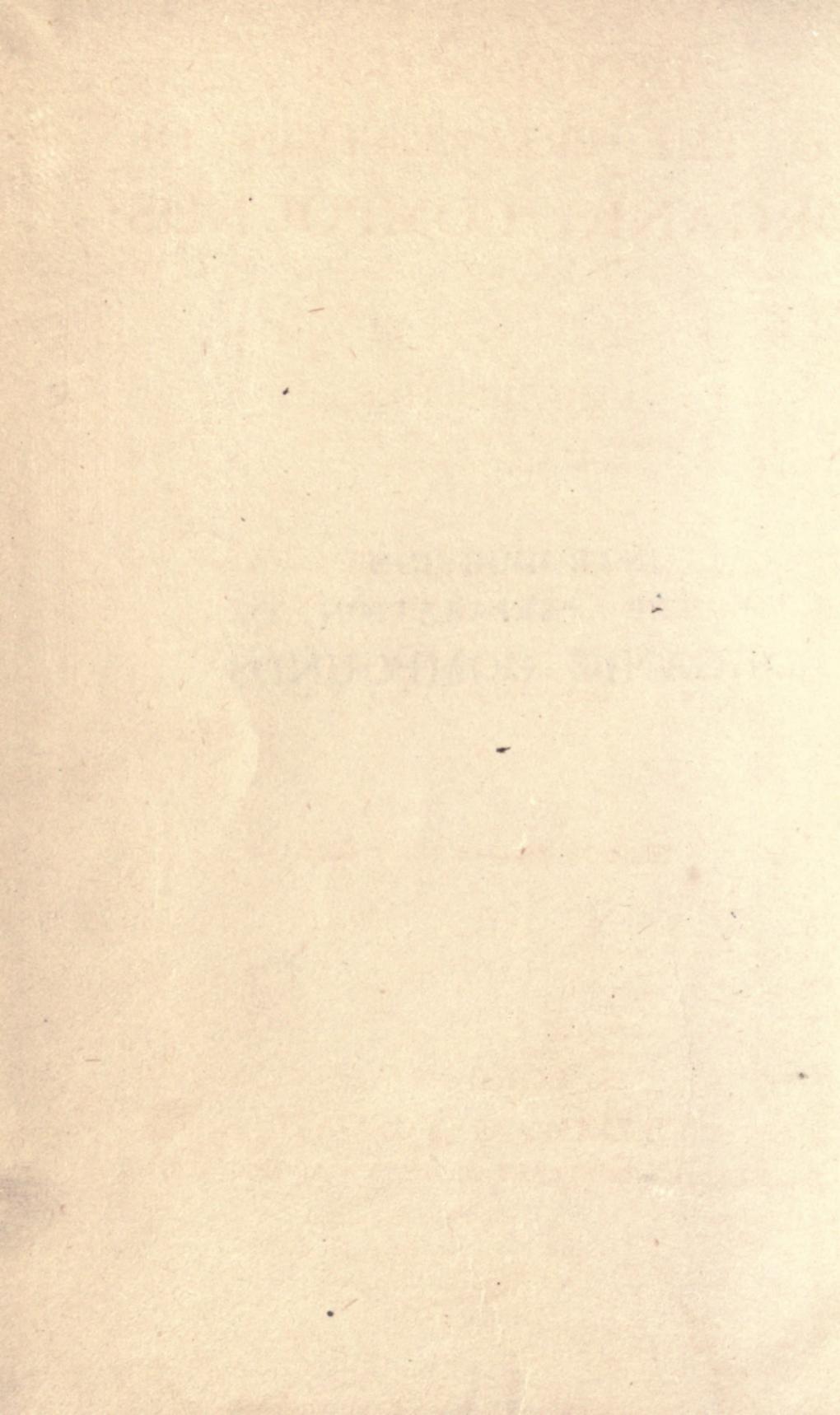


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**INTRODUCTION
TO THE PREPARATION OF
ORGANIC COMPOUNDS**



INTRODUCTION TO THE PREPARATION OF ORGANIC COMPOUNDS

BY

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UNIVERSITY OF BERLIN.

TRANSLATED, WITH THE AUTHOR'S SANCTION, FROM
THE NEW (EIGHTH) GERMAN EDITION BY

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PREFACE TO THE FIRST EDITION.

THIS Introduction first took shape four years ago in Erlangen for the purpose of facilitating for myself and my demonstrator the elementary practical instruction in organic chemistry.

A year ago it was rewritten and manifolded for the use of the students in the laboratory at Würzburg. As in a short time all the copies were disposed of, and inquiries are also frequently made for it from outside, I have decided to have it printed.

The considerations which have governed the selection and arrangement of the preparations are for the most part of a practical nature, such as the cost of the materials and apparatus, and the easiness, shortness, and freedom from danger of the operations themselves.

The prescriptions are often tested, and are

such that the student can make all the preparations in one Semester at a cost of about forty shillings for materials.

Examples are included of almost all operations, and of the commonest synthetic methods.

Theoretical explanations are avoided as far as possible, because it is more stimulating for the students to obtain information on the strength of their own observations by consulting the original literature or the text-books, or by verbal instruction.

In working out and practically testing the directions, I have had the assistance of Dr Wilhelm Wislicenus, to whom my thanks are due.

EMIL FISCHER.

WÜRBURG, *July* 1887.

PREFACE TO THE SEVENTH EDITION.

IN comparison with the sixth edition, the number of preparations has had to be increased by one-half in order to include some new reactions, and in order to be able to give attention to the field of research chiefly worked upon in the organic department of this laboratory.

As, however, the course thereby became so extensive that most students were no longer able to complete it in three or four months, I have divided it into two parts. The first contains the exercises required of chemists. With the exception of those marked in index and contents-list with a star, they are here compulsory, *i.e.* they must be carried out before the usual piece of research is commenced.

The second part is intended chiefly for medics and biologists who wish to acquaint themselves with the methods of organic chemistry. For previous practice they usually carry out preparations 1, 2, 3, 4, 8, 12, 18, 23, 26, 29, 34, 35, 49, 54, 55, 56, 66 in the first part, and they usually require for both lots not more than one Semester.

In order to prevent accidents, the students in this laboratory are made aware of the dangers of chemical work by means of detailed notices, and it seemed to me advisable to place these warnings at the beginning of this book. There is, in addition, at the end a small table giving the strengths of the most common solutions, the concentrations of which are chosen to be simple multiples of the normal strength. Their use has proved very convenient owing to the simplification of calculations which it effects. In the rewriting of the book, which has also been extended to the older preparations and takes into account the practical experience of the last five years, I have been ably assisted by

PREFACE TO THE SEVENTH EDITION ix

Professors and Doctors R. Pschorr, O. Emmerling, O. Diels, E. Abderhalden, F. Sachs, H. Leuchs, E. Königs, and R. Kempf, and I wish to offer them my hearty thanks. To Professor Diels I am also indebted for the skilful preparation of the drawings.

EMIL FISCHER.

BERLIN, *April* 1905.

PREFACE TO THE EIGHTH EDITION.

CONSIDERABLE changes have only been made in the second part, and have the object of making the work easier. In this way, for instance, dulcite takes the place of sorbite, which is difficultly crystallisable; and the hydrolysis of glue, which is rather too difficult for a beginner, is replaced by the preparation of glycocoll ester and *d*-alanine from silk.

EMIL FISCHER.

BERLIN, *September* 1908.

PRECAUTIONS NECESSARY FOR THE AVOIDANCE OF ACCIDENTS.

As the eyes are more especially endangered in chemical work, the habitual use of thick, protecting glasses is urgently recommended.

I. Danger of Fire.

CARE is particularly necessary in working with ether, petroleum-ether, ligroin, benzene, carbon disulphide, and alcohols.

On account of the danger of fire, not more than 1 li. of any of these substances may be brought on to the working-bench.

In distilling inflammable liquids, a receiver must be employed, and care taken that water runs through the condenser. It is convenient to lay a cloth over the top of the receiver to distribute the vapour in the air.

If the distillate should catch fire, endeavours should not be made to extinguish the fire with dusters or by blowing it, but the source of heat should be removed.

The flame then often goes out in a short time when distillation stops.

The boiling of substances with low-boiling solvents must always be carried out under reflux condenser on the water-bath, unless mere test-tube experiments are being made. Care must be exercised in shaking round on account of the possibility that the liquid may be over-heated.

Inflammable substances may not be thrown into the waste-boxes, but must be washed away down the sinks.

II. Poisonous Gases and Vapours.

Especial care should be taken not to inhale chlorine, bromine, the vapours of nitrous and nitric acids, of hydrocyanic acid, hydrogen phosphide, phosphorus chlorides, acid chlorides, and alkyl sulphates.

All work with substances of this kind, as well as with fuming acids, may only be carried out in a fume-chamber with a good draught.

Substances with a strong smell, such as benzoyl chloride, benzyl chloride, acetic anhydride, isonitriles, mustard-oils, mercaptans, etc., must not be thrown into the sinks.

III. Injury or Poisoning by means of caustic or poisonous substances, or by strong acids.

Caustic potash, caustic soda, dry sodium ethylate, and potassium cyanide, when being powdered in a mortar,

must be wrapped in paper, or covered with a cloth, in order to prevent the projection of particles or the formation of dust.

During fusions with alkali the eyes must be protected by goggles, and the hands by means of gloves.

In the determination of melting points the bath of sulphuric acid must be so placed, and the flame held in such a manner, that if the flask should crack, the eyes, hands, or knees cannot get splashed with the hot acid. Special precautions must be taken in determining the melting points of explosive substances.

In working with poisonous substances, such as hydrocyanic acid, potassium cyanide, arsenious acid, yellow phosphorus, alkaloids, etc., the hands and the work-place are to be kept clean, and cleaned if necessary after contact with such substances.

Sodium amalgam may only be prepared in a fume-chamber with a good draught. The eyes and hands must be protected from the projected particles of metal.

IV. Explosions.

Substances which are known to be explosive, such as diazosalts, certain nitro-compounds, etc., may on no account be prepared in large quantities.

Even small quantities of explosive substances must not be introduced into glass vessels (specimen tubes or desiccators), but must be preserved in cardboard boxes.

Vessels in which chemical reactions are proceeding must not as a rule be closed.

Bottles in which the existence of a high pressure is likely (*e.g.* aluminium chloride) must be covered with a cloth while being opened.

In the use of the bomb-furnaces the following rules must be observed.

The iron tubes must not be taken out of the furnace until quite cold, and then in such a way that the mouth of the tube is kept pointing towards the wall.

The opening of the glass tube must be carried out in the bomb-furnace room. It is allowed to slide out of the iron tube until the capillary just projects. The tip of this is then heated in a gas-flame till it melts, the mouth of the iron tube being all the time directed towards the wall. When the gas-pressure has reduced itself through the blown-out capillary, the latter is carefully cracked off; sometimes more gas then escapes, if the capillary was blocked up. Then, and not before, may the tube be removed from the iron covering.

In no circumstances, not even when no pressure is expected in the tube, may it be removed from the iron tube before it has been opened in the manner just described.

Sealed tubes which contain liquid gases must be opened while they are immersed in liquid air. A mask, goggles, and thick gloves must be worn.

Ordinary glass vessels, such as Erlenmeyer flasks,

common flasks, etc., must not be connected with the pump, but only thick-walled filtering vessels, vacuum desiccators, or good distilling flasks.

In vacuum distillations the apparatus should first be tested while empty to see if it will stand the atmospheric pressure. The eyes must always be protected by means of a pane of glass, or with goggles. Care should also be taken that the connection between the apparatus and the pump is open.

Special care is required in working with metallic sodium or potassium. Quantities of sodium exceeding 5 g. must not be kept on the benches, but in the iron cupboard provided for this purpose. While work is being carried on with the metal, *e.g.* in reductions with sodium and alcohol, it must not be allowed to lie in the air on the bench, but must be placed under petroleum, ligroin, or dry ether.

Sodium residues must not be thrown into the waste-boxes or sinks, but put into the sodium residue bottles provided.

When sodium wire has been made the metal cylinder must first be washed with alcohol until the sodium has dissolved, and then with water.

In all preparations where sodium is employed, such as sodium ethylate and sodio-acetoacetic ester, particles of sodium frequently remain unattacked, and so in the further treatment (addition of water, etc.,) great care is required.

PRECAUTIONS

Among inorganic reagents potassium chlorate should be especially noticed. Through confusion of it with potassium chloride many serious accidents have occurred.

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INTRODUCTION TO THE PREPARATION OF ORGANIC COMPOUNDS.

PART I.

1. Nitrobenzene. $C_6H_5 \cdot NO_2$.

IN a flask of about 300 c.c. capacity are mixed 150 g. concentrated sulphuric acid and 100 g. ordinary nitric acid of specific gravity 1·41. The mixture is cooled to room temperature, and 50 g. benzene are added in small portions, the flask being frequently shaken and cooled meanwhile by means of cold water.

The flask must not be closed, since gases are evolved during the reaction. In the course of the operation the nitrobenzene separates as an oily layer on the top of the acid mixture.

A sample of this oil, when poured into water, must sink in it; if it does not, much unchanged benzene is still present. When all the benzene has been added, the shaking is continued for about half an hour longer, the mixture being warmed at the same time to about 60°.

The whole contents of the flask are then poured into about 1 li. of water, and after stirring round, the oil which is precipitated and sinks to the bottom is separated in a funnel from the acid solution. The oil is again washed with water, separated from the water as completely as possible in the funnel, and transferred to a small flask of about 100 c.c. capacity along with 5-10 g. of granulated calcium chloride.

If the mixture is frequently shaken, the oil is sufficiently dry in twelve hours. It is now filtered from the calcium chloride into a fractionating flask, which should only be about half filled by the liquid. The fractionation is carried out in the apparatus shown in fig. 1, two or three bits of porous earthenware about

as big as peas having previously been put into the liquid.

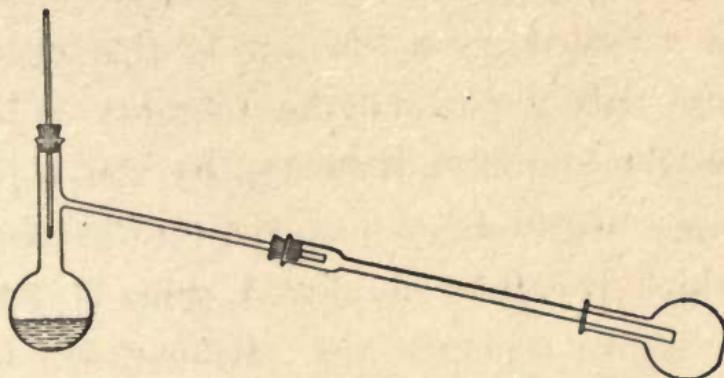


FIG. 1.

To begin with, small quantities of water and benzene usually pass over; these must be collected separately. The thermometer then rises quickly to about 205° (uncorrected), and the nitrobenzene distils over within a few degrees.

The distillation is interrupted when the contents of the flask get very brown. To effect a complete purification, the nitrobenzene may be subjected to a second distillation. If the operation be carefully con-

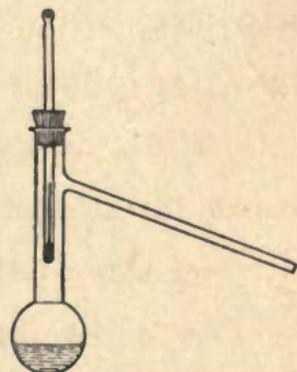


FIG. 2.

ducted, 80–85 % of the theoretical yield of pure nitrobenzene is obtained.

The boiling point of the nitrobenzene is found a few degrees too low in this process, because only a part of the mercury column of the thermometer is heated by the vapour. The apparatus suffices, however, for the purpose for which it is here employed, since it is only necessary to separate the nitrobenzene from unchanged benzene or from dinitrobenzene of very high boiling point.

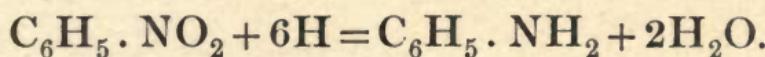
For the accurate determination of boiling points, distilling flasks with long necks are employed in conjunction with short thermometers (fig. 2). In the case of substances of high boiling point, the form suggested by Zincke is employed. The mercury thread must be completely immersed in the vapour during the distillation.

The same apparatus serves also for the testing of thermometers, water, naphthalene, diphenylamine, etc., being used as boiling liquids. In this case the height of

the barometer must also be taken into account.

2. Aniline. $C_6H_5 \cdot NH_2$.

The equation representing the formation of aniline is :—



As reducing agents tin, zinc, iron, and various acids, and also ammonium sulphide, may be employed. For experiments on a small scale, where the price of the materials is not so important, tin and hydrochloric acid are especially suitable. 90 g. granulated tin and 50 g. nitrobenzene are brought together in a flask of about 1 li. capacity, and to the mixture strong hydrochloric acid is added in small portions with frequent shaking. The mass becomes fairly hot, and the vigour of the reaction must be moderated by placing the flask in cold water from time to time. The reaction is finished when the smell of the nitrobenzené has quite disappeared.

During the operation the tin double salt of aniline very often separates from the solution as a white crystalline mass. At the end enough water is added to dissolve the salt completely, and the liquid is then poured off from the unchanged tin.

The acid solution is now treated with an excess of concentrated sodium hydrate until the white oxides of tin which at first separate have gone into solution again, and dark-coloured metallic tin is precipitated. This causes the precipitation of the aniline as an oil, which can be straightway extracted with ether—a method which is generally applicable with substances of this kind. It is, however, more convenient to distil the base first in steam.

The apparatus shown in fig. 3 serves for this purpose. The flask *a* contains the aniline solution, and is placed at an angle in order to prevent any liquid from being blown over into the flask. It does not need to be warmed. Steam is led in through the tube *b*; it is taken

either from the steam supply or generated in some kind of boiler. The aniline distils over very easily with the steam. The process is stopped as soon as the distillate runs down clear. The oily aniline can be separated from the aqueous distillate by means of a siphon. The yield is, however, better if the

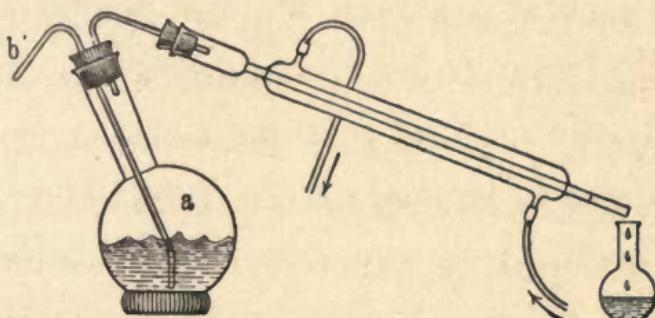


FIG. 3.

distillate be shaken with about half its volume of ether; the ethereal solution is separated, dried with granulated potassium carbonate, then filtered, and evaporated from a flask on the water-bath. The aniline remains behind as a clear, yellow oil, and is fractionated in the same way as the nitrobenzene. The yield is almost quantitative. Boiling point about 181° (uncorr.).

Reactions of Aniline.

1. *Bleaching-powder Test.*—A trace of aniline is dissolved in water and treated with a filtered solution of bleaching powder, whereupon an intense blue-violet coloration is produced.

The test also serves for the recognition of benzene, which is converted into aniline beforehand by the method just described.

2. *Slight Solubility of the Sulphate.*—A few drops of the base are treated with dilute sulphuric acid, and the precipitated sulphate is recrystallised from hot water.

3. *Formation of Diazobenzene.*—A few drops of the base are dissolved in dilute nitric acid, and then treated with a few drops of sodium nitrite solution. The solution remains clear, but on warming a vigorous evolution of gas occurs, and a brown oil separates which possesses the characteristic smell of nitro-phenol.

4. A drop of aniline is treated with the same

amount of chloroform, then an alcoholic solution of potassium hydrate is added, and the mixture is warmed. The very unpleasant smell of phenylisonitrile at once makes itself evident. For this reason the experiment is to be carried out in the fume-chamber.

3. Acetanilide. $C_6H_5 \cdot NH(C_2H_3O)$.

20 g. aniline are boiled with 30 g. glacial acetic acid under a reflux condenser, preferably in a flask with a condenser ground into the neck, for 6–10 hours, until a sample on cooling sets to a mass of crystals.

The reaction mixture, while still hot, is poured in a thin stream into about 500 c.c. of hot water. To the substance which has gone into solution is added as much animal charcoal as will lie on the point of a knife, and the liquid is boiled for a minute. It is then poured through a folded filter paper, which has been moistened with hot water and placed in a heated funnel. The acetanilide

which separates from the filtrate on cooling is filtered off at the pump, and dried in a vacuum desiccator. If it be not white in colour, the crystallisation from hot water with addition of animal charcoal must be repeated. The purity of the product is controlled by the determination of its melting point.

For this purpose a small quantity of it is dried, powdered, and introduced into a capillary tube (fig. 4). The determination is carried out in the apparatus shown in fig. 5. The flask is about four-fifths filled with concentrated sulphuric acid. The thermometer reaches to the middle of the liquid and is supported in a cork which is placed loosely in the neck of the flask. The capillary is stuck to the thermometer, which is wetted with a little sulphuric acid, in such a position that the substance is at the centre of the

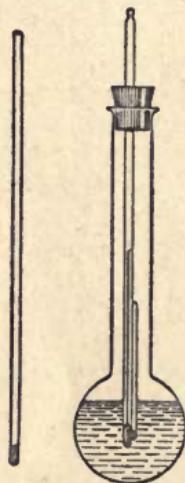


FIG. 4. FIG. 5.

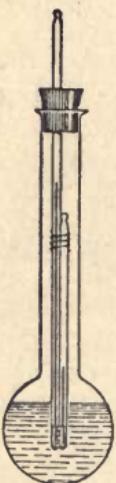


FIG. 6.

bulb. A standardised thermometer¹ must always be used.²

Melting point 115°–116°.

Reaction.—On boiling with alkalies, acet-anilide gives a smell of aniline.

4. Thiocarbanilide. $\text{CS}(\text{NH} \cdot \text{C}_6\text{H}_5)_2$.

50 g. aniline, 50 g. alcohol, 50 g. carbon disulphide, and about 0.25 g. crystalline sulphur are gently boiled for 5–6 hours on a water-bath under an effective condenser in the fume-chamber. This mixture gradually sets to a pasty mass of laminar crystals. Finally, the

¹ Such thermometers are supplied by the leading German instrument-makers, and bear the word "Normalthermometer" etched on the stem.—*Tr.*

² By this method somewhat too low a value is found for the melting point, because only a small part of the mercury thread of the thermometer is in the bath. Most melting points are, however, determined in this way, and are quoted in the literature as "uncorrected." In order to find the true melting point, a table of corrections is prepared for the thermometer by determining in the apparatus shown in fig. 6 its variation from the short Zincke thermometer for a large number of temperatures.



carbon disulphide is distilled off from the water-bath with the condenser attached in the other direction (*Caution! Dangerous inflammability of carbon disulphide*), and the residue is washed with cold, very dilute hydrochloric acid to remove unchanged aniline. The crystals, after filtering off, are dissolved under reflux condenser on the water-bath in a large volume of absolute alcohol. The solution is filtered boiling hot, and hot water is added to the filtrate until a turbidity is just produced. On cooling the thiocarbanilide separates out in crystalline form, and is filtered off and dried in the steam oven. The product must be colourless and odourless; its purity is controlled as before by the melting point (152°). Yield almost quantitative.

5. Phenyl-thiocarbimide (Phenyl Mustard-oil). $C_6H_5 \cdot N = CS$.

30 g. of finely powdered thiocarbanilide are gently boiled with three times that quantity of

concentrated hydrochloric acid for three-quarters of an hour under a reflux condenser in the fume-chamber. The whole contents of the flask are then poured into water; the mustard-oil is distilled off in steam, extracted from the distillate with ether, and after evaporating off the ether the residue is dried with calcium chloride and distilled. Yield 10 g.

Reactions of Phenyl Mustard-oil.

A few drops mixed with a like quantity of aniline react vigorously at once, yielding thiocarbanilide.

Monophenyl-thiocarbamide, which is also solid, is quickly formed on shaking with concentrated ammonia.

6. β -Phenylhydroxylamine.



60 g. nitrobenzene are suspended in $1\frac{1}{2}$ li. water, 30 g. ammonium chloride are added, and 80 g. zinc-dust are then added in small portions in the course of half an hour, the mix-

ture being well stirred meanwhile by means of a turbine. The temperature must be continuously observed, and by suitable cooling maintained between 15° and 17°. In an hour the experiment is usually ended, as may be recognised by the disappearance of the smell of nitrobenzene.

The reaction mixture is filtered as quickly as possible through a folded filter, and to the filtrate 500 g. of finely powdered common salt are added. This immediately precipitates the β -phenylhydroxylamine as a thick mass of colourless needles, which, after standing for half an hour in ice, are filtered off with a porcelain funnel at the pump, and washed with a very little cold water.

The product thus obtained is dried *in vacuo* over sulphuric acid. Yield 54 g.

This product still contains, however, some sodium chloride. To effect complete purification a part of it is recrystallised from hot benzene. Melting point 81°.

Reaction.—Reduction of Fehling's solution.

7. Nitrosobenzene. $C_6H_5 \cdot NO$.

(Bamberger, *Ber. d. d. chem. Ges.*, **27**, 1555.)

2 g. pure and finely powdered β -phenyl-hydroxylamine are dissolved by shaking in an ice-cold mixture of 6 g. concentrated sulphuric acid and 100 c.c. water, and to the solution is then added, in one portion, a previously prepared and well-cooled solution of 2·4 g. potassium bichromate in 150 c.c. water. In a few seconds the crystallisation of the nitrosobenzene commences, and it is complete when the mixture has stood about half an hour in ice. The nitrosobenzene is filtered off at the pump, washed with water, and dried *in vacuo* over sulphuric acid. The yield is nearly quantitative, and the product has the correct melting point (68°).

Experiment.—Some nitrosobenzene is heated in a test-tube with a little water. On boiling, the steam carries with it oil-drops of an emerald-green colour, which have a very choking smell,

and on cooling set to a mass of snow-white crystals. Nitrosobenzene in the solid state is white, but when fused or in solution it is green.

8. Ethyl Benzoate. $C_6H_5 \cdot COOC_2H_5$.

50 g. benzoic acid are dissolved in 100 g. absolute alcohol, 10 g. concentrated sulphuric acid are added, and the mixture is boiled under a reflux condenser for four hours. Finally, about half the alcohol is distilled off on the water-bath, and the residue is diluted with 300 c.c. water, and neutralised with solid, powdered sodium carbonate, in order to remove all sulphuric acid and unchanged benzoic acid.

The oil which has been separated is taken up with ether, the ethereal solution evaporated, and the residue dried over pure potassium carbonate and fractionated. The potassium carbonate should be prepared by heating pure bicarbonate, and must be heated before use to render it quite anhydrous.

Boiling point of the ester, 212° . Yield, 55 g.

9. *m*-Brombenzoic Acid. $C_6H_4Br \cdot COOH$.

6 g. benzoic acid, 8 g. bromine, and about 40 g. water are introduced into a tube of thick-walled, "hard" glass, which has been sealed and rounded off at one end, and at the other drawn off into as strong as possible a capillary. The tube is now heated for about twelve hours

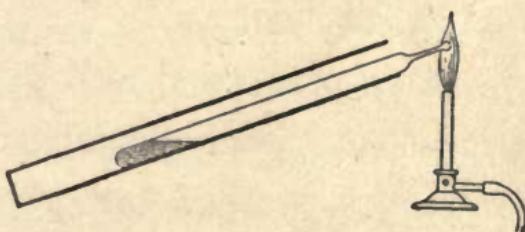


FIG. 7.

at 140° – 150° in an air-bath (the so-called "bomb-furnace" or "shooting-oven"). Such tubes are always opened as soon as they are quite cold in the following way, on account of the high pressure inside them. By carefully inclining the wrought-iron tube the glass tube is brought so far forward that the capillary just projects from the open end, and it is then heated at its extreme tip until the glass melts (fig. 7).

If there is pressure inside, the capillary gets blown out, and a small hole is formed through which the gases escape. This operation must also be carried out in such a manner that if an explosion occurs the fragments of glass cannot endanger anyone. As soon as the gases have escaped, the tube can be taken out from the iron covering, and opened in the usual way by scratching with a file or glass-knife and cracking off with a hot glass bead.

If the operation proceeded well the bromine will have almost completely disappeared. The reaction product is washed out of the tube, filtered, rubbed up in a mortar with water, and then boiled in a flask with about 500 c.c. water for about an hour in order completely to remove unchanged benzoic acid. The solution is finally treated with animal charcoal and filtered hot; on cooling it deposits the brombenzoic acid in crystalline form. One or two crystallisations from water suffice to render it quite pure. Yield 7 g. Melting point 155° .

10. Benzoyl Chloride. $C_6H_5 \cdot CO \cdot Cl$.

50 g. dry benzoic acid are placed in a flask of about 500 c.c. capacity along with 90 g. phosphorus pentachloride, and the mixture is shaken. As a rule the reaction then begins spontaneously. If it does not, the mixture must be gently warmed. The mass liquefies with vigorous evolution of fumes of hydrochloric acid. The reaction is finished as soon as all the benzoic acid has gone into solution.

The liquid is now a mixture of benzoyl chloride, phosphorus oxychloride, and small quantities of phosphorus pentachloride taken in excess. If any phosphorus pentachloride is still undissolved, the liquid part is poured off, and is then fractionally distilled. The portion boiling at 140° - 210° contains the benzoyl chloride, which is purified by further fractionation.

The boiling point of benzoyl chloride is 199° . The yield amounts to about 50 g.

The product must be kept in well-closed vessels in order to protect it from the moisture of the air.

Reactions of Benzoyl Chloride.

1. A few drops of the oil are boiled with water until they go into solution; on cooling benzoic acid separates out. The decomposition takes place more rapidly on warming with sodium hydrate or sodium carbonate, the easily soluble sodium benzoate being formed.

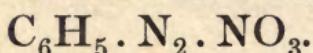
2. A few drops of benzoyl chloride are mixed with about double their volume of alcohol, whereupon the smell of benzoic ester makes itself evident.

3. A few drops of the chloride are mixed with rather more than the same amount of aniline. The liquid gets very hot, and sets to a mixture of aniline hydrochloride and benz-anilide. On washing with water the latter remains undissolved, and may be recrystallised from hot alcohol.

11. Benzamide. $C_6H_5 \cdot CONH_2$.

15 g. commercial ammonium carbonate are finely powdered in a mortar (in the fume-chamber), and to this 10 g. benzoyl chloride are gradually added with constant stirring. If the smell of the latter does not completely vanish, a few grams more ammonium carbonate must be added to the mixture. The mass is now extracted with a moderate amount of *cold* water to remove ammonium chloride and the excess of ammonium carbonate, and the residue after filtration is recrystallised from the smallest possible quantity of hot water. Yield about 6 g.

Instead of the ammonium carbonate a concentrated solution of ammonia may be used, but the yield is not so good. Melting point of benzamide, 128° . On warming with alkalies it quickly evolves ammonia.

12. Diazobenzene Nitrate.

20 g. aniline, contained in a beaker which is well cooled from outside, are carefully treated with concentrated nitric acid of specific gravity 1·41, diluted with half its volume of water, until the whole mass sets to a thick paste of crystals. The crystalline matter is separated as completely as possible by filtration at the pump, and washed with a little water. About 5 g. of the moist salt are powdered, and just covered with water in a small flask; the flask is then carefully cooled in ice water and nitrogen trioxide is led in. The latter is evolved in the flask *a* (fig. 8) from lumps of arsenic trioxide and ordinary nitric acid, and is freed from nitric acid in the empty flask *b*.

The stream of gas may be regulated at will by alternately gently warming the flask *a* or cooling it with cold water.

The température in the small flask *c* must not rise above 10°. The red gas is passed in

until all the aniline nitrate has disappeared, the flask *c* being frequently shaken. Usually the aniline salt dissolves completely, giving a clear solution; only when too little water is present does diazobenzene nitrate separate out during the reaction, but this is easily distinguished from the aniline salt by its crystalline form. As soon as the reaction is finished the contents of *c* are poured into three times their volume of absolute alcohol, and ether is then added as long as the separation of white needles continues.

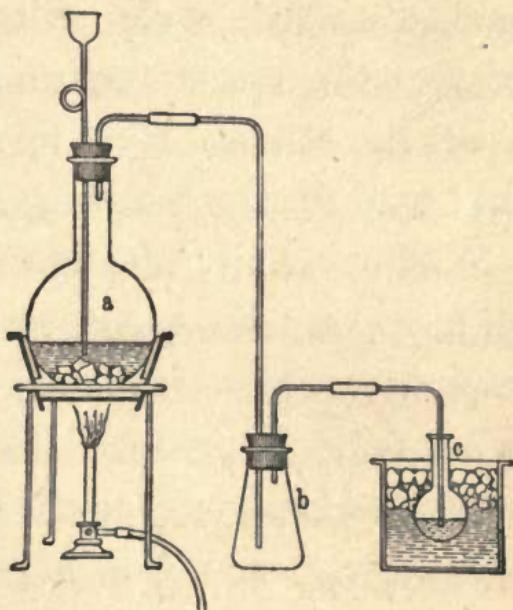


FIG. 8.

If at the beginning too much water has been added to the aniline nitrate, a thick aqueous solution of diazobenzene nitrate separates instead of the crystals. It is then necessary, after pouring off the mixture of alcohol and

ether, to dissolve the substance again in absolute alcohol, and precipitate once more with ether. The precipitated diazobenzene nitrate, which in the dry state is a dangerous explosive, is filtered off at the pump, washed with ether, and dissolved while still damp in ice-cold water ; the aqueous solution is then separated from the ethereal layer by means of a syphon, and used for the following tests :—

1. On warming the liquid vigorous evolution of nitrogen takes place, and a dark brown oil separates, which smells strongly of nitrophenol. This latter is produced by the action of the nitric acid set free on the phenol first formed. For this reason the sulphates and not the nitrates are employed in the preparation of phenols from the aromatic amines.

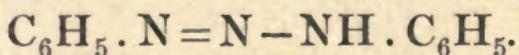
2. If the diazobenzene nitrate solution is treated with an aniline salt and an excess of sodium acetate, a yellow crystalline precipitate of diazoamidobenzene is produced.

3. If an acetic acid solution of dimethyl-aniline is added to the diazobenzene solution,

a splendid red coloration quickly appears.
(Formation of an azo-dye.)

4. If the diazobenzene solution is treated with a solution of bromide in hydrobromic acid, a reddish-brown oil separates out and very quickly sets to a mass of laminar crystals, if it is washed with a little ether after pouring off the aqueous layer. The crystals consist of diazobenzene perbromide, $C_6H_5 \cdot N_2Br_3$. If a sufficient quantity is available, it may be used to prepare diazobenzene-imide. For this purpose the crystals are treated with concentrated ammonia. A vigorous action occurs and the crystals vanish; in their place appears a dark oil of peculiar, stupefying odour, which consists largely of diazobenzene-imide.

13. Diazoamidobenzene.



10 g. aniline are dissolved in a mixture of 100 g. water and the quantity of strong hydrochloric acid calculated for $2\frac{1}{2}$ molecules (the

strength of the acid must be determined with the hydrometer). The solution is then carefully cooled from outside by means of ice-water, and finally by throwing in pieces of ice, and is then converted into diazobenzene chloride by the addition of the exact amount of sodium nitrite required for 1 molecule, dissolved in a little water.¹

An excess of nitrite must be carefully avoided (?), while an insufficient amount of it does not affect the purity of the diazoamidobenzene, but only the yield (?). During the diazotisation a further 10 (or better, 11) g. aniline are dissolved in 50 g. water and just the requisite amount of hydrochloric acid (at most 1 mol. hydrochloric acid to 1 mol. aniline); the mix-

¹ The percentage of nitrite contained in the commercial sodium nitrite must be previously determined by titration with potassium permanganate. With practice, it is possible to work with an uncertain amount of sodium nitrite. The end of the diazotisation is then recognised by testing a drop of the solution on a porcelain tile. As long as the liquid still contains unchanged aniline, the addition of sodium acetate solution to a drop of it gives after a short time a turbidity due to diazoamidobenzene.

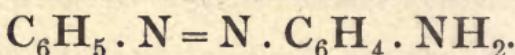
ture is well cooled and added to the solution of the diazobenzene chloride, and then the whole solution is treated with about 40 g. sodium acetate dissolved in a little water.

This precipitates the diazoamidobenzene as a pure yellow, crystalline substance. If the product is dark-yellow or brown, either an excess of diazo-compound is present, or the temperature of the liquid has been too high.

The separation of the diazoamidobenzene continues for some time. When after about half an hour a sample of the mother-liquor gives no further precipitate on addition of more sodium acetate, the solid is filtered off through a porcelain funnel at the pump, carefully washed with cold water, and well pressed to free it as far as possible from the water. The mass is then at once dissolved in hot ligroin of boiling point 70° - 100° or thereabouts, and the solution is filtered hot to remove the water suspended in it. On cooling, the diazoamidobenzene separates in well-formed, dark yellow crystals. If the preparation has been badly

carried out, the crystals have a brown colour.
Yield 15 g.

14. Amidoazobenzene.



10 g. powdered diazoamidobenzene are dissolved in 20 g. aniline, and 5 g. solid aniline hydrochloride are added. The mixture is warmed to 40°–50°, until a sample on warming with alcohol and hydrochloric acid no longer evolves gas. ($\frac{1}{2}$ –1 hour.) The reaction mixture is poured into excess of very dilute acetic acid, and the base which separates is allowed to solidify, filtered off and washed with water. The substance is then boiled up with about 2 li. water, and hydrochloric acid is carefully added until a sample of the bluish-red solution deposits pure blue crystals on cooling. The liquid is then filtered, and on cooling the hydrochloride of amidoazobenzene separates out in steel-blue needles. The remainder of the substance can be precipitated from the solution by adding common salt.

For the preparation of the free base the hydrochloride is boiled with twice its weight of alcohol, and concentrated ammonia is added in drops until everything has dissolved and the colour has changed to light brown.

On cautiously adding water the base separates in small yellow crystals. It may be recrystallised from dilute alcohol. Yield about 8 g.

15. Sulphanilic Acid. $\text{C}_6\text{H}_4 < \begin{matrix} \text{NH}_2 \\ \text{SO}_3\text{H} \end{matrix} \begin{matrix} (1) \\ (4) \end{matrix}$.

50 g. aniline are gradually added, with constant stirring, to 150 g. fuming sulphuric acid (containing 8%–10% anhydride¹), and the mixture is then heated in an oil-bath for 3–4 hours to 170°. The reaction is complete when a sample deposits no aniline on treating with water and a slight excess of sodium hydrate. The whole is then poured into about $\frac{1}{3}$ li. of

¹ This must be prepared by adding about 20 g. commercial fuming sulphuric acid, which contains 70% sulphur trioxide, to 130 g. concentrated sulphuric acid.

ice-water, and the sulphanilic acid crystallises out. It is more or less coloured, according to the purity of the aniline and the way in which the heating has been carried out. For the purpose of purification it is dissolved in rather more than the calculated amount¹ of hot, very dilute sodium hydrate (the sodium salt of sulphanilic acid is difficultly soluble in concentrated alkali), boiled with animal charcoal and precipitated from the filtrate with dilute acid.

If the product is still coloured, the treatment with animal charcoal must be repeated. Yield 55–60 g.

Of the salts of this acid the sodium compound is the best crystallised. It separates on cooling from the concentrated solution of the acid in hot, dilute sodium hydrate in well-formed, colourless crystals.

¹ As far as possible the quantities of reagents should always be calculated beforehand. This is rendered most convenient if the ordinary solutions of acids, alkalies, and salts are made up to be simple multiples of normal strength.

16. Diazobenzene Sulphonic Acid.

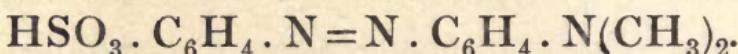


20 g. sulphanilic acid, dried on the water-bath and finely powdered, are dissolved in the heat in the calculated amount of sodium hydrate of about twice normal strength, and the solution is diluted until on cooling to 50° no crystallisation occurs. This solution is now treated with rather more than the calculated amount of sodium nitrite, and the mixture is poured, with constant stirring, into an excess of *cold*, dilute sulphuric acid. In a short time the diazo-compound separates out as a white, crystalline mass. To favour crystallisation the liquid is cooled, and after it has stood for some time the substance is filtered off.

The diazo-compound is comparatively stable: it may even be recrystallised from water at 60°. It also dissolves in alkalies without decomposing, and is precipitated again by acids. The compound can be kept in the dry state, but

must not be dried at 100°. In dealing with the dry product caution is, however, always necessary, for it sometimes explodes violently when rubbed. Yield good.

17. Helianthin.



The diazobenzene sulphonic acid prepared as above described is dissolved in the smallest possible quantity of dilute sodium hydrate, kept cold with ice, and the liquid is poured into a solution of the calculated amount of dimethylaniline in acetic acid. The sodium salt of the dye thereupon separates in shining, reddish-yellow, laminar crystals.

These crystals are filtered off and recrystallised from hot water. If a warm solution of the salt is treated with dilute hydrochloric acid in moderate excess, the free dye is precipitated as a shining, reddish violet, crystalline powder. For the preparation of the dye it is not necessary to isolate the diazo-compound;

one may start with sulphanilic acid and carry out the diazotisation and formation of the dye in one operation, as follows:

1 mol. (10 g.) sulphanilic acid is dissolved in exactly 1 mol. dilute sodium hydrate, treated with 1 mol. sodium nitrite, and then 1 mol. hydrochloric acid is added in the cold. This solution is treated straight away with 1 mol. dimethylaniline in a little hydrochloric acid, and caustic soda is again added. The sodium salt of the dye soon separates out. The precipitation may be rendered more complete by adding common salt.

18. Phenyl-hydrazine. $C_6H_5 \cdot NH - NH_2$.

1. 50 g. aniline are dissolved in $2\frac{1}{2}$ mol. concentrated hydrochloric acid and 300 g. water, well cooled, and diazotised while still carefully cooled with the calculated amount of sodium nitrite. The liquid is then poured into a cold, saturated solution of $2\frac{1}{2}$ mol. sodium sulphite.

For this purpose the commercial solution of sodium bisulphite, containing about 40% NaHSO_3 , is neutralised with caustic soda.

A sample of the liquid must remain clear on boiling, otherwise enough sulphite has not been added. The solution is now warmed in a large, round-bottomed flask on the water-bath in the fume-chamber, treated with zinc-dust and acetic acid until it becomes colourless, then filtered hot from the zinc-dust. The hot filtrate, which contains sodium phenyl-hydrazine sulphonate, is treated at once in the warm with one-third its volume of fuming hydrochloric acid. (*With care!*) The mixture then sets to a crystalline paste of phenyl-hydrazine hydrochloride. When the solution is cold it is filtered off at the pump and freed from the mother-liquor as well as possible by pressing. The salt is treated with excess of caustic soda and well shaken, and the base which separates is taken up with ether. The ethereal solution is dried 12 hours with potassium carbonate, evaporated, and the residue

distilled *in vacuo* with the aid of the apparatus shown in fig. 9. *a* and *b* are distilling flasks. The former is in an oil-bath, and must be only one-third full at most. In order to render boiling easier, a small stream of air is allowed

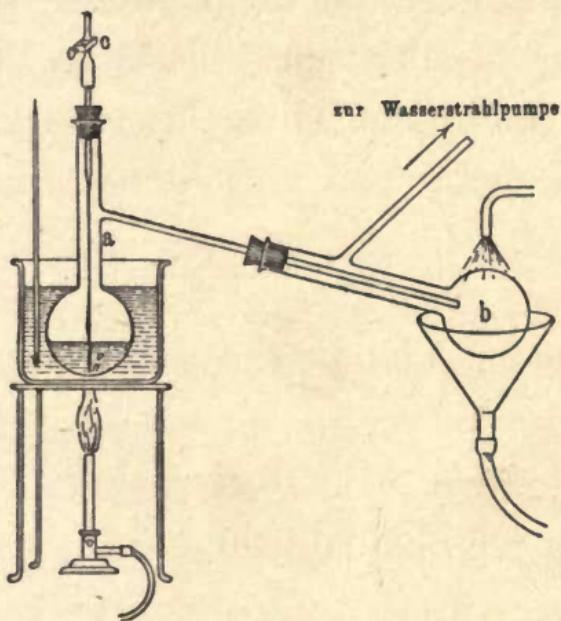


FIG. 9.

to enter through a capillary during the operation, the amount being regulated by the pinch-cock *c*. The second flask is cooled with running water. At a pressure of 12 mm. the phenyl-hydrazine distils from 120°–140°.

2. 10 g. aniline are dissolved in 100 c.c.

concentrated hydrochloric acid, diazotised by addition of the calculated amount of sodium nitrite, and this solution is added slowly, with constant stirring, to a cold, strongly acid solution of tin dichloride, prepared by dissolving 60 g. commercial tin dichloride in hydrochloric acid. The phenylhydrazine which at once separates out is further treated as described above.

Reactions of the Base.

1. It reduces Fehling's solution even in the cold.
2. It yields with hydrochloric acid the difficultly soluble hydrochloride.

19. Benzonitrile. $C_6H_5 \cdot CN$.

(Sandmeyer, *Ber. d. d. chem. Ges.*, 17, 2653.)

The following operations as far as the completion of the distillation in steam are to be carried out in a fume-chamber with a good draught.

In the first place, a solution of copper cyanide is prepared by allowing a solution of 56 g. potassium cyanide in 100 c.c. water to flow gradually into a warm solution of 50 g. copper sulphate in 200 c.c. water, which is contained in a 2 li. flask. A vigorous effervescence occurs at first (*poisonous cyanogen!*), and a precipitate is formed, which afterwards dissolves. The liquid is warmed to about 70° , and to it is added in small portions a solution of diazobenzene chloride, which has been previously prepared by diazotising a solution of 19 c.c. (= 18.6 g.) aniline in 160 c.c. water and 40 c.c. concentrated hydrochloric acid with 15 g. sodium nitrite in 40 c.c. water. When the addition is completed, the liquid is warmed on the water-bath for $\frac{1}{4}$ hour, then the nitrile which swims as a dark oil on the surface is driven over in steam, and the distillate extracted with ether. The ethereal solution is shaken repeatedly with dilute caustic soda and with dilute sulphuric acid, and is finally dried with anhydrous potassium carbonate. The

filtered solution leaves, when the ether has been evaporated off, a brown oil, which is purified by fractionation. The yield amounts to about 13 g.

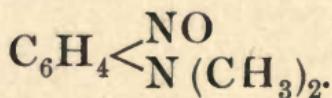
20. Monoethylaniline. $C_6H_5 \cdot NH \cdot C_2H_5$.

50 g. aniline and 65 g. ethyl bromide (rather more than the calculated amount) are kept gently boiling under reflux condenser on the water-bath for 1–2 hours, until the mixture has almost entirely solidified. It is dissolved in water, and the small amount of unchanged ethyl bromide is removed by boiling; the solution is then rendered alkaline with caustic soda, and the precipitated bases are extracted with ether. The oil remaining behind after evaporation of the ether is a mixture of unchanged aniline, mono- and di-ethylaniline. It is dissolved in excess of dilute hydrochloric acid (100 g. fuming hydrochloric acid and 500 g. water), cooled with ice, and treated with about 37 g. sodium nitrite. This leads to the forma-

tion of diazobenzene chloride, nitrosodiethyl-aniline hydrochloride, and ethylphenylnitrosamine. The last separates out as a dark-coloured oil, and is extracted at once with ether.

After evaporating off the ether, the nitrosamine is reconverted into ethylaniline by reduction with tin and hydrochloric acid, in the same way as nitrobenzene; the base is isolated from the hydrochloric acid solution, just as the aniline was, and after drying with potassium carbonate it is distilled. Boiling point 204°. Yield 20–25 g.

21. Nitrosodimethylaniline.



20 g. dimethylamine are dissolved in 100 g. 20% hydrochloric acid, and to the well-cooled solution the calculated quantity of sodium nitrite, dissolved in a little water, is added in drops with constant stirring. The hydro-

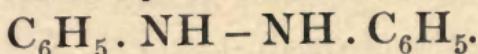
chloride of the nitroso-compound begins to separate out in yellow needles during the reaction. It is allowed to stand for about an hour to complete the crystallisation, then filtered at the pump and washed with dilute hydrochloric acid. The salt can easily be purified by recrystallisation from hot water. To prepare the free base it is suspended in water and decomposed with caustic soda in the cold, the base being extracted with ether. On evaporating off the ether the compound is deposited in splendid yellowish-green laminæ.

Yield almost quantitative.

Reactions.

1. The hydrochloric acid solution of the base is quickly decolorised by tin or zinc. (Formation of *para*-amido-dimethylaniline).
2. When boiled with sodium hydrate the nitroso-compound gives the smell of dimethylamine, and at the same time the alkaline solution turns deep red from formation of nitrosophenol.

22. Hydrazobenzene.



(Alexejew, *Zeitschr. f. Chem.*, 1867, 33; 1868, 497; cf. Erdmann, *Org. Präp.*)

Nitrobenzene is reduced with caustic soda and zinc. In order to hasten the solution of the nitrobenzene, a little alcohol is added.

On account of the vigour of the reaction, the zinc-dust must be added gradually, and the liquid must be well stirred if the action is to proceed well. In addition, the alcohol which distils off during the process must be condensed by means of a reflux condenser.

These conditions are easily fulfilled with the help of the accompanying apparatus (fig. 10). The round-bottomed flask *a* is of about $1\frac{1}{2}$ li.

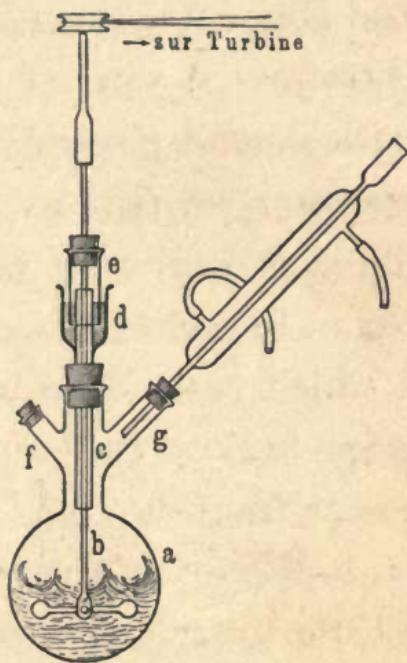


FIG. 10.

capacity ; its neck is about 4 cm. wide ; and the stirring apparatus is made fast in the top of it by means of a rubber bung. Very efficient and convenient for insertion in the flask is the form of stirrer suggested by Schultze, in which the vanes lie vertically downwards when at rest and horizontal when in motion. The stirrer *b* is connected with an efficient water-turbine or with a small electric motor, and should make 400–500 revolutions per minute, so that the liquid is kept very actively in motion. The rod of the stirrer passes through a glass bearing *c* which is fixed with a rubber cork into the large flask. In order that no vapour may escape from the flask, a glass tube *d* is fastened on to the top of the bearing, and in it is placed a little water. A small glass cylinder *e* is fixed to the stirring-rod by means of a rubber cork, and so a very effective “ seal ” is made for the vapour coming from below. Into the neck of the large flask two side-tubes are fused at an angle of 45°. One of them, *f*, has an internal diameter of 2 cm., and is 2–3 cm. long. It is

closed with a cork, and serves for the introduction of the zinc-dust. The other, *g*, is about 5 cm. long and is connected with a reflux condenser. Into the large flask are introduced 50 g. or 42 c.c. nitrobenzene, 180 c.c. caustic soda (30 %), 20 c.c. water, and 50 c.c. alcohol. The mixture being kept in vigorous movement by means of the stirrer, about 10 g. zinc-dust are thrown in through the tube *f*, most conveniently by the use of a small specimen tube. The liquid soon gets warm. The addition of the zinc-dust is continued, but in smaller portions (3-4 g.), until the liquid begins to boil. Since the reaction may become so violent that the mixture froths up and fills the whole flask, it is advisable to wait before each addition of zinc-dust until the frothing has ceased. The risk of frothing over becomes less towards the end of the operation. The process may easily be so carried out that it is completed in about $\frac{3}{4}$ hour. The completion can be recognised by the change in colour of the liquid, which at first is quite red, and at the end only yellowish;

this may be observed if necessary by withdrawing a small quantity of the liquid by means of a pipette, and filtering it. The amount of the zinc-dust which is required depends upon its composition. As a rule 100–125 g. are enough. After all the zinc has been added, the stirring is continued for another 15 minutes; about 1 li. cold water is then added, and the mixture of zinc-mud and precipitated hydrazobenzene is filtered off through a porcelain funnel. When the alkali has been removed by washing with water, and the water as completely as possible by filtration at the pump, the hydrazobenzene is dissolved out by boiling the substance with about $\frac{3}{4}$ li. alcohol on the water-bath. The hot solution is filtered at the pump, and on cooling and subsequent immersion in a freezing mixture the greater part of the hydrazobenzene separates out as an almost colourless mass of shining laminar crystals. The zinc-dust is boiled up again with the mother-liquor, and after filtering the liquid is treated while still hot with a large quantity of

hot water, whereupon the rest of the hydrazo-benzene separates out in nicely crystalline form, though coloured somewhat orange. The total yield amounts to about 33 g., or 88 % of the theory. By recrystallising from hot alcohol, the product may be obtained quite colourless and possessing the melting point 125°-126°. It is best preserved in a sealed tube, since it slowly becomes coloured in the air owing to oxidation.

The behaviour of the substance towards Fehling's solution is characteristic, for, like phenylhydrazine, it reduces it strongly in the warm.

If it is desired to dispense with the stirring arrangement above described, which, though very effective, is rather complicated, a round-bottomed flask of $1\frac{1}{2}$ li. capacity is employed, which carries only the side-tube *f* for introducing the zinc-dust. The neck of the flask is closed with a bung through which passes a fairly wide glass tube; this is joined to a reflux condenser by means of a short rubber tube, so

that the flask can be well shaken with the hand during the reduction. The introduction of the zinc-dust is effected through the side tube, as previously described. As, however, the shaking cannot be carried out so regularly as the stirring, the reaction does not proceed so smoothly, and so the yield is somewhat smaller.

Benzidine.

The conversion of hydrazobenzene into benzidine, $\text{NH}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{C}_6\text{H}_4 \cdot \text{NH}_2$, takes place most smoothly with very dilute acid at a low temperature. 5 g. finely powdered hydrazobenzene are shaken with 125 c.c. of 3 % hydrochloric acid at 20°–30°. If the hydrazobenzene taken is pure, it dissolves almost completely in the course of 15–30 minutes. The liquid is finally warmed to 45°–50° for a short time; a little water is added in case any benzidine salt has crystallised out, and the warm solution is then filtered. From the almost colourless filtrate the sulphate and hydrochloride of benzidine can be precipitated by addition of

sulphuric and hydrochloric acids respectively. To obtain the free base the cold solution is made alkaline with caustic soda, and the precipitate produced is filtered off at the pump and washed with cold water. Yield about 85 %. For complete purification the benzidine is recrystallised from a large quantity of hot water or from a little hot alcohol. The substance melts towards 125°. Unlike hydrazobenzene, the base does not reduce Fehling's solution.

23. Ethyl Iodide. C_2H_5I .

10 g. amorphous phosphorus and 50 g. absolute alcohol are placed in a flask, and in the course of 1-1½ hours 100 g. powdered iodine are added in small portions with frequent shaking. The mixture is shaken round at intervals and allowed to stand at ordinary temperature for some hours, then heated for an hour on the water-bath under a reflux condenser, and finally most of the liquid is distilled off on the water-bath.

The residue consists of amorphous phosphorus and a concentrated solution of phosphorous and phosphoric acids, which cannot be utilised further.

The distillate, which is coloured brown owing to the presence of free iodine, is a mixture of alcohol and ethyl iodide. It is treated with several times its volume of water, and with an amount of caustic soda sufficient, when the liquid is vigorously shaken, completely to decolorise the ethyl iodide which separates out.

The oil is then separated in a funnel, dried with granulated calcium chloride, and distilled off from it on the water-bath.¹ If the alcohol has been removed entirely by the washing with water, the product is chemically pure. When preserved in glass vessels, ethyl iodide gradually acquires a violet or brown colour owing to separation of free iodine. This may be prevented by adding a little finely divided silver to the liquid. Yield 100 g.

¹ All liquids which boil below 100° may be distilled over calcium chloride.

24. Aldehyde and Aldehyde-Ammonia.



200 g. potassium bichromate, rubbed up in a mortar until the pieces are the size of a pea, are treated with 600 g. water in a flask of at least 2 li. capacity which is connected with a condenser and a receiver cooled in a freezing mixture. Into it a mixture of 200 g. alcohol and 270 g. concentrated sulphuric acid is allowed to flow in a slow stream, the flask being frequently shaken. The mixture becomes hot and takes on a green colour, and a considerable amount of aldehyde distils over, along with some alcohol and water. The last portions of aldehyde contained in the reaction mixture are finally driven over by warming.

The distillate is distilled again from the flask *a*, which is placed on a water-bath. The vapour passes through the condenser *d*, which is inclined upwards and by means of the siphon and rubber tube *f* is filled with water at 25°

from the vessel *e*. The flow of this water is controlled by the screw-pinchock *h*.

In the condenser the alcohol and water are condensed, while the aldehyde vapour passes through the tube *i* and the dropping-funnel *b* into the receiver *c*. This last contains dry,

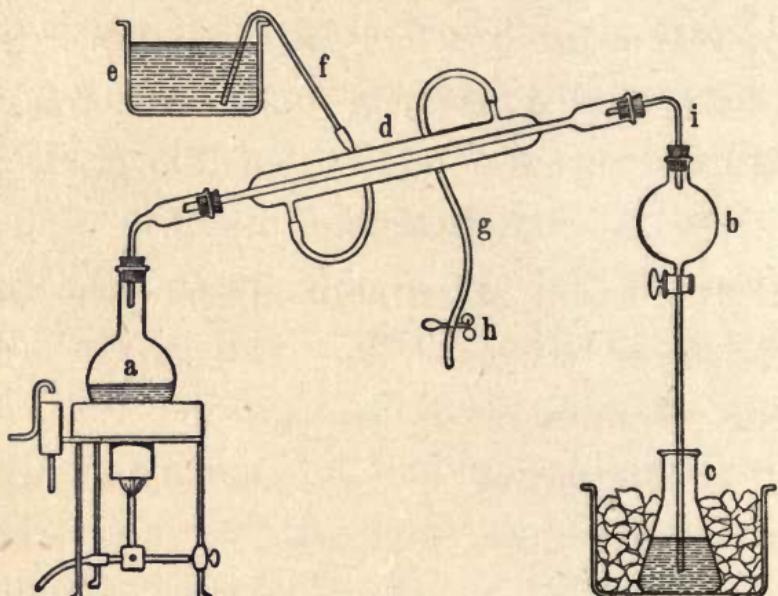


FIG. 11.

well-cooled ether, which readily absorbs the aldehyde. If the ether is afterwards carefully cooled and dry ammonia¹ is passed into it, aldehyde-ammonia at once separates in crystals.

¹ This is either taken from a cylinder, or obtained by heating concentrated ammonia solution and dried by passage over quicklime.

These are filtered off at the pump, washed with ether, and dried on blotting paper. To obtain pure aldehyde the crystals are distilled with dilute sulphuric acid, the aldehyde being dried with calcium chloride and again distilled. Boiling point 21°.

The freshly prepared aldehyde-ammonia may be conveniently employed at once for preparation 57.

Reactions.

1. Reduction of an ammoniacal silver solution—silver mirror. The test may fail if excess of ammonia is present.
2. Coloration of an aqueous aldehyde solution on warming with alkalies.
3. Conversion into paraldehyde by means of a drop of concentrated sulphuric acid.

25. Ethylene Bromide. $C_2H_4Br_2$.

50 g. absolute alcohol are mixed with 300 g. concentrated sulphuric acid and placed in the flask *a* (fig. 12), which has a capacity of about

2 li. (In the drawing the flask is too small in proportion.) The mixture is carefully heated until a vigorous evolution of ethylene begins. From the dropping-funnel, the lower opening of which has been drawn out somewhat, a

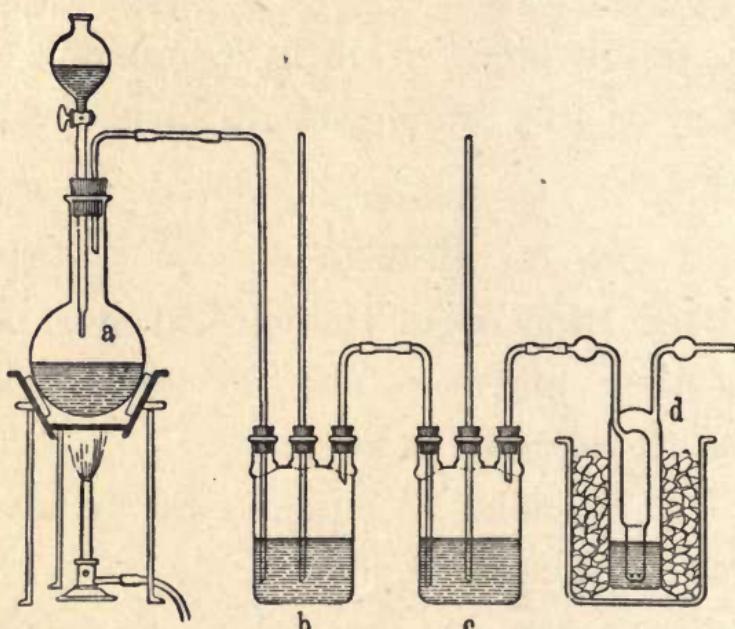


FIG. 12.

mixture of 1 part alcohol and 2 parts concentrated sulphuric acid is allowed to flow in at such a rate that a constant evolution of gas occurs without undue frothing. The gases evolved pass through the two washing bottles *b* and *c*, of which the former is filled with

water, and the latter with dilute caustic soda to which a little phenolphthalein has been added as indicator. From these they pass into the absorption vessel *d*, which contains 100 g. bromine and is cooled in ice. The ethylene is passed in until the bromine is quite decolorised. To effect this it may be necessary to recharge the generating flask. The contents of the absorbing vessel are now washed with dilute caustic soda, and the oil is separated, dried with calcium chloride, filtered from this, and then fractionated. Boiling point 131·5°. Yield 100 g.

26. Glycol. $\text{C}_2\text{H}_4(\text{OH})_2$.

(Zeller and Hüfner, *Journ. für prakt. Chem.*, 11, 229.)

94 g. ethylene bromide, 69 g. pure potassium carbonate (prepared from bicarbonate), and 500 g. water are boiled under reflux condenser for about 10 hours, until all the bromide has disappeared. It is advisable to introduce one or two wooden splints into the flask in order

to facilitate ebullition and the mixing of the oil with the water.

When the oil has disappeared the aqueous solution is evaporated *in vacuo* from a bath containing water at about 50°, the apparatus described in the case of phenyl-hydrazine being used. The crystalline mass which is left behind looks almost dry. It is extracted twice with absolute alcohol, filtered, and the alcoholic filtrate is again evaporated *in vacuo*. The residue is immediately fractionated, preferably at ordinary pressure from an oil-bath. Boiling point of glycol 197°. Yield 9–10 g.

27. Methylamine. CH_3NH_2 .

(A. W. Hofmann, *Ber. d. d. chem. Ges.*, 15, 765.)

25 g. acetamide are freed from oily matter by pressing on a porous tile, or between filter paper with the hand-press, and are then treated with 23 c.c. bromine in a flask of $\frac{1}{2}$ li. capacity. The flask is well cooled in ice-water, and as much of a solution of 40 g. potassium hydrox-

ide in 350 c.c. water is added, in small portions, as is required to turn the solution bright yellow. The liquid is then poured into a solution of 80 g. potassium hydroxide in 150 c.c. water, contained in a litre flask, and previously warmed to about 75° . A thermometer is inserted, and the mixture is then carefully warmed on the water-bath until the temperature has risen to about 70° . The liquid now begins to evolve heat, and care must be taken by prompt cooling to prevent the temperature from rising above 75° . As soon as the solution, maintained at 70° - 75° , has become clear and colourless, while in addition no further spontaneous rise of temperature can be noticed, it is digested for a little while longer at the above temperature, then a condenser is fitted and the amine is distilled off until the distillate is no longer alkaline. The end of the condenser must be connected with a wide adapter bent downwards and immersed to a depth of 1 cm. in dilute hydrochloric acid; or the apparatus described in Prep. 24 may be em-

ployed to prevent the hydrochloric acid from sucking back. When the distillation is finished, the acid solution is evaporated, the powdered residue dried at about 110° and extracted with about 15 times its weight of hot absolute alcohol. There remains undissolved a certain amount of ammonium chloride; from the filtrate methylamine hydrochloride crystallises out in thin, shining laminæ. It is convenient to filter the hot solution at the pump through a porcelain funnel which has been warmed beforehand in the drying oven. The substance remaining in the mother-liquor can be obtained by evaporating the solution to about one-third of its original volume.

The yield amounts to about 13 g. methylamine hydrochloride.

Reactions of Methylamine.

1. On warming a little with concentrated caustic soda, the smell of the gas may be noticed, also its inflammability.
2. A concentrated aqueous solution of the

salt is treated with platinum chloride : crystalline form of the chloroplatinate under the microscope. To be compared with ammonium chloroplatinate.

3. Behaviour of the acidified aqueous solution on adding a few drops of sodium nitrite solution and gently warming.

4. *Isonitrile Test.* (See Aniline.)

5. *Mustard-oil Test.*—As much methylamine hydrochloride as will lie on the point of a small knife is treated in a test-tube with 1–2 drops of concentrated sodium hydrate, then with a drop of carbon disulphide and 3–4 drops of alcohol. To the mixture is added a little water and an excess of dilute silver nitrate solution. On now heating to boiling point, the very choking smell of methyl-mustard-oil makes itself evident.

The conversion of an acid into an amine can also be effected by the method of Curtius, *via* the ester, hydrazide, azide, and urethane (*Journ. f. prakt. Chem.*, 50, 275, 295; 52, 210–215, 227, 243).

28. Benzyl Chloride. $C_6H_5 \cdot CH_2Cl$.

100 g. toluene and 5 g. phosphorus pentachloride, as chlorine carrier, are weighed in a flask of about 300 c.c. capacity, then allowed to boil gently under an efficient reflux condenser, while a pretty rapid stream of dried chlorine is passed through from a cylinder.

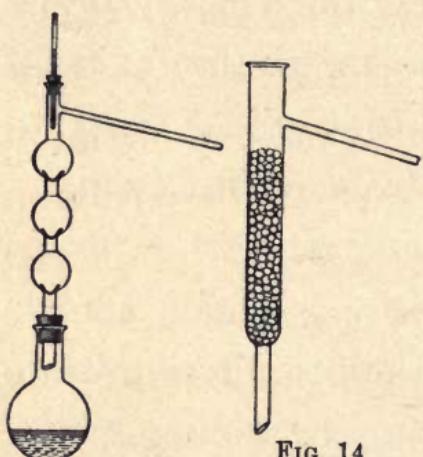


FIG. 13.

FIG. 14.

The operation is interrupted when the increase in weight of the flask amounts to about 37 g., corresponding to the addition of 1 atom of chlorine. This in-

crease in weight is very quickly reached in sunlight, but on dull days it is only attained after several hours.

The reaction mixture is immediately subjected to fractional distillation. Unchanged toluene passes over first, then follows the main

part of the distillate, the benzyl chloride, which is collected from 160°–190°, and as residue there remains a mixture of products containing a greater proportion of chlorine, especially benzal chloride.

The benzyl chloride is purified by a second fractionation. For this the ordinary fractionating flasks should not be used, but preferably the apparatus due to Linnemann shown in fig. 13, in which the lower openings of the three bulbs are each covered with a piece of platinum gauze; or the Hempel fractionating column filled with glass beads may be employed (fig. 14).

Boiling point 176°. Yield about 50 g.

29. Benzaldehyde. $C_6H_5\cdot CHO$.

50 g. benzyl chloride are boiled with 40 g. copper nitrate and 250 g. water for 5–8 hours, until a sample of the oil is found to contain no chlorine, or, at any rate, only very little. In order to avoid the oxidation of the aldehyde

vapour by the air during this long process, it is necessary to lead a slow current of carbon dioxide through the apparatus; in the later operations also the air must be excluded as far as possible.

The oil is now extracted with ether, the ether evaporated, and the oil continuously shaken with a concentrated solution of sodium bisulphite—the commercial solution of 40 % NaHSO_3 being used. The substance sets to a mass of crystals of the aldehyde-bisulphite compound. A few hours later these are filtered off at the pump and washed, first with a little water, then with alcohol. When the alcohol has been removed by the pump, the crystals are warmed with dilute sulphuric acid, and the liberated aldehyde extracted with ether. The ethereal solution is dried with anhydrous sodium sulphate, the ether evaporated, and the aldehyde distilled. Boiling point 179°. Owing to the ready oxidisability of benzaldehyde, a considerable loss occurs. Yield only 16–20 g.

30. Benzyl Alcohol. $C_6H_5 \cdot CH_2 OH$.(R. Meyer, *Ber. d. d. chem. Ges.*, 14, 2394.)

50 g. benzaldehyde are shaken until a permanent emulsion is formed with a cold solution of 45 g. solid caustic potash in 30 g. water in a stoppered bottle of 300–400 c.c. capacity. The mixture is allowed to stand for 15–20 hours, during which time it solidifies owing to separation of potassium benzoate. Water is now added sufficient to dissolve the crystals, and the benzyl alcohol goes into solution as well. The liquid is therefore straightway extracted several times with ether, and the ethereal solution treated with sodium bisulphite solution to remove the small proportion of unchanged benzaldehyde. The ether is separated, carefully washed with dilute caustic soda, filtered and evaporated. The residual oil is fractionated, and the greater part of it passes over within a few degrees, being pure benzyl alcohol. The yield amounts to about 90% of the theory. Boiling point of the alcohol 206°.

31. Benzoin. $C_6H_5 \cdot CO \cdot CHO \cdot C_6H_5$.(Zincke, *Liebigs Ann.*, 198, 150.)

50 g. benzaldehyde are boiled with 5 g. fresh potassium cyanide (the commercial product containing 96 % KCN), 100 g. alcohol, and 100 g. water for 15–20 minutes under reflux condenser. On cooling the benzoin separates out in a crystalline mass. It is filtered at the pump, and recrystallised from alcohol with the addition of animal charcoal. The first mother-liquor is again heated to boiling with about 2 g. potassium cyanide, and the benzoin formed is separated as before. Yield about 45 g. Melting point 134°.

32. Benzil. $C_6H_5 \cdot CO \cdot CO \cdot C_6H_5$.

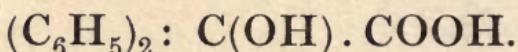
20 g. benzoin are heated with nitric acid of sp. gr. 1·41 on the water-bath. A vigorous reaction takes place: the crystals soon change into a yellow oil, which is at first a mixture of

benzil and benzoin. By frequent shaking care is taken that the oil comes into close contact with the acid.

The oxidation takes 1-2 hours. The completion of the conversion is best recognised by means of Fehling's solution. To carry out the test, a drop of the oil is poured into water, where it at once crystallises ; the crystals are dissolved in alcohol and diluted with water ; Fehling's solution is then added and the liquid is warmed to 60° - 70° . As long as benzoin is still present, a precipitate of cuprous oxide is formed. As soon as the oxidation is finished the product is poured into water, and when the crystalline mass has set it is dissolved in hot alcohol. On cooling the benzil separates out in splendid yellow prisms. The yield is very good.

The purity is controlled by the determination of the melting point, 95° .

33. Benzilic Acid.



In a silver or copper¹ crucible 40 g. solid potassium hydroxide are melted with a little water, then the liquid is allowed to cool to 150°, and 10 g. dry benzil are added with constant stirring. The benzil melts, and is soon converted into a solid mass of potassium benzilate. As soon as all the oil has disappeared, the whole is dissolved in water and the benzilic acid precipitated by acidifying with hydrochloric acid. When the solution is cold the crystalline matter is filtered off and washed with cold water.

The raw acid thus obtained generally contains small quantities of benzoic acid. To remove

¹ For most fusions with caustic alkali crucibles and spatulæ of copper may be employed, and are to be preferred because they are so much cheaper than silver.

To determine the temperature of the fused substance, ordinary thermometers can be used, if they are protected from the action of the alkali by means of a close-fitting covering of thin copper foil. If strong enough, they may also serve as stirrers.

this, the product is boiled in a dish with water until the smell of benzoic acid has disappeared.

The benzilic acid, which is not volatile, is then purified by recrystallisation from hot water. Yield almost quantitative.

Melting point 150°.

Characteristic Reaction.

The acid dissolves in concentrated sulphuric acid, giving a splendid reddish-violet colour, which on dilution with water disappears again.

The following newer mode of preparation is more convenient.

(H. v. Liebig, *Ber. d. d. chem. Ges.*, 41, 1644.)

20 g. benzil, 20 g. solid potassium hydroxide, and 40 c.c. water are placed in a flask, and when the potash has dissolved 50 c.c. alcohol are added. The flask is set on a boiling water-bath and the contents allowed to boil for 10–12 minutes (not longer); the solid thereupon gradually dissolves and the solution becomes

brown. The liquid, which is sometimes already full of crystalline matter, is poured while boiling hot into a beaker, and crystallisation is accelerated by cooling and stirring. The thick paste of crystals, which is coloured dark green by the admixed mother-liquor, is filtered off at the pump through hardened filter paper after standing for half an hour in ice. The solid is well pressed and carefully washed with 40–50 c.c. ice-cold alcohol, so that the filtrate finally runs through almost colourless. The well-pressed, almost colourless mass of crystals is then dissolved in about 400 c.c. water, and the pale yellow solution after filtration is heated to boiling in a dish. On acidifying with about 20 c.c. boiling hot, dilute sulphuric acid, part of the benzilic acid is precipitated as a yellowish oil, which, however, at once crystallises ; the rest separates out in colourless needles on cooling the solution.

The yield amounts to about 90 % of the theoretical.

34. Cinnamic Acid. $C_6H_5.CH:CH.COOH$.

(*Perkin's Reaction.*)

20 g. benzaldehyde, 30 g. freshly distilled acetic anhydride, and 10 g. anhydrous (*i.e.* fused), finely powdered sodium acetate are boiled together for 8 hours under a reflux condenser in an oil-bath. The reaction mixture is poured while still hot into four or five times its volume of water, and steam is passed through until all the unchanged benzaldehyde is driven off. At the same time the excess of acetic anhydride gets distilled over, or dissolved as acetic acid. The residue, which is a mixture of water and acetic acid, in which a brown oil is suspended, deposits on cooling a considerable quantity of cinnamic acid.

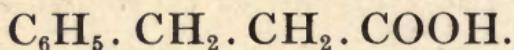
The mixture is therefore not filtered, but treated at once in the warm with excess of solid sodium carbonate. The cinnamic acid dissolves at once in the form of its sodium salt, and the solution is filtered hot through a wet folded filter paper to remove the undissolved oil.

On acidifying the filtrate with hydrochloric acid a crystalline mass of cinnamic acid separates out even in the warm. To complete the crystallisation the liquid is allowed to cool ; the precipitated cinnamic acid is then filtered off, and purified by one or two crystallisations from hot water.

Determination of melting point 133°.

Yield 15–20 g.

35. Hydrocinnamic Acid.



10 g. powdered cinnamic acid are dissolved in 50 g. water, and the calculated amount of sodium hydrate in a stoppered bottle of about 200 c.c. capacity, and to the solution $2\frac{1}{2}$ % sodium amalgam¹ is gradually added with

¹ For the preparation of the amalgam, 500 g. pure, dry mercury are poured into a porcelain mortar in a fume-chamber with a good draught, and the $2\frac{1}{2}$ % of metallic sodium are added in fairly rapid succession in pieces as big as a two-shilling piece, each separate slice being pressed on to the bottom of the mortar by means of the

vigorous shaking. If the amalgam is of good quality, 200 g. of it will suffice.

Finally, the alkaline solution is poured off from the mercury, precipitated with hydrochloric acid, and the hydrocinnamic acid which separates is purified by recrystallisation from a sufficient quantity of water. The purity is controlled by a determination of the melting point, 47°. Yield very good.

36. Hexahydrobenzene. C₆H₁₂.

(Sabatier and Senderens, *Comptes rend.*, 132, 210.)

A mixture of equal weights of nickel oxide and coarsely powdered pumice is moistened with water, dried, broken up to a coarse powder, and reduced with hydrogen in a 40 cm. compstle. In this way it is possible, if some care is exercised, easily to avoid troublesome inflammation of the metal and the projection out of the dish of pieces of burning sodium. Nevertheless, it is absolutely necessary during the operation to protect the eyes with the glass window of the fume-chamber, and the hands by means of gloves.

The product is stored in stoppered bottles with wide mouths and protecting caps.

bustion tube at as low a temperature as possible. The conversion is accompanied by a change of colour from black to light grey. It is complete when no more steam is evolved. The tube is then heated to 180° – 190° in a suitable furnace (*e.g.* a Volhard petroleum furnace, fig. 15), and a slow stream of dry hydrogen is led through,

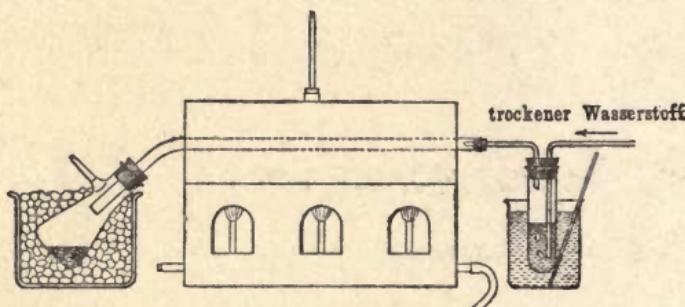


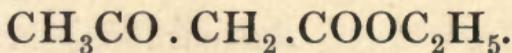
FIG. 15.

which on the way has passed through a vessel containing about 30 c.c. of benzene. The hexahydrobenzene formed condenses in the ice-cooled receiver. The stream of hydrogen should not exceed 100 c.c. per minute. In order to shorten the operation, the benzene may be warmed to 30° . After about 7 hours the process is stopped. The benzene which has not been volatilised is weighed, and the

distillate, which contains some benzene, is treated with a nitrating mixture of sulphuric and nitric acids. The oil is separated from the heavier acid, washed with water, and dried over calcium chloride. On fractionating, hexahydrobenzene passes over at 80° - 82° .

Yield at least 80 % of the benzene volatilised.

37. Acetoacetic Ester.



(Wislicenus, *Liebigs Ann.*, 186, 214.)

By means of the press 30 g. sodium wire are pressed into 300 g. best commercial ethyl acetate, and the flask is at once connected with a reflux condenser. The liquid soon begins to boil. When the evolution of heat slackens, the flask is heated on the water-bath until the metal has completely dissolved. Dilute sulphuric acid (1 : 5) is now cautiously poured, with constant shaking, into the liquid, while the latter is still warm, until the reaction is acid; it is then allowed to cool. The two liquids are very thoroughly mixed by shaking,

and when they have separated again the upper layer is removed, washed once more with a little water, and then the greater part of the unchanged ethyl acetate is distilled off from a flask on the water-bath. The residue is then several times fractionally distilled. The fraction from 175°–185° contains almost pure acetoacetic ester. The yellow residues which remain in the distilling vessel set on cooling to a solid crystalline paste of dehydracetic acid. The yield of acetoacetic ester amounts at most to 50 g., but is often considerably less if the solution of the metal took a long time, or if (this comes to the same thing) larger quantities are employed in one operation.

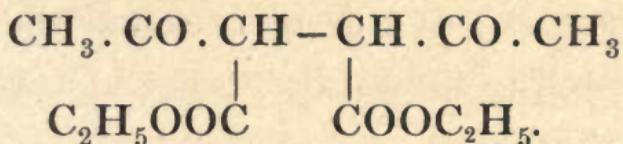
Reactions of Acetoacetic Ester.

1. *Coloration with ferric chloride.*

2. *Solubility in alkalies.*—The ester is precipitated again by acids. If, however, the alkaline solution is boiled for some time, the ester is completely decomposed, yielding alcohol, carbon dioxide, acetone, and smaller quantities

of acetic acid. It suffers similar decomposition on lengthy boiling with dilute acids.

38. Diacetosuccinic Ester.



In a stoppered bottle of 500 c.c. capacity provided with a reflux condenser 25 g. aceto-acetic ester are dissolved in 150 g. pure ether which has been dried over sodium, and to this solution 5 g. sodium are added, preferably in the form of fine wire. The wire is made with the aid of a press. During the pressing it is necessary to let the wire fall straight into ether, or, better, into toluene, in order to protect it from the moisture of the air.

A vigorous evolution of hydrogen accompanies the gradual conversion of the sodium into an extremely finely divided mass of sodio-acetoacetic ester. The main reaction is complete in 1-2 hours. Part of the sodium is then so covered by the sodio-acetoacetic ester that

it is not further acted upon. The bottle is therefore closed for a moment with the stopper and vigorously shaken. The metal becomes bright again, and the evolution of hydrogen begins afresh. If this operation is repeated a few times, the metal disappears in a comparatively short time.

20 g. finely powdered iodine are now dissolved in pure ether, and the solution added in small portions, with constant shaking, to the sodio-acetoacetic ester. The reaction takes place at once, and a large amount of sodium iodide is precipitated. As soon as the colour of the iodine no longer vanishes at once the solution is filtered, the ether evaporated off, and the diacetosuccinic ester allowed to solidify. It is then pressed on a porous tile, and recrystallised from warm 50 % acetic acid.

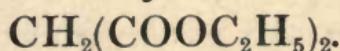
Characteristic Reaction of 1,4 Diketones.

(L. Knorr, *Ber. d. d. chem. Ges.*, 19, 46.)

A small quantity of diacetosuccinic ester is dissolved in glacial acetic acid, a solution of

ammonia in excess of acetic acid is added, and the mixture boiled for half a minute. Dilute sulphuric acid is then added, and the liquid boiled again while a pine-wood splint is held in it. An intense red coloration of the splint indicates the formation of a pyrrole derivative.

39. Diethyl Malonate.



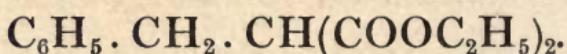
100 g. powdered chloracetic acid are treated with 150 g. broken ice and dissolved in 125 g. caustic soda of $33\frac{1}{3}\%$ strength. If the liquid is still acid, it is exactly neutralised with caustic soda, and then treated with a solution of 69 g. potassium cyanide in 130 g. water, which has a temperature of 40° . The mixture becomes warm spontaneously, and the temperature rises to 50° - 60° . After standing for an hour it is slowly warmed to 100° , and maintained an hour at this temperature. It is then allowed to cool to 20° ; 125 g. caustic soda of the above strength are again added, and the liquid is again warmed to 100° , until

no more ammonia is evolved. This is usually the case after 2-3 hours. When a sample of the liquid treated with more sodium hydrate gives no more ammonia on boiling, the conversion of the cyanacetic acid into malonic acid is complete. A warm 25 % solution of calcium chloride is then added as long as a precipitate is produced. For this purpose about 120 g. of commercial anhydrous calcium chloride, or the corresponding amount of the crystallised salt, are required. The precipitated calcium malonate forms at first a thick amorphous paste, but in the course of 24 hours changes completely into a crystalline mass. It is filtered off at the pump, washed with a very little water, and well pressed, preferably with the hand-press. The salt is finally dried on the water-bath; it then still contains some water of crystallisation, which it loses at 100° *in vacuo*, but its removal is not necessary for the present purpose. The yield amounts to 90-95 % of the theory.

For the esterification with alcohol and

gaseous hydrochloric acid 250 c.c. absolute alcohol are employed to 100 g. calcium salt, which has been dried as well as possible on the water-bath, and a flask of about 1 li. capacity is used. As the calcium malonate is apt to stick together in lumps during the operation, it is best to pour the whole of the alcohol over about 20 g. of the salt to begin with. A rapid stream of well-dried hydrochloric acid is passed in, so that the liquid becomes warm, and fresh portions (each time 15–20 g.) are then introduced in the course of half an hour, as fast as the salt disappears, until everything has dissolved, and the alcoholic liquid is saturated with hydrochloric acid. After standing for 24 hours the solution is evaporated to a small volume under diminished pressure, and the residual ester taken up in ether. The ethereal solution is dried with calcium chloride, the ether is distilled off, and the residue fractionated.

Boiling point 197°–198° (corr.). Yield 75 % of the theory.

40. Benzylmalonic Ester.

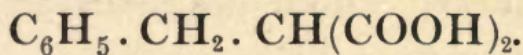
(M. Conrad, *Liebigs Ann.*, 204, 174.)

7.2 g. sodium (1 atom) are dissolved in 150 c.c. absolute alcohol, then 50 g. malonic ethyl-ester and 43 g. pure, commercial benzyl chloride are added. In a few minutes' time much heat is evolved, and the clear solution deposits a precipitate of sodium chloride ; after 10 minutes the alcohol is evaporated off on the water-bath without previous filtration. The reaction of the liquid is at the end only weakly alkaline. The residue is treated with water to dissolve the sodium chloride, and the oil which separates is taken up in ether. The ethereal solution is dried with potassium carbonate, or with anhydrous sodium sulphate ; the ether is distilled off, and the residue is fractionated under diminished pressure. At 11 mm. pressure the benzylmalonic ester passes over for the most part at 166°–169° as a colourless mobile oil. The distillate is collected up to

175°. The yield amounts to 45–50 g. (calculated 78 g.). A second fractionation yields 40–45 g. of a product, which boils at 166°–168°.

The ester boils under 15 mm. pressure at 173°, under 20 mm. at 183°, and under 25 mm. at 188°.

41. Benzylmalonic Acid.



30 g. benzylmalonic ester are made into an emulsion with 35 g. concentrated caustic potash (sp. gr. 1·32) (2·2 mol.) by vigorous shaking in a round-bottomed flask of about 250 c.c. capacity. On gently warming on the water-bath, solution suddenly occurs. The saponification is completed by heating for an hour longer on the water-bath, and most of the alcohol produced is evaporated at the same time. A small amount of oil is precipitated, and this is removed by extraction with ether. An amount of dilute hydrochloric acid is now

added to the aqueous solution, rather more than equivalent to that of alkali taken, and in order to remove the benzylmalonic acid set free the liquid is extracted with ether, first with 50 c.c., and then several times with portions of 25 c.c. each.

The ethereal solution is dried with anhydrous sodium sulphate, filtered, and the ether is then evaporated off completely, the last traces being removed in the vacuum desiccator. The almost colourless residue solidifies entirely. Yield 21 g. The raw product is recrystallised from 140 c.c. hot benzene. Melting point 117° (corr.). Yield of pure substance 19.5 g. (theory 24 g.).

Conversion into Hydrocinnamic Acid.

1 g. benzylmalonic acid is heated in a wide test-tube in a bath to 180° . A vigorous evolution of carbon dioxide begins, and continues for about 10 minutes. On cooling the mass solidifies. It is recrystallised from hot water, and has the melting point of hydrocinnamic acid, 47° . Yield almost quantitative.

42. Terephthalic Acid. $C_6H_4(COOH)_2$.(Beilstein, *Liebigs Ann.*, 133, 41.)

10 g. commercial *p*-xylene are boiled under reflux condenser with a mixture of 40 g. potassium bichromate, 30 c.c. concentrated sulphuric acid, and 60 c.c. water. The solution gradually acquires a green colour, and the terephthalic acid separates out, especially on the sides of the flask, as a slightly coloured, incoherent mass. After 15 hours the unattacked hydrocarbon is distilled off in steam, and the cooled solution is filtered. To purify the raw terephthalic acid which has separated, it is dissolved in a warm, dilute solution of sodium carbonate, and precipitated again from the filtrate by means of hydrochloric acid. Yield 4 g. Characteristic of this acid is its extremely slight solubility in water, alcohol, and ether.

43. Pyruvic Acid. $CH_3.CO.COOH$.

100 g. tartaric acid and 240 g. potassium pyrosulphate are finely powdered, carefully

mixed, and then distilled from an oil-bath, the temperature of which must not rise above 220° . As distilling vessel is employed a round-bottomed flask which has at least 2 li. capacity, and of which the neck has been cracked off as short as possible.

During the distillation, which takes 4 or 5 hours, a quantity of strongly smelling gases is evolved (hence the fume-chamber must be used), and an aqueous solution of pyruvic acid passes over. The distillation is interrupted when no further amount of oil-drops appears in the condenser. The distillate is at once subjected to fractional distillation, the fraction from 130° – 180° being collected separately, and purified by another rectification. The purified pyruvic acid boils at 165° – 170° .

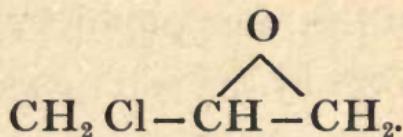
Yield 20–25 g.

Reaction with Phenylhydrazine.

An acetic acid solution of phenylhydrazine is treated with an aqueous solution of pyruvic acid; the reaction product separates out at

once in beautiful yellow needles. This serves for the recognition of pyruvic acid.

44. Epichlorhydrin.



200 g. glycerine, which has been heated to remove water in open dishes (in the fume-chamber) until a thermometer placed in it indicated 170° , are dissolved in the same volume of glacial acetic acid, and into this solution is passed a rapid stream of hydrochloric acid, generated and dried in the usual way, until the liquid is saturated at ordinary temperature. The solution is then warmed on the water-bath, and the passage of hydrochloric acid continued about 6 hours more. The mixture is allowed to stand for about 12 hours, and is then subjected to fractional distillation. At first a large amount of hydrochloric acid is evolved, then aqueous acetic acid distils over, and finally a mixture of dichlorhydrin and acetodichlorhydrin. The fraction from 160° - 220° is

collected by itself, and worked up for epichlorhydrin without further purification.

From the fraction 110°–160° a small amount of the same product can be precipitated in oily form by the addition of water. The total yield of raw product amounts to about 120 % of the glycerine used.

The conversion of this product into epichlorhydrin is effected by treating it with aqueous alkali. 100 g. caustic potash are dissolved in twice that weight of water; the solution is cooled to room temperature, and it is then gradually poured into the raw dichlorhydrin with continual shaking and cooling with water. The oily product changes into mobile epichlorhydrin. The conversion takes place at room temperature smoothly and pretty completely, but the alkaline solution must not be allowed to get very warm, because then the epichlorhydrin itself is further saponified. When the operation is finished the epichlorhydrin is repeatedly extracted with ether; the ethereal solution is dried with sodium sulphate and

filtered ; the ether is then evaporated, and the residue fractionated. (See benzyl chloride.) The fraction boiling above 130° is for the most part unchanged aceto-dichlorhydrin, and is again treated with caustic potash. Boiling point of epichlorhydrin 119°. Yield about 45 g.

Reaction.

The substance dissolves on warming in caustic potash ; *i.e.* it is converted into glycerine.

45. Acrolein. $\text{CH}_2:\text{CH}.\text{CHO}$.

200 g. glycerine, dried as described in No. 44, and 400 g. potassium bisulphate, which has been broken into pieces the size of a pea, are introduced into a metal retort of the shape shown in fig. 16, which has a volume of at least 4 li. It is well to let the mixture stand in the closed vessel for several days beforehand. *a* is a vessel of copper, or, preferably, of iron, with a strong projecting rim, on which the lid *c* is fastened air-tight by means of the clamping-screws *c* and a ring of asbestos card. The

glass tube *d* is inserted in the neck of the lid, and leads to the condenser, which is connected air-tight with a two-bulb receiver or with a fractionating flask. From the receiver, which is best made of metal, and is placed in a freezing mixture, a tube leads into the chimney of an efficient draught-cupboard. The contents of

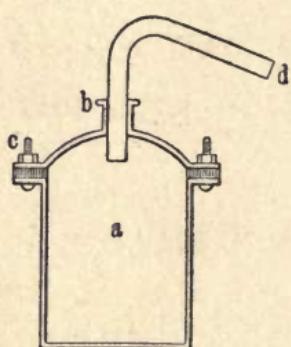


FIG. 16.

the retort are slowly heated with the aid of a gas-furnace. At first only water distils over, then the mass becomes brown and froths up, and a considerable amount of acrolein distils, in addition to water and sulphurous acid. The distillation takes several hours, and is only stopped when no further considerable quantity of liquid passes over.

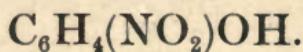
The distillate consists of two layers, of which the upper is acrolein and the lower water. It contains much sulphur dioxide. To remove this, the liquid is treated with powdered litharge until the latter is no longer converted into

white lead sulphite even on vigorous shaking. As soon as this is the case, the whole is distilled off from the water-bath, care being again taken that the receiver is well cooled.

On account of the horrible smell of acrolein, all these operations are carried out in the fume-chamber. The product obtained is dried with calcium chloride and again distilled from the water-bath. The more rapidly the work is carried out the smaller is the loss from polymerisation. Yield about 35 g.

The product polymerises on standing; the change takes place in a few minutes if the acrolein is treated with a little alkali or with a solution of potassium cyanide.

46. Ortho- and Para-nitrophenol.



50 g. crystallised phenol are slowly added to 300 g. nitric acid of sp. gr. 1.11 with constant shaking and cooling by means of cold water. The liquid acquires a dark brown colour even

at the commencement, and soon deposits a dark, resinous mass. It is shaken round at intervals, and allowed to stand for some hours in the cold; the acid is then decanted as well as possible from the oil, which is washed a few times with water and distilled in steam. Only the *ortho*-nitro-compound passes over, in the form of a pure yellow oil which crystallises in long needles in the receiver. Yield 15–20 g. The product does not require further purification. The *o*-nitrophenol may be obtained in beautiful crystalline form as follows: the product purified by steam distillation is carefully dried between filter paper; it is then dissolved in absolute ether, and about one and a half times its volume of petroleum ether is added. As the liquid spontaneously evaporates, splendid crystals are deposited. Melting point 45°.

For the preparation of the *para*-compound, the tarry residue from the distillation is boiled up with dilute caustic soda and animal charcoal, and filtered. The dark coloured alkaline solu-

tion is evaporated, and then treated with very concentrated caustic soda (1:1). The sodium salt of *para*-nitrophenol then separates out, especially on cooling, as a yellow, crystalline mass. It is freed from the mother-liquor by being spread on a porous plate, then again dissolved in a little water, and precipitated with caustic soda. The nitrophenol is obtained from the pure sodium salt by the action of acids as an oil, which crystallises, and is recrystallised from hot water with the addition of a few drops of dilute hydrochloric acid. Melting point 114°.

47. Picric Acid. $C_6H_2(NO_2)_3OH$.

10 g. phenol are mixed with 10 g. concentrated sulphuric acid, and the mixture is added in very small portions to about 30 g. nitric acid of sp. gr. 1·4. A vigorous reaction occurs, with a tremendous evolution of red fumes. The mixture is now warmed for 1-2 hours on the water-bath, as long as any considerable

action of the nitric acid is to be observed. During the heating the liquid loses its initial dark colour, which changes to a golden yellow. At the same time a dark yellow oil is often precipitated ; this consists chiefly of dinitro-phenol. In order to convert this latter completely into picric acid, the mixture is repeatedly warmed with fuming nitric acid (with care) on the water-bath, until finally a clear, brown liquid is obtained, and a sample of the solution, diluted with water, gives yellow crystals, which dissolve to a clear solution in boiling water, without leaving behind any oil. The whole is now poured into water, and when the liquid is cold the crystals which separate are filtered off and recrystallised from hot water.

48. Anisole. $C_6H_5 \cdot OCH_3$.

(Ullmann, *Liebigs Ann.*, 327, 114.)

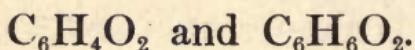
30 g. phenol are dissolved in 100 c.c. water, and 40 c.c. caustic soda of ten times normal strength in a round-bottomed flask of 500 c.c.

capacity. 50 c.c. commercial dimethyl sulphate¹ are added to the solution, which is then *continually* shaken. The beginning of the reaction is shown by the solution's becoming turbid, like milk, while a light layer of oil floating on the aqueous solution takes the place of the heavy dimethyl sulphate at the bottom of the liquid. A fair amount of heat is evolved in the action, and care is taken by cooling that the temperature (to be examined by means of a thermometer dipping in the liquid) remains at 40°–50°. The reaction is finished as soon as no more heat is evolved, and the temperature begins to sink below 40°, even when not externally cooled. To destroy the excess of dimethyl sulphate the liquid is then heated to boiling with frequent shaking. When it is cold again it is treated with caustic soda till the reaction is alkaline; ether is then added,

¹ Dimethyl sulphate has no smell, but it is poisonous. Care must therefore be taken not to inhale its vapour. The above operations, until the dimethyl sulphate has been destroyed, must therefore be carried out in the fume-chamber.

and after thoroughly shaking in a separating funnel the two layers are separated. The ethereal solution is then dried with anhydrous potassium carbonate, preferably at once by shaking in the funnel, then filtered and warmed on the water-bath till all the ether has evaporated. The residue is purified by fractionation. The boiling point of anisole is 155°. The yield amounts to 90 % of the theory.

49. Quinone and Hydroquinone.



(Nietzki, *Ber. d. d. chem. Ges.*, **19**, 1467; Schniter, *ibid.*, **20**, 2283.)

29 g. aniline are dissolved in 600 c.c. water and 160 g. sulphuric acid; the solution is cooled to 10°–12°, and then at exactly the same temperature and with constant shaking 20 g. finely powdered potassium bichromate are added in the course of an hour, in portions of 1 g. at a time. The liquid is allowed to stand overnight, and then a further 40 g. potassium bichromate are added in the same way and at

the same temperature as before, until the blue-black colour of the solution has changed to brown. The solution is now at once extracted several times with a fair quantity of ether. If the ethereal layer is difficult to separate from the aqueous solution, a few c.c. of alcohol may be added to the ether each time after shaking ; this causes the solid particles suspended in the ether to sink more quickly. On evaporating the ether the quinone remains as a yellowish-brown coloured, crystalline mass. The quantity of raw product amounts to about 20 g. The purification of quinone is best effected by distillation in steam in the following way. The quinone is placed in the dry state in a distilling flask, and a rapid current of steam is led over it. The steam quickly carries with it the quinone, which separates out again in the condenser and receiver in bright yellow crystals. When the distillation is effected in this manner only a little quinone is lost. 20 g. raw product yield about 17 g. distilled, chemically pure substance.

To convert it into hydroquinone the pure, very finely powdered quinone is suspended in water, and sulphur dioxide¹ is passed in until complete solution and decolorisation has taken place. The liquid is now repeatedly extracted with ether, and when the solution is afterwards evaporated the hydroquinone is left as a crystalline mass.

The formation of greenish-black quinhydrone in the reduction of quinone should be especially noticed.

50. Salicylic Aldehyde. $C_6H_4(CHO)OH$.

(Tiemann and Reimer, *Ber. d. d. chem. Ges.*, 9, 824.)

50 g. phenol are mixed with a solution of 100 g. sodium hydroxide in 160 g. water; the solution is warmed to 50°–60° in a flask provided with a reflux condenser, and then 75 g.

¹ If liquid sulphur dioxide cannot be obtained, the gas may be prepared from the commercial solution of sodium bisulphite. When concentrated sulphuric acid is allowed to fall into it from a dropping-funnel, a stream of gas is produced, which is regular and easy to control.

chloroform are gradually added in small portions through the tube of the condenser.

A vigorous reaction takes place, and the initially pale yellow liquid acquires first a violet and finally a deep red colour. When all the chloroform has been added, the reaction mixture is warmed under reflux condenser for half an hour longer, and the excess of chloroform is then distilled off.

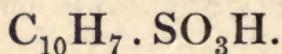
The aqueous solution is now acidified with dilute sulphuric acid, and distilled with steam as long as any considerable quantity of oil-drops passes over. The whole of the distillate, which contains phenol and salicylic aldehyde, is extracted with ether, and the ethereal solution, after being somewhat concentrated, is thoroughly shaken for a long time with a concentrated solution of sodium bisulphite.

The compound of salicylic aldehyde and bisulphite separates out in thin shining laminæ, which often make the whole liquid a pasty mass. In this process the phenol remains dissolved in the ether. As soon as a sample

of the ethereal liquid, when shaken with a little sodium bisulphite, deposits no more crystals, the whole mass is filtered, pressed, and washed with alcohol to remove completely the ethereal solution of phenol. The pure crystals are then decomposed with dilute sulphuric acid in the warm ; the salicylic aldehyde is taken up in ether, and, after evaporating off the ether, dried with calcium chloride and distilled. Boiling point 196°.

The yield amounts to about 17 % of the phenol used.

51. β -Naphthalene Sulphonic Acid.



To 120 g. 96 % sulphuric acid, previously warmed to 90°–100°, 100 g. finely powdered naphthalene are added a little at a time with constant stirring. When all has been added (in about a quarter of an hour), the mixture is slowly heated to 160° and maintained 12 hours at this temperature. If the naphthalene is

good, in this time all of it but a few parts per cent. will be sulphonated, and except for a slight turbidity the liquid will dissolve entirely in water.

The solution is now poured into $1\frac{1}{2}$ li. water, neutralised at boiling temperature with milk of lime, and filtered hot through a cloth. The calcium sulphate is well pressed, boiled up again with 1 li. water, again filtered through linen and well pressed. The filtrates are evaporated until a sample sets to a thick paste on cooling.

The concentrated liquid is allowed to crystallise for 24 hours, and after filtration the calcium salt is pressed as dry as possible, so that the more soluble salts of the α -mono-sulphonic acid and of the di-sulphonic acid are removed in the mother-liquor.

To convert the calcium salt into the sodium salt, it is dissolved in a large quantity of hot water and treated, at boiling temperature, with sodium carbonate solution, until a sample, after filtering, gives no further precipitate with sodium carbonate.

The solution of the sodium salt is filtered at the pump, and evaporated until crystals begin to separate in the hot liquid. It is then allowed to crystallise, pressed, and the moist salt dried on the water-bath.

If the mother-liquor of the sodium salt is again worked up for salt by concentrating it, it is easy to obtain, if the work is well done, from every 100 g. naphthalene 130–150 g. sodium β -naphthalene-sulphonate, which is free from α -sulphonic acid and di-sulphonic acid.

52. β -Naphthol. $C_{10}H_7 \cdot OH$.

In a copper crucible heated by a powerful flame 300 g. solid caustic soda, containing as high a percentage of NaOH as possible, and 30 g. of water are melted and raised to a temperature of 280° , being stirred meanwhile with a copper spatula. (This operation requires caution. The eyes and hands must be protected. The temperature is measured by means

of a thermometer encased in a copper sheath.) 100 g. very finely powdered and dried sodium β -naphthalene-sulphonate are then added as quickly as may be, with constant stirring. The addition is regulated by the temperature, which must not sink much below 260° . When all is added the temperature is raised quickly, with constant stirring, to 320° .

The course of the fusion is as follows :—

The caustic soda, which at a temperature of 280° is quite mobile, becomes somewhat thicker on the addition of the sodium β -naphthalene-sulphonate ; but if the temperature does not sink below 260° , it can still be stirred quite easily. When all the salt is added and the temperature approaches 300° , the fused substance begins to increase in volume from formation of steam, and turns into a bright yellow, sticky mass. This characteristic appearance indicates the commencement of the reaction, which at 310° – 320° is complete in a few minutes, and is accompanied by a vigorous evolution of steam, froth, and bubbles.

The end of the process is recognised by the fact that the above-mentioned yellow, sticky mass becomes darker and quite mobile, and if the stirring is stopped it separates into two layers ; of these the upper is brownish-yellow and transparent, and consists for the most part of sodium-naphthol with a little caustic soda and sulphite.

When the "melt" has settled into these two layers the flame is removed, and the sodium-naphthol is either ladled out, or mechanically separated from the caustic soda underneath when it is cold. The sodium-naphthol is dissolved in hot water and decomposed while hot with hydrochloric acid of 15 % strength. After it has cooled, the naphthol is filtered off at the pump and washed with water. It is best recrystallised from a large quantity of hot water.

From 100 g. good sodium β -naphthalene-sulphonate it is easy to obtain 55 g. β -naphthol.

53. Reduction of Naphthol to Naphthalene.

(Distillation with Zinc-dust.)

(Baeyer, *Liebigs Ann.*, 140, 295.)

As regards the way in which it is carried out, the operation resembles a volumetric nitrogen determination. In order to obtain the zinc-dust in a state corresponding to the coarse copper oxide, small pieces of pumice are moistened and shaken with zinc-dust until the whole surface of the stone is covered. They are then dried for 4 hours at 150°. The combustion tube, which is drawn out at one end so that a stream of hydrogen can be led through it, is charged as follows: first a layer, 10 cm. long, of zinc-pumice, then a carefully prepared mixture of 3 g. β -naphthol and 30 g. zinc-dust, and finally such an amount of zinc-pumice that the tube is altogether two-thirds full. A channel is then made through the tube by gentle tapping, and it is then placed in a combustion furnace which is somewhat inclined, so

that the open part of the tube is below and the whole of the empty portion projects out of the furnace. A stream of dry hydrogen is passed through until the air is displaced, and then the current of gas is made slower, while first the zinc-pumice and finally the mixture of naphthol and zinc-dust are raised to a feeble red-heat. The naphthalene formed distils and sublimes into the empty, projecting part of the tube. If it threatens to cause a stoppage, the place affected is warmed by drawing the tube back into the furnace for a little while, until the mass has melted. Only very small amounts of naphthalene are carried away by the stream of hydrogen ; if it is desired to recover these, or if, as in other cases, the products of distillation are easily volatile, it is necessary to attach an adapter to the tube and lead the vapour into some condensing arrangement. When the distillation is finished (it takes altogether about three-quarters of an hour) the part of the tube containing the naphthalene is cut off, and the hydrocarbon taken out with a spatula and

recrystallised from a little hot alcohol with the addition of animal charcoal. If the product is still coloured, it is completely purified by sublimation. Melting point 79°. Yield about 1 g.

54. Potassium Cyanate and Urea.



(Erdmann, *Ber. d. d. chem. Ges.*, 26, 2442.)

Commercial, coarsely powdered yellow prussiate of potash is spread out in thin layers in large dishes, and heated to a moderate temperature until the crystals are splintered in all directions. The salt is then, while still warm, rubbed to a fine powder and dried for some hours at a similar temperature.

Before using the product it is indispensable to make sure (by heating a sample in a test-tube) that it contains no trace of water. 200 g. of this anhydrous potassium ferrocyanide are intimately mixed while warm with 150 g. fused potassium bichromate, and the mixture is then introduced in portions of 5–6 g. into the same iron dish, which is however now heated with a

powerful triple-burner. When the bright incandescence which occurs on each addition is over, the blackened mass is pushed each time to the edge of the dish. No ammonia should be evolved in the process. The black product is powdered while warm, and in a boiling water-bath of sufficient size it is boiled for two minutes with thorough shaking with a previously warmed mixture of 900 c.c. 80% alcohol and 100 c.c. methyl alcohol. The clear solution is decanted through a folded filter into an Erlenmeyer flask kept cold in a freezing mixture. The mother-liquor from the cyanate which crystallises out is at once poured back on to the black mass and again boiled up for two minutes. Five or six repetitions of the operation suffice to exhaust the latter completely. The different portions of cyanate are filtered through the same funnel, washed with ether, and dried over sulphuric acid. Yield 80–90 g.

The mother-liquor filtered off is at once worked up for urea by adding to it, with constant shaking, a solution of 70 g. ammonium

sulphate in 100 c.c. hot water. When the precipitated potassium sulphate has been filtered off, the alcohol is distilled off. The residue after evaporation to dryness is extracted with 96 % alcohol, which dissolves out the urea. The substance is obtained quite pure by recrystallising once from boiling amyl alcohol (in the fume-chamber).

Reactions of Urea.

1. Precipitation with nitric acid.
2. Precipitation with mercuric nitrate.
3. Decomposition by boiling alkali with liberation of ammonia.
4. Decomposition by nitrous acid. Nitrogen and carbon dioxide are evolved, even in the cold.

55. Alloxan and Alloxantine.

15 g. finely powdered uric acid¹ are treated

¹ Uric acid is obtained by boiling 25 g. snake excrement with very dilute caustic soda (50 g. 40 % solution to 500 g. water) in a round-bottomed flask until it is nearly all dissolved. The liquid is filtered hot, and to the filtrate hydrochloric acid is added.

in a flask with 30 g. fuming hydrochloric acid (sp. gr. 1·19) and 40 g. water, and 4 g. powdered potassium chlorate are gradually added to the solution, which has previously been warmed to about 30°. The addition must be spread over three-quarters of an hour. Except for slight impurities, the uric acid goes entirely into solution. When this is the case the liquid, filtered if necessary, is diluted with about 30 g. water, and then a pretty strong current of sulphuretted hydrogen is led in until it is saturated. Amorphous sulphur is first precipitated, and then crystalline alloxantine as well. The separation of the latter is finally completed by well cooling the liquid, and the whole precipitate is filtered and washed with cold water. The mass is then boiled up with hot water and the undissolved sulphur is filtered off. Alloxantine separates out from the filtrate when cold in pure white, finely developed prisms. Yield 10–12 g.

Reactions of Alloxantine.

1. Coloration with baryta-water.
2. Reduction of an ammoniacal silver solution.

To convert it into alloxan the finely powdered alloxantine is treated with about $1\frac{1}{2}$ parts of water, warmed on the water-bath, and then concentrated nitric acid is added in drops, until all the alloxantine has gone into solution. The solution is placed in a desiccator over sulphuric acid. After some time the alloxan separates in splendidly formed, transparent crystals, which are freed from adherent mother-liquor by pressing on blotting-paper or on a porous tile.

Reactions of Alloxan.

1. *Formation of murexide.*—A small quantity of alloxan is dissolved in a few drops of water on a piece of platinum foil and carefully evaporated; a red spot remains which, when treated with ammonia, acquires a reddish-purple colour.

2. *Formation of alloxanic acid.*—An aqueous solution of alloxan, when treated with an excess of baryta-water, gives a white precipitate of barium alloxanate.

56. Quinoline. C₉H₇N.

(Skraup, *Monatshefte*, 2, 141.)

24 g. nitrobenzene, 38 g. aniline, 120 g. glycerine, and 100 g. concentrated sulphuric acid are cautiously mixed in a flask of 1½ li. capacity, and heated together under reflux condenser in a fume-chamber, until the reaction just begins. If the flame is removed this does not proceed too vigorously. When it is finished the liquid is kept boiling for two hours longer, then it is diluted with water, and the nitrobenzene distilled off in steam. The solution is rendered alkaline with sodium hydrate and again distilled with steam. The distillate contains quinoline and aniline. To remove the latter the mixture is treated with an excess of hydrochloric acid, and sodium

nitrite is then added until the smell of nitrous acid persists even on shaking; the solution is heated to boiling until all the diazobenzene is destroyed (*i.e.* till the evolution of gas has ceased). The liquid is now made alkaline again with caustic soda and distilled with steam. The distillate is extracted with ether; the latter is evaporated and the residual quinoline dried with solid caustic potash and distilled. Yield about 40 g.

Boiling point 237°.

A few drops of the base are dissolved in hydrochloric acid and treated with platinum chloride. The chloroplatinate is precipitated as an orange-yellow compound, which crystallises from hot, dilute hydrochloric acid in red needles.

57. Hydrocollidine- and Collidine-dicarboxylic Esters.

(Hantzsch, *Liebigs Ann.*, 215, 8.)

13 g. freshly prepared aldehyde-ammonia are treated in a beaker with 50 g. acetoacetic ester and the mixture is warmed over a free

flame. The aldehyde-ammonia dissolves, and very soon the liquid becomes turbid owing to separation of water. The heating is continued till the solution boils gently; the flame is then removed if the action becomes vigorous, and replaced when the ebullition subsides again. In five minutes the reaction is complete, and the liquid is viscous and rendered turbid by the numerous drops of water in it. About an equal volume of dilute hydrochloric acid is then added to the liquid with constant stirring. In a short time the oil sets to a white crystalline mass. This is filtered off, washed with dilute hydrochloric acid, then with water, pressed, and finally recrystallised from the smallest quantity of hot alcohol. The first crop amounts to about 27 g. and is almost chemically pure. By concentrating the mother-liquor a further 7 g. may be obtained, but this product is less pure.

For the conversion into collidine-dicarboxylic ester the carefully powdered hydro-compound is treated with approximately the

same weight of alcohol, and gaseous nitrous acid (prepared from arsenic trioxide and nitric acid) is passed into the mixture, which is cooled meanwhile with water, until a clear solution is produced and a sample of the liquid dissolves entirely in dilute hydrochloric acid. The alcohol is then evaporated, the residual oil shaken with excess of dilute sodium carbonate solution, and finally taken up with ether. The oil which remains behind on evaporating the ether is dried with potassium carbonate and distilled. The collidine-dicarboxylic ester passes over within a few degrees at 305°. The yield of pure, distilled ester amounts to about 80 % of the hydro-compound.

Concerning the further conversion of the ester into collidine-dicarboxylic acid see *Ann.*, 215, 26.

58. α -Methylindol (Methylketol). C_9H_9N .

(*Liebigs Ann.*, 236, 126.)

30 g. phenylhydrazine are treated with rather more than the calculated amount of com-

mmercial acetone (boiling point 56°–58°). As a rule 18 g. acetone are sufficient. The mixture gets very hot and soon deposits a considerable quantity of water. To complete the reaction the liquid is warmed for about half an hour on the water-bath, and then a drop of the solution is tested with Fehling's solution. If the latter is strongly reduced unchanged phenylhydrazine is still present, and so more acetone must be added, until finally the reducing power has become very slight.

The oil, which is rendered turbid by water-drops, is first heated for about half an hour in a large copper crucible on the water-bath in order to remove the excess of acetone; the residue is then mixed with 200 g. commercial, dry zinc chloride, and again heated on the water-bath with frequent stirring, in order to effect a thorough mixing.

If the crucible is now placed in an oil-bath heated to 180°, the mass begins to get brown in a few minutes. The vessel is then removed from the bath. The reaction is soon complete

if the mixture is stirred; it may easily be followed by observing the coloration and evolution of steam. To dissolve the zinc chloride the dark-coloured melt is treated on the water-bath with three to four times its volume of water and a little hydrochloric acid, and the whole liquid is straightway distilled in steam. The methylketol passes over, slowly but completely, as a pale yellow oil which quickly solidifies. It is filtered off, melted again, and when it has solidified it is freed as far as possible from adherent water by blotting it with filter paper. The substance is finally distilled. Yield 20 g.

The product must be preserved in well-closed vessels, preferably in sealed tubes.

Reaction with Wooden Splint.

A small quantity of methylketol is boiled in a test-tube with water, and into the vapour a pinewood splint moistened with strong hydrochloric acid is introduced. The wood acquires a vivid red colour.

59. Diphenyl. $C_6H_5 \cdot C_6H_5$.

Diphenyl is prepared by heating the vapour of benzene to a red heat. The boiling flask *S*, of about $1\frac{1}{2}$ li. capacity (fig. 17), contains 500 g. benzene which can be heated to boiling by means of a water-bath. The flask is provided with a cork bored with three holes. Through one of the holes passes the safety-funnel *a*; through the second the tube *b*, which leads to the iron tube *R*, which is filled with pieces of pumice, and is heated to a bright red heat in an efficient combustion furnace. For the tube *R* a wrought-iron tube of about 1 m. length and 20 mm. internal diameter (such as is used for gas-piping) may be employed. The benzene vapour passes from the boiling-flask into the red-hot tube, and is there partially converted into diphenyl, hydrogen, and other products. The unchanged benzene, along with the volatile diphenyl, passes on through the tube *e* into the condenser *K*, flowing thence back again into the flask through the tube *c*, the end of which

is below the surface of the benzene. The tube *d* allows the hydrogen to escape from the apparatus. The operation is continued for 6–10 hours, the apparatus working continuously. The contents of the flask then consist of a pretty concentrated solution of diphenyl in

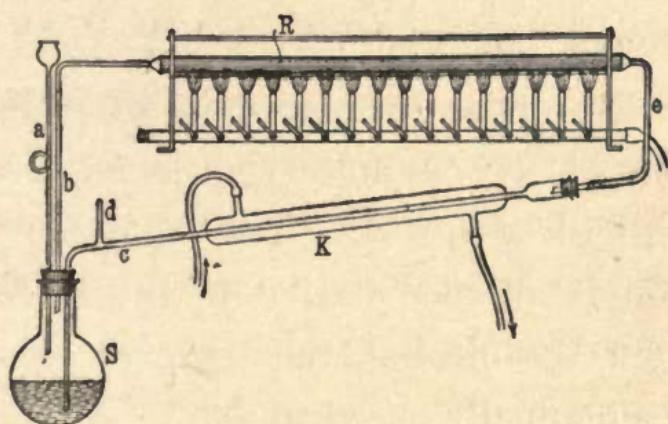


FIG. 17.

benzene. The latter is distilled off from the water-bath and the residue fractionated. The fraction boiling above 150° solidifies in the receiver, and consists of almost pure diphenyl. It is purified by recrystallisation from alcohol. The yield depends considerably on the temperature. If the gas-pressure is poor the ordinary combustion furnace is not hot enough; in this

case a Fletcher furnace or a coke-furnace may preferably be used. When the process is well carried out the yield exceeds 100 g.

60. Benzoyl-acetone.



(Claisen, *Ber. d. d. chem. Ges.*, 20, 2179.)

4 g. sodium are dissolved in 60 g. absolute alcohol (which is as anhydrous as possible) in a boiling-flask with a short but wide neck. This solution is at once heated in the oil-bath to drive off the alcohol, the temperature of the bath being finally raised to 200°. At the same time a slow current of very carefully dried hydrogen is passed through the flask. In this way the sodium ethylate required for the preparation is obtained as a completely white, dry crust, which may usually be freed from the walls of the vessel by careful shaking, and with the aid of a glass rod broken up sufficiently to enable it to be taken out of the flask. If this is not possible, the flask is smashed. The

sodium ethylate is quickly powdered in a mortar, at once returned to the flask, and, while well cooled with ice-water, treated with 35 g. dry ethyl acetate. After about 15 minutes 20 g. acetophenone are added, and the crystallisation of the sodium benzoyl-acetone then quickly begins. Ether is now added, and the mixture is allowed to stand for some hours in order that the separation of the sodium compound may be complete. It is afterwards filtered and washed with ether till the liquid runs through clear. The sodium compound is dried at ordinary temperature, dissolved in cold water, and the benzoyl-acetone precipitated with acetic acid. The raw product is an almost colourless, crystalline mass which is almost pure. Yield about 19 g.

Reactions of Benzoyl-acetone.

1. Its solution in dilute alcohol gives an intense Bordeaux red colour with ferric chloride, and with copper acetate a green, crystalline precipitate of the copper salt.

2. Benzoyl-acetone dissolves very readily in cold sodium hydrate, but decomposes on warming with production of acetophenone, which separates in oily drops if the solution was not too dilute.

61. Benzophenone. $C_6H_5 \cdot CO \cdot C_6H_5$.

100 g. benzoic acid are heated to boiling with rather more than the calculated amount of slaked lime and ten times the weight of water, until the acid is completely dissolved and the liquid reacts alkaline. It is then filtered hot from the excess of slaked lime. On cooling most of the calcium benzoate separates out from the filtrate in white needles. The remainder is obtained on evaporating the mother-liquor. The salt is filtered as well as possible at the pump, pressed by means of the press, and completely dried in metal dishes over a free flame.

The mass is now introduced into a metal retort (made of iron or copper: see under

acrolein), which is connected with a long condenser-tube. The retort must not be filled more than two-thirds full at most. It is heated over a powerful gas-burner, so that the dry distillation of the salt proceeds as quickly as possible. A pale brown coloured mixture of benzene, benzophenone, and aromatic products first distils over. The distillation is stopped when the distillate becomes brown and viscous. The distillate is dried with calcium chloride, and then fractionated. The fraction 250° – 310° contains the benzophenone. The product sometimes soon solidifies, but more frequently remains syrupy for days. The crystallisation begins, however, at once when a small quantity of solid benzophenone is added. The crystals are freed from the oily mother-liquor by pressing between filter paper or by spreading on a porous tile, and are recrystallised from ligroin.

Yield 15–20 g. Boiling point of benzophenone 305° .

$\text{C}_6\text{H}_5 \cdot \underset{\parallel}{\text{C}} \cdot \text{C}_6\text{H}_5$
62. Benzophenone-oxime. ||
 NOH

10 g. pure benzophenone and 12 g. hydroxylamine hydrochloride are dissolved in a mixture of 130 c.c. alcohol and 80 c.c. water, and after the addition of a solution of 20 g. sodium hydroxide in 30 c.c. water are boiled for an hour under reflux condenser.

The reaction mixture is then treated with a large quantity of water and acidified with dilute sulphuric acid, whereupon the benzophenone-oxime separates out in crystalline form.

After standing for some hours the product is filtered, washed with water and dried.

The yield is almost quantitative, and the substance is pure without further treatment.
Melting point 141°.

• Beckmann Transformation.

Conversion of Benzophenone-oxime into Benzanilide.

3 g. benzophenone-oxime are dissolved in 40 c.c. absolute ether which has been dried over

sodium, and to this solution 4 g. very finely powdered phosphorus pentachloride are added in small portions.

The ether is then distilled off, and the oily residue, which consists of phosphorus oxychloride and benzalide chloride, is rubbed up in a mortar with broken ice. This converts the oil into a solid, granulated product, which is finely powdered, filtered at the pump, washed with water and dried. The transformation proceeds quantitatively. The benzalide ($C_6H_5 \cdot CO \cdot NH \cdot C_6H_5$) formed is recrystallised from boiling alcohol, and is then quite pure. Melting point 162° .

63. Phenanthrene-quinone. $C_{14}H_8O_2$.

(Gräbe, *Liebigs Ann.*, 167, 139.)

30 g. phenanthrene (as pure as possible) are dissolved in the heat in 120 g. acetic acid, and a solution of 70 g. chromic acid in about 200 g. strong acetic acid is gradually added. This latter solution is prepared by dissolving the

chromic acid in a very little water, and then pouring the aqueous solution into glacial acetic acid. The mixture gets warm spontaneously, and it is easy so to carry out the operation that the temperature remains approximately at the boiling point of the acetic acid. Finally most of the acetic acid is distilled off and the residue is then treated with water. The reddish-yellow crystalline mass precipitated, which contains the quinone along with some unchanged hydrocarbon, is filtered and washed with a little hot water. To purify the raw product it is treated in the warm with a dilute solution of sodium bisulphite; the filtrate is warmed on the water-bath, and the quinone precipitated by acidifying with sulphuric acid. This product is then recrystallised from a large quantity of boiling alcohol.

64. Triphenylmethane. $\text{CH}(\text{C}_6\text{H}_5)_3$.

(Friedel and Crafts, *Bull. soc. chim.*, 37, 6.)

A mixture of 500 g. benzene, as pure and dry as possible, and 100 g. chloroform, con-

tained in a 2 li. flask, is gently warmed, and 150 g. sublimed, powdered aluminium chloride¹ is added in four or five portions. The mixture is then warmed for about 2 hours under reflux condenser, so that the benzene is kept boiling. The reaction product is now constantly shaken and *very cautiously* poured into an equal volume of ice-water, hydrochloric acid being afterwards added until the aluminium compounds are dissolved.

The benzene solution is separated, freed from suspended water by pouring it through a dry folded filter, and distilled on the water-bath. In carrying out all these operations great caution must be exercised on account of the great inflammability of benzene vapour. The residue is distilled from a fractionating flask which has been covered with asbestos paper, the fraction which passes over above 150° being collected separately.

¹ Bottles filled with aluminium chloride must be opened with care owing to the pressure which frequently exists in them.

In this process a vigorous evolution of hydrochloric acid takes place towards 200° ; it is due to the decomposition of complicated chlorides. Above this temperature a mixture of diphenylmethane and triphenylmethane distils. The distillation is continued, without a thermometer, until the residue suffers evident decomposition. The raw distillate is again fractionated; the triphenylmethane distils above 300° , and solidifies in the receiver. For the purpose of purification it is dissolved in hot benzene; on cooling, finely developed crystals separate, which consist of a compound of benzene with triphenylmethane. If necessary these may again be recrystallised from benzene in the same manner. The crystals easily lose their benzene when warmed on the water-bath, and by recrystallising the fused residue from hot alcohol the pure triphenylmethane is obtained in colourless prisms or laminæ of melting point 93° . The yield depends largely on the quality of the aluminium chloride used, and may amount to 10–30 g.

Conversion of Triphenylmethane into Rosaniline.

A small quantity of the hydrocarbon (about 0·5 g.) is dissolved in a few c.c. of cold, fuming nitric acid. On addition of water, the nitro-compound is precipitated in yellow flocculent masses. This is filtered, dissolved in hot glacial acetic acid and reduced with zinc-dust. The solution, after dilution with water, is filtered, rendered alkaline with ammonia, and the base precipitated is filtered off. This product contains a considerable quantity of para-leucaniline. If a sample of it be heated with strong hydrochloric acid on platinum foil, the beautiful colour of fuchsine quickly appears when the acid has evaporated.

65. Triphenyl-carbinol. $(C_6H_5)_3C \cdot OH$.

(Grignard Reaction.)

1·2 g. of bright magnesium ribbon is cut into pieces 1–2 cm. in length, and is treated in a well-dried, round-bottomed flask of about 300 c.c. capacity with a solution of 8 g. phenyl

bromide in 40 g. sodium-dried ether, to which a scrap of iodine has been added. If the flask is now warmed under reflux condenser in a stream of dry hydrogen (no flame must approach the end of the condenser), the magnesium in a short time begins to dissolve. The first sign of this is the appearance of light flocculæ in the liquid ; they are due to moisture, which can never absolutely be excluded, and they vanish again as the process of solution advances. When the magnesium has completely dissolved, except for traces of impurities,—this should be the case in two hours at most—the heating is discontinued and the liquid treated at ordinary temperature with a solution of 9·1 g. benzo-phenone in 25 g. absolute ether. The liquid first acquires a bright red colour, then a thick, tough mass is precipitated, which, when the heating is renewed, reacts vigorously, and solidifies in the course of half an hour. The reaction mixture is then allowed to cool, and pieces of ice and dilute sulphuric acid are then added. When decomposition has taken place,

steam is passed through until the distillate is clear. This removes ether and all the by-products which have been formed (benzene, diphenyl), and the triphenyl-carbinol remains behind in an almost pure state. After recrystallisation from benzene it shows the correct melting point, 159° . Yield about 10 g.

The equations representing its formation are :

1. $\text{C}_6\text{H}_5\cdot \text{Br} + \text{Mg} = \text{C}_6\text{H}_5\cdot \text{Mg}\cdot \text{Br}$.
2. $\text{C}_6\text{H}_5\cdot \text{Mg}\cdot \text{Br} + \text{C}_6\text{H}_5\cdot \text{CO}\cdot \text{C}_6\text{H}_5 =$
 $\text{C}_6\text{H}_5\cdot \text{C}\cdot \text{C}_6\text{H}_5$
 $\text{C}_6\text{H}_5\begin{array}{c} \diagup \\ \diagdown \end{array} \text{O}\cdot \text{Mg Br}$.
3. $\text{C}_6\text{H}_5\cdot \text{C}\cdot \text{C}_6\text{H}_5$
 $\text{C}_6\text{H}_5\begin{array}{c} \diagup \\ \diagdown \end{array} \text{O Mg Br} + \text{H}_2\text{O} =$
 $(\text{C}_6\text{H}_5)_3\text{C}\cdot \text{OH} + \text{OH}\cdot \text{Mg Br}$.

Characteristic Reactions.

The solution in concentrated sulphuric acid is intensely red; in glacial acetic acid it is colourless, but becomes deep yellow on addition of a drop of concentrated hydrochloric acid.

66. Malachite-green.

Leuco-base. $C_6H_5 \cdot CH[C_6H_4N(CH_3)_2]_2$.

(O. Fischer, *Liebigs Ann.*, 206, 122.)

20 g. benzaldehyde, 50 g. dimethylaniline, and 40 g. solid zinc chloride are mixed in a porcelain dish and heated with frequent stirring for some hours on the water-bath, until the smell of the aldehyde has become very faint. If the mass becomes too stiff during the heating, it is advisable to dilute it with a little water. When the action is finished the substance is washed into a flask with water, and a strong current of steam is sent through until the unchanged dimethylaniline has distilled off. The remaining green-coloured leuco-base may easily be separated from the zinc chloride solution, and in the cold it sets to a hard mass. This is dissolved in hot absolute alcohol. If the solution is not too concentrated, the base separates on cooling in clumps of small, fine, almost colourless needles. From a concentrated solution it often separates first as an oily

substance, which, however, always completely crystallises on standing. By repeating the operation a perfectly colourless product is obtained.

Yield 90 % of the theory.

Oxidation of the Leuco-base.

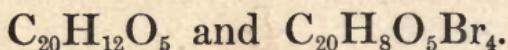
1 part leuco-base is dissolved in 100 parts of dilute hydrochloric acid, which is of such strength that to every 1 molecule of base there are exactly 4 molecules hydrochloric acid. The solution is cooled, and to it is added in the course of five minutes with thorough shaking the calculated amount of lead peroxide suspended in 6 parts of water. The shaking is continued for five minutes longer, and the liquid is then filtered.

The dye solution obtained is treated with 2 molecules zinc chloride, and then with a hot, concentrated solution of common salt, until, when a sample is filtered, the liquid passes through only faintly coloured.

When the liquid is quite cold the precipitated

dye is filtered off, dissolved in the smallest possible quantity of hot water, filtered, and again precipitated with salt solution.

67. -Fluorescein and Eosin.



(A. Baeyer, *Liebigs Ann.*, 183, 3.)

10 g. powdered phthalic anhydride and 14 g. commercial resorcinol are heated in an oil-bath to 195° - 200° until the evolution of steam ceases and the initially liquid substance has become quite solid. The mass is broken up, boiled with water, filtered, then dissolved in dilute sodium hydrate, covered with ether, and precipitated with dilute sulphuric acid. In this condition fluorescein is very readily taken up by ether. If the separated ethereal solution is treated with alcohol, and the ether then evaporated, the fluorescein is deposited in red, crystalline crusts, which are now almost insoluble in ether. The extremely strong fluorescence of the ammoniacal solution of the

substance is remarkable. The formation of fluorescein is used as a reaction for phthalic acid or for resorcin. Yield almost quantitative. To convert it into eosin the finely powdered fluorescein is mixed with four times its weight of glacial acetic acid, and then the calculated amount of bromine (4 molecules), which is also diluted with four times its weight of glacial acetic acid, is added. Complete solution takes place in the warm, and on the addition of water the eosin is precipitated in red flocculent masses. These are dried, and recrystallised from a large quantity of boiling alcohol.

68. Anthraquinone. $C_{14}H_8O_2$.

(*Ber. d. d. chem. Ges.*, 6, 1347.)

Estimation of Anthracene.

5 g. commercial, very finely powdered anthracene are dissolved at boiling temperature in 220 c.c. glacial acetic acid. The solution is filtered, if necessary, and treated at boiling

temperature with a solution of 50 g. chromic acid in 50 c.c. 50% acetic acid, a little at a time, until the liquid, even after prolonged heating, produces in course of time a red spot on a silver coin (?). When cold the solution is diluted with 750 c.c. water. After standing for some hours the precipitate is filtered off, and washed with water, then with potassium hydrate, and finally again with water. The anthraquinone so obtained forms fine yellow needles. For purposes of analysis only 1 g. raw anthracene is taken, and a correction is also applied for the anthraquinone which remains in solution.

69. Alizarine. $C_{14}H_6O_2(OH)_2$.

10 g. sodium anthraquinone-monosulphonate are added to 50 g. sodium hydroxide dissolved in the same quantity of hot water, and the mixture is treated with 3 g. potassium chlorate in concentrated solution. The mass must possess a pretty thick consistency at 120° - 130° ;

if this is not the case it is evaporated. A wrought-iron tube with gas-tight screw-stopper, which has been tested to a pressure of 20 atmospheres, is filled two-thirds full with the substance, and heated in an oil-bath for 20 hours at 175° - 185° .

Instead of the oil-bath an aniline vapour-bath of the form indicated in fig. 18 may be used; this requires less attention. *a* is a cylindrical copper vessel 65 cm. high and 13 cm. internal diameter, and is strengthened by an iron ring. The lid *b* is fastened air-tight to this by the aid of screws *c* and a ring of asbestos card. Into the two tubulures in the lid a thermometer and an air condenser are introduced. In the lower part of the bath a perforated copper plate is fixed on which rests the iron tube *d*. 200-250 g. aniline are placed in the bath, and the liquid is heated directly with a flame so strongly that the thermometer, when immersed

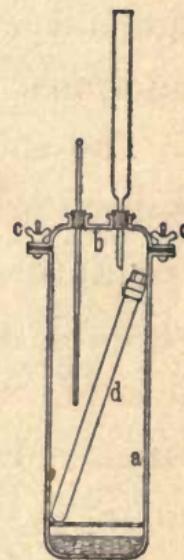


FIG. 18.

to a depth of 20 cm. in the bath, indicates the boiling point of aniline.

The apparatus is allowed to cool to 70°, and the fused mass is removed, partly by mechanical means and partly by boiling with water. The sodium alizarine dissolves with difficulty, and so it is necessary to boil it vigorously.

The solution is neutralised with dilute sulphuric acid, boiled for a quarter of an hour to improve the physical condition of the precipitate, then allowed to cool to 70° and filtered. The precipitate is washed with hot water until no more sulphuric acid can be found in the filtrate.

The alizarine can be obtained in needles by subliming it between two watch-glasses on a sand-bath at about 300°.

70. Camphor-oxime. $C_{10}H_{16}NOH$.

(Auwers, *Ber. d. d. chem. Ges.*, **22**, 605.)

10 g. camphor are dissolved in 150 g. ordinary alcohol, a concentrated aqueous solu-

tion of 10 g. hydroxylamine hydrochloride is added, then a concentrated solution of 15 g. solid sodium hydroxide, and the whole is warmed on the water-bath. If necessary a further quantity of alcohol is added to complete the solution of the camphor. When, after about an hour, a sample on dilution with water does not deposit any more camphor, the reaction is finished. The alcoholic liquid is now diluted with a large quantity of water, filtered if necessary from the slight flocculent precipitate, and treated with acetic acid until the reaction is weakly acid. This precipitates the camphor-oxime as a colourless, crystalline mass. The yield of the product amounts to about 75 % of the theory. To purify it, it is recrystallised from dilute alcohol.

PART II.

71. Furfurol. C₄H₈O . CHO.

200 g. bran are mixed with a solution of 200 g. concentrated sulphuric acid and 600 g. water in a large flask, and the liquid is then distilled off until the distillate amounts to about 600 c.c. In order to isolate the furfurol from this, it is neutralised with sodium carbonate, treated with about 150 g. sodium chloride, and then about 200 c.c. are distilled off. The distillate is again saturated with sodium chloride, and extracted with ether. When the ether is evaporated off the furfurol remains as a coloured oil, and is purified by distillation. Yield about 5 g.

Characteristic reactions for furfurol may be obtained with an aqueous solution of phenyl-hydrazine hydrochloride, or of aniline acetate.

In the former case an oil is formed, which soon crystallises; in the second, a beautiful red colouration is produced.

72. Anhydrous Grape-sugar. $C_6H_{12}O_6$.

(Soxhlet, *Journ. prakt. Chem.*, 21, 245.)

60 c.c. fuming hydrochloric acid (sp. gr. 1.19) are added to $1\frac{1}{2}$ li. 90 % alcohol, and the mixture is warmed to 45° - 50° in the water-bath; 500 g. very finely powdered cane-sugar (best quality) are then added in small portions, and the liquid is frequently shaken and maintained at the same temperature until the sugar has dissolved. The liquid is filtered if necessary, and when it is cold a small quantity (about $\frac{1}{2}$ g.) anhydrous grape-sugar is added, and the mixture allowed to stand for several days at room temperature. The crystallisation is accelerated by frequent stirring. The grape-sugar separates out in small, colourless crystals, which are finally filtered off at the pump and washed with absolute alcohol.

For complete purification the product is dissolved in a very little hot water, and absolute alcohol is added in the warm until the solution becomes turbid. On cooling and frequently stirring, the sugar separates in crystals.

Reactions of Grape-sugar.

1. The aqueous solution becomes brown on warming with alkalies, and acquires a peculiar smell.

2. It reduces Fehling's solution very strongly in the warm.

3. *Conversion into Phenyl-glucosazone.*—1 g. grape-sugar is heated on the water-bath with a clear solution of 2 g. phenylhydrazine, and 2 g. acetic acid in 20 c.c. water. In the course of 10–15 minutes the separation of fine yellow needles commences.

4. *Fermentation Test.*—10 c.c. of an aqueous grape-sugar solution of about 2 % strength are thoroughly shaken until well mixed with about 1 g. fresh yeast, which has been thoroughly washed with water. The liquid is then

introduced into the fermentation tube (fig. 19), and by suitable manipulation of the apparatus transferred from the bulb into the graduated, cylindrical part, care being taken that no air-bubbles remain in the latter.

The fermentation is generally completed after standing for 15–20 hours at room temperature, and from the amount of carbon dioxide which has been evolved the percentage of grape-sugar in the solution can be approximately determined.

A blank experiment with the same amount of water and yeast, but with no sugar, must yield no gas.

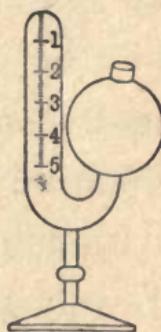


FIG. 19.

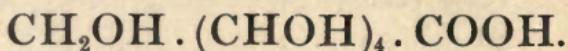
73. Mannose. $C_6H_{12}O_6$.

200 g. sieved turnings from Brazil nuts are heated in the boiling water-bath for eight hours with 400 g. 6% hydrochloric acid, the liquid being frequently stirred. It is then filtered hot through a cloth, the residue being

well pressed and again extracted with the same quantity of water. The brown-coloured mother-liquor is treated while warm with animal charcoal, again filtered, then neutralised with caustic soda in the cold, and finally a solution of 50 g. phenylhydrazine in 100 c.c. 25% acetic acid is added. The crystallisation of the difficultly soluble mannose-phenylhydrazone soon commences. After some hours the product is filtered off and washed with cold water. The yield amounts to about 75 g. The raw product is recrystallised with the addition of animal charcoal from 80–100 times its weight of water. To convert it into the sugar 25 g. of the purified and finely powdered hydrazone are gradually added to a hot mixture of 600 c.c. water and 12 g. benzaldehyde, which is kept in the form of an emulsion in a flask by means of a stirrer. If the stirring is efficient the hydrazone quickly dissolves, and the separation of benzaldehyde-phenylhydrazone soon commences. As a rule the decomposition of the sugar-

derivative is completed in 20–30 minutes. The liquid is then filtered through a folded filter, and when cold it is extracted with ether to remove the excess of benzaldehyde. The solution is decolorised by treating it with animal charcoal in the warm, and the filtrate is evaporated under diminished pressure to a syrup. If a crystal of mannose is now added, it is sometimes possible to cause the mass to solidify on long standing. The mass is then freed from syrup by pressure or by spreading on a porous tile, and completely purified by recrystallisation from a very little water.

74. Gluconic Acid.



50 g. American grape-sugar are dissolved in 300 g. water and treated in a stoppered bottle with 100 g. bromine. The mixture is allowed to stand, with frequent shaking, for three days at ordinary temperature (20° – 25°), until all the bromine has dissolved.

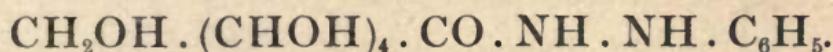
The solution is now quickly boiled in a porcelain dish with constant stirring, until the bromine has all disappeared. (*Fume-chamber.*) Care must be taken to avoid overheating of the sides of the dish, because then blackening of the contents occurs. To remove the hydrobromic acid the solution is now diluted to about 500 c.c. in a large dish at ordinary temperature, and it is almost neutralised by treatment with lead carbonate suspended in water. The liquid is filtered at the pump, and washed with a little cold water.

Sulphuretted hydrogen is passed through the liquid to remove the dissolved lead, and the filtered solution is neutralised by boiling it for half an hour with precipitated calcium carbonate. The filtrate is evaporated, first over the free flame, and later on the water-bath, to about 120 c.c., and treated when cold with a little crystallised calcium gluconate. Crystallisation begins in a few hours. After 24 hours the mass is filtered at the pump, washed with cold water, then dissolved in the smallest quantity

of hot water, decolorised with animal charcoal, and set aside to crystallise. The salt now separates in colourless, cauliflower-like aggregates of crystals.

After 24 hours it is filtered, washed with cold water and dried on the water-bath. Yield about 30 g.

75. Phenylhydrazide of Gluconic Acid.



5 g. calcium gluconate are dissolved in 30 g. hot water in a flask, then treated with 5 g. phenylhydrazine and 5 g. 50 % acetic acid, and the mixture is heated for $1\frac{1}{2}$ hours on the water-bath.

When cold the solution is allowed to stand for some hours ; the precipitated hydrazide is then filtered off, and recrystallised from hot water with addition of a little animal charcoal.

Colourless crystals. The compound melts with decomposition at 200°.

✓

76. Saccharic Acid.

$\text{COOH} \cdot (\text{CHOH})_4 \cdot \text{COOH}$.

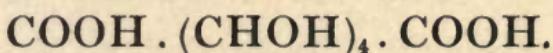
50 g. anhydrous grape-sugar are heated in a dish on the water-bath with 350 g. nitric acid (sp. gr. 1.15), and with continual stirring are evaporated to a syrup. This is dissolved in a little water, and again evaporated. The heating is discontinued forthwith if the mass begins to acquire a brown colour.

The substance is now dissolved in about 150 g. water and neutralised with a concentrated solution of potassium carbonate. 25 c.c. 50 % acetic acid are then added, and the liquid is evaporated to a volume of about 80 c.c. On frequent rubbing and long standing in the cold the acid potassium saccharate crystallises out. It is filtered off 12 hours later at the pump, washed with a very little cold water, then recrystallised from a moderate quantity of hot water with addition of animal charcoal.

The salt must be quite colourless, and when a hot dilute solution of it is treated with

calcium chloride and ammonia, it should not betray the presence of oxalic acid. Yield about 15 g.

77. Mucic Acid.



100 g. lactose are evaporated in a porcelain dish with 1200 g. nitric acid (sp. gr. 1·15) to a volume of about 200 c.c., the mixture being kept stirred towards the end. The mass becomes thick and pasty owing to separation of mucic acid. When cold it is diluted with water, filtered at the pump, and washed with cold water. In order to determine the yield of raw product, which should amount to about 36 g. dry substance, the wet mass is weighed and an aliquot part of it (about 1 g.) is dried at 100°.

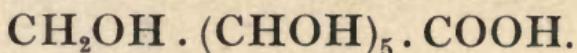
To purify it completely, the mucic acid is dissolved in sodium hydrate, and precipitated again with acid. It must be noticed, however, that only the neutral sodium salt is easily soluble in water, and, moreover, its solubility

also is decreased by excess of alkali. It is therefore best to calculate approximately the amount of sodium hydrate and to add that quantity in the form of normal caustic soda solution. For the above amount of raw product about 335 c.c. of normal alkali are required. The mucic acid dissolves in this liquid on shaking without the application of heat. If the solution is yellow it is decolorised by warming with animal charcoal. If already colourless, it is treated at once with enough hydrochloric acid to combine with all the sodium.

For this purpose about 67 c.c. of five times normal hydrochloric acid are necessary. The addition of the acid must not take place in the warm, but at ordinary temperature; otherwise part of the mucic acid is converted into the easily soluble lactone. The mucic acid soon crystallises out after the addition of the hydrochloric acid. To complete the crystallisation the liquid is allowed to stand for an hour at a low temperature (preferably at 0°), then filtered

at the pump, washed with cold water till the filtrate no longer gives a chlorine reaction, and dried at 100°. Yield 32 g.

78. α -Glucoheptonic Acid.



100 g. anhydrous grape-sugar are dissolved in 500 c.c. 3 % hydrocyanic acid, and treated with 10 drops of ordinary ammonia. The mixture is allowed to stand for 4–5 days at room temperature, and is then treated with a solution of 130 g. barium hydrate in 400 c.c. water, and boiled in a dish until the ammonia has disappeared.

The liquid is now acidified with dilute sulphuric acid; the hydrocyanic acid is driven off by boiling (*fume-chamber*), and the sulphuric acid quantitatively precipitated with strong baryta-water. After boiling up with animal charcoal the solution is filtered and evaporated to a syrup on the water-bath. On lengthy standing the lactone of α -glucoheptonic acid

separates in crystals. These are rubbed up with a little 80 % alcohol and filtered at the pump. The substance is then dissolved in three times its weight of water, and treated with animal charcoal in the warm. The filtrate is concentrated and set aside to crystallise.

79. α -Glucoheptose. $C_7H_{14}O_7$.

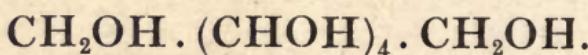
20 g. of the heptonic-lactone are dissolved in 200 g. water in a thick-walled bottle of about 600 c.c. capacity, and cooled in a freezing mixture till the formation of ice begins. 1·5 c.c. dilute sulphuric acid are now added, and then 100 g. $2\frac{1}{2}$ % sodium amalgam, which should be as pure as possible. The mixture is at once vigorously shaken, and at short intervals further portions of sulphuric acid are added, 2 c.c. at a time, so that the reaction of the liquid always remains acid. It is advisable to keep the liquid as cool as possible meanwhile by repeated immersion in the freezing mixture. The amalgam is used up in the course of

10–15 minutes; this opportunity is taken to cool the solution again till ice forms in it, then a further 100 g. of amalgam is added, and the above procedure repeated. As soon as 300 g. amalgam have been used in this way, the operation is stopped; it generally takes about 50 minutes. The solution after it has been separated from the mercury is treated with such a quantity of sodium hydroxide that it still remains alkaline after standing for half an hour. The object of this is to turn the unchanged lactone into the sodium salt. The solution is exactly neutralised with sulphuric acid, then clarified by warming with a little pure animal charcoal, and filtered. Into the hot solution eight times its volume of hot 96 % alcohol is poured with constant stirring, and the mixture is allowed to stand for 12 hours at room temperature. This precipitates the sodium sulphate and the greater part of the organic sodium salts, while the sugar usually all remains in solution.

From the filtrate the alcohol is distilled off

on the water-bath, and the aqueous solution remaining is concentrated till crystallisation begins, first over the free flame and finally on the water-bath. On cooling the sugar soon separates as a thick crystalline mass. After standing for some hours this is filtered off at the pump as well as possible and washed, first with 50 %, then with 80 %, and finally with absolute alcohol. After drying the white product is free from ash, and almost chemically pure. The yield varies from 32 % to 38 % of the lactone taken. From the mother-liquor only a little more of the sugar is usually obtainable, since its crystallisation is prevented by the presence of other products.

80. Dulcitol.



10 g. galactose are dissolved in 100 g. water in a stoppered bottle of about 400 c.c. capacity. The solution is vigorously and continuously shaken at ordinary temperature with 35 g.

$2\frac{1}{2}$ % sodium amalgam until most of the amalgam is used up. Every 15 minutes during the operation the liquid is neutralised with dilute sulphuric acid. Amalgam is now added again in quantities of 30 g. at a time, and the shaking and neutralisation is continued until 5 drops of the solution will only reduce 1 drop of Fehling's solution.

The temperature must not rise above 25° . The operation requires about 3 hours. The quantity of good amalgam required amounts to 300–400 g.

The solution after having been separated from the mercury is exactly neutralised with sulphuric acid, and is poured hot into four times its volume (about 900 c.c.) hot 95 % alcohol.

If the filtered liquid is now concentrated on the water-bath to a volume of about 20 c.c., the dulcitol separates in crystalline form. After standing in ice it is filtered off at the pump and recrystallised from a little hot water. If the sodium sulphate which was precipitated by the

alcohol contains any organic matter, it is boiled up with 80 % alcohol, and the filtrate added to the first alcoholic solution. The yield of pure dulcitol amounts to about 5 g.

✓ 81. α -Methyl-glucoside. $C_6H_{11}O_6 \cdot CH_3$.

(E. Fischer, *Ber. d. d. chem. Ges.*, **28**, 1151.)

The compound is produced when grape-sugar is heated for a long time to 100° with a very dilute solution of hydrochloric acid in dry methyl alcohol. Commercial methyl alcohol, free from acetone, is dried by standing over quicklime for some days, and distilled. About 10 c.c. of the dry solvent in a small flask are then weighed along with a delivery tube for the gas, and dried gaseous hydrochloric acid is then led in, the liquid being cooled so that no evaporation of the solution occurs. The quantity of acid can then be determined from the increase in weight. The solution of hydrochloric acid thus prepared is diluted with pure methyl alcohol so that it contains 0·25 %

of the acid. To 100 g. of this diluted solution 25 g. finely powdered, anhydrous grape-sugar are added, and the liquid is boiled under reflux condenser for about three-quarters of an hour until the sugar has all dissolved. The pale yellow liquid now contains an intermediate product, probably glucose-dimethylacetal, which on prolonged heating to 100° is converted into glucoside. The liquid is therefore introduced into one or two wide sealed glass tubes (see under Prep. 9), and heated for 50 hours in the water-bath provided for heating bomb-tubes. The solution is then evaporated to about one-third of its volume and well cooled. After standing a long time, or sooner if "inoculated" with a small crystal, the α -methyl-glucoside separates out in small colourless needles, which after standing for 12 hours are filtered off. The yield amounts to about 45 % of the grape-sugar. By prolonged heating of the mother-liquor to 100° with fresh methyl-alcoholic solution of hydrochloric acid, a further portion of glucoside may be prepared.

To purify the raw product it is sufficient to recrystallise it at once from 18 parts of hot ethyl alcohol.

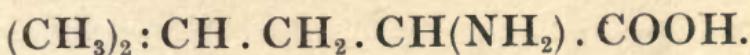
w
82. Glucosamine Hydrochloride.



The carapaces and claws of lobsters, which have been cleaned as far as possible mechanically, are digested for 24 hours with cold dilute hydrochloric acid. They may then be cut up easily and freed from adherent fibres and flesh. 100 g. of the material thus prepared are covered in a porcelain dish with fuming hydrochloric acid, and heated till gently boiling on a sand-bath. The chitin quickly goes into solution, and the liquid becomes dark in colour. The liquid is evaporated until a considerable crystallisation of glucosamine hydrochloride has taken place, then allowed to cool, filtered at the pump through linen or hardened paper, and washed with a little cold hydrochloric acid. The mother-liquor on further evapora-

tion yields a second crop of crystals. To purify the salt it is dissolved in warm water, and the solution is concentrated till crystallisation begins.

83. Racemic Leucine.

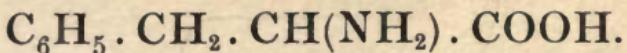


(*Method of Strecker. Cf. Limpricht, Liebigs Ann., 94, 243; and E. Fischer, Ber. d. d. chem. Ges., 33, 2372.*)

50 g. isovaleric-aldehyde are dissolved in 100 c.c. absolute ether, and the solution is cooled and saturated with dry ammonia. The water formed in the reaction is separated by means of a funnel; the ethereal solution is shaken with a little potassium carbonate, filtered, and evaporated *in vacuo* at a temperature not greater than 25°. The oily residue of valeraldehyde-ammonia, which frequently soon crystallises, is at once suspended in 100 c.c. water; the liquid is cooled, and 36 c.c. 50 % hydrocyanic acid are gradually added. The mixture is allowed to stand, with

frequent shaking, for 12 hours, and then a mixture of 400 c.c. hydrochloric acid (sp. gr. 1·19) and 200 c.c. water is added. This produces a lumpy precipitate, which is dissolved by prolonged boiling in a flask, then boiled for 2 hours more after the addition of another 200 c.c. water, and finally evaporated on the water-bath to remove the hydrochloric acid. The residue is warmed with about 60 c.c. water, and made faintly alkaline with ammonia. When cold the leucine which has separated is filtered at the pump, and washed with cold water until all the ammonium chloride has been removed. Yield about 25 g. It depends on the quality of the isovaleraldehyde used. To purify it completely the product is dissolved in a fair quantity of hot water, boiled with animal charcoal, and crystallised by cooling the filtrate. The substance remaining in the mother-liquor is obtained by concentrating or by precipitating with alcohol.

84. Racemic Phenylalanine.

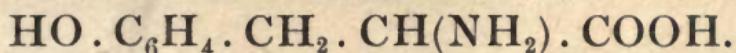


(E. Fischer, *Ber. d. d. chem. Ges.*, 37, 3064.)

50 g. benzylmalonic acid are dissolved in 250 g. dry ether, and 50 g. bromine ($1\frac{1}{5}$ molecules) are gradually added in daylight. At first the halogen rapidly disappears, and clouds of hydrobromic acid are evolved. At the end the liquid is coloured reddish-brown by the excess of bromine. When it has stood for half an hour the ethereal solution is shaken with a little water, sulphuric acid being gradually added until the red colour of the bromine disappears. The ethereal layer is then separated, again washed with a little water, and then carefully evaporated. The solid residue is recrystallised from about 250 c.c. of hot benzene. Yield 95 % of the theory. The benzylbrommalonic acid when dried *in vacuo* at 80° melts towards 137° (corr.). The benzylbrommalonic acid containing water is now heated in an oil-bath to 125° – 130° , and the fused mass evolves

gases vigorously (carbon dioxide and a certain amount of hydrobromic acid). The reaction is complete in the course of half to three-quarters of an hour. The residue is a yellow oil, which even at a low temperature does not crystallise, and which in the main consists of phenyl- α -brompropionic acid. For the purpose of purification it is washed with water, taken up in ether, and dried with sodium sulphate ; the ether is then distilled off again. The mobile, almost colourless oil remaining is dissolved in five times its volume of 25 % aqueous ammonia, and either heated for 3 hours to 100° in a sealed tube or allowed to stand for 3–4 days at ordinary temperature. On evaporation of the ammoniacal solution an almost colourless residue is left, and this chiefly consists of ammonium bromide and phenylalanine. On boiling with alcohol the amino-acid is left undissolved. One recrystallisation from hot water suffices for complete purification. Yield 60 % of the theory (calculated on the benzylbrom-malonic acid taken).

✓ 85. Tyrosine.

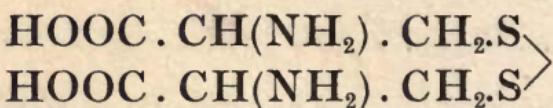


(Abderhalden and Teruuchi, *Zeitschr. f. physiol. Chem.*, 48, 528.)

100 g. silk-waste are boiled for 6 hours under reflux condenser with 300 c.c. fuming hydrochloric acid (sp. gr. 1·19). The greater part of the hydrochloric acid is removed by evaporating the brown-coloured solution under diminished pressure; the residue is dissolved in water, filtered, and made up to a known volume. The percentage of hydrochloric acid is determined by titration of an aliquot part of the liquid, and the amount of sodium hydroxide calculated for the whole solution is then added with ice-cooling and constant stirring. A brownish-black precipitate is at once produced. After it has stood for an hour in ice-water, it is filtered off at the pump, dissolved again in hot water, and boiled vigorously with about 10 g. animal charcoal. The filtered liquid is now colourless, and deposits pure tyrosine on

cooling. By concentrating the mother-liquor a second crop of crystals may be obtained. Yield 5–6 g.

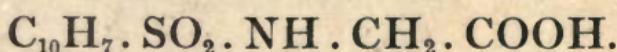
86. Cystine.



750 g. commercial horsehair are boiled in a flask of 3 li. capacity with $1\frac{1}{2}$ li. concentrated hydrochloric acid (about 30 % strength) for 6 hours under reflux condenser. The dark-coloured liquid is then diluted with 4 li. water, and, while kept fairly cool, is treated with concentrated potassium hydroxide (33 %) until the reaction is only faintly acid. To clarify the liquid it is warmed and vigorously stirred for some time with about 40 g. animal charcoal, then filtered. The filtrate is now exactly neutralised with potassium hydroxide, and is then set aside to crystallise at low temperature, preferably in the ice-chest, for five to six days. The cystine which separates is filtered at the pump, washed with cold water, then dissolved

in the smallest possible quantity of warm, 10% ammonia, again treated with animal charcoal in the warm, and finally precipitated from the filtrate by addition of acetic acid. If this operation is repeated once more, the final product is quite colourless and free from tyrosine. The yield amounts to 15–16 g. In reality the amount is considerably larger, since much of it remains in the mother-liquor. The direct crystallisation from the dilute solution has the advantage, however, that a pure product is obtained quickly, and, moreover, the evaporation of large quantities of liquid is avoided.

87. β -Naphthalene-sulphoglycine.

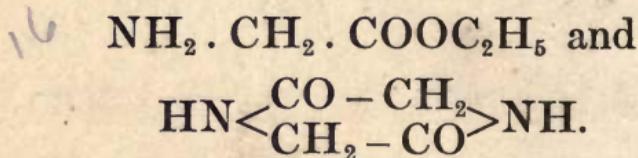


(E. Fischer and P. Bergell, *Ber. d. d. chem. Ges.*, 35, 3780.)

2 g. glycocoll are dissolved in the quantity of normal sodium hydroxide calculated for 1 mol., and to this an ethereal solution of 2 mol. β -naphthalene-sulphochloride is added. The

mixture is shaken in a stoppered bottle on the shaking machine at ordinary temperature. Three times at intervals of about an hour the same amount of normal alkali is again added. After about 4 hours the aqueous liquid, which still reacts alkaline, is separated from the ethereal layer in a funnel, filtered, and acidified with hydrochloric acid. The oil which is precipitated soon crystallises. For complete purification it is recrystallised from hot water. The compound forms laminæ, which are often pointed, and are usually aggregated in tufts. It softens at 151° and melts at 156° (corr. 159°).

88. Glycocollester and Glycine-anhydride.



+ 50 g. commercial glycocollester hydrochloride are treated with 25 c.c. water, which only suffice for partial solution. 100 c.c. ether

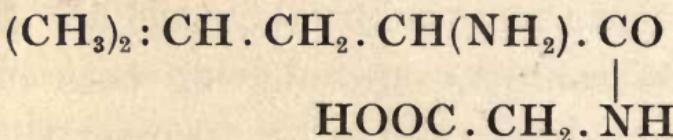
are then added, and the whole is well cooled in a freezing mixture while treated with 40 c.c. sodium hydroxide (33 % strength). Finally such an amount of dry, granulated potassium carbonate is added with cooling and shaking as to turn the aqueous layer into a thick paste. After vigorously shaking the ethereal solution is poured off, the residue is shaken two or three times more with ether, and the united ethereal solutions after having been filtered are allowed to stand, with frequent shaking, first for ten minutes with dry potassium carbonate, then for several hours with sodium sulphate. When the ether has been evaporated the residue is distilled under diminished pressure. At 10 mm. it boils at $51\cdot5^{\circ}$ - $52\cdot5^{\circ}$, and so the receiver must be well cooled. Yield about 50 % of the hydrochloride used.

20 g. glycine-ester are cooled and treated with 12 g. water, and the mixture is then allowed to stand at room temperature for some days. The anhydride separates out during this time in beautifully crystalline form. It

is filtered, washed with a little cold water, and dried *in vacuo* over sulphuric acid. Yield about 7 g.

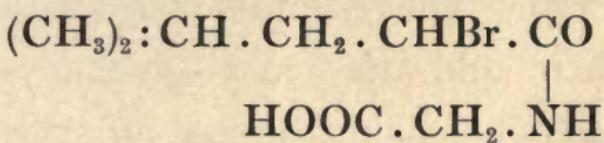
For the direct preparation of glycine-anhydride from glycocoll-ester hydrochloride see *Ber. d. d. chem. Ges.*, 39, 2930.

89. Leucyl-glycine.



10 g. glycocoll are dissolved in 133 c.c. (1 mol.) normal caustic soda, and while cooled with ice and vigorously shaken, the solution is treated alternately with 170 c.c. cooled normal caustic soda and 37 g. (1 mol.) α -bromoisocapronyl-bromide in four portions, each new addition being made only when the smell of the acid bromide has disappeared. The whole operation lasts about twenty minutes. The liquid is filtered from the small amount of oil it contains, and then treated with 35 c.c. of five times normal hydrochloric acid. The oil which

is precipitated is extracted with ether, and the condensation-product precipitated from the ethereal solution, after the latter has been concentrated, by the addition of a large quantity of petroleum ether. The product, α -bromoisocapronyl-glycine,



soon crystallises. It is filtered at the pump, washed with petroleum ether, and recrystallised from hot water or from chloroform. Melting point 133° . Yield of pure substance about 26 g., or, if the mother-liquor is worked up, 29 g.

The chief fraction of the raw product can also be obtained in crystalline form at once if the alkaline solution is first made slightly acid, treated with a few crystals previously prepared, and then continually stirred while the rest of the hydrochloric acid is slowly poured into it.

The α -bromoisocapronyl-glycine is converted into leucyl-glycine by dissolving it in five times

its weight of 25 % ammonia, and allowing the solution to stand for four days at room temperature. The crystalline paste of ammonium bromide and dipeptide which is produced when the solution is concentrated on the water-bath is treated with absolute alcohol, and again evaporated. The residue is boiled with alcohol, and when cold the leucyl-glycine, which is insoluble in alcohol, is filtered off at the pump, and washed with alcohol until a sample of it dissolved in water gives no further precipitate with silver nitrate. The dipeptide is purified by dissolving it in fifteen times its weight of hot water; on cooling about half the product separates out in crystalline form. By concentrating the mother-liquor and precipitating with alcohol the rest may be obtained. The substance melts with decomposition towards 243°. Yield 80 % of the theory. The product should not contain any bromine.

90. *d*-Alanine and Glycocol-ester Hydrochloride.

As raw material the cheap waste of the raw silk of Milan is employed. 500 g. are treated with 2 li. fuming hydrochloric acid (sp. gr. 1.19) and frequently shaken round, until in the course of an hour the threads have fallen to pieces. The flask is then warmed, with frequent shaking, on the steam-bath ; the liquid foams considerably and a dark violet solution is produced. This is now boiled under reflux condenser for 6 hours, and it is advisable to add one or two spoonfuls of animal charcoal. When quite cold the acid liquid is filtered through a coarse but strong filtering-cloth and then evaporated under diminished pressure (10-15 mm.) at 40°-45° to a thick syrup. This is treated while still warm with 3 li. absolute alcohol, and a very rapid current of dry hydrochloric acid is passed in, without cooling and with frequent shaking, until the liquid is saturated. In this process complete solution

must occur, and the alcohol must get hot enough to boil. The operation should usually be finished in $1\frac{1}{2}$ hours. If the current of hydrochloric acid, and consequently the rise in temperature, was too small, the mixture must be boiled afterwards for half an hour on the water-bath in order to render the esterification as complete as possible. If the very dark brown liquid is now cooled to 0° and "inoculated" with a few small crystals of glycocoll-ester hydrochloride, the greater part of the glycocoll will separate in the course of 12 hours at 0° as ester hydrochloride in the form of a thick paste of crystals. The mass is filtered at the pump through coarse linen, well pressed, and washed with a little ice-cold alcohol. The acid alcoholic solution is again evaporated as completely as possible under low pressure from a bath at $40^{\circ}-45^{\circ}$, and the residual syrup is again esterified with $1\frac{1}{2}$ li. alcohol and hydrochloric acid gas as before. If the cold solution is "inoculated" and allowed to stand for two days at 0° , the remainder of the glycocoll is for

the most part precipitated as ester hydrochloride. The solution after filtration is again evaporated under diminished pressure. The syrup left behind contains the hydrochlorides of the other amino-acid esters. In order to set the esters free, the residue is dissolved by vigorous shaking at ordinary temperature in the smallest quantity of water (about $\frac{1}{4}$ volume). To the solution is added about twice its volume of ether, and the whole is carefully cooled in a mixture of ice and salt. Strong caustic soda is then cautiously added until the free acid is about neutralised, and finally a saturated solution of potassium carbonate. On vigorous shaking a considerable part of the liberated esters goes into solution in the ether. The ether is now poured off and replaced by fresh. The whole is carefully cooled, then an excess of concentrated alkali is added, and immediately afterwards potassium carbonate in small portions, until the whole mass has become a thick paste. The ether is repeatedly renewed during the operation. The extraction with ether is continued until the

extracts are colourless. This requires 4-5 li. ether. The united ethereal solutions, which are brown in colour, are shaken for five minutes with potassium carbonate, then poured off, and dried for twelve hours over anhydrous sodium sulphate. When the greater part of the ether has been evaporated at ordinary pressure on the water-bath, the distillation is continued under a pressure of 10-12 mm. To begin with, at ordinary temperature ether passes over. If the distilling vessel is now warmed in warm water, a first fraction is obtained, which still contains alcohol and ether, but also some glycocoll ester and alanine ester. When the temperature of the bath has risen to 55°, the main part of the alanine ester begins to boil. The operation is discontinued when at a bath-temperature of 80° nothing more distils over. In this way 110-125 g. distillate are obtained, consisting for the most part of alanine ester.

To obtain free alanine the alanine ester is heated for about six hours with five times its weight of water on the water-bath, until the

alkaline reaction has disappeared. The solution is then evaporated on the water-bath till crystallisation begins. If the liquid is now allowed to stand at 0°, about 30 g. alanine separate out, and optical examination shows this to consist of almost pure *d*-compound. From the mother-liquor a second crop of 20–25 g. may be obtained, and this still consists of fairly pure, active amino-acid, so that the total yield amounts to 50–55 g. The last mother-liquor still contains a fair amount of active alanine, but it is mixed with so much racemic substance that it cannot be separated from it by mere recrystallisation from water. The first two crops are dissolved once more in hot water and the liquid evaporated on the water-bath till it begins to crystallise. At 0° a large quantity of the pure, active amino-acid separates out.

APPROXIMATE CONCENTRATION OF REAGENTS.

Reagent.	Specific Gravity.	Approximate Normality.	1 li. Normal solution corresponds to c.c.	100 g. contain 100 c.c.	100 c.c. contain
Sulphuric acid, conc.	1.84	36. $\frac{\text{H}_2\text{SO}_4}{2}$	28	95.6 g H_2SO_4	175.9 g H_2SO_4
Sulphuric acid, dil. (1 li. + 6.4 li. water)	1.16	5. $\frac{\text{H}_2\text{SO}_4}{2}$	200	21.5 g H_2SO_4	24.5 g H_2SO_4
Hydrochloric acid, conc.	1.19	12. HCl	82.5	37.2 g HCl	44.3 g HCl
Hydrochloric acid, dil. (1 li. + 1.5 li. water)	1.08	5. HCl	200	16.8 g HCl	18.2 g HCl
Nitric acid, conc.	1.4	14.5. HNO_3	69	65.3 g HNO_3	91.4 g HNO_3
Nitric acid, dil. (1 li. + 2 li. water)	1.17	5. HNO_3	200	27.1 g HNO_3	31.5 g HNO_3
Acetic acid, conc.	1.06	18. $\text{C}_2\text{H}_4\text{O}_2$	56.5	100 g $\text{C}_2\text{H}_4\text{O}_2$	106 g $\text{C}_2\text{H}_4\text{O}_2$
Acetic acid, dil. (1 kilog. + 1 li. water)	1.06	9. $\text{C}_2\text{H}_4\text{O}_2$	113	50 g $\text{C}_2\text{H}_4\text{O}_2$	53.1 g $\text{C}_2\text{H}_4\text{O}_2$
Caustic potash.	1.32	7.5. KOH	130	33 g KOH	43.2 g KOH
Caustic soda (1 kilog. [about 90 %] + 2 li. water)	1.36	10. NaOH	100	30 g NaOH	40 g NaOH
Ammonia	0.91	13.3. NH_3	75	25 g NH_3	22.7 g NH_3

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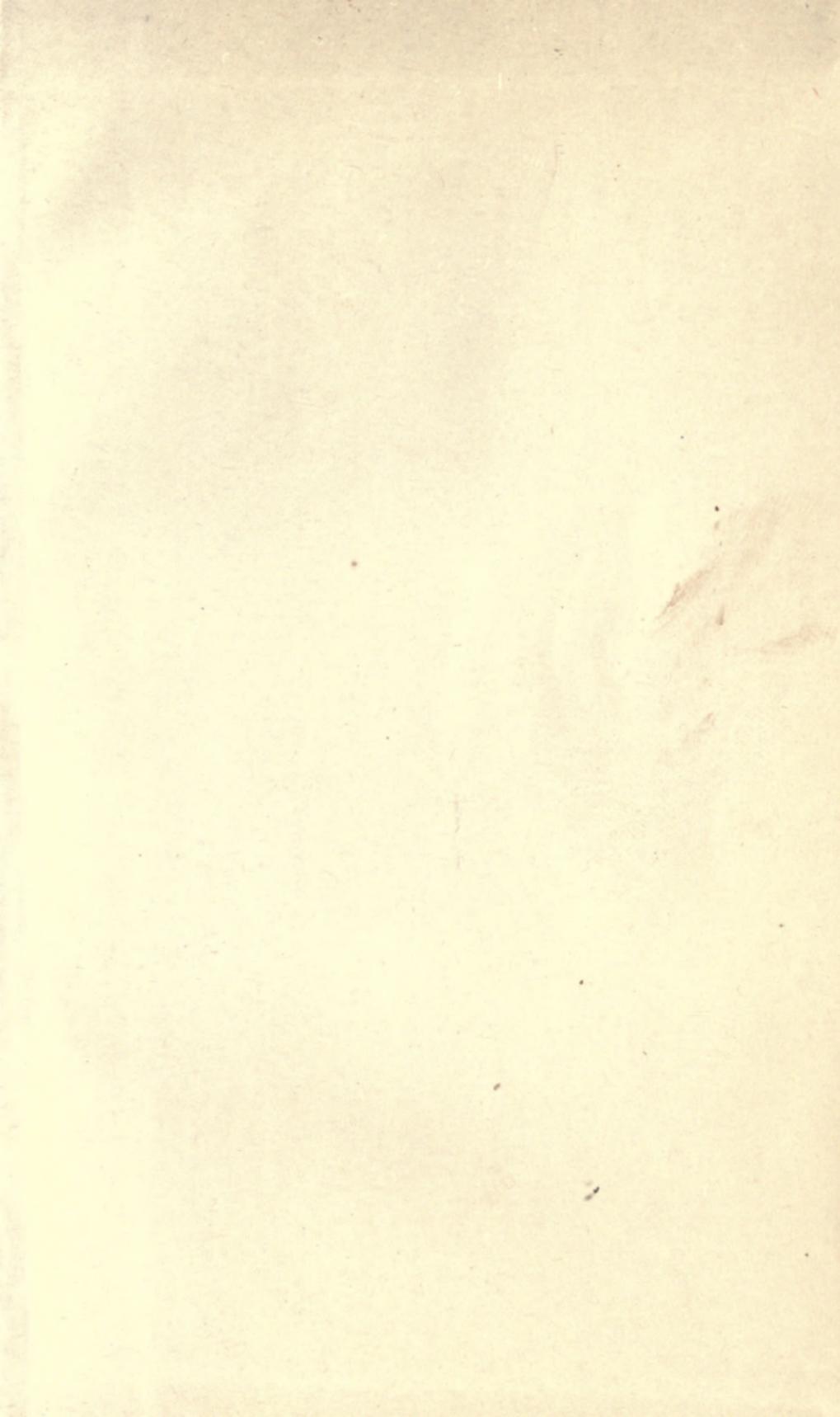
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