

Omar Elmalak, Mordecai Rabinovitz\* and Jochanan Blum\*

Department of Organic Chemistry, The Hebrew University of Jerusalem,  
Jerusalem 91904, Israel

Received November 30, 1992

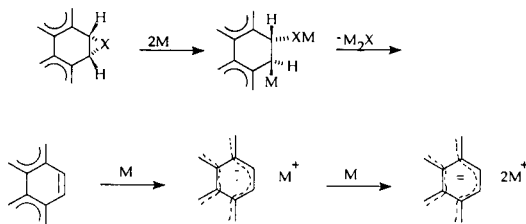
K-Region oxides and imines of phenanthrene, chrysene, benz[*a*]anthracene, and dibenz[*a,h*]anthracene react in tetrahydrofuran with lithium and sodium to give the parent hydrocarbons. In the presence of excessive metal, the latter are converted into dianions from which the parent compounds can be regenerated upon quenching with oxygen. Metalate derivatives of the oxides and imines are proposed to be the corresponding reaction intermediates in the deoxygenation and deamination processes.

*J. Heterocyclic Chem.*, **30**, 291 (1993).

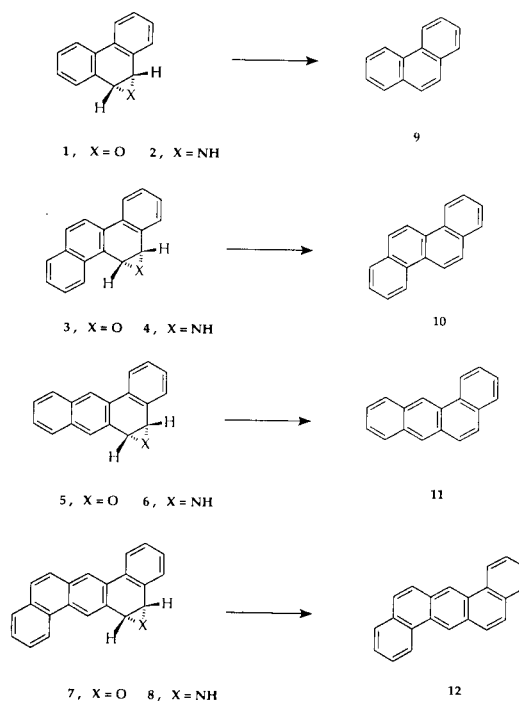
Owing to the exceptionally high mutagenic and carcinogenic activity of polycyclic arene oxides and arene imines, the chemistry of these compounds became the focus of numerous studies [1,2]. Since the oxiranes and azirides are considered as products of metabolic activation of polycyclic aromatic hydrocarbons, their transformation back to the parent compounds is of interest. However, only a few successful studies for deoxygenation of arene oxides (by enzymes [3], iron-porphyrin complexes [4] and thione reagents such as *N*-methylbenzothiazole-2-thione, thioacetamide, thiosemicarbazone [5]) have been reported. The deamination of arene imines has, so far, been accomplished only under nitrosating conditions (isoamyl nitrite and triethylamine) [6].

We now wish to report a new method by which both arene oxides and arene imines are smoothly converted into the corresponding parent hydrocarbons. When solutions of the K-region oxides or imines of phenanthrene, chrysene, benz[*a*]anthracene and dibenz[*a,h*]anthracene (**1-8**) in tetrahydrofuran are treated with either lithium or sodium followed by quenching of the reaction mixtures with oxygen, the respective hydrocarbons **9-12** are formed.

By analogy to the reaction of lithium with aliphatic epoxides [7] two metal atoms (lithium as well as sodium) are assumed to add to the aromatic arene oxides or imines. This process is followed by elimination of the corresponding metal oxide or amide as illustrated below.



Although these two steps are generally completed within a few hours, for best results the reactions have been allowed to proceed until the hydrocarbons were converted completely into dianions (several days) [8,9]. Under these



**Table 1**  
Deoxygenation of Arene Oxides and Deamination of Arene Imines  
with Lithium or Sodium in Tetrahydrofuran [a]

Starting Compound	Reaction time (days) [b,c]		Product	Yield (%) [c]	
	Li	Na		Li	Na
<b>1</b>	4	4	<b>9</b>	95	95
<b>2</b>	9	7	<b>9</b>	92	95
<b>3</b>	9	7	<b>10</b>	96	91
<b>4</b>	11	10	<b>10</b>	93	97
<b>5</b>	6	5	<b>11</b>	93	90
<b>6</b>	14	12	<b>11</b>	96	94
<b>7</b>	16	13	<b>12</b>	100	97
<b>8</b>	15	14	<b>12</b>	98	99

[a] Conditions as described in the Experimental. [b] Until formation of the dianion of the hydrocarbon was completed. [c] Average of at least three experiments.

conditions uniformly high yields were obtained (Table 1) provided the reactions were conducted under complete exclusion of air and moisture and the metals employed were of high purity.

When lithium of purity less than 99%, or sodium wire that had not been freshly distilled into the reaction vessel was employed, or when the solvent was not freshly dried over sodium-potassium alloy, the reaction time increased substantially, and the yields dropped to 60-70%.

The progress of the reactions could be followed both by the changes in color and by  $^1\text{H}$  nmr measurements. It has been noticed that in the initial stages, during which addition of the metal, to the oxide (or imine) and elimination of metal oxide (or amide) takes place, the reaction mixtures maintain their original color. During this period the peaks of the oxiran (or aziridine) ring protons gradually vanish and transient signals of the parent hydrocarbons appear. These signals, however, disappear rapidly when the reaction mixtures turn brown or violet, owing to the formation of the radical anions of the arenes. Only when the latter have been converted into dark blue (or green) dianions their characteristic high-field resonance peaks show up [8,9].

It is noteworthy that although sodium reacts with aliphatic epoxides to give alcohols [7], this metal converts arene oxides into hydroxyl-free hydrocarbons. Only when the reaction mixtures were not carefully freed from air or moisture some phenolic products could be detected (also when lithium had been employed in the processes). Likewise, in the presence of traces of oxygen or water, arene imines proved to form some aromatic amines. We have shown, however, that neither the phenols nor the amines are converted by the alkali metals into the parent hydrocarbons, and therefore they cannot be regarded as intermediates in the deoxygenation and deamination processes.

## EXPERIMENTAL

1a,9b-dihydrophenanthro[9,10-*b*]oxirene (**1**) [10], 1a,9b-dihydro-1*H*-phenanthro[9,10-*b*]azirine (**2**) [11], 1a,11c-dihydrochryseno[5,6-*b*]oxirene (**3**) [12], 1a,13c-dihydro-1*H*-chryseno[5,6-*b*]azirine (**4**) [12], 1a,11b-dihydrobenz[3,4]anthro[1,2-*b*]oxirene (**5**) [10], 1a,11b-dihydro-1*H*-benz[3,4]anthra[1,2-*b*]azirine (**6**) [6], 1a,13b-dihydrodibenz[3,4:7,8]anthra[1,2-*b*]oxirene (**7**) [13] and 1a,13b-dihydro-1*H*-dibenz[3,4:7,8]anthra[1,2-*b*]azirine (**8**) [6] were prepared as previously described.

General Procedures for Deoxygenation of Arene Oxides and Deamination of Arene Imines.

### A.

For small scale experiments an nmr tube (o.d. 5 mm) narrowed near its upper end and equipped with a three stage modified Kugelrohr, was charged with  $10^{-2}$  mmole of the appropriate arene oxide or arene imine. Sodium wire (0.1 mmole/purity >99.5%) was placed under oxygen-free argon in the Kugelrohr

and distilled at  $>10^{-4}$  Torr with the aid of a free flame into the upper part of the nmr tube. Finally, the tube was connected to a vessel in which octadeuteriotetrahydrofuran was dried over a 1:5 sodium-potassium alloy and 1 ml of the solvent was introduced in the nmr tube by distillation. The reaction tube was cooled to  $-78^\circ$ , sealed, turned upside down and kept at  $0^\circ$  with occasional shaking. When the reaction mixture started to turn brown or violet (usually after 3 hours) the temperature was lowered to  $-18^\circ$ . After several days the color turned deep blue or green. The progress of the reaction was periodically monitored by  $^1\text{H}$  nmr measurements. The process was terminated when no further changes in the spectrum of the dianions took place. For deoxygenation and diamination experiments with lithium the Kugelrohr was eliminated, and the lithium wire (purity >99%) was placed directly in the upper narrowed part of the nmr tube.

### B.

In a typical large scale experiment, a 500 ml round bottomed flask with a large magnetic bar was charged under oxygen-free argon with 25 mmoles of either sodium or lithium wire, 250 ml of absolute tetrahydrofuran (freshly distilled over sodium-potassium alloy into the reaction vessel) and 5 mmoles of the aromatic reactant in 50 ml of the same solvent. The mixture was purched with argon, stirred vigorously for 3 hours at  $0^\circ$  and then left to stand at  $-18^\circ$ . When the formation of the dianion was completed, the mixture was cooled to  $-70^\circ$ , and quenched carefully with a mixture of air and argon. The solvent was removed under reduced pressure. Water and dilute acid were added and the organic material extracted with benzene and chromatographed on silica gel, using hexane and mixtures of benzene and ether as eluent.

Acknowledgements.

This study was supported by the U.S.-Israel Binational Science Foundation (BSF) (Grant No. 89-00019), and by the Israel Science Foundation administered by the Israel Academy of Sciences and Humanities (Grant No. 378/89).

## REFERENCES AND NOTES

- [1] See *e.g.* Polycyclic Aromatic Hydrocarbons: Chemistry and Carcinogenicity, R. G. Harvey, ed, Cambridge University Press, Cambridge, U.K., 1991.
- [2] See *e.g.* M. Roll, S. Shtelzer, A.-A. Stark and J. Blum, *Mutagenesis*, **5**, 25 (1990) and references cited therein.
- [3] J. Booth, A. Hewer, R. G. Keysell and P. Sims, *Xenobiotica*, **5**, 197 (1975).
- [4] N. Miyata, T. Santa and M. Hirobe, *Chem. Pharm. Bull.*, **32**, 377 (1984).
- [5] G. W. Griffin, K. Ishikawa and S. K. Satra, *J. Heterocyclic Chem.*, **13**, 1369 (1976).
- [6] J. Blum, J. Yona, S. Tsaroom and Y. Sasson, *J. Org. Chem.*, **44**, 4138 (1979).
- [7] K. N. Gurudutt and B. Ravindranath, *Tetrahedron Letters*, **21**, 1173 (1980).
- [8] See A. Minsky and M. Rabinovitz, *J. Am. Chem. Soc.*, **106**, 6755 (1984).
- [9] A detailed account on the conversion of polycyclic aromatic hydrocarbons into dianions under our experimental conditions will be reported in a separate paper.
- [10] M. S. Newman and S. Blum, *J. Am. Chem. Soc.*, **86**, 5598 (1964).
- [11] S. Shtelzer, M. Weitzber, J. Jeries, T. Sheradsky, Z. Aizenshtat and J. Blum, *J. Heterocyclic Chem.*, **21**, 1 (1984).
- [12] E. Abu-Shqara, S. Elg'amal and J. Blum, *J. Heterocyclic Chem.*, **27**, 1681 (1990).
- [13] E. Boyland and P. Sims, *Biochem. J.*, **97**, 7 (1965).