of synthesis of the polyamines are different, spermine probably being synthesized in the subcellular particles, which have been shown to be altered by ethionine treatment.[13] It may be mentioned that carbon tetrachloride treatment also results in an increase in spermidine and a decrease in spermine (unpublished observations). Further, spermine synthesis, unlike that of spermidine, has not been successful in particle-free microbial preparations.[14]

Little is known of the fate of the polyamines in the animal organism at present. Large doses of ethionine (Table 1) caused a fall of about 30 % in spermidine within 24 h and about 50 % in spermine within 3 days, calculated per organ. Provided that this is also valid in intact animals, these values reflect the turnover rate of the polyamines in the rat liver.

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Oxidation of Heterocyclic Tertiary Bases by Quinones

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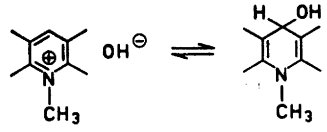
The present work is an extension of an earlier investigation[1] concerning the reaction between *p*-benzoquinone and pyridine in an alkaline medium in the presence of dimethyl sulphate. In that paper it was suggested that this reaction could possibly be used for the oxidation of analogues of pyridine as well. The present work has been carried out in order to test this possibility.

In the previous work, *p*-benzoquinone and dimethyl sulphate were allowed to react with N-methylpyridinium methosulphate in alkaline methanol solution. In the present experiments the steps of the reaction took place separately in the following manner: (1) reaction between the tertiary heterocyclic base and dimethyl sulphate, (2) decomposition of excess dimethyl sulphate and neutralization of the resultant solution with aqueous potassium hydroxide, (3) reaction between *p*-benzoquinone and the quaternary N-methyl hydroxide * under basic conditions. Thus, the reaction product formed from *p*-benzoquinone was not hydroquinone dimethyl ether, but hydroquinone itself. This compound is not so easily isolated from the reaction mixture as its dimethyl ether, nor is it as stable in alkaline solution. However, as the chief aim was to isolate the oxidation products formed from the heterocyclic bases and as the yields appeared to be better, the reactions were carried out in the way described above.

The following compounds gave positive results: quinoline, isoquinoline, acridine,

* Probably better expressed, especially with higher pyridine analogues, as its isomeric equilibrium form, a N-methyl-dihydro-hydroxy compound or so-called pseudo-base:[13,14]



phenanthridine, benzo[f]quinoline and benzo[h]quinoline. Dibenz[ah]acridine and dibenz[ch]acridine failed to react under these conditions in the expected way. The oxidation products obtained were identified as the corresponding N-methylquinolones, -acridones, etc., by mixed m.p. determination and comparison of U.V. and I.R. spectra with authentic samples prepared by Decker oxidation[3] of the same heterocyclic bases.

In the earlier experiments[1] the methylated oxidation product of pyridine, N-methyl-2-pyridone, could be isolated only when separately formed N-methylpyridinium hydroxide was allowed to react with *p*-benzoquinone. In the present work the respective methylated oxidation products of the bases mentioned above could also be isolated, although in lower yields, when the reaction was carried out in the same way as previously.[1] Thus proof is provided for the validity of the original proposal made by Gripenberg[2] that the reaction is analogous to Decker oxidation[3] of N-alkylpyridinium hydroxide and higher analogues to N-alkyl-2-pyridone, -quinolones, etc., with potassium ferricyanide.

High-potential chloranil (with ethanol or ethylene chlorohydrin as solvent), 4,4′-diphenoquinone and 3,3′,5,5′-tetramethoxy-4,4′-diphenoquinone (with ethanol or acetone as solvent), and 2,5-diphenyl-*p*-benzoquinone were substituted for *p*-benzoquinone in some of the experiments. Of these compounds, the first, second, and third were either too sparingly soluble to react at all, or formed only tarry products. 2,5-Diphenyl-*p*-benzoquinone gave no better results under these conditions than *p*-benzoquinone. Tarry or resinous by-products hampering the isolation and purification of the reaction products were formed in the experiments with *p*-benzoquinone, too.

Although it is thus possible to oxidize a number of heterocyclic bases to the corresponding N-methylpyridone analogues with benzoquinone, the method does not appear to have any advantage over Decker oxidation as regards yields and ease of manipulation.

Experimental. U.V. spectra were measured in ethanol solution with a Beckman DK-2 spectrophotometer, and I.R. spectra with a Beckman IR-5 spectrophotometer (potassium bromide disc method). All melting points are uncorrected.

Quinoline (1.29 g; 10 mmole) was added to 5 ml of dimethyl sulphate, and the solution kept at water-bath temperature for 30 min. The mixture was then cooled to *ca.* 50°, and potassium hydroxide (2.95 g in 100 ml of water) added. After the disappearence of the two layers the mixture was neutralized with 0.5 N potassium hydroxide solution and placed on an ice-bath. *p*-Benzoquinone (1.08 g; 10 mmole) and then gradually aqueous potassium hydroxide (0.5 g in 100 ml of water) were added to the stirred mixture which was then allowed to reach room temperature. The mixture was then extracted with ether (3 × 100 ml), the extracts combined and dried (sodium sulphate) and the ether evaporated. Recrystallization from petroleum ether gave N-methyl-2-quinolone (0.56 g; 35 %), m.p. 72° (lit.[4] m.p. 74°), U. V. spectrum,[5] I.R. spectrum: 3058 m, 1657 s, 1587 s, 1570 m, 1497 w, 1449 m, 1442 m, 1400 m, 1332 m, 1315 m, 1267 m, 1225 m, 1175 w, 1163 w, 1138 m, 1122 m, 1058 w, 1036 w, 1008 w, 963 w, 941 m, 922 w, 864 m, 851 w, 841 m, 826 w, 763 w, 748 s, 739 m, 687 m cm^{-1}. Hydroquinone (0.32 g; 29 %) was obtained from the aqueous solution after acidification (dilute sulphuric acid), extraction with ether (2 × 100 ml), drying (sodium sulphate) and removal of the ether. Hydroquinone was identified by its m.p. and U.V. spectrum.

N-Methyl-1-isoquinolone (0.39 g; 24.5 %) was prepared in the same way, m.p. 55° (lit.:[6] 55.5–56°), U.V. spectrum,[6] I.R. spectrum: 3086 m, 1653 s, 1629 s, 1605 s, 1558 m, 1493 m, 1452 m, 1433 m, 1404 m, 1376 w, 1351 s, 1316 m, 1299 m, 1258 m, 1220 w, 1193 m, 1151 m, 1099 m, 1058 m, 1022 m, 952 m, 690 s cm^{-1}; the yield of hydroquinone was 0.20 g (18 %).

N-Methylacridone, N-methylphenanthridone and N-methylbenzoquinolones were prepared in the same way, with the exception that the bases were refluxed in excess dimethyl sulphate for 15 min. The final products were recrystallized from dilute ethanol.

Acridine (1.79 g; 10 mmole) gave N-methylacridone (1.31 g; 63 %), m.p. 202° (lit.:[7] m.p. 202°), U.V. spectrum,[8] I.R. spectrum: 3012 w, 1639 s, 1608 s, 1511 s, 1497 s, 1468 s, 1447 m, 1374 s, 1347 m, 1325 w, 1297 s, 1274 s, 1236 w, 1186 s, 1174 m, 1135 m, 1105 w, 1052 m, 1041 m, 963 w, 941 s, 877 w, 866 m, 862 m, 803 m, 787 w, 755 s, 671 s, 644 m cm^{-1}; the yield of hydroquinone was 0.39 g (35 %).

Phenanthridine (1.79 g; 10 mmole) gave N-methylphenanthridone (1.59 g; 76 %), m.p. 107–8° (lit.:[9] m.p. 108.5° corr.), U.V. spectrum,[10] I.R. spectrum: 3077 m, 1658 s, 1616 s, 1595 s, 1575 m, 1538 w, 1515 m, 1495 m,

1452 m, 1447 s, 1428 m, 1376 w, 1355 s, 1342 s, 1325 m, 1295 m, 1239 w, 1214 w, 1192 w, 1161 w, 1139 m, 1107 m, 1059 w, 1043 m, 1006 m, 972 w, 956 w, 940 w, 877 w, 869 m, 853 m, 776 w, 743 s, 720 s, 682 m, 649 m cm^{-1}; the yield of hydroquinone was 0.42 g (38 %).

Benzo[f]quinoline (1.79 g; 10 mmole) gave N-methylbenzo[f]quinolone (1.16 g; 55 %), m.p. 182° (lit.:[11] m.p. 183°), U.V. spectrum: λ_{max} (log ε) 243 (4.89), 250 s (4.46), 272 (4.01), 287 (4.04), 298 (4.11), 311 (4.01), 338 (3.72), 346 (3.80); I.R. spectrum: 3058 w, 1661 s, 1626 m, 1582 m, 1563 m, 1504 m, 1473 m, 1451 m, 1433 w, 1416 m, 1391 w, 1342 m, 1281 m, 1233 m, 1206 m, 1169 m, 1130 w, 1111 m, 1057 w, 1026 w, 957 m, 863 w, 851 m, 809 s, 790 w, 782 m, 751 s, 727 w, 687 w, 654 w cm^{-1}; the yield of hydroquinone was 0.34 g (31 %).

Benzo[h]quinoline (1.79 g; 10 mmole) gave N-methylbenzo[h]quinolone (0.98 g; 47 %), m.p. 174° (lit.:[12] m.p. 178°), U.V. spectrum: λ_{max} (log ε) 219 (4.31), 233 (4.54), 270 (4.45), 281 (4.48), 307 (3.60), 346 (3.43); I.R. spectrum: 3077 w, 1653 s, 1613 s, 1600 s, 1553 m, 1504 m, 1471 m, 1439 w, 1427 m, 1406, 1389 w, 1366 w, 1337 w, 1302 w, 1266 m, 1220 w, 1169 w, 1151 m, 1130 m, 1117 m, 1044 w, 1028 m, 990 w, 979 m, 962 w, 905 w, 870 m, 839 s, 809 m, 786 w, 769 m, 763 s, 749 m, 719 w, 697 m, 662 w, 653 m cm^{-1}; the yield of hydroquinone was 0.31 g (28 %).

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