Synthetic Methods of Organic Chemistry

A Thesaurus

by W. THEILHEIMER

Volume I · 1942-1944

With a foreword by T. REICHSTEIN
Translated from the German
by HANS WYNBERG

A translation of W. THEILHEIMER,

Synthetische Methoden der Organischen Chemie, Repertorium I

Foreword

A well-organized system is already in operation for the continued recording of new organic compounds. It consists of volumes appearing periodically (*e.g.*, Beilstein's *Handbuch* and abstracting journals such as *Chemical Abstracts*), and the system has now become indispensable for a chemist working in any branch of the subject. On the other hand, barely the beginnings of a similar system exists for the publication of the actual methods of chemistry. Consequently, it is often very tedious for the research worker and industrial chemist to obtain information concerning the procedures for new syntheses and degradation reactions which are most likely to have a good chance of success. Therefore, it often becomes very difficult for the specialist in a particularly narrow field to complete an unusually difficult reaction. Should he happen to venture into a new field of research he may have to spend valuable time in solving problems that may have been solved by others, but are obscured in the tangled mass of literature.

Of the books on methods available, that of Houben is still the best, although somewhat out of date. However, the enormous difficulties encountered in the preparation of an all-embracing and systematic classification of the matter in hand have not been solved, for much time is often wasted in finding the desired reaction, and the same reaction is often described in different places and in different volumes.

Books on methods which really do meet modern needs exist only in strictly circumscribed fields, *e.g.*, *Newer Methods of Preparative Organic Chemistry* (Interscience, New York), and *Organic Reactions* (Wiley, New York) edited by R. Adams. However, there are no comprehensive periodic supplements of the large collective works and current abstracts, so useful for the recording of compounds.

Dr. Theilheimer has undertaken to fill the gap in question in this series of volumes. He has now encountered two main difficulties, first, in making the correct selection of material, and second, in introducing a classification with sufficient coverage of the subject. A new, truly fundamental method of organic chemistry is discovered, at the most, every ten years. In practice, however, real success often follows decisively significant, although small, variations in a procedure. The determination of what should be considered to be new, and therefore to be included in this series, is largely a matter of personal opinion.

Since a recognized, comprehensive method of classification of chemical reactions does not exist, the author has attempted to arrange and characterize the reactions in question on a purely formal basis by means of symbols. Whether or not this system will endure will depend largely upon its success in actual use. Even if our colleagues do not approve of the symbols, and continue to look up particular reactions in the alphabetic index, this collection of methods, which is to be brought up-to-date periodically, will remain of value.

T. Reichstein

Author's Preface

In the series of volumes beginning with this book there are going to be recorded regularly: new methods for the synthesis of organic compounds, improvements of known methods, and also old proved methods that are now scattered about in the specialized journals and in the original published work. The first volume will deal with the literature of 1942–1944. The second volume will include the works of the years 1945–1946 and the foreign work of the earlier war years published in journals not generally available. Further volumes are expected to follow yearly.

The attempt has been made to develop the system of Weygand (*Organisch-chemische Experimentierkunst*, Barth, Leipzig, 1938), which groups reactions on a less simple, but on a more purely formal, basis. This had led to the invention of reaction symbols that can be classified systematically. It contrasts with the current trivial, or author-naming, method using terms such as "Oxidation" or "Friedel-Crafts reaction." By means of these new reaction symbols, the methods can be traced without knowing the common name—a simplification for the foreign reader in particular. The difficulties on hand make it imperative that the system should not receive a final definition in this volume. Since the material was put together step by step many changes had to be made during the writing of the manuscript. In order not to delay the appearance of the first volume the rearrangement of some of the articles which would have required further extensive changes had to be deferred; cross-references are made in such cases. The system will be improved and completed in the following volumes as the result of further experience and ideas; we will always be grateful for new suggestions. The first volume should therefore be considered as being in the nature of a trial.

Readers who are accustomed to the old classification will find this used in the complete alphabetic index. It is thought that the volumes should be used for immediate reference in the laboratory. They should provide a quick survey of the situation at hand, and obviate the necessity of first

searching the entire literature. Syntheses are recorded in the alphabetic index by starting materials and end products, along with the systematic indexing of the methods. Another innovation is the indexing of very complex compounds. General terms, such as synthesis, exchange, and heterocyclics, are especially emphasized.

The articles are limited to what is necessary for an appraisal of the applicability of a desired synthesis. This would include, for instance, the number and nature of the reaction steps, the yield, and the importance of the literature in question. In order to carry out a particular synthesis it is therefore still necessary to have recourse to *Chemical Abstracts* * or other abstracting journals, and also, if possible, to the original papers. To avoid repetition where the same method is applied in similar cases, the actual instance chosen is the one most fully described and giving the best yield. Syntheses that are split up into their various steps and are recorded in different places can be followed with the help of the notations "s.m." and "Prepn."

This book is dedicated in the hope that the material will serve as a useful tool for chemists, especially for the younger ones who still have little experience of their own, also in the hope that the first volume may serve to bring returning veterans and war workers up-to-date in their temporarily abandoned fields.

I should like to thank heartily Dr. H. Erlenmeyer for valuable advice and encouragement, and also Dr. T. Reichstein for the introduction.

Basle, November, 1945.   *W. Theilheimer*

Method of Classification

The following directions serve to explain the system of indexing.

Reaction Symbols
The first part of the symbol refers to the chemical bonds formed during the reaction. These bonds appear in the reaction symbols as the symbols for the two elements which have been linked together (*e.g.*, the bond between hydrogen and nitrogen, as HN). The order of the elements is the same as in *Chemisches Zentralblatt* and in Beilstein's *Handbuch der organischen Chemie*: H, O, N, S, Hal (Halogen), and other elements. C is always placed last.

* *PUBLISHER'S NOTE:* In translating this book, references to *Chemisches Zentralblatt* have been changed to corresponding *Chemical Abstracts* references where available.

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The "principle of the latest position" determines the order of the element symbols, and is used whenever possible.

The methods of obtaining a particular chemical bond are subdivided according to its method of formation. Four types are distinguished: addition ($\Downarrow$), rearrangement ($\curvearrowright$), exchange ($\Uparrow\!\Downarrow$), and elimination ($\Uparrow$).

The next part of the symbol refers to the types of bond which are destroyed in the reaction. As a general rule, only one of the elements that forms the bond is mentioned, namely, the one which (according to the "principle") is last in the above order of elements. In addition reactions the destroyed double bond or ring is shown by two element symbols.

The use of the reaction symbols will be made clearer by the following simplifying stipulations. (1) The chemical bond is rigidly classified according to structural formula, with no consideration of the mechanism of the reaction. (2) Double or triple bonds are treated as being equivalent to two or three single bonds, respectively. (3) Generally speaking, only stable compounds are taken into consideration. Intermediary compounds, such as Grignard compounds and sodiomalonic esters, are therefore not expressed in the reaction symbols.

Examples   Addition of hydrogen bromide to a carbon-to-carbon
              double bond: Hal C$\Downarrow$CC (HC$\Downarrow$CC).
              Beckmann rearrangement: OC$\curvearrowright$ON.
              Ketone synthesis by the Friedel-Crafts reaction: CC$\Uparrow\!\Downarrow$Hal.
              Dehydrogenation: CC$\Uparrow$H.

Systematic Review See page x.

Reagents Used in the Methods

A further subdivision, which cannot be expressed by the reaction symbols, is made on the basis of the reagents used to bring about some of the reactions. The order usually follows that of the periodic classification. Reagents made up of many components are indexed according to the element responsible for the reaction, e.g., $KMnO_4$ under Mn, NaClO under Cl. When a constituent of the reagent goes into the product of the reaction, the remainder of the reagent, which acts as a carrier of this constituent, is the criterion for the classification; for example, phosphorus is the carrier in a chlorination with PCl_5 and sodium in a nitrosation with $NaNO_2$.

The material in this subdivision is arranged with the simple examples first and the more complicated ones following. When changes in several chemical bonds occur during one reaction, as in the formation of a new ring, or if the reaction can be carried out in different ways, it will neces-

sarily be indexed in many places. The main entry in such cases will follow according to the "principle of the latest position"; the other entries will be cross-referenced back to it.

Alphabetic Index

The names of the methods, types of compound, reagents, etc. are classified in the alphabetic index at the end of the book. Individual compounds and individual authors (when a method is not named after them) are found, as usual, in the index of the abstract journals. Very complex compounds, as those with several reactive groups, are referred to under the derived simpler compounds, under the term "see also" (e.g., aminocarboxylic acids are found under amines and under carboxylic acids). Methods of synthesis for a given substance are indexed under the name of the substance itself, with "from" appended, e.g., carboxylic acids from alcohols, hydrocarbons. Syntheses which are carried out from a particular starting material are indexed under the starting material, followed by a subentry, s.m., which represents starting material for the preparation of (for example, alcohols, s.m. ketones, carboxylic acids).

Generally speaking, classes of compounds are designated by reference to the functional group that is changed during the reaction. A reaction in which an amino alcohol is prepared from an aminocarboxylic acid is therefore indexed under "Alcohols from carboxylic acids" or "Carboxylic acids, s.m. alcohols." Ring signs may also refer to the corresponding hydrogenated rings, unless the latter are also listed specifically. Greek letters and single letters which are separated from the proper word by a hyphen are not considered to take part in the alphabetic arrangement, e.g., "O-Acetyl derivatives" are indexed under "A."

Abbreviations

abs.	absolute	Ex	example	N	normality
alc.	alcoholic	F.e.s.	further ex-amples see	Pr	propionic
aq.	aqueous			prepn.	preparation
Ar.	aromatic	F.m.s.	further methods see	satd.	saturated
asym.	asymmetrical			sec.	secondary
atm.	atmosphere(s)	hr(s).	hour(s)	soln.	solution
Bz	benzene	liq.	liquid	s.m.	starting material
concd.	concentrated	Me	methyl		
d.	density	min.	minutes	sym	symmetrical
dil.	dilute	m.p.	melting point	tert	tertiary
Et	ethyl			Y	yield

Symbols

Addition	⇓	Elimination	⇑	Rearrangement	↻
Electrolysis	↯	Exchange	⇅	Ring opening	C
				Ring closure	O

Formation of H—O Bond by:

Addition

Addition to Hydrogen and Carbon
See OC ⇩ HC

HO ⇩ HC

Addition to Oxygen and Carbon
See HC ⇩ OC, CC ⇩ OC

HO ⇩ OC

β-Hydroxyl Alkyl Amines
See 277.

Rearrangement

HO ↳

Hydroxynaphthoquinones
See 581.

Exchange

Carbon ↟

HO ⇅ C

Sodium hydroxide

NaOH

Opening of the Coumarin Ring
See 104.

Sodium alcoholate

NaOR

Deacetylation of Glycosides

OAc → OH

1. Tetraacetylprotocatechualdehyde-4-β-ᴅ-glucoside is dissolved in abs. MeOH. 1 mole Na is added; after its complete reaction a soln. of citric acid in abs. MeOH is added → protocatechualdehyde-4-β-ᴅ-glucoside (s.m. 551). Y = 66.8%. L. Reichel and J. Marchand, *Ber. 76*, 1132 (1943); *C.A. 1944*, 4944. Methods, see L. Reichel, *Ann. 553*, 88 (1942); *C.A. 1943*, 5062.

Alkali in pyridine

## Ether Cleavage   ROR → ROH
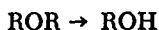
2. Cleavage of phenolic ethers can be accomplished by boiling with an alkali metal in dry pyridine. Ex: BzPh ether with Na in C_5H_5N → phenol; Y = 90%. Also: anisole → phenol; Y = 94%. Phenetole → phenol; Y = 95%. F.e.s. V. Prey, *Ber.* 76, 156 (1943); *C.A. 1943*, 5380.

Potassium bicarbonate $KHCO_3$

Partial Saponification   OAc → OH
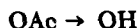
3. 1.4 g. 3-β-acetoxy-D-homo-17-androstanone is heated for 3 hrs. with MeOH–$KHCO_3$ on the water bath → 1.05 g. 3-β-hydroxy-D-homo-17-androstanone. M. W. Goldberg and E. Wydler, *Helv. Chim. Acta 26*, 1142 (1943); *C.A. 1944*, 367.
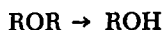
Deacetylation of Glycosides
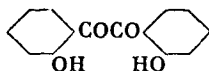   See 220.
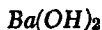
Barium hydroxide $Ba(OH)_2$
   See 217.

*Barium methylate*   . $Ba(OR)_2$

4. Pentaacetyl-β-methyl-D-manno-D-galaheptoside (prepn., see 218) is treated with $(MeO)_2Ba$ → β-methyl-D-manno-D-galaheptoside. Y = 91%. E. M. Montgomery and C. S. Hudson, *J. Am. Chem. Soc. 64*, 247 (1942); *C.A. 1942*, 1906.

5. Maltose octaacetate is shaken with $(MeO)_2Ba$ (prepn., see original) at room temp. → maltose monohydrate. W. A. Mitchell, *J. Am. Chem. Soc. 63*, 3534 (1941); *C.A. 1942*, 1019. Methods, see Weltzien and Singer, *Ann. 443*, 104 (1925).

Aluminum chloride $AlCl_3$

Ether Cleavage   ROR → ROH

6.

2,2'-Dimethoxybenzil is heated for 7 hrs. at 55° with pulverized $AlCl_3$ in $PhNO_2$ → 2,2'-dihydroxybenzil. Y = 50–66%. F.e.s. R. Kuhn, L. Birkofer and E. F. Möller, *Ber.* 76, 900 (1943); *C.A. 1944*, 2950.

7. 2,2'-Dimethoxy diphenyl sulfone is boiled with $AlCl_3$ in xylene → 2,2'-dihydroxy diphenyl sulfone. Y = 60–70%. F.e.s. G. Machek and H. Haas, *J. prakt. Chem. 160*, 41 (1942); *C.A. 1943*, 5040.

*Formic acid-acetyl chloride*   *HCOOH–CH₃COCl*
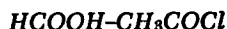
Degradation of Methylated Polysaccharides   ROR → ROH
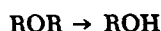
8. Methylated polysaccharides can be decomposed at room temp. into simple methylated sugars by HCO_2H and AcCl as a catalyst. After removal of the formic acid, if necessary after previous glucosidation [see K. Freudenberg and W. Jacob, *Ber. 74,* 162 (1941)], the sugars can be distilled *in vacuo.* The procedure is not suitable for free and acetylated polysaccharides, methylated wood, and proteins. K. Freudenberg, T. Ploetz and W. Jacob, *Ber. 75,* 1694 (1942); *C.A. 1944,* 1213.

Pyridinium hydrochloride

Ether Cleavage   ROR → ROH
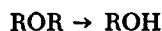
9. The following compounds can be cleaved with pyridinium hydrochloride and dry HCl at 200–10°: anisol, nerolin, veratrol, guaiacol. V. Prey, *Ber. 75,* 350 (1942); *C.A. 1943,* 3072.

   See also 610.

Hydrochloric acid   *HCl*

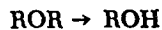### Cleavage of Trityl Ethers   ROR → ROH
   See 216.

Glycoside Cleavage

10. *g*-Strophanthin (rhamnose glycoside of *g*-strophanthidin) is allowed to stand for a few days with HCl in Me_2CO → *g*-strophanthidin. Y = 80%. C. Mannich and G. Siewert, *Ber. 75B,* 737 (1942); *C.A. 1943,* 3441.

Hydrobromic acid   *HBr*

Ether Cleavage   ROR → ROH

11. 8-Methoxyquinoline is refluxed in HBr (d. 1.5) for 3–4 hrs. → 8-hydroxyquinoline. Y = 90%. F. E. King and J. A. Sherred, *J. Chem. Soc. 1942,* 415; *C.A. 1942,* 5821.

12. 6-Methoxy-1-naphthoic acid (prepn., see 189) is refluxed with 48% HBr in glacial AcOH → 6-hydroxy-1-naphthoic acid. Y = 90%. L. Long, Jr., and A. Burger, *J. Org. Chem. 6,* 852 (1941); *C.A. 1942,* 763.

Palladium black   *Pd*

Cleavage of Benzyl Ethers   ROR → ROH

13.

$$C_6H_5CH_2O$$
$$C_6H_5CH_2O \bigcirc C \cdot C \cdot CH_3 \longrightarrow HO \bigcirc C \cdot C \cdot CH_3$$

with substituents OH, NH_2, H, H on left structure and HO, OH, NH_2, H, H on right structure.
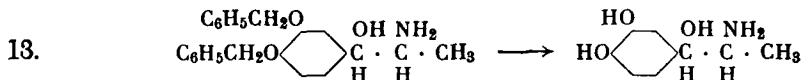
1-(3,4-Dibenzylhydroxyphenyl)-2-aminopropanol (prepn., see 292) is dissolved in MeOH and 3N HCl and reduced with a prehydrogenated suspension of 22% Pd-C at room temp. and atm. pressure → 1-(3,4-dihydroxyphenyl)-2-aminopropanol. Y = quant. V. Bruckner and G. v. Fodor, *Ber.* 76, 466 (1943); *C.A. 1943*, 6656.

14. 5-Benzyloxy-2-indolecarboxylic acid (prepn., see 562) is reduced with Pd–C in MeOH → Me 5-hydroxy-2-indolecarboxylate. Y = 70%. F. Bergel and A. L. Morrison, *J. Chem. Soc. 1943*, 49; *C.A. 1943*, 3429.

Cleavage of Trityl Ethers

See 216.

Elimination

Oxygen ↑   HO ⇑ O

Sodium sulfite Na_2SO_3

Alcohols from Peroxides   · OOH → OH

15.
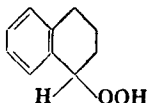
The corresponding alc. is obtained in a smooth reaction by the reduction of the peroxides with Na_2SO_3. Ex: Tetralin peroxide with Na_2SO_3 in H_2O → α-tetralol. Y = 90%. F.e.s. H. Hock and Shon Lang, *Ber.* 75, 313 (1942); *C.A. 1943*, 3749.

16.
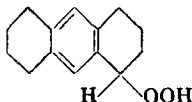
Octahydroanthracene peroxide (prepn., see 132) is stirred with H_2O–Na_2SO_3 in MeOH for 1 hr. at room temp. and for 2 hrs. at 75° → octahydroanthrol. Y = 85%. H. Hock and Shon Lang, *Ber.* 76, 1130 (1943); also, *Ber.* 77, 257 (1944); *C.A. 1944*, 4935.

Formation of H—N Bond by:

Addition

Addition to Nitrogen   HN ⇓ NN

Zinc dust   **Zn**

Hydrazo Compounds from Azo Compounds   N : N → NH · NH

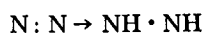17. **Total Reduction of Disazo Compounds.** 4,4'-Bis(benzeneazo)biphenyl, $C_{24}H_{18}N_4$, is stirred in pyridine with Zn dust and glacial AcOH is added during which the reaction mixture heats up to 28° → 4,4'-bis(benzenehydrazo)biphenyl. Y = almost quant.

    Partial Reduction of Disazo Compounds. 4,4'-Bis(benzeneazo)biphenyl is treated with Zn dust in pyridine with gradual addn. of a little glacial AcOH → 4-benzenehydrazo-4'-benzeneazobiphenyl. Y = 90%. P. Ruggli and K. Hölzle, *Helv. Chim. Acta 26,* 814 (1943); *C.A. 1944,* 2640.

18. **Mild Reduction to Sensitive Hydrazo Compounds.** 2-Aminoazobenzene (0.5 g.) is reduced with Zn and NH_3 at 50–5° in alc. under N_2 → 0.35 g. 2-aminohydrazobenzene. F.e.s. P. Ruggli and K. Hölzle, *Helv. Chim. Acta 26,* 1190 (1943); *C.A. 1944,* 547.

Hydrogen sulfide H_2S

Partial Reduction of Nitrazo Compounds   N : N → NH · NH

19. 4-Aminobiphenyl-4'-azobenzene in NH_3–alc. suspension is treated with H_2S → 0.95 g. 4-nitrobiphenyl-4'-hydrazobenzene. P. Ruggli and K. Hölzle, *Helv. Chim. Acta 26,* 814 (1943); *C.A. 1944,* 2640; also, *Helv. Chim. Acta 26,* 1190 (1943); *C.A. 1944,* 547.

Sulfur dioxide SO_2

Hydrazinocarboxylic Acids   · NHNH₂
    See 261.

Addition to Nitrogen and Carbon   HN ⇓ NC
    See HC ⇓ NC

Without additional reagents
See NC ⇓ NC, 490.

Lithium **Li**

Closure of the Triazine Ring **O**
See 285.

Sodium alcoholate **NaOR**
See NC ⇓ NC NaOR

Rearrangement HN ↷

O-Acyl from N-Acyl Derivatives N · Ac → O · Ac
See 154.

Exchange

Oxygen ↟ **HN ⇌ O**

Electrolytic ⚡
See 292.

Sodium amalgam **Na,Hg**

Amines from Oximes CHNOH → CH₂NH₂

20. 16 g. $Me_2NCH_2CH_2C(:NOH)Me$ is reduced with 6% Na–Hg in 10% $AcOH$ → 15 g. 2-amino-4-dimethylaminobutane. E. Ghigi, *Ann. Chim. applicata 32*, 3 (1942); *C.A. 1943*, 1385.

Amines from Nitro Compounds
See 28.

Zinc **Zn**

Alkylamino Compounds from Nitro Compounds NO₂ → NHR

21. $C_6H_5NHCOC_6H_4NO_2 + CH_3CHO + 8 H \rightarrow C_6H_5NHCOC_6H_4NHCH_2CH_3$

1 g. *p*-nitrobenzanilide is treated with Zn and H_2SO_4 in alc., while $AcHNH_3$ is added dropwise → 0.65 g. 4-ethylaminobenzanilide. G. Lockemann, T. Lobenstein and W. Neumann, *Ber. 75B*, 1911 (1943); *C.A. 1944*, 1216.

N-Amino from *N*-Nitroso Compounds $N \cdot NO \rightarrow N \cdot NH_2$
    See 255.
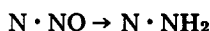
Aluminum   *Al*

Amines from Nitro Compounds $NO_2 \rightarrow NH_2$
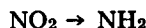
22. Et 5-nitro-2-thiophenecarboxylate is treated with activated Al scale in moist ether while CO_2 is passed through the reaction mixture $\rightarrow$ Et 5-amino-2-thiophenecarboxylate. Y = 78%. O. Dann, *Ber. 76,* 419 (1943); *C.A. 1943,* 6260.

Aluminum amalgam   *Al,Hg*
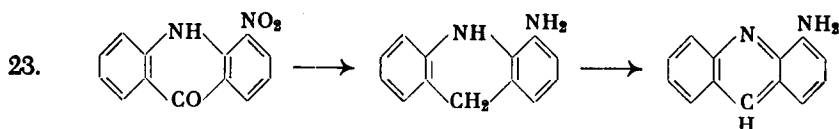
Aminoacridines from Nitroacridones

23.

Nitroacridone is reduced to the corresponding aminoacridane with Na amalgam in CO_2 atm., or with Al amalgam without use of CO_2. Then $FeCl_3$ oxidizes it to aminoacridone. Ex: 1-Aminoacridine; Y = 70%. 2-Aminoacridine; Y = 70%. 3-Aminoacridine; Y = 75%. A. Albert and B. Ritchie, *J. Indian Chem. Soc. 60,* 120 (1941); *C.A. 1942,* 5823.

Stannous chloride   *SnCl₂*

Partial Reduction of Dinitro Compounds $NO_2 \rightarrow NH_2$
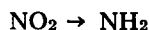
24. 2,4-Dinitrodimethylaniline (prepn., see 330) in warm EtOH is reduced with $SnCl_2$ in alc. HCl $\rightarrow$ 2-amino-4-nitrodimethylaniline. Y = 72%. E. E. Ayling, J. H. Gorving and L. E. Hinkel, *J. Chem. Soc. 1942,* 755; *C.A. 1943,* 1398.

25. The 1-nitro group of 1,2-dinitronaphthalenes can be reduced advantageously with $SnCl_2$ dissolved in glacial AcOH · HCl. The 1,5- and 1,8-dinitronaphthalenes, however, are reduced to the corresponding diamines. 1,5-Dinitronaphthalene is reduced to 5-nitro-1-naphthylamine and 1,6-dinitronaphthalene to 5-nitro-2-naphthylamine with an aq. Na_2S soln. Ex: 1,6-Dinitronaphthalene is dissolved in hot glacial AcOH and treated with $SnCl_2$ in glacial AcOH · HCl for 45 min. under 30° $\rightarrow$ 6-nitro-1-naphthylamine. Y = 60%. $1,5\text{-}C_{10}H_6(NO_2)_2$ (pulverized) wetted with EtOH, is treated with an aq. soln. of crystalline Na_2S for 15 min. at 95° (improved method by Hodgson and Walter, *J. Chem. Soc. 1933,* 1346) $\rightarrow 1,5\text{-}C_{10}H_6(NH_2)NO_2$. Y = 60.5%. H. H. Hodgson and H. S. Turner, *J. Chem. Soc. 1943,* 318; *C.A. 1943,* 6258.

Sulfur   S

Amino Aldehydes from Nitro Hydrocarbons
  See 162.

Sodium sulfide $Na_2S(SnCl_2)$
  See 25.

Sodium hyposulfite $Na_2S_2O_4$

Amines from Nitroso Compounds $NO \rightarrow NH_2$
  See 360.

Amines from Nitro Compounds $NO_2 \rightarrow NH_2$

26. 1-Methyl-9-nitrophenanthrene is treated with $Na_2S_2O_4$ in H_2O–MeOH
    $\rightarrow$ 1-methyl-9-aminophenanthrene. Y = nearly quant. T. Hasselstrom,
    J. Am. Chem. Soc. 63, 2527 (1941); *C.A. 1941,* 739.

Iron   *Fe*

27. *m*-Bromonitrobenzene is treated with iron powder and HCl gas in alc.
    $\rightarrow$ *m*-bromoaniline. Y = 86%. B. W. Speekmann and J. P. Wibaut, *Rec.
    trav. chim. 61,* 383 (1942); *C.A. 1944,* 2327.
      See also 30.

Nickel   *Ni(Cu)*

28. Reductions with HCOOH and Cu or Ni. The decomposition of
    HCOOH into H_2 and CO_2 in the presence of Cu or Ni is used for
    reductions under pressure. This method is particularly suitable for
    the reduction of small amounts of material. When Cu is used as the
    catalyst only the side chain of aromatic compounds is reduced, whereas
    Ni also reduces the nucleus. Catalysts: 1. Cu: Kieselguhr which has
    been cleaned with boiling HNO_3 is wetted with an aq. 10% $Cu(NO_3)_2$
    soln., made yellow (alkaline) with 2N soda soln. and dried and
    reduced after an H_2O washing. 2. Ni: Similarly shaken with an aq.
    10% $NiSO_4$ soln. Ex: With Cu: 0.01 mole benzaldehyde $\rightarrow$ 1.92 g. mixt.
    of 56% $PhCH_2OH$ and 18% PhMe $\rightarrow$ $PhNO_2$ $\rightarrow$ $PhNH_2$. Y = 100%.
    With Ni: 0.01 mole $PhNO_2$ $\rightarrow$ 1.64 g. cyclohexylamine. R. R. Davies
    and H. H. Hodgson, *J. Chem. Soc. London 1943,* 281; *C.A. 1943,* 5370.

29. Benzoyl-*o*-nitroaniline is reduced with Raney Ni in alc. $\rightarrow$ benzoyl-
    o-phenylenediamine. Y = 96%. P. Ruggli and J. Rohner, *Helv. Chim.
    Acta 25,* 1533 (1942); *C.A. 1943,* 5947.

Palladium   **Pd**

$$COCH_2CHCOOH$$
$$NH_2 \quad \overset{|}{N}H_2$$
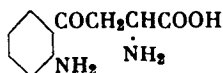
30. *o*-Nitrophenacylaminoacetic acid · HCl is reduced with Pd black in H_2O and treated with $H_2SO_4 \rightarrow d,l$-kynurenine sulfate. Y = 87%. The reduction with Fe yields only 75%. A. Butenandt, W. Weidel, R. Weichert and W. v. Derjugin, Z. *physiol. Chem.* **279**, 27 (1943); *C.A. 1944,* **2044.**

Nitrogen ↟   **HN ⇅ N**

Sodium hyposulfite $Na_2S_2O_4$

Reductive Cleavage of Azo Compounds $N{=}N \rightarrow NH_2$
   See 173.

Nickel   **Ni**
   See 398.

Carbon ↟   **HN ⇅ C**

Sodium hydroxide   *NaOH*

Hydrolysis of Acylated Amines $NHAc \rightarrow NH_2$

31. Acetylsulfanilyl derivs. are hydrolyzed by boiling for 1–1.5 hrs. with 10% NaOH. Ex: Acetylsulfanilyl-2-aminopyridine-5-sulfonic acid (prepn., see 274) → sulfanilyl-2-aminopyridine-5-sulfonic acid. Y = 81%. Acetylsulfanilyl-2-aminopyridinesulfonic acid → sulfanilyl-2-aminopyridinesulfonic acid. Y = 96%. C. Naegeli, W. Kündig and E. Suter, *Helv. Chim. Acta* **25**, 1485 (1942); *C.A. 1943,* 5949.
   See also 35.

Potassium hydroxide   *KOH*

Opening of the Hydantoin Ring   **C**
   See 568.

Alkali alcoholate

Hydrolysis of Acylated Amines $NHAc \rightarrow NH_2$

32. Acetylamino compounds which contain a nitro group in the *o*- or *p*-position are easily hydrolyzed by boiling with alc. and the corresponding Na alcoholate. The acetyl group is thereby split off as the ester.