603. *The Synthesis of Cephalin (Phosphatidylethanolamine) and Batyl, Chimyl, Glycol, and Alkyl Analogues.*

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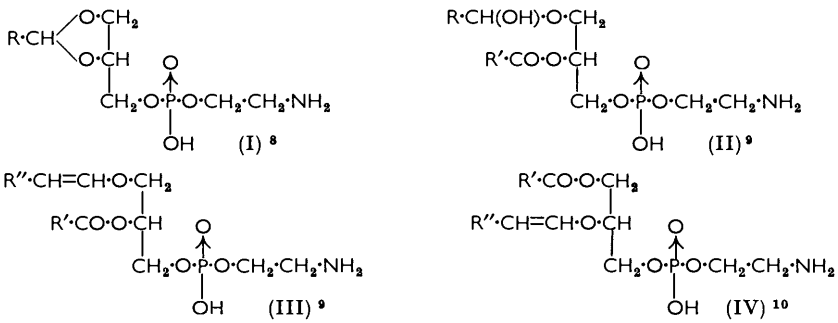
Series of cephalins and batyl, chimyl, glycol, and alkyl analogues have been prepared by the silver salt–iodide interchange method described previously. The method produces high yields and avoids the formation of undesirable by-products. The relation of the batyl and the chimyl compounds to the structure of plasmalogens is indicated.

Cephalins have been synthesised by Rose,[1] Hunter, Roberts, and Kester,[2] Bevan and Malkin,[3] and Baer, Maurukas, and Russell,[4] by the action of phosphorus oxychloride or phenyl phosphorodichloridate on diglycerides, followed by further reaction with *N*-protected ethanolamine and subsequent removal of protecting groups. The above methods invariably give rise to unwanted bisphosphatidyl compounds which are troublesome to remove, and in order to avoid both this and the use of difficultly prepared, unstable 1 : 2-diglycerides, we have used the silver salt–iodide interchange method, described previously for the preparation of phosphatidic acids [5] and phosphatidylserine.[6] Glycerol 1-iodide 2 : 3-distearate [7] was allowed to react with silver 2-(benzyloxycarbonylamino)ethyl phenyl phosphate in boiling benzene in the dark, and the protecting groups were then removed by hydrogenolysis. This synthesis is superior to any that we have previously used, and the products melt sharply, without the sintering well below the melting point reported by other workers.[1,4]

Batyl and chimyl analogues of cephalin are of interest in connection with the structure of plasmalogens, for which the following formulæ have been proposed:



R = $C_{17}H_{35}$ or $C_{15}H_{31}$
R'' = $C_{16}H_{33}$ or $C_{14}H_{29}$ } and corresponding unsaturated radicals
R' = various fatty acid radicals

Compound (I) has been isolated from a natural source in a pure state [11] and its structure has been established by synthesis,[12] but it has been suggested that it is possibly an artefact, produced during extraction from the other above types.[10,13]

[1] Rose, *J. Amer. Chem. Soc.*, 1947, **69**, 1384.
[2] Hunter, Roberts, and Kester, *ibid.*, 1948, **70**, 3244.
[3] Bevan and Malkin, *J.*, 1951, 2667.
[4] Baer, Maurukas, and Russell, *J. Amer. Chem. Soc.*, 1952, **74**, 152.
[5] Baylis, Bevan, and Malkin, *Chem. and Ind.*, 1955, 67.
[6] Bevan, Malkin, and Tiplady, *J.*, 1957, 3086.
[7] Fischer, *Ber.*, 1920, **53**, 1621; see also Bevan, Malkin, and Smith, *J.*, 1955, 1383.
[8] Feulgen and Bersen, *Z. physiol. Chem.*, 1939, **260**, 217.
[9] Klenk and Debuch, *ibid.*, 1954, **296**, 179.
[10] Rapport, Lerner, Alonzo, and Franzl, *J. Biol. Chem.*, 1957, **225**, 859.
[11] Thannhauser, Boncoddo, and Schmidt, *ibid.*, 1951, **188**, 417.
[12] Egerton and Malkin, *J.*, 1953, 2800; Malkin, Baylis, Bevan, and Webley, *Olii Grassi Colori*, 1956, **33**, 226. (Dr. Webley has now synthesised the optically active form by the Ag salt method.)
[13] Baer and Stancer, *J. Amer. Chem. Soc.*, 1953, **75**, 4510.

Compounds (II), (III), and (IV) have not so far been isolated in a pure state, but Klenk and Debuch [9] found that a reasonably pure specimen of plasmalogen on catalytic reduction with Raney nickel yielded a mixture of batyl and chimyl analogues of cephalin. We are not aware of any evidence concerning the catalytic reduction of hemiacetals of type (II), but there is little doubt that the substituted vinyl ethers (III) and (IV) would be reduced to the batyl (chimyl) derivatives and their isomers respectively.

We have therefore synthesised a number of batyl and chimyl analogues of cephalin for comparison with the naturally derived products. For this we employed the method described above, using acylated batyl (chimyl) iodides and xylene instead of benzene. These compounds are practically indistinguishable from the true cephalins of the same chain lengths in physical properties (solubility, m. p., *X*-ray data), and it seems to us not at all unlikely that they may occur naturally, but have hitherto escaped detection because of this remarkably close similarity. The recent isolation of a natural long-chain ether, glycerol lysophosphatide, by Carter *et al.*[14] supports this view.

Acylglycol cephalin analogues have not been prepared previously, but the corresponding glycol lecithins were synthesised by Baer,[15] who showed that they were intermediate in properties between lecithin and lysolecithin and had hæmolytic properties. We have prepared a series for general comparisons by the above silver salt method and find no unusual features. The group exhibits the expected m. p., solubility, and *X*-ray relations.

The only previous synthesis of an alkyl analogue of cephalin is due to Christensen [16] who prepared 2-aminoethylcetyl phosphate in low yield starting from ethylene chlorohydrin, phosphoryl chloride, and cetyl alcohol. The silver salt method gives high yields of these compounds, and we have prepared a series from C_{12}, C_{14}, C_{16}, and C_{18} *n*-alkyl iodides.

The solubility of the above compounds in organic solvents diminishes sharply as the number and length of the hydrocarbon chains decrease. All are white and crystalline. Alkyl and glycol cephalins, from glacial acetic acid, and batyl and chimyl cephalins, from chloroform, crystallise in characteristic spherulitic forms, previously reported for cephalins.[3]

The m. p. data given in Table 1 are of interest because of the fall in m. p. with increasing molecular weight. This unusual property is a feature of high-melting long-chain compounds, which with increasing length of chain, approach the m. p. limit for hydrocarbon chains (*ca.* 125°) [17] (cf., *e.g.*, even-membered dibasic acids and fatty acid amides).

TABLE 1. *M.p.s of cephalins and cephalin analogues.*

Carbon content of fatty acids or alkyl group	Cephalin [3]	Cephalin analogues			
		Batyl	Chimyl	Alkyl	Glycol
C_{18}	196°	195°	198°	239°	216°
C_{16}	198	197	201	242	218
C_{14}	207	200	205	245	222
C_{12}	210	203	207	249	224

X-*Ray Examination.*—This was carried out as described in earlier papers.[3,18] Long spacings of batyl and chimyl cephalins were difficult to determine, but no difficulty was experienced with the short spacings which are given (Table 2) with those of cephalin for comparison. The data are the averages of those for eight different batyl and chimyl derivatives (lauroyl, myristoyl, palmitoyl, and stearoyl) and the averages of four different cephalins.[3] No individual spacing differs from the average by more than 0·04 Å.

The above long spacings plotted against the number of carbon atoms in the acyl groups give a straight line with an intercept at C = 0 of 26 Å. The data correspond with an arrangement of double molecules lying vertically between the reflecting planes.

For alkyl cephalins (Table 4), the long spacings and the intensities of the side spacings

[14] Carter, Galanos, Gigg, Law, Teishi Nakayama, Smith, and Weber, *Fed. Proc.*, 1957, **16**, 819.
[15] Baer, *J. Amer. Chem. Soc.*, 1953, **75**, 5533.
[16] Christensen, *J. Biol. Chem.*, 1940, **135**, 399.
[17] Garner and King, *J.*, 1936, 1368.
[18] " Progress in the Chemistry of Fats," Vol. 1, p. 1, Pergamon Press Ltd., London, 1952.

show a marked discontinuity in structure between C_{14} and C_{16}. If the long spacings are plotted against the number of carbon atoms in the alkyl group, they fall on parallel lines intercepting the axes at C = 0 at **16·6** Å (C_{16}, C_{18}) and **12·4** Å (C_{12}, C_{14}). The data at

TABLE 2. *Short spacings* (Å)

Batyl and chimyl cephalins	5·91 w	4·86 w	4·14 vs	3·83 m	3·56 w
Cephalin	5·92 w	4·93 w	4·18 vs	3·86 m	3·60 w

Intensity: m = moderate; vs = very strong; w = weak.

TABLE 3. *Acylglycol cephalins.*

Carbon atoms in acyl group	Long spacing (Å)	Short spacings (Å)				
12	56·9	5·8 m	5·3 m	4·7 m	4·0 s	3·8 s
14	61·6	5·7 m	5·2 m	4·6 m	4·0 s	3·8 s
16	66·9	5·8 m	5·2 m	4·7 m	4·0 s	3·8 s
18	72·0	5·8 m	5·2 m	4·6 m	4·0 s	3·8 s

TABLE 4. *Alkyl cephalins* (*alkyl β-aminoethyl phosphates*).

Carbon atoms in alkyl group	Long spacing (Å)	Short spacings (Å)				
12	24·7	5·8 w	5·4 w	4·6 m	4·0 s	3·8 s
14	26·7	5·8 w	5·4 w	4·6 m	3·9 s	3·8 s
16	32·6	5·8 w	5·4 w	4·6 vs	4·0 s	3·9 s
18	34·7	5·8 w	5·4 w	4·6 vs	3·9 s	3·8 s

present available do not distinguish between an arrangement of single molecules tilted at angles of 55° 40′ and one of double molecules tilted at an angle of 24° 20′ across the reflecting planes.

EXPERIMENTAL

Silver 2-(Benzyloxycarbonylamino)ethyl Phenyl Phosphate.—*N*-Benzyloxycarbonylethanolamine (50·4 g.) in dry chloroform (*ca.* 300 c.c.) was added with stirring and ice-cooling to phenyl phosphorodichloridate (54·7 g.) in dry chloroform (50 c.c.) and dry quinoline (35 g.) during 8 hr. After being kept overnight at room temperature, the chloroform was removed under reduced pressure at <40°, and pyridine (20 g.) was then added, followed by water (10 c.c.) dropwise, with stirring and cooling. After 24 hr. at room temperature, water (150 c.c.) was added, followed by three equivalents of potassium carbonate (57·2 g.). The aqueous solution was extracted with ether (3 × 200 c.c.) to remove, *inter alia*, the bisphosphoryl compound and was finally taken to dryness under reduced pressure at <40°. The residue was extracted with ethanol until it no longer gave a positive nitrogen test, and on evaporation of the combined extracts (reduced pressure, <40°), there remained the potassium salt of the acid (56—57 g.) in the form of a viscous oil. This was taken up in water (50 c.c.), and the solution was made just acid to litmus with 2N-nitric acid. Silver nitrate (28 g. in 28 c.c. of water) was then added with vigorous stirring, and after storage overnight the precipitated *silver salt* was filtered off, washed successively with water and ethanol, and dried in *vacuo* over concentrated sulphuric acid for several days (yield 52 g.) (Found: Ag, 23·6. $C_{16}H_{17}O_6NPAg$ requires Ag, 23·5%).

In the following silver salt interchange reactions, it is important that the salt and all reagents be thoroughly dry.

1 : 2-*Distearoylphosphatidyl Ethanolamine.*—Glycerol 1-iodide 2 : 3-distearate (1·84 g., 0·0025 mole) in dry benzene (50 c.c.) was refluxed with the above silver salt (1·37 g., 0·003 mole) in the dark with stirring, for 3 hr. After cooling and filtration (Filtercel) the solvent was removed under reduced pressure at <40° and the residue was taken up in ether. The ethereal solution was treated with aqueous sodium hydrogen carbonate solution, to remove traces of acidic material which is usually produced in this reaction, and after being washed with water and dried the solvent was removed under reduced pressure and the residue crystallised twice from light petroleum (b. p. 40—60°). It (2 g., 83%) had m. p. 47—48° (Found: C, 68·7; H, 9·5; N, 1·5; P, 3·0. Calc. for $C_{55}H_{92}O_{10}NP$: C, 68·9; H, 9·7; N, 1·5; P, 3·2%).

Hydrogenolysis. The above distearoyl compound (0·9 g.) was hydrogenated in glacial acetic acid (30 c.c.) at 1 atm. in the presence of 1 : 1 palladium black–palladium oxide (Adams)

(1·0 g.) until hydrogen uptake ceased. After removal of excess of hydrogen, chloroform was added to dissolve precipitated product, and the catalyst was filtered off and washed with chloroform. The filtrate was evaporated to dryness under reduced pressure and final traces of impurities were removed from the residue by extraction with boiling ether (3 × 100 c.c.). Final crystallisation from ethanol gave material (0·6 g.) of m. p. 198° (Found: C, 65·6; H, 10·7; N, 2·0; P, 4·0. Calc. for $C_{41}H_{82}O_8NP$: C, 65·9; H, 11·0; N, 1·9; P, 4·2%). This compound was identical with that previously prepared.[3]

Dipalmitoyl and dimyristoyl cephalin were prepared similarly.

Batyl and Chimyl Alcohol.[19]—These were prepared by the method used by Howe and Malkin [20] for the preparation of glycerol 1-benzyl ether.

1:2-O-iso*Propylideneglycerol* 1-*octadecyl ether*. Sodium (4·4 g., 0·19 mole) was granulated under boiling xylene and 1 : 2-*O-iso*propylideneglycerol [21] (29 g., 0·22 mole) was added dropwise to the stirred, cooled mixture. After the initial reaction had subsided, the reaction was completed by refluxing and stirring. Octadecyl iodide (72·2 g., 0·19 mole) in dry xylene (150 c.c.) was then added to the gently refluxing, stirred mixture during 15 min. and heating and stirring were continued for a further 6 hr. After cooling, the precipitated sodium iodide was removed and washed with chloroform, and the solvent was removed under reduced pressure. The residual viscous oil was dissolved in ether, washed, and dried (Na_2SO_4). After removal of solvents the residue was distilled *in vacuo* (b. p. 210—215°/1 mm., m. p. 32—33°; 49·6 g., 68%) (Found: C, 74·8; H, 12·2. Calc. for $C_{24}H_{48}O_3$: C, 75·0; H, 12·5%).

Batyl alcohol. The above *iso*propylidene compound (49·6 g.) was heated on a water-bath with 10% aqueous acetic acid (425 c.c.) with frequent shaking until the original emulsion had disappeared (*ca.* 2 hr.). After cooling, ice-cold water was slowly added to the solution until precipitation was complete. The product was filtered off, through a filter with a large area, and washed with water. The product was then heated for 0·5 hr. with excess of dilute sodium hydroxide solution on a water-bath and after cooling was filtered, washed free from alkali with water, and dried in *vacuo*. On crystallising from acetone, 40·5 g. (90%) of pure batyl alcohol were obtained, having m. p. 71—72° (Found: C, 73·3; H, 12·9. Calc. for $C_{21}H_{44}O_3$: C, 73·3; H, 12·8%).

Chimyl alcohol. 1 : 2-*O-iso*Propylideneglycerol (30·3 g.), sodium (4·6 g.), and hexadecyl iodide (70·4 g.) yielded 50·7 g. (71%) of the *iso*propylideneglycerol ether, b. p. 173—178°/2 mm. (Found: C, 74·3; H, 12·1. Calc. for $C_{22}H_{44}O_3$: C, 74·2; H, 12·4%).

This (50·7 g.), on hydrolysis with 10% aqueous acetic acid, yielded 41·0 g. (91%) of chimyl alcohol, m. p. 62—63° (Found: C, 72·4; H, 12·5. Calc. for $C_{19}H_{40}O_3$: C, 72·2; H, 12·7%).

Batyl and Chimyl 1-*Iodide*.—These were prepared by the interaction of the toluene-*p*-sulphonates of the alcohols and sodium iodide in dry acetone. We had considerable difficulty in acylating the alcohols. Neither toluene-*p*-sulphonyl chloride nor the bromide reacts with the alcohols in pyridine or in a variety of solvents with pyridine * at varying temperatures, but we finally obtained the sulphonyl derivatives as follows. Potassium (2·0 g., 0·053 mole) was granulated under dry xylene (250 c.c.) at 100°, by vigorous stirring, then cooled to 40°. Batyl alcohol (18·2 g., 0·053 mole) was added in bulk with vigorous stirring and after the initial reaction had subsided the mixture was refluxed and stirred until all the potassium had reacted. The mixture was cooled to room temperature, becoming gelatinous, and toluene-*p*-sulphonyl chloride (10·1 g., 0·053 mole) was added to the stirred mixture. Reaction began at once with a slight rise in temperature which cleared the gelatinous precipitate, and shortly afterwards potassium chloride began to separate. Stirring at room temperature was continued for 3 hr. and at 60° for 30 min. The precipitated potassium salt was removed by filtration and washed with chloroform, and after removal of the solvent from the filtrate and washings, the resultant viscous oil was dissolved in pyridine (20 c.c.) and the solution was poured into ice-cold water (200 c.c.) to remove any excess of toluene-*p*-sulphonyl chloride.

The oil which separated was extracted with ether, and the solution was filtered to remove unchanged batyl alcohol and washed successively with N-hydrochloric acid, saturated sodium

* We have since found that these alcohols are acylated satisfactorily in concentrated solutions in pyridine.

[19] See Stegerhoek and Verkade, *Rec. Trav. chim.*, 1956, **75**, 143, for an alternative method of preparation.

[20] Howe and Malkin, *J.*, 1951, 2663.

[21] Malkin and Shurbagy, *J.*, 1936, 1634.

hydrogen carbonate solution, and water. After drying (Na_2SO_4) and removal of solvent under reduced pressure, there remained 13·2 g. (40%) of a viscous oil. This proved difficult to crystallise, but after its dissolution in light petroleum (b. p. 40—60°) and storage for several days 3·5 g. of *batyl toluene*-p-*sulphonate* crystallised, having m. p. 59—61°, raised to 61—62° by further crystallisation from the same solvent (Found: C, 67·8; H, 10·0. $C_{28}H_{50}O_5S$ requires C, 67·5; H, 10·0%). Evaporation of the mother-liquor and drying in *vacuo* at 40° yielded 9·5 g. of viscous oil (A). This slightly impure product could be satisfactorily carried through to the acylated batyl iodide, which lends itself better to purification.

Batyl 1-*iodide*. Batyl toluene-*p*-sulphonate (3 g.) in dry acetone (100 c.c.) containing sodium iodide (3 g.; 3 times theoretical amount) was refluxed for 24 hr. After cooling, the precipitated sodium toluene-*p*-sulphonate was filtered off, washed with acetone, and dried (1·1 g., 100%) and the filtrate and washings were evaporated to dryness under reduced pressure. The iodide was extracted from the residue with ether, and the ethereal solution was washed with 10% sodium thiosulphate solution and with water, and dried. Removal of ether under reduced pressure yielded a white solid (2·4 g., 90%), m. p. 41—43°. No suitable solvent could be found for the crystallisation of this compound. It is very soluble in methanol and ethanol, acetone, benzene, hexane, and light petroleum. Crystallisation did not occur from these during some days at 0°. Both the m. p. range and the analytical data suggest that the above product contained a little unchanged ester.

The viscous oil (A) (9·5 g.) was treated as above with sodium iodide (8·4 g.) in acetone, 3·4 g. of sodium toluene-*p*-sulphonate being precipitated (theor. 3·7 g.). Working up as above gave 7·0 g. of a viscous oil (80%).

[Added, June 23rd, 1958.] Batyl alcohol (3·44 g.) was added to a mixture of toluene-*p*-sulphonyl chloride (2·5 g.) and pyridine (5 c.c.) with shaking and slight warming until all the batyl alcohol had dissolved. Pyridine hydrochloride soon began to separate and after storage overnight water was added and the product was extracted with ether. After treatment of the ethereal solution as described previously, there remained a solid which after two crystallisations from light petroleum (b. p. 40—60°) yielded 2·8 g. of batyl toluene-*p*-sulphonate, m. p. 61—62°.

Batyl 1-*iodide* 2-*stearate*. Batyl 1-iodide (2 g., 0·0044 mole) was refluxed with stearoyl chloride (1·33 g., 0·0044 mole) in dry benzene (50 c.c.) containing dry pyridine (3 c.c.) for 6 hr. The precipitated pyridine hydrochloride was then removed and the benzene distilled off under reduced pressure. The viscous residue was dissolved in ether, and the ethereal solution was washed successively with N-hydrochloric acid, saturated sodium hydrogen carbonate solution, 10% sodium thiosulphate solution, and water, and dried (Na_2SO_4). After removal of solvent, the residue was crystallised from ethanol, and after recrystallisation the product still melted over a range of 36—41°. The impurity was found to be stearic acid, and this was removed by passing a chloroform solution of the product a few times down a column of Amberlite resin IRA-400(OH). Removal of chloroform and crystallisation from ethanol yielded colourless *diester* (2·0 g., 65%), m. p. 37—38° (Found: C, 64·8; H, 10·5. $C_{39}H_{77}O_3I$ requires C, 65·0; H, 10·7%). The above slightly impure iodide (7 g.; viscous oil) was acylated in a similar manner with stearoyl chloride (4·6 g.) to yield 6·6 g. (61·0%) of pure product, m. p. 37—38°.

Similarly batyl 1-iodide (3·6 g.) and palmitoyl chloride (2·2 g.) gave *batyl* 1-*iodide* 2-*palmitate* (3·5 g., 65%), m. p. 31—32° (Found: C, 64·0; H, 10·3. $C_{37}H_{73}O_3I$ requires C, 64·6; H, 10·55%).

Batyl 1-iodide (5·9 g.) and myristoyl chloride (3·2 g.) gave batyl 1-iodide 2-myristate (5·3 g., 61%); batyl 1-iodide (4·5 g.) and lauroyl chloride (2·2 g.) gave the 2-laurate (4 g., 63%).

The myristoyl and lauroyl compounds were liquids at room temperature and could not readily be purified by crystallisation. They were purified to some extent by two extractions with warm methanol, the latter being removed by decantation. A chloroform solution of the product was then passed down a resin column as already described.

2-*Acyl Chimyl* 1-*Iodides*.—The chimyl iodide and acyl iodides were made as described for the batyl compounds.

Chimyl 1-*toluene*-p-*sulphonate*. Chimyl alcohol (28·6 g.), potassium (3·5 g.), and toluene-*p*-sulphonyl chloride (17·1 g.) yielded 5·3 g. of crystalline *product* [from light petroleum (b. p. 40—60°)], m. p. 53—54° (Found: C, 66·6; H, 9·8. $C_{26}H_{46}O_5S$ requires C, 66·4; H, 9·8%). 20·8 g. of slightly impure product were also obtained as a viscous oil.

Chimyl 1-*iodide*. The above solid toluene-*p*-sulphonyl compound (5·0 g.) was refluxed with sodium iodide (4·8 g.) in dry acetone (150 c.c.) for 24 hr. Sodium toluene-*p*-sulphonate (2·0 g.;

theor. 2·06 g.) was precipitated. After working up as for batyl iodide, a white solid (4·2 g., 93%) was obtained (m. p. 35—37°). No suitable solvent could be found for crystallisation and analysis indicated the presence of a small amount of sulphonyl compound.

The viscous oil (20·8 g.) from the previous experiment was treated with sodium iodide (20·0 g.) as above; 7·5 g. of sodium toluene-*p*-sulphonate were precipitated (88% yield; theor. 8·6 g.). After working up as previously described, 16·2 g. (86%) of viscous oil were obtained.

Chimyl 1-iodide (4·1 g.) and stearoyl chloride (2·9 g.) gave *chimyl 1-iodide 2-stearate* (5·1 g., 77%), m. p. 32—33° (Found: C, 63·9; H, 10·4. $C_{37}H_{73}O_3I$ requires C, 64·2; H, 10·6%).

Chimyl 1-iodide (5·3 g.) and palmitoyl chloride gave *chimyl 1-iodide 2-palmitate* (5·5 g., 66%), m p. 25—26° (Found: C, 63·0; H, 10·2. $C_{35}H_{69}O_3I$ requires C, 63·3; H, 10·4%).

Chimyl 1-iodide (5·3 g.) and myristoyl chloride (3·0 g.) gave chimyl 1-iodide 2-myristate (5 6 g., 70%); chimyl 1-iodide (5·1 g.) and lauroyl chloride (2·6 g.) gave chimyl 1-iodide 2-laurate (5·4 g., 74%). The myristoyl and lauroyl compounds were liquid and were purified in a similar manner to the batyl compounds.

2-Aminoethyl 2-O-Stearoylbatyl Phosphate (Stearoyl Batyl Cephalin).—Batyl 1-iodide 2-stearate (6·7 g., 0·0093 mole) in dry xylene (30 c.c.) was added to a solution of silver 2-(benzyloxycarbonylamino)ethyl phenyl phosphate (4·6 g., 0·01 mole) in boiling xylene (200 c.c.) in the dark with vigorous stirring. Silver iodide was precipitated almost immediately, and refluxing and stirring were continued for 30 min. After cooling to room temperature, the silver salt was filtered off (Filtercel) and washed with benzene, and the filtrate was evaporated under reduced pressure at <50°. The residue was taken up in ether, treated twice with saturated sodium hydrogen carbonate solution, washed with water, and dried (Na_2SO_4). After removal of ether under reduced pressure, there remained 7·7 g. of low-melting solid. This was hydrogenolysed in glacial acetic acid (150 c.c.) and chloroform (50 c.c.) at slightly >1 atm. in the presence of 2 g. of a 1 : 1 mixture of palladium black–platinum oxide (Adams). When the uptake of hydrogen had ceased, the catalyst was removed and washed with chloroform, and the solvents were removed from the filtrate under reduced pressure at <40°. Final traces of acetic acid were removed by azeotropic evaporation with benzene. The residue was extracted three times with ether, and crystallised from chloroform–ethanol, giving the *phosphate* (2·9 g., 48%), m. p. 195° (decomp.) (Found: C, 67·0; H, 11·4; N, 2·1; P, 4·1. $C_{41}H_{84}O_7NP$ requires C, 67·1; H, 11·5; N, 1·9; P, 4·2%). The overall yield based on iodo-compound is 42%.

The remaining batyl analogues were made similarly. The *palmitoyl derivative* was crystallised from chloroform–ethanol, and the *myristoyl* and *lauroyl derivatives* from ethanol (see below). Yields were 38—41%. M. p.s are in Table 1.

Palmitoyl (Found: C, 66·2; H, 11·3; N, 2·1; P, 4·3. $C_{39}H_{80}O_7NP$ requires C, 66·4; H, 11·3; N, 2·0; P, 4·4%).

Myristoyl (Found: C, 65·5; H, 11·1; N, 2·2; P, 4·7. $C_{37}H_{76}O_7NP$ requires C, 65·6; H, 11·2; N, 2·1; P, 4·6%).

Lauroyl (Found: C, 64·6; H, 11·1; N, 2·1; P, 4·8. $C_{35}H_{72}O_7NP$ requires C, 64·7; H, 11·1; N, 2·2; P, 4·8%).

The corresponding *acyl chimyl cephalins* (see below) were made similarly except that the time of refluxing in xylene was reduced from 30 min. to 10 min. with a considerable improvement in yield (50—58%). Stearoyl and palmitoyl derivatives were crystallised from chloroform–ethanol, and myristoyl and lauroyl derivatives from ethanol. M. p.s are in Table 1.

Stearoyl (Found: C, 66·0; H, 11·4; N, 2·0; P, 4·5. $C_{39}H_{80}O_7NP$ requires C, 66·4; H, 11·3; N, 2·0; P, 4·4%).

Palmitoyl (Found: C, 65·4; H, 11·0; N, 2·0; P, 4·7. $C_{37}H_{76}O_7NP$ requires C, 65·6; H, 11·2; N, 2·1; P, 4·6%).

Myristoyl (Found: C, 64·4; H, 11·1; N, 2·3; P, 4·5. $C_{35}H_{72}O_7NP$ requires C, 64·7; H, 11·1; N, 2·3; P, 4·8%).

Lauroyl (Found: C, 63·6; H, 11·1; N, 2·3; P, 5·2. $C_{33}H_{68}O_7NP$ requires C, 63·8; N, 11·0; N, 2·3; N, 5·0%).

Glycol and alkyl cephalins (see below) were made as described for cephalins, by using 2-iodoethyl fatty esters [22] and alkyl iodides respectively. Yields were of the order of 75—85%. M. p.s are in Table 1.

Glycol cephalins: *stearoyl* (Found: C, 58·4; H, 10·3; N, 3·3; P, 6·8. $C_{22}H_{46}O_6NP$ requires C, 58·5; H, 10·2; N, 3·1; P, 6·9%); *palmitoyl* (Found: C, 56·5; H, 10·0; N, 3·3; P, 7·0.

[22] Bevan, Malkin, and Smith, *J.*, 1955, 1043.

$C_{20}H_{42}O_6NP$ requires C, 56·7; H, 10·0; N, 3·3; P, 7·3%); *myristoyl* (Found: C, 54·6; H, 9·7; N, 3·5; P, 7·9. $C_{18}H_{38}O_6NP$ requires C, 54·7; H, 9·6; N, 3·5; P, 7·9%); *lauroyl* (Found: C, 52·3; H, 9·3; N, 3·9; P, 8·2. $C_{16}H_{34}O_6NP$ requires C, 52·3; H, 9·3; N, 3·8; P, 8·4%).

2-*Aminoethyl phosphates*: *octadecyl* (Found: C, 61·2; H, 11·1; N, 3·9; P, 7·9. $C_{20}H_{44}O_4NP$ requires C, 61·1; H, 11·2; N, 3·6; P, 7·9%); hexadecyl (Found: C, 59·0; H, 11·2; N, 3·9; P, 8·5. Calc. for $C_{18}H_{40}O_4NP$: C, 59·2; H, 11·0; N, 3·8; P, 8·5%); *tetradecyl* (Found: C, 56·9; H, 10·8; N, 4·3; P, 9·4. $C_{16}H_{36}O_4NP$ requires C, 57·0; H, 10·7; N, 4·2; P, 9·2%); *dodecyl* (Found: C, 54·4; H, 10·3; N, 4·6; P, 10·0. $C_{14}H_{32}O_4NP$ requires C, 54·4; H, 10·4; N, 4·5; P, 10·0%).

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