

the residue was taken up in dry acetone, filtered, run almost to dryness as above, taken up in water, the bitter principle salted out with ammonium sulfate, dissolved in acetone, again taken almost to dryness as above, taken up in 95% alcohol and diluted to volume with water. Its concentration was determined by means of Fehling's solution by the Munson-Walker method. The oleuropein content of the flesh of twenty samples of olives, representing several varieties and several degrees of maturity, was found to range from 0.59 to 2.28%. The Mission variety was highest in content of bitterness and the Sevillano lowest. Manzanillo and Barouni varieties were also rich and the Ascolano poor in bitterness content. Green fruit was richer than the ripe in content of the bitter glucoside. The average concentration of all samples was about 1.0%. Bourquelot and Vintileco reported 2% oleuropein in the fruit used by them.

Olives frozen on the trees in December, 1932, were found still to be intensely bitter ten days later, but devoid of the levorotatory oleuropein. On standing for another ten days the bitter taste disappeared. The fruit contains an emulsin-like enzyme that was liberated by freezing, and possibly another enzyme that split or oxidized the bitter ester remaining after hydrolysis of the glucoside.

Summary and Conclusions

1. The bitter principle was separated from olives and purified by a method that gave a product of considerably higher specific rotation than obtained by the method of Bourquelot and Vintileco.¹

2. It was found to be a bitter glucoside readily hydrolyzed by an enzyme occurring in olive leaves and by "Pectinol," a commercial *Penicillium* mold preparation. Emulsin hydrolyzed it slowly; invertase did not attack it.

3. Acid hydrolysis liberated *d*-glucose and an

ether soluble, bitter ester not present before hydrolysis. During hydrolysis by Pectinol enzyme or by mineral acid the optical rotation changed from strongly levo to dextro, as the glucoside was split and dextrose liberated. The bitter ester was readily hydrolyzed by alkalis with the loss of its bitter taste.

4. The glucoside when treated with sodium hydroxide lost its bitter taste, but retained its levorotation if the treatment was not too severe.

5. From the products of alkaline hydrolysis was isolated a crystalline acid that gave the same qualitative reactions, same x-ray spectrum, and possessed the same melting point as caffeic acid. The melting point was not depressed by mixing the two acids. An unidentified crystalline phenol (not pyrocatechol) was also isolated.

6. From consideration of the properties determined it might be concluded that the bitter principle appears to have both a glucoside linkage and an ester linkage. The former is split by mineral acids, emulsin and other enzymes of emulsin-like nature, and the ester linkage by alkalis and apparently by an enzyme occurring in olives.

7. The bitter glucoside was found to be present in olive flesh to the extent of about 1% on the average, but its concentration in green fruit of the Mission and Manzanillo varieties was considerably higher, and in ripe fruit of the Ascolano and Sevillano varieties, considerably less than this general average.

BERKELEY, CALIF.

RECEIVED JUNE 29, 1934

[CONTRIBUTION No. 112 FROM THE RESEARCH LABORATORY OF ORGANIC CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY]

The Preparation of Derivatives for the Identification of Alkyl Chlorides¹

BY H. W. UNDERWOOD, JR., AND JOHN C. GALE

No satisfactory method for the identification of alkyl chlorides is at present available. Marvel, Gauerke and Hill² prepared crystalline derivatives of a number of alkyl bromides and iodides and of five chlorides by the preparation of the Grignard compounds and the reaction of these with the corresponding mercuric halides to give the alkyl mercuric halides. Gilman and Furry³ character-

ized several organomagnesium halides, including benzyl chloride, by reaction with α -naphthyl isocyanate to give the α -naphthalides. They stated that these derivatives were less soluble, better crystallized, higher melting, and more easily purified than the corresponding anilides. Schwartz and Johnson⁴ identified in a corresponding manner sixteen alkyl bromides and three chlorides, namely, *t*-butyl, *t*-amyl and benzyl by converting the halides into the anilides. These anilides were in general satisfactory derivatives.

(1) Because of the death of Professor Underwood the present paper has been prepared by the junior author.

(2) C. S. Marvel, C. Gauerke and E. Hill, *THIS JOURNAL*, **47**, 3009 (1925).

(3) H. Gilman and M. Furry, *ibid.*, **50**, 1214 (1928).

(4) A. M. Schwartz and J. R. Johnson, *ibid.*, **53**, 1063 (1931).

The isomeric compounds which melted closely together were distinguished by mixed melting points with known anilides.

A procedure for the identification of alkyl chlorides has been developed by the writers from the method of Schwartz and Johnson. *p*-Toluides and α -naphthalides have been made of the chlorides which the anilides failed to distinguish. The substituted amides have been found to be readily prepared and to be satisfactory derivatives.

Discussion of Experiments

The Grignard Reaction.—Four-tenths of a gram of magnesium turnings and 0.1 g. of iodine⁵ were placed in a 15-cm. Pyrex test-tube, the mixture covered with ether and the reaction allowed to proceed for five minutes. The liquid was decanted and the tube warmed with a free flame to evaporate the residual ether and then heated to dull redness. The product, which was cooled somewhat before use, was dull gray or brown; if overheated it sintered, blackened and lost part or all of its activity. To prepare the Grignard reagent a solution of 10 millimoles of the chloride in about 5 cc. of absolute ether was added at once to the warm activated magnesium and the tube connected with a cork to a small water condenser. A visible reaction, which caused the ether to boil, usually started without heating within one minute. This reaction continued for about one-half hour, after which the solution was gently refluxed for ten minutes to complete the reaction. The mixture was diluted with 5 to 10 cc. of ether and cooled to room temperature.

In the preparation of the Grignard reagents of the two gaseous chlorides a special cooling apparatus was found to be necessary to minimize evaporation. A tube was used which was jacketed above the reaction zone for a distance of 10 cm. with solid carbon dioxide in the case of methyl chloride, and with a mixture of sodium chloride and ice for ethyl chloride. About 30 millimoles of the liquefied chloride was dissolved in 5 cc. of ether and quickly transferred to the jacketed tube containing the activated magnesium; the reaction proceeded as usual.

In the preparation of the Grignard compounds of *t*-butyl and *t*-amyl chlorides it was found to be essential to add the ethereal solutions slowly to the magnesium. The magnesium was covered with a small amount of the ethereal solution of the chloride; when the reaction was nearly over the remainder was added from a dropping funnel at a rate of not more than one drop in five seconds. About one hour was required to make these Grignard compounds.

To the Grignard solution in a 150-cc. Erlenmeyer flask about 3 millimoles of the phenyl, *p*-tolyl or α -naphthyl isocyanate⁶ in 5 cc. of absolute ether was added slowly from a dropping funnel with shaking over a period of from three to five minutes. Moisture was excluded by wrapping a

(5) This method of activation was developed from that reported by Gilman, "The Fourth Organic Chemistry Symposium," New Haven, Conn., Dec. 29, 1931. It has been found to produce more active magnesium than the usual addition of a crystal of iodine.

(6) The yields of the Grignard reagents were such that there was an excess over that needed to react with this amount of isocyanate.

layer of cotton batting around the stem of the funnel so that it fitted snugly in the mouth of the flask.

The reaction mixture was decomposed by pouring it with stirring into a mixture of 1 cc. of concentrated hydrochloric acid and 25 cc. of ice and water.⁷ The ether layer was separated, dried with anhydrous magnesium sulfate, decanted and evaporated.

The products⁸ were decolorized with carbon when necessary and crystallized from ligroin (b. p. 90–120°).⁹ It was necessary to remove all ligroin from the derivatives before melting points were taken; this was done by allowing the products to stand overnight in a vacuum desiccator containing concentrated sulfuric acid and paraffin shavings. The usual yield of purified material was about one hundred milligrams. The time required for the preparation of the derivative varied from one and one-half to two hours.

Discussion of Results

Table I gives the melting points of derivatives; these were taken by the method of Mulliken.¹⁰ The boiling points of the chlorides are the best data available.

The anilides were found to be satisfactory derivatives for methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl, *t*-butyl, *t*-amyl, cyclohexyl, benzyl, β -phenylethyl and *p*-chlorobenzyl chlorides and for 2-chlorohexane. Both anilides and α -naphthalides failed to distinguish satisfactorily iso- and *s*-butyl chlorides; the *p*-toluides clearly separated them as well as the other butyl chlorides. The choice of derivative for the amyl chlorides varied with the individual case. The α -naphthalides were considered of questionable value as derivatives of this group of chlorides as the compound prepared from *n*-amyl chloride did not melt sharply after several crystallizations.

3- and 2-Chloropentanes.—The anilide prepared from 3-chloropentane was found to be a mixture of the 3- and 2-chloropentane derivatives. 3-Chloropentane was prepared by treating synthetic diethylcarbinol (b. p. 115–116°) with dilute hydrochloric acid. The chloride obtained after fractionation through a good column boiled at 96.7–97.1° corr. (758 mm.); $n_D^{25.00}$ 1.4059; $d_{25.00}^{25.00}$ 0.8707. 2-Chloropentane, b. p. 97–98°, was made from the alcohol by the hydrochloric acid–zinc chloride method. The majority of the boiling points given in the recent literature for 3- and 2-chloropentanes are similar to the values of

(7) If the organic product precipitated at the interface this was collected.

(8) In order to increase the yields it was found to be desirable to extract the drying agent with warm ligroin and to use the resulting liquid for the crystallization.

(9) Certain of the derivatives were found to be not readily soluble in low boiling ligroin.

(10) S. P. Mulliken, "Identification of Pure Organic Compounds," John Wiley and Sons, Inc., New York City, 1904, Vol. I, p. 218.

TABLE I
 MELTING POINTS OF DERIVATIVES

Chloride ^a	B. p., °C.	Melting points (uncorr.)		
		Anilide	<i>p</i> -Toluide	α -Naphthalide
Methyl	-23.7	112-113	.....	.....
Ethyl	12.5	104-104.5	.....	.....
Isopropyl	36.5	104-104.5	.....	.....
<i>n</i> -Propyl	46.5	91-92	.....	.....
<i>t</i> -Butyl	51	132-133 ^b	119-120 ⁱ	146-147 ⁱ
<i>s</i> -Butyl	68	105.5-106.5	92.5-93 ⁱ	128-129 ⁱ
Isobutyl	68.5	109-110	106-107	125-126
<i>n</i> -Butyl	78	62-63	72-73	109-110
1-Chloro-2,2-dimethylpropane	84.4 ^c	.....	.....	.....
<i>t</i> -Amyl	86	90-91 ^b	83-83.5 ⁱ	137-138 ⁱ
2-Chloro-3-methylbutane	91 ^d	.....	.....	.....
3-Chloropentane	96.7-97.1	126-127	107.5-108.5 ⁱ	117-118 ⁱ
2-Chloropentane	96-97 ^e	86-87	90-91 ⁱ	102.5-103.5 ⁱ
1-Chloro-2-methylbutane	97.6-99 ^f	.....	.....	.....
Isoamyl	99	110-110.5	61.5-62.5 ⁱ	110-111 ⁱ
<i>n</i> -Amyl	106	94-95	74-75	.....
2-Chlorohexane	125-126 ^e	91-92 ⁱ	.....	.....
Cyclohexyl	142.5	143-144	.....	.....
<i>n</i> -Heptyl	159.5 ^g	.....	.....	.....
Benzyl	179	115-116 ^b	.....	.....
β -Phenylethyl	192-198 (760 mm.) dec. 82-84 (16 mm.)	96	.....	.....
<i>p</i> -Chlorobenzyl	214	165-166 ^h	.....	.....

^a The Eastman Kodak chlorides: isobutyl, *n*-amyl, isoamyl, *t*-amyl, cyclohexyl, benzyl (technical), β -phenylethyl, and *p*-chlorobenzyl (practical) boiled within two-degree intervals with the exception of benzyl chloride (b. p. 175-180°). The other chlorides were synthesized from the alcohols. The boiling points of the two gaseous chlorides were not determined; the others boiled within one-degree intervals with the exception of *n*-propyl chloride (b. p. 46-48°) and 2-chlorohexane (b. p. 125-127°). Moisture was eliminated by drying the chlorides and containers; hydrogen chloride was excluded by the neutralization of the chlorides if necessary with solid sodium bicarbonate and by the inclusion of soda lime as well as calcium chloride in the drying tubes which closed the reaction vessels.

^b Anilides were prepared from *t*-butyl, *t*-amyl, and benzyl chlorides by Schwartz and Johnson, THIS JOURNAL, 53, 1063 (1931); their melting points were similar to those found by the writers.

^c 1-Chloro-2,2-dimethylpropane (neopentyl chloride) has been made recently by the chlorination of neopentane by F. C. Whitmore and G. Fleming, THIS JOURNAL, 55, 4161 (1933). The chloride boiled at 84.4° (760 mm.) and the anilide made from it melted at 125-126°. This derivative should distinguish the chloride from those identified by the writers with the exception of 3-chloropentane; the boiling points of these chlorides are separated by twelve degrees, therefore they should not be confused.

^d 2-Chloro-3-methylbutane. When the preparation of this chloride was attempted from the alcohol *t*-amyl chloride was obtained. 2-Chloro-3-methylbutane, b. p. 91° (753 mm.), was reported by Wischnegradsky, *Ann.*, 190, 357 (1877), by the addition of hydrogen chloride to isopropyl ethylene. Crossley and Perkin, *J. Chem. Soc.*, 73, 17 (1898), reported the corresponding anilide to melt at 75° and the *p*-toluide to melt at 103-104°.

^e The Grignard compounds of 2-chloropentane and 2-chlorohexane were not found in the literature.

^f 1-Chloro-2-methylbutane, b. p. 96-98.4°, from synthetic *s*-butylcarbinol, b. p. 126.2-129.9°, could not be made to form a Grignard reagent. The corresponding anilide was reported by Schwartz and Johnson, THIS JOURNAL, 53, 1063 (1931), to melt at 88°; the *p*-toluide by Bentley, *J. Chem. Soc.*, 67, 268 (1895), to melt at 75°.

^g *n*-Heptyl chloride, b. p. 159-160, did not react with magnesium to give a Grignard reagent. The corresponding anilide was reported by Schwartz and Johnson to melt at 57°.

^h The anilide from *p*-chlorobenzyl chloride was crystallized from 95% ethyl alcohol.

ⁱ The thirteen new derivatives were analyzed for nitrogen by the semimicro combustion method and the results are given in Table II.

the writers. The purification of the derivatives of 3-chloropentane was difficult. The *p*-toluide required seven crystallizations, the α -naphthalide four; after nine crystallizations the anilide melted at the point reported in the literature but following the first crystallization a product

melting at 86-87° was obtained from the filtrate. A mixed melting point determination showed this material to be identical with the anilide prepared from 2-chloropentane. A similar result was secured with the anilide made from 3-chloropentane prepared by the hydrochloric acid-zinc

TABLE II
ANALYSES

Chloride	Derivative	Nitrogen, %	
		Found	Calcd.
<i>s</i> -Butyl	<i>p</i> -Toluide	7.48	7.61
	α -Naphthalide	6.42	6.17
<i>t</i> -Butyl	<i>p</i> -Toluide	7.39	7.52
	α -Naphthalide	6.21	6.17
Isoamyl	<i>p</i> -Toluide	7.27	7.42
	α -Naphthalide	5.90	5.97
<i>t</i> -Amyl	<i>p</i> -Toluide	7.06	7.14
	α -Naphthalide	6.19	6.23
2-Chloropentane	<i>p</i> -Toluide	7.00	6.83
	α -Naphthalide	5.95	5.97
3-Chloropentane	<i>p</i> -Toluide	6.98	6.83
	α -Naphthalide	6.01	5.81
2-Chlorohexane	Anilide	6.99	7.23

chloride method. These results indicated that the supposedly pure 3-chloropentanes contained some 2-chloropentane. No product was obtained from the derivatives of 2-chloropentane which corresponded to 3-chloropentane.

Schwartz and Johnson⁴ stated that the purification of the anilide made from 3-bromopentane

was difficult and involved great loss of material. Sherrill, Otto and Pickett¹¹ found that 3-bromopentane could be prepared pure only by great care in the hydrobromination of 3-pentanol, otherwise a mixture of 3- and 2-bromopentanes was obtained. Ayres¹² reported that 2-chloropentane could be converted into 3-chloropentane by the action of heat and pressure and that this conversion was accelerated by catalysts.

Summary

A method has been developed for the preparation of crystalline derivatives from eighteen alkyl chlorides, including a number of isomers. *p*-Tolyl isocyanate has been used as a characterizing agent for organomagnesium halides and has enabled us to distinguish between chlorides of closely similar boiling point.

(11) M. L. Sherrill, B. Otto and L. Pickett, *THIS JOURNAL*, **51**, 3023 (1929).

(12) E. E. Ayres, *Ind. Eng. Chem.*, **21**, 899 (1929).

CAMBRIDGE, MASS.

RECEIVED JUNE 29, 1934

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF NOTRE DAME]

A Rapid Catalytic Preparation of Sodamide in Liquid Ammonia and Some of its Uses in the Preparation of Acetylenic Materials

BY THOMAS H. VAUGHN, R. R. VOGT AND J. A. NIEUWLAND

A solution of sodamide in liquid ammonia is known to be a valuable reagent in a number of organic reactions, but the difficulty of obtaining such a solution has limited its use. Sodamide is prepared commercially by the action of gaseous ammonia on molten sodium, but the necessity of storing and grinding it out of contact with both air and moisture, and the hazards of prolonged storage, make it undesirable for general laboratory use.

Sodamide is also formed slowly¹ in solutions of sodium in liquid ammonia, and a few attempts have been made to catalyze this reaction.²

We have found that in the presence of sodium oxides, sodamide can be prepared quickly at -33° by adding ammonia-soluble iron, nickel or cobalt salts to the solution of sodium in liquid ammonia in the ratio of 0.001 mole or less of the salt to one gram atom of sodium. It was found that a number of factors influenced the rate of

reaction. The reaction is more rapid in dilute sodium solutions and the rate is a direct function of the iron, nickel or cobalt salt concentration.

In most of our work we have used the salt $\text{Fe}(\text{NO}_2)_3 \cdot 6\text{H}_2\text{O}$ as a catalyst, 0.3 g. of the material being used for each mole of sodium. Sodium hydroxide is a pronounced, though weak, negative catalyst, while sodium oxides are active catalysts, being about equally effective in large or small amounts, which must be present along with the iron salt to effect the conversion. The oxide may be formed by the action of atmospheric oxygen on the sodium solution or sodium peroxide may be added. The first form is more active, no doubt due to its finely divided state, and is usually more convenient to employ.

The exact method of adding the catalyst is also important. The most rapid conversion is produced by adding the finely powdered ferric nitrate to the total amount of ammonia, adding 1-3% of the sodium and bubbling dry air through the solution until the excess sodium is oxidized.

(1) Joannis, *Compt. rend.*, **112**, 392 (1891).

(2) Ewan, British Patent, 222,718 (1923); McGee, *THIS JOURNAL*, **43**, 586 (1921); Burgess and Smoker, *Chem. Rev.*, **8**, 265 (1931).