Dr. D. L. Turner and Dr. J. M. Vandenbelt. We thank Parke, Davis and Company for their assistance.

Summary

1. Twelve new sapogenins and two new pro-sapogenins have been isolated. The original isolation procedure for each is described. Additional sources for these have been reported previously.[3]

2. Chemical interrelationships between these and the previously characterized sapogenins have been carried out. Structures for the new sapogenins and the pro-sapogenins have been proposed.

3. Neochlorogenin, β-neochlorogenin, 7-ketogitogenin, 7-ketoyuccagenin and 6-ketotigogenin have been prepared.

4. The positions of the hydroxyl groups in digitogenin have been further established at C-2, C-3 and C-15.

5. Diosgenin and tigogenin have been interrelated with kryptogenin, further illustrating the spiro-ketal nature of the sapogenin side-chain.

6. Bethogenin has been shown to be a derivative of kryptogenin.

7. A biogenetic relationship of the sapogenins has been proposed and correlated with the seasonal changes of the steroidal content of various plants.

STATE COLLEGE, PENNA. RECEIVED[123] MARCH 11, 1947

(123) Original manuscript received June 26, 1944.

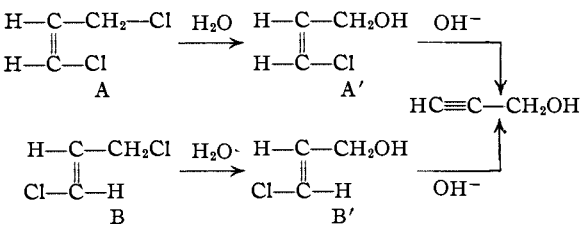
NOTES

The *cis-trans* Isomers of 1,3-Dichloropropene

BY LAWRENCE J. ANDREWS AND RICHARD E. KEPNER

The terms *alpha* and *beta* were formerly used to designate, respectively, the low and high boiling isomers of 1,3-dichloropropene.[1] On the basis of comparative studies of the rates of hydrolysis of the isomeric dichlorides as catalyzed by the cuprous chloride–chloride ion complex and of the comparative rates of dehydrochlorination of the corresponding 3-chloro-2-propen-1-ols the *alpha* isomer has been assigned the *trans* and the *beta* isomer the *cis* configuration.[2] In surveying the evidence on which these assignments of structure are based we have noted that there is still doubt as to the correct geometric configurations of the two compounds.

For purposes of discussion the two dichlorides will be designated A and B and the corresponding alcohols as A′ and B′, as represented below.



The catalytic action of cuprous chloride in the hydrolysis of allyl chloride in dilute hydrochloric acid solution has been explained on the assumption that the reaction is facilitated by formation of an intermediate complex between the olefin and $CuCl_2^-$.[3] Since the rate of hydrolysis of *beta* 1,3-dichloropropene under these conditions is much more rapid than that of the *alpha* isomer, it has been assumed that formation of an olefin–$CuCl_2^-$ complex occurs more readily with the *beta* than with the *alpha* isomer.[2] Hatch and Roberts have made the further assumption that the factors influencing the formation of such a complex are similar to those involved in the mercuration of an olefin. Since *cis*-methyl cinnamate and *cis*-stilbene are mercurated faster than the corresponding *trans* isomers,[4] they have concluded that beta 1,3-dichloropropene is the *cis* isomer. Though Hatch and Roberts do not show structural formulas, it seems likely that the *cis* isomer to which they refer should be represented by formula A, in which the two hydrogen atoms attached to the ethylenic linkage are *cis* with respect to each other.

In a mercuration reaction of the type under consideration it has been shown that the mercurating agent, methoxymercuric acetate, adds to the double bond of the olefin.[5] On the other hand the hydrolysis of a dichloropropene is a substitution reaction. However the formation of a complex between dichloropropene and $CuCl_2^-$, resulting in an enhanced rate of hydrolysis of the unsaturated halide, might be explained on the assumption that the complex were formed by addition of the $CuCl_2^-$ to the double bond of the olefin. There is still no experimental evidence to indicate that the mechanism of formation of this complex would be similar to or different from that of the

(1) Hatch and Moore, THIS JOURNAL, **66**, 285 (1944).

(2) Hatch and Roberts, *ibid.*, **68**, 1196 (1946).

(3) Hatch and Estes, *ibid.*, **67**, 1730 (1945).

(4) Thomas and Wetmore, *ibid.*, **63**, 136 (1941), have assigned the *cis* configuration to the 2-butene isomer which mercurates faster.

(5) (a) Wright, *ibid.*, **57**, 1993 (1935); (b) Romeyn and Wright, *ibid.*, **69**, 697 (1947).

mercuration reaction. At present, therefore, it seems unwise to the authors to attempt an assignment of geometric configuration to the dichloropropenes on the basis of an interpretation of their $CuCl_2^-$ catalyzed hydrolysis rates in terms of the steric course of mercuration reactions.

The chloroalcohol obtained by hydrolysis of α-1,3-dichloropropene is readily dehydrochlorinated by aqueous sodium hydroxide while that obtained from the *beta* isomer is not.[1] On the basis that chlorofumaric acid is dehydrochlorinated more readily than chloromaleic acid, Hatch and Roberts concluded that the *alpha* dichloride and chloroalcohol were the *trans* isomers (presumably B and B′).

However a survey of the literature indicates that in general dehydrohalogenation of vinyl halides takes place most readily when the hydrogen and halide are *trans* to each other.[6] For example, chlorofumaric acid,[6] *trans*-2-bromo-2-butene[7] and *cis*-dichloroethylene[8] all dehydrohalogenate more readily than the isomers of opposite geometric configuration. From these facts it would seem better to reach a conclusion opposite to that of Hatch and Roberts and to assign the structures A and A′ to the *alpha* isomers and B and B′ to the *beta* isomers.

In the opinion of the authors a definite assignment of geometric configuration for the 1,3-dichloropropenes cannot be made on the basis of available experimental evidence. It is possible that further studies of the mechanisms of dehydrohalogenation of substituted vinyl halides and of the cuprous chloride–chloride ion complex catalyzed hydrolysis reactions would clarify this situation.

(6) (a) Michael, *J. prakt. Chem.*, [2] **52**, 289 (1895); (b) Michael, THIS JOURNAL, **40**, 704, 1674 (1918).
(7) Wislicenus and Schmidt, *Ann.*, **313**, 216 (1900).
(8) Chavanne, *Compt. rend.*, **154**, 776 (1912).

DIVISION OF CHEMISTRY
COLLEGE OF AGRICULTURE
UNIVERSITY OF CALIFORNIA
DAVIS, CALIFORNIA RECEIVED JANUARY 27, 1947

Nicotinic Anhydride

BY C. O. BADGETT

Preparation of nicotinic anhydride by the reaction of nicotinyl chloride with sodium nicotinate and subsequent distillation of the anhydride from the reaction mixture has been reported previously.[1] However, the synthesis of pure nicotinyl chloride from nicotinic acid[2,3] or from nicotinic acid nitrate[4] is difficult, time-consuming, and poorly productive because of the troublesome separation of the acid chloride from pyridine hydrochloride by distillation.

A simplified method for the preparation of nicotinic anhydride from nicotinic acid has been developed in this Laboratory. Excellent yields of essentially pure product are obtained by a process in which distillation procedures are eliminated and the anhydride is crystallized from the liquid portion of the reaction mixture. The improvement over previously reported methods is achieved by high temperature removal of hydrogen chloride from nicotinyl chloride hydrochloride in inert solvents.

(1) Graf, *Biochem. Z.*, **229**, 164–168 (1930).
(2) Späth and Spitzer, *Ber.*, **59B**, 1477–1486 (1926).
(3) Meyer and Graf, *ibid.*, **61**, 2202–2215 (1928).
(4) Douglass and Forman, THIS JOURNAL, **56**, 1609 (1934).

Preparation

Into a 500-cc. three-necked, round-bottom flask equipped with a condenser fitted with a calcium chloride drying tube, air-tight stirrer and dropping funnel, were placed 40.6 g. (0.33 mole) of nicotinic acid and 100 cc. of anhydrous nitrobenzene. Over a period of ten minutes, 39.3 g. (0.33 mole) of redistilled thionyl chloride was added dropwise. The temperature of the reaction mixture was raised gradually to 210° and maintained for one hour, or until all gas evolution had ceased. The reaction mixture was allowed to cool, then 53.1 g. (0.33 mole) of potassium nicotinate was introduced in one portion, and the mixture was heated to 210° for three hours, after which it was allowed to cool to approximately 100° and poured into a 1500-cc. beaker. One liter of anhydrous benzene and 10 g. of Norit were added. The mixture was then boiled for about ten minutes and filtered through a heated Buchner funnel, and the filtrate was cooled to room temperature. The 49.5 g. of nicotinic anhydride which crystallized had a melting point of 119.8–121.5°.[5] Concentrating the mother liquors to approximately 150 cc. gave a second crop of crystals, which weighed 14.6 g. and had a melting point of 119.1–121.3°. A third crop of 2.5 g. was obtained by further concentration and crystallization, bringing the total weight of nicotinic anhydride to 66.6 g. This represented a yield of 88.9%. The combined crops of crystals recrystallized once from hot benzene gave a pure anhydride melting at 122.5–123.5°. However, the crude anhydride was of sufficient purity to be used in most syntheses.

Anal. Calcd. for $C_{12}H_8N_2O_3$: C, 63.16; H, 3.53; N, 12.28. Found: C, 63.15; H, 3.63; N, 12.23.

Direct reaction of 1 mole of potassium nicotinate with 0.5 mole of thionyl chloride gave lower yields than this procedure. Use of other solvents in the preparation of nicotinic anhydride was investigated. Nitrobenzene gave the best yields and product. The following table shows the solvent used and yield of anhydride obtained.

Solvent	Yield, %
Nitrobenzene	88.9
o-Dichlorobenzene	78.3
Deobase[6]	47.9
p-Cymene	26.6

(5) Melting points reported are uncorrected.
(6) Deobase is deodorized kerosene. It was redistilled and only the cut boiling at 205–215° was used.

U. S. DEPARTMENT OF AGRICULTURE
EASTERN REGIONAL RESEARCH LABORATORY
CHESTNUT HILL STATION
PHILADELPHIA 18, PA. RECEIVED APRIL 28, 1947

The Preparation of 1-Phenyl-1,3-butadiene

BY E. C. COYNER AND G. A. ROPP[1]

In connection with a study of Diels–Alder reactions of aryl-substituted dienes, an investiga-

(1) Research Corporation Fellow.

tion of the preparation of 1-phenyl-1,3-butadiene from four phenylbutenols (I–IV) has been made.

I $C_6H_5CH(OH)CH_2CH{=}CH_2$[2]
II $C_6H_5CH{=}CHCH(OH)CH_3$[3]
III $C_6H_5CH(OH)CH{=}CHCH_3$[4]
IV $C_6H_5CH_2CH(OH)CH{=}CH_2$[5]

Alcohols (I–III) were obtained by the Grignard reaction, but attempts to prepare (IV) by this reaction using the procedure of Delaby, who reported a 5% yield, gave only phenylbutadiene dimer, b. p. 250° (33 mm.),[6] and higher polymers. Alcohol (IV) is therefore probably the least stable of the four studied.

1-Phenyl-3-buten-1-ol (I) is the most stable of the alcohols (*vide infra*) and was obtained in 77% yield; it was used in preparing 1-phenyl-1,3-butadiene (46% yield from alcohol) *via* the reactions

$$\text{I} \xrightarrow{\text{HBr}} C_6H_5CH(Br)CH_2CH{=}CH_2 \xrightarrow{\text{pyridine}} C_6H_5CH{=}CH{-}CH{=}CH_2$$

Data on the relative stability of alcohols (I–III) under dehydrating conditions were obtained by measuring the rates of water formation in solutions of each of the alcohols in benzene containing 0.1% concentrated sulfuric acid. The determined stabilities are (I) > (II) = (III). This procedure gave isolable quantities of diene monomer (6%) from (III) only.

Experimental

1-Phenyl-1,3-butadiene.—Dry hydrogen bromide was passed into a solution of 54.3 g. of 1-phenyl-3-buten-1-ol in 230 cc. C. P. benzene under reflux for five hours. Ninety per cent. of the theoretical amount of water was separated from the reaction mixture after two hours. After the benzene solution was washed free of acid with dilute aqueous sodium bicarbonate and dried over anhydrous magnesium sulfate, it was added to 39.5 g. of pyridine and a few mg. of hydroquinone, and the resulting solution was mechanically stirred and heated under reflux for eleven hours. The supernatant liquid was decanted from the yellow, tacky precipitate which was then washed twice with benzene and was found to contain 93.5% of the theoretical amount of bromide ion; it was almost completely soluble in water. The benzene washings were combined with the decanted solution and the whole was washed seven times with water and dried over anhydrous magnesium sulfate. A small amount of hydroquinone was added and the benzene was removed *in vacuo*. The residue was a red oil which gave, upon distillation, 22 g. of 1-phenyl-1,3-butadiene [46%, based on (I)], b. p. 75–79° (6.5 mm.),[7] m. p. 1–3°.[6]

Dehydration of 1-Phenyl-3-buten-1-ol, 4-Phenyl-3-buten-2-ol and 1-Phenyl-2-buten-1-ol.—A solution of each alcohol in an equal volume of benzene containing about 0.1% concentrated sulfuric acid was heated under reflux and the returning condensate was passed over a trap from which the water was periodically withdrawn and its volume measured. Under these conditions 1-phenyl-3-buten-1-ol (I) was dehydrated only 16% in three hours while both 4-phenyl-3-buten-2-ol (II) and 1-phenyl-2-buten-1-ol (III) gave about 35% of the theoretical amount of water during the first hour and no additional water after three hours. The reaction mixtures were washed free of acid with dilute aqueous sodium bicarbonate, dried over anhydrous magnesium sulfate and distilled in the presence of hydroquinone *in vacuo*. In addition to polymeric residues which were obtained from all of the alcohols, phenylbutadiene, b. p. 96–99° (25 mm.), was obtained from the reaction with 1-phenyl-2-buten-1-ol (III) in 6% yield and 63% unchanged alcohol was recovered from the reaction with 1-phenyl-3-buten-1-ol (I).

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF TENNESSEE
KNOXVILLE, TENN. RECEIVED NOVEMBER 25, 1946

(2) Klimenko, *J. Russ. Phys.-Chem. Soc.*, **43**, 212 (1911).
(3) Klages, *Ber.*, **35**, 2649 (1902).
(4) Burton, *J. Chem. Soc.*, 455 (1929).
(5) Delaby, *Compt. rend.*, **194**, 1248 (1932).
(6) Liebermann and Riber, *Ber.*, **35**, 2697 (1902).
(7) Muskat and Herrman, THIS JOURNAL, **53**, 252 (1931).

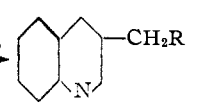
Evidence of Rearrangement of Polymethylol Compounds Related to Neopentane

BY ROBERT W. BROWN[1] AND GREGG DOUGHERTY

The neopentyl system in polymethylol compounds of the type $R_2C(CH_2OH)_2$ and $RC(CH_2OH)_3$ is much more stable than it is in neopentyl alcohol, as is shown by the fact that the halides of these polyalcohols can be prepared without rearrangement by treatment with hydrogen halides.[2] The report of Fischer and Winter,[3] however, that methyl isopropyl ketone and isovaleraldehyde are formed in small amounts by the action of sulfuric acid on 2,2-dimethylpropanediol-1,3 at 200° suggests that some sort of rearrangement of the carbon skeleton takes place under sufficiently drastic conditions.

The trimethylol compounds are largely destroyed by treatment with concentrated acids at high temperatures, but as rearrangement of these compounds with migration of the alkyl group would lead to β-alkylglycerols, it appeared that the conditions of the Skraup synthesis might lead to isolable derivatives.

$$R{-}C(CH_2OH)_3 \xrightarrow{H^+} R{-}C(CH_2OH)_2{-}CH_2^+ \longrightarrow {}^+C(CH_2OH)_2{-}CH_2R \longrightarrow HO{-}C(CH_2OH)_2{-}CH_2R \xrightarrow[C_6H_5NO_2]{H_2SO_4,\ C_6H_5NH_2}$$



When 2-(hydroxymethyl)-2-methylpropanediol-1,3 was heated with aniline, nitrobenzene, and sulfuric acid, a vigorous reaction set in at about 160°. After six hours of heating at 160–170° a heavy tar was obtained, which after steam distillation and removal of primary and secondary amines by diazotization gave 10–25% yields of 3-ethylquinoline.

Under the same conditions 2-(hydroxymethyl)-2-ethylpropanediol-1,3 reacted in the same manner as the lower homolog; the product in this case being 3-propylquinoline.

(1) Present address: Naugatuck Chemical Division, U. S. Rubber Co., Naugatuck, Conn.
(2) Whitmore, "Organic Chemistry," D. Van Nostrand Co., New York, N. Y. 1937, pp. 368, 382.
(3) Fischer and Winter, *Monatsh.*, **21**, 301 (1900).

The quinoline derivatives were characterized by preparation of the picrates and methiodides, by analysis of the latter for iodide ion, and by oxidation to 3-quinolinecarboxylic acid.

Experimental

Materials.—The trimethylol compounds were supplied by the Heyden Corporation. A sample of 2-(hydroxymethyl)-2-methylpropanediol-1,3 was also prepared by condensation of an excess of formaldehyde with propionaldehyde in the presence of calcium hydroxide; m. p. after recrystallization from dioxane, 198–199°.

Reaction of 2-(Hydroxymethyl)-2-methylpropanediol-1,3.—A mixture of 7 g. of the alcohol, 10 g. of aniline, 11 ml. of nitrobenzene and 20 ml. of sulfuric acid was heated to 160°. A vigorous reaction set in, necessitating removal of the heating bath and external cooling of the flask. After this subsided the mixture was heated at 160–170° for six hours. The reaction mixture was made basic with 30% sodium hydroxide solution, steam distilled, the distillate acidified with dilute sulfuric acid and extracted with 30 ml. of chloroform. The acid solution was then cooled to 5° and diazotized with 10% sodium nitrite solution until an excess persisted for twenty minutes as shown by starch–iodide paper. At the end of this time the solution was heated slowly to boiling on the steam-bath. It was then made strongly basic with 30% sodium hydroxide solution and steam distilled. The distillate was extracted with three 50-ml. portions of ether and the extract dried over sodium sulfate. Removal of the ether gave 2.6 g. (28%) of crude product. Distillation at 12–13 mm. gave 2.3 g. (25%) of 3-ethylquinoline, b. p. 126–131°. The picrate was prepared by addition of a saturated solution of picric acid in alcohol to an alcoholic solution of the base; yellow needles from alcohol, m. p. 199.5–200.5°. The methiodide was prepared by reaction of the base with methyl iodide at room temperature and recrystallized from alcohol; m. p. 190–191.5°.

Anal. Calcd. for $C_{12}H_{14}NI$: I, 42.41. Found: I, 42.12.

Oxidation.—One gram of the base was dissolved in 50 ml. of 4% sulfuric acid and to it was added a solution of 4 g. of sodium dichromate in an equal volume of the same acid. The solution was heated for fifty hours on the steam-bath, then made basic with concentrated ammonium hydroxide. The hot suspension of hydrous chromic oxide was filtered off with suction and the cake washed with 30 ml. of dilute ammonia. The filtrate and washings were boiled with charcoal, filtered, acidified with acetic acid and cooled. The precipitated acid was filtered off and dried over sulfuric acid; m. p. 279–280° after recrystallization from alcohol–benzene.

Anal. Calcd. for $C_{10}H_7O_2N$: neut. equiv., 173. Found: neut. equiv., 171.

Reaction of 2-(Hydroxymethyl)-2-ethyl-propanediol-1,3.—Eight grams of the alcohol, 12 g. of aniline, 12 g. of nitrobenzene, and 25 ml. of sulfuric acid were treated as described above. The product was 1.5 g. (15%) of light yellow oil boiling at 137–140° under 11 mm. pressure. Picrate, yellow needles from alcohol, gave a m. p. 174–175°; methiodide gave a m. p. 131–132°. Oxidation with chromic acid as described above gave 3-quinolinecarboxylic acid, m. p. 279–280°.

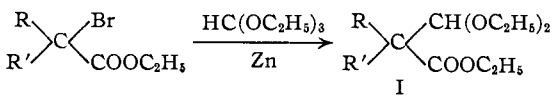
Anal. Calcd. for $C_{13}H_{16}NI$: I, 40.52. Found: I, 40.21.

FRICK CHEMICAL LABORATORY
PRINCETON UNIVERSITY
PRINCETON, NEW JERSEY RECEIVED MAY 29, 1947

Diethyl Acetals of α-Formyl Esters

BY N. C. DENO

Tschitschibabin,[1] using a modification of the Reformatsky reaction, prepared the diethyl acetals of ethyl formylacetate and ethyl α-formylpropionate from the appropriate α-bromo ester, zinc, and ethyl orthoformate in yields of 38 and 64%, respectively. The reaction can be represented as



Shdanowitsch[2] reported that the reaction was successful with ethyl α-bromoisobutyrate.

In the present investigation this reaction has been applied successfully to eight α-bromo esters including the three previously investigated. Although diethyl α,α′-dibromoadipate and bromomalonic ester reacted with zinc and ethyl orthoformate, no acetal was detected.

From six of the α-bromo esters, acetal esters (I) were obtained in yields of 44–58% (Table I). On hydrolysis by alkali followed by acidification and treatment with 2,4-dinitrophenylhydrazine in 20% sulfuric acid, the acetal esters were converted to the 2,4-dinitrophenylhydrazones of simple aldehydes. Thus the derivative of isobutyraldehyde was obtained from the diethyl acetal of ethyl α-formyl isobutyrate. With the diethyl acetal of ethyl α-formyl-*n*-valerate, which was expected to give the 2,4-dinitrophenylhydrazone of *n*-valeraldehyde, only an impure product was obtained.

The acetal esters, when treated with 2,4-dinitrophenylhydrazine in 20% aqueous sulfuric acid, gave 2,4-dinitrophenylhydrazones without hydrolysis of the ester group. Their properties are listed in Table II.

Tschitschibabin[1] reported that the product from ethyl α-bromoacetate was contaminated with ethyl β-ethoxyacrylate formed by splitting out of ethanol from the acetal. Under the conditions used in the present investigation the product was about an equal mixture of ethyl β-ethoxyacrylate and the diethyl acetal of ethyl formylacetate. This mixture could be converted completely to the acrylate ester by heating at 190–200° (gentle refluxing) for one hour.

The product isolated from ethyl bromocyanoacetate was ethyl α-cyano-β-ethoxyacrylate.

This reaction constitutes a good preparative method for diethyl acetals of α-formyl esters. It is especially valuable when there are two alkyl groups in the α position, since esters such as ethyl isobutyrate undergo base-catalyzed formylation only with difficulty.[3]

Experimental

Diethyl Acetals of α-Formyl Esters.—In all runs listed in Table I the following procedure was used which gave better temperature control than the method of Tschitschibabin which did not use any solvent. About 100 g.

(1) Tschitschibabin, *J. prakt. Chem.*, **73**, 326 (1906).

(2) Shdanowitsch, *J. Russ. Phys.-Chem. Soc.*, **42**, 1279 (1910).

(3) Hudson and Hauser (THIS JOURNAL, **63**, 3156 (1941)) obtained a 16% yield of ethyl α-formylisobutyrate using triphenylmethylsodium as the agent to condense ethyl formate and ethyl isobutyrate.

TABLE I

DIETHYL ACETALS OF α-FORMYL ESTERS

α-Bromo ester (ethyl α-bromo-)	Acetal ester (diethylacetal of ethyl α-formyl-)	Yield, %	B. p., °C. 20 mm.	Saponification equivalent Calcd.	Found	Formula	Analyses, %[a] Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found
Propionate	Propionate	44[b]	99–102	204	200	$C_{10}H_{20}O_4$				
n-Butyrate	*n*-Butyrate	51	112–117	218	217	$C_{11}H_{22}O_4$	60.52	60.58	10.16	10.37
Isobutyrate	Isobutyrate	58.5[c]	104–107	218	220	$C_{11}H_{22}O_4$	60.52	60.00	10.16	10.01
n-Valerate	*n*-Valerate	56.5	116–120	232	228[d]	$C_{12}H_{24}O_4$	62.04	61.73	10.41	10.28
n-Caproate	*n*-Caproate	46.5	132–136	246	246	$C_{13}H_{26}O_4$	63.38	63.28	10.64	10.23
Hexahydrobenzoate	Hexahydrobenzoate	52.5	149–152		[e]	$C_{14}H_{26}O_4$	65.08	65.07	10.14	10.17

[a] Microanalyses by Micro-Tech Laboratories, Skokie, Illinois. [b] Prepared by Tschitschibabin.[1] [c] Obtained by Shdanowitsch.[2] [d] This ester required twenty hours refluxing in 0.5 *N* aqueous ethanolic sodium hydroxide for complete saponification instead of the usual two hours. [e] Attempts to quantitatively saponify this ester with alkali were unsuccessful.

TABLE II

2,4-DINITROPHENYLHYDRAZONES OF α-FORMYL ESTERS

α-Formyl ester (Ethyl α-formyl-)	2,4-Dinitrophenylhydrazone Appearance, yellow	M. p.,[b] °C.	Formula	Analyses, %[a] Carbon Calcd.	Carbon Found	Hydrogen Calcd.	Hydrogen Found
Propionate	Needles	110–111.5	$C_{12}H_{14}O_6N_4$	46.45	46.64	4.55	4.47
n-Butyrate	Flakes	106–108	$C_{13}H_{16}O_6N_4$	48.14	48.35	4.97	4.80
Isobutyrate	Needles	104.5–105	$C_{13}H_{16}O_6N_4$	48.14	48.10	4.97	5.02
n-Valerate	Needles	121–123	$C_{14}H_{18}O_6N_4$	49.70	49.62	5.36	5.25
n-Caproate	Blades	86.5–88	$C_{15}H_{20}O_6N_4$	51.13	51.10	5.71	5.60
Hexahydrobenzoate	Needles	150–152	$C_{16}H_{20}O_6N_4$	52.74	52.80	5.53	5.54

[a] Microanalyses by Micro-Tech Laboratories, Skokie, Illinois. [b] The 2,4-dinitrophenylhydrazones were recrystallized to constant m. p. from methanol.

of granulated zinc was washed with dilute hydrochloric acid, and then rinsed three times each with water, methanol and acetone. The zinc was dried at 100° and 20 mm. for ten minutes and used immediately. A crystal of iodine and 25 cc. of dry benzene were added to the zinc. The benzene was heated to reflux and a solution of 0.2 mole of the α-bromoester and 40 cc. (0.24 mole) of ethyl orthoformate[4] in 75 cc. of dry benzene was added dropwise at a rate to maintain vigorous refluxing. A little heat was applied along with vigorous stirring to keep the zinc agitated. The addition took about forty-five minutes. A few minutes after the addition was completed a gum precipitated making further stirring impossible. After adding 25 additional grams of zinc prepared as described above, heat was applied and the mixture refluxed for six hours.

The mixture was cooled and the clear liquid decanted into a mixture of 200 cc. of ether and 100 g. of ice. The flask was rinsed with ether (the gummy precipitate contains very little of the product and need not be removed from the flask). An excess of acetic acid was added at 0°. The ether layer was washed with water and cold sodium bicarbonate solution, dried over sodium sulfate, and the product distilled at 20 mm. after removal of solvent.

Ethyl β-Ethoxyacrylate.—The product obtained from ethyl bromoacetate using the standard procedure boiled sharply at 88–89° (12 mm.). However a saponification equivalent of samples from different runs gave values ranging from 150–170 (calcd. for ethyl β-ethoxyacrylate, 144; for the diethyl acetal of ethyl formylacetate, 190). The yield from 16.7 g. (0.2 mole) of ethyl bromoacetate was 13 g. (this is a 39% yield assuming that it is an equal mixture of the acrylate and acetal). The product was gently refluxed for one hour at 190–200° during which ethanol slowly distilled. The ethyl β-ethoxyacrylate was then distilled as a colorless oil (b. p. 189–193°) weighing 8.5 g. (over-all yield from ethyl bromoacetate is 30%). The saponification equivalent was 142 (calcd. 144).

Ethyl α-Cyano-β-ethoxyacrylate.—Ethyl bromocyanoacetate (5.9 cc., 0.05 mole) and 8.25 cc. of ethyl orthoformate were dissolved in 70 cc. of dry benzene. Zinc (25 g.) prepared in the usual way was added to the mixture. A very vigorous reaction started which required external cooling. After the initial reaction had subsided, the mixture was refluxed for two hours. The reaction mixture was cooled and extracted with cold dilute acetic acid followed by cold sodium bicarbonate solution. The benzene solution was treated with Norite and dried over magnesium sulfate. Filtration and removal of solvent left 2.0 g. (37%) of discolored crystals of ethyl α-cyano-β-ethoxyacrylate. Recrystallization from absolute ethanol gave white, massive crystals (m. p. 49–50°) which gave no m. p. depression with an authentic sample prepared by the method of Claisen.[5]

2,4-Dinitrophenylhydrazone of Hexahydrobenzaldehyde.—The hexahydrobenzaldehyde was prepared from cyclohexylmagnesium bromide and ethyl orthoformate and also from the diethyl acetal of ethyl α-formylhexahydrobenzoate by saponification and decarboxylation on acidification. The 2,4-dinitrophenylhydrazone crystallized from methanol in yellow needles, m. p. 168–169°.

Anal. Calcd. for $C_{13}H_{15}O_4N_4$: C, 53.60; H, 5.20. Found: C, 53.47; H, 5.43.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MICHIGAN
ANN ARBOR, MICHIGAN

RECEIVED MAY 3, 1947

(4) The reagents must be free of all hydroxylic solvents. Commercial samples of ethyl orthoformate were frequently found to contain large amounts of ethanol. This must be removed by fractional distillation.

(5) de Bollemont, *Bull. soc. chim.*, [3] **25**, 20 (1901).

Synthesis of Glucosides of Digitoxigenin, Digoxigenin and Periplogenin[1]

BY ROBERT C. ELDERFIELD, FREDERICK C. UHLE AND JOSEF FRIED

In a previous communication the synthesis of several glycosides of strophanthidin has been reported.[2] Pharmacological tests on these substances[3] revealed the interesting fact that the nature of the carbohydrate component played a dominant role in determining the cardiac activity of the glycosides.

We now wish to report the synthesis of three additional glycosides, digitoxigenin-(3)-β-*d*-glucoside, digoxigenin-(3)-β-*d*-glucoside and periplogenin-(3)-β-*d*-glucoside. These were all prepared *via* the tetraacetyl glucosides by the classical Koenigs and Knorr synthesis from the aglycones and acetobromoglucose which establishes the configuration of the glucosides. The point of attachment of the glucose to the aglycone is most likely the 3-position because of the low reactivity of the other hydroxyl groups in the aglycones. Deacetylation of the acetyl glucosides was accomplished with barium methoxide.

Details of the pharmacological examination of these substances have already been reported.[4] All of the glucosides thus prepared were more powerful than the parent natural glycosides, digitoxin, digoxin and periplocymarin.

Experimental[5,6]

The procedures used for the synthesis of the new glucosides was similar to those used in the cases of the strophanthidin glycosides[2] with some deviations in each case. A typical example is given with variations as indicated being used in the other cases.

Digitoxigenin-(3)-tetraacetyl-β-*d*-glucoside.—A mixture of 373 mg. of digitoxigenin, 500 mg. of dry silver oxide, 1 g. of anhydrous magnesium sulfate and 10 ml. of absolute dioxane was stirred at room temperature for one hour in a 3-necked flask equipped with a dropping funnel and a calcium chloride tube. A solution of 820 mg. of acetobromoglucose in 4 ml. of absolute dioxane was then added dropwise over a period of an hour. After the mixture had been allowed to react at room temperature for twenty-four hours, the silver salts and the magnesium sulfate were filtered off and the filtrate was concentrated under reduced pressure. The remaining viscous, colorless oil was stirred with 5 ml. of anhydrous ether until it had completely solidified. The crystalline material was freed from liquid by decantation and was stirred three or four more times with fresh 5-ml. portions of dry ether. When pentane was added carefully to the combined ether washings until a slight turbidity appeared, an additional amount of crystalline material was obtained. This precipitation of the mother liquors with pentane was continued until no more solid material separated. The crystals obtained in this way consisted of almost pure digitoxigenin tetraacetyl-β-*d*-glucoside. It was obtained in analytically pure state by recrystallizing it several times from dilute alcohol, from which it separated in fine, long needles, which melted with decomposition at 163–168°. For analysis the compound was dried over phosphorus pentoxide at 100° and 15 mm.: $[\alpha]^{25}D$ −8.6°; (*c* 0.348 in 95% alcohol).

Anal. Calcd. for $C_{37}H_{52}O_{13}$: C, 63.1; H, 7.4. Found: C, 63.1; H, 7.7.

The crystalline material obtained by digesting the original oily reaction product with ether consisted of a mixture of unreacted digitoxigenin and its tetraacetyl glucoside. Separation was effected by fractional crystallization from dilute alcohol, in which digitoxigenin is less soluble then its acetyl glucoside. Pure digitoxigenin tetraacetyl-β-*d*-glucoside was obtained from the mother liquors having the properties described above, the total yield being 15%. The recovered digitoxigenin was used again in the reaction after recrystallization from ethyl acetate.

Digitoxigenin-(3)-β-*d*-glucoside.—To a solution of 96 mg. of digitoxigenin β-*d*-tetraacetylglucoside in 15 ml. of absolute methanol was added 0.2 ml. of approximately 0.5 *N* barium methylate solution in absolute methanol. After the solution had been allowed to stand overnight in the refrigerator, the barium was quantitatively precipitated by adding two drops of 10% sulfuric acid. The solution was rendered slightly alkaline by the addition of 1–2 drops of ammonia, and the barium sulfate was removed by filtration. The filtrate was concentrated under reduced pressure and the residue taken up in 5 ml. of absolute alcohol. After centrifuging off some undissolved ammonium sulfate, the solution was concentrated to about half its volume and ether was carefully added. The solution was kept at room temperature overnight, when rosets of needles as well as amorphous particles settled out. More ether was added in small portions to complete the precipitation of the glucoside. When this process of slow crystallization was repeated twice or three times, using 95% alcohol instead of absolute, the digitoxigenin-(3)-β-*d*-glucoside was obtained in very well formed flat platelets, which contained 1 mole of water and melted with decomposition at 242–246°. For analysis the substance was dried at 80° and 15 mm. over phosphorus pentoxide: $[\alpha]^{25}D$ −4.9; (*c* 0.516 in 95% alcohol).

Anal. Calcd. for $C_{29}H_{44}O_9 \cdot H_2O$: C, 62.8; H, 8.4. Found: C, 62.8; H, 8.6.

Digoxigenin-(3)-tetraacetyl-β-*d*-glucoside.—This was prepared similarly using 390 mg. of digoxigenin. Recrystallization of the combined material from the ether pentane treatment of the crude product from dilute alcohol yielded a first crop of digoxigenin monohydrate, m. p. 170–172°; from the mother liquors, after several recrystallizations, 150 mg. of light feathery needles melting at 183–204°. This was pure enough for the subsequent deacetylation. In order to secure an analytically pure sample, five further recrystallizations from dilute alcohol were necessary. The pure acetyl glucoside formed felty needles which melted at 194–199°: $[\alpha]^{25}D$ −3.3°, (*c* 0.766 in 95% alcohol).

Anal. Calcd. for $C_{37}H_{52}O_{14}$: C, 61.5; H, 7.3. Found: C, 61.5; H, 7.4.

Digoxigenin-(3)-β-*d*-glucoside.—The acetyl glucoside (235 mg.), m. p. 183–204°, obtained above was deacetylated as before. Contaminating digoxigenin was removed by concentration of the absolute alcoholic solution to a small volume on which the aglycone crystallized. The filtrate from the digoxigenin was evaporated to dryness under reduced pressure and the residue was taken up in 15 ml. of absolute alcohol. To this solution 8 ml. of ether was carefully added. On refrigeration, the glucoside crystallized as clusters of prisms. After several more recrystallizations from the same solvents it melted at 268° (dec.). Yield was 90 mg.: $[\alpha]^{27}D$ −1.4°; (*c* 0.356 in 95% alcohol).

Anal. Calcd. for $C_{29}H_{44}O_{10}$: C, 63.3; H, 8.0. Found: C, 62.9; H, 8.2.

Periplogenin-(3)-tetraacetyl-β-*d*-glucoside.—This was prepared as in the above cases. The crude oily product was practically completely soluble in anhydrous ether.

(1) Part of this work was done under a grant from Eli Lilly & Co., to whom we wish to express our sincere appreciation.

(2) Uhle and Elderfield, *J. Org. Chem.*, **8**, 162 (1943).

(3) Chen and Elderfield, *J. Pharmacol. Exp. Therap.*, **76**, 81 (1942).

(4) Chen, Elderfield, Uhle and Fried, *ibid.*, **77**, 401 (1943).

(5) All melting points are corrected for stem exposure.

(6) Microanalyses by Mr. Saul Gottlieb.

When petroleum ether (Skellysolve B) was added to this clear ether solution, an oily product separated. After the mixture had been allowed to stand overnight, the oil had not crystallized but crystalline material was present throughout the solution. This crystalline material, when carefully separated from the oil, gave a negative Legal (nitroprusside) test. The oil was crystallized from a mixture of alcohol and water. After two recrystallizations, 350 mg. (19%) of product was obtained. The compound crystallizes as needles, which contain 1.5 moles of water of crystallization. The melting point depends upon the rate of heating, but ordinarily the compound melts at 145–150° after preliminary sintering. For analysis it was dried over calcium chloride at 75° and 10 mm.

Anal. Calcd. for $C_{37}H_{52}O_{14}\cdot 1.5H_2O$: C, 59.4; H, 7.4. Found: C, 59.4; H, 7.4.

Periplogenin-(3)-β-*d*-glucoside.—The viscous oil obtained on deacetylation was crystallized initially from ethyl acetate saturated with water, and recrystallized from 95% alcohol–ether. It crystallized as fine needles containing two waters of crystallization and melted at 195–200° (dec.). For analysis it was dried over calcium chloride at 75° and 10 mm.

Anal. Calcd. for $C_{29}H_{44}O_{10}\cdot 2H_2O$: C, 59.2; H, 8.2. Found: C, 59.5; H, 8.0.

DEPARTMENT OF CHEMISTRY
COLUMBIA UNIVERSITY
NEW YORK 27, N. Y.

RECEIVED MAY 8, 1947

Pyrolysis of Diketene

BY J. T. FITZPATRICK

There is considerable evidence in favor of the Boese–Wilson[1] vinylaceto-β-lactone structure for diketene.[1–5] However, on pyrolysis this structure would be expected to give allene and carbon dioxide as well as the previously observed product, ketene.[1,3] It has now been found that significant amounts of these by-products are present in ketene made in a "ketene lamp"[1] with a Nichrome filament. The amount of impurities depends on both the temperature and the condition of the filament. A filament which had been used for some time gave a product containing 13% allene and carbon dioxide in approximately equal amounts; after thorough cleaning with nitric acid the filament gave only 8% by-products. When a used filament was operated at a voltage lower than usual, the by-products accounted for more than 18% of the reacted diketene.

The diketene used was commercial material which had been redistilled in the laboratory; it boiled at 62° at 75 mm., and froze at −6.5 to −7.0°; its purity was estimated to be well over 99%. It was cracked in a ketene lamp with a filament made of approximately 14 ft. of no. 22 B. and S. gage Nichrome wire. The rate of cracking was 320–350 g./hour with 75 volts, or 50–55 g./hour with 55 volts on the filament. After passing through a partial condenser to remove unreacted diketene, the products were condensed and weighed in tared traps cooled with liquid air. The material was vaporized from these traps and passed through 0.25% aqueous sulfuric acid at 50–55° to remove the ketene. The small amount of residue which did not vaporize at room temperature was considered to be unreacted diketene. The blow-off gas from the absorber was again collected in tared traps and weighed. Samples of this condensate were analyzed in the mass spectrograph by the South Charleston Works Laboratory of this Company. A typical analysis was: carbon dioxide, 53.9%; allene, 45.1%; acetone, 0.4%; and trifling amounts of other compounds, including 0.1% ketene. Lack of a reaction with silver nitrate solution showed the absence of methylacetylene, which is nearly indistinguishable from allene in the mass spectrograph.

(1) Boese, *Ind. Eng. Chem.*, **32**, 16 (1940).
(2) Hurdis and Smyth, THIS JOURNAL, **65**, 89 (1943).
(3) Rice and Roberts, *ibid.*, **65**, 1677 (1943).
(4) Taufen and Murray, *ibid.*, **67**, 754 (1945).
(5) Bauer, Bregman and Wrightson, paper presented before the Division of Physical Chemistry of the American Chemical Society at the Atlantic City meeting, April, 1946.

RESEARCH AND DEVELOPMENT DEPARTMENT
CARBIDE AND CARBON CHEMICALS CORPORATION
SOUTH CHARLESTON, W. VA.

RECEIVED JUNE 16, 1947

Selenenyl Sulfur Compounds

BY OLAV FOSS

Twiss, Jones and Hadley[1] reported the reactions of *o*-nitrobenzeneselenenyl bromide[2] with mercaptobenzthiazole and thiocarbonyl salts. We have found that *o*-nitrobenzeneselenenyl bromide reacts rapidly with sodium or potassium thiocyanate, di-O-alkylmonothiophosphates,[3] thiosulfonates, and sulfinates, to give *o*-nitrobenzeneselenenyl thiocyanate, di-O-alkylmonothiophosphates, thiosulfonates and sulfinates, respectively. The general procedure consists in dissolving 1 g. of the bromide in 3–4 ml. of ethyl acetate and 5 ml. of methanol, and adding a slight excess of the thio salt or sulfinate, dissolved in 10 ml. of methanol. The product thereon crystallizes out rapidly (in the case of di-O-alkylmonothiophosphates after addition of some water). Potassium *o*-nitrobenzeneselenenyl thiosulfate was obtained by reaction of the bromide, dissolved in benzene, with a slight excess of potassium thiosulfate in the double amount of water. The crystals are stable, and have a yellowish green color. The di-O-ethylmonothiophosphate was obtained as a yellowish green oil. Among the compounds prepared are these in Table I.

TABLE I

Compound (R = *o*-nitrophenyl)	M. p., °C. (uncor.)	Selenium, % Calcd.	Found
RSeSCN	107[a]	30.5	30.4
$RSeSPO(OCH_3)_2$	79[b]	23.1	23.1
$RSeSPO(OC_2H_5)_2$	Oil	21.3	21.5
$RSeS_2O_2CH_3$	96[b]	25.3	25.3
$RSeS_2O_2C_2H_5$	90[b]	24.2	24.0
$RSeS_2O_2C_6H_5$	147[c]	21.1	21.3
$RSeS_2O_2C_6H_4CH_3$-*p*	148[c]	20.3	20.2
$RSeS_2O_2C_6H_4Br$-*p*	169[c]	17.4	17.1
$RSeSO_2C_6H_5$	109[d]	23.1	23.1
$RSeSO_2C_6H_4CH_3$-*p*	118[d]	22.2	22.0
$RSeSO_2C_6H_4CH_3$-*o*	95[e]	22.2	22.2
$RSeSO_2C_6H_4Br$-*p*	126[c]	18.8	18.7
$RSeS_2O_3K$	*ca.* 190[d] dec.	22.4	22.4

[a] Crystallized from carbon tetrachloride. [b] Crystallized from carbon disulfide. [c] Crystallized from benzene. [d] Crystallized from ethanol. [e] Crystallized from methanol.

(1) Twiss, Jones and Hadley, British Patent 441,653 (1936).
(2) Behaghel and Seibert, *Ber.*, **66**, 708 (1933).
(3) Foss, *Acta Chemica Scandinavica*, **1**, 8 (1947).

Some reactions of the tabulated compounds are mentioned below. The reactions are rapid and quantitative, and serve to characterize the compounds as derivatives of RSe^+.

In ethyl acetate–ethanol solutions *o*-nitrobenzeneselenenyl thiocyanate, di-O-alkyl monothiophosphates and thiosulfonates react with aqueous sodium thiosulfate as follows

$$RSeX + S_2O_3^- = RSeS_2O_3^- + X^-$$

This is analogous to the behavior of the corresponding sulfenyl compounds.[4]

o-Nitrobenzeneselenenyl sulfinates, in ethyl acetate–ethanol or ethanol solutions, react with aqueous potassium cyanide to give *o*-nitrophenyl selenocyanate

$$RSeSO_2R' + CN^- = RSeCN + R'SO_2^-$$

o-Nitrobenzeneselenenyl thiosulfate reacts with sodium cyclopentamethylenedithiocarbamate thus

$$RSeS_2O_3^- + C_5H_{10}NCS_2^- = RSeS(S)CNC_5H_{10} + S_2O_3^-$$

The product has previously been prepared[1] from the bromide.

(4) Foss, *ibid.*, in press.

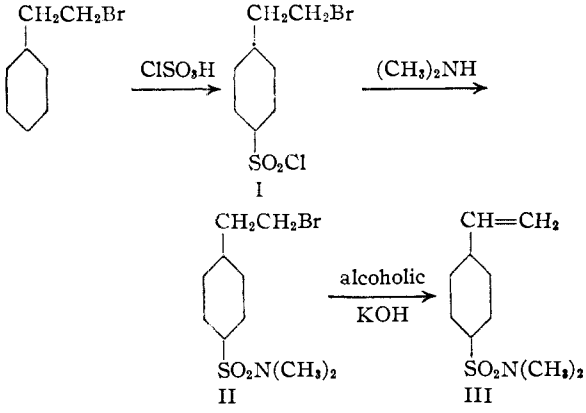
INSTITUTT FOR UORGANISK KJEMI
NORGES TEKNISKE HOGSKOLE
TRONDHEIM, NORWAY

RECEIVED APRIL 19, 1947

Preparation and Polymerization of *p*-N,N-Dimethylsulfonamidostyrene[1]

BY G. ESLER INSKEEP AND RUDOLPH DEANIN

As a part of the general program for the study of substituted styrenes as replacements for styrene in GR-S, *p*-N,N-dimethylsulfonamidostyrene (III) has been prepared, polymerized and copolymerized with butadiene. The new styrene derivative was prepared by the following series of reactions.



p-N,N-Dimethylsulfonamidostyrene polymerizes very readily at its melting point to give a high melting polymer which dissolves slowly in nitromethane and is insoluble in acetone, amyl acetate, benzene and chloroform. It copolymerizes readily with butadiene in soap emulsion in the presence of potassium persulfate and dodecyl mercaptan. The substituted styrene enters the growing copolymer more rapidly than does butadiene.

(1) This investigation was carried out under the sponsorship of the Office of Rubber Reserve, Reconstruction Finance Corporation, in connection with the Government Synthetic Rubber Program.

Experimental

β-(*p*-Chlorosulfonylphenyl)-ethyl Bromide (I).—To 1 kg. (8.5 moles) of chlorosulfonic acid in a 2-liter three-necked flask equipped with stirrer, dropping funnel, and outlet to a vapor trap was added 315 g. (1.7 moles) of β-phenylethyl bromide over a period of two hours; the temperature was held below 27° by external cooling with water. After another hour the contents were poured over a large quantity of ice, the aqueous layer was decanted, and the semi-solid product was triturated in ice-water. Attempts to recrystallize the sulfonyl chloride or to distil it at a pressure of 7 mm. were unsuccessful. The yield of crude product was 431 g. or 89%.

In some runs a small amount of crystalline by-product m. p. 159–160° (cor.), was separated from the sulfonyl chloride (*e. g.*, by its relative insolubility in alcohol). Analysis and rough determination of molecular weight by boiling point rise of chloroform showed this to be the corresponding sulfone.

Anal. Calcd. for $C_{16}H_{16}O_2SBr_2$: C, 44.46; H, 3.73; mol. wt., 432. Found: C, 45.41; H, 4.04; mol. wt., 408; S and halogen present.

β-(*p*-Sulfonamidophenyl)-ethyl Bromide.—A small portion of the sulfonyl chloride was heated with ammonium hydroxide and the sulfonamide was recrystallized repeatedly from alcohol, m. p. 185.5–186° (cor.).

Anal. Calcd. for $C_8H_{10}O_2SNBr$: N, 5.30. Found: N, 5.30.

β-(*p*-N,N-Dimethylsulfonamidophenyl)-ethyl Bromide (II).—To 920 g. (5.1 moles) of 25% aqueous dimethylamine was added in portions 431 g. (1.5 moles) of crude β-(*p*-chlorosulfonylphenyl)-ethyl bromide. The mixture was stirred frequently during an interval of two hours; its maximum temperature was approximately 60°. An equal volume of water was added and the aqueous layer was decanted. Benzene (500 ml.) was added and the solution was washed with water and dried overnight with calcium chloride. The solvent was removed at reduced pressure; the residual brown oil became partly solid upon standing. The solid portion was separated on a Buchner funnel; it weighed 113 g., or 25% of theoretical. Four recrystallizations from alcohol followed by thorough drying gave a product, m. p. 99–100° (cor.).

Anal. Calcd. for $C_{10}H_{14}O_2SNBr$: C, 41.05; H, 4.80 Found: C, 41.45; H, 4.82.

***p*-N,N,-Dimethylsulfonamidostyrene** (III).—A solution of 34 g. (0.6 mole) of potassium hydroxide in 400 ml. of 95% alcohol was heated to 50° and a slurry of 113 g. (0.4 mole) of crude dimethylsulfonamidophenylethyl bromide in 300 ml. of alcohol, also at 50°, was added rapidly; the temperature rose 10°. The mixture was allowed to stand fifteen minutes, and the precipitated potassium bromide was removed by filtration. The cooled solution was made neutral to litmus with dilute hydrochloric acid and diluted to 4 liters with water. The yellow liquid which separated was removed and the aqueous layer was extracted three times with 200-ml. portions of chloroform. The solvent was removed at reduced pressure and the residue was added to the main portion of the product. The liquid readily recrystallized in the ice box; its weight was 77 g. or 94% of the theoretical amount. Two recrystallizations from alcohol gave 55 g. (67%) of colorless product melting at 60–61° (cor.); two further recrystallizations from a large volume of high-boiling petroleum ether brought the m. p. to 63–63.5° (cor.).

Anal. Calcd. for $C_{10}H_{12}O_2SN$: C, 56.84; H, 6.20. Found: C, 57.01; H, 6.22.

Oxidation of this material with potassium permanganate gave the known *p*-N,N-dimethylsulfonamidobenzoic

acid,[2] m. p. 249–251° (reported melting point 255–256°). This establishes the para relationship of the vinyl and sulfonamide groups, as well as the relationships of the corresponding groups in its two parent compounds, although there is no reason to believe that the crude sulfonyl chloride does not contain appreciable amounts of the other isomers.

Polymerization.—A benzene solution of the monomer after a week in the ice box had deposited a white, powdery polymer which was not appreciably soluble in any of a wide range of solvents such as chloroform, water, alcohol and ethanolamine. When the decanted benzene was evaporated on the steam cone, the residue was found to consist principally of a similarly insoluble polymer from which smaller amounts of soluble polymer were separated by successive extractions with hot dioxane and hot benzene; these soluble portions were left as glassy solids upon evaporation of the solvents. The density of the insoluble polymer was approximately 1.25.

When the solid monomer was heated to 70° for five minutes, it first melted and then polymerized to a yellow, vitreous solid. This polymer had a softening point of 190–210°. It was insoluble in acetone, amyl acetate or benzene swelled in chloroform; and dissolved slowly in nitromethane. The molecular weight of the polymer, calculated from the relative viscosity of the nitromethane solution by means of the Kemp–Peters–Staudinger equation,[3] was 20,900.

Anal. Calcd. for $C_{10}H_{13}O_2SN$: C, 56.8; H, 6.2; N, 6.6; S, 15.2. Found: C, 55.8; H, 6.0; N, 6.2; S, 15.4.

Copolymerization with Butadiene.—The monomer copolymerized readily with butadiene in the following formula.

Butadiene	15.0 g.
p-N,N-Dimethylsulfonamidostyrene	5.0
Water	36.0
Soap[a]	1.0
Potassium persulfate	0.06
OEI[b]	0.10

[a] Procter and Gamble Soap Flakes (silica free). [b] A commercial product containing a mixture of straight chain mercaptans of 10–16 carbon atoms.

When this emulsion recipe was placed in a four-ounce polymerization bottle and rotated end over end for six hours at 50°, a 76% conversion of copolymer was obtained. This copolymer was 84% soluble in benzene, and its dilute benzene solution had an intrinsic viscosity of 1.59. Elementary analysis of the copolymer indicated that it contained 29.4% by weight of *p*-N,N-dimethylsulfonamidostyrene. The calculated *alpha*-value[4] of 2.96 indicates that the substituted styrene entered the copolymer much more rapidly than did butadiene.

Anal. Calcd. for 29.4% substituted styrene in copolymer: C, 79.5; H, 9.7; N, 2.0; S, 4.5. Found: C, 79.6; H, 9.4; N, 2.0; S, 4.5.

(2) de Jong, *Verslag Akad. Wetenschappen Amsterdam*, **32**, 14 (1923).

(3) A. R. Kemp and H. Peters, *Ind. Eng. Chem.*, **34**, 1097 (1942).

(4) F. T. Wall, THIS JOURNAL, **63**, 1862 (1941).

NOYES CHEMICAL LABORATORY
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

RECEIVED APRIL 5, 1947

Some *s*-Butyl- and 1,4-Di-*s*-butylbenzene Derivatives

BY D. I. LEGGE[1]

A number of new derivatives of *s*-butyl- and 1,4-di-*s*-butylbenzene have been prepared. 1,4-Di-*s*-butylbenzene-2-sulfonyl chloride, like the corresponding diisopropylbenzene derivative,[2] loses an alkyl group on nitration. There is evidence pointing to partial loss of a *s*-butyl group when 1,4-di-*s*-butylbenzene reacts with chlorosulfonic acid, since after hydrolysis of the resulting sulfonyl chloride, the second crop of sulfonic acid sodium salt contains a rather high per cent. of sodium.

Experimental Part

Nitration of sulfonyl chlorides was performed with a large excess of 96% nitric acid, at 1 to 4° for thirty minutes, finally warming in the atmosphere to 25° and pouring immediately onto ice. Other derivatives were prepared by the methods already described.[3]

s-Butylbenzene-4-sulfonanilide.[4]—The oily crude product (87%) was triturated with petroleum ether and recrystallized from the same solvent. It gave white crystals (25%), m. p. 65.0–66.0°.

Anal. Calcd. for $C_{16}H_{19}O_2NS$: C, 66.4; H, 6.6. Found: C, 66.6; H, 6.5.

2-Nitro-*s*-butylbenzene-4-sulfonamide.—The pale yellow nitrosulfonyl chloride, an oil (61%), gave a slightly yellow sulfonamide (95%). This gave a red solution in 5% isopropyl alcohol from which it crystallized as silvery white flakes, m. p. 111.2–112.0°.

Anal. Calcd. for $C_{10}H_{14}O_4N_2S$: C, 46.5; H, 5.5. Found: C, 46.7; H, 5.4.

1,4-Di-*s*-butylbenzene-2-sulfonic Acid Sodium Salt.—The pale yellow liquid sulfonyl chloride (40 g.) was hydrolyzed with 100 ml. of 20% sodium hydroxide, some insoluble material, probably a sulfone, was filtered off, and the sodium salts were crystallized in two fractions; (a) 92%, (b) 8%.

Anal. Calcd. for $C_{14}H_{21}O_3SNa$: Na, 7.8. Found: (a) Na, 7.8. Calcd. for $C_{14}H_{21}O_3SNa \cdot 4H_2O$: H_2O, 19.7. Found: (a) H_2O, 19.8.

Both (a) and (b) were reconverted to sulfonyl chlorides using phosphorus pentachloride, and other derivatives were prepared from (a).

Anal. Calcd. for $C_{14}H_{21}O_3SCl$: Cl, 12.3. Found: Cl (by hydrolysis) (a), 12.3; (b), 12.6.

Sulfonamide.—The crude product (85%) from 16 g. of sulfonyl chloride crystallized slowly from the initially formed oil. Recrystallization from a large volume of 1% isopropyl alcohol gave flat, white plates (57%), m. p. 63.2–64.1°.

Anal. Calcd. for $C_{14}H_{23}O_2NS$: C, 62.4; H, 8.5. Found: C, 62.5; H, 8.4.

Sulfonanilide.—The crude oily solid (91%) from 14 g. of sulfonyl chloride, gave 66% of white crystals, m. p. 105.4–106.3° when recrystallized from 90% isopropyl alcohol.

Anal. Calcd. for $C_{20}H_{27}O_2NS$: C, 69.6; H, 7.9. Found: C, 69.5; H, 7.8.

4-Nitro-*s*-butylbenzene-2-sulfonyl Chloride.—Nitration of 1,4-di-*s*-butylbenzene-2-sulfonyl chloride gave 89% of white oily solid which turned yellow on standing. It crystallized from petroleum ether in buff colored plates (38%), m. p., 71.4–72.0°.

Anal. Calcd. for $C_{10}H_{12}O_4NSCl$: Cl, 12.8. Found: Cl (by hydrolysis), 12.8.

Sulfonamide.—White flakes (91%) from isoöctane, m. p. 171.4–171.7°.

Anal. Calcd. for $C_{10}H_{14}O_4N_2S$: C, 46.6; H, 5.5. Found: C, 46.4; H, 5.3.

(1) Present address: Anglo Transvaal Consolidated Investment Co., Ltd., Johannesburg, South Africa.

(2) Newton, THIS JOURNAL, **65**, 2439 (1943).

(3) Legge, *ibid.*, **69**, 2078, 2086 (1947).

(4) For orientation, *cf.* Huntress and Autenrieth, *ibid.*, **63**, 3446 (1941).

Sulfonanilide.—White crystals (89%) from isoöctane, m. p., 133.5–134.2°.

Anal. Calcd. for $C_{16}H_{18}O_4N_2S$: C, 58.0; H, 5.3. Found: C, 57.8; H, 5.1.

RESEARCH LABORATORIES
TRINIDAD LEASEHOLDS LIMITED
POINTE-A-PIERRE
TRINIDAD, B. W. I.

RECEIVED JULY 25, 1946

Production of Radioactive Carbon Monoxide from Barium Carbonate

BY JOSEPH T. KUMMER[1]

It has been found possible to prepare conveniently a supply of radioactive carbon monoxide of a specific activity and sufficient in quantity for use in the study of many catalytic reactions. This is done by exchanging, over a hot tungsten filament, the C^{14} in a small amount of carbon dioxide obtained from barium carbonate of high specific activity (about 0.5% of the carbon in the barium carbonate was C^{14}) with the carbon in a large amount of normal carbon monoxide. Since the apparatus and procedure are extremely simple, and since such exchange experiments have not previously been described for a tungsten surface,[2] they are described below in conjunction with Fig. 1. It is hoped that the method will be useful to those wishing to employ carbon monoxide for tracer studies.

The system is completely evacuated, before the exchange run, to 10^{-5} mm. or better. Then, with stopcock A closed, the bulb containing 85% H_3PO_4 is rotated and the acid allowed to react with a few mg. of the radioactive barium carbonate. When stopcock A is opened, the carbon dioxide is allowed to pass through the Dry Ice trap into trap X, cooled in liquid nitrogen. The acid–carbonate mixture is evacuated and warmed to drive all of the carbon dioxide out of the solution and into trap X. This carbon dioxide is next allowed to evaporate into the electric light bulb and is diluted with the required amount of carbon monoxide, manometer C being used for estimating approximately the amount of carbon monoxide added. If the light bulb is run at 60–80 volts overnight (sixteen hours) the exchange will be complete. No experiments have been made as to the rate of exchange or length of time it would take if the bulb were run at 110 volts. Carbon filament bulbs were originally tried but were found to be unsatisfactory because their filaments burned out in an atmosphere of carbon monoxide within a few hours. After a year of use, the tungsten filament showed no deterioration. When the exchange is complete, the radioactive carbon monoxide is pumped into the storage reservoir by means of a Töpler pump through

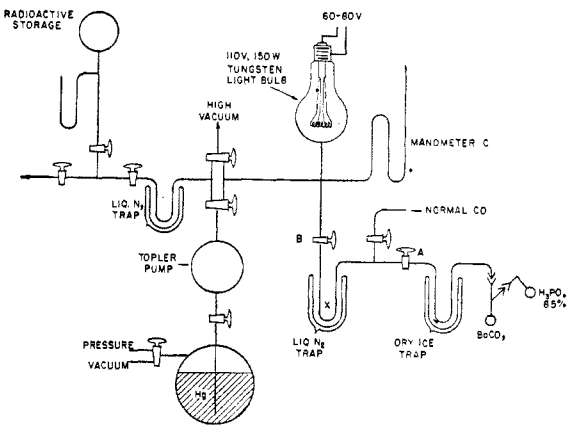


Fig. 1.

a liquid nitrogen trap, to remove the carbon dioxide.

Below are data for a particular test run using a new, 150-watt, 110-volt Westinghouse tungsten filament light bulb.

A sample of 2.6 mg. of BaC^*O_3[3] was taken; it was capable of producing approximately 10^7 disintegrations per minute. The C^*O_2 in trap X was flushed into the light bulb by 200 cc. of normal carbon monoxide (to a total pressure of about 300 mm.) after the liquid nitrogen was removed from trap X. After the C^*O_2 and carbon monoxide had been mixed by a few strokes of the Töpler pump, a 1-cc. sample was removed for analysis (*without* interposing a liquid nitrogen trap); this sample showed 42,000 disintegrations per minute per cc. of gas.

A similar sample taken *through* a liquid nitrogen trap for removing carbon dioxide showed 190 disintegrations per minute per cc. of gas.

After the filament in the bulb had been operated at 70 volts for sixteen hours, a 1-cc. sample removed *through* a liquid nitrogen trap showed a count of 42,100 disintegrations per minute per cc. of gas. Apparently, therefore, the exchange over the tungsten filament was complete in this period of time.

(1) Gulf Research & Development Company Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa.

(2) Brandner and Urey, *J. Chem. Phys.*, **13**, 351 (1945), have studied the kinetics of C^{13} exchange between CO and CO_2 over quartz, Au, and Ag.

(3) An asterisk is used to designate C^{14}.

RECEIVED JULY 10, 1947

Thiophene-Containing Antihistaminic Agents

BY L. P. KYRIDES, F. C. MEYER AND F. B. ZIENTY

The high order of antihistaminic activity recently reported for the thiophene analog (I)[1,2,3] of Pyribenzamine was observed[4] on (I) prepared in this Laboratory and tested prior to Dr. Weston's disclosure. In addition, several other

(1) Weston, THIS JOURNAL, **69**, 980 (1947).

(2) Clapp, Clark, Vaughan, English and Anderson, *ibid.*, **69**, 1549 (1947).

(3) Roth, Richards and Shepperd, *Federation Proc.*, **6**, 366 (1947).

(4) Lee, Dinwiddie and Chen, *J. Pharmacol. Expll. Therap.*, **90**, 83 (1947).

analogs of known antihistaminic agents have been prepared and evaluated.

Whereas N,N-dimethyl-N′-phenyl-N′-(2-thenyl)-ethylenediamine (2740 R. P.) (II), the thiophene analog of Antergan,[5] recently was reported to be devoid of antihistaminic activity,[6] our compound proved to be approximately two-thirds as active as Antergan. The diethyl analog (III) of (II) is only one-fifth as active as Antergan; (I) is more active than (II) and has given encouraging results in man.

2-[N-(2′-Thenyl)-anilinomethyl]-2-imidazoline (IV), the thiophene analog of Antistine,[7] 2-(N-benzylanilinomethyl)-2-imidazoline, was found to be only 5% as active as Antergan, and the thiophene analog (V) of N-(2-pyridyl)-benzamide[8] proved to be inactive.

The products were tested for pharmacologic and therapeutic activity in the Lilly Research Laboratories.

Experimental[9]

N,N-Dimethyl-N′-phenyl-N′-(2-thenyl)-ethylenediamine (II).—N,N-Dimethyl-N′-phenylethylenediamine (VI)[10] (26.6 g.) in 100 cc. of benzene was converted to the monohydrochloride, 10.7 g. of 2-thenyl chloride in 35 cc. of benzene was added, and the mixture was stirred at 65–70° for six hours. The mixture was agitated with 80 g. of 25% sodium hydroxide solution at 60° for one hour, and the benzene layer was separated. A dark-colored liquid, weight 15 g., was present between the aqueous and benzene layers; this probably was a quaternary compound resulting from reaction of 2-thenyl chloride with the dimethylamino group. The benzene layer yielded upon distillation 15.8 g. of recovered (VI) and 7.0 g. (42.5%) of (II), a yellow oil, b. p. 185–186° (8 mm.).

The base (II), dissolved in a 3:1 solution of carbon tetrachloride and acetone, upon treatment with hydrogen chloride yielded the monohydrochloride, which was recrystallized from acetone containing a small amount of water; m. p. 183–184°.

Anal. Calcd. for $C_{15}H_{20}N_2S\cdot HCl$: Cl, 11.9. Found: Cl, 11.9.

When it was endeavored to prepare (II) by the procedure used for (III), the quaternary salt was the chief product. Attempts to prepare (II) by the reaction of N-(2-thenyl)-aniline (VII) and N,N-dimethyl-β-chloroethylamine hydrochloride proved unsuccessful, since none of the high boiling amines obtained corresponded in properties with those of (II).

N,N-Diethyl-N′-phenyl-N′-(2-thenyl)-ethylenediamine (III).—A solution of 6.6 g. (0.05 mole) of 2-thenyl chloride in 65 cc. of benzene was dropped into a solution of 19.2 g. (0.10 mole) of N,N-diethyl-N′-phenylethylenediamine (VIII)[11] in 100 cc. of butanol at 25° during two hours. The mixture was stirred at 25° for twenty hours, treated with excess aqueous alkali, and the organic layer was separated and distilled. Nine grams of (VIII) was recovered and 9 g. (59%) of (III)[12] was obtained; b. p. 157–160° (2 mm.).

When (III) was treated with hydrogen chloride as under (II), the dihydrochloride was precipitated as an oil which soon solidified. After recrystallization from aqueous acetone, the salt melted at 144–145°.

Anal. Calcd. for $C_{17}H_{24}N_2S\cdot 2HCl$: Cl, 19.6. Found: Cl, 19.7.

N-(2-Thenyl)-aniline (VII).—One mole (93 g.) of aniline was heated with agitation at 95–100° as 39.8 g. (0.3 mole) of 2-thenyl chloride was added in one and one-half hours. The mixture was maintained at 95–100° for four hours, cooled and treated with aqueous sodium hydroxide (0.3 mole). The oil layer was separated, washed with water, and dried over sodium sulfate. The crude product was fractionated under reduced pressure. After a forerun of recovered aniline, there was obtained 43 g. (76%) of (VII); b. p. 150–155° (4 mm.), $n^{20}D$ 1.6295.

Anal. Calcd. for $C_{11}H_{11}NS$: N, 7.4. Found: N, 7.8.

Ethyl N-Phenyl-N-(2-thenyl)-aminoacetate (IX).—A mixture of 30 g. (0.16 mole) of (VII) and 9.8 g. (0.08 mole) of ethyl chloroacetate was heated at 120° for six hours. The mixture was cooled, treated with aqueous sodium hydroxide (0.1 mole), benzene was added, and the organic layer was separated, washed with water and dried. After removal of the solvent, the crude product was fractionated; yield, 10 g. (45%) of (IX), b. p. 155–165° (0.3 mm.).

Anal. Calcd. for $C_{15}H_{17}NO_2S$: N, 5.1. Found: N, 5.1.

2-[N-(2′-Thenyl)-anilinomethyl]-2-imidazoline (IV).—A mixture of 13 g. (0.047 mole) of (IX) and 25 g. of ethylenediamine (97.4% assay) was heated at the boiling point as ethanol, water, and some ethylenediamine were removed slowly through a small fractionating column over a period of twenty hours. The vapor temperature at the end was 116° and the batch temperature rose to 130–135°. After removing the excess ethylenediamine, the residue was fractionated to yield 7 g. (55%) of (IV), b. p. 190–200° (0.4 mm.). The base was converted to the monohydrochloride, which was recrystallized from acetone-ethanol; m. p. 219–220°.

Anal. Calcd. for $C_{15}H_{17}N_3S\cdot HCl$: Cl, 11.5. Found: Cl, 11.8.

N-(2-Pyridyl)-2′-thiophenecarboxamide (V).—To a solution of 47 g. (0.5 mole) of 2-aminopyridine in 250 cc. of dry toluene 12 g. (0.5 mole) of sodium hydride was added, and the mixture was warmed slowly to reflux as hydrogen was evolved. After refluxing for one and one-half hours, the resulting slurry of the sodium derivative of 2-aminopyridine was cooled to 80° and 73.3 g. (0.5 mole) of 2-thenoyl chloride[13] was added dropwise in one hour. The mixture then was refluxed for two hours, cooled, filtered and the salt cake was washed with toluene. The filtrate upon distillation yielded 87 g. (85%) of (V), b. p. 165–170° (2 mm.). The product, which solidified on cooling, was converted to the monohydrochloride in methyl ethyl ketone–ethanol mixture and the salt was allowed to crystallize; m. p. 215–217°, with slight previous softening.

Anal. Calcd. for $C_{10}H_8N_2OS\cdot HCl$: Cl, 14.7. Found: Cl, 14.6.

(5) Halpern, *Arch. intern. pharmacodynamie*, **68**, 339 (1942).

(6) Viaud, *Produits Pharmaceutiques*, **2**, 53 (1947).

(7) Meier and Bucher, *Schweiz. med. Wochschr.*, **76**, 294 (1946); Schindler, *ibid.*, **76**, 300 (1946); abstract in *J. Am. Med. Assoc.*, **131**, 1536 (1946).

(8) Mayer, *J. Allergy*, **17**, 153 (1946).

(9) All melting points are corrected.

(10) Huttrer, Djerassi, Beears, Mayer and Scholz, THIS JOURNAL, **68**, 2001 (1946).

(11) Dewar, *J. Chem. Soc.*, 622 (1944).

(12) A sample of this base was prepared by Mr. D. G. Sheets.

(13) Blicke and M. F. Zienty, THIS JOURNAL, **63**, 2945 (1941); Jones and Hurd, *ibid.*, **43**, 2444 (1921).

RESEARCH LABORATORIES
MONSANTO CHEMICAL CO.
ST. LOUIS 4, MISSOURI

RECEIVED JUNE 19, 1947

The Vibration Spectrum of Nitric Acid

BY OTTO REDLICH

The fairly weak Raman line 1538 cm.$^{-1}$ in the Raman spectrum of pure nitric acid was interpreted[1] as due to the out-of-plane vibration for

(1) O. Redlich and L. E. Nielsen, THIS JOURNAL, **65**, 634 (1943).

the reason that the other eight lines and vibrations were satisfactorily correlated. The large difference between 1538 and the frequency 830 of the out-of-plane vibration of the nitrate ion was pointed out.

M. Freymann and R. Freymann[2] recently reported a moderately strong double band 771 and 792 cm.$^{-1}$ in the infrared spectrum of nitric acid vapor corresponding to a weak line 768 in the Raman spectrum of Simon and Hoeppner.[3] The correlation of this band with the out-of-plane vibration, mentioned but not finally adopted by Freymann and Freymann, is strongly supported by the fact that 1538 cannot be correlated with any other vibration. Obviously the Raman line 1538 represents not the fundamental but the first harmonic of the out-of-plane vibration.

With this change the earlier analysis of the vibration spectrum appears to represent all known data in a satisfactory way. Some of our conclusions coincide with earlier results of Mathieu and Massignon.[4]

The somewhat unusual intensity of 1538 can hardly be explained by accidental degeneracy with vibration 4 (1669 cm.$^{-1}$) since the selection rules for C_{2v} do not permit this resonance. A slight interaction with 1301 cm.$^{-1}$ appears to be possible.

The author is obliged to Professor G. Herzberg for a helpful discussion.

(2) M. Freymann and R. Freymann, *Compt. rend.*, **222**, 1339 (1946).

(3) A. Simon and H. Hoeppner, *Kolloid-Z.*, **85**, 8 (1939).

(4) J. P. Mathieu and D. Massignon, *Ann. phys.*, **16**, 5 (1941).

SHELL DEVELOPMENT COMPANY
EMERYVILLE, CALIFORNIA RECEIVED JUNE 7, 1947

The Allergenic Principles of Poison Ivy. VI. Note on the Synthesis of 3-Substituted Catechols[1,1a]

BY HOWARD S. MASON

In this study, 3-bromocatechol and its diphenylmethylene ether have been synthesized to provide the nuclear fragment for the synthesis of unsaturated allergens related to the catechols of poison ivy. 2,3-Dimethoxydihydrocinnamyl halides have also been prepared; these substances proved refractory toward demethylation.

Experimental

2,3-Dimethoxybromobenzene.—2,3-Dimethoxybenzoic acid was prepared from 2,3-dimethoxybenzaldehyde[2] in 84% yield by permanganate oxidation.[3] This substance was converted to 2,3-dimethoxybenzamide in 88% yield.[4] The amide furnished 2,3-dimethoxyaniline in 83% yield by adapting to the synthesis the procedure for the Hofmann rearrangement worked out by Buck and Ide.[5] Bigelow's procedure for the Sandmeyer replacement[6] was then modified for the preparation of 2,3-dimethoxybromobenzene; this resulted in a considerably improved yield. To a cuprous bromide solution prepared in 275 ml. of water was added a solution of 2,3-dimethoxybenzenediazonium sulfate prepared from 52 g. of 2,3-dimethoxyaniline hydrochloride. The addition required two hours; the reaction mixture was kept boiling vigorously and the product steam-distilled out as formed. The principal product distilled at 111–113° at 9 mm. and weighed 53 g. (89%). After cooling overnight, the compound solidified. It then melted at 22.7–23.2°. Simonsen and Rau[7] report a boiling point of 114° at 5 mm. Their product did not crystallize.

Anal. Calcd. for $C_8H_9O_2Br$: C, 44.3; H, 4.18. Found: C, 44.5; H, 4.45.

The compound was further identified by the preparation of 2,3-dimethoxy-5-nitrobromobenzene, which melted at 112.3–112.7°. The reported melting point is 112–113°.[7]

3-Bromocatechol.—2,3-Dimethoxybromobenzene was most efficiently demethylated by treating this ether with aluminum trichloride in chlorobenzene.[8] To 50 ml. of dry chlorobenzene was added 5.0 g. of 2,3-dimethoxybromobenzene and 5.0 g. of anhydrous aluminum trichloride. The mixture was refluxed for three and one-half hours, then poured into water and extracted with ether (400 ml.). The ether solution was dried and the solvent evaporated; the residue was then distilled. The principal fraction was an oil which boiled at 118–120° at 9 mm. After crystallization from isoöctane–pentane, long silky needles melting at 40.5–41.5° were obtained. The product weighed 3.5 g. (80%).

Anal. Calcd. for $C_6H_5O_2Br$: C, 38.1; H, 2.68. Found: C, 38.3; H, 2.71.

2,3-Diacetoxybromobenzene.—This substance crystallized from aqueous methanol in needles melting at 83–84°.

Anal. Calcd. for $C_{10}H_9O_4Br$: C, 44.0; H, 3.32. Found: C, 44.1; H, 3.37.

3-Bromocatechol Diphenylmethylene Ether.—3-Bromocatechol (19 g.) and dichlorodiphenylmethane (24 g.) were mixed with a little dry benzene and warmed on a hot-plate until hydrogen chloride no longer evolved. The product crystallized from methanol in white tablets melting at 75.5–76°; the yield was 97%.

Anal. Calcd. for $C_{19}H_{13}O_2Br$: C, 64.6; H, 3.71. Found: C, 64.6; H, 3.68.

Ethyl 2,3-Dimethoxycinnamate.—The procedure for the Claisen reaction developed by Marvel and King[9] was adapted to this synthesis. The principal product from 83 g. of 2,3-dimethoxybenzaldehyde distilled at 195–197° at 15 mm. and weighed 101 g. (86%). For identification, this ester was hydrolyzed to 2,3-dimethoxycinnamic acid, m. p. 179–180°; this m. p. has previously been reported to be 181°.[10]

Anal. Calcd. for $C_{11}H_{12}O_4$: C, 63.5; H, 5.77. Found: C, 63.6; H, 5.79.

Ethyl 2,3-Dimethoxydihydrocinnamate and 2,3-Dimethoxydihydrocinnamyl Alcohol.—Ethyl 2,3-dimethoxycinnamate was hydrogenated over copper chromite catalyst according to the general directions of Folkers and Adkins.[11]

(1) Article not copyrighted. For the fifth paper in this series, see Mason, THIS JOURNAL, **67**, 1538 (1945).

(1a) The author regrets that the work of Keil, Wasserman and Dawson, *J. Exp. Med.*, **80**, 275 (1944), was not mentioned in the last article.

(2) The starting material was generously furnished by the Monsanto Chemical Company.

(3) Perkin and Robinson, *J. Chem. Soc.*, **105**, 2383 (1914).

(4) Mauthner, *J. prakt. Chem.*, **149**, 328 (1937).

(5) Buck and Ide, "Organic Syntheses," Coll. Vol. II, A. H. Blatt, editor, John Wiley and Sons, Inc., London, 1943, p. 44.

(6) Bigelow, "Organic Syntheses," 2nd ed., Coll. Vol. I, H. Gilman and A. H. Blatt, editors, John Wiley and Sons, Inc., New York, N. Y., 1941, p. 136.

(7) Simonsen and Rau, *J. Chem. Soc.*, **113**, 785 (1918).

(8) Dawson, Wasserman and Keil, THIS JOURNAL, **68**, 534 (1946).

(9) Marvel and King, "Organic Syntheses," 2nd ed., Coll. Vol. I, H. Gilman and A. H. Blatt, editors, John Wiley and Sons, Inc., New York, N. Y., 1941, p. 252.

(10) Chakravarti, *J. Indian Chem. Soc.*, **6**, 207 (1929).

(11) Folkers and Adkins, THIS JOURNAL, **54**, 1145 (1932).

To the ester (50 g.) was added 5 g. of catalyst and the mixture placed under a pressure of 1840 lb. of hydrogen. The temperature was then slowly raised. Hydrogenation of the double bond took place at a pressure of 2550 lb. and a temperature of 146°. If the hydrogenation were interrupted at this point, an approximately quantitative yield (98%) of ethyl 2,3-dimethoxydihydrocinnamate, b. p. 174–176° at 13 mm., could be obtained.

Anal. Calcd. for $C_{13}H_{18}O_4$: C, 65.6; H, 7.57. Found: C, 65.6; H, 7.55.

At a pressure of 2680 lb. and a temperature of 224°, further hydrogen was consumed and the principal product weighing 34 g. (86%), distilled at 160–165° at 13 mm. The product failed to crystallize. For identification, a phenylurethan was prepared. This compound melted at 62.7–63.2° after crystallization from petroleum ether.

Anal. Calcd. for $C_{18}H_{21}O_4N$: C, 68.6; H, 6.70. Found: C, 68.4; H, 6.67.

2,3-Dimethoxydihydrocinnamyl Chloride and Bromide.—The halides corresponding to 2,3-dimethoxydihydrocinnamyl alcohol were prepared by the action of thionyl chloride or hydrogen chloride, and hydrogen bromide or 48% hydrobromic acid. They were separated and subjected to a variety of demethylation procedures without further identification. The dihydric phenols could not be isolated; resins were frequent products. Nor was it found possible to prepare by demethylation the 2,3-dihydroxybenzyl halides. However, during sealed tube demethylations in the presence of concentrated hydrobromic and hydriodic acids, catechol itself was formed and isolated in yields up to 18% from these 3-substituted catechol ethers. This has also been encountered during acid demethylation of 2,3-dimethoxy-*n*-pentadecylbenzene,[1] and by Haworth[12] during the acid demethylations of 3- and 4-substituted catechol ethers. Lability of alkyl substituents in the veratrole molecule under these conditions is thus indicated.

Acknowledgment.—I am indebted to Dr. Arthur T. Ness and to Mr. Charles A. Kinser for the microchemical analyses.

(12) Haworth and Woodcock, *J. Chem. Soc.*, 999 (1947).

CONTRIBUTION FROM THE
OFFICE OF DERMATOLOGY
INDUSTRIAL HYGIENE DIVISION
UNITED STATES PUBLIC HEALTH SERVICE
BETHESDA, MD. RECEIVED FEBRUARY 14, 1947

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY AND PHYSICS OF THE PENNSYLVANIA STATE COLLEGE]

New Sources for Sapogenins

BY RUSSELL E. MARKER, R. B. WAGNER, PAUL R. ULSHAFER, EMERSON L. WITTBECKER, DALE P. J. GOLDSMITH AND CLARENCE H. RUOF

The isolations of various steroidal sapogenins from many plant sources have been reported previously from this Laboratory.[1,2,3] The results of our studies on additional plants are now summarized.

Among the new sources for steroidal sapogenins is the seed of *Trigonella Foenum-graecum* L. (Foenugreek). For their isolation 460 kg. of seeds were processed. There has been isolated from the mother liquor after the separation of diosgenin (yield, about 1.0 g./kg. dry seed),[4] two more sapogenins, namely, tigogenin (trace) and gitogenin (yield, 0.1 g./kg. dry seed). The last two sapogenins have occurred jointly in other plants, namely, *Yucca Whipplei* Torr. subsps. *intermedia*, *Agave gracilipes* Trel. and *Agave Schottii* Engelm. However, this is the first and single case of the occurrence of all three in the same plant. The significance of this finding has been discussed.[3b]

Lilagenin has been isolated from the sapogenin fraction of *Lilium rubrum magnificum*.[5] In addition, a small amount of yuccagenin was found.

In our preliminary paper,[3a] we erroneously reported *Samuela Faxoniana* Trel. to be a source for smilagenin. Actually, it is a new source for sarsasapogenin.

Other new sources are listed in the accompanying tables.

TABLE I

PLANTS CONTAINING DIOSGENIN AND KRYPTOGENIN

Plant	Location	Yield g. per kg. (dry) plant Dios.	Krypt.
Balanites aegyptica Wall.	Southern Mexico	5.0	1.0
Dioscorea floridiana Bartlett	Southern Georiga	1.7	...
Dioscorea glauca Muhl.	North Carolina,	1.0	...
Trillium Catesbaei Ell.	North Carolina	...	0.1
Trillium cernum L.	North Carolina	...	1.0
Trillium decumbens Harbison	North Carolina	...	0.5
Trillium declinatum Gleason	Tennessee	5.0	1.0
Trillium erectum L.	North Carolina	3.0	0.2
Trillium Hugeri Small	North Carolina	3.0	...
Trillium ludovicianum Harbison	Georgia	5.0	...
Trillium recurvatum Beck	Mississippi	4.0	Trace
Trillium simile Gleason	North Carolina	4.0	...
Trillium stamineum Harbison	Georgia	...	0.8
Trillium Vaseyi Harbison	North Carolina	0.4	...
Trillium viride Beck	North Carolina	...	0.5

PLANTS CONTAINING SITOSTEROL

Plant	Location	Yield, g. per kg. dry plant
Areca Catechu L.	Commercial	Trace
Arisaema triphyllum Schott	Commercial	0.5
Jatrorrhiza palmata Miers	Commercial	Trace
Smilacina racemosa Desf.	State College, Pa.	Trace
Zanthorhiza apiifolia L'Hérit	Commercial	Trace

The identities of the above compounds were established by analyses of the genins and their acetates along with melting point and mixed melting point determinations on both. Generalized isolation procedures have been reported.[3b]

SCHOOL OF CHEMISTRY AND PHYSICS
THE PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNA. RECEIVED MARCH[6] 11, 1947

(1) Marker, Turner and Ulshafer, THIS JOURNAL, **62**, 2542 (1940).

(2) Marker, Wagner and Ulshafer, *ibid.*, **64**, 1283 (1942).

(3) (a) Marker, Wagner, Ulshafer, Wittbecker, Goldsmith and Ruof, *ibid.*, **65**, 1199 (1943); (b) **69**, 2167 (1947); (c) for supplementary tables, order Document 2384 from American Documentation Institute, 1719 N Street, N. W., Washington 6, D. C., remitting 50¢ for microfilm or $2.10 for photocopies.

(4) Marker, Wagner, Ulshafer, Goldsmith and Ruof, *ibid.*, **65**, 1247 (1943).

(5) Marker, Turner, Shabica, Jones, Krueger and Surmatis, *ibid.*, **62**, 2620 (1940).

(6) Original manuscript received June 26, 1944.

The Use of a Fluorescent Adsorbent for the Chromatography of Colorless Compounds

BY JOHN W. SEASE

When colorless compounds which absorb ultraviolet light are chromatographed on a fluorescent

TABLE I

SEPARATIONS OF PAIRS OF COMPOUNDS ON SILICA COLUMNS MADE FLUORESCENT BY ADDITION OF FLUORESCENT ZINC SULFIDE

Compound A	Mg.	Compound B	Mg.	Petroleum ether developer, ml.	Zones,[a] mm. I	II	III	IV	V
Azoxybenzene	10	Nitrobenzene	10	100	22	20	20	20	60
p-Nitrobenzyl bromide	18.2	Nitrobenzene	10	100	20	10	40	20	50
Salicylaldehyde	2.6	Nitrobenzene	6	50	50	15	10	10	20
Cinnamaldehyde	4.9	Salicylaldehyde	2.6	40	0	5	40	10	35
Cinnamaldehyde	4.2	Azoxybenzene	8.0	50	15	5	20	30	30
p-Nitrobenzyl bromide	14.6	Azoxybenzene	8.0	65	45	20	5	30	5
Cinnamaldehyde	4.9	*p*-Nitrobenzyl bromide	14.6	200	0	2	45	15	80
p-Nitrobenzyl bromide	10.9	Salicylaldehyde	5.1	160	35	15	5	10	80
Xanthone	3.6	*p*-Nitrobenzyl bromide	10.9	80	0	5	10	8	120
Nitrobenzene	6.0	Iodoform	4.6	25	15	10	55	30	35

[a] Each chromatogram is described in terms of the following zones, whose thicknesses in mm. are given by the numbers under the corresponding Roman numerals: I, fluorescent (empty) section; II, shadow (upper zone, Compound A); III, fluorescent (empty) section; IV, shadow (lower zone, Compound B); V, fluorescent (empty) section.

adsorbent, the fluorescence is found, under appropriate conditions, to decrease in those regions of the column where the zones of colorless, non-fluorescing adsorbate are located. Adsorbents with fluorescent and adsorptive properties suitable for this work may be conveniently prepared by mixing a finely powdered inorganic fluorescent material with a standard chromatographic adsorbent, such as alumina or silica gel. With the aid of such a mixture it has been found possible to follow visually the development of chromatograms of some colorless, non-fluorescing substances as readily as in the case of fluorescent compounds.[1]

A series of experiments using silica gel with which had been mixed a small amount of fluorescent zinc sulfide (no. 62)[2] led to the following adsorption sequence, the compounds being listed in order of decreasing adsorption affinity when developed with petroleum ether

{Cinnamaldehyde[3]
{Xanthone[3]
p-Nitrobenzyl bromide
{Salicylaldehyde[3]
{Azoxybenzene[3]
Nitrobenzene
Iodoform

Details of the individual chromatograms are given in Table I.

(1) After submission of this manuscript for publication the author learned of a prior publication by H. Brockmann and F. Volpers (*Ber.* **80**, 77 (1947)) in which the application of fluorescent adsorbents to chromatography of colorless compounds is described. Their adsorbents were prepared by adsorbing morin, diphenylfluorindinesulfonic acid, or salicylic acid on alumina, by adsorbing berberine on silicic acid, or by adsorbing morin or diphenylfluorindinesulfonic acid on magnesia or calcium carbonate. The limits for exciting radiation were found to be 250–400 mμ.

(2) Three fluorescent zinc sulfides were obtained through the courtesy of the Patterson Screen Division of E. I. du Pont de Nemours and Co., Inc., Towanda, Pa.: No. 16, Blue fluorescence, no afterglow; No. 50, Yellow fluorescence, afterglow; No. 62, Yellow fluorescence, no afterglow.

(3) Bracketed pairs could not be separated completely (*i. e.*, with an empty, fluorescing interspace between the shadowed zones) when developed with petrolum ether on columns of 15 cm. or less in length and therefore are not included in Table I. Partial separations were obtained, however, so that the relative adsorption affinities could be determined.

Both an argon glow lamp[4a] and an incandescent ultraviolet lamp[4b] were found to be suitable light sources for practical work.[5]

Three different zinc sulfides were tested in preliminary experiments.[2] All three gave approximately equivalent results, although yellow fluorescence was found to be preferable since both available ultraviolet sources had an appreciable output of violet or blue light.

Qualitative tests were carried out with the optical system of a Beckman Spectrophotometer as an ultraviolet source in order to learn what wave lengths were effective in exciting the fluorescence. All three zinc sulfides were found to be sensitive to approximately the same wave lengths. For practical purposes the upper and lower limits for the exciting radiation were found to be approximately 390 and 330 mμ, respectively. This applies to the mixture of zinc sulfide and silica (2.5% no. 62 zinc sulfide) as used in these experiments, *i. e.*, packed inside a standard Pyrex chromatographic tube[6] and wet with petroleum ether.

The use of other inorganic fluorescent materials which are sensitive to wave lengths below 330 mμ is being investigated at the present time.

Experimental

A solution in 5–10 ml. of petroleum ether (Skellysolve B, b. p. 60–70°) of the two substances to be separated was poured on a column (1.8 cm. diameter, 9–15 cm. long) of silicic acid (Eimer and Amend, C. P., mixed with 2.5% of no. 62 fluorescent zinc sulfide[2]). Movement of the zones on development with additional petroleum ether was observed by illuminating the column in a darkened room with ultraviolet light.[4a,b]

At the conclusion of development the column was extruded and each portion of adsorbent containing a shadowed zone was cut out. Elution of each zone with 30–40

(4) (a) Cenco No. 71370, complete with ultraviolet filter; (b) Purple X, General Electric Co.; no filter was used.

(5) The broad spectral band furnished by such light sources is undesirable. A considerable increase in sensitivity of detection would be expected if there were available a much narrower spectral band whose average wave length approximated that of the spectral absorption maximum of the compound being observed on the column.

(6) Manufactured by Scientific Glass Apparatus Co., Bloomfield, N. J.

ml. of 96% ethanol gave a solution whose qualitative and quantitative composition could easily be determined on a Beckman Spectrophotometer.

The adsorbent can be recovered by placing in a chromatographic tube, washing with enough 96% ethanol to wet the entire column, then washing with three times this volume of petroleum ether, and finally drying in the air at room temperature. Silica–zinc sulfide mixture so recovered showed slightly weaker adsorptive properties than fresh adsorbent, but was its equivalent for all practical purposes. Both fresh and recovered mixtures were used in this work.

HALL LABORATORY OF CHEMISTRY
WESLEYAN UNIVERSITY
MIDDLETOWN, CONNECTICUT RECEIVED MARCH 7, 1947

Osmotic and Activity Coefficients of Lithium Bromide and Calcium Bromide Solutions

BY R. A. ROBINSON AND H. J. MCCOACH

The osmotic and activity coefficients of lithium chloride and calcium chloride solutions have been determined recently[1,2] up to the highest concentrations. Similar measurements on the bromides have now been made to extend the concentration range beyond that of earlier measurements.[3,4]

Isopiestic determinations were made using platinum dishes as it has been found that some corrosion of silver dishes occurs with concentrated bromide solutions. Calcium chloride and sulfuric acid were used as reference electrolytes. The molalities of pairs of solutions of equal vapor pressure are given in Table I. From these measurements the osmotic and activity coefficients given in Table II were evaluated. This table contains values at low concentrations, the earlier data having been recalculated to conform with more recent reference data.[5]

TABLE I

MOLALITIES OF ISOPIESTIC SOLUTIONS AT 25°

LiBr	$CaCl_2$	LiBr	$CaCl_2$	LiBr	$CaCl_2$	LiBr	$CaCl_2$
4.837	3.110	5.937	3.756	6.913	4.345	7.942	4.984
9.388	5.980	10.12	6.553	11.02	7.426	11.87	8.342

LiBr	H_2SO_4	LiBr	H_2SO_4	LiBr	H_2SO_4	LiBr	H_2SO_4
11.95	12.85	13.61	15.29	14.33	16.32	15.46	17.88
16.14	18.80	16.47	19.20	16.58	19.35	17.09	20.04
18.39	21.64	18.99	22.35	19.85	23.21		

$CaBr_2$	$CaCl_2$	$CaBr_2$	$CaCl_2$	$CaBr_2$	$CaCl_2$	$CaBr_2$	$CaCl_2$
1.422	1.524	1.766	1.897	2.140	2.309	2.152	2.321
2.554	2.764	2.584	2.801	2.791	3.026	3.116	3.387
3.565	3.888	3.785	4.158	3.922	4.312	4.435	4.965
5.144	5.952	5.595	6.655	5.726	6.893	5.984	7.470
6.170	7.831	6.286	8.067	6.406	8.375	6.583	8.730
6.630	8.838	6.863	9.498	6.965	9.815	7.216	10.41

$CaBr_2$	H_2SO_4	$CaBr_2$	H_2SO_4	$CaBr_2$	H_2SO_4	$CaBr_2$	H_2SO_4
7.636	16.10	7.922	16.81	8.406	17.97	9.210	19.61

(1) R. A. Robinson, *Trans. Faraday Soc.*, **41**, 756 (1945).
(2) R. H. Stokes, *ibid.*, **41**, 637 (1945).
(3) R. A. Robinson, THIS JOURNAL, **57**, 1161 (1935).
(4) R. A. Robinson, *Trans. Faraday Soc.*, **38**, 445 (1942).
(5) (a) S. Shankman and A. R. Gordon, THIS JOURNAL, **61**, 2370 (1939); (b) R. H. Stokes and B. J. Levien, *ibid.*, **68**, 333 (1946); (c) R. H. Stokes, *ibid.*, **69**, 1291 (1947).

TABLE II

OSMOTIC AND ACTIVITY COEFFICIENTS OF LITHIUM AND CALCIUM BROMIDE AT 25°

	LiBr		$CaBr_2$	
m	φ	γ	φ	γ
0.1	0.943	0.796	0.863	0.532
.2	.944	.766	.878	.492
.3	.952	.756	.900	.482
.4	.960	.752	.927	.483
.5	.970	.753	.958	.491
.6	.981	.758	.990	.505
.7	.993	.767	1.022	.522
.8	1.007	.777	1.057	.543
.9	1.021	.789	1.093	.568
1.0	1.035	.803	1.131	.597
1.2	1.067	.837	1.207	.665
1.4	1.098	.874	1.286	.747
1.6	1.130	.917	1.370	.848
1.8	1.163	.964	1.455	.970
2.0	1.196	1.015	1.547	1.121
2.5	1.278	1.161	1.790	1.657
3.0	1.364	1.341	2.048	2.54
3.5	1.467	1.584	2.297	3.89
4.0	1.578	1.897	2.584	6.28
4.5	1.687	2.28	2.908	10.66
5.0	1.793	2.74	3.239	18.47
6.0	1.989	3.92	3.880	55.8
7.0	2.206	5.76	4.463	163.0
8.0	2.432	8.61	4.809	375
9.0	2.656	12.92	4.969	696
10.0	2.902	19.92	...	.....
11.0	3.150	31.0	...	.....
12.0	3.356	46.3	...	.....
13.0	3.581	70.6	...	.....
14.0	3.776	104.7	...	.....
15.0	3.912	146.0	...	.....
16.0	4.025	198.0	...	.....
17.0	4.110	260	...	.....
18.0	4.173	331	...	.....
19.0	4.216	411	...	.....
20.0	4.217	485	...	.....

CHEMISTRY DEPARTMENT
AUCKLAND UNIVERSITY COLLEGE
NEW ZEALAND RECEIVED JUNE 26, 1947

A Claisen Condensation by a Primary Grignard Reagent

BY S. B. SOLOWAY AND F. B. LAFORGE

The abnormal reactions of the Grignard reagents have been frequently reported in the literature. In the majority of such reactions the Grignard reagent has been prepared from either a secondary or a tertiary halide. Recently the Claisen condensation of esters by the agency of *t*-butylmagnesium chloride has been reported.[1] In this note we describe a mixed ketone–ester condensation by means of a Grignard reagent prepared from a primary halide.

The reaction between ethyl levulinate and the Grignard reagent is known to give low yields of

(1) Zook, McAleer and Horwin, *ibid.*, **68**, 2404 (1946).

lactone: 28% for hexyl chloride, 31% for hexyl bromide,[2] 29% for amyl chloride[3] and 38% (based on crude product) for β-bromonaphthalene.[4]

We have treated ethyl levulinate with amylmagnesium bromide and have increased the yield of lactone to 41% based on the halide, by employing a 50% excess of the ester. After the lactone had been distilled off, a large amount of material remained, which has been investigated. From this by-product a tri-keto acid, probably 4,6,9-trioxocapric acid, m. p. 118°, was the only compound that could be isolated. This acid evidently resulted from the hydrolysis of the ester arising from the condensation of the ester group of one molecule of ethyl levulinate with the methyl group of another molecule.

$$2CH_3COCH_2CH_2COOC_2H_5 \xrightarrow{C_5H_{11}MgBr} CH_3COCH_2CH_2COCH_2COCH_2CH_2COOC_2H_5$$

It is quite possible that the actual condensation agent is ethoxymagnesium bromide which would be present by the reaction of the Grignard reagent with the ester grouping as well as by the reaction which occurs after addition of the reagent to the carbonyl group.[5]

$$C_5H_{11}\overset{\displaystyle CH_3}{\overset{|}{C}}CH_2CH_2CO_2C_2H_5 \longrightarrow C_5H_{11}\overset{\displaystyle CH_3}{\overset{|}{C}}(OMgBr)CH_2CH_2CO + C_2H_5OMgBr$$

$$\text{(cyclic: } C_5H_{11}\overset{\displaystyle CH_3}{\overset{|}{C}}CH_2CH_2CO \text{ with O bridging the quaternary C and the carbonyl C)}$$

Other possible structures for the acid include $CH_3COCH_2CH_2COCH(COOH)CH_2COCH_3$ and $CH_3COCH_2CH_2COCH(COOH)COCH_3$ of which the first would probably be unstable.

That the condensation resulted in a straight-chain compound containing only one acetyl group seems highly probable from the terminal methyl determination.[6] The results show that on an average 66% of one acetyl group was converted to acetic acid. This figure is in agreement with the terminal methyl value observed for the semicarbazone of ethyl methyl ketone (67%).[5]

Experimental

The Grignard reaction was carried out by the inverse addition of the reagent, prepared from 302 g. (2 moles) of amyl bromide and 48 g. (2 g. atoms) of magnesium in 500 ml. of ether, to 432 g. (3 moles) of ethyl levulinate in 600 ml. of benzene. The reaction proceeded in the usual manner, and the product was distilled, yielding 140 g. (41% based on halide) of γ-methyl-γ-pelargonolactone, b. p. 110° (0.5 mm.), $n^{25}D$ 1.4468. The higher boiling fraction, which was not distilled, amounted to 205 g.

4,6,9-Trioxocapric Acid.—Twenty-five grams of the undistilled fraction was treated with 100 ml. of 10% sodium hydroxide and allowed to stand overnight at room temperature. After about 1 g. of neutral material had been removed by ether extraction, the solution was acidified with dilute hydrochloric acid, saturated with sodium chloride, and extracted with ether. The ether solution was washed free of acid with salt solution and dried, and the solvent was removed. The residue, 15.6 g., was subjected to high-vacuum distillation and yielded 2 g. of uncharacterized material. The residue was then poured into a beaker and, after about a week, crystals formed in the dark-brown mass. Trituration with cold ethyl acetate yielded 2.6 g. of crystals, which upon recrystallization from ethyl acetate melted at 118°.

Anal. Calcd. for $C_{10}H_{14}O_5$: C, 56.07; H, 6.59; neut. equiv., 214; 1 CH_3, 7.0. Found: C, 56.09; H, 6.53; neut. equiv., 215; CH_3, 4.4, 4.8.

The acid yielded a monosemicarbazone, m. p. 193°.

Anal. Calcd. for $C_{11}H_{17}O_5N_3$: C, 48.70; H, 6.32. Found: C, 49.02; H, 6.29.

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE
AGRICULTURAL RESEARCH ADMINISTRATION
U. S. DEPARTMENT OF AGRICULTURE
BELTSVILLE, MD. RECEIVED MARCH 10, 1947

(2) Frank and co-workers, *ibid.*, **66**, 4 (1944).
(3) LaForge and Barthel, *J. Org. Chem.*, **10**, 222 (1945).
(4) Robinson and Slater, *J. Chem. Soc.*, 376 (1941).
(5) Grignard, *Compt. rend.*, **135**, 627 (1902).
(6) Barthel and LaForge, *Ind. Eng. Chem., Anal. Ed.*, **16**, 434 (1944).

Heats of Polymerization of Some Unsaturates

BY L. K. J. TONG AND W. O. KENYON

The heats of polymerization of certain unsaturates have been measured and found to be: methyl acrylate 18.7 ± 0.2, vinyl acetate 21.3 ± 0.2, acrylonitrile 17.3 ± 0.5, and vinylidene chloride 14.4 ± 0.5 kcal./mole of monomeric unit. The unsaturates used were highly purified for these measurements. The calorimeter and the technique of its operation have been described previously.[1] With the exception of methyl acrylate, corrections have been made for unreacted monomers. The heat of polymerization value for methyl acrylate was determined using 0.01% of benzoyl peroxide catalyst, while vinyl acetate was determined with 0.018% and 0.035% of the catalyst. These latter values did not vary significantly. Measurements with acrylonitrile were made using catalyst concentrations of 0.05 to 0.20%, and with vinylidene chloride using 0.25 to 0.86%. The final values given above for the two latter monomers were determined by extrapolation to zero catalyst concentration. All determinations reported were at 76.8°. The $-\Delta H$ of 21.3 kcal./mole for vinyl acetate is quite different from the value of 28.0 reported by Houwink[2] and 8.0 ± 0.4 by Mark, *et al.*[3] Based on considerations of the stability of the polymerizable double bond, vinyl acetate should show a larger value of $-\Delta H$ than do methyl acrylate or styrene, wherein the double bond is conjugated. Our value of 21.3 is close to those calculated by

(1) Tong and Kenyon, THIS JOURNAL, **67**, 1278 (1945); **68**, 1335 (1946); **69**, 1402 (1947).
(2) Houwink, "Chemie und Tech. der Kunststoff," Vol. I, Akad. Verlags., Leipzig, 1940, p. 60.
(3) Goldfinger, Josefowitz and Mark, THIS JOURNAL, **65**, 1432 (1943).

Flory[4] for monomers in which the reacting double bond is not in resonance.

(4) Flory, THIS JOURNAL, **59**, 241 (1937).

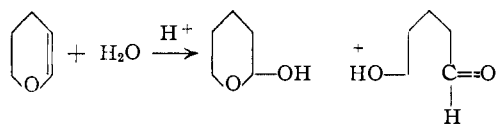
RESEARCH LABORATORIES
EASTMAN KODAK COMPANY
KODAK PARK WORKS
ROCHESTER 4, N. Y.

RECEIVED JULY 2, 1947

Dihydropyrane Addition Products

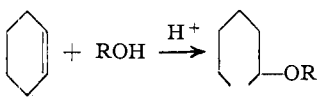
BY G. FORREST WOODS AND DAVID N. KRAMER

2,3-Dihydropyrane is the dehydration product of a hemiacetal and as such has been shown to add water[1] readily in the presence of a trace of mineral acid yielding an equilibrium mixture of 5-hydroxypentanal and 2-hydroxytetrahydropyrane. Paul[1a] observed that methyl alcohol



added to dihydropyrane and from this reaction 2-methoxytetrahydropyrane was obtained.

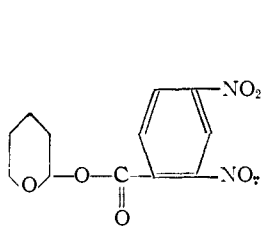
We have prepared a number of acetals from 2,3-dihydropyrane according to the equation below modifying the procedure of Paul



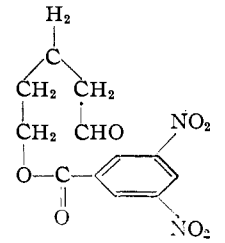
These acetals are stable in a basic medium and are therefore easily isolated after destruction of the acid catalyst with a strong inorganic base.

Hydrolysis of these acetals by acids in an aqueous medium in the presence of 2,4-dinitrophenylhydrazine yielded 5-hydroxypentanal-2,4-dinitrophenylhydrazone.

For purposes of identification of 2,3-dihydropyrane the yellow 2,4-dinitrophenylhydrazone of 5-hydroxypentanal, the hydrolysis product of dihydropyrane, has been used. We have found that 3,5-dinitrobenzoic acid when mixed with an excess of dihydropyrane forms an addition product which is excellent for characterization. This product does not form a semicarbazone when treated with free semicarbazide in methanol. Therefore, the structure (I) is preferred to that of (II) for this substance.



I



II

Experimental

Acetal Formation.—Equimolar quantities of alcohol and dihydropyrane in the presence of a trace of concentrated hydrochloric acid were shaken and allowed to stand for three hours. The reaction is exothermic. A few pellets of sodium hydroxide were then added to the reaction mixture to destroy the acid, and the product isolated directly by distillation. The pure material was obtained by redistillation in the presence of a few pellets of sodium hydroxide.

The 2,4-dinitrophenylhydrazone of 5-hydroxypentanal from these acetals were prepared in the usual manner. The yellow crystalline material obtained melted at 107–109° and gave no depression in a mixed melting point determination with an authentic sample.[1c]

The 3,5-Dinitrobenzoate of 2-Hydroxytetrahydropyrane.—Five grams of 3,5-dinitrobenzoic acid was dissolved with warming in a 50% excess of dihydropyrane. Upon cooling, 5 cc. of ether was added and the product slowly crystallized as needles. After a second recrystallization from 80% dihydropyrane–ether, a pale yellow solid was obtained which melted sharply at 103°. The yield was essentially quantitative.

Anal. Calcd. for $C_{12}H_{12}O_7N_2$: C, 48.65; H, 4.05. Found: C, 49.05; H, 4.46.

TABLE I

ACETALS FROM DIHYDROPYRANE

R =	B. p., °C.	N_D	Yield, %	Calcd., % C	Calcd., % H	Found, % C	Found, % H
Methyl-[a]	125	1.4260	85	62.07	10.35	62.06	10.01
Ethyl-[b]	146	1.4248	93	64.62	10.76	65.04	10.58
n-Propyl-	165	1.4280	91	66.67	11.11	66.27	11.00
Allyl-	126	1.4440	70	67.53	9.86	67.48	10.07
n-Butyl-	183	1.4312	75	68.39	11.33	68.45	11.36
Phenyl-	103 (4 mm.)	1.5290	37	74.16	7.87	73.96	7.92
Benzyl-	107 (3 mm.)	1.5128	41	75.00	8.33	74.63	8.40
Furfuryl-	124 (24 mm.)	1.4828	34	65.92	7.78	65.96	8.06
2,2′-(*sym*-Ethylenedioxy-ditetrahydropyrane)	164 (32 mm.)	1.4610	40	62.53	9.56	62.54	9.74

[a] *Cf.* ref. 1a. [b] This substance has been prepared by catalytic hydrogenation of 2-ethoxy-Δ^3-dihydropyrane [Woods and Sanders, THIS JOURNAL, **68**, 2483 (1946)]. [c] In the addition of equimolar quantities of ethylene glycol to dihydropyrane, mixtures of di-tetrahydropyrane and mono-tetrahydropyrane addition products are obtained. Ratios of two moles of ethylene glycol to one mole of dihydropyrane were used to favor the preparation of the monomer which could not be obtained in a pure state. The dimer was obtained by adding two moles of dihydropyrane to one mole of ethylene glycol. In each case, the two products could be separated from the initial reaction mixture by fractional distillation.

(1a) R. Paul, *Bull. soc. chim.*, [5] **1**, 973 (1934).
(1b) Schniepp and Geller, THIS JOURNAL, **68**, 1646 (1946).
(1c) Woods and Sanders, *ibid.*, **68**, 2111 (1946).

CHEMISTRY DEPARTMENT
UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

RECEIVED APRIL 1, 1947