

A mixture of salicylic acid (50 g.), primary normal amyl alcohol (200 g.), and concentrated sulfuric acid (2 cc.) was heated under a reflux condenser for about four hours. The apparatus was provided with a trap to remove the water that was formed. After the unreacted alcohol had been removed by distillation at atmospheric pressure, the residue was washed with 10% potassium carbonate and dissolved in ether, and the ether solution was dried over anhydrous sodium sulfate. The high-boiling material remaining after the removal of the ether was fractionated under reduced pressure by means of a Widmer column. The fraction that boiled at 116–121° and 1.4 mm. pressure was collected. The yield was 64 g.:  $n_D^{25}$  1.5042,  $d_4^{25}$  1.0552,  $[M]_D$  found 58.40, calcd. 58.30.

*Anal.*<sup>5</sup> Calcd. for  $C_{12}H_{16}O_3$ : C, 69.23; H, 7.87. Found: C, 69.15; H, 7.82.

In all these experiments some ether was formed, the amount increasing with the time of refluxing the reaction mixtures.

**Secondary Normal Amyl Salicylate.**—The methyl-*n*-propylcarbinol employed in this experiment was obtained by fractional distillation of a commercial grade of the carbinol in a Dupont-Palkin<sup>4</sup> type of still. The purified carbinol had the properties: b. p. 61.8–64.7° at 85 mm.,  $n_D^{25}$  1.4065,  $d_4^{25}$  0.8041,  $[M]_D$  found 26.91, calcd. 26.815.

A mixture of 40 g. of salicylic acid, 50 cc. of thionyl chloride, and 0.08 g. of anhydrous aluminum chloride was heated under reflux in a water-bath maintained at 40–50° until the acid was entirely dissolved. The solution was then concentrated at reduced pressure to remove hydrogen chloride and excess thionyl chloride. One-half of the residue, a clear, greenish-yellow liquid, was transferred to a 125-cc. Erlenmeyer flask, and 30 cc. of methyl-*n*-propylcarbinol was added in small portions. The mixture was cooled in an ice-bath for several hours, and then, with the flask stoppered with a calcium chloride tube, allowed to stand for twenty-four hours. The solution was washed several times with ice water, then with a small quantity of dilute sodium bicarbonate, and again several times with ice water. The material was dried in ether over anhydrous sodium sulfate and, after removal of the ether, was purified by repeated distillation under reduced pressure. The yield was 9.8 g. The ester boiled at 107–110° and 4–5 mm.:  $n_D^{25}$  1.5020,  $d_4^{25}$  1.0470,  $[M]_D$  found 58.60, calcd. 58.30.

*Anal.* Calcd. for  $C_{12}H_{16}O_3$ : C, 69.23; H, 7.87. Found: C, 69.16; H, 7.81.

**Tertiary Amyl Salicylate.**—The tertiary amyl alcohol was a commercial grade which boiled at 100–102°. To the remaining half of the salicyl chloride prepared from 40 g. of salicylic acid by the procedure described above, 125 cc. of tertiary amyl alcohol was added slowly with vigorous shaking, the flask being kept cold in an ice-bath. Considerable hydrogen chloride was given off and some heat was evolved during the process. After standing in the ice-bath for several hours, the solution deposited a small quantity of crystalline material. This was removed by filtration, and the filtrate was distilled under reduced pressure. The pure ester was obtained by fractional distillation under reduced pressure. The yield was 6.5 g. It boiled at 84–86° and 3

mm. pressure:  $n_D^{25}$  1.5064,  $d_4^{25}$  1.0533,  $[M]_D$  found 58.74, calcd., 58.30.

*Anal.* Calcd. for  $C_{12}H_{16}O_3$ : C, 69.23; H, 7.87. Found: C, 69.12; H, 7.88.

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE  
U. S. DEPARTMENT OF AGRICULTURE  
WASHINGTON, D. C.

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## Reactions of Fluorinated Derivatives with Sodium, Potassium and Magnesium

BY ALBERT L. HENNE

Stable fluorinated compounds have been subjected to the action of magnesium in the hope of obtaining a Grignard reaction, and of sodium in the hope of obtaining a Wurtz reaction. In both cases the action was immediate and complete but the results were entirely different from those hoped for. The vigorous character and completeness of the reactions showed the futility of further work in the same direction and, therefore, the unexpected results are presented for publication. Some of these results (representative of what happens in other cases) were as follows.

(1)  $CHF_2CH_2I$  was dissolved in ether and allowed to drip onto clean magnesium. A reaction took place instantly. A small portion gave a faint test with Michler's ketone, indicating the formation of a Grignard compound; however, after a short period, the Grignard test was no longer positive. As the addition of  $CHF_2CH_2I$  to the magnesium was continued, a gas was evolved which was caught in bromine. It was observed that the reaction of this gas with bromine took place in the vapor phase, not the liquid, and the absorption was therefore incomplete. The gas was vinyl fluoride, as shown by the facts that the dibromide  $CH_2BrCH_2Br$  was the only compound found and that it was quite pure. Due to faulty experimental conditions only 50% of the vinyl fluoride was recovered as dibromide. The resulting magnesium salt was an equimolecular mixture of magnesium iodide and magnesium fluoride. Both salts are soluble in ether and in water, the fluoride as a colloid, and on account of this, a test for fluorine fails to give positive results before the magnesium fluoride has been brought from the colloidal to the crystalline stage.

(2) Attempts to cause  $CHF_2CH_2Br$  to act upon magnesium were unsuccessful.

(3) A piece of sodium or potassium reacted

(5) We are indebted to Dr. W. G. Rose for the microcombustions.

energetically with  $\text{CHF}_2\text{CH}_2\text{Br}$  or  $\text{CHF}_2\text{CH}_2\text{I}$ . The reaction was run in ethyl ether, where it still was very vigorous and complete. Instead of acting upon the iodine atom only, the alkali metal removed one atom of fluorine and one atom of iodine, and gave a quantitative yield of sodium fluoride and sodium iodide or bromide. In doing so it behaved like magnesium or zinc.

(4) In contrast with the preceding result, fluorinated derivatives of methane (namely,  $\text{CCl}_2\text{F}_2$ ,  $\text{CHClF}_2$  and  $\text{CHBrF}_2$ ) remained unaffected when passed through molten sodium.

THE MIDGLEY FOUNDATION  
DEPARTMENT OF CHEMISTRY  
THE OHIO STATE UNIVERSITY  
COLUMBUS, OHIO

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### Preparation of Methylaluminum Chlorides

BY VINCENT F. HNIZDA AND CHARLES A. KRAUS

The methyl- and ethylaluminum chlorides have not been reported in the literature until recently. Walker and Willson<sup>1</sup> showed that methyl chloride reacts with aluminum metal when catalyzed by iodine or aluminum chloride, forming an unidentified product which "may be expressed" as  $\text{Me}_2\text{AlCl}$  plus  $\text{MeAlCl}_2$ . Hall and Nash<sup>2</sup> isolated the ethylaluminum chlorides from the products of polymerization of ethylene with a mixture of aluminum and aluminum chloride, and identified the double salt  $\text{EtAlCl}_2 \cdot \text{NaCl}$ . Later, Grosse<sup>3</sup> reported the melting and boiling points of the four methyl- and ethylaluminum chlorides.

Since none of these articles gives a satisfactory method of preparation of the compounds in question, it seems desirable to describe briefly the simple method which has been used successfully in these Laboratories since some time prior to the appearance of the articles cited. This description pertains primarily to the methyl chlorides; the ethyl chlorides and the methyl and ethyl bromides have been prepared similarly.

The desired amount of aluminum metal, preferably in an alloy such as Aluminum Company of America Alloy 12 (8% copper), is cut in clean, dry shavings or chips. These are placed in a glass or steel reaction vessel equipped with: halide inlet and product discharge lines, temperature and pressure gages, provision for heating and cooling, and a safety blow-out. The catalyst, about 0.1% of anhydrous

aluminum chloride (or iodine, or the product of a previous preparation) is placed in one spot on top of the aluminum, and the reaction vessel closed. Air is pumped or flushed out, and methyl chloride gas introduced to a pressure of one atmosphere (or more, depending on the equipment used). If the reaction fails to start in one hour at room temperature, the charge is heated to  $100^\circ$ . Once started, the reaction is autocatalytic and highly exothermic. More methyl chloride is added, and cooling is applied, at such rates as to maintain a suitable rate of reaction and to keep the temperature of the charge below  $75^\circ$ . At higher temperatures, side reactions may occur with the formation of gas.

When no more methyl chloride is absorbed, the reaction is completed. The reaction of the aluminum is quantitative, while any iron or copper in the alloy remains unattacked. Side reactions are negligible. In a typical preparation, about 60 millimoles of aluminum in the form of alloy took up 88.9 millimoles of methyl chloride with the formation of only 0.9 millimole of methane; the non-volatile residue contained no aluminum and 0.4 milliatom of chlorine; no iron or copper was detected in the distilled product.

The water-white, oily liquid is decanted or vacuum distilled, from the remaining metallic sludge, into a suitable closed container. If desired, this product can be diluted with methyl chloride to lower its viscosity and to facilitate the removal of samples from the container. Such methyl chloride solutions apparently are stable in glass or steel containers, and react slowly with copper or lead. The stability of solutions of the bromides and of the corresponding ethyl compounds is less assured, and is under investigation. In any case, a safety blow-out for the container is recommended. These aluminum compounds are, of course, highly reactive toward air, moisture, and other oxygen compounds; however, their oxidation or inflammation in air is not violent.

The product of the methyl chloride reaction is almost exactly an equimolecular mixture of dimethylaluminum chloride and methylaluminum dichloride. No evidence of either trimethylaluminum or of aluminum chloride is obtained on fractional distillation. Analysis is effected by hydrolysis of a sample with wet ether followed by dilute nitric acid, and determination of the amount of methane evolved, and of the aluminum and chloride content of the solution. In a typical preparation, this analysis gave 13.58 milliatoms of aluminum, 19.60 of chlorine, and 20.46 millimoles of methane, or a ratio of  $\text{Me}:\text{Al}:\text{Cl}$  of 1.507:1:1.443.

When the individual compounds are desired, they may be separated from their mixture by fractional vacuum distillation, or the dimethylaluminum chloride may be obtained in pure form by heating the mixture with excess sodium chloride and distilling the dimethyl compound from the monomethyl addition compound. Analysis of a typical distillate from the latter procedure gave 23.4 milliatoms of aluminum, 23.6 of chlorine, and 47.1 millimoles of methane, or a ratio of  $\text{Me}:\text{Al}:\text{Cl}$  of 2.01:1:1.01.

RESEARCH LABORATORIES  
ETHYL GASOLINE CORPORATION  
DETROIT, MICHIGAN  
NEWPORT ROGERS LABORATORY  
BROWN UNIVERSITY  
PROVIDENCE, R. I.

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(1) W. O. Walker and K. S. Willson, *Refrig. Eng.*, **34**, 89, 126 (1937).

(2) F. C. Hall and A. W. Nash, *J. Inst. Petroleum Tech.*, **23**, 679 (1937).

(3) Abstracts, American Chemical Society, Dallas Meeting, 1938.