the reaction of the readily available oximes with chlorodiphenylphosphine in the presence of triethylamine at -40°C. The compounds, (3)[9] and (4),[10] are known, and the structures of new compounds, (5) and (6), were easily deduced on the basis of the comparison of the spectral data (Table 2) with those of 3 and 4. To optimize the reaction conditions, we carried out the reaction of N-diphenylphosphinyl-1-phenylethanimine (3)[9] as the precursor of 1-azaallyl anion (7) at first.

The general procedure are as follows: after the compound (3) in THF was treated with two and half molar equivalent amounts of lithium diisopropylamide (LDA, 2.5 molar equivalent amounts) or more bulky lithium bis(trimethylsilyl)amide[11](2.5 molar equivalent amounts) at -78°C for 10 min, 2-chlorotropone (8) was added to the solution and, after stirred at -78°C for 1 h, the mixture was stirred at room temperature or under reflux for periods indicated in Table 1. The reaction mixtures were then poured into water and extracted with benzene, and the products were purified through tlc on silica gel (Hexane/AcOEt=1/1). The reaction conditions and the yields of the products are summarized in Table 1. When LDA was employed as a base, a complicated reaction was observed after addition of 8 and stirring at room temperature for 1 h. Even a trace amount of 2-isopropylaminotropone, which is expected from the nucleophilic attack of isopropylamine to 8, was not observed (Table 1, Entry 1).[12] When a more bulky lithium bis(trimethylsilyl)amide was employed, better results were obtained to give 1-azaazulene (9)[13] and 4H-4-oxocyclohepta[b]pyrrole (10) (Table 1, Entries 2-5, Scheme 1.). Although the ratio of 3/8 as well as the reaction temperature affect the yields of the products, the best result was obtained in Entry 3.

In a similarity of the reaction of (vinilimino)phosphoranes, the pathways for the formation of 9 and 10 are postulated (Scheme 2). The enamine-type alkylation of 7 on C-7 of 8 gives the intermediate (11). The following proton transfer in 11 regenerates 1-azaallyl anion (12), which undergoes intramolecular aza-Wittig reaction to give 13, dehydrochlorination of which gives 9. As far as 10 is concerned, the intermediate (12) possibly undergoes dehydrochlorination to provide tropone nucleus (14). When the ratio



Scheme 1.

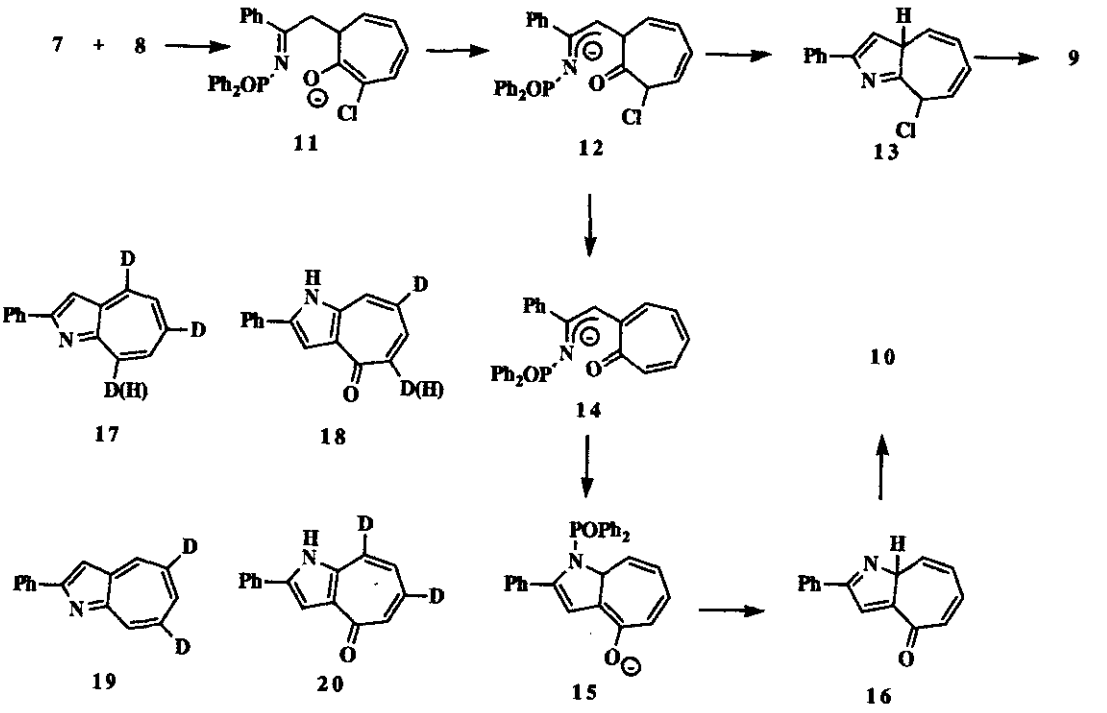
Table 1. The reaction of 7 with 2-chlorotropone (8)

Entry	Molar ratio of (3)/(8)	Base	Reaction Temp/°C[a]	Reaction Time/h[a]	Product yield/% (9)	(10)
			-78	1		
1	1 : 1	LDA	room temperature	1	none	none
			-78	1		
2	1 : 1	$LiN(SiMe_3)_2$	room temperature	42	25	3
			-78	1		
3	1 : 1	$LiN(SiMe_3)_2$	reflux	16	41	10
			-78	1		
4	2 : 1	$LiN(SiMe_3)_2$	reflux	16	23	21
			-78	1		
5	1 : 2	$LiN(SiMe_3)_2$	reflux	16	31	9

a. After addition of 8

of 3/8 was increased (in the presence of more excess base), the yield of 10 was improved as compared to that of 9 (Table 1, Entry 4). The compound (14) then undergoes intramolecular Michael addition and following 1,5-hydrogen migration to provide 10.

A confirmation whether the first nucleophilic attack of 1-azaally anion (7) occurs on C-2 or C-7 of 8 was made by the reaction of 2-chloro-3,5,7-trideuteriotropone with 7. In



Scheme 2.

the former case, the formation of 17 and 18 was expected, while in the latter case, the formation of 19 and 20. The unambigious ^{1}H-nmr spectral studies of the products, 19[4a] and 20 (Table 2), revealed that H-5, 7 of 9 and H-6, 8 of 10 were completely replaced by deuterium. Thus the nucleophilic attack of 7 on C-7 of 8 was confirmed as in the case of the reaction of (1-phenyl)vinyliminophosphorane.[4]

In the aforementioned manner (Table 1, Entry 3), other novel imines (4), (5), and (6) were reacted with 8 similarly. In the case of 1-azaallyl anion (21) derived from N-3,4-dihydro-1(2H)-naphthylidenediphenylphosphinamide (5), the expected products, (22), was ob-

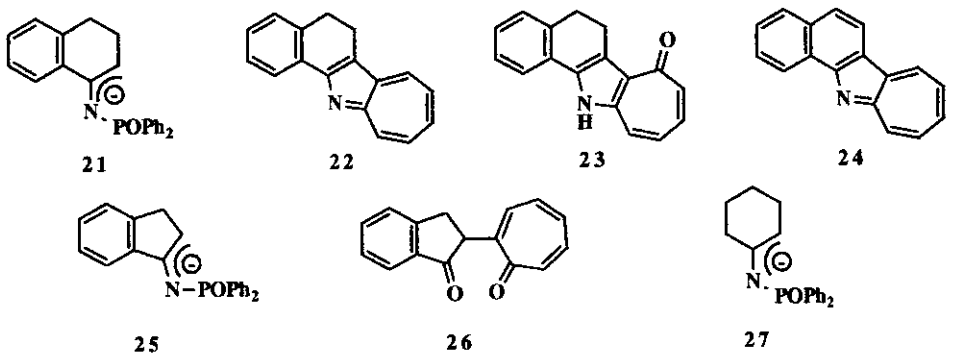
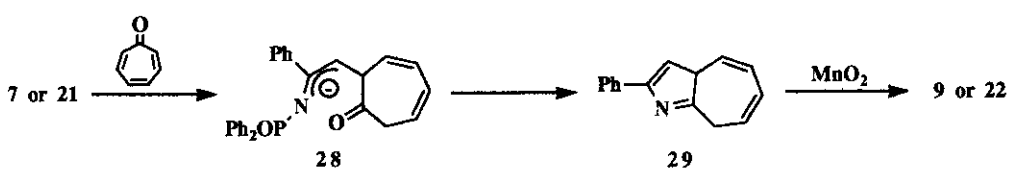


Figure 3.

tained in a 63 % yield and a trace amount of 4H-4-oxocyclohepta[b]pyrrole derivative (23), the structure of which was tentatively assigned according to the spectral data. The compound (22) was dehydrogenated easily by DDQ in refluxing benzene and benzo[g]cyclohepta[b]indole (24)[14] was obtained as violet crystals in a 66 % yield. On the other hand, the reaction of 1-azaallyl anion (25) generated from 1-indenylidenediphenylphosphinamide (6) with 8 resulted in the formation of unidentified orange powder, after purification by tlc (silica gel, Hexane/AcOEt=1/1). The powder was hydrolyzed in acidic media to furnish 26, the ^{1}H-nmr spectra of which were in good agreement with the authentic specimen prepared by an alternative way: the reaction of lithium enolate of 1-indanone with 8.[15] The failure in obtaining 1-azaazulene skeleton in this case may be attributable to the prior dehydrochlorination constructing tropone nucleus to the expected intramolecular aza-Wittig reaction. On the other hand, the reaction of 1-azaallyl anion (27), generated from known 4,[10] with (8) afforded no expected product and only decomposition of 8 or 27 was observed under a wide range of reaction conditions. Thus the phenyl group of 1-azaalyl anions in the present reactions seems to be important.

The reactions of 7, 21, 25, and 27 with tropone were also carried out in a similar manner.



Scheme 3.

Only in the case of 7 and 21, 1-azaazulene derivatives (9) and (22) were obtained in 7 % and 30 % yields, respectively, after dehydrogenation by using MnO_2. The reaction of 7 or 21 with tropone follows the pathway depicted in Scheme 3.[4] In this case, 4H-4-oxocyclohepta[b]pyrrole derivatives were not obtained.

In summary, we have demonstrated that phenyl-substituted 1-azaallyl anion (7) reacts with tropone or 2-chlorotropone to give phenyl-substituted and condenced 1-azaazulene ring systems. The scope and limitations as well as the synthetic applicability of 1-azaallyl anions are now underway.

Table 2. Physical data of new compounds (5, 6, 10, 20, 22, 23, and 26)

5: light yellow crystals; mp 82-83 °C (from PhH and Ether); ir ($CHCl_3$) 2979, 1630, 1600, 1447, 1178 cm^{-1}; ^{1}H-nmr (90 MHz, $CDCl_3$) δ 2.05 (2H, tt, J=6.15, 6.59 Hz, H-3), 2.89 (2H, t, J=6.15 Hz, H-4), 3.22-3.39 (2H, m, H-2), 7.06-8.10 (13H, m, H-Ph, H-5, 6, and 7), 8.41 (1H, dd, J=6.92, 2.42 Hz, H-8); ^{13}C-nmr (100 MHz, $CDCl_3$) δ 22.90, 29.68, 35.49, 35.62, 126.54, 127.39, 128.28, 128.40, 129.03, 131.24, 131.26, 131.48, 131.56, 132.41, 132.57, 132.78, 133.95, 134.19, 134.36, 135.66, 143.71, 182.13; ms (m/z) 347 (M^++2, 4%), 346 (M^++1, 24%), 345 (M^+, 100%); High ms Calcd for $C_{22}H_{20}NOP$: 345.1283. Found: 345.1263.

6: white crystals; mp 130-132 °C (from PhH and Ether); ir ($CHCl_3$) 2988, 1642, 1607, 1448, 1181, 1103 cm^{-1}; ^{1}H-nmr (90 MHz, $CDCl_3$) δ 2.80-3.20 (4H, m, H-2, 3), 7.10-7.97 (14H, m, H-Ph, H-4, 5, 6, and 7); ^{13}C-nmr (100 MHz, $CDCl_3$) δ 28.61, 34.90, 35.02, 123.95, 126.01, 127.16, 128.24, 128.29, 128.36, 131.25, 131.27, 131.51, 131.60, 132.41, 134.06, 134.16, 135.44, 139.95, 140.18, 153.35, 190.84; ms (m/z) 332 (M^++1, 14%), 331 (M^+, 62%), 330 (M^+-1, 17%); High ms Calcd for $C_{21}H_{18}NOP$: 331.1127. Found: 331.1176.

10: light yellow crystals; mp 170-171 °C (from EtOH); ir ($CHCl_3$) 3397, 3016, 3009, 1654, 1612, 1486, 1221, 1215, 1145 cm^{-1}; ^{1}H-nmr (400 MHz, $CDCl_3$) δ 6.79 (1H, s, H-3), 7.44-7.53 (3H, m, H-Ph), 7.49 (1H, dd, J=7.48, 7.10 Hz, H-7), 7.60 (1H, d, J=7.69 Hz, H-5), 7.67 (1H, dd, J=7.69, 7.10 Hz, H-6), 7.74-7.79 (2H, m, H-Ph), 8.41 (1H, d, J=7.48 Hz, H-8), 10.47 (1H, br s, H-1); ^{13}C-nmr (125 MHz, $CDCl_3$) δ 104.43, 124.97, 126.14, 126.59, 126.73, 127.51, 129.29, 129.38, 129.61, 132.93, 134.33, 138.36, 139.48, 163.85(One peak is hindered.); ms (m/z) 223 (M^++2, 4%), 222 (M^++1, 44%), 221 (M^+,

100%); High ms Calcd for $C_{16}H_{11}NO$: 221.0841. Found: 221.0821.

20: light yellow crystals; ^{1}H-nmr (400 MHz, $CDCl_3$) δ6.79 (1H, br s, H-3), 7.45-7.54 (3H, m, H-Ph), 7.48 (1H, br s, H-7), 7.60 (7H, s, H-5), 7.74-7.77 (2H, m, H-Ph), 10.31 (1H, br s, H-1); ms (m/z) 224 (M^++1, 37%), 223 (M^+, 100%), 222 (M^+-1, 19%); High ms Calcd for $C_{16}H_9NOD_2$: 223.0966. Found: 223.0942.

22: oil, ir ($CHCl_3$) 2943, 1601, 1587, 1506, 1466, 1425, 1327, 1207 cm^{-1}; ^{1}H-nmr (90 MHz, $CDCl_3$) δ 3.16 (4H, br s, H-6, 7), 7.17-7.67 (6H, m, H-2, 3, 4, 8, 9, and 10), 8.15-8.62 (3H, m, H-1, 5, and 11), ^{13}C-nmr (100 MHz, $CDCl_3$) δ 20.33, 29.23, 122.50, 125.47, 127.24, 127.61, 128.46, 129.15, 130.00, 131.79, 132.12, 134.39, 136.23, 139.80, 142.07, 159.19, 163.32; ms (m/z) 232 (M^++1, 18%), 231 (M^+, 100%), 230 (M^+-1, 75%); High ms Calcd for $C_{17}H_{13}N$: 231.1048. Found: 231.1014.

23: light yellow crystals; ir ($CHCl_3$) 3396, 2996, 1653, 1632, 1607, 1489 cm^{-1}; ^{1}H-nmr (90 MHz, $CDCl_3$) δ 2.99 (4H, br s, H-6, 7), 7.10-7.85 (7H, m, H-2, 3, 4, 8, 9, 10, and 11), 8.51 (1H, d, J=6.59 Hz, H-1), 10.3 (1H, br s, H-12); ms (m/z) 248 (M^++1, 19%), 247 (M^+, 100%), 246 (M^+-1, 41%); High ms Calcd for $C_{17}H_{13}NO$: 247.0997. Found: 247.1035.

26: red crystals; mp 93-95 °C (from EtOH); ir ($CHCl_3$) 3010, 2931, 1706, 1580, 1477 cm^{-1}; ^{1}H-nmr (500 MHz, $CDCl_3$) δ 3.18 (1H, dd, J=5.04, 16.82 Hz, H-3'), 3.47 (1H, dd, J=8.41, 16.82 Hz, H-3'), 3.73 (1H, dd, J=5.04, 8.41 Hz, H-2'), 7.00-7.90 (9H, m, H-2, 3, 4, 5, 6, and 7, H-4', 5', 6', and 7'); ^{13}C-nmr (100 MHz, $CDCl_3$) δ 33.43, 55.65, 124.13, 126.23, 127.33, 133.61, 133.93, 134.40, 135.99, 136.94, 137.55, 140.91, 152.62, 154.30, 185.51, 204.75; ms (m/z) 237 (M^++1, 18%), 236 (M^+, 100%), 235 (M^+-1, 17%); High ms Calcd for $C_{16}H_{12}O_2$: 236.0837. Found: 236.0842.

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