TABLE I

COMPARISON OF THE EFFECTS OF ADDITIVES ON THE RETROGRADATION RATE OF CORN AMYLOSE. BASIS OF COMPARISON IS THE TIME REQUIRED TO REACH THE INFLECTION POINT ON THE IBC–AGE CURVE

Amylose concentration = 0.1%; temperature = 3 + 1°

| Additive | Concn., *M* | Time, hours | Additive | Concn., *M* | Time, hours |
|---|---|---|---|---|---|
| None | 0.1 | 45 | $K_2SO_4$ | 0.1 | 85 |
| KI | .1 | >>500 | $K_2SO_4$ | .05 | 61 |
| KBr | .1 | 230 | $MgSO_4$ | .1 | 38 |
| KCl | .1 | 105 | $MgSO_4$ | .05 | 42 |
| KF | .1 | 70 | $LaCl_3$ | .01 | 58 |
| NaI | .1 | >>500 | $LaCl_3$ | .001 | 52 |
| NaBr | .1 | 230 | $ThCl_4$ | .001 | 18 |
| NaCl | .1 | 100 | $ThCl_4$ | .0001 | 42 |
| NaF | .1 | 60 | NaCl | 0.1 | 100 |
| LiBr | .1 | 155 | Plus $ThCl_4$ | $0.5 \times 10^{-4}$ | 70 |
| LiCl | .1 | 60 | Plus $ThCl_4$ | $1.0 \times 10^{-4}$ | 60 |
| $NH_4I$ | .1 | >>500 | Plus $ThCl_4$ | $2.0 \times 10^{-4}$ | 43 |
| $NH_4Cl$ | .1 | 80 | Plus $ThCl_4$ | $4.0 \times 10^{-4}$ | 32 |
| $BaCl_2$ | .1 | 230 | Plus $ThCl_4$ | $10.0 \times 10^{-4}$ | 23 |
| $CaCl_2$ | .1 | 110 | Plus $ThCl_4$ | $25.0 \times 10^{-4}$ | 15 |
| $MgCl_2$ | .1 | 85 | Glucose | 0.1 | 45 |
| $BaCl_2$ | .01 | 50 | Sucrose | .1 | 61 |
| $Ca(NO_3)$ | .1 | >>500 | Urea | .1 | 100 |
| $Ca(NO_3)$ | .02 | 70 | Urea | .4 | 200 |

in Table I are made so that film formation does not affect these comparisons. However, in Fig. 4, the IBC values shown are uncorrected for the removal of a part of the amylose to the films at the times the later aliquots were taken. The apparent approach to a lower limiting IBC, than was characteristic of amylose alone, was due entirely to loss of amylose from the suspension to the film.

The following observations may be made regarding the effects of salts or other additives on the retrogradation process of corn amylose. (1) Any influence that additives have on the retrogradation process is proportionate at *all* stages of the process. (2) Salts of monovalent anions and monovalent cations all retard retrogradation, the anions demonstrating a wider lyotropic spread than the cations. Anions are effective in the order $F^- < Cl^- < Br^- < I^-$ while the order for the cations is $Li^+ < Na^+ < MH_4^+ < K^+$. Films were formed only in the solutions containing $Cl^-$ and $F^-$. (3) Those salts that act as cold gelatinizing agents for starch (*e.g.*, $Ca(NO_3)_2$ and alkali iodides) exhibit a very marked retardation effect on retrogradation. (4) Some cations of high valency (*e.g.*, $Th^{++++}$) cause an acceleration of the retrogradation process. (5) Increase in concentration of a given salt increases the effect of that salt on the retrogradation process. (6) Urea, a strong hydrogen bonding reagent, retards the retrogradation process.

## Discussion

While the salient features of the course of the retrogradation process are apparent from the results reported, the scope of the study is too limited as yet to attempt any hypothetical interpretations. It is to be emphasized that the change in IBC which is followed in this study reflects only the progress of the process through which the "helical" form of the amylose molecule is converted to the intermolecular hydrogen bonded "crystal" form as retrogradation proceeds. The initial high degree of aggregation of amylose when dispersed with KOH, while still in the helical form, as reported by Paschall and Foster[10] would not be detected by the method employed in the present study.

(10) E. F. Paschall and J. F. Foster, *J. Polymer Sci.*, **9**, 73, 85 (1952); THIS JOURNAL, **75**, 1177, 1181 (1953).

ST. PAUL 1, MINNESOTA

---

[CONTRIBUTION FROM THE NAVAL STORES STATION, U. S. DEPARTMENT OF AGRICULTURE[1]]

# The Thermal Isomerization of Neoabietic Acid

BY VIRGINIA M. LOEBLICH AND RAY V. LAWRENCE

RECEIVED OCTOBER 22, 1956

A chromatographic study of the products formed by the thermal isomerization of neoabietic acid at 200° has shown that they consist almost entirely of palustric acid and *l*-abietic acid. The concentration of the various acids present in the isomerized products indicated that the formation of *l*-abietic acid was favored in this isomerization. A new crystalline derivative, neoabietenol, was prepared and characterized. The rate of isomerization of this alcohol and of methyl neoabietate were found to be much slower than the rate of isomerization of the free acid, indicating that the isomerization is catalyzed by the $H^+$ of the carboxyl group.

Neoabietic acid is one of the major constituents of pine oleoresin and rosin.[2] It is an abietic-type resin acid and thus subject to isomerization by heat and acids to *l*-abietic acid. This factor of isomerization is largely responsible for the major changes in rosin during processing and the preparation of commercial derivatives.

For this reason, a series of thermal and acid isomerization studies have been initiated in this Laboratory on the abietic-type acids in oleoresin and rosin—namely, levopimaric acid,[3,4] neoabietic acid and the most recently isolated palustric acid.[5]

The present paper describes a study of the thermal isomerization of pure neoabietic acid. A temperature of 200° was found to give a measurable rate of isomerization. Eight samples were heated over a period of 72 hours and the progress of the isomerization was followed by obtaining the specific

(1) One of the laboratories of the Southern Utilization Research Branch, Agricultural Research Service, U. S. Department of Agriculture. Article not copyrighted.

(2) G. C. Harris and T. F. Sanderson, THIS JOURNAL, **70**, 334 (1948); **70**, 339 (1948).

(3) V. M. Loeblich, D. E. Baldwin, R. T. O'Connor and R. V. Lawrence, *ibid.*, **77**, 6311 (1955).

(4) D. E. Baldwin, V. M. Loeblich and R. V. Lawrence, *ibid.*, **78**, 2015 (1956).

(5) V. M. Loeblich, D. E. Baldwin and R. V. Lawrence, *ibid.*, **77**, 2823 (1955).

rotation, ultraviolet absorption spectrum and chromatographic analysis of each sample (Table I). These data furnished a complete analysis of the components of thermally isomerized neoabietic acid and showed that, on heating at 200°, it isomerized to palustric and *l*-abietic acids. During the first 5 hours the palustric and *l*-abietic acid content increased until a maximum of 14% palustric acid was obtained. The percentage of palustric acid then remained relatively constant and the *l*-abietic acid content increased until, at the end of 72 hours, the product approached an equilibrium mixture of 13% palustric acid, 82% *l*-abietic acid and 5% neoabietic acid.

In comparing the products of the isomerization of neoabietic acid at 200° with those of levopimaric acid at 155°,[3] several interesting observations were noted—(1) by graphic comparisons and calculation of the rate coefficients, *k*, the thermal isomerization of neoabietic acid did not appear to be either a first- or second-order reaction; (2) during the first hour neoabietic acid isomerized to *l*-abietic acid and palustric acid at a ratio of 2:1, respectively, whereas levopimaric acid isomerized to equal amounts of each of these acids; and (3) the concentration of palustric acid reached a maximum of 14% in the neoabietic acid isomerization compared to 37% in the levopimaric acid isomerization. These last two observations indicate that neoabietic acid is more readily isomerized to *l*-abietic acid than to palustric acid, whereas levopimaric acid forms both of these acids with equal ease. This conclusion becomes even more apparent when the analysis of the products of the 0.5 hr. isomerization of neoabietic and levopimaric acids at 200° is compared:

| | Palustric, % | *l*-Abietic, % | Neoabietic, % |
|---|---|---|---|
| Levopimaric acid | 34 | 52 | 14 |
| Neoabietic acid | 5 | 11 | 84 |

The data also show that neoabietic acid is more stable to heat than levopimaric acid. After 30 minutes levopimaric acid has been completely isomerized to other isomeric acids while neoabietic acid is still the major component present.

The rate of isomerization of methyl neoabietate at 200° was also measured by the change in specific rotation and specific extinction coefficient (Table II). After 168 hours, 88% of the ester remained unchanged. The ultraviolet absorption spectrum of the thermally isomerized ester indicated the presence of the corresponding derivatives of abietic and palustric acids. Its marked stability to heat, coupled with the retarded isomerization rate of methyl levopimarate,[3] showed that the thermal isomerization of the resin acids is primarily ionic in character—being catalyzed by the $H^+$ of the carboxyl group.

Neoabietic acid was quantitatively reduced to neoabietenol using an ether suspension of lithium aluminum hydride. This new crystalline derivative had a m.p. 98–99.5° and specific extinction coefficient, $\alpha$, at 251–2 m$\mu$ of 88.1. The specific rotation of a 1% solution of neoabietenol in the common organic solvents was determined and, in all cases, was found to be of greater positive magnitude than the specific rotation of the acid.

The rate of isomerization of neoabietenol was measured at 200° by the change in specific rotation and specific extinction coefficient (Table III). At the end of 168 hours the specific rotation had decreased from 184.6 to +142.5° and the specific extinction coefficient had decreased from 88.3 to 74.0. The ultraviolet absorption spectrum of the isomerized neoabietenol indicated the presence of the alcohols of *l*-abietic and palustric acids. Although some isomerization of the neoabietenol did occur, it was much more stable than the free acid but not as stable as methyl neoabietate.

## Experimental

The neoabietic acid used for the thermal isomerization studies was prepared by the method of Loeblich and Lawrence.[6] It had an $[\alpha]_D$ +160° (2% in EtOH), m.p. 167–169°, and was shown by chromatographic and ultraviolet absorption analysis to contain more than 98% neoabietic acid.

Two-gram samples of neoabietic acid were placed in constricted tubes and the air replaced with $N_2$ by thorough flushing and repeated evacuation. The tubes were sealed off under high vacuum and then heated in an oil-bath at 200° for specified lengths of time.

**Analysis of the Thermally Isomerized Neoabietic Acid.**—The data obtained on each sample included the specific rotation, chromatographic analysis and ultraviolet absorption analysis. The chromatographic procedure and the values used to calculate the specific rotations and specific extinction coefficients are described by Loeblich, Baldwin, O'Connor and Lawrence.[3] A summary of the data on the thermal isomerization of neoabietic acid at 200° is given in Table I.

TABLE I

SUMMARY OF DATA ON THE THERMAL ISOMERIZATION OF NEOABIETIC ACID AT 200°

| Time, hr. | $[\alpha]_D$, 2% EtOH | $\alpha$ at 241 m$\mu$ | Palustric, % | *l*-Abietic, % | Neoabietic, % | Calcd. $[\alpha]_D$ | Calcd. $\alpha$ at 241 m$\mu$ |
|---|---|---|---|---|---|---|---|
| 0.25 | +144° | .. | 2 | 5 | 93 | +145° | .. |
| 0.50 | +124 | .. | 5 | 11 | 84 | +126 | .. |
| 1 | +88 | 71 | 10 | 23 | 67 | +91 | 73 |
| 2 | +52 | 72 | 10 | 38 | 51 | +49 | 71 |
| 3 | +12 | 69 | 11 | 51 | 38 | +15 | 71 |
| 5 | −23 | 66 | 14 | 64 | 22 | −22 | 67 |
| 8 | −46 | 70 | 13 | 71 | 16 | −40 | 68 |
| 72 | −66 | 66 | 13 | 82 | 5 | −68 | 68 |

The identity of the palustric, *l*-abietic and neoabietic acids was confirmed by separating 3.5 g. of a 2-hr. isomerized sample on a large (200 g. silicic acid) chromatographic column.[5] Acids having the following physical constants were isolated: palustric acid, m.p. 162–167°, $[\alpha]_D$ +71.5°, $\alpha$ 31.0 at 265–266 m$\mu$; *l*-abietic acid, m.p. 175–182°, $[\alpha]_D$ −105.1°, $\alpha$ 77.2 at 241 m$\mu$; neoabietic acid, m.p. 167–169°, $[\alpha]_D$ +159°, $\alpha$ 80 at 251 m$\mu$.

**Thermal Isomerization of Methyl Neoabietate at 200°.**—Methyl neoabietate was prepared by treating an ether solution of neoabietic acid with an excess of an ether solution of diazomethane. Removal of the ether by distillation, followed by crystallization of the product from methanol, yielded the ester, m.p. 61.5–62°, $[\alpha]_D$ +147.8°, acid no. 0, and a specific extinction coefficient, $\alpha$, of 81.0. The rate of isomerization at 200° was observed by the change in the specific rotation and the specific extinction coefficient at 252 m$\mu$ (Table II).

**Preparation of Neoabietenol.**—Ten grams of neoabietic acid, $[\alpha]_D$ +160°, was dissolved in 200 ml. of anhydrous ether and this solution was added to a 100-ml. ether suspension of 3.5 g. of lithium aluminum hydride. The mixture was refluxed for four hours. The excess lithium aluminum hydride was destroyed with water, and the mixture was acidified with 3 *N* acetic acid, washed neutral, dried over sodium sulfate and evaporated to dryness. Upon re-

(6) V. M. Loeblich and R. V. Lawrence, *J. Org. Chem.*, **21**, 610 (1956).

TABLE II

THERMAL ISOMERIZATION OF METHYL NEOABIETATE AT 200°

| Time, hr. | $[\alpha]_D$, 2% EtOH | $\alpha$ at 252 m$\mu$ |
|---|---|---|
| 0 | +148° | 81.0 |
| 1 | +144 | 80.5 |
| 2 | +145 | 80.2 |
| 5 | +146 | 80.0 |
| 16 | +145 | 79.8 |
| 72 | +144 | 79.8 |
| 168 | +133 | 71.5 |

moval of the last traces of ether under vacuum, neoabietenol crystallized. The yield was quantitative. After two recrystallizations from ethanol–water the melting point was constant at 98–99.5° and the specific extinction coefficient at 251–252 m$\mu$ was 88.3.

*Anal.* Calcd. for $C_{20}H_{32}O$: C, 83.27; H, 11.18. Found: C, 83.56, 83.30; H, 11.10, 11.16.

The specific rotation of a 1% solution of neoabietenol in various organic solvents was: ethanol, +184.6°; methanol, +179.0°; benzene +200.6°; acetone, +197.7°; ether, +189.2°; chloroform, +187.0°; acetonitrile, +182.0°; heptane, +200.1°; isoöctane, +199.1°; cyclohexane, +204.0°.

TABLE III

THERMAL ISOMERIZATION OF NEOABIETENOL AT 200°

| Time, hr. | $[\alpha]_D$ 2% EtOH | $\alpha$ at 252 m$\mu$ |
|---|---|---|
| 0 | +184.6° | 88.3 |
| 8 | +161.4 | 81.1 |
| 16 | +149.5 | 77.8 |
| 72 | +146.8 | 75.3 |
| 168 | +142.5 | 74.0 |

**Thermal Isomerization of Neoabietenol at 200°.**—One-gram samples of neoabietenol were sealed in evacuated tubes as described above and heated at 200° for various lengths of time. The rate of isomerization was measured by the change in the specific rotation and the specific extinction coefficient at 252 m$\mu$ (Table III).

OLUSTEE, FLORIDA

---

[CONTRIBUTION FROM THE RESEARCH LABORATORIES, MEDICAL CORPS, ISRAEL DEFENCE FORCES]

# The Cyclization Reaction of Di-(*p*-halogenophenyl)-trifluoromethylcarbinols

BY SASSON COHEN

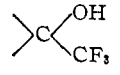
RECEIVED OCTOBER 18, 1956

Solutions of di-(*p*-halogenophenyl)-trifluoromethylcarbinols in concentrated sulfuric acid yield 3-halogeno-6-hydroxy-9-trifluoromethylfluorenes upon dilution with water, and the corresponding 6-methoxy compounds upon dilution with methanol. The trifluoromethyl group in the latter substances undergoes alkaline methanolysis to yield methyl 3-halogeno-6-methoxyfluorene-9-carboxylates, which are further degraded, by oxidation, to 3-halogeno-6-methoxyfluorenones. In the case of 3-chloro-6-methoxyfluorenone, the identity of the product has been proved by an unambiguous synthesis.

In a study of the chemical and biochemical behavior of the recently described di-(*p*-halogenophenyl)-trifluoromethylcarbinols (I),[1–5] it has been observed that the color of their halochromic solutions in concentrated sulfuric acid changes within a few minutes from intensely purple ($\lambda_{max}$ 570–580 m$\mu$) to orange ($\lambda_{max}$ 495 m$\mu$); in more concentrated solutions, this change is accompanied by the liberation of gas which, in the case of the fluoro compound (I, X = F), was identified as hydrogen fluoride. The reaction is specific for the *p*-halogen compounds, as di-(*p*-methoxyphenyl)-trifluoromethylcarbinol gives a fairly stable halochromic solution in concentrated sulfuric acid ($\lambda_{max}$ 580 m$\mu$); the color fades only very slowly, and the solution becomes colorless.

This behavior of the di-(*p*-halogenophenyl)-trifluoromethylcarbinols (I) seemed to deserve a more detailed study. Its results will be discussed for the case of the difluoro compound $C_{14}H_9F_5O$ (I, X = F). When the orange solution in concentrated sulfuric acid was diluted with water, a phenolic compound $C_{14}H_8F_4O$ was obtained, while dilution with methanol led to its methyl ether. Treatment with a mixture of acetic and hydrobromic acids led to substance $C_{14}H_8F_4O$, in which the presence of a hydroxyl group was indicated by the preparation of a crystalline acetyl derivative.

That the original $CF_3$ grouping was still present in the molecule could be demonstrated by the treatment of the compound $C_{15}H_{10}F_4O$ with dilute methanolic alkali: the methyl ester $C_{16}H_{13}FO_3$ of a carboxylic acid was formed, the $CF_3$ group being replaced by a carbomethoxy group. The ease with which the reaction took place proved, in view of previous results for this type of compounds,[5] that the substance $C_{15}H_{10}F_4O$ no longer contained the system



which is extremely resistant to hydrolysis, but rather the grouping

$$>CH\cdot CF_3$$

which hydrolyzes easily. Oxidation of the methyl ester $C_{16}H_{13}FO_3$ with alkaline hydrogen peroxide gave a *yellow* ketone $C_{14}H_9FO_2$, which had the spectral properties of a fluorenone derivative (Fig. 1). Also the ultraviolet absorption spectra of the previously mentioned substances (see, *e.g.*, Fig. 2) pointed to the presence of a fluorene system. The yellow ketone $C_{14}H_9FO_2$ must, therefore, be a fluoro-methoxy-fluorenone. Its formula is that of 3-fluoro-6-methoxyfluorenone (V, X = F).

The same series of reactions has been carried out with di-(*p*-chlorophenyl)-trifluoromethylcarbinol

(1) E. D. Bergmann, A. S. Tahori, A. Kaluszyner and S. Reuter, *Nature*, **176**, 266 (1955).

(2) A. Kaluszyner, S. Reuter and E. D. Bergmann, THIS JOURNAL, **77**, 4146 (1955).

(3) A. S. Tahori, *J. Econom. Entomol.*, **48**, 638 (1955).

(4) S. Reuter, S. Cohen, R. Mechoulam, A. Kaluszyner and A. S. Tahori, *Rivista di Parassitol.*, **17**, 125 (1956).

(5) R. Mechoulam, S. Cohen and A. Kaluszyner, *J. Org. Chem.*, **21**, 801 (1956).