T H E S I S .

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of

MASTER OF SCIENCE AND HONOURS

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Codeword: Braid

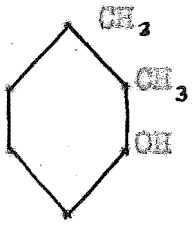
T H E S I S.

"The Chlorination of certain of the Xylenols".

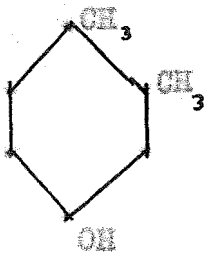
INTRODUCTION .

As is well known, phenol and its homologues and many of the substances containing phenolic (OH) groups generally, are much used as disenfectants. Recently it has been found that treatment of such a substance with gaseous chlorine in most cases greatly increases its bacteriacidal efficiency, the Rideal-Walker coefficient being definitely increased, and this is found to be so with the commercial mixture of xylenols obtained as a gas-works by-product, but to what particular compounds this is due is unknown. There is no record of any of the chloro-xylenols having been prepared by direct chlorination, though several bromo-xylenols have been made by the direct action of the reagent on the xylenol dissolved in some solvent, usually glacial acetic acid. The object of this investigation was, therefore, to study the direct chlorination of the xylenols and to isolate the mono-chloro-xylenols formed in the first stage of chlorination of certain of the xylenols, and of the commercial mixture of crude xylenols obtained in gas-works practice.

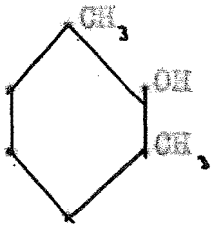
All the six possible isomeric xylenols are known, and are with one exception crystalline solids.



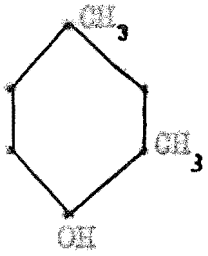
(I) Ortho-3-xylenol. A crystalline solid.m.p.75°C. b.p.218°C.(Nolting and Forel B.18 2673.)



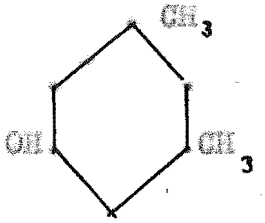
(II) Ortho-4-xylenol. A crystalline solid m.p.61-65°C b.p.225°C (Jacobsen B 17 161.) b.p. 220°C (Behal).



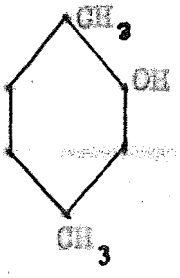
(III) Meta-2-xylenol. Solid.m.p. 47-48°C (Jacobsen B. 12 607) b.p. 203°C (Gattermann A 357 327)



(IV) Meta-4-xylenol. A refrangent colourless liquid. b.p. 211°C(Jacobsen B 11 24)

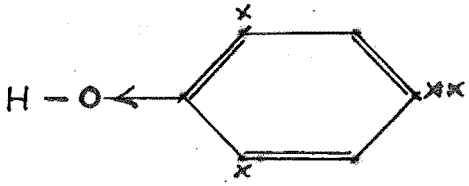


(V) Meta-5-xylenol. Solid.m.p. 64°C b.p. 219°C (Tohl B 18 362) (Noelting and Forel B 18 2679)



(VI) Para-xylenol. Crystalline solid. m.p. 74°5° C.

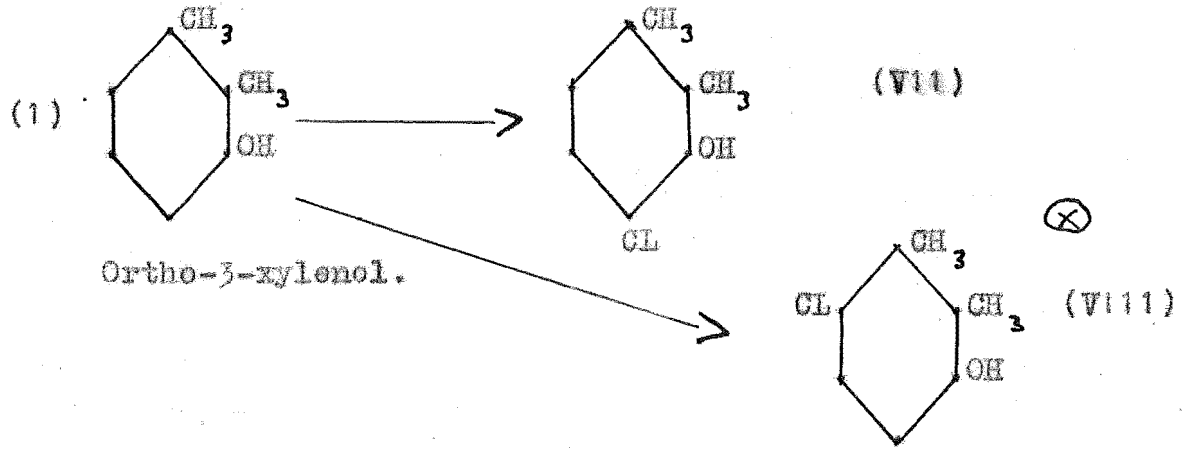
When these xylenols are chlorinated, the chlorine will, under the strongly activating o-p- direction of the phenolic (OH) group, substitute in the position o- and p- to the (OH), and compounds in which this is not so are not likely to be encountered by direct chlorination. Since the inductive effect is away from the benzene ring, and is felt most in the o- position, the ortho/para ratio for the (OH) is low. Thus the formation of the substitution products with the substituent p- to the (OH) is favoured, as the electron density is higher in the p- position.



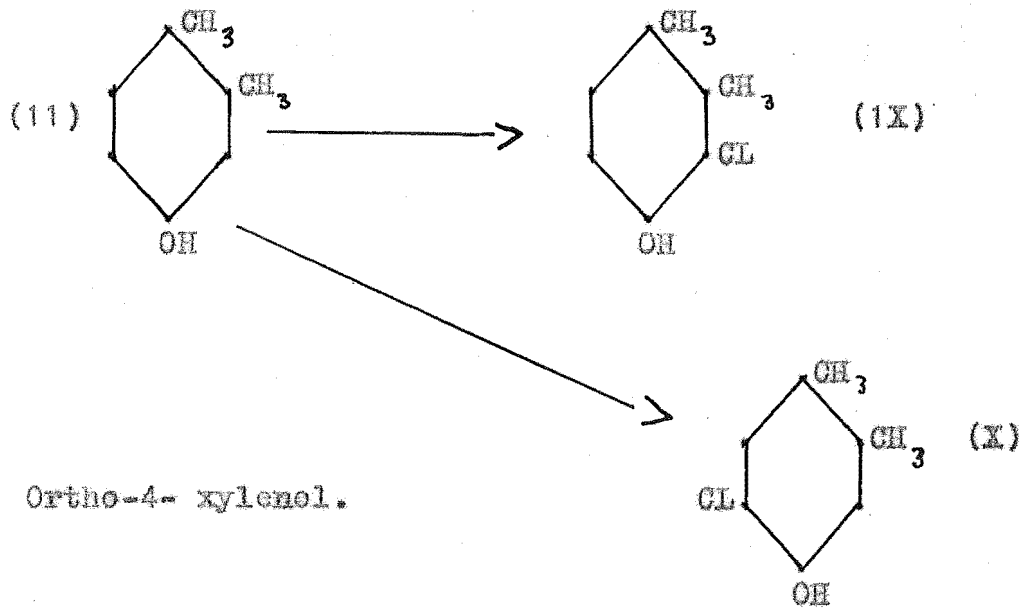
In certain cases such as meta-5-xylenol (V), the inductive effect of the two methyl groups towards the ring assists the inductive effect of the (OH) in making the electron density greater in the position p- to the (OH) and therefore tends further to favour p- rather than o- substitution.

Consequently the structural formulae of any mono-chloro-xylenols which may be encountered, will be contained among the following, which are the probable compounds to be derived from each of the xylenols.

The most likely compounds, those in which the chlorine is para to the (OH) as above, are marked with a cross.

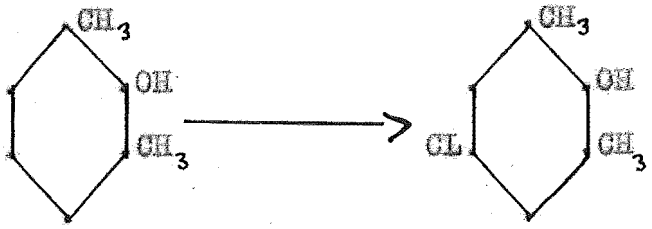


Ortho-3-xylenol.



Ortho-4- xylenol.

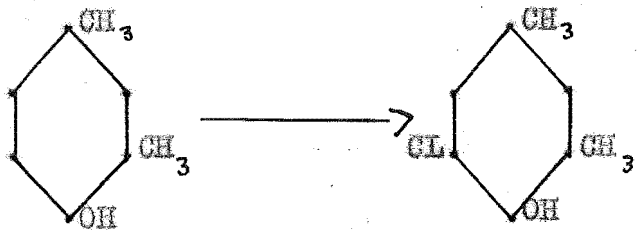
(111).



(X1).

Meta-2-xylenol.

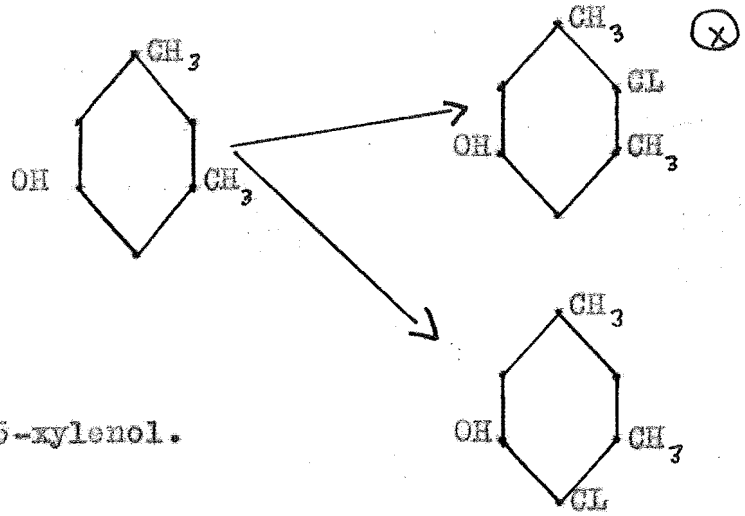
(1V).



(X11)

Meta-4-xylenol.

(V)

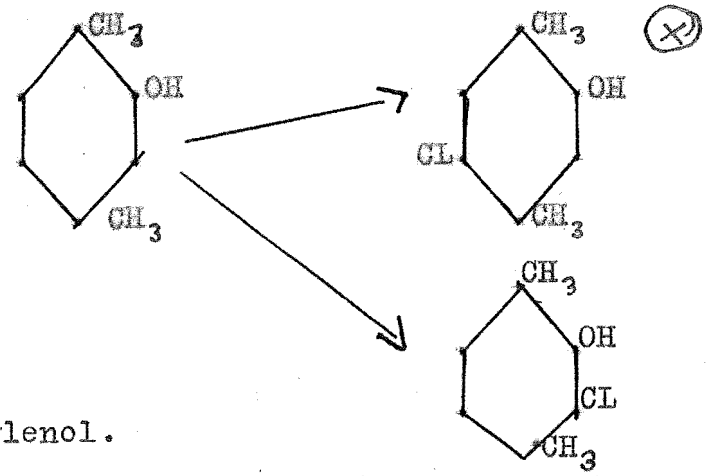


(X111).

(X1V).

Meta-5-xylenol.

(V1).



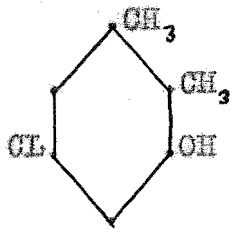
(XV)

(XV1)

Para-xylenol.

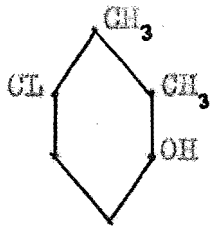
Although none of these compounds has been prepared by direct chlorination, some of them and some other chloro-xylenols have been made by other methods. The following mono-chloro-xylenols have been described by Hinkel, Collins and Ayling. J.C.S.(1923) 123 2968 and (1924) 125. 1847.
These were prepared from either the nitro-xylidines or from the amino-xylenols, the chlorine being introduced by diazotizing, followed by the Sandmeyer reaction.

(XV11)



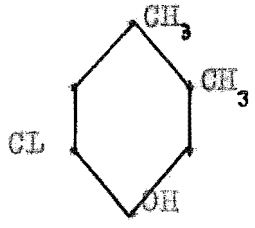
5-chloro-o-3 xylenol. m.p. 81-82°C
Fine glistening needles from petrol-ether.
Benzoyl derivative. Transparent prisms from alcohol m.p. 88 C.

(V111)



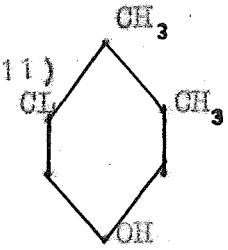
6-chloro-o-3-xylenol. m.p. 84-5°C
Soluble in organic solvents. Benzoyl derivative. Transparent plates from absolute alcohol, fine needles from aqueous alcohol m.p. 102°C

(X)



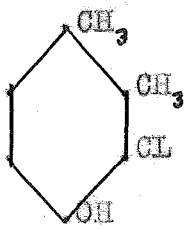
5-chloro-o-4-xylenol. m.p. 71-5-72-5°C
Colourless needles. Benzoyl derivative crystallizes from well-cooled alcohol in transparent rhombic crystals m.p. 43°C.

(XV111)



6-chloro-o-4-xylenol. m.p. 98°C.
Crystallized from light petroleum 60-80 in long silky needles. Benzoyl derivative. difficult to solidify. Fine needles from alcohol m.p. 42°C

(1X)

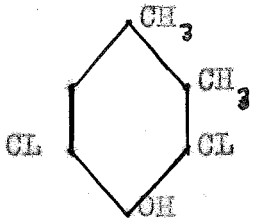


3-chloro-o-4-xylenol. m.p. 27°C
Crystallized from light petroleum in transparent crystals. Benzoyl derivative from alcohol m.p. 87°C

Of these only the chloro-xylenols (V111) (1X) and (X) are likely to be formed by direct chlorination of the xylenols for reasons already given.

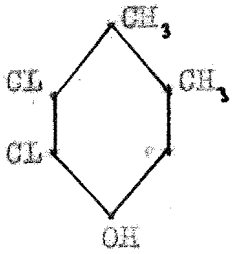
The following dichloro-xylenols were also described by the same authors.

(X1X)



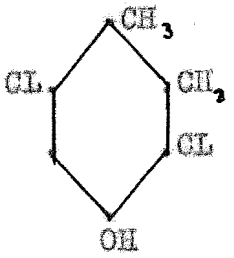
3:5 dichloro-o-4-xylenol. m.p. 52°C
Feathery crystals from light petroleum. Benzoyl derivative. White crystals from light petroleum m.p. 89°C

(XX)



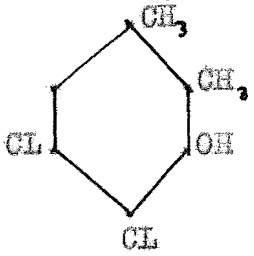
5:6 dichloro-o-4-xylenol m.p. 102.5°C
Clumps of radiating needles from light petroleum. Benzoyl derivative from alcohol in transparent prisms m.p. 94°C

(XX1)



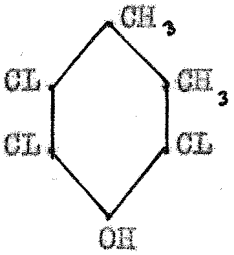
3:6 dichloro-o-4-xylenol m.p. 84°C
Crystallized from light petroleum in long flat needles. Benzoyl derivative from methyl alcohol in flat transparent needles m.p.124 C

(XX11)



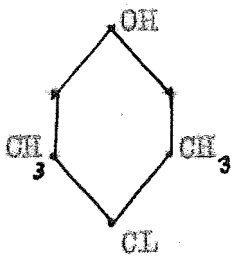
4:5 dichloro-o-3- xylenol m.p. 95°C
Crystallized from light petroleum in fine stellate masses. Benzoyl derivative, difficult to solidfy;from light petroleum in transparent crystals m.p. 133°C

(XX111)



Trichloro-o-4-xylenol. m.p. 182.5°C.
From light petroleum in fine needles.
Benzoyl derivative,transparent crystals from alcohol m.p. 120°C

(XXIV)

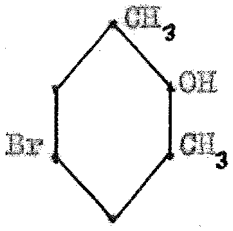


Rudolf.Lesser and Georg Gad (Ber.123.56 (B) 963-978) describe 2-chloro-m-5-xylenol (m.p. 115-116°C), made by the action of sulphuryl chloride on the m-5-xylenol dissolved in chloroform, and also a p-chloro-xylenol of unknown constitution,obtained by the action of sulphuryl chloride on the p-xylenol dissolved in chloroform (m.p. 74-75°C)

No other chloro-xylenols have been described in the literature.

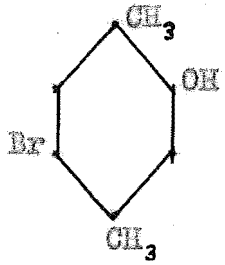
The following mono-bromo-xylenols have been described and were prepared by the action of bromine on the corresponding xylenol dissolved in glacial acetic acid.

(XXV)



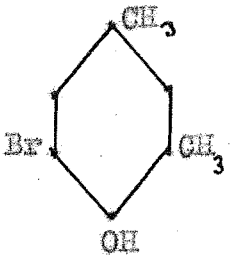
5-Brom-meta-2- xylenol. Crystalline solid (Auwers,Markovite B.41 2336.

(XXVI)



5-Brom-para-2-xylenol. Crystalline solid (Jacobsen B.11 .27.Auwers,Ercklentz A.302. 113)

(XXVII)



5-Brom-meta-xylenol.

An oily refrangent liquid b.p. 108-9°C/20 mm (Orton, Coates and Burdett J.C.S. 96. 45.)

The starting materials in the present work were three samples of commercially "pure" xylenols labelled, ortho, meta and para respectively, and a crude mixture of xylenols obtained from coal-tar and produced by the local gas-works.

ORTHO-XYLENOL.

This was a light brownish crystalline solid, soluble in most organic solvents and in caustic soda solution, giving a faint precipitate. The melting point was 45°C.
This is much too low for either of the ortho-xylenols, so that the sample was either a mixture of both, or one and some impurity.

META-XYLENOL.

A light brown solid consisting of small needle-shaped crystals soluble in common organic solvents, and soluble in caustic soda solution. The melting point of this sample was 61-63°C., hence it was slightly impure meta-5-xylenol.(V). It gave a benzoyl derivative whichcrystallized from cooled petrol-ether in big tabular crystals, slightly yellow in colour, m.p. 24 C. This has not been described in the literature.

PARA-XYLENOL.

Pink needle-shaped crystals, soluble in common organic solvents, and in caustic soda, m.p. 71°C. Hence impure p-xylenol (Vi).

CRUDE MIXTURE OF XYLENOLS.

This was a yellow refrangent oil, with a rather objectionable smell, and soluble in caustic soda without a precipitate. It was soluble in common organic solvents, alcohol, ether, benzene, etc. From the boiling range it was concluded that the mixture contained a considerable proportion of meta-5-xylenol (V). This is in agreement with the views of Schulze, who found that meta-5-xylenol forms the chief constituent of the xylenols in coal-tar. The fact that the crude xylenol was a liquid at ordinary temperatures, led to the view that it would probably contain some of the only liquid member of the xylenol series, meta4-xylenol. In support of this, was the fact that the crude mixture gave a blueish colouration with ferric chloride. Meta-4-xylenol gives a blue colour with ferric chloride, and is the only xylenol to give any colour with this reagent. The crude xylenol could not be made to crystallise, although it was well cooled and seeded with crystals of the "pure" xylenols described above. The crude mixture was benzoylated, but unfortunately the resulting oil would not crystallize, although it was seeded with crystals of the benzoyl

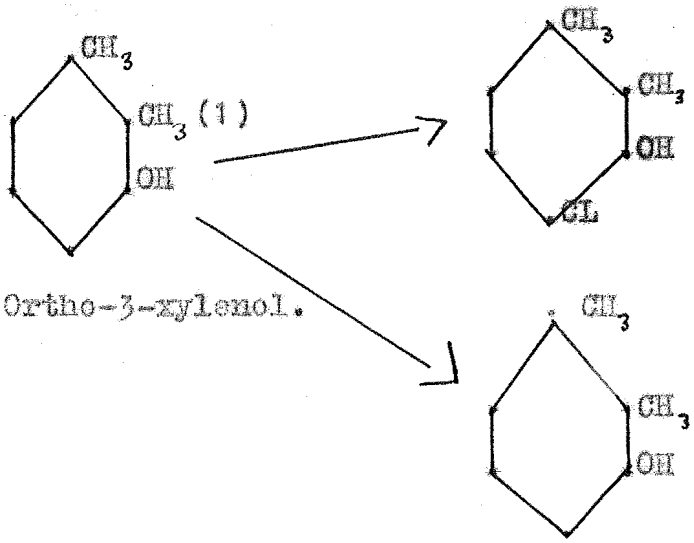
derivative of meta-5-xylenol (already described) and different solvents were used. This was probably due to the low m.p. of the benzoyl derivative of meta-5-xylenol, which would be so reduced by the presence of any impurities, that the resulting mixture would be liquid at room temperatures. The composition of the crude mixture therefore could not be determined with certainty, though it probably contained among other things, meta-5-xylenol and meta-4-xylenol.

The method of chlorination used in this investigation was to pass dry chlorine gas through the xylenol dissolved in glacial acetic acid, in presence of iron wire as catalyst. Glacial acetic acid was chosen as solvent, as it has been used in this role with success by many workers on the halogenation of phenolic compounds (earlier references) After removal of the acetic acid the products of chlorination were fractionally crystallized.
The results obtained with each xylenol are discussed individually below:-

<u>o-Xylenol</u>- The chlorination of the ortho sample gave a chloro-xylenol which crystallized from petrol-ether in long silky needles, m.p. 81.5°C and soluble in common organic solvents. The benzoyl derivative of this compound

was prepared and crystallised from dilute alcohol in flakes, m.p. 56°C.

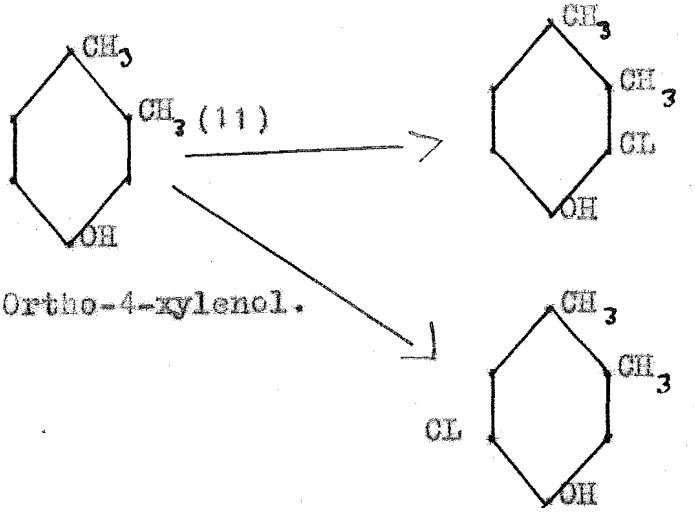
Assuming that the ortho-xylenol sample was a mixture of o-3-xylenol (1) and o-4-xylenol (11) the possible products of chlorination are those set out in the following:-



Ortho-3-xylenol.

(V11).
4-chloro-o-3-xylenol.
Not described in the literature.

(V111)
6-chloro-o-3-xylenol.
m.p. 84.5°C



Ortho-4-xylenol.

(1X)
3-chloro-o-4-xylenol.
m.p. 27°C.

(X)
5 chloro-o-4-xylenol.
m.p. 71.5-72.5°C.

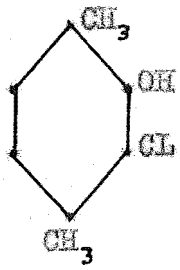
Of the four possible ptoducts three have been described (earlier references). Of these (1X) and (X) have

too low a melting point to be identical with the compound obtained. This must therefore be either 4-chloro-o-3-xylenol(VII)which has not been described, or 6-chloro-o-3-xylenol(VIII). Although the substance obtained was recrystallized several times, the melting point was sharp and could not be raised above 81.5°C. The benzoyl derivative was prepared and gave a melting point of 56°C, while that of the benzoyl derivative of 6-chloro-o-3-xylenol is given by Hinkel as 102°C (loc. cit.) This indicates that the chloro-derivative isolated was (VII) and not (VIII) , but this is not conclusive,however, as, owing to lack of material, the benzoyl derivative prepared could not be recrystallized, and hence the m.p. 56°C will probably be subject to considerable correction. On the other hand, (VIII) is the product most to be expected on the theoretical grounds already given, and the description of (VIII) given by Hinkel,etc, agrees with the description of the substance isolated. the melting points being close enough for the two to be identical. The matter could not be definitely proven for one or the other owing to the lack of material.

Para-xylenol.

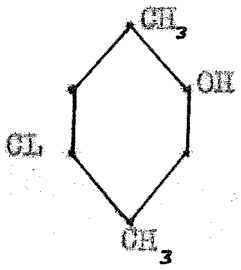
This gave a mono-chloro-xylenol which crystallized

from petrol-ether in long white glistening needles, m.p. 70°C, soluble in common organic solvents. The structural formula of this compound will be either



(XVI)

3-chloro-p-2-xylenol.



(XV)

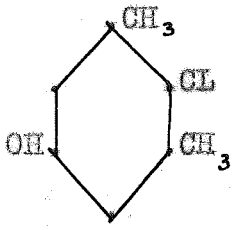
5-chloro-p-2-xylenol.

probably 5-chloro-p-2-xylenol (XV), for reasons already stated. As neither compound has been described, and the amount of material was insufficient for further investigation, it was not possible to prove which of these substances had been obtained.

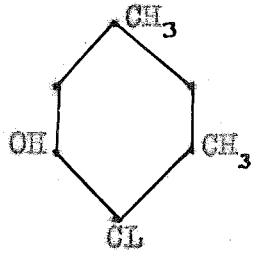
Meta-xylenol.

The chlorination of this xylenol which has already been shown to be meta-5-xylenol (V) yielded a mono-chloro-xylenol which crystallized from petrol-ether as a white glistening mass of feathery crystals, very like shiny cotton wool in appearance and having melting point 115°C.

From the chlorination of this xylenol the two following mono-chloro-xylenols are possible, but the first is the more likely, as has already been discussed.



(X111)



(X1V)

2-Chloro-meta-5-xylenol. 4-Chloro-meta-5-xylenol.

2-Chloro-meta-5-xylenol has already been described by (Rudolf Lesser and Gad) m.p. 115°C. It is therefore apparent that the compound obtained above was 2-Chloro-meta-5-xylenol. It dissolves only slowly in 10% caustic soda solution. The benzoyl derivative of this compound was prepared as a white powder which crystallized from petrol-ether in very fine white needles, m.p. 67°C. This has not been described in the literature.

Crude xylenol mixture.

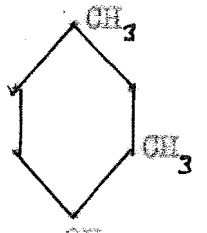
The products obtained were (a) a solid mono-chloro-xylenol, which was the main product, (b) a liquid mono-chloro-xylenol, and (c) a solid di-chloro-xylenol. These are described below:-

(a) The mono-chloro-xylenol crystallized from petrol-ether as a mass of fine crystals, m.p. 114°C. A mixed melting point showed this to be identical with the 2-chloro-m-5-xylenol obtained from m-5-xylenol, and described above. This chloro-xylenol was the main product obtained, in

agreement with the view already put forward, that the crude xylenol mixture consisted largely of m-5-xylenol.

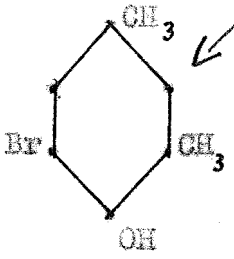
This mono-chloro-xylenol was a colourless, highly refrangent, oily liquid, b.p. 104-107°C/20 mm., volatile in steam.

The only mono-chloro-xylenol which would be expected to be a liquid is 5-chloro-m-xylenol (XII) as (1) 5-bromo-m-4-xylenol (XXVII) has been prepared and is an oily liquid with a boiling point a little higher than that of the compound described above, (2) m-4-xylenol is the only liquid member of the xylenol series, and on chlorination would be expected to give (XII) and (3) 5-chloro-4-hydroxy-methyl benzene has been prepared and is an oily liquid.(Schall and Dralle (B.12. 2528)



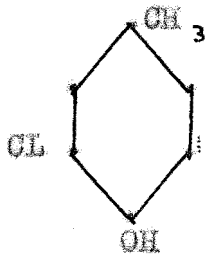
(IV)

Oily liquid.



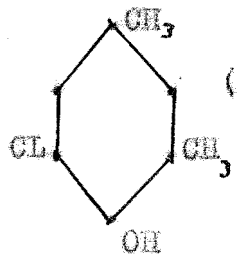
(XXVII)

Described as an oily liquid.



(XXVIII)

Described as an oily liquid.

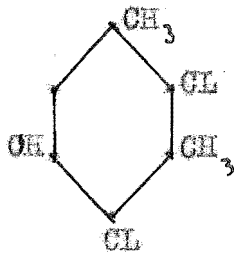


(XII)

Not described.

It has already been shown that the crude xylenol probably contained m-4-xylenol. It therefore seems extremely likely that the liquid mono-chloro-xylenol isolated was 5-chloro-m-4-xylenol.

(c) The di-chloro-xylenol obtained crystallized from petrol-ether in small white flakes, m.p. 85°C. The orientation of this compound is unknown, but it is probably



(XXIX)

2:4-dichloro-m-5-xylenol

as m-5-xylenol has been shown to be a main constituent of the "crude", and its mono-chloro-compound isolated, and it seems likely that the di-chloro compound would be formed by the further chlorination of a mono-chloro-compound. As m-4-xylenol would be much less likely to form a di-chloro compound by direct chlorination, it seems quite probable that the above formula gives the correct orientation of the di-chloro-xylenol isolated.

SUMMARY.

(1) The chlorination of ortho-xylenol gave a mono-chloro-derivative, the orientation of which could not be arrived at with certainty, but which is either 4-chloro-o-3-xylenol or 6-chloro-o-3-xylenol, probably the latter.

(2) The chlorination of meta-xylenol gave 2-chloro-m-5-xylenol, of which the benzoyl derivative was prepared.

(3) The chlorination of para-xylenol gave a mono-chloro-derivative, either 3-chloro-p-2-xylenol or 5-chloro-p-2-xylenol, probably the latter.

(4) The chlorination of commercial "crude" xylenol gave:-

(a) 2-chloro-m-5- xylenol, as main product.

(b) A liquid mono-chloro-xylenol, probably 5-chloro-m-4-xylenol.

(c) A di-chloro-xylenol, probably 2:4 di-chloro-m-5-xylenol.

(5) The "crude" xylenol was found to consist largely of meta-5-xylenol, of which the benzoyl derivative was prepared.

INDEX TO EXPERIMENTAL SECTION.

EXPERIMENTAL.

1. "CRUDE" XYLENOL.

(a) Distillation.

The xylenol mixture was distilled, the bulk of the mixture distilling over the narrow ranges:-

216-217°C/758 mm (i)

218-219°C/758 mm (ii)

No further separation could be made by repeated distillation. These two fractions were colourless oils, which darkened to yellow on keeping, (ii) slightly more than (i).

(b) Attempted crystallization.

Samples of each fraction were cooled in a freezing mixture of ice and salt, but no crystallization took place. Separate portions of each fraction were seeded with crystals of o-, m-, and p-xylenols and cooled, but still no crystallization took place. At the temperature of the freezing mixture the liquids went viscous, with faint white streaks appearing on the introduction of the xylenol crystals only.

(c) Attempted isolation of a benzoyl derivative.

By Schotten-Baumann method. The crude (4.05 grams) was dissolved in 10% NaOH solution (20 cc) and benzoyl chloride (5.7 gms) was added gradually, the mixture

being kept cool by running water. The product of the reaction separated as a brownish-red oil, which did not solidify on pouring into ice-cold water. This oil could not be made to crystallize from either petrol-ether, ether, alcohol or benzene at room temperatures, nor from these solvents on cooling in ice and salt, nor on cooling the oil itself. An attempt to make it crystallize was also made by seeding with crystals of the benzoyl derivative of meta-5-xylenol (see below) and cooling. These crystals dissolved in the oil, but it did not induce crystallization.

11. META-5-XYLENOL.

Preparation of the benzoyl derivative.

Meta-5-xylenol (2 grams) was dissolved in 10% NaOH solution (10 cc) and benzoyl chloride (2.8 grams) was added. When the xylenol was dissolved in the caustic soda, the mixture solidified, and more water had to be added to redissolve it. The benzoyl derivative separated as a yellowish oil which did not solidify on pouring into ice-cold water. It crystallized from cooled petrol-ether in tabular plates, which were recrystallized twice from petrol-ether. Colourless tabular plates m.p. 24° C.

111. GENERAL METHOD OF CHLORINATION.

The chlorine gas was generated by the action of sulphuric acid on a mixture of pickling salt and manganese dioxide, and thoroughly dried by passage through two wash-bottles of

conc. sulphuric acid, and then through a drying tube filled with pumice soaked with conc. sulphuric acid. The dried gas was then led into a conical flask which acted as a trap and thence into the reaction flask. This trap was found to be necessary to prevent the xylenol from sucking back into the drying tubes when the pressure on the generating flask was released to introduce fresh acid. In the reaction flask was the xylenol dissolved in glacial acetic acid, and a little iron wire as catalyst. The reaction vessel was fitted with an open vent tube drawn fine, so that there would be a steady stream of hydrochloric acid gas escaping and thereby preventing water vapour from entering.

IV <u>ISOLATION AND PROPERTIES OF CHLORO-DERIVATIVES</u>.

Obtained by the chlorination of "pure" o-, m-, and p-. xylenols.

(a) Chloro-o-xylenol.

Ortho-xylenol (9.5 grams) was dissolved in glacial acetic acid (25 cc) and when the increase in weight of the reaction flask showed that the calculated amount of chlorine (2.75 gms) had been introduced, the chlorinated xylenol solution was poured into ice-cold water, ether was added, and the acetic acid neutralized with sodium carbonate solution. The whole was transferred to a large separating funnel and the aqueous layer run off. The ether layer was dried with anhydrous sodium carbonate, the ether solution being decanted off, filtered, and the ether evaporated off. This left a red solid which was dried on porous earthenware, and then

refluxed for two hours with powered animal charcoal, using petrol-ether as solvent, filtered, and the charcoal on the filter paper washed with hot petrol-ether. This treatment was effective in decolourising the solution, from which the chloro-xylenol separated as a faintly brown coloured solid, soluble in hot petrol-ether . It was recrystallized three times from hot petrol-ether, and about two grams were obtained as long white needles, m.p. 81.5°C.

Analysis by ter Meulen method gave:-

Cl= 22.52% : 22.58 % : Mean - 22.55%.

Calculated for mono-chloro-xylenol 22.68%.

On the evaporation of the mother liquor, a number of isolated brown crystals was left. These were cubical in shape, and on closer examination had the appearance of being made up of a number of tiny needles. They gave a m.p. of 80°C. A mixed melting point with the crystals of chloro-o-xylenol obtained above gave no depression, showing the two substances to be identical. The benzoyl derivative of this compound was prepared by the Schotten-Baumann method. Chloro-o-xylenol (.3380 grams) was dissolved in 10% NaOH solution (10 cc) and benzoyl chloride (.37 grams) was added. The benzoyl derivative separated as white flakes, which were filtered off and washed with distilled water. Dilute alcohol was then poured through the filter paper after it had dried. The benzoyl derivative separated from the alcohol in white flakes, m.p. 56°C. There was insufficient for recrystallization.

(b) Chloro-meta-5-xylenol.

Meta-5-xylenol (7.5 grams) was dissolved in glacial acetic acid (20 grams) and the calculated amount of chlorine (2.2 grams) was added. The resulting liquid was reddish in colour and was treated as described above for chloro-o-xylenol. After refluxing with animal charcoal, the resulting solution in petrol-ether was almost colourless. On evaporation of the solvent, a white crystalline solid separated out. This was recrystallized from petrol-ether twice and dried on porous earthenware. It was obtained in fine glistening needles (2 grams) m.p. 113°C.

Analysis by Carius method gave :-

Cl = 22.62% : 22.56% : Mean - 22.59%.

Calculated for mono-chloro-xylenol 22.68%

Preparation of the benzoyl derivative of 2-chloro-m-5-xylenol

2-chloro-m-5-xylenol (1 gram) was dissolved in 10% NaOH solution (10 cc) and benzoyl chloride (1.2 grams) was added as described earlier. On pouring into ice-cold water, the benzoyl derivative separated as a white powder, which was filtered off, washed with distilled water and dried on a porous plate, where it was left as a white powder. It was recrystallized from petrol-ether in fine white thread-like crystals, m.p. 67°C.

(c) Chloro-p-xylenol.

P-xylenol (9 grams) was dissolved in glacial acetic acid (20 gms) and the calculated amount of chlorine (2 grams) was added. The resulting liquid was red in colour and was treated as described for chloro-o-xylenol.

It was not appreciably decolourised by refluxing with animal charcoal. Chloro-p-xylenol separated from the petrol-ether as a red crystalline solid which was re-crystallized several times from hot petrol-ether. The first solids separating were reddish-brown, but this colour gradually disappeared after recrystallizing a number of times. This was continued until the solid separating was colourless. About 1.5 grams of chloro-p-xylenol was obtained. It crystallized from petrol-ether in long white needles m.p. 70°C. and was soluble in common organic solvents and in hot petrol-ether (60-80) but not very soluble in cold.

Analysis by Carius method gave :-

Cl= 22.56% : 22.60% : Mean - 22.58%

Calculated for mono-chloro-xylenol 22.68%

V. <u>ISOLATION OF CHLORO-DERIVATIVES OBTAINED BY THE CHLORINATION OF "CRUDE" XYLENOL.</u>

(a) First method.

The xylenol mixture was dried by standing over anhydrous sodium sulphate for three weeks. It was then chlorinated as described for the "pure" xylenols. The final product after the introduction of the calculated amount of chlorine was a dark oily liquid, black by reflected light, red by transmitted light. The colour change was probably due to the presence of impurities as benzene derivatives are seldom coloured. This liquid dissolved in caustic soda solution going pinkish in colour. On addition of hydrochloric acid

a white precipitate was produced together with a reddish oil which floated on the surface. This was thought to be evidence in favour of the presence of a liquid chloro-xylenol in the mixture.

The liquid was treated in two different ways, the first og which was not so convenient for the isolation of the solid mono-chloro-derivative, but was used for the isolation of the liquid mono-chloro-derivative. This method consisted of pouring the chlorinated mixture on to melted ice, adding ether and shaking. It was allowed to separate into two layers and the aqueous layer run off, taking with it most of the acetic acid and water soluble impurities. The upper layer was then heated gently over a water bath to evaporate off the ether. The resulting liquid was then fractionally distilled under reduced pressure, through an air condenser, care being taken to ensure uniform heating, as otherwide superheating and bumping occured.

The following fractions were collected:-

(i) A colourless mobile liquid fraction, boiling up to ... ... 104°C/20mm

(ii) A yellow transparent oil, boiling .. 106-130°C/20mm

(iii) A yellow liquid which solidified to a yellowish-white solid in the condenser.

A noticeable halt in the steady rise of temperature was

observed at 120°C/20 mm, but otherwise the distillation was quite continuous, the temperature ranges of the fractions being somewhat arbitarily chosen , 130°C being that at which the first solid separated out in the condenser. The distillation was stopped when the residue in the flask started to fume. This residue was a black solid, and was not worked up any further, this accounting in part for the poor yield obtained by this method of extraction, as a big proportion of the solid material must have been lost in this residue.

The liquid fraction (ii) was refractionated in flasks with fractionating necks under 20 mm pressure. It was separated into three fractions:-

(a) Yellow oil... ... ... 106-122°C/20 mm.

(b) Yellow oil... ... ... 122-133°C/20 mm.

(c) Deep yellow oil ... ... 133-142°C/20 mm.

Solid remained in the flask as a brownish-black mass. All these fractions contained chlorine; the distillation again being continuous.

(a) was further fractionated in a flask with a longer fractionating neck, and fractions collected where the boiling point remained constant for any length of time. A fraction 110-114°C/20 mm. was collected where a considerable proportion of the liquid distilled over. The remainder boiled over a range with no particular halts, just a steady rise of

temperature. (b) was similarly fractionated, and again a portion was collected at 110-114°C/20 mm. , and added to that from (a).

This fraction 110-114°C/20 mm. was refractionated, but no further separation into definite fractions could be accomplished.

Analysis by ter Meulen method gave:-

Cl= 8.60% : 8.64% : Mean - 8.62%

This is far too low for a mono-chloro-xylenol, and evidently the distillate was a mixture, probably of chloro-xylenol in meta-4-xylenol, the only liquid member of the series. This liquid distillate (24 grams) was dissolved in glacial acetic acid (20 grams) , and the calculated amount (7.5 grams) of chlorine added to bring the chlorine content up to the theoretical 22.68%.

The further chlorinated liquid, which did not darken beyond a straw colour, was poured into melting ice and extracted with ether as before. The ether was evaporated off and the residual liquid was fractionated under reduced pressure. After five refractionations of this liquid, a small amount of a fraction boiling over the range 104-107°C/20 mm. was isolated. This was a colourless highly refrangent oil, with a very slight odour. It was volatile in steam.

Analysis gave the following results:-

Cl (ter Meulen method)= 22.48;22.42;22.54: mean- 22.48%

H = 5.52 : 5.81 : mean- 5.67%

C = 61.24 : 61.34 : mean- 61.27%

Calculated for mono-chloro-xylenol:-

Cl = 22.68%

H = 5.79%

C = 61.35%

The oil was therefore a mono-chloro-xylenol, the constitution of which has been dealt with in the theoretical section.

It was noticeable throughout these distillations that except in the case of the fractionating of the already fairly constant boiling point liquids, no matter which of the later fractions was distilled, solid matter always remained in the distilling flask on cooling.

Only a very small amount of solid was isolated for the reason already given, and a second chlorination was done and a different method of isolation used.

(b) Second method.

The chlorination was carried out exactly as before. The method of extraction used this time was different, and yielded much more of the solid product than did the first method. The chlorinated liquid was poured into ice-cold water, ether added, and the acetic acid eliminated by sodium carbonate solution as described under 1Va . The aqueous layer was run off, and the ether layer dried by shaking with anhydrous

sodium sulphate. The ether was decanted off and filtered, the liquid was then heated gently to evaporate off the ether. The residual liquid was then fractionated under reduced pressure. This time, however, the distillation was carried on only until the first trace of solid separated out from the liquid which came over. (about 120°C/20mm.)
The distillation was then stopped. The residue in the flask was a brown viscous liquid, which solidified on cooling to a brown semi-solid mass. Petrol-ether (60-80°C) was added to this, which gradually dissolved, giving a reddish-brown solution . This solution was refluxed with powdered animal charcoal for two hours to remove the colour, but without much success. The petrol-ether was then evaporated off, leaving a greyish-brown semi-solid mass. This was dried on porous earthenware for three days, a coarse whiteish crystalline solid remaining. This was fractionally crystallized from petrol-ether, until a white crystalline solid of sharp melting point was obtained, which was dried on porous earthenware and re-crystallized from hot petrol-ether as a glistening mass of feathery crystals, m.p. 114°C.

A mixed melting point showed that this was 2-chloro-m-5-xylenol, identical with that obtained from meta-5-xylenol and described under 1Tb.

From the mother liquors a small amount of a white crystalline solid was obtained, which when dried on a porous

plate and recrystallized from hot petrol-ether had m.p.85 C.

The later liquid fraction of the distillation on standing, deposited a few crystals of a colourless substanee. These crystals were nearly three-quarters of an inch long and needle-shaped. The liquid was carefully drained off them, and they were dried on a porous tile and recrystallized twice from petrol-ether, and then gave m.p. 85°C. The melting point suffered no depression when mixed with the crystals m.p.85°C obtained above, showing the two to be identical.

Analysis by ter Meulen method gave:-

Cl = 37.05%

Calculated for a di-chloro-xylenol = 37.14%

The substance was, therefore, a di-chloro-xylenol, the possible constitution of which is discussed in the theoretical section.

APPENDIX.

METHODS OF ANALYSIS.

(a) Chlorine.

The analysis for chlorine was done by the method due to ter Meulen. (Organic Chemical Analysis. Thorpe and Whiteley).

This consists of passing a stream of purified hydrogen through a wash-bottle of concentrated ammonia, and leading the resulting mixture of hydrogen and ammonia through a silica tube open at the far end. The substance to be analysed is placed in a boat in the front end of the tube, the middle of which is strongly heated in a Fletcher furnace. The substance is vapourised by means of gentle heating. The vapour passes with the hydrogen and ammonia through the furnace, where it is converted into the ammonium halide, which sublimes onto the cool part of the tube, and is afterwards washed out with distilled water and estimated by Volhards method.

In the case of some of the chloro-xylenols to be analysed, it was found that the crystals were so light, that on melting they gave only a minute quantity of liquid, which was quite invisible through the silica tube used in the

ter Meulen method. This difficulty, combined with the fact that the chloro-xylenols were available only in such small quantities, made it very difficult to control the rate of vapourization of the substance under investigation, and hence the results obtained in these cases were not good. In these instances, therefore, the standard Carius method of analysis was used, with better results.

(b) Carbon and Hydrogen.

This was done by a standard combustion analysis, using a lead chromate packing in the combustion tube.