conducted without additional heating, in a stoppered and shielded Pyrex pressure-vessel, by shaking on a Parr apparatus. Both mono- and dialkylations were accomplished within 4 to 8 hr. The results of the influence of several solvent systems and bases on the alkylation reaction are tabulated.

Many 2,2-disubstituted cyanoacetamides prepared by the above method were converted to *N*-alkyl-2,2-dialkylcyanoacetamides by a method similar to that of Galat and Elion (10) for the acylation of amine by amide. While this method was effective for *N*-alkyl derivatives, it failed for *N*-dialkyl products when using secondary amine salts. Recourse to acylation of amine by ester, using appropriate aliphatic secondary amine (or in the instances of cyclic derivatives, pyrrolidine, piperidine, and morpholine), provided the desired amides which were subsequently alkylated at C-2.

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Lawsone Derivatives III

Cyclizations Involving Side Chains

By H. MACHATZKE, W. R. VAUGHAN*, CHARLOTTE L. WARREN, and G. R. WHITE

In continuing efforts to prepare a stable 3-ω-bis-β-chloroethyl aminoalkyl-2-hydroxy-1,4-naphthoquinone the preparation and reactions of several ω-substituted alkyllawsones have been examined. The ultimate objective of the research was not achieved as a consequence of unexpectedly facile cyclizations, either of the 3-side chain to the lawsone nucleus or by macrocyclic dimerization. The nature of these cyclizations is discussed, and the structures of the cyclic products are delineated.

THE OBJECTIVES of this continuing research have been discussed in a previous paper (1), and it should be noted in this respect that lawsone derivatives have for a considerable number of years been of interest as potential chemotherapeutic agents, particularly as antimalarials (2–4) and as antitumor compounds (1).

The purpose of the present paper is to report reactions which interfere with the preparation of 3-ω-bis-2′-hydroxyethylaminoalkyl-2-hydroxy-1,4-naphthoquinones. Two types of interfering cyclizations were encountered: (*a*) a previously recognized one in which a 3-ω-chloroalkyl-side chain closes to the 2- or 4-oxygen of 2-hydroxy-1,4-naphthoquinone (lawsone), and (*b*) an unexpected dimerization of a 3-ω-carboxyalkyllawsone to a macrolactide.

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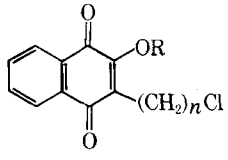
DISCUSSION

Four 3-ω-chloroalkyllawsones were investigated (I) as alkylating agents for bis-β-hydroxyethylamine (diethanolamine). And in each case the reaction desired was simple alkylation of diethanolamine, but in none was this achieved. In the case of I*a* simple cyclization to the 2-hydroxyl, as reported by Moser (4), was observed. But a mixture of II and the isomeric III (8, 9-benzo-7, 10-dioxo-2-oxabicyclo-[4.4.0]deca-1[6], 8[9]-diene and 9,10-benzo-7, 8-dioxo-2-oxabicyclo[4.4.0]-deca-1[6], 9[10]-diene, respectively) was shown to be present. The structure of III is assigned on the basis of its infrared spectrum, microanalysis, and acid isomerization[1] (5) to II. The formation of III in about 10% yield was demonstrated by comparision of the infrared spectrum of the product with spectra of pure II and pure III. And when I*b* was used in place of I*a*, the yield of III increased to about 40% at the expense of II. But when I*c* was used in place of I*a* with diethanolamine a considerably more complex reaction was encountered, with production of III accounting for but 14% of the initial I*c*, and the only other readily characterizable product (IV) being the result of 1,4-addition of diethanolamine to lawsone with reduction. Scheme I represents a rationale for the

[1] *Cf.* conversion of β-lapachone to α-lapachone.

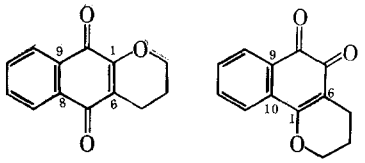
formation of the two isolated products, III and IV. The structure assigned to IV is inferred from its infrared spectrum, which shows no quinone absorption but which has a broad hydroxyl band, which in turn is confirmed as an alcohol function by preparation of a 1-napthylurethan.

It is noteworthy that a cyclization of I*c* can occur, apparently without the intervention of a base other than a hydroxylic solvent. For when an attempt was made to alkylate bis-β-hydroxyethylsulfide with I*c* by heating at reflux temperature for 10 days in 80% ethanol, a mixture was obtained which was identified as consisting of 78% III (isolation, infrared spectrum, and melting point) and about 20% II. The authors suggest the reactions outlined in Scheme II account for this phenomenon.



a, $n = 3$, R = H
b, $n = 3$, R = $COCH_3$
c, $n = 3$, R = OCH_3
d, $n = 4$, R = H

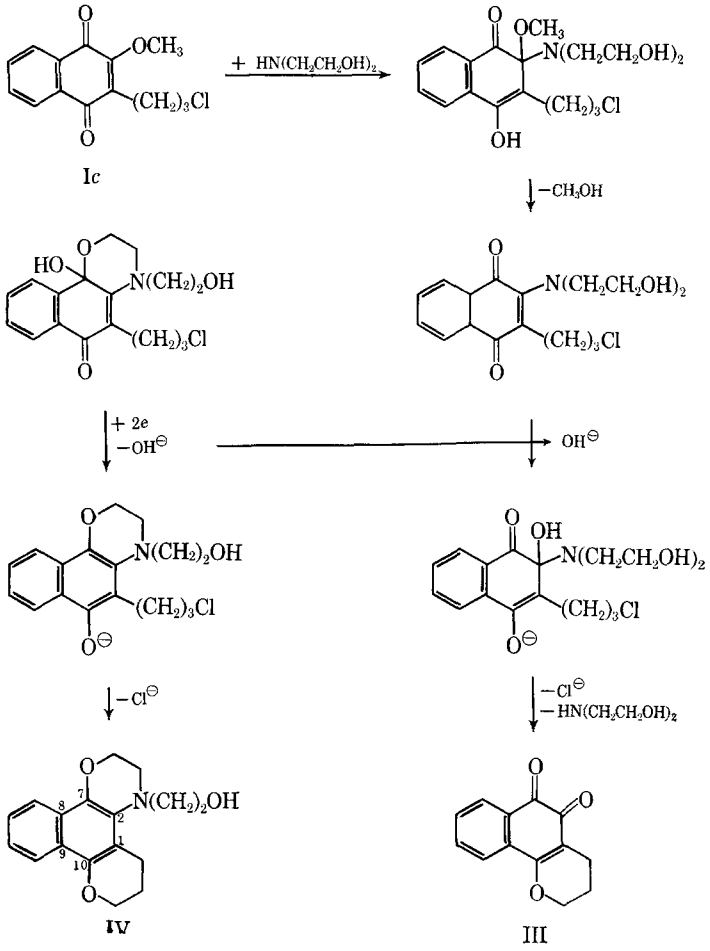
I



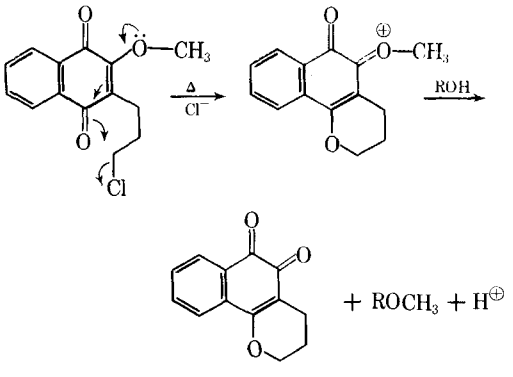
II III

The conversion of III to II in the presence of an acid catalyst is an established type of reaction (*cf.* identification of III under *Experimental*). It should be noted that the production of III in the reaction of I*c* with diethanolamine, as suggested in Scheme I may in fact be the result of minor competition of the reactions of Scheme II with the conjugate addition-reduction leading to IV.

Although Fieser (6) has reported that 3-(10-bromodecyl)-2-hydroxy-1,4-naphthoquinone may be converted quantitatively to a tertiary amine by treatment with diethylamine, no characterizable product could be isolated from the reaction between I*d* and diethanolamine. Presumably reactions analogous



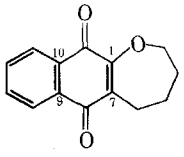
Scheme I



III

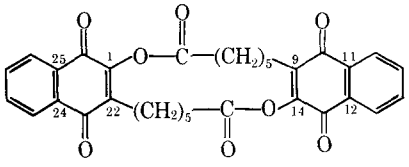
Scheme II

to those proposed in Scheme I occurred, complicated by the fact that competition between cyclizations and dimerizations is to be expected, since intramolecular cyclization would lead to seven-membered rings. That the suggested intramolecular cyclization to a seven-membered ring is not impossible is to be seen in the results of an attempt to convert *Id* to the corresponding iodide by treatment of its sodium salt with sodium iodide in aqueous solution. The only characterizable product, V (9,10-benzo-8,11-dioxo-2-oxabicyclo[5.4.0]undeca-$1^{7},9^{10}$-diene), exhibits an infrared spectrum similar to that of II.



V

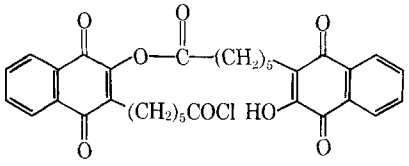
While precedent for the foregoing cyclizations was at hand, the behavior of 6-(2-hydroxy-1,4-naphthoquinon-3-yl)hexanoic acid (VI)(1) with thionyl chloride is entirely unprecedented. In initial experiments involving these two reagents there separated from the mixture a compound, VII, which analyzed for $C_{32}H_{28}O_8$. And acetylated VI (VIII) (1) also reacted with thionyl chloride to produce VII. The analysis and molecular weight of VII leave no doubt that it is the consequence of a dimeric condensation, and the infrared spectrum of VII exhibits absorptions characteristic of the 1,4-napthoquinone system as well as of a vinyl ester. Consequently, it seems most reasonable to describe VII as 11,12,24,25-dibenzo-2,15-dioxa-3,10,13,16,23,26-hexaoxotricyclo-[20,4,$0^{9,14}$]hexaeicosa-$1^{22},9^{14},11^{12},24^{26}$-tetraene (the lactide of VI).



VII

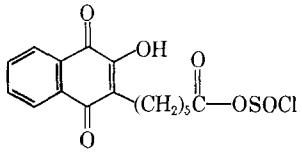
Subsequent attempts to duplicate the original experiments with both VI and VIII led to inconsistent results, and consequently a careful investigation of reaction conditions was undertaken. Of paramount importance in arriving at reproducible results was the observation that VI may be obtained in different forms which depend upon the solvent used for recrystallization: thus, one of these melts at 113° when recrystallized from benzene, another melts at 94° when recrystallized once from aqueous methanol and at 112° upon further recrystallization from the same solvent. Furthermore, the lactide (VII) apparently exists also in different crystal forms: m.p. 240° from benzene–petroleum ether (b.p. 40–60°), and m.p. 210° from benzene (which affords a nearly white product possessing the same infrared spectrum as the higher melting form, but nevertheless giving a mixed melting point with the latter of 224°). The details of this study appear in Table I.

The isolation of two compounds, the acid chloride (X) of the dimeric half ester, and what appears to be



X

the chlorosulfite of VI (XI),



XI

is to be noted (Table I and *Experimental*), but neither substance could be obtained sufficiently pure for microanalysis.

Attempts to convert VII, IX, X, and XI to the bis-β-hydroxyethylamide by reaction with diethanolamine were for the most part unsuccessful and will be reported in a subsequent paper. But by contrast, the simple amide of VI (XII) was readily obtained by refluxing VI with thionyl chloride and pouring the crude product (IX) into excess concentrated aqueous ammonia. The resultant mixture is deep blue and becomes red upon acidification. The anilide (XIII) of VI was also prepared from IX.

The preparation of VIII is readily achieved by treating VII with acetic anhydride–boron trifluoride etherate (1) and VIII may be converted to its acid chloride (albeit not in sufficient purity for analysis) by refluxing VIII with thionyl chloride using high dilution in chloroform. The identity of the product (XIV) as the acid chloride is inferred by examination of its infrared spectrum.

From the data presented here the sequence of reactions leading to production of VII may be inferred to be as follows:

$$\text{VI} + \text{SOCl}_2 \xrightarrow{(a)} \text{XI} \xrightarrow{(b)} \text{IX} \xrightarrow{(c)} \text{X} \xrightarrow{(d)} \text{VII}$$

TABLE I.—REACTIONS OF VI WITH THIONYL CHLORIDE[a]

Acid			Thionyl Chloride		Product				
mmole	M.p., °C.	Recryst. Solvn.	ml.	mmole	Compd.	Yield, %	Color	Solvn.	M.p., °C.
1	113	C_6H_6	1.44	20	VII	45	Yellow	A[b]	233–240
1	113	C_6H_6[c]	1.44	20[d]	VII	61	Yellow	A[b]	242–249
3.47	94	aq. MeOH	5.0	79.4[d]	IX	86	Yellow	...	Oil[e,f]
2.6	112	aq. MeOH	6.0	95.3[d]	X				Oil[g]
3.0	112	aq. MeOH	6.0	95.3[d]	X	92			Oil[h]
1.7	104	CH_3NO_2	5.0	79.4	VII	87	White	C_6H_6[i]	200[j]
1.0	113[k]	C_6H_6	1.44	20[l]	?[m]				

[a] General conditions: reagents mixed and refluxed 40 min.; evaporated *in vacuo;* benzene added and distilled off. [b] A, benzene–petroleum ether (b.p. 40–60°). [c] If analytically pure, refluxing with thionyl chloride for 40 min. affords about 60% VII, m.p. 240°. [d] Freshly distilled thionyl chloride. Careful purification of the reagent in the usual manner did not change results from those obtained using redistilled commercial product. [e] Anilide (XIV) prepared. (See under *Experimental.*) [f] Chief contaminant is X (infrared spectrum and chemical behavior). [g] Infrared spectrum similar to that of IX but contains additional bands at 1770 cm.$^{-1}$ (v.s.) and 3080 cm.$^{-1}$ (W). [h] Infrared spectrum same as for X but appears to lack band at 686 cm.$^{-1}$. [i] Washed with petroleum ether. [j] Infrared spectrum identical to that of VII but mixed m.p. 224°. [k] Under "high dilution" conditions in refluxing chloroform the product appears to be XI (infrared spectrum and chemical behavior). [l] VI dissolved in 100 ml. benzene and mixture refluxed 90 min. [m] Infrared spectrum of product suggests no reaction occurred, but product "tacky."

Two of the steps in this reaction sequence (*c*) and (*d*) involve acylation of the hydroxyl group of lawsone by an acyl chloride produced *in situ* by the action of thionyl chloride upon an acid. This, of course, is not the usual manner of acylating either an alcohol or enol, and consequently it seemed desirable to obtain evidence that such a process is indeed a reasonable one, and to this end the reactions of lawsone with acetic acid and thionyl chloride were investigated.

When equivalent amounts of acetic acid and lawsone are mixed and refluxed with thionyl chloride, the product consists principally of 2-chloro-1,4-naphthoquinone. But if excess acetic acid is used and the reaction with thionyl chloride is maintained at ice-bath temperature for 3 hr. and then refluxed for 1 hr., a 67% yield of 2-acetoxy-1,4-naphthoquinone is readily obtained. Thus, it is possible to bring about the kind of reaction implied by the dimerization (*c*) and the cyclization (*d*). However, the reason why it appears to be possible to halt the reaction series at IX when the lower melting form of VI is used remains obscure. Likewise the reproducible formation of the two different crystal forms of VII from samples of VI differing in purity also remains obscure.

The bimolecular dehydration of lawsone to di-1,4-naphthoquinon-2-yl ether by dicyclohexylcarbodiimide is an interesting extension of the use of this latter reagent.

EXPERIMENTAL[2]

2-Acetoxy-3-(3′-chloropropyl)-1,4-naphthoquinone (Ib).—To a suspension of 1.0 Gm. of 2-hydroxy-3-(3′-chloropropyl)-1,4-naphthoquinone (*Ia*) (4) in 5 ml. of acetic anhydride was added 1 ml. of boron trifluoride-etherate, and after 20 min. at room temperature, the mixture was poured into water, whereupon yellow crystals separated. The product was recrystallized from aqueous methanol: 1.13 Gm. (95%), m.p. 98–99°.

[2] Melting points uncorrected. Kofler block method indicated by superscript *k* where used. Microanalyses by Spang Microanalytical Laboratory, Ann Arbor, Mich. Infrared spectra of Nujol mulls obtained with Perkin-Elmer model 21 double beam spectrophotometer. The authors are indebted to Mr. B. E. Wenzel and Mr. Gunter Schütze for preparation of certain of these spectra.

Anal.—Calcd. for $C_{15}H_{13}ClO_4$: C, 63.5; H, 4.95; Cl, 12.1. Found: C, 63.72; H, 4.91; Cl, 12.21.

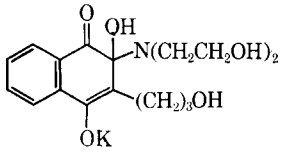
Reaction of 3-(3′-Chloropropyl)-2-hydroxy-1,4-naphthoquinone (Ia) (4) with Diethanolamine.—A solution of 1.0 Gm. of *Ia* (0.004 mole) and 0.42 Gm. of diethanolamine (0.004 mole) in 100 ml. of absolute ethanol was refluxed for 3 hr., during which time the color of the solution changed from red to yellow. Upon cooling and filtering, there was deposited 0.750 Gm. of yellow crystals, m.p. 215–216°, which were identified by mixed melting point as 8,9-benzo-7,10-dioxo-2-oxabicyclo[4.4.0]deca-1^6,8^9-diene (II). [Reported m.p. 220–221°(4).]

Evaporation of the red filtrate to about 5 ml., followed by cooling, afforded orange crystals (0.15 Gm., m.p. range > 15°). This material subsequently was shown by identity of infrared spectra to be identical with 9,10-benzo-7,8-dioxo-2-oxabicyclo[4.4.0]deca-1^6, 9^{10}diene (III) produced in the following experiment.

Reaction of 3-(3′-Chloropropyl)-2-methoxy-1,4-naphthoquinone (Ic) (1) with Diethanolamine.—A solution of 2.65 Gm. of *Ic* (10 mmoles) and 1.05 Gm. of diethanolamine (10 mmoles) in 100 ml. of absolute ethanol containing 1.40 Gm. (10 mmoles) of potassium carbonate was refluxed for 20 hr. The solution was then filtered and concentrated *in vacuo,* the residual oil being dissolved in 5 ml. of absolute ethanol. Addition of dry ether precipitated 1.5 Gm. of a brown crystalline product, m.p. 150° dec.

Anal.—Calcd. for $C_{17}H_{22}KNO_6$: C, 54.4; H, 5.90; K, 10.4; N, 3.73. Found: C, 55.8; H, 5.24; K, 12.1; N, 2.98.

This corresponds approximately to the following possible product (*cf.* Scheme I):



The filtrate from the preceding dilution was evaporated to an oil which was diluted with hydrochloric acid and extracted with ether, which upon concentration afforded orange-red crystals which were recrystallized from absolute ethanol: 0.3 Gm.

(14 %), m.p. 181–182°. The infrared spectrum is the same as that for III isolated above.

Anal.—Calcd. for $C_{13}H_{10}O_3$: C, 72.89; H, 4.71. Found: C, 72.72; H, 4.91.

Upon heating with concentrated hydrochloric acid for 0.5 hr. (5)[1] this substance was converted into II, as shown by mixed melting point (215–216°) and comparison of infrared spectra.

The acidic aqueous filtrate from the preceding isolation of III was neutralized with sodium hydroxide and the mixture then was extracted with ether from which separated a dark oil. This subsequently solidified and was then recrystallized from absolute ethanol: 0.3 Gm. (14 %), m.p. 128–129°, of 3-aza-8,9-benzo-6,11-dioxatricyclo-[8.4.$0^{2,7}$] tetradeca-1^{10}, 2^7, 8^9-triene (IV).

Anal.—Calcd. for $C_{17}H_{19}NO_3$: C, 71.60; H, 6.70; N, 4.91. Found: C, 71.40; H, 6.61; N, 4.82.

Infrared spectrum shows no carbonyl absorption but a broad band in the 3000 cm.$^{-1}$ region. The product upon reaction with 1-napthylisocyanate affords a urethan, m.p. 140–141°.

Anal.—Calcd. for $C_{28}H_{26}N_2O_4$: C, 74.00; H. 5.78; N, 6.18. Found: C, 74.04; H. 5.82; N, 6.45.

Reaction of 3-(4′-Chlorobutyl)-2-hydroxy-1,4-naphthoquinone (Id) (4) with Sodium Iodide–Sodium Carbonate.—A solution of 3.0 Gm. of Id (11.5 mmoles) and 2.0 Gm. of sodium iodide (13 mmoles) in 100 ml. of acetone containing 2.0 Gm. (20 mmoles) of sodium carbonate was refluxed for 20 hr. and then filtered. The filtrate was evaporated *in vacuo* and the residue dissolved in 10 ml. of methanol. Dilution of the methanol solution with 100 ml. of water and acidification with hydrochloric acid caused separation of an oil which crystallized on cooling in the refrigerator. Recrystallization from aqueous methanol afforded 2.5 Gm. of impure crystals, m.p. 64–70°, which could not be further purified by recrystallization. Trituration of this material with dilute sodium hydroxide, until the basic washings were colorless, left a yellow material which was then thrice recrystallized from aqueous methanol: 0. 5. Gm. (19%), m.p. 100–101°, mol. wt. (Rast) 212, 222 (calcd. 228), 9,10-benzo-8,11-dioxo-2-oxabicyclo[5.4.0]undeca-1^7, 9^{10}-diene (V).

Anal.—Calcd. for $C_{14}H_{12}O_3$: C, 73.70; H, 5.31. Found: C, 73.78; H, 5.41.

The infrared spectrum is characteristic of a 1,4-naphthoquinone.

6-(2-Hydroxy-1,4-naphthoquinon-3-yl)hexanoic Acid (VI).—This compound was prepared by a previously published procedure (1). It was usually recrystallized from benzene (m.p. 113°), but recrystallization from aqueous methanol (m.p. 112°) afforded a product which behaved differently with thionyl chloride, although no difference between the two was detectable upon infrared analysis. Two (presumably less pure) products (m.p. 94°) from aqueous methanol or from nitromethane (m.p. 104°) also appeared to behave in still another different manner with thionyl chloride. Consequently, it is important to note the source of VI in the succeeding experiments.

11,12,24,25-Dibenzo-2,15-dioxa-3,10,13,16,-23,26-hexaoxotricyclo[20.4.$0^{9,14}$]hexaeicosa-1^{22},9^{14},-11^{12},24^{25}-tetraene (VII) (Lactide of VI).—The following procedure is typical, and results of runs with VI of various origins are shown in Table I.

A mixture of VI (m.p. 113° from benzene) (288 mg., 1.0 mmole) and freshly distilled thionyl chloride (1.5 ml., 20 mmoles) was refluxed for 40 min., then evaporated under reduced pressure to dryness, the last traces of thionyl chloride being removed by addition and distillation of benzene. The solid residue (252 mg., 93.0%) was recrystallized from benzene–petroleum ether (b.p. 40–60°) to give 179 mg. (66%) of VII as yellow crystals, m.p. 244°. Mol. wt. calcd.: 540.5. Found (Rast): 515.

Anal.—Calcd. for $C_{32}H_{28}O_8$: C, 71.15; H, 5.23. Found: C, 71.41; H, 5.43.

Using essentially the same procedure for VIII, the acetyl ester of VI (1), VII was produced in 75% yield, m.p. 238–240°, with infrared spectrum identical to that of VII prepared from VI.

6-(2-Hydroxy-1,4-naphthoquinon-3-yl)hexanoyl Chloride (IX).—Most attempts to prepare IX from VI by treatment of the acid with thionyl chloride without resorting to high-dilution conditions afforded only VII. However, reactions which lead to IX from VI are recorded in Table I, the product never being obtained pure, but its existence being inferrable from infrared analysis and subsequent reaction. It should be noted that the α-methyl derivative of IX has been obtained from the α-methyl derivative of VI without the difficulties encountered in the present work (7).

6-{2-[6′-(2′-Hydroxy-1′,4′-naphthoquinon-3′-yl)-hexanoyl]-1,4-naphthoquinon-3-yl}hexanoyl Chloride (X).—This compound was not isolated in sufficiently pure condition for microanalysis. Its existence is inferred from its infrared spectrum which contains a very strong peak at 1770 cm.$^{-1}$ (vinyl ester carbonyl) and a band at 3080 cm.$^{-1}$ (hydroxyl). Otherwise the spectrum resembles the spectrum of IX. (See Table I.)

6-(2-Hydroxy-1,4-naphthoquinon-3-yl)hexanoyl Chlorosulfite (XI).—The preparation of XI employed conditions identical to those reported below for XIV, starting from VI, from 2.88 Gm. of which in 100 ml. of chloroform and 200 Gm. of thionyl chloride in 1 L. of chloroform, mixing requiring 72 hr. and refluxing being continued for 48 hr., there was obtained 4.04 Gm. of a brown intractable oil, whose infrared spectrum suggests XI. It afforded positive test for sulfur, supporting the spectrographic inference. The infrared spectrum shows bands at 3400 cm.$^{-1}$, 1745 cm.$^{-1}$, 1400 cm.$^{-1}$, and 1200 cm.$^{-1}$, the last two bands being characteristic of the —SO_2Cl group (8). There is no absorption characteristic of an acid chloride.

Reaction of crude XI (4.04 Gm.). with diethanolamine (10.5 Gm., tenfold excess) at 150° for 2 hr. afforded a dark blue product which was acidified with 200 ml. of concentrated hydrochloric acid, the resulting solution being continuously extracted with ether for 6 days. The ethereal extract was filtered, dried, and evaporated to give a dark red oil, paper chromatography of which (butanol–ethanol–water, 4:3:3) showed but one red band. The infrared spectrum is similar to that of the expected diethanolamide, to be reported in a subsequent paper.

6-(2-Hydroxy-1,4-naphthoquinon-3-yl)hexanamide (XII).—A mixture of 4.00 Gm., (1.38 mmoles) of VI and freshly distilled thionyl chloride (70 ml.) (*cf.* Table I, for preparation leading to IX) was refluxed for 40 min. and then concentrated under reduced pressure to an oil (IX) which was added

dropwise to an ice-cold ammonia solution (130 ml., sp. gr. 0.880) and then stirred overnight. Next 100 ml. of 5% hydrochloric acid was added, followed by addition of 1:1 hydrochloric acid until the pH was 7 (30 ml.). The yellow precipitate (3.51 Gm.) was filtered off and washed with 50 ml. of water, the filtrate being extracted with chloroform (six 25-ml. portions). Evaporation of the chloroform extracts and combination of the residue with the residual solid from filtration followed by recrystallization from toluene afforded 2.76 Gm. (69%) of XII, m.p. 154°.

Anal.—Calcd. for $C_{16}H_{17}NO_4$: C, 66.88; H, 6.11. Found: C, 66.95; H, 5.96.

6-(2-Hydroxy-1,4-naphthoquinon-3-yl)hexananilide (XIII).—A sample of crude IX (0.88 Gm., 0.29 mmole) was dissolved in 12 ml. of benzene to which was added 0.27 Gm. of aniline, the mixture being refluxed for 2 hr. After cooling, the solution was washed with water (three 4-ml. portions), with filtration after each wash, from a copious brown precipitate, which was recrystallized from ethanol–petroleum ether (b.p. 40–60°) to give 0.45 Gm. (44%) of XIII as yellow rhombs, m.p. 159–160°.

Anal.—Calcd. for $C_{22}H_{21}NO_4$: C, 72.71; H, 5.83; N, 3.86. Found: C, 72.45; H, 6.03; N, 3.89; ash, 0.29.

6-(2-Acetoxy-1,4-naphthoquinon-3-yl)hexanoyl Chloride (XIV).—A solution of 3.3 Gm. of VIII (0.01 mole) in 100 ml. of chloroform was dropped into a vigorously stirred refluxing solution of 100 Gm. of thionyl chloride in 1 L. of chloroform over an 8-hr. period. The solvent and excess thionyl chloride were then removed *in vacuo* and benzene added and distilled off. After filtration of the oily residue through sintered glass (residue 100 mg. of dark red crystals) it was dissolved in a solution of ammonia in ethanol and allowed to stand overnight. Upon removal of the solvent there remained a crystalline ester, m.p. 71–73° (reported 72–74°), whose infrared spectrum was superimposable upon that of the ethyl ester of VI (1).

The infrared spectrum of XII has bands at 1880–1800 $cm.^{-1}$, (acid chloride), 1790 $cm.^{-1}$ (vinyl acetate carbonyl), 1685–1695 $cm.^{-1}$ (quinone), 1185 $cm.^{-1}$ (phenolic acetate). No trace of the macrocyclic lactide (VII) was detectable.

Reaction of Lawsone with Acetic Acid in Thionyl Chloride.—A solution of 1.75 Gm. (0.01 mole) of lawsone, 10 ml. of thionyl chloride, and 3 ml. (0.05 mole) of acetic acid was stirred in an ice bath for 3 hr. and then reflxed for 1 hr. Volatile material was removed *in vacuo*, and residual thionyl chloride was removed by addition and distillation of benzene, and then the residue was triturated with cold methanol from which there was obtained on evaporation 0.45 Gm. of 2-chloronaphthoquinone (9) (infrared). The methanol-insoluble pale yellow residue was again treated with methanol, leaving 1.45 Gm., (67%) of 2-acetoxy-1,4-naphthoquinone, m.p. 127–129° K.). [Reported (10) 130°.] With less acetic acid only 2-chloro-1,4-naphthoquinone could be isolated.

Di-1,4-naphthoquinon-2-yl Ether.—To a solution of 1.74 Gm. (0.01 mole) of lawsone in 50 ml. of ethyl acetate and 10 ml. of acetone was added a solution of 0.95 Gm. of dicyclohexylcarbodiimide (0.005 mole) in 20 ml. of acetone. After stirring at room temperature for 2 hr., the solution was filtered, and the filtrate evaporated to dryness. The brown-orange residue was treated with dimethylformamide and filtered, leaving a greenish yellow material which was washed with water, methanol, and ether, and finally was dissolved in chloroform. Addition of ether precipitated 0.45 Gm. of green-yellow crystals, m.p. ~340° dec.

Anal.—Calcd. for $C_{20}H_{10}O_5$: C, 72.75; H, 3.06. Found: C, 72.79; H, 2.84.

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