2-Hydroxy-5-nitrobenzoic acid. Same as procedure used for IV. There was obtained 1.8 g. of the crude acid. The acid was purified by recrystallizing from water (decolorizing charcoal) m.p. 225–229° (lit.,[8] m.p. 227°, 229–230°). The ethyl ester prepared as before, was recrystallized from ethanol-water, m.p. 96–97° (lit.,[9] m.p. 102°).

5-Acetamido-2-ethoxybenzotrifluoride. Method A. Same as Method A, used for V. Recrystallization of the product from ethanol-water gave 4.2 g. (57%) of 5-acetamido-2-ethoxybenzotrifluoride as white crystals, m.p. 137.5–139.0°.

Method B. Same as Method B, used for V. Recrystallization of the product from ethanol-water (decolorizing charcoal) gave 4.8 g. (65%) of 5-acetamido-2-ethoxybenzotrifluoride as white crystals, m.p. 138.0–139.0°.

Anal. Calcd. for $C_{11}H_{12}F_3NO_2$: C, 53.44; H, 4.89; N, 5.65. Found: C, 53.48; H, 4.93; N, 5.67.

5-Acetamido-2-aminobenzotrifluoride. Method A. A solution of 30.0 g. (0.12 mole) of 5-acetamido-2-nitrobenzotrifluoride in 200 cc. of ethanol was added dropwise during 1 hr. to a boiling mixture of 25.0 g. of iron powder, 3.0 g. of ammonium chloride, and 250 cc. of water. After refluxing the reaction mixture for 4 hr. the hot mixture was filtered. The product was removed from the cooled filtrate by several ether extractions. After drying the ether extract over anhydrous magnesium sulfate the ether was removed by evaporation giving 15.0 g. (57%) of crude product. Several recrystallizations from benzene gave 5-acetamido-2-aminobenzotrifluoride as white crystals, m.p. 118–119°.

Method B. To a solution of 6.2 g. (0.025 mole) of 5-acetamido-2-nitrobenzotrifluoride in 50 cc. of methanol *ca.* 25 mg. of platinum oxide was added. Reduction was effected in a Parr low pressure catalytic hydrogenation apparatus at 60 p.s.i.g. After removal of the catalyst by filtration, the filtrate was evaporated to near dryness. The product was purified by recrystallization from benzene giving 4.0 g. (76%) of 5-acetamido2-aminobenzotrifluoride as tan crystals m.p. 116–118°.

Anal. Calcd. for $C_9H_9F_3N_2O$: C, 49.54; H, 4.16; N, 12.85. Found: C, 49.29; H, 4.00; N, 13.04.

5-Acetamido-2-aminobenzotrifluoride was hydrolyzed in the presence of hydrochloric acid. Neutralization of the acid solution gave 2,5-diaminobenzotrifluoride, m.p. 55–57°, (lit.,[10] m.p. 58°).

Diazotization of 5-acetamido-2-aminobenzotrifluoride, sulfuric acid and sodium nitrite, followed by reduction with copper in the presence of ethanol or by heating, gave 3-acetamidobenzotrifluoride, m.p. 103–104° (lit., [11] m.p. 105°).

4,4'-Dinitro-2,2'-bis(trifluoromethyl)diphenyl ether (VI) *Method A.* A solution of 22.55 g. (0.1 mole) of 2-chloro-5-nitrobenzotrifluoride in 50 cc. of absolute ethyl ether was added to an etheral suspension of 8.15 g. of sodium ethylate. After refluxing the heterogeneous reaction mixture 34 hr. 8 g. of starting material was recovered by steam distillation. The residual mixture from the steam distillation was filtered and the solid product recrystallized several times from absolute ethanol (decolorizing charcoal) gave 5.5 g. (14%) of VI light cream-colored needles, m.p. 140–141°.

Method B. A solution of 22.55 g. (0.1 mole) of 2-chloro-5-nitrobenzotrifluoride in 150 cc. of absolute isopropyl alcohol was added to a solution of 14.0 g. of potassium hydroxide dissolved in 200 cc. of absolute isopropyl alcohol. After agitating the solution 4 hr. at room temperature, the mixture was refluxed 1 hr. Isopropyl alcohol was removed by distillation leaving *ca.* 100 cc. of the reaction mixture. After removing the inorganic salts by filtration an equal volume of ice and water was added to the filtrate. The solid product was collected by filtration. Product was purified by recrystallization from 95% ethanol giving 4.5 g. (11%) VI. The product had the same melting point as that prepared by Method A and there was no depression when the two were mixed.

Anal. Calcd. for $C_{14}H_6F_6N_2O_5$: C, 42.44; H, 1.53; N, 7.07. Found: C, 42.35; H, 1.56; N, 7.09.

HOPEWELL, VA.

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

Substituted Styrenes. VI. Syntheses of the Isomeric Formylstyrenes and *o*- and *m*-Vinylbenzoic Acid

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Laboratory methods have been devised for the preparation of *o*-, *m*-, and *p*-formylstyrene and for *o*- and *m*-vinylbenzoic acid.

In a continuation of studies[1] concerning the preparation, absorption spectra and reactions of substituted styrenes, syntheses were devised for the isomeric formylstyrenes and for *o*- and *m*-vinylbenzoic acid.

Wiley and Hobson[2] have reported the preparation of *p*-formylstyrene by the decarboxylation of *p*-formylcinnamic acid. Impure *m*-formylstyrene was obtained by the same method but attempts to prepare the *ortho* isomer by the decarboxylation of *o*-formylcinnamic acid afforded only 1-indanone. Morris and co-workers[3] have observed that a

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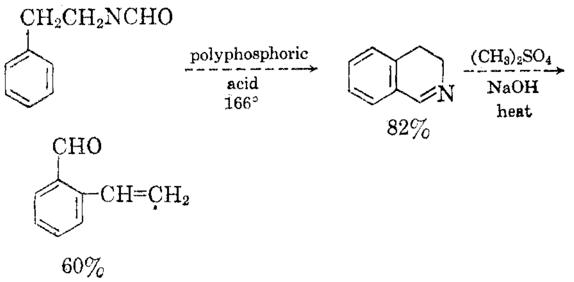
[1] W. J. Dale and C. W. Strobel, *J. Am. Chem. Soc.*, **76**, 6172 (1954); W. J. Dale and G. Buell, *J. Org. Chem.*, **21**, 45 (1956); W. J. Dale and H. E. Hennis, *J. Am. Chem. Soc.*, **80**, 3645 (1958); W. J. Dale and H. E. Hennis, *J. Am. Chem. Soc.*, **81**, 2143 (1959); W. J. Dale and P. E. Swartzentruber, *J. Org. Chem.*, **24**, 955 (1959).

[2] R. H. Wiley and P. H. Hobson, *J. Am. Chem. Soc.*, **71**, 2429 (1949).

[3] L. R. Morris, R. A. Mock, C. A. Marshall, and J. H. Howe, *J. Am. Chem. Soc.*, **81**, 377 (1959).

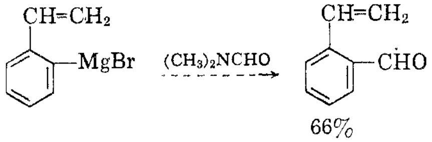
Sommelet reaction performed on a mixture of *o*- and *p*-vinylbenzyl chlorides resulted in a mixture of *o*- and *p*-formylstyrenes.

In the present study, *o*-formylstyrene was prepared from 2,3-dihydroisoquinoline by reaction with dimethyl sulfate in sodium hydroxide solution,[4] a general method of cleavage employed by Gensler[5] for a variety of *o*-acylstyrenes.



The preparation of 3,4-dihydroisoquinoline in low yield by a similar reaction has been reported previously.[6] However, by using a slight modification of the method of Snyder and Werber (heating at 166° for three hours rather than at 145° for an hour and a half), this compound was obtained in 82% yield from *N*-β-phenylethylformamide. The extent of formation of *o*-vinylbenzoic acid from the aldehyde during the reaction in strongly basic solution was negligible when the reaction temperature was maintained below 85°.

o-Formylstyrene was also prepared in this study in 66% yield by reaction of the Grignard reagent from *o*-bromostyrene with dimethylformamide in tetrahydrofuran solution, a modification of the Bouveault reaction for aromatic aldehydes, as described by Smith and Bayliss.[7]



The *para* isomer was obtained in a similar way in 55% yield from the reaction of *p*-vinylphenylmagnesium chloride[8] with dimethylformamide. The reactions of *p*-vinylphenylmagnesium chloride with *N*-methylformanilide and with ethyl orthoformate were also investigated as possible routes to *p*-formylstyrene. However, the *N*-methylformanilide was difficult to remove from the impure styrene and the product from the reaction with ethyl orthoformate, after hydrolysis in acid solution, consisted mostly of polymer.

m-Formylstyrene was prepared in 71% yield from *m*-vinylphenylmagnesium bromide in a manner similar to the above preparations for the *ortho para* isomers. It is noteworthy that the attempted preparation of *m*-vinylphenylmagnesium chloride from *m*-chlorostyrene gave only polymer, whereas the Grignard reagent formed satisfactorily from *p*-chlorostyrene. The preparation of the Grignard reagent from *m*-bromostyrene using either dry ether or tetrahydrofuran as solvent was successful. However, with ether as solvent, the yield of *m*-formylstyrene was lower (52%) than with tetrahydrofuran as solvent (71%) and there was difficulty in initiating the Grignard reaction.

The *o*- and *m*-vinylbenzoic acid were obtained in 94 and 83% yields, respectively, by carbonation of the Grignard reagents derived from *o*- and *m*-bromostyrene.

EXPERIMENTAL[9]

3,4-Dihydroisoquinoline. This compound was prepared by a modification of the method of Snyder and Werber.[6] Into a 1-l. round bottomed flask, equipped with a Hershberg stirrer, were placed 500 ml. of polyphosphoric acid and 250 g. (1.68 moles) of *N*-β-phenylethylformamide.[10] The mixture was warmed to 120° and stirring was begun. The temperature was raised slowly to 166° and maintained at this level, with vigorous stirring, for 3 hr. The mixture was then poured onto 2 l. of cracked ice and water and stirred until all the polyphosphoric acid had dissolved. Sodium hydroxide and ice were added alternately to the cold solution until it was strongly basic. The mixture was then extracted with four 250-ml. portions of ether and the combined extracts were dried over sodium sulfate. The solvent was removed under reduced pressure and the residue was distilled. There was obtained 181 g. (82%) of 3,4-dihydroisoquinoline, b.p. 69–72° (2 mm.), n_D^{20} 1.5910; m.p. of picrate, 179–181°; lit.,[6] m.p. 176–177°.

o-Formylstyrene from 3,4-dihydroisoquinoline. Into a 2-l. round bottomed flask, equipped with a stirrer and condenser, were placed 300 g. of sodium hydroxide and 1200 ml. of water. Stirring was begun and the temperature was raised to 70°. Fifty grams (0.382 mole) of 3,4-dihydroisoquinoline was added, after which 150 ml. of dimethyl sulfate was added slowly, with stirring. The mixture was stirred for 2 hr. at a temperature of 82–85°. It was then cooled, extracted with three 150-ml. portions of ether, washed five times with dilute hydrochloric acid, twice with water, twice with saturated sodium carbonate solution, and dried over magnesium sulfate. The ether was removed by distillation and distillation of the residue yielded 30 g. (60%) of *o*-formylstyrene, b.p. 113–115° (18 mm.); n_D^{20} 1.5829.

Anal. Calcd. for C_9H_8O: C, 81.79; H, 6.10. Found: C, 81.46; H, 6.04. Semicarbazone, white needles from ethanol; m.p. 190–191°.

Anal. Calcd. for $C_{10}H_{11}N_3O$: C, 63.47; H, 5.86. Found: C, 63.13; H, 5.79. 2,4-Dinitrophenylhydrazone, orange needles from ethanol; m.p. 197–198°.

Anal. Calcd. for $C_{15}H_{12}N_4O_4$: C, 57.69; H, 3.87. Found: C, 57.82; H, 4.00.

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[4] The preparation of *o*-formylstyrene is taken from a portion of a thesis submitted by C. W. Strobel in partial fulfillment of the requirements for the Ph.D. degree, University of Missouri, 1956.

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(7) L. I. Smith and M. Bayliss, *J. Org. Chem.*, **6**, 437 (1941).

(8) J. R. Leebrick and H. E. Ramsden, *J. Org. Chem.*, **23**, 935 (1958).

(9) All melting points are uncorrected. The carbon and hydrogen analyses were performed by Drs. Weiler and Strauss of Oxford, England.

(10) H. Decker, *Ann.*, **395**, 286 (1913).

o-Formylstyrene from o-bromostyrene. o-Bromostyrene was prepared from *o*-bromophenylmethylcarbinol[11] by the method of Emerson and Lucas,[12] b.p. 60–61° (3 mm.), n_D^{25} 1.5985; lit.,[13] b.p. 65° (4 mm.), n_D^{25} 1.5983. The Grignard reagent prepared from 18.6 g. (0.1 mole) of *o*-bromostyrene and 2.4 g. (0.1 g.-atom) of magnesium turnings in 150 ml. of tetrahydrofuran was cooled to 20°; a solution of 6.8 g. (0.1 mole) of dimethylformamide in 50 ml. of tetrahydrofuran was then added dropwise over a 0.5-hr. period. The reaction mixture was stirred for 2 hr. after the addition was complete and then was allowed to remain overnight under a nitrogen atmosphere. The mixture was hydrolyzed with saturated ammonium chloride solution, the layers were separated and the aqueous layer was extracted twice with 50-ml. portions of ether. The extracts were combined and dried over magnesium sulfate. After removal of the solvent under reduced pressure, the residue was distilled; yield, 8.8 g. (66%) of *o*-formylstyrene, b.p. 70–75° (1 mm.), n_D^{20} 1.5827.

Preparation of p-Formylstyrene. A solution of 14.6 g. (0.2 mole) of dimethylformamide in 100 ml. of dry tetrahydrofuran was added dropwise over a 1 hr. period to a solution of *p*-vinylphenylmagnesium chloride[8] (0.2 mole, from 27.6 g. *p*-chlorostyrene and 4.9 g. of magnesium) in 150 ml. of tetrahydrofuran. The temperature was maintained at 20° during the addition; higher temperatures resulted in polymer formation and lower yields. The reaction mixture was stirred for 2 hr. and then allowed to remain overnight under a nitrogen atmosphere. The product was hydrolyzed with saturated ammonium chloride solution and the layers were separated. The aqueous layer was extracted three times with 50-ml. portions of ether; the extracts were combined and dried over magnesium sulfate. The solvent was removed under reduced pressure and the residue was distilled. The fraction distilling at 75–80° (1 mm.) was collected; yield, 14.4 g. (55%), n_D^{23} 1.5892; lit.,[2] b.p. 92–93° (14 mm.), n_D^{25} 1.5872.

The 2,4-dinitrophenylhydrazone of *p*-formylstyrene was prepared in the usual manner, m.p. 235–236°.

Anal. Calcd. for $C_{15}H_{12}N_4O_4$: C, 57.69; H, 3.87. Found: C, 57.33; H, 3.93.

Attempts were made to prepare *p*-formylstyrene from the reaction of *p*-vinylphenylmagnesium chloride with *N*-methylformanilide in dry tetrahydrofuran solution. The infrared spectrum of the impure product showed the presence of *p*-formylstyrene and unchanged *N*-methylformanilide. The mixture could not be separated satisfactorily by distillation and the procedure was abandoned.

In another experiment, *p*-vinylphenylmagnesium chloride and ethyl orthoformate in tetrahydrofuran were refluxed for 1 hr. Hydrolysis of the product with dilute sulfuric acid apparently caused polymerization of any *p*-formylstyrene so formed.

Preparation of m-formylstyrene. m-Bromostyrene was prepared from *m*-bromophenylmethylcarbinol[11] using the dehydration method of Emerson and Lucas.[12] Magnesium (5.5 g., 0.23 g.-atom) was placed in a three necked flask equipped with stirrer, reflux condenser, and dropping funnel. *m*-Bromostyrene (36.6 g., 0.2 mole) in 150 ml. dry tetrahydrofuran was then added dropwise, over a period of 1.5 hr., while nitrogen gas was bubbled through the solution; the temperature throughout the addition was 65° and this temperature was maintained for one-half hour after addition was complete. The mixture was stirred for an additional hour without heating and then cooled to 20°. While this temperature was maintained, a solution of 14.6 g. (0.2 mole) of dimethylformamide in 100 ml. of tetrahydrofuran was added dropwise to the Grignard reagent. The reaction mixture was stirred for 2 hr. after the addition was complete and then was allowed to remain overnight under nitrogen. The solution was poured onto cracked ice and hydrolyzed with saturated ammonium chloride solution. The layers were separated and the aqueous layer was extracted twice with 50-ml. portions of ether; the extracts were combined and dried over magnesium sulfate. The solvent was removed under reduced pressure and the residue was distilled. The fraction distilling at 74–78° (1 mm.) was collected; yield, 18.6 g. (71%), n_D^{25} 1.5760.

Anal. Calcd. for C_9H_8O: C, 81.79; H, 6.10. Found: C, 81.41; H, 6.16. A 2,4-dinitrophenylhydrazone was prepared in the usual manner, m.p. 229–230°.

Anal. Calcd. for $C_{15}H_{12}N_4O_4$: C, 57.69; H, 3.87. Found: C, 57.45; H, 3.57.

m-Vinylbenzoic acid. The Grignard reagent prepared from 18.4 g. (0.1 mole) of *m*-bromostyrene and 2.4 g. (0.1 g.-atom) of magnesium in 100 ml. of tetrahydrofuran was cooled and poured onto crushed dry ice. The product was hydrolyzed with dilute hydrochloric acid, the layers were separated and the aqueous layer was extracted twice with 50-ml. portions of ether. The ether extracts were added to the original organic layer which was then stirred into a 20% sodium hydroxide solution. The ether layer was discarded, the aqueous layer was filtered to remove polymer and then was acidified with dilute hydrochloric acid. The crude acid which separated was collected on a filter and recrystallized from a 20% ethanol-water solution; yield, 12 g. (83%) m.p. 95–96° (lit.,[14] m.p. 95–96°).

Anal. Calcd. for $C_9H_8O_2$: C, 72.96; H, 5.44. Found: C, 73.30; H, 5.63.

o-Vinylbenzoic acid. This compound was prepared from *o*-bromostyrene in a manner very similar to the above preparation for the *meta* isomer; yield (94%), m.p. 94–95°.

Anal. Calcd. for $C_9H_8O_2$: C, 72.96; H, 5.44. Found: C, 72.94; H, 5.19.

COLUMBIA, MO.

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