(one to ten hours) then the pyridine was stripped from the mixture under vacuum. The residue was partitioned between 100 cc. each of benzene and 10% aqueous potassium hydroxide and the dried benzene layer was fractionally distilled to give the substituted acetone.

We wish to acknowledge the technical assistance of Messrs. Charles Anderson and Kenneth Hutton.

NEW YORK 11, N. Y. RECEIVED MARCH 28, 1951

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, THE UNIVERSITY OF TEXAS]

A Study of the Interaction of Certain Unsaturated Grignard Reagents and Nitriles[1,2]

BY HENRY R. HENZE, GEORGE L. SUTHERLAND AND GAYLE D. EDWARDS

Previously, the Grignard reagent prepared from allyl bromide had been shown to react "abnormally" (in the ratio of 2:1) with nitriles to form carbinamines rather than ketones. In this investigation, the Grignard reagent prepared from methallyl chloride, although used in large excess, reacted with ethoxyacetonitrile to form a mixture of products. As a result of reaction in a 2:1 ratio, some of the expected carbinamine was obtained (10% yield); however, most of the reactants interacted in 1:1 ratio to form a mixture of two isomeric ketones (60% yield); finally, about 5% of a dienol, structurally analogous to the carbinamine, was isolated from the reaction mixture. Similarly, lower homologs of both the carbinamine and the isomeric unsaturated ketones resulted from interaction of methoxyacetonitrile and the methallylmagnesium chloride. Since the activity of benzyl chloride is thought to approach that of an allyl halide, the former was converted into a Grignard reagent and the latter allowed to react with ethoxyacetonitrile; however, no evidence of carbinamine formation was found. The initial attempt to methylate a tertiary carbinamine by the Wallach modification of the Leuckart reaction was successful.

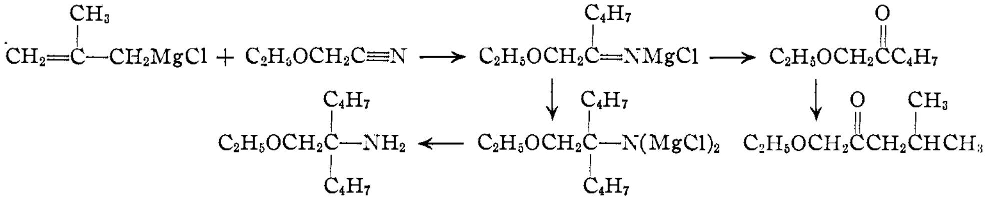
For some time past, there has been conducted in this Laboratory an intensive study of the preparation of substituted ketones of the alkoxy-, aryloxy- and halogenoalkoxyalkyl (or aryl) types. These ketones, for the most part, have been synthesized by means of a modification, by Béhal and Sommelet,[3] of the Grignard reaction. In this case the Grignard reagent adds to the nitrile in an equimolecular ratio. Upon hydrolysis of the adduct, either a stable ketimine or, in sequence, a ketone was obtained

$$RMgX + R'C{\equiv}N \longrightarrow RR'C{=}N{-}MgX \longrightarrow RR'C{=}NH \longrightarrow RR'C{=}O$$

Allen and Henze[4] attempted to prepare allyl ethoxymethyl ketone from interaction of equivalent quantities (1:1) of α-ethoxyacetonitrile and allylmagnesium bromide. However, the Grignard reagent added to the nitrile in 2:1 molecular ratio, and the sole product isolated from hydrolysis of the adduct was neither a ketimine nor a ketone, but a primary amine, namely, diallylethoxymethylcarbinamine $(CH_2CH{=}CH_2)_2(C_2H_5OCH_2)C\text{-}NH_2$. Since a nitrile is considered to be the least active[5] of the common functional groups to which Grignard reagents add, this "abnormal" behavior has been attributed to the greater reactivity of allylmagnesium bromide over the alkylmagnesium halides. Such greater activity was demonstrated also by the ability of allylmagnesium bromide to react by addition to the adducts formed by interaction of an excess of alkylmagnesium halides to a nitrile. Hydrolysis of these (second) addition products yielded tertiary carbinamines[4] of the type $RR'(CH_2CH{=}CH_2)C\text{-}NH_2$.

Tamele, *et al.*,[6] have reported the preparation of β-methallylmagnesium chloride in a 90 mole per cent. yield, as determined by titration and by measurement of the isobutylene produced on hydrolysis of the reagent.[7]

It has now been found that when methallylmagnesium chloride in excess was allowed to react with ethoxyacetonitrile, ketonic material as well as carbinamine was obtained as hydrolysis products



$$CH_2{=}\overset{\overset{CH_3}{|}}{C}{-}CH_2MgCl + C_2H_5OCH_2C{\equiv}N \longrightarrow C_2H_5OCH_2\overset{\overset{C_4H_7}{|}}{C}{=}NMgCl \longrightarrow C_2H_5OCH_2\overset{\overset{O}{\|}}{C}C_4H_7$$

$$C_2H_5OCH_2\underset{\underset{C_4H_7}{|}}{\overset{\overset{C_4H_7}{|}}{C}}{-}NH_2 \longleftarrow C_2H_5OCH_2\underset{\underset{C_4H_7}{|}}{\overset{\overset{C_4H_7}{|}}{C}}{-}N(MgCl)_2 \qquad C_2H_5OCH_2\overset{\overset{O}{\|}}{C}CH_2\overset{\overset{CH_3}{|}}{C}HCH_3$$

The ketonic material could be hydrogenated and converted into the known ethoxymethyl isobutyl ketone. Ozonolysis of the ketonic material yielded a mixture of formaldehyde, acetone, ethoxyacetone, ethoxypyruvic acid and acetic acid. Therefore, the ketonic material was a mixture of two isomers; however, it was chiefly 1-ethoxy-4-methyl-3-penten-2-one. The unsaturated carbinamine readily underwent catalytic hydrogenation to form 1-(ethoxymethyl)-3-methyl-1-(2-methylpropyl)-1-butylamine.

Methoxyacetonitrile reacted with methallylmagnesium chloride in a wholly analogous manner to yield the methoxymethylcarbinamine [1-(meth-

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[1] From a portion of the Ph.D. dissertation of George Leslie Sutherland, June, 1950.

[2] From the M.A. thesis of Gayle Dameron Edwards, August, 1948.

[3] A. Béhal and M. Sommelet, *Compt. rend.*, **138**, 89 (1904).

[4] B. B. Allen and H. R. Henze, THIS JOURNAL, **61**, 1790 (1939).

[5] C. E. Entemann, Jr., and J. R. Johnson, *ibid.*, **55**, 2900 (1933).

[6] M. W. Tamele, C. J. Ott, K. E. Marple and G. Hearne, *Ind. Eng. Chem.*, **33**, 115 (1941).

[7] In order to prove that methallylmagnesium chloride was typical in its reactions, it was converted through reaction with acetaldehyde and subsequent hydrolysis of the adduct into the secondary alcohol (4-methyl-4-penten-3-ol) in 65% yield. The Barbier synthesis also was successfully applied using acetone, methallyl chloride and magnesium.

oxymethyl) - 3 - methyl - 1 - (2 - methylallyl) - 3-butenylamine] and a mixture of 1-methoxy-4-methyl-4-penten-2-one and its 3-ene isomer. Both of these unsaturated ketones on hydrogenation yielded the known 1-methoxy-4-methyl-2-pentanone. Here, too, the composition of the ketone mixture was demonstrated through ozonolysis.

Since benzyl chloride exhibits activity greater than that of alkyl halides and more nearly similar to that of the allyl halides, benzyl chloride was converted into a Grignard reagent and the latter was treated with one-half equivalent of ethoxyacetonitrile. Upon hydrolysis of the adduct, no evidence for the presence of a carbinamine could be detected, and the sole product of reaction isolated was 1-ethoxy-3-phenyl-2-propanone.

When phenoxyacetonitrile and the methallyl Grignard reagent reacted, by hydrolysis of the adduct there was obtained a poor yield of carbinamine and ketonic material, chiefly 4-methylphenoxy-4-penten-2-one, predominated. Likewise, only a small yield of 1-allyl-1-[2-(2-ethoxyethoxy)-ethyl]-3-butenylamine resulted from interaction of β-(2-ethoxyethoxy)-propionitrile with allylmagnesium bromide; however, instead of authentic ketonic material a considerable amount of resinous product was obtained.

Experimental

Preparation of a Grignard Reagent from Methallyl Chloride.[8]—The commercial product was stored over anhydrous calcium chloride before slow distillation through an efficient 20-cm. fractionation column. A fraction boiling at 70–72° (744 mm.)[9] was collected and stored over anhydrous chloride.

A solution of 90.5 g. (1 mole) of methallyl chloride in 1250 ml. of anhydrous ether was added dropwise to 73 g. (3 gram atoms) of magnesium turnings covered with dry ether containing a few drops of methyl iodide. The mixture was agitated briskly by means of a Hershberg stirrer[10] during the addition and subsequently for an hour at room temperature. The reagent formed a very viscous mass, and was difficult to separate completely from the excess magnesium. In several experiments the magnesium was removed by suction filtration through a Büchner funnel, in others the reagent was employed as formed; no difference in kind or amounts of products, due to presence or absence, could be noted.

To the Grignard reagent was added a solution of 42.5 g. (0.5 mole) of ethoxyacetonitrile in 200 ml. of anhydrous ether at a rate such as to cause gentle refluxing of the solvent. After approximately 80% of the nitrile had been added, the reaction product developed an intense yellow color. At this point, refluxing of the solvent slowed down and could be restored to the faster rate only by a more rapid addition of the nitrile solution. The mixture was stirred overnight while being heated on a steam-cone.

The reaction mixture was poured onto cracked ice and the two layers were separated.[11] The aqueous layer was acidified with dilute hydrochloric acid, then made slightly basic with sodium carbonate, and was extracted twice with 100-ml. portions of ether. These ether extracts were combined with the original ethereal layer. The solvent was removed by distillation and the residual liquid was extracted with 50 ml. of 3% hydrochloric acid; the acid-soluble portion (A) was studied at once, and the acid-insoluble material (B) was subsequently examined.

Fraction (A) was made basic with 10% sodium hydroxide solution and the mixture extracted with ether. The extract was fractionally distilled, two portions being collected.

A_1: b.p. 105–110° (27 mm.); 2.5 g.; unsaturated and nitrogen-free; d^{20}_4 0.9047; n^{20}_D 1.4552; ΣMR ($C_{12}H_{22}O_2$) 59.85; MR calcd. 59.49. This material should be one of the isomeric ethoxydecadienols, probably 4-ethoxymethyl-2,6-dimethyl-1,6-heptadien-4-ol. By reaction with 3,5-dinitrobenzoyl chloride, a solid derivative formed: m.p. 149–151° (dec.).

Anal. Calcd. for $C_{19}H_{24}N_2O_6$: N, 7.14. Found: N, 6.90.

A_2: b.p. 115–116° (27 mm.); 10 g.; nitrogen present; d^{20}_4 0.8814; n^{20}_D 1.4608; ΣMR 61.75; MR calcd. 61.46.

Anal. Calcd. for $C_{12}H_{23}NO$: C, 73.04; H, 11.75. Found: C, 72.89; H, 11.71.

This amine was acylated with acetic anhydride to yield a solid derivative; m.p. 98–100°.

Anal. Calcd. for $C_{14}H_{25}NO_2$: N, 5.86. Found: N, 6.09.

A solution of 20 g. of 1-(ethoxymethyl)-3-methyl-1-(2-methallyl)-3-butenylamine was made acidic to litmus, and shaken with 0.2 g. of reduced Adams catalyst under an atmosphere of hydrogen. When hydrogen uptake ceased, the catalyst was removed by filtration and the filtrate was concentrated at reduced pressure. The residue was made basic with 10% sodium hydroxide solution and the organic layer was distilled at reduced pressure. A central fraction, of the 15 g. obtained of 1-(ethoxymethyl)-3-methyl-1-(2-methylpropyl)-butylamine, boiled at 108° (23 mm.); d^{20}_4 0.8481; n^{20}_D 1.4375; ΣMR 62.70; MR calcd. 62.25.

Anal. Calcd. for $C_{12}H_{27}NO$: C, 71.58; H, 13.52. Found: C, 71.70; H, 13.60.

When the acid-insoluble (B) was distilled, the product boiled at 94–95° (32 mm.); 40 g.; nitrogen-free; d^{20}_4 0.9207; n^{20}_D 1.4528; ΣMR 40.33; MR calcd. 41.72.[12]

Anal. Calcd. for $C_{18}H_{14}O_2$: C, 67.57; H, 9.92. Found: C, 67.40; H, 9.45.

Ozonolysis of the Ketonic Material (B).—A stream of oxygen carrying 8% ozone[13] was bubbled through a solution of 1.9861 g. of (B) in 35 ml. of carbon tetrachloride. The product of reaction was decomposed by treatment with ice-water and a small amount of zinc dust. Two layers formed and were separated; the carbon tetrachloride layer (B_2) was extracted with water and the extract was combined with the initial aqueous layer, and the whole (B_1) was diluted to 250 ml.

The aqueous layer (B_1) gave a positive qualitative test for formaldehyde; an alcoholic solution of dimethone reacted with 100 ml. of (B_1) to form 0.209 g. of a solid derivative (B_{1a}); m.p. 187–188°. The condensation product of formaldehyde and dimethone[14] was prepared and melted at 187°; a mixture of that material and (B_{1a}) melted at 187–189°.

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[8] This is the trade name (Shell Development Company) of a product reported to contain about 96% of 3-chloro-2-methylpropene and approximately 4% of the isomeric "β,β-dimethylvinyl chloride." The chlorine atom of the latter is claimed to be extremely inert and not to react with magnesium under the conditions commonly utilized in forming the Grignard reagent, see ref. 6.

[9] J. Burgin, W. Engs, H. P. A. Groll and G. Hearne [*Ind. Eng. Chem.*, **31**, 1413 (1935)] reported b.p. 72.2°.

[10] E. B. Hershberg, *ibid.*, *Anal. Ed.*, **8**, 313 (1936).

[11] Difficulty was encountered in the earlier experiments because the ether solution contained ketone(s) and carbinamine which formed azeotropic mixtures that boiled lower than did the pure amine. Fractions of the azeotrope had essentially a constant value for index of refraction, and, from the mixture, picrate, acetyl and benzoyl derivatives of the carbinamine could be isolated, but no solid semicarbazone derivative of the ketone(s) formed. Of course, neither analytical data nor molecular refraction calculations could be reconciled to any one expected product.

[12] Although the data from analysis of this ketonic material indicated a pure compound, the value calculated from experimental data for molecular refraction was considerably higher than the summation value for the structure assigned to the ketone. A consideration of the possibility of exaltation of the molecular refraction, due to conjugation of the carbonyl group with the carbon–carbon double bond, led to ozonolysis of the liquid and detection of both formaldehyde and acetone among the cleavage products. This proof of conjugation of unsaturation in a portion of the ketonic material is in agreement with the results of E. E. Blaise [*Bull. soc. chim.*, [3] **33**, 43 (1905)], who found that allylic ketones are readily converted into propenyl ketones by being heated or by contact with mild acid or alkali. There is little possibility of rearrangement within methallylmagnesium chloride itself, since it has been shown [R. B. Wagner, THIS JOURNAL, **71**, 3214 (1949)] that the sole product of its carbonation and subsequent hydrolysis of the adduct was 3-methyl-3-butenoic acid.

[13] J. M. Church, F. C. Whitmore and R. V. McGrew, *ibid.*, **56**, 176 (1934).

[14] W. Weinberger, *Ind. Eng. Chem.*, *Anal. Ed.*, **3**, 365 (1931).

The amount of acetone contained in the 250-ml. solution of (B_1) was estimated by the method of Penzoldt,[15] which requires at least 0.006 g. of acetone for a successful test. The smallest volume of (B_1) which gave a positive reaction was 2 ml.; this amount is equivalent to a total of 0.75 g. of acetone obtained as a result of the ozonolysis.

The carbon tetrachloride phase (B_2) was extracted with sodium bicarbonate solution to yield an aqueous extract and the carbon tetrachloride layer (B_{2a}). The very slightly alkaline layer was acidified and extracted with ether; removal of the solvent produced residual material (B_{2b}) which reacted with *p*-phenylphenacyl bromide to yield a solid derivative; m.p. 101–102°.

Anal. Calcd. for $C_{19}H_{18}O_5$: C, 69.93; H, 5.56. Found: C, 69.74; H, 5.50.

This *p*-phenylphenacyl ester of (B_{2b}) was saponified; calcd. for $C_{19}H_{18}O_5$: sapn. val. 326; found: sapn. val. 311. The mixture was filtered and the filtrate containing (B_{2b}) reacted with 2,4-dinitrophenylhydrazine to form a solid product[16] which melted at 155–156°, then resolidified and remelted at 162–164°.

The carbon tetrachloride solution (B_{2a}) was distilled and a drop of the residual liquid (B'_{2a}) was added to a dilute ferric chloride solution which developed a pink color. B'_{2a} material was heated with 10% sodium hydroxide solution; after acidification, a portion of the liquid reacted with *p*-phenylphenacyl bromide to give a solid derivative (B'_{2aa}); m.p. 111–113°. For comparison, the *p*-phenylphenacyl ester of acetic acid was prepared and melted at 111°; a mixture with (B'_{2aa}) melted at 111–113°. The remainder of the acidified solution reacted with 2,4-dinitrophenylhydrazine to form the solid (B_{2ab}); m.p. 145–147°. Ethoxyacetone was prepared and treated with 2,4-diintrophenylhydrazine to furnish the solid derivative; m.p. 144–146°; a mixture with product (B_{2ab}) melted at 146–147°.

A solution of 13 g. of the ketonic material (B) in 75 ml. of alcohol was acidified with hydrochloric acid, added to 0.15 g. of reduced Adams catalyst, and shaken under an atmosphere of hydrogen. After absorption of hydrogen and filtration from the catalyst, the solvent was evaporated, the residue treated with solid sodium hydroxide, and the non-aqueous layer was distilled. The product[17] (8 g.) boiled at 72–73° (20 mm.) and yielded a semicarbazone melting at 119–120°.

Interaction of Ethoxyacetonitrile and Benzylmagnesium Chloride.—A solution of the Grignard reagent was prepared by addition of 126 g. (1 mole) of benzyl chloride in 500 ml. of anhydrous ether to 24.3 g. (1 gram-atom) of magnesium turnings, and treated with a solution of 43 g. (0.5 mole) of ethoxyacetonitrile in 100 ml. of dry ether. The addition product was hydrolyzed by addition of ice-cold hydrochloric acid. The ether layer was separated and dried over anhydrous sodium sulfate; the aqueous layer was made basic with sodium carbonate. No organic matter was extracted by treatment with ether.

By distillation of the acid-insoluble ether extract, there was obtained 51 g. (57% yield) of 1-ethoxy-3-phenyl-2-propanone[18] boiling at 112–116° (3 mm.).

Interaction of Methoxyacetonitrile with Methallylmagnesium Chloride.—A solution of 90.5 g. (1 mole) of methallyl chloride in 1250 ml. of dry ether was added to 73 g. (3 gram-atoms) of magnesium turnings, and, in turn, a solution of 35.5 g. (0.5 mole) of methoxyacetonitrile in 200 ml. of dry ether. The adduct was hydrolyzed with ice-cold, dilute hydrochloric acid, and the products investigated as in the case of the ethoxy analog.

The diallylmethoxymethylcarbinamine obtained boiled over a range of 85–110° (25 mm.) and weighed 30 g. (33% yield); the major portion boiled at 108–110° (25 mm.); d^{20}_4 0.8918; n^{20}_D 1.4660; ΣMR 57.16; *MR* calcd. 56.92.

Anal. Calcd. for $C_{11}H_{21}NO$: C, 66.12; H, 10.25. Found: C, 66.30; H, 10.30.

The ether solution of acid-insoluble material was distilled at reduced pressure and 11 g. (17% yield) of product, boiling at 69–75°, was obtained. Redistillation yielded a central portion of 1-methoxy-4-methyl-4(and 3)-penten-2-one, boiling at 75° (20 mm.); d^{20}_4 0.9363; n^{20}_D 1.4481; ΣMR 35.72; *MR* calcd. 36.57.

Anal. Calcd. for $C_7H_{12}O_2$: C, 65.59; H, 9.44. Found: C, 65.26; H, 9.40.

A solution of 7.5 g. of this ketone mixture in 75 ml. of alcohol was shaken with 0.1 g. of reduced Adams catalyst under an atmosphere of hydrogen. After 20 minutes, the mixture was filtered and the filtrate fractionated to yield 5 g. of the known 1-methoxy-4-methyl-2-pentanone[19]; n^{20}_D 1.4133.

Two grams of the mixture of isomeric, unsaturated ketones in 18 ml. of carbon tetrachloride was ozonized; after treatment with 50 ml. of ice-water and 0.5 g. of zinc dust, the aqueous extract gave positive qualitative tests[20] for formaldehyde and for acetone.

Hydrogenation of the Disubstituted Methoxymethylcarbinamine.—A solution of 12 g. of 1-(methoxymethyl)-3-methyl-1-(2-methallyl)-3-butenylamine in 75 ml. of alcohol was shaken with 0.2 g. of reduced Adams catalyst under an atmosphere of hydrogen. The catalyst was removed and the filtrate fractionated under diminished pressure. A 10-g. fraction was collected at 102–104° (27 mm.); d^{20}_4 0.8455; n^{20}_D 1.4368; ΣMR 58.10; *MR* calcd. 58.02.

Anal. Calcd. for $C_{11}H_{25}NO$: C, 70.53; H, 13.45. Found: C, 70.47; H, 13.73.

Methylation of 1-(Methoxymethyl)-3-methyl-1-(2-methylpropyl)-butylamine.—A mixture of 6.93 g. (0.037 mole) of this saturated carbinamine, 9.48 g. (0.185 mole) of 90% formic acid and 6.6 g. (0.0815 mole) of 37% aqueous formaldehyde solution was heated on a steam-bath for three hours; 3.5 ml. of concd. hydrochloric acid was added and the solution was boiled to yield a thick sirup. The latter was made alkaline with 10% sodium hydroxide solution and the organic layer was separated and distilled: 5.5 g. (69% yield) of **1-methoxymethyl-N,N,3-trimethyl-1-(2-methylpropyl)-butylamine** was collected; b.p. 120–122° (30 mm.); d^{20}_4 0.8548; n^{20}_D 1.4457; ΣMR 67.82; *MR* calcd. 67.14.

Anal. Calcd. for $C_{13}H_{29}NO$: C, 72.49; H, 13.57. Found: C, 72.82; H, 13.98.

Interaction of Phenoxyacetonitrile with Methallylmagnesium Chloride.—To 73 g. (3 gram-atoms) of magnesium turnings was added a solution of 90.5 g. (1 mole) of methallyl chloride in 1250 ml. of anhydrous ether and, in turn, 75 g. (0.5 mole) of phenoxyacetonitrile in 200 ml. of dry ether. After being stirred for one hour, the adduct was hydrolyzed with cracked ice. The ether solution was separated, extracted with two 300-ml. portions of 3% hydrochloric acid, and the acid-insoluble material was set aside for subsequent study. The acid extracts were combined and made alkaline by addition of 10% sodium hydroxide solution; the organic material was then removed by extraction with ether. After overnight drying with anhydrous sodium sulfate, the solution was fractionated; 6 ml. was collected in 1-ml. fractions boiling over the range 110–141° (4 mm.). This material decolorized solutions of bromine and of potassium permanganate. There was considerable variation in the refractive index of the various fractions and the calculated values for molecular refraction were not in agreement with the summation value for the anticipated carbinamine. The central fraction had b.p. 139–141° (4 mm.); d^{20}_4 1.0022; n^{20}_D 1.5303; ΣMR 76.63; *MR* calcd. 75.65. This fraction reacted with acetic anhydride to yield the derivative melting at 150–152°.

Anal. Calcd. for $C_{18}H_{25}NO_2$ (acetyl derivative of anticipated carbinamine): N, 4.88. Found: N, 3.68.

The ether solution containing the acid-insoluble hydrolysis products of the adduct was dried over anhydrous sodium sulfate before being distilled. The distillate came over in the range 110–188° (40 mm.) and weighed 46 g. Twelve

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[15] Penzoldt, *Arch. klin. med.*, **34**, 132 (1883); through "The Merck Index," 5th Ed., Merck and Company, Inc., Rahway, N. J., 1940, p. 635.

[16] D. B. Sprinson and E. Chargaff [*J. Biol. Chem.*, **164**, 425 (1946)] prepared the 2,4-dinitrophenylhydrazone of ethoxypyruvic acid and recorded m.p. 155°, resolidification, and refusion at 164–167°.

[17] M. Sommelet [*Ann. chim. phys.*, [8] **9**, 483 (1906); *Bull. soc. chim.*, [4] **1**, 377 (1907)] reported b.p. 73–74° (20 mm.) and m.p. of 119° for the semicarbazone of 1-ethoxy-4-methyl-2-pentanone.

[18] M. Darmon [*Compt. rend.*, **197**, 1328 (1933)] listed a b.p. of 116–118° (1 mm.) for this benzyl ketone.

[19] H. R. Henze and N. E. Rigler [THIS JOURNAL, **56**, 1350 (1934)] reported b.p. 163–164° (754 mm.); n^{20}_D 1.4140.

[20] "The Merck Index," 5th Ed., Merck and Company, Inc., Rahway, N. J., 1940, color tests Nos. 1530 and 1749 (for formaldehyde) and Nos. 920 and 3376 (for acetone).

fractions were collected, all of essentially the same density, but increasing in refractive index as b.p. rose. A fraction (no. 8) boiling at 185–187° (40 mm.) was representative of the majority of the distillate; d^{20}_4 1.0365; $n^{20}\text{D}$ 1.5356; ΣMR 55.21; MR calcd. 57.20.

Anal. Calcd. for $C_{12}H_{14}O_2$: C, 75.73; H, 7.42. Found: C, 75.95; H, 7.43.

The material reacted with semicarbazide hydrochloride to form a semicarbazone which, after two recrystallizations from dilute alcohol, melted at 151–152°.

Anal. Calcd. for $C_{13}H_{17}N_3O_2$ (semicarbazone of 4-methyl-1-phenoxy-4(or 3)-penten-2-one): C, 63.14; H, 6.93; N, 16.99. Found: C, 63.41; H, 7.05; N, 17.36.

Fraction No. 3 had d^{20}_4 1.0391; $n^{20}\text{D}$ 1.5187; ΣMR 55.21; MR calcd. 55.66; but b.p. 120–132° (40 mm.).

Interaction of β-(2-Ethoxyethoxy)-propionitrile with Allylmagnesium Bromide.—The Grignard reagent was prepared from 121 g. (1 mole) of allyl bromide and 73 g. (3 gram-atoms) of magnesium under 770 ml. of anhydrous ether. The excess magnesium was removed by rapid filtration through a Buchner funnel, and the filtrate was treated with 106 g. (0.5 mole) of β-(2-ethoxyethoxy)-propionitrile[21] in 750 ml. of dry ether. The mixture was stirred during 24 hours and then was hydrolyzed with ice and water. The ether layer was extracted with two 300-ml. portions of 3% hydrochloric acid. These extracts were made alkaline with 10% sodium hydroxide solution and extracted with ether. The ether extracts of[13] acid-soluble and of acid-insoluble materials were separately dried over anhydrous sodium sulfate. Concentration of the acid-insoluble extract yielded 35 g. of orange-red resinous material. Distillation of the acid-soluble extract produced 14 g. (12% yield) of amine boiling at 117–120° (3 mm.); d^{20}_4 0.9220; $n^{20}\text{D}$ 1.4649; ΣMR 68.02; MR calcd. 68.15.

Anal. Calcd. for $C_{13}H_{25}NO_2$: C, 68.83; H, 11.08. Found: C, 68.15; H, 11.10.

Although this product, **1-allyl-1-[2-(2-ethoxyethoxy)-ethyl]-3-butenylamine**, reacted readily with acetic anhydride, benzoyl chloride and picric acid, no crystalline product resulted.

Seven grams of this substituted butenylamine was dissolved in 50 ml. of absolute alcohol and shaken under an atmosphere of hydrogen with 0.1 g. of reduced Adams catalyst. After filtration from the catalyst, the solvent was removed and the product fractionated; 4 g.; b.p. 114–115° (1 mm.); d^{20}_4 0.8937; $n^{20}\text{D}$ 1.4450; ΣMR 68.96; MR calcd. 69.13.

Anal. Calcd. for $C_{13}H_{29}NO_2$: C, 67.48; H, 12.63. Found: C, 66.73; H, 12.94.

Although this carbinamine, **1-[2-(2-ethoxyethoxy)-ethyl]-1-propylbutylamine**, reacted readily with picric acid, the product did not solidify.

AUSTIN, TEXAS RECEIVED MARCH 20, 1951

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[21] H. A. Bruson, U. S. Patent 2,280,792; through *C. A.*, **36**, 5590 (1942).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, THE UNIVERSITY OF TEXAS]

The Interaction of Certain Grignard Reagents with Cinnamonitrile[1]

BY HENRY R. HENZE AND LEO R. SWETT

Cinnamonitrile reacted readily with ethylmagnesium bromide, benzylmagnesium chloride, allylmagnesium bromide and phenylmagnesium bromide, respectively; the subsequent behavior of each adduct upon hydrolysis established the fact that these addition products resulted from 1,2-addition to the nitrile group. However, the hydrolysis products varied according to the specific agent used. Thus, upon hydrolysis of the adducts derived from the ethyl, benzyl and phenyl reagents by means of dilute hydrochloric acid, the corresponding styryl ketones were obtained. But when an ice-cold solution of ammonium chloride was used for hydrolysis, nitrogenous products, having the analytical compositions corresponding to ketimines, resulted. However, molecular weight determinations established these products to be dimers, in this respect confirming the very recent findings of Piper and Wright. Depending upon the ratio in which allylmagnesium bromide reacted with cinnamonitrile, the product was either a ketine dimer or a carbinamine.

It is well established that alkyl- or arylmagnesium halides react with nitriles in a 1:1 molecular ratio to yield addition products; the latter are ketimine derivatives. Although hydrolysis, especially by means of acids, usually yields ketones, occasionally hydrolysis produces ketimines sufficiently stable to permit of their isolation.

In 1939, there was reported[2] the first instance in which two equivalents of a Grignard reagent added to one of an alkoxynitrile, subsequent hydrolysis of the adduct yielded a tertiary alkyl primary amine (termed a carbinamine) of the type $ROCH_2(CH_2{=}CHCH_2)_2C{-}NH_2$. Later studies have shown that this behavior is characteristic of nitriles in general. Allylmagnesium bromide also reacts with the addition product resulting from interaction of an alkylmagnesium halide and a nitrile; here, too, hydrolysis of this adduct yields a carbinamine. This greater activity of the unsaturated Grignard reagent has been shown also by methallylmagnesium chloride[3]; however, in this case, upon hydrolysis of the adduct, some isomeric, unsaturated ketones were isolated in addition to a carbinamine.

Some attention had previously been paid elsewhere to the interaction of Grignard reagents and *unsaturated* nitriles.[4] Since the latter may contain conjugated double-bond systems, 1,4-addition, as well as 1,2-addition to the nitrile is conceivable. The 1,4-addition in 1:1 ratio of reactants, might be expected to produce an adduct from which, upon hydrolysis, a saturated nitrile would result

$$\begin{aligned}&RCH{=}CH{-}C{\equiv}N + R'MgX \longrightarrow\\ &\qquad RR'CH{-}CH{=}C{=}N{-}MgX \longrightarrow\\ &\qquad\quad RR'CH{-}CH{=}C{=}NH \rightleftarrows RR'CHCH_2CN\end{aligned}$$

Thus, Kohler[5] observed that although cinnamonitrile and methylmagnesium iodide interacted through 1,2-addition and ultimately yielded benzalacetone, α-phenylcinnamonitrile reacted with ethylmagnesium bromide as a result of 1,4-addition to produce β-ethyl-α-phenylhydrocinnamonitrile. However, in the interaction of α-phenylcinnamonitrile and phenylmagnesium bromide, both ω-

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[1] Abstracted from the M.A. thesis of Leo R. Swett, January, 1950.

[2] Allen and Henze, THIS JOURNAL, **61**, 1790 (1939).

[3] Henze, Sutherland and Edwards, *ibid.*, **73**, 4915 (1951).

[4] Runge, "Die organische Synthese mit Hilfe von Organometallverbindungen," Wissenschaftliche Verlagsgesellschaft m. b. H., Stuttgart, 1944, pp. 431–432.

[5] Kohler, *Am. Chem. J.*, **35**, 386 (1905).