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The Rearrangement of Hydrazones and Semicarbazones

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Hydrazones have been rearranged to amides by means of sodium nitrite and concentrated sulfuric acid. The reaction was found to be general except for a side reaction of hydrolysis which became the predominant one with entirely aliphatic hydrazones. Similarly, semicarbazones rearranged to amides under more strenuous conditions and in lower yields. The stereoisomeric hydrazones and semicarbazones of *p*-methoxy- and *p*-bromobenzophenone rearranged, and configurations were assigned or suggested on the basis of the benzanilides isolated.

Conditions and Scope.—The rearrangement of hydrazones to amides by means of sodium nitrite and concentrated sulfuric acid, as communicated previously,[2] is dependent on diazotization of a very weak base which thus requires a strong diazotizing agent such as nitrosyl sulfate

$$R_2C{=}NNH_2 \xrightarrow{ONOSO_3H} RCONHR + N_2 + H_2SO_4$$

No previous rearrangement of hydrazones by this preferred procedure is recorded in the literature, though some attempts using pyrolysis with strong acid catalysts are described.[3,4] Xanthopoulos[4] heated the alleged *syn* and *anti* forms of *p*-bromo- and *p*-chlorobenzophenone hydrazones at 450° with zinc chloride and reported 70–80% yields of acids and anilines (derived from the benzanilides) as well as significant trends with the various isomers. Pyrolysis of hydrazones with acid catalysts is not the preferred procedure for rearrangement, and no significance can be attached to the results of Xanthopoulos with the *syn–anti* isomers since these compounds were probably hydrazone–azine forms (see Experimental, Section 5). Rearrangement of N-substituted hydrazones, such as benzophenone phenylhydrazone, to *p*-phenylenediamines also has been reported,[5] but this reaction involves a *p*-semidine rather than a Beckmann-type rearrangement.

The most suitable procedure for rearrangement of hydrazones was found to be a quite simple one: one equivalent of hydrazone was added portionwise to cold 90% sulfuric acid containing 1.5 equivalents of sodium nitrite. Considerable foaming took place due to the rapid evolution of nitrogen gas. Higher concentrations of sulfuric acid gave comparable yields of amides which, however, were slightly discolored. Lower concentrations of sulfuric acid gave increasingly lower yields of amides. Diluents of sulfuric acid, other than water, could be used: 10% acetic acid was as effective as 10% water; 10% ether was less effective. Strong acids, other than sulfuric acid, were less effective: perchloric acid gave charred products; phosphoric acid gave an unstable nitrosating medium; ethanesulfonic acid gave an amide of comparable yield but of poor quality. The study of the scope was therefore undertaken using 90% sulfuric acid.

The rearrangement of hydrazones to amides was found to be general with the yields ranging from excellent to poor, respectively, in the sequence: diaryl ketone hydrazones > arylalkyl > dialkyl. The reason for the poor yields, or no yield at all, with the completely aliphatic hydrazones was ascribed to their increased tendency to hydrolyze to the parent ketones or to be converted to azines under the conditions of rearrangement.

Since the same amide was obtained from both the oxime and hydrazone rearrangement, the conclusion was that the hydrazone rearrangement offered no synthetic advantages over the Beckmann synthesis of amides with the possible exception that the extreme rapidity of hydrazone transformation may be of potential value. However, the discovery of the rearrangement has served to complete a parallel series of reactions in which each series has transition complexes of marked similarity (if not identity). The first series is illustrated[6]

$$\begin{tikzcd}
ROH \arrow[dr, "H^+"] & \\
RCl \arrow[r, "AlCl_3"] & R^+ \\
RNH_2 \arrow[ur, "HNO_2"'] &
\end{tikzcd}$$

Comparison with the above series has enabled completion of the following parallel series[6] and may well serve to complete others

$$\begin{tikzcd}
R_2C{=}NOH \arrow[dr, "H^+"] & \\
R_2C{=}NCl \arrow[r, "SbCl_5^7"] & R_2C = N^+ \\
R_2C{=}NNH_2 \arrow[ur, "ONOSO_3H"'] &
\end{tikzcd}$$

The Rearrangement of Semicarbazones.—It was originally postulated that any structure such as $R_2C{=}NNHY$, where Y is replaced by hydrogen under the conditions of rearrangement, should undergo the hydrazone rearrangement. Semicarbazones, which fall in this classification, were found to rearrange in accordance with this view

$$R_2C{=}NNHCONH_2 \xrightarrow{2ONOSO_3H} RCONHR + 2N_2 + CO_2 + 2H_2SO_4.$$

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[1] Chemistry Department, Presbyterian College, Clinton, S. C. In part from the Ph.D. thesis of K.N.C., "The Rearrangement of Semicarbazones and Stereoisomeric Hydrazones," 1951, University Microfilms, Inc., Ann Arbor, Mich.

(2) D. E. Pearson and C. M. Greer, THIS JOURNAL, **71**, 1895 (1949).

(3) J. Stieglitz and J. K. Senior, *ibid.*, **38**, 2727 (1916); J. Stieglitz and R. L. Brown, *ibid.*, **44**, 1270 (1922); E. C. Gilbert, *ibid.*, **49**, 286 (1927).

(4) John Xanthopoulos, *Univ. Chicago Science Series*, **4**, 195 (1925–1926); **3**, 111 (1924–1925); *C. A.*, **22**, 3639 (1928).

(5) W. Theilacker and O. R. Leichtle, *Ann.*, **572**, 121 (1951).

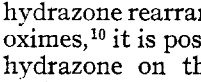
(6) The transition complexes have been skeletonized for comparison's sake.

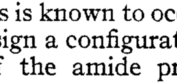
(7) W. Theilacker and H. Mohl, *Ann.*, **563**, 99 (1949).

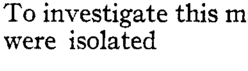
Diazotization of semicarbazones is a well-known procedure for the regeneration of the parent ketone. However, the procedure makes use of weak or dilute, aqueous acids,[8] whereas the rearrangement is conducted in concentrated sulfuric acid. The conditions were similar to those of the hydrazone rearrangement but more vigorous: elevated temperature (about 35°), a larger excess of sodium nitrite (5/1 ratio), and more concentrated sulfuric acid. The yields were decidedly poorer ranging from 70% with diaryl ketone semicarbazones to 15–30% with arylalkyl compounds and with very little or no rearrangement of the aliphatic semicarbazones. Again, hydrolysis was a competing reaction. The mechanism of rearrangement may be a stepwise degradation to the hydrazone followed by the usual rearrangement—a possibility partly supported by the less facile tendency for rearrangement of benzophenone-4-phenylsemicarbazone, $(C_6H_5)_2C{=}NNHCONHC_6H_5$. Under comparable conditions this compound gave only a 9% yield of benzanilide compared to a 70% yield for benzophenone semicarbazone. Benzalazine rearranged in 21% yield to formanilide (isolated as benzanilide). The corresponding oxime conversion has been studied recently.[9] No anilides were obtained on attempted rearrangement of benzophenone thiosemicarbazone or acetophenone guanylhydrazone. The postulate, therefore, that structures such as $R_2C{=}NNHY$ should degrade to the hydrazone and rearrange, does not hold in all instances using the conditions described in the Experimental section.

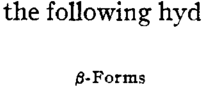
The Rearrangement of Stereoisomeric Hydrazones and Semicarbazones.—If one makes the logical assumption of migration of the *anti* group in the hydrazone rearrangement, as is known to occur with oximes,[10] it is possible to assign a configuration to a hydrazone on the basis of the amide produced. To investigate this matter the following hydrazones were isolated

α-Forms β-Forms


$C_6H_5\overset{NNH_2}{\overset{\|}{C}}C_6H_4Br\text{-}p$, m.p. 104°


$p\text{-}BrC_6H_4\overset{NNH_2}{\overset{\|}{C}}C_6H_5$, oil


$p\text{-}CH_3OC_6H_4\overset{NNH_2}{\overset{\|}{C}}C_6H_5$, m.p. 96°


$C_6H_5\overset{NNH_2}{\overset{\|}{C}}C_6H_4OCH_3\text{-}p$, m.p. 84°

It was definitely established by the hydrazone rearrangement of each form that the configurations of *p*-bromobenzophenone hydrazones were as illustrated since each yielded the anilide to be expected from *anti* migration.

However, both forms of *p*-methoxybenzophenone yielded practically the same mixture of anilides (75% N-benzoyl-*p*-anisidine and 25% of N-anisoylaniline). Since it was also found that solution of the β-form in concentrated sulfuric acid converted it in more than 50% yield to the α-form (but not *vice versa*), the indication was that the configurations of the *p*-methoxybenzophenone hydrazones were as illustrated. If so, it is interesting to note that the α-hydrazone forms (those having higher melting points and obtained in greater yield) have the group of greatest migratory aptitude in the position *anti* to the amino group of the hydrazone. This generality applies to the stereoisomers of the halogen-substituted benzophenone oximes[11,12] as well as the two isomers of *p*-methoxybenzophenone oxime.[12]

In an analogous manner, the *syn–anti* forms of *p*-bromo- and *p*-methoxybenzophenone semicarbazones were isolated and subjected to rearrangement. It was not possible to assign configurations unequivocally since mixtures of anilides were obtained in each case, no doubt owing to the more strenuous conditions of rearrangement. However, the ratio of anilides obtained again suggested that the group of greatest migratory aptitude was *anti* with respect to the urea group of the semicarbazone.

Experimental[13]

(1) **The Preparation of Hydrazones.**—The crystalline hydrazones were made by refluxing for several hours one equivalent of ketone and two equivalents of 85% hydrazine hydrate dissolved in the minimum amount of absolute alcohol to achieve homogeneity at the boiling point. The hydrazones obtained on cooling, filtering and washing were recrystallized from petroleum ether (b.p. 69°) or ethylene chloride depending on their solubility. It was not necessary to resort to removal of water by chemical means,[14] to use of a higher boiling solvent[15] or to acetic acid catalysis. The liquid hydrazones were synthesized by the method of Lock and Stach.[16] The yields and physical properties are described in Section 3.

(2) **The Preparation of Azines and Semicarbazones.**—The azines were prepared by the method of Taipole[17] in which one plus equivalents of hydrazine hydrate and two equivalents of ketone in acetic acid were heated under reflux for several hours. It was not necessary to make the hydrazone and convert it to the azine with sulfuric acid[14] or to remove water by azeotropic distillation.[18] It was found that hydrazones were converted to the azines by recrystallization from acetic acid and this conversion accordingly is effected without isolation in the above procedure. It was also found that aluminum chloride hexahydrate had unusual catalytic activity in a similar conversion: benzophenone hydrazone (1 g. in 15 ml. of alcohol) was added all at once to a boiling solution of 2 g. of aluminum chloride hexahydrate in 10 ml. of water; the mixture turned yellow and on continued heating deposited yellow needles (0.8 g.) which on recrystallization from ethanol melted at 164–165° (mixed m.p. with benzophenone azine undepressed). Zinc, magnesium and cobalt chlorides, under comparable conditions, had no such effect, the hydrazone, m.p. 98–99°, being recovered.

The semicarbazones, with the exception of the stereoisomeric ones, were made by the method of Anziani,[19] using 1 equivalent of ketone, 2 equivalents of semicarbazide hydrochloride, 1.2 equivalents of sodium hydroxide and sufficient water and ethanol to dissolve all components at the boiling point.

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[8] St. Goldschmidt and W. L. C. Veer, *Rec. trav. chim.*, **65**, 796 (1946); D. H. Hey and D. S. Morris, *J. Chem. Soc.*, 2319 (1948); M. L. Wolfrom, L. W. Georges and S. Soltzberg, THIS JOURNAL, **56**, 1794 (1934).

[9] E. C. Horning and V. L. Stromberg, *ibid.*, **74**, 5151 (1952).

[10] A. H. Blatt, *Chem. Revs.*, **12**, 215 (1933).

[11] J. Meisenheimer and H. Meis, *Ber.*, **57B**, 289 (1924); A. Hantzsch, *ibid.*, **24**, 51 (1891); R. Demuth and M. Dittrich, *ibid.*, **23**, 3609 (1890); J. Meisenheimer, P. Zimmerman and U. v. Kummer, *Ann.*, **446**, 205 (1926); W. Kottenhahn, *ibid.*, **264**, 170 (1891).

[12] A. Schafer, *ibid.*, **264**, 152 (1891); A. Hantzsch, *Ber.*, **24**, 51 (1891). The β-form, contrary to the forms of all other isomers, was the stable isomer and yielded N-benzoyl-*p*-anisidine.

[13] All melting points are corrected and boiling points uncorrected. Analyses by Clark Microanalytical Laboratory, Urbana, Ill.

[14] H. H. Szmant and C. McGinnis, THIS JOURNAL, **72**, 2890 (1950); **74**, 240 (1952).

[15] C. L. Arcus and R. J. Mesley, *J. Chem. Soc.*, 181 (1953).

[16] G. Lock and K. Stach, *Ber.*, **77B**, 293 (1944); *C. A.*, **40**, 5011 (1946).

[17] K. A. Taipole, *Ber.*, **63B**, 243 (1930).

[18] C. G. Overberger, *et al.*, THIS JOURNAL, **75**, 2078 (1953).

[19] P. Anziani, *Bull. soc. chim.*, **6**, 954 (1944).

(3) The Conditions and Scope of the Hydrazone Rearrangement.—The best conditions for the rearrangement of benzophenone hydrazone were found to be as follows: 25 ml. of 90% sulfuric acid was placed in a narrow, tall beaker of 125–150 ml. capacity and cooled with stirring. Sodium nitrite (2.0 g., 0.029 mole) was added slowly so that the temperature did not exceed 15°. Ground benzophenone hydrazone (m.p. 98–99°, 3.9 g., 0.02 mole) was added portionwise to the well-stirred and cooled solution of nitrosyl sulfate at such a rate that the foam did not leave the sphere of action. The addition was complete in 45 minutes, and the temperature never exceeded 15°. After the foaming had subsided, the dark red solution was poured onto a slurry of ice and 60 ml. of concentrated ammonium hydroxide. The precipitate was separated by filtration, thoroughly washed and air-dried (3.9 g., m.p. 153–160°). Recrystallization from ethanol yielded benzanilide (3.2 g., m.p. 163–164°, 82%, mixed m.p. with authentic benzanilide undepressed).

The effect of concentration of sulfuric acid was as follows: 96% acid, 97% crude yield but benzanilide was slightly discolored; 85% acid, 90% crude yield; 70% acid, 70% crude yield. The effect of other modifications is mentioned in the Discussion section. Using the best procedure, the hydrazones (0.02 mole) listed below were subjected to rearrangement.

***p*-Nitroacetophenone Hydrazone.**—Hydrazone yield, 73% of orange needles from ethylene chloride, m.p. 149–151°; hydrolysis equiv. calcd. 179, found[20,21] 178. The rearrangement product was *p*-nitroacetanilide (quantitative crude yield, m.p. 202–211°, recrystallized in 75% yield, m.p. 213–215° which was undepressed on mixture with an authentic sample).

***p*-Methylacetophenone Hydrazone.**[16]—The liquid hydrazone was added dropwise from a separatory funnel to the nitrosyl sulfate solution. The rearrangement product was aceto-*p*-toluidide (80% crude yield, m.p. 118–146°, recrystallized in 60% yield, m.p. 146–148° which was undepressed on mixture with an authentic sample).

***p*-Acetophenone Hydrazone.**[16]—The rearrangement product was acetanilide (70% yield, m.p. 102–110°, recrystallized in 50% yield, m.p. 113–114.5° which was undepressed by mixture with authentic acetanilide).

***p*-Hydroxyacetophenone Hydrazone.**—Hydrazone yield, 66%; it was necessary to recrystallize from alcohol containing hydrazine hydrate in order to prevent hydrolysis, m.p. 153–154.5°; hydrolysis equiv. calcd. 150, found 151. This compound was an allergen. The rearrangement product, obtained by continuous ethyl acetate extraction, was *p*-hydroxyacetanilide (80% yield, m.p. 153–157°; after four recrystallizations from water, m.p. 163–164° which was undepressed by mixture with authentic *p*-hydroxyacetanilide, m.p. 169–170.5°).

Diisopropyl Ketone Hydrazone.—Hydrazone yield, 60%, b.p. 90–91° (43 mm.), $n^{25}{}_D$ 1.457. It was the only liquid hydrazone isolated which could be distilled at atmospheric pressure (b.p. 177–179°) without disproportionation to the azine and hydrazine. The hydrazone rapidly absorbed moisture so that analytical data were poor; hydrolysis equiv. calcd. 128, found 137, 138. The rearrangement product, isolated by continuous ether extraction, was N-isopropylisobutyramide (40% yield, m.p. 103–104°, reported m.p. 107°).[22]

Cyclohexanone Hydrazone.[23]—Caprolactam was not obtained but rather traces of cyclohexanone and considerable resinous material. It was noted with this and other aliphatic hydrazones that clouds of white vapor (hydrazine sulfate particulate(?) formed immediately over the reaction mixture on contact with the hydrazone. This would indicate rapid azine formation.

Other examples of diaryl ketone hydrazone rearrangements are given in Sections 6 and 8.

(4) The Isolation of the Stereoisomeric *p*-Methoxybenzophenone Hydrazones.—*p*-Methoxybenzophenone[24] (21.2 g., 0.1 mole), anhydrous hydrazine (17 g., 0.53 mole) and 40 ml. of absolute ethanol were refluxed for 8 hours, then cooled to room temperature and finally overnight in the refrigerator. The crystals were separated by filtration, washed with cold, absolute ethanol and air-dried, 15.2 g., m.p. 65–80°. After two recrystallizations from absolute ethanol, the α-form was obtained as white needles, m.p. 95–96°, reported[25] m.p. 96°. The filtrate and washings from the original reaction mixture were combined with 200 ml. of methylcyclohexane and distilled to a volume of 100 ml. in order to remove the alcohol. The lower layer of hydrazine was removed from the 100-ml. residue and the upper layer combined with 200 ml. more of methylcyclohexane and again distilled to a volume of 100 ml. The alcohol-free residue was then refrigerated and deposited 4.7 g. of crystals, m.p. 61–67°. After two recrystallizations from a mixture of 20 ml. of methylcyclohexane and 5 ml. of ether, the β-form was obtained as rather dense, large crystals, 2.8 g., m.p. 81.5–84°; wasteful crystallization from absolute ethanol raised the m.p. to 83–85°, reported[25] m.p. 86°. Seeding greatly facilitated all separations, and care was necessary to avoid contamination with acid fumes which promote azine formation.

(5) The Isolation of the Stereoisomeric *p*-Bromobenzophenone Hydrazones.—Following the procedure in Section 4, 9.4 g. (34%) of the α-isomer, m.p. 104–104.5°, was isolated. The β-isomer (6 g.) separated as an oil, and all attempts to crystallize it failed. Xanthopoulos[4] reported the α-isomer as melting at 166–167° and the β-isomer at 102.5–103.5°. Obviously, his β-form was identical to the α-form reported here, and his α-form was indicated to be the azine as follows: the azine was prepared by the first two general methods described in Section 2, yellow needles, m.p. 170.5–171.5°.

Anal. Calcd. for $C_{26}H_{18}N_2Br_2$: N, 5.4. Found: N, 5.0.

(6) The Rearrangement of the Stereoisomeric *p*-Methoxybenzophenone Hydrazones.—Both α- and β-forms yielded practically the same product on rearrangement: quantitative crude yield, m.p. 152–153.5°, recrystallized from alcohol in 87% yield, m.p. 155–156°; reported m.p. of N-benzoyl-*p*-anisidine (A) was 156° and of N-anisoylaniline (B) 173–174°. However, on hydrolysis of 0.8 g. of anilide, m.p. 155–156°, 0.1 g. (19%) of anisic acid and 0.25 g. (58%) of benzoic acid was obtained. (The separation was based on the volatility of benzoic acid in presence of steam.) A melting point curve of the two authentic anilides was then determined, and it was shown that B depressed the m.p. of A only slightly (with no widening of the m.p. range), whereas A depressed the m.p. of B profoundly.[1]

The over-all results indicated that the *p*-methoxyphenyl group migrated in the ratio of 3/1 compared to the phenyl group.

(7) The Conversion of α-*p*-Methoxybenzophenone Hydrazone to the β-Form.—It was already established by Chuang[26] that the above forms were not polymorphs. The α-form (0.75 g., m.p. 93–95°) was dissolved in 4 ml. of cold, concentrated sulfuric acid. The solution turned yellow and became warm. After 30 minutes, the solution was poured with vigorous stirring into a slurry of ice and sodium bicarbonate solution; the yield was 0.6 g., m.p. 75–88°. After recrystallization from absolute ethanol, the α-form was obtained, 0.4 g., 53%, m.p. 94–95.5°, which was undepressed by mixture with the original α-form.

Identical treatment of the β-form, 0.25 g., m.p. 83–85°, gave a quantitative yield of crude product, m.p. 62–80°, which on recrystallization from 2 ml. of absolute ethanol yielded the α-form, 0.15 g., 60%, m.p. 92–94.5°, mixed m.p. with original α-form undepressed. Thus, it was shown that sulfuric acid caused equilibration of the two forms with the α-form in preponderance, and the over-all results suggest that the α-form has the *p*-methoxyphenyl group *anti* to the amino group in the hydrazone.

(8) The Rearrangement of the Stereoisomeric *p*-Bromobenzophenone Hydrazones.—The α-form (m.p. 104°) yielded N-*p*-bromobenzoylaniline, 90% crude, m.p. 180–190°; 65% on recrystallization from ethanol, m.p. 200.5–204°, reported m.p. 201–202°; hydrolysis product, *p*-bromobenzoic acid, m.p. 254–255°, with no evidence of benzoic

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[20] D. E. Pearson, This Journal, **72**, 4170 (1950).

[21] It was necessary to reflux this hydrazone with acid for 10 hours to complete hydrolysis.

[22] V. Meyer and A. Warrington, *Ber.*, **20**, 500 (1887); J. U. Nef, *Ann.*, **310**, 326 (1900).

[23] N. Kizhner and S. Byelov, *J. Russ. Phys. Chem. Soc.*, **43**, 577 (1911); *C. A.*, **6**, 347 (1912); D. B. Dutt and P. C. Guha, *J. Indian Chem. Soc.*, **27**, 151 (1950).

[24] S. Chodroff and H. C. Klein, This Journal, **70**, 1647 (1948).

[25] E. A. Sloan, Doctoral Dissertation, Univ. of Chicago, 1938.

[26] Chang-Kong Chuang, Ph.D. Dissertation, Univ. of Chicago, "Stereoisomeric Hydrazones" (July, 1924).

acid. The *β*-form (oil) yielded N-benzoyl-*p*-bromoaniline, 70% crude, m.p. 178–190°, 33% on recrystallization, m.p. 199–200°, reported m.p. 205°; hydrolysis of 1 g. yielded 0.3 g. (70%) of benzoic acid and 0.07 g. (10%) of *p*-bromobenzoic acid. The oily hydrazone was evidently contaminated with its isomer. The results were conclusive enough to warrant assigning the *anti*-phenyl configuration to the *α*-isomer and the *anti-p*-bromophenyl structure to the *β*-form which is an oil (or possibly a very low melting solid when pure).

(9) **The Rearrangement of Semicarbazones.**—The best procedure for the rearrangement of benzophenone semicarbazone was found to be as follows: 30 ml. of 99–100% sulfuric acid (prepared by mixing concentrated and fuming acid) was placed in a narrow, tall beaker equipped with stirrer, and sodium nitrite (8.0 g., 0.116 mole) was added slowly. Ground benzophenone semicarbazone (m.p. 167–168°, 4.78 g., 0.02 mole) was added portionwise to the nitrosyl sulfate solution maintained at 37° or at that temperature where nitrogen evolution was brisk. The addition was complete in 2 hours, but it was advantageous to continue stirring for an additional 3 hours or longer. The mixture was poured on to a slurry of ice and 95 ml. of concentrated ammonium hydroxide, and the precipitate was removed by filtration, thoroughly washed and air-dried. The precipitate was benzanilide, 4.1 g. crude yield; 2.83 g., 72%, m.p. 158–160° on recrystallization from ethanol; mixed m.p. undepressed with authentic benzanilide. Higher or lower concentrations of sulfuric acid or dilution with pyridine[27] were less effective. The following semicarbazones (0.02 mole) were subjected to the above procedure:

***p,p'*-Dichlorobenzophenone Semicarbazone** (m.p. 191.5–192.5°).—The rearrangement product was N-*p*-chlorobenzoyl-*p*-chloroaniline, 84% crude, m.p. 191–205°, 70% yield when recrystallized from ethanol, m.p. 212–212.5°, reported m.p. 207°, further identified by hydrolysis to *p*-chlorobenzoic acid and *p*-chloroaniline.

Anal. Calcd. for $C_{14}H_{11}Cl_2N_3O$: N, 13.64. Found: N, 13.69.

***p,p'*-Dimethylbenzophenone Semicarbazone** (m.p. 143–144°, reported m.p. 140°).—The rearrangement product was N-*p*-toluoyl-*p*-toluidine, 56% yield, m.p. 162–163°, reported m.p. 160°, further identified by hydrolysis to *p*-toluic acid and *p*-toluidine.

Acetophenone Semicarbazone (m.p. 195–198°).—The rearrangement product was acetanilide, 17%, m.p. 111–112°.

***p*-Chloroacetophenone Semicarbazone** (m.p. 201.5–202.5°).—The rearrangement product was *p*-chloroacetanilide, 7% yield after four recrystallizations from ethanol, m.p. 178–179°, mixed m.p. with authentic anilide undepressed.

Diisopropyl Ketone Semicarbazone (m.p. 157–158°).—The products were N-isopropylisobutyramide, 10%, m.p. 106–106.5°, 15% acetone (isolated as 2,4-dinitrophenylhydrazone, m.p. 124–125°), and some diisopropyl ketone. Cyclohexanone and acetone semicarbazones failed to yield any rearrangement products.

(10) **The Rearrangement of Miscellaneous Carbonyl Derivatives.**—The rearrangement of benzophenone-4-phenylsemicarbazone (m.p. 163–164°) yielded 50% benzophenone, m.p. 47–48°, and 9% of benzanilide isolated as benzoic acid. Benzophenone thiosemicarbazone (m.p. 173–174°) yielded 53% benzophenone and a small amount of an unidentified compound (m.p. 117–119°). Acetophenone guanylhydrazone (m.p. 182.5–183.5°, literature[28] m.p. 182.5°) yielded only a small amount of acetophenone. Benzalazine, m.p. 93–94°, yielded 47% of benzaldehyde, b.p. 175–176°, and 21% of aniline (isolated as benzanilide).

(11) **The Isolation of Stereoisomeric Semicarbazones.**—*p*-Methoxybenzophenone semicarbazone was separated into the *α*-form, m.p. 178.5–179.5°, and the *β*-, m.p. 154.4–155°, in close agreement with the directions of Bruzau.[29] The isomeric *p*-bromobenzophenone semicarbazones were separated by fractional crystallization from methanol. The more insoluble *α*-form crystallized in transparent plates which became opaque on drying, 41% yield, m.p. 177–178°.

Anal. Calcd. for $C_{14}H_{12}BrN_3O$: N, 13.21. Found: N, 13.17.

The *β*-form was obtained in 26% yield, needles, m.p. 170.5–171.5°. A mixture of the two forms melted at 140–155°.

Anal. Calcd. for $C_{14}H_{12}BrN_3O$: N, 13.21. Found: N, 13.39.

(12) **The Rearrangement of the Stereoisomeric Semicarbazones.**—The rearrangement products from both forms of *p*-methoxybenzophenone semicarbazone were so impure that it was necessary to hydrolyze and identify the acids. The *α*-isomer, m.p. 179°, yielded 5.7% anisic acid and 10.2% benzoic acid. The *β*-isomer, m.p. 155°, yielded 20.8% anisic acid and 20.5% benzoic acid.

The *α*-*p*-bromobenzophenone semicarbazone, m.p. 178°, yielded a mixture of anilides, 81%, m.p. 174–180°. On hydrolysis, one gram of the mixture yielded 0.55 g. (76%) of *p*-bromobenzoic acid and 0.15 g. (33%) of benzoic acid. The *β*-form (m.p. 171°) also yielded a mixture of anilides, m.p. 158–170°. On hydrolysis, 1 g. of the mixture yielded 0.4 g. (55%) of *p*-bromobenzoic acid and 0.17 g. (39%) of benzoic acid. It was also found that either the *α*- or *β*-form was isomerized to a mixture (m.p. 168–180°) of the two forms by concentrated sulfuric acid held at 37°. The data in this Section were not sufficiently clean-cut for assignment of configurations, though they were suggestive of correlation with the structure of the corresponding hydrazones.

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