Reactions with Aziridines, 45[1]. – Arene Hydrides, 5[2]

# Reversibility of Carbonyl Attack on *N*-Benzoylaziridines Prior to Ring Opening by Carbanions. – Strong Influence of the Gegen Ion

**Thomas Mall and Helmut Stamm***

Pharmazeutisch-Chemisches Institut der Universität Heidelberg, Im Neuenheimer Feld 364, D-6900 Heidelberg

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A previous report had shown that anthracene hydride $AH^-$ or the xanthenyl anion $X^-$, respectively, at first add to the carbonyl group of *N*-benzoylaziridines since high yields of benzoyl dihydroanthracene **3** or benzoyl xanthene **11** were obtained when in early stages the reaction was quenched with protons. The respective intermediate carbonyl adducts **2** and **10** had been considered to be precursors of products resulting from homolysis of the aziridine ring. It is now shown that quenching of the reaction between $AH^-$ or $X^-$ and *N*-benzoylaziridines **1a,b** with methyl iodide or aroyl chlorides results in substantial yields of products derived from either $AH^-$ (or $X^-$) or **1a,b**. This indicates that **2** (or **10**) are in equilibrium with $AH^-$ (or $X^-$) and **1a,b**. Study of the gegen ion influence with $X^-$ revealed that the equilibrium concentrations of **10**-$Na^+$ were much lower than those of **10**-$Li^+$ while simultaneously the ring opening of **1a** was distinctly faster with $X^-Na^+$ than with $X^-Li^+$. This finding suggests that, contrary to the previous assumption, the equilibrium concentrations of $X^-$ and **1a** are responsible for the (homolytic) ring opening.

**Reaktionen mit Aziridinen, 45[1]. – Arenhydride, 5[2]. – Reversibilität des Carbonylangriffs bei *N*-Benzoylaziridinen vor der Ringöffnung durch Carbanionen. – Starker Gegenion-Einfluß**

Ein früherer Bericht hatte gezeigt, daß Anthracenhydrid $AH^-$ bzw. das Xanthenylanion $X^-$ zuerst die Carbonylgruppe von *N*-Benzoylaziridinen angreifen, da in frühen Stadien der Reaktion ein Abstoppen mit Protonen hohe Ausbeuten an Benzoyldihydroanthracen **3** bzw. Benzoylxanthen **11** liefert. Die entsprechenden Carbonyladdukt-Zwischenstufen **2** und **10** waren als Vorläufer von Produkten angesehen worden, die aus einer Homolyse des Aziridinringes hervorgehen. Es wird jetzt gezeigt, daß Abstoppen der Reaktion zwischen $AH^-$ bzw. $X^-$ und den *N*-Benzoylaziridinen **1a,b** mit Methyliodid oder Aroylchloriden hohe Ausbeuten an Produkten ergibt, die sich von $AH^-$ (bzw. $X^-$) oder **1a,b** ableiten. Dies zeigt an, daß **2** (bzw. **10**) im Gleichgewicht mit $AH^-$ (bzw. $X^-$) und **1a,b** stehen. Untersuchung des Gegenion-Einflusses bei $X^-$ ergab, daß die Gleichgewichtskonzentrationen an **10**-$Na^+$ viel niedriger waren als diejenigen an **10**-$Li^+$, während gleichzeitig die Ringöffnung von **1a** mit $X^-Na^+$ deutlich schneller war als mit $X^-Li^+$. Dieser Befund legt die Vermutung nahe, daß im Gegensatz zur früheren Annahme die Gleichgewichtskonzentrationen an $X^-$ und **1a** für die (homolytische) Ringöffnung verantwortlich sind.

A recent[3] paper reported a homolytic ring opening of *N*-acylaziridines by anthracene hydride $AH^-$ (or xanthenyl anion $X^-$). It was assumed that single electron tranfer (SET) forms the radical $AH^\cdot$ (or $X^\cdot$) and the ketyl of the *N*-acylaziridine. A non-aromatic ketyl was thought to undergo homolytic opening immediately. Since *N*-aroylaziridines first formed a carbonyl adduct (**2a,b** and analogues), the respective aromatic ketyls were supposed to combine with $AH^\cdot$ or $X^\cdot$ in a reversible manner. This two-step formation of the carbonyl adduct was favoured over the classic ionic mechanism. We now present results showing clearly that $AH^-$ ($X^-$) and *N*-aroylaziridines form the carbonyl adducts **2a,b** (**10**) reversibly and in a classic ionic mechanism. The equilibrium involved lies heavily on the side of the adducts as previously[3] shown by 94% isolated yield of the ketone **3** (or 83% of ketone **11**, 14% of **1a** not converted) under conditions of time and temperature (5 minutes at −65°C or going from −65°C to room temperature during 50 minutes) that were insufficient for ring cleavage of **1a**. However, the mere existence of this equilibrium opens the possibility of an alternative mechanism producing the required ketyl by SET between the small equilibrium concentrations of $AH^-$ (or $X^-$) and *N*-aroylaziridine.

The high yields of ketones **3** and **11** were obtained when the reaction between $AH^-$ or $X^-$, respectively, and **1a** or other *N*-benzoylaziridines[3] was quenched with acid. Since protonation of all anions occurs practically instantaneously, the yields of **3** and **11** can be taken as the percentage of carbonyl adducts **2** (or **10** and analogues) present at the moment of quenching. Substitution of more slowly reacting and discriminating electrophiles for the rapid and non-discriminating proton could be a means for detecting and capturing $AH^-$ (or $X^-$), a very high ranking nucleophile. This is indeed born out by the experiments of Table 1 when short reactions prior to quenching with an electrophile prevented aziridine ring cleavage by $AH^-$.

In run 1 of Table 1 the reaction between $AH^-$ and **1a** was quenched with a large excess of methyl iodide. This provided a quantitative formation of methyldihydroanthracene **5** along with a high yield of oxazoline **6**. Clearly, methyl iodide is very good for trapping both species on the left side of the upper equilibrium in Scheme 1, i. e. $AH^-$ as well as

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**1a**, the latter by the well-known[4] iodide-ion-catalyzed isomerization **1a** → **6** (Scheme 1).

Scheme 1

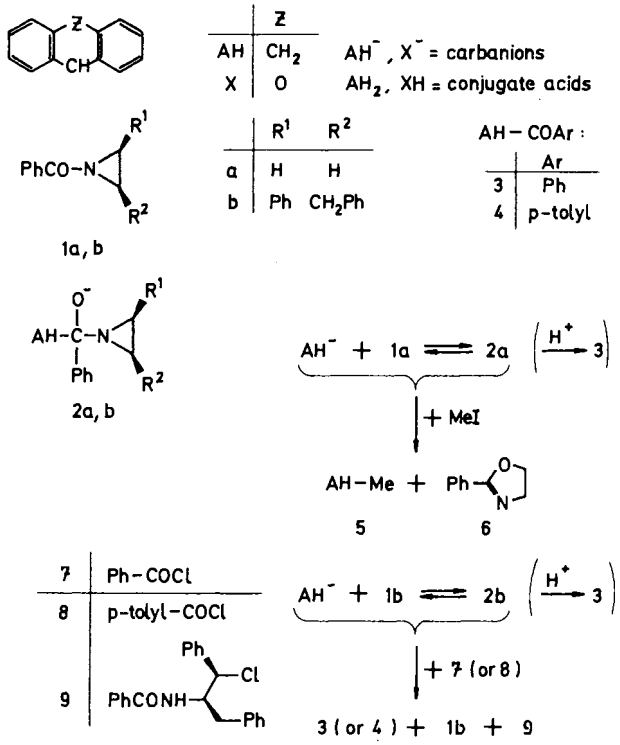


Table 1. Reactions of $AH^-Li^+$ with **1a,b** quenched with electrophiles

| Run | [mmol] $AH_2$ | [mmol] BuLi | [mmol] **1a,b** | [mmol] Electrophile | Time[a] $t_1$ | $t_2$ | $t_3$ | Products % yield[b] |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.5 | 5 | 5, **1a** | 50–60, MeI | 15 s | 30 s | 0 | (100) **5**, (87) **6** |
| 2 | 6.25 | 5 | 4.88, **1b** | 5, 7[c] | 7 min | 0 | 0 | 51/3, 3/9, 81/**1b** |
| 3 | 6.25 | 5 | 4.79, **1b** | 5, 8[c] | 5 min | 5 min | 2 h | 69/4, 58/9, 30/**1b** |

[a] Dropwise addition of **1a,b** during time $t_1$. After subsequent time $t_2$ the electrophile was added, at once in run 1, during 5 min in runs 2 and 3. $t_3$ = time for the reaction with the electrophile. All steps were performed at room temperature. – [b] Yields in parentheses: $^1$H-NMR analysis. – [c] Dissolved in 10 ml of THF.

For **1b**, in the reaction with $AH^-$, protonic quenching had also shown[3] that in the early stages of the reaction the predominant species (56% after 25 minutes at room temperature, 15% of **1b** not converted) is the carbonyl adduct **2b**. When this reaction of **1b** with $AH^-$ was quenched with benzoyl chloride (**7**) (run 2), 83% of **1b** was recovered and 3% of **1b** was converted into **9** by chloride ion attack. 50% of the expected **3** was isolated. That **3** came from the reaction of **7** with $AH^-$ of the second equilibrium in Scheme 1 was proven by run 3 that had been quenched with *p*-toluoyl chloride (**8**). Here, the respective ketone **4** was isolated. Due to the longer time for reaction in this run, much more of **1b** had been converted into **9**, the sum of **9** and recovered **1b** being the same as in run 2. Formation of the corresponding oxazoline from **9** is retarded since the poorly nucleofugal chloride ion would have to be replaced in this cyclization and/or since this cyclization would suffer from steric hindrance.

Scheme 2

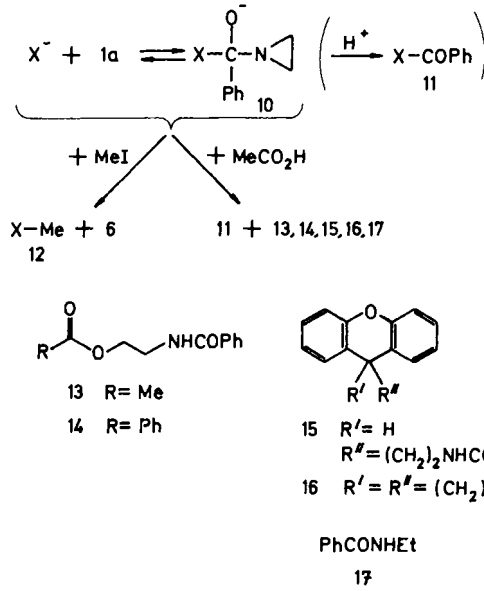


Table 2. Reactions of $X^-Li^+$ and $X^-Na^+$ with 5 mmol of **1a** in THF[a]

| Run | [mmol] XH | [mmol] Base | Temperature[b] and time[c] | Products % yield[d] |
|---|---|---|---|---|
| 1 | 5 | 5 BuLi | rt, 30 s[e] | (87) **6**, (100) **12** |
| 2 | 10 | 7.5 $NaNH_2$ | –65°C → rt, 50 min | 14/**11**, 3/**15**, 43/**13**, 5/**14** |
| 3 | 10 | 7.5 $NaNH_2$ | –65°C → rt, 50 min | 3/**11**, 14/**15**, (trace) **16**, (20) **1a**, 20/**13**, 14/**14** |
| 4 | 10 | 7.5 $NaNH_2$ | rt, 65 min | 30/**11**, 7/**15**, 13/**13**, 24/**14** |
| 5 | 10 | 7.5 $NaNH_2$ | rt, 20 h | (trace) **11**, (60) **15**, (20) **16**, (3) **17**, (7) **14** |
| 6 | 10 | 7.5 BuLi | rt, 20 h | 74/**11**, (18) **15**, (5) **16**, (≤3) **17** |
| 7 | 7.5 | 6.25 BuLi | rt, 14 d | 0/**11**, (54) **15**, (35) **16**, (11) **17** |

[a] 90–120 ml of THF. – [b] rt = room temperature. – [c] Except for run 1, the reactions were quenched with about one equivalent (with an excess in run 2) of glacial acetic acid. – [d] Yields in parentheses: $^1$H-NMR analysis. – [e] Run 1 was quenched with 50–60 mmol of MeI.

In some reactions of $X^-$ with **1a** (Scheme 2, Table 2) the influence of the gegen ion, $Li^+$ or $Na^+$, was studied. Capturing $X^-$ and **1a** with methyl iodide (run 1) provided a result quite analogous to that of the $AH^-$ reaction in Table 1 (entry 1). Together with the reported[3] protically quenched experiment (vide supra), this result establishes a classic ionic carbonyl attack and its reversibility. However, when the reported[3] reaction with protic quenching was repeated with $X^-Na^+$ (runs 2 and 3 in Table 2), the yield of **11** dropped from the reported 83% to 14% or 3%, respectively, in favor of unreacted **1a** and its artifacts **13** and **14**. The acetate **13** arises from **1a** and the acetic acid that was

injected to quench the reaction. This conversion **1a**→**13** depends on the amount of acetic acid as well as on time and temperature during workup. We assume that **14** is formed analogously from **1a** and benzoic acid, but it is not clear how benzoic acid can arise from **1a** under the conditions of the reaction and/or the workup. Besides the low yield of **11**, the isolation or detection of ring-opened products **15** and **16** is noteworthy since no ring opening had been observed under the same conditions[3] with $X^-Li^+$ (vide supra).

Obviously, there is a marked influence of the gegen ion on the carbonyl attack, either on the reaction rate or on the equilibrium, or on both. Favoring the formation or increasing the equilibrium concentration of **10** by $X^-Li^+$ as compared to $X^-Na^+$ is not unexpected when one considers the similarities of organolithium and organomagnesium compounds. Bad kinetics or thermodynamics of **10** as result of $Na^+$ imply higher concentrations of $X^-$ and **1a**, thus accelerating ring opening of **1a** irrespective of the mechanism, $S_N2$ or SET. These tendencies, i.e. less formation of **10** and faster ring opening when $Na^+$ is the gegen ion, are also observed in the room temperature reactions (runs 4 and 5). Particularly impressive is the comparison of the two 20-hours experiments (runs 5 and 6) that were performed under precisely the same conditions except for the choice of the gegen ion: with $Na^+$ (run 5) a total (**15** + **16** + **17**) of 83% ring opening and no ketone **11** was found, with $Li^+$ (run 6) a total of 26% ring opening and 74% of **11**. The long-time run 7 secured that **10**, the precursor of **11**, is completely converted into ring-opened products even with $Li^+$ as gegen ion. The detection of *N*-ethylbenzamide (**17**) in runs 5–7, both with $Li^+$ and $Na^+$, confirms the proposed[3] homolytic ring opening. The tendency of $X^-$ to form mono (**15**) and bis(amidoethyl) derivatives (**16**) in comparable yields has been reported previously[5,3].

We have not performed corresponding experiments with $AH^-Na^+$, but it appears reasonable to assume a similar influence of the gegen ion in reactions with $AH^-$. Since the observed reversibility of carbonyl attack may be a general phenomenon in aziridine chemistry, it may be worthwile to reinvestigate known[6] carbonyl reactions of *N*-acylaziridines under aprotic conditions using acyl groups COR whose R cannot be eliminated from the carbonyl adduct.

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## Experimental

*General Methods and Materials:* See ref.[3], e. g. spectroscopy, chromatography on silica gel (column dimensions in cm), TLC and preparative TLC, purification of THF, reaction conditions (continuous stirring under purified nitrogen for all reactions). Aziridines **1a,b** have been described previously (see ref.[3]).

Reactions with $AH^-Li^+$ *or* $X^-Li^+$: The solution of $AH_2$ or **XH** in 50–70 ml of THF was cooled to freezing of THF, and then BuLi (solution in hexane, concentration determined by Gilman double titration) was added. When the mixture had reached room temperature, **1a,b** (dissolved in 20 ml of THF) were added dropwise. Reaction time and mode of quenching are given in Table 1.

*Reactions with* $X^-Na^+$: The solution of **XH** in 70–100 ml of THF was refluxed for 2–3 hours[5] with sodium amide dispersion (50% in toluene) under nitrogen. After cooling to room temperature or to −65°C (dry ice/methanol[3]), respectively, the solution of **1a** in 20 ml of THF was added dropwise within 5 minutes. The mixture was allowed to stand without cooling or heating for the time given in Table 2. Then the glacial acetic acid was added.

*Workup:* The solvent was removed under reduced pressure and the residue taken up in $CH_2Cl_2$ and washed with water. Evaporation of the organic layer provided a residue whose further treatment is given below for each run.

*Table 1, run 1:* $^1$H-NMR analysis of the residue indicated 450 mg of (excess) $AH_2$, 980 mg (100%) of **5**, and 640 mg (87%) of **6** by comparison with authentic samples, that were prepared (**5**) from $AH_2$ with an excess of both BuLi and MeI in THF or (**6**[4,7]) prolonged heating of **1a** to more than 120°C. – **5**: $^1$H NMR ($CDCl_3$, 250 MHz): δ = 1.38 (d, *J* = 6.2 Hz, Me), 3.81 (d, *J* = 18.5 Hz, 10-H pseudo eq), 3.98 (q, *J* = 7.2 Hz, 9-H pseudo eq), 4.06 (d, *J* = 18.5 Hz, 10-H pseudo ax), 7.10–7.30 (m, 8 aromatic H); these data agree reasonably well with those reported previously[8] from a 60-MHz spectrum. – **6**: $^1$H NMR ($CDCl_3$, 250 MHz): δ = 3.99 ($m_c$, t-like, "*J*" ca. 9.5 Hz, $NCH_2$), 4.34 ($m_c$, t-like, "*J*" ca. 9.5 Hz, $OCH_2$), 7.37–7.57 (m, *m*-H and *p*-H of Ph), 7.91–7.98 (m, *o*-H of Ph).

*Table 1, run 2:* Chromatography (70 × 1.5, toluene) yielded 673 mg of hydrocarbons (mainly $AH_2$), 640 mg of **3**[3], 185 mg of a mixture consisting ($^1$H NMR) of 70 mg of **3** (total 710 mg, 51%) and 115 mg of **1b**, 1126 mg of **1b** (total 1241 mg, 81%), and 53 mg (3%) of **9**.

*N-(1-Benzyl-2-chloro-2-phenethyl)benzamide* (**9**): M.p. 158 to 160°C. – $^1$H NMR ($CDCl_3$, 250 MHz): δ = 3.09 ($m_c$, 2 benzylic H), 4.86 ($m_c$, NCH), 5.14 (d, *J* = 3.4 Hz, ClCH), 6.44 (d, br, *J* = 8.9 Hz, NH), 7.21–7.38 (m, 2 Ph), 7.38–7.54 (m, *m*-H and *p*-H of benzoyl), 7.65–7.72 (m, *o*-H of benzoyl). – IR (KBr): 3320 $cm^{-1}$ (NH), 1641 (amide I), 1538 (amide II).

$C_{22}H_{20}ClNO$ (349.8) Calcd. C 75.52 H 5.76 N 4.00
Found C 75.47 H 5.65 N 4.27

*Table 1, run 3:* Chromatography (90 × 1.5) with toluene yielded 568 mg of hydrocarbons (mainly $AH_2$), 989 mg (69%) of **4**, and 450 mg (30%) of **1b**. Elution with dichloromethane/ethyl acetate (8:1) provided 969 mg (58%) of **9**.

*9-(p-Toluoyl)-9,10-dihydroanthracene* (**4**): M.p. 109–110°C (petroleum ether, b.p. 40–60°C). – $^1$H NMR ($CDCl_3$, 250 MHz): δ = 2.41 (s, Me), 3.94 (d, *J* = 18.5 Hz, 10-H pseudo eq), 4.51 (d, *J* = 18.5 Hz, 10-H pseudo ax), 5.98 (s, 9-H pseudo eq), 7.08–7.41 (m, 10 aromatic H), 7.94–8.02 (m, 2 *o*-H of aroyl). – IR (KBr): 1669 $cm^{-1}$ (C=O).

$C_{22}H_{18}O$ (298.4) Calcd. C 88.56 H 6.08
Found C 88.28 H 6.16

*Table 2, run 1:* $^1$H-NMR analysis of the residue indicated 640 mg (87%) of **6** and 980 mg (100%) of **12** by comparison with authentic samples. Sample of **6** vide supra. The sample of **12** was prepared from **XH** with an excess of both BuLi and MeI in THF. –**12**: $^1$H NMR ($CDCl_3$, 250 MHz): δ = 1.47 (d, *J* = 7.5 Hz, Me), 4.07(q, *J* = 7.5 Hz, 9-H), 7.03–7.09 (m, 4 aromatic H), 7.17–7.27 (m, 4 aromatic H). These data agree reasonably well with those reported previously[9] from a 60-MHz spectrum.

*Table 2, run 2:* Chromatography (20 × 3) yielded (with toluene) 1718 mg of mixture A and (with ethyl acetate) 802 mg of mixture B. Chromatography (70 × 1.5, toluene) of mixture A provided

1470 mg of **XH** and 204 mg (14%) of **11**[3]. Chromatography (70 × 1.5) of mixture B with dichloromethane/ethyl acetate (10:1) provided 101 mg of mixture C; subsequent elution with dichloromethane/ethyl acetate (2.7:1) yielded 446 mg (43%) of **13**. Preparative TLC of mixture C with dichloromethane/ethyl acetate (10:1) yielded 37 mg (6%) of **14** and 46 mg of **15**[5] (upper zone).

*2-(Benzoylamino)ethyl Acetate* (**13**): M.p. 45–46°C. – $^1$H NMR ($CDCl_3$, 250 MHz): δ = 2.05 (s, Me), 3.65–3.72 (m, q-like, $NCH_2$), 4.26 ($m_c$, t-like, "*J*" ca. 5.6 Hz, $OCH_2$), 7.07 (s, br, NH), 7.36–7.48 (m, *m*-H and *p*-H of benzoyl), 7.77–7.80 (m, *o*-H of benzoyl). – IR (KBr): 3360 $cm^{-1}$ (NH), 1735 (O–C=O), 1642 (amide I), 1534 (amide II).

$C_{11}H_{13}NO_3$ (207.2) Calcd. C 63.75 H 6.32 N 6.76
Found C 64.01 H 6.45 N 6.60

*2-(Benzoylamino)ethyl Benzoate* (**14**): M.p. 85–88°C (ref.[10] 88–89°C). – $^1$H NMR ($CDCl_3$, 250 MHz): δ = 3.80–3.86 (m, q-like, $NCH_2$), 4.52 ($m_c$, t-like, "*J*" ca. 5.5 Hz, $OCH_2$), 6.97 (s, br, NH), 7.35–7.58 (m, *m*-H and *p*-H of 2 benzoyl), 7.76–7.80 (m, *o*-H of *N*-benzoyl), 8.01–8.05 (m, *o*-H of *O*-benzoyl). – IR (KBr): 3260 $cm^{-1}$ (NH), 1723 (O–C=O), 1641 (amide II), 1563 (amide II).

$C_{16}H_{15}NO_3$ (269.3) Calcd. C 71.36 H 5.61 N 5.20
Found C 71.25 H 5.62 N 5.01

*Table 2, run 3:* Chromatography (20 × 3) provided (with toluene) 1755 mg of mixture A and (with ethyl acetate) 535 mg of mixture B. Chromatography (70 × 1.5) of mixture A yielded (toluene) 1632 mg of **XH**, (toluene) 39 mg (3%) of **11**, and (dichloromethane/ethyl acetate, 3.7:1) 34 mg of **1a**. Chromatography (70 × 1.5) of mixture B with dichloromethane/ethyl acetate (10:1) provided 71 mg of **1a**, a mixture consisting of ($^1$H NMR, 90 MHz) 39 mg of **1a** (i.e. summed up to 144 mg, 20%) and 41 mg of **15**, 30 mg of **15** (i.e. summed up to 71 mg, 14%) containing a trace ($^1$H NMR, 250 MHz) of **16**[5], and 92 mg (14%) of **14**. Further elution with dichloromethane/ethyl acetate (3.7:1) yielded 208 mg (20%) of **13**.

*Table 2, run 4:* Chromatography (20 × 3) provided (toluene) 1862 mg of mixture A and (ethyl acetate) 543 mg of mixture B. Chromatography (70 × 1.5, toluene) of mixture A yielded 1198 mg of **XH** and 441 mg (30%) of **11**. Preparative TLC (dichloromethane/ethyl acetate, 10:1) of mixture B provided (from top to bottom) 112 mg (7%) of **15**, 158 mg (24%) of **14**, and 132 mg (13%) of **13**.

*Table 2, run 5:* Chromatography (60 × 1.5) with toluene provided 1028 mg of **XH** and 42 mg of a fraction that contained a trace of **11**. Further elution with dichloromethane/ethyl acetate (1:1) provided 1294 mg of a mixture consisting ($^1$H NMR, 250 MHz) of 47 mg (7%) of **14**, 987 mg (60%) of **15**, 238 mg (20%) of **16**, and 22 mg (3%) of **17**[3].

*Table 2, run 6:* Chromatography (60 × 1.5) with toluene provided 891 mg of **XH** and 1059 mg (74%) of **11**. Further elution with dichloromethane/ethyl acetate (1.5:1) yielded 378 mg of a mixture consisting ($^1$H NMR, 250 MHz) of 296 mg (18%) of **15**, 60 mg (5%) of **16**, and ≤ 22 mg (≤ 3%) of **17**.

*Table 2, run 7:* Chromatography (20 × 3) yielded (toluene) 919 mg of **XH** and (ethyl acetate) 1386 mg of a mixture consisting ($^1$H NMR, 250 MHz) of 888 mg (54%) of **15**, 416 mg (35%) of **16**, and 82 mg (11%) of **17**.

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[1] Reactions with Aziridines, 43: T. Mall, H. Stamm, *J. Org. Chem.* **52** (1987) 4812. – Reactions with Aziridines, 44: G. Bentz, N. Besbes, A. Laurent, H. Stamm, *Tetrahedron Lett.* **28** (1987) 2511.
[2] Arene Hydrides, 4: A. Sommer, H. Stamm, A. Woderer, *Chem. Ber.* **121** (1988) 387.
[3] H. Stamm, A. Sommer, A. Woderer, W. Wiesert, T. Mall, P. Assithianakis, *J. Org. Chem.* **50** (1985) 4946.
[4] H. W. Heine, *Angew. Chem.* **74** (1962) 772.
[5] H. Stamm, W. Wiesert, *Arch. Pharm. (Weinheim, Ger.)* **312** (1979) 133.
[6] Carbonyl attack under aprotic conditions has been reported for ethyl aziridine-1-carboxylate: A. Hassner, A. Kascheres, *Tetrahedron Lett.* **1970**, 4623; H. Stamm, *Tetrahedron Lett.* **1971**, 1205; H. Stamm, W. Wiesert, *Chem. Ber.* **111** (1978) 2665. Clearly, with this particular acyl, elimination of the ethoxide ion from the carbonyl adduct can make the carbonyl attack irreversible in the end.
[7] A. A. Goldberg, W. Kelly, *J. Chem. Soc. (London)* **1948**, 1919.
[8] R. G. Harvey, L. Arzadon, J. Grant, K. Urberg, *J. Am. Chem. Soc.* **91** (1969) 4535.
[9] T. Jojima, H. Takeshiba, T. Konotsune, *Chem. Pharm. Bull.* **20** (1972) 2191.
[10] S. Gabriel, *Ber. Dtsch. Chem. Ges.* **38** (1905) 2405.


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