

Journal of the IIS

S.A

8

1925

Am 2, N/4

N2C.8A.8

1961/2

JOURNAL

OF THE

Indian Institute of Science.

CONTENTS.

STUDIES IN ESTERIFICATION.

BY

B. V. Bhide and J. J. Sudborough.



DR. M. O. FORSTER, F.R.S., CHAIRMAN OF EDITORIAL BOARD.

JOURNAL
OF THE
INDIAN INSTITUTE OF SCIENCE.

VOLUME I.—(1914-18).

Part I.—Borohydrates. II. On the Radioactivity of the Rocks of the Kolar Gold Fields. III. Lead Cyanide. IV. A Graphical Treatment of the Skin Effect. V. A Method of Predetermining the effect of Field Distortion in Continuous-Current Generators. VI. Some Experiments on Brush Contact Resistance. VII. On Magnesium Boride and Amorphous Boron. VIII. Oil from the Flowers and Leaves of *Lavandula Burmanni*. IX. Oil from the Flowers and Leaves of *Lantana Camara*. X. Borohydrates. Part II.—XI. Studies on Alcoholysis: I. Dilatometric Determination of the Velocity of Alcoholysis in the presence of a large excess of Alcohol. XII. The replacement of Sulphonic Acid groups in Aminosulphonic Acids by Halogen Atoms. XIII. Note on the Dielectric Strength of Samples of Biotite Mica from the Forest of Kodarma. XIV. Additive Compounds of Trinitrobenzene. XV. Additive Compounds of *s*-Trinitrobenzene with Amino Derivatives of Complex Aromatic Hydrocarbons. XVI. Additive Compounds of *s*-Trinitrobenzene with Heterocyclic Compounds containing Nitrogen in the Ring. XVII. The Determination of the Iodine Values of Fats and Oils by Winkler's Bromate Method. XVIII. Chemical Examination of the Root of *Nerium Odorum*. XIX. The Oil Contents of Some South Indian Oil Seed Cakes. XX. Experimental and Analytical Investigations of the actions taking place in a synchronous machine during the starting period. XXI. The Radioactivity of Rocks from the Mysore State.

VOLUME II.—(1918-19).

Part I.—The Training of Students in Applied Chemistry. II. Indian Essential Oils. III. The Oleo-resin from *Hardwickia pinnata*. IV. The Oleo-resin from *Dipterocarpus indicus*. V. i. The Vapour Pressures of Acetone. ii. The Vapour Pressures of concentrated Solutions. VI. Note on the Oil from Compressed Oil Gas. VII. Wood Distillation. Parts i. and ii. VIII. i. Studies on Alcoholysis. ii. Alcoholysis in the absence of a catalyst. IX. Tests for Ganja and other products from *Cannabis indica*. X. Some Experiments on the Cathode Fall. Part i. In Neon and Helium. Part ii. In Argon, Hydrogen and Nitrogen. XI. The Hydrolysis of Napthol Ethers. XII. The Enolisation of Carbonyl Compounds under the Influence of Grignard's Reagents. XIII. Some Enzymes of the Leaf of *Lantana camara*. XIV. A Laboratory Vacuum Film Evaporator. XV. Oil Splitting by Castor Seed Lipase. Parts i. to iv.

VOLUME III.—(1920).

Part I.—Studies on Alcoholysis III. The Alcoholysis of Aromatic Esters and the inhibiting influence of Ortho-substituents. II.—An Automatic Separator for use in Essential Oil Distillation. III.—The Starting Conditions in Synchronous Machines. IV.—Studies in the Fermentation of Cellulose. V.—Tartaric Acid from Tamarinds. VI.—Studies in the Bio-Chemistry of the Mahua Flower. VII.—The Perishing of Paper in Indian Libraries. VIII.—The Conservation of Nitrogen with special reference to Activated Sludge. IX.—Wood Distillation. Part iii. The Distillation of Some Mysore and Baroda Woods and of Certain Waste Products: Part iv. The Tar from Coconut Shells.

Price, Rs. 1-8.]

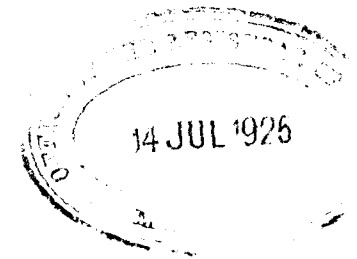
[Vol. 8A, Part VIII, pp. 89 to 127.]

JOURNAL

OF THE

Indian Institute of Science.

CONTENTS.



STUDIES IN ESTERIFICATION.

BY

B. V. Bhide and J. J. Sudborough

DR. M. O. FORSTER, F.R.S., CHAIRMAN OF EDITORIAL BOARD.

196112-

2

A m 2, N 14

N 25-8A-8



STUDIES IN ESTERIFICATION.

By B. V. Bhide and J. J. Sudborough.

In continuation of the work on the relations between the esterification constants of carboxylic acids and their structure¹ the constants of the following acids have been determined at 25° in the presence of excess of anhydrous ethyl alcohol and using hydrogen chloride as catalyst:—

1. *n*-Valeric, 2. caproic, 3. nonoic, 4. decoic, 5. lauric, 6. myristic, 7. palmitic, 8. stearic, 9. erucic, 10. brassidic, 11. allylactic, 12. hydrocinnamic, 13. *isopropyl*acetic, 14. *isobutyl*acetic, 15. *isoamyl*acetic, 16. methyl-*n*-propylacetic, 17. methylallylacetic, 18. methyl-*n*-butylacetic, 19. methylbenzylacetic, 20. methylisopropylacetic, 21. methylisobutylacetic, 22. ethyl-*n*-butylacetic, 23. di-*n*-propylacetic, 24. *cycloheptanemonocarboxylic*, 25. *bicycloheptanemonocarboxylic*, 26. *cyclohexyl*acetic, 27. *cyclohexene*acetic, 28. *cyclohexylidene*acetic, 29. *p*-methyl*cyclohexyl*acetic, 30. *p*-methyl*cyclohexene*acetic, 31. *p*-methyl*cyclohexylidene*acetic, 32. Δ¹-tetrahydrobenzoic, 33. Δ²-tetrahydrobenzoic, 34. *cycloheptatrienecarboxylic*, 35. *o*-toluic, 36. *m*-toluic, 37. *p*-toluic, 38. hexahydro-*m*-toluic, 39. hexahydro-*p*-toluic, 40. β-*cyclohexylpropionic*, 41. Δ²-*cyclohexene*acetic, 42. adipic, 43. pimelic, 44. suberic, 45. α-*cyclogeranic*, 46. β-*cyclogeranic*.

The constants have all been calculated with the aid of Goldschmidt and Udby's formula²

$$k_c t = (r + a) \log_e a/(a - x)$$

where $r = 0.15$, as constant values cannot be obtained when the usual equation for a unimolecular reaction is employed, owing to the disturbing action of the water formed during the course of the reaction.³ In the tables which follow k_1 is used to denote the value of k calculated according to this formula and then recalculated for 0.1 N hydrochloric acid assuming that k_c is proportional to the concentration of the catalyst.

The results given in the present paper, in combination with a few earlier results, lead to the following generalisations.

¹ *Ber.*, 1894, 27, 510, 1580, 3146. *J. Chem. Soc.*, 1898, 73, 81; 1899, 75, 476; 1904, 85, 534; 1905, 87, 1840; 1907, 91, 1033; 1909, 95, 315, 975; 1911, 99, 1307; 1912, 101, 237, 1227. *This Journal*, 1923, 6, 41.

² *Z. physikal. Chem.*, 1907, 60, 728.

³ More recently Goldschmidt, *ibid.*, 1920, 94, 235, has recommended using $r = 0.25$ as the values for k then agree even better. This value has not been used in the present paper, as we wished to compare our values with some earlier values obtained by using $r = 0.15$.

A. SATURATED MONOBASIC ALIPHATIC ACIDS.

1. *Normal chain acids.*—In 1908 attention was drawn to the fact that in the series of normal fatty acids the esterification constant falls from formic to butyric acid and then remains fairly constant as far as stearic acid. The values given at that date refer to methyl alcohol at 15° and were obtained by using the usual equation for a unimolecular reaction.¹

Table I gives the values for the esterification constants of the same acids calculated with the aid of Goldschmidt and Udby's formula for anhydrous ethyl alcohol at 25° and using 0.1 N hydrogen chloride as catalyst.

TABLE I.

Normal fatty acid	k_1
Acetic	0.796 ^a
Propionic	0.550 ^a
Butyric	0.270 ^a
Valeric	0.268
Caproic	0.267
Nonoic	0.270
Decoic	0.269
Lauric	0.272
Myristic	0.269
Palmitic	0.276
Stearic	0.276
Allylacetic	0.274
Erucic	0.279
Brassicic	0.273

These values show that the constant falls from acetic to butyric and then remains practically constant, the values for the acids examined between butyric and stearic vary by only 1.5 per cent. The last three values given in Table I are of interest as they show that an olefine linking in the molecule of a normal fatty acid has little or no effect on the rate of esterification provided it is sufficiently far removed from the carboxylic group.

2.—*The effect on the rate of esterification of attaching a methyl group to the penultimate carbon atom in the molecule of a normal fatty acid.*—The figures given in Table II illustrate this effect.

¹ *J. Chem. Soc.*, 1908, 93, 211.

^a Goldschmidt and Udby, *Z. physikal. Chem.*, 1908, 60, 743.

TABLE II.

Acid	Formula	k_1
Propionic ...	$\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}.$	0.550
isobutyric ...	$\begin{array}{c} \text{CH}_3 \\ \diagup \\ \text{CH} \cdot \text{CO}_2\text{H}. \\ \diagdown \\ \text{CH}_3 \end{array}$	0.156
n-butyric ...	$\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}.$	0.270
isopropylacetic ...	$\begin{array}{c} \text{CH}_3 \\ \diagup \\ \text{CH} \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}. \\ \diagdown \\ \text{CH}_3 \end{array}$	0.0518
n-valeric ...	$\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}.$	0.268
3-methyl-n-valeric.	$\begin{array}{c} \text{CH}_3 \\ \diagup \\ \text{CH} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}. \\ \diagdown \\ \text{CH}_3 \end{array}$	0.247
n-hexoic ...	$\text{CH}_3 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}.$	0.267
4-methyl-n-hexoic ...	$\begin{array}{c} \text{CH}_3 \\ \diagup \\ \text{CH} \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}. \\ \diagdown \\ \text{CH}_3 \end{array}$	0.267

The introduction of the methyl group into the propionic acid molecule reduces the constant from 0.550 to 0.156, in the n-butyric acid molecule from 0.270 to 0.0518, in the n-valeric acid molecule from 0.268 to 0.247 and in the n-hexoic acid molecule it produces no effect.

The numbers are interesting as showing the effect of the proximity of the isopropyl to the carboxylic group on the rate of esterification: isopropylformic = 0.156; isopropylacetic = 0.05; isopropylpropionic = 0.247 and isopropyl-n-butyric = 0.267, thus the isopropyl group has its maximum inhibiting effect when introduced into the acetic acid molecule.

3. *Dialkylated acetic acids.*—Advani and Sudborough have shown that the ethyl and n-propyl groups in dialkylated acetic acids have practically the same effect on the rate of esterification.¹

The values given in Table III show that in the series of dialkylated acetic acids the ethyl group has a greater inhibiting effect than the methyl, but that ethyl, n-propyl, n-butyl, allyl and isobutyl have practically the same effect.

¹ *This Journal*, 1923, 6, 65.

TABLE III.

Acid	k_1
Dimethylacetic ...	0.156
Methylethylacetic ...	0.038
Methyl- <i>n</i> -propylacetic ...	0.0355
Methyl- <i>n</i> -butylacetic ...	0.0345
Methylallylacetic ...	0.0421
Methyl- <i>isopropyl</i> acetic ...	0.0110
Methyl- <i>iso</i> -butylacetic ...	0.0318
Diethylacetic ...	0.0031
Ethyl- <i>n</i> -propylacetic ...	0.0031
Ethyl- <i>n</i> -butylacetic ...	0.00283
Di- <i>n</i> -propylacetic ...	0.00285

It will be observed that the *isopropyl* group has a greater retarding effect than the *n*-propyl or *n*-butyl group as already pointed out in the case of mono-substituted acetic acids (cf. Table II).

The inhibiting effect of the benzyl group is less than that of the ethyl group as can be seen by a comparison of the values given in Table IV.

TABLE IV.

Acid	k_1
<i>n</i> -butyric acid ...	0.270
Hydrocinnamic acid ...	0.321
Methylethylacetic acid ...	0.0384
Methylbenzylacetic acid ...	0.0553

B. SATURATED DIBASIC ALIPHATIC ACIDS.

The values for the constants of the acids of the oxalic series are given in Table V.

TABLE V.

Acid	k_1
Malonic ^{1, 2} ...	...
Succinic ² ...	0.217
Glutaric ² ...	0.314
Adipic ...	0.301
Pimelic ...	0.282
Suberic ² ...	0.264

¹ Diethylmalonic acid cannot be esterified by alcohol and a mineral acid, Preiswerk, *Helv. Chim. Acta.*, 1919, 2, 647.

² Kailan, *Z. physikal. Chem.*, 1913, 85, 715. The value for k for malonic acid is 3.39 and for succinic 4.87. These values are calculated with the aid of the formula $k = \frac{1}{t} \log \frac{a}{a-x}$, and cannot be compared directly with the values for k_1 given in the tables.

³ Butyric acid with a γ -*isopropyl* substituent has a somewhat lower constant, viz., 0.245: cf. Table II.

The value for suberic acid is interesting as it is practically the same as the values for *n*-butyric acid and its homologues, for allyl acetic and for *isopropyl-n*-valeric thus indicating that practically all γ -substituted butyric acids have the same esterification constant, viz., 0.265.

C. CYCLIC ACIDS.

1. *Cycloparaffin monocarboxylic acids*.—The constants for a number of these acids have already been given by Advani and Sudborough and these are incorporated in Table VI together with new values.

The *cyclopropane* acids are the most difficult to esterify and when arranged in the order of increasing readiness of esterification the other cyclic acids follow the order 7, 6, 5 and 4 carbon rings.

TABLE VI.

Acid	Formula	k_1
Bicycloheptanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH} \\ \quad \\ \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH} \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.0137
Cyclopropanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \\ \\ \text{CH}_2 \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.0320
Cycloheptanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \\ \quad \quad \\ \text{CH}_2 \cdot \text{CH}_2 \cdot \text{CH}_2 \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.0499
Cyclohexanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \cdot \text{CH}_2 \\ \quad \\ \text{CH}_2 \cdot \text{CH}_2 \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.0812
Cyclopentanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \cdot \text{CH}_2 \\ \quad \\ \text{CH}_2 \cdot \text{CH}_2 \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.196
Cyclobutanecarboxylic ...	$\begin{array}{c} \text{CH}_2 \\ \\ \text{CH}_2 \end{array} \text{CH} \cdot \text{CO}_2\text{H}$	0.544

With the exception of the *cyclopropane* acids the remaining cyclic acids are esterified more readily than their open chain analogues, e.g., the corresponding dialkylated acetic acids which have the following constants:—

Dimethylacetic = 0.156

Diethylacetic = 0.0031

Methylethylacetic = 0.038

Dipropylacetic = 0.0028

The bicyclic acid which may be regarded as a *cyclohexane* ring condensed with the *cyclopropanecarboxylic* acid ring has a value 1/2.5 that of the simple *cyclopropane* acid.

It has been shown in an earlier paper¹ that *isobutyric* (dimethyl-acetic) acid is esterified about 40 times as rapidly as α -methylacrylic acid, hence it follows that *cyclopropanecarboxylic acid* is esterified about 8 times as rapidly as α -methylacrylic acid, $\begin{matrix} \text{CH}_3 \\ \diagup \\ \text{C} \cdot \text{CO}_2\text{H} \\ \diagdown \\ \text{CH}_3 \end{matrix}$; and as acrylic acid is esterified 3.6 times as rapidly as α -methylacrylic acid it follows that the *cyclopropane acid* is esterified 2.2 times as rapidly as its structural isomeric acrylic acid.

2. *Relative influence of phenyl and cyclohexyl groups on the rate of esterification.*—A comparison of the esterification constants of benzoic acid and the three toluic acids with those of their hexahydro-derivatives shows that the reduction of the benzene ring produces a marked increase in the constant as shown in Table VII.

TABLE VII.

	k_1		k_1
Benzoic ...	0.00242	Hexahydrobenzoic ...	0.0812
<i>p</i> -Toluic ...	0.00197	Hexahydro- <i>p</i> -toluic ...	0.08509
<i>m</i> -Toluic ...	0.00261	Hexahydro- <i>m</i> -toluic ...	0.0827
<i>o</i> -Toluic ...	0.000718	Hexahydro- <i>o</i> -toluic ...	...

The effect of the reduction of the ring when the phenyl group is further removed from the carboxyl group is indicated by the figures given in Table VIII.

TABLE VIII.

	k_1		k_1
Phenylacetic acid ...	0.320	<i>cyclohexylacetic acid</i> ...	0.0809
β -Phenylpropionic acid ...	0.321	β - <i>cyclohexylpropionic acid</i> ...	0.141

3. *Influence of a para-methyl group on the rate of esterification of a cyclic acid.*—The values given in Table IX prove that the presence of a para-methyl group in a cyclic acid usually produces an increase in the esterification constant, with the exception of benzoic acid where the introduction of a *para* methyl produces a slight retardation.

TABLE IX.

	k_1
Benzoic acid ...	0.00242
<i>p</i> -Methylbenzoic acid ...	0.00197
<i>Cyclohexeneacetic acid</i> ...	0.108
<i>p</i> -Methyl- <i>cyclohexeneacetic acid</i> ...	0.118
<i>Cyclohexylideneacetic acid</i> ...	0.00228
<i>p</i> -Methyl- <i>cyclohexylideneacetic acid</i> ...	0.00234
<i>Cyclohexylacetic acid</i> ...	0.0809
<i>p</i> -Methyl- <i>cyclohexylacetic acid</i> ...	0.0899

¹ Sudborough and Davies, *J. Chem. Soc.*, 1909, 98, 976.

Gyr¹ has determined the esterification constants of certain acids in methyl alcohol at 15°. The constants are calculated by the usual formula for unimolecular reactions and are as follows:—

Phenylacetic ...	3.44	Diphenylacetic ...	0.201
<i>p</i> -Methylphenylacetic ...	3.66	Phenyl- <i>p</i> -tolylacetic ...	0.212

4. *Influence of cyclic olefine linkings on the rate of esterification of a monobasic acid.*—In earlier papers² attention has been drawn to the inhibiting effect on esterification produced by the introduction of an $\alpha\beta$ -olefine linking in the case of a monobasic aliphatic acid, whereas the presence of a $\beta\gamma$ -linking in such an acid has a slight accelerating effect. The values obtained when such linkings are present in the case of cyclic acids are given in Table X.

TABLE X.

Acid	Formula	k_1
<i>Cyclohexylacetic</i>	$\text{CH}_2 \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH}_2 \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{CH} \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}$	0.0809
<i>Cyclohexeneacetic</i>	$\text{CH}_2 \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH} \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{C} \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}$	0.108
<i>Cyclohexylideneacetic</i>	$\text{CH}_2 \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH}_2 \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{C} : \text{CH} \cdot \text{CO}_2\text{H}$	0.00228
<i>p</i> -methyl- <i>cyclohexeneacetic</i>	$\text{CH}_3 \cdot \text{CH} \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH} \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{C} \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}$	0.118
<i>p</i> -methyl- <i>cyclohexylideneacetic</i>	$\text{CH}_3 \cdot \text{CH} \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH}_2 \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{C} : \text{CH} \cdot \text{CO}_2\text{H}$	0.00234
Δ^2 -tetrahydrobenzoic	$\text{CH}_2 \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH}_2 \\ \diagdown \text{CH} : \text{CH} \end{matrix} \text{CH} \cdot \text{CO}_2\text{H}$	0.0829
Δ^3 -tetrahydrobenzoic	$\text{CH}_2 \begin{matrix} \diagup \text{CH}_2 \cdot \text{CH}_2 \\ \diagdown \text{CH}_2 \cdot \text{CH} \end{matrix} \text{C} \cdot \text{CO}_2\text{H}$	0.00220
Δ^2 - <i>cyclohexeneacetic acid</i>	$\text{CH}_2 \begin{matrix} \diagup \text{CH} : \text{CH} \\ \diagdown \text{CH}_2 \cdot \text{CH}_2 \end{matrix} \text{CH} \cdot \text{CH}_2 \cdot \text{CO}_2\text{H}$	0.0731

¹ Ber., 1907, 41, 4318.

² *J. Chem. Soc.*, 1905, 87, 1840; 1907, 91, 1033; 1909, 95, 315; 1911, 99, 2307.

The following ratios are of interest :—

TABLE XI.

Ratio of k for saturated acid to k for $\beta\gamma$ -unsaturated acid.

Saturated	$\beta\gamma$ unsaturated	Ratio
<i>n</i> -Hexoic ...	... Hydrosorbic ...	... 1 : 1.32
γ -Phenyl- <i>n</i> -butyric ...	... $\beta\gamma$ -Phenylcrotonic ...	... 1 : 1.57
<i>n</i> -Valeric ...	... Ethylidenepropionic ...	... 1 : 1.40
<i>d</i> -Phenyl- <i>n</i> -valeric ...	... β -Phenylethylidenepropionic ...	... 1 : 2.07
Cyclohexylacetic ...	... Cyclohexeneacetic ...	... 1 : 1.33
Hexahydrobenzoic ...	... Δ^2 -Tetrahydrobenzoic ...	... 1 : 1.02

TABLE XII.

Ratio of k for saturated acid to k for $\alpha\beta$ -unsaturated acid.

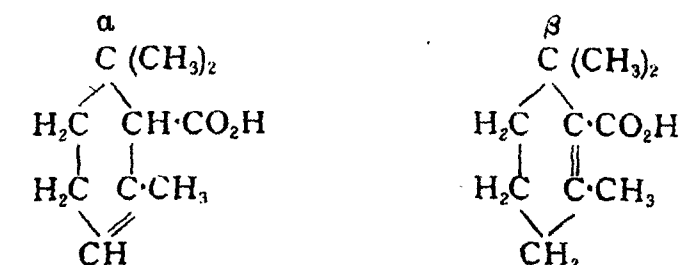
Saturated	Unsaturated	Ratio
<i>n</i> -Butyric ...	... Crotonic ...	... 39 : 1
β -Phenylpropionic ...	... Cinnamic ...	... 50 : 1
Methyl hydrogen succinate ...	... Methyl hydrogen maleate ...	... 20 : 1
<i>n</i> -Valeric ...	... β -Ethylacrylic ...	... 36 : 1
Hydratropic ...	... Atropic ...	... 51 : 1
<i>iso</i> Valeric ...	... Dimethylacrylic ...	... 43 : 1
Methyl- <i>isopropyl</i> acetic ...	... Trimethylacrylic ...	... 30 : 1
β -Furfurylpropionic ...	... β -Furfurylacrylic ...	... 61 : 1
<i>d</i> -Phenyl- <i>n</i> -valeric ...	... Phenylpropylidenecetic ...	... 30 : 1
Cyclohexylacetic ...	... Cyclohexylidenecetic ...	... 35 : 1
ρ -Methyl-cyclohexylacetic ...	... ρ -Methyl-cyclohexylidenecetic ...	... 38 : 1
Hexahydrobenzoic ...	... Δ^1 -Tetrahydrobenzoic ...	... 37 : 1

A comparison of the values for benzoic and cyclohepta- $\Delta^{1:3:5}$ -triene-carboxylic acids is of interest. The Kekulé formula for benzoic acid has a conjugate $\alpha\beta$ -linking and in addition a $\beta\gamma$ -olefine linking, whereas the triene-acid has the $\alpha\beta$ -conjugate linking but no $\beta\gamma$ -linking. From this it would follow that the triene-acid should have a lower constant than the benzoic acid, and as cyclohexanecarboxylic acid has a higher value than cycloheptanecarboxylic acid this should augment the difference. The actual values are benzoic acid = 0.00240 and cycloheptatriene-1-carboxylic acid = 0.00184, giving a ratio 1 : 0.78.

5. Influence of di-ortho-substituents.—In the benzoic series it is well known that two ortho-substituents inhibit esterification by the catalytic process at temperatures between 0° and 70°. So far no

experiments have been made with di-ortho-substituted cyclohexanecarboxylic acids. We took up the study of the esterification of the α and β -cyclogeranic acids with the object of studying the effects of the $\alpha\beta$ and $\beta\delta$ -unsaturated linkings on the rate of esterification; but at 25° with hydrogen chloride as catalyst no ester had been formed at the end of 30 days.

These results show that the ortho-methyl substituents in these acids, as in the benzoic series, have a marked inhibiting effect on esterification.



EXPERIMENTAL.

PREPARATION OF ACIDS.

The following acids were purchased and were purified by distillation or crystallisation:—Propionic, *isovaleric*, caproic, nonoic, decoic, lauric, myristic, palmitic, stearic, erucic, brassidic, benzoic, *o*-toluic, *m*-toluic, *p*-toluic, suberic and adipic. The melting or boiling points of these and of all the other acids after purification and as actually used for esterification are given in Table XIII.

The remaining acids were prepared in these laboratories and the following notes are of value :—

Allylacetic acid.—Allylmalonic acid was obtained in 80 per cent. yield by hydrolysing the ethyl ester with a 50 per cent. excess of alcoholic potash, and when distilled gave an almost theoretical yield of crude allylacetic acid boiling at 176–186°. When fractionated the pure acid was obtained boiling at 185–186° under a pressure of 685 mm.

isoAmylacetic acid.—A 67 per cent. yield of ethyl *iso*amylmalonate was obtained by Hoffmann's method¹ from ethyl malonate and *iso*amyl bromide. The ester was hydrolysed with alcoholic potash and the dibasic acid and distillation gave a 90 per cent. yield of crude *iso*amylacetic acid boiling at 200–206° under a pressure of 685 mm.

¹ Ber., 1890, 28, 1498.

Dialkylated acetic acids.—Most of the acids of this series were prepared by introducing alkyl groups into the ethyl malonate molecule hydrolysing the esters by Perkin's method¹ and distilling the dibasic acid so obtained.

In the preparation of the alkylated malonic esters it was found that the water-content of the alcohol employed had a marked effect on the yield of condensation product, as shown by the following results:—In the preparation of ethyl *n*-butylmalonate the yield was 20 per cent. using 95 per cent. alcohol, but rose to 74 per cent. of the theoretical when 99.9 per cent. alcohol was used. In the case of ethyl *isopropyl*-malonate the yield was 58 per cent. of theoretical with 99.7 alcohol and 68 per cent. with 99.9 per cent. alcohol.

For the hydrolysis of the esters the following procedure was adopted:—One part by weight of ester was hydrolysed with twice the theoretical amount of potassium hydroxide dissolved in two parts by weight of 50 per cent. alcohol. The ester was added gradually to the alkali and the whole well shaken. Usually the potassium ethyl salt separated during the course of the reaction and the mixture was heated on the water-bath until this had disappeared, an operation which usually required 4–5 hours. The product was diluted with its own volume of water, evaporated to its original volume and shaken with ether, to remove traces of unsaponified ester; the aqueous solution was acidified with dilute sulphuric acid and again extracted with ether. This method usually gave yields of from 80 to 85 per cent. of the theoretical.

Methyl-n-butylacetic acid.—*n*-Butyl iodide was prepared by Linne-mann's method² from the corresponding alcohol, care being taken to pass in dry hydrogen iodide slowly especially at the beginning of the reaction. The yield was 73 per cent. of the theoretical and the boiling point 125–127° under a pressure of 685 mm. Rasetti's method³ was used for the condensation and the yield of dibasic ester was 74 per cent. of the theoretical. The yield of monobasic acid was practically theoretical.

Ethyl-n-butylacetic acid.—A yield of 74 per cent. of ethyl ethyl-*n*-butylmalonate was obtained as compared with 53 given by Raper.⁴ An 80 per cent. yield of crude monobasic acid boiling at 220–225° under 685 mm. pressure was obtained.

Methyl-n-propylacetic acid.—An 80 per cent. yield was obtained by heating the dibasic acid at 180° and then distilling.

¹ *J. Chem. Soc.*, 1896, 69, 1477.
² *Bull. Soc. chim.*, 1905, [111], 33, 688.

³ *Annalen*, 1872, 161, 198.
⁴ *J. Chem. Soc.*, 1907, 91, 1837.

Methyl-isopropylacetic acid.—The methods, details and yields were much the same as those given by Perkin.¹

Methyl-isobutylacetic acid was prepared by the method given by Burrows and Bentley.²

Methylallylacetic acid.—The ester of the dibasic acid was prepared by methylating ethyl allylmalonate according to the following process:—60 grams of ethyl allylmalonate are added to a well-cooled solution of 7 grams of sodium in 75 cc. of 99.9 per cent. alcohol and to this mixture 50 grams of methyl iodide are added gradually so that the temperature does not rise above 40° and the whole is kept over night. Next day the alcohol is removed, the residue diluted with water and extracted with ether when a 74 per cent. yield of ethyl methylallylmalonate is obtained boiling at 222–226° under 685 mm. pressure. The dibasic acid obtained by hydrolysis with alcoholic potash (1.5 mols.) and subsequent crystallisation from benzene forms leaflets, melting at 98–99°.

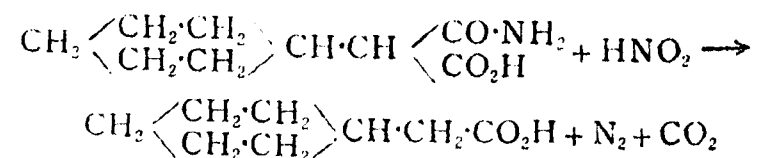
0.127 gram required 17.3 cc. of 0.09069N. potassium hydroxide. Equivalent = 79.1. Theory for $C_7H_{10}O_4$ = 79.

When heated for an hour at 160° and then distilled, it yields crude methylallylacetic acid, which after three fractionations was obtained as a colourless liquid boiling at 188–189° under a pressure of 683 mm. 0.2020 gram required 19.1 cc. of the same alkali for neutralisation. Equivalent = 114.2. Theory for $C_6H_{10}O_2$ = 114.

Cycloheptane-1-carboxylic acid was prepared by Zelinsky's method³ from suberic acid by the following series of reactions:—suberic acid → suberone → suberol → suberyl bromide → magnesium compound → cyclopentanecarboxylic acid. The yield of suberone was the same as that given by Mager,⁴ viz., 30 to 35 per cent. of the theoretical, and the yield of suberol 80 per cent. when prepared by Markownikoff's method.⁵ The yield of suberyl bromide obtained by heating suberol with hydrobromic acid (sp. gr. 1.92) for five hours at 100° was 65 per cent. of the theoretical and the yield of cyclic acid from the bromide, 40 per cent. In this way from 100 grams of suberic acid it is possible to obtain only 5 grams of cycloheptane-carboxylic acid.

³ *J. Chem. Soc.*, 1896, 69, 1477.
⁴ *Ibid.*, 1895, 67, 511.
⁵ *Ber.*, 1902, 35, 2691.
⁶ *Annalen*, 1893, 275, 357.
⁷ *Ibid.*, 1903, 327, 63.

Cyclohexylacetic acid, $\text{CH}_2 \begin{smallmatrix} \text{CH}_2\text{CH}_2 \\ \text{CH}_2\text{CH}_2 \end{smallmatrix} \text{CH}\cdot\text{CH}_2\cdot\text{CO}_2\text{H}$, has been obtained by Wallach¹ by reducing ethyl cyclohexanolacetate with zinc dust, hydrogen bromide and glacial acetic acid with a yield of 48 per cent. of the weight of the ester taken. It has also been prepared by Perkin² by condensing cyclohexyl bromide with ethyl sodiummalonate, hydrolysing and removing carbon dioxide; but the yield of dibasic ester is only 33 per cent. of the theoretical. A third method consists in using ethyl cyanoacetate in place of ethyl malonate, but the yields are even lower. The method we have adopted and found convenient is the treatment of Robinson's cyclohexylmalonamic acid³ with sodium nitrite in 90 per cent. sulphuric acid solution.



For this purpose 25 grams of cyclohexylmalonamic acid were dissolved in 380 cc. of 90 per cent. sulphuric acid and heated on the water bath until the evolution of carbon dioxide ceased. After cooling to 0°, 15 grams of sodium nitrite in 20 cc. of water was added gradually with continuous stirring; after one hour, the solution was gradually warmed on the water bath and well stirred until evolution of nitrogen and carbon dioxide ceased. On cooling, the mass was diluted with three times its volume of water and extracted three times with ether, the ethereal solution dried and the ether removed. The residue was extracted with sodium carbonate to separate the acid from small amounts of amide which remained undissolved, the clear solution acidified and extracted with ether. A 60 per cent. yield of the crude acid was obtained as a colourless liquid boiling at 228–230° under a pressure of 685 mm.

Attempts were made to reduce the volume of sulphuric acid, but it was found that under such conditions part of the amic acid separated and escaped action.

Cyclohexeneacetic acid, $\text{CH}_2 \begin{smallmatrix} \text{CH}_2\text{CH} \\ \text{CH}_2\text{CH}_2 \end{smallmatrix} \text{C}\cdot\text{CH}_2\cdot\text{CO}_2\text{H}$, was prepared by Wallach's method from cyclohexanone by the three stages⁴:—

Cyclohexanone $\rightarrow$ methyl cyclohexan-1-ol-1-acetate $\rightarrow$ methylcyclohexeneacetate $\rightarrow$ cyclohexeneacetic acid, potassium hydrogen sulphate

¹ *Annalen*, 1907, 353, 295.
² *Ibid.*, 1924, 128, 227.

³ *J. Chem. Soc.*, 1909, 95, 1363.
⁴ Wallach, *Annalen*, 1908, 347, 345.

being used at the second stage and the yield at each stage being 70–80 per cent. of the theoretical.

p-Methyl-cyclohexeneacetic acid¹ was prepared in the same manner from *p*-methylcyclohexanone and the yields were much the same.

Cyclohexylideneacetic acid, $\text{CH}_2 \begin{smallmatrix} \text{CH}_2\text{CH}_2 \\ \text{CH}_2\text{CH}_2 \end{smallmatrix} \text{C}:\text{CH}\cdot\text{CO}_2\text{H}$, and the corresponding *p*-methyl derivative were obtained by heating the hydroxy-acids (2 grams) with acetic anhydride (5 grams) and the yield of unsaturated acid was 2 grams.²

When the experiments were started, no methyl bromoacetate was available and attempts were made to utilise the corresponding ethyl ester, but with boiling benzene as diluent no condensation occurred. It was found, however, that by replacing the benzene by toluene the ethyl bromoacetate, zinc and ketone reacted readily, and the reaction became so brisk that external cooling was necessary. The yield of ethyl cyclohexanolacetate was 77 per cent. of the theoretical and it formed a colourless liquid boiling at 132–135° under a pressure of 11 mm.

Cyclohepta- $\Delta^{1:3:5}$ -triene-1-carboxylic acid, was prepared by Buchner's method³ and the yield was slightly less than that given by this author.

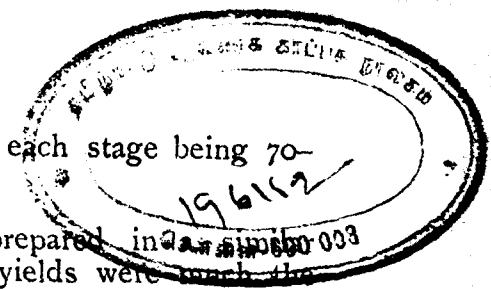
Bicycloheptanecarboxylic acid or 1-B 1:3, cycloheptane-2-carboxylic acid, $\text{CH}_2\text{CH}_2\text{CH} \begin{smallmatrix} \text{CH}_2\text{CH}_2\text{CH} \\ \text{CH}_2\text{CH}_2\text{CH} \end{smallmatrix} \text{CH}\cdot\text{CO}_2\text{H}$.—The ester of this acid was prepared by condensing ethyl diazoacetate with tetrahydrobenzene obtained from cyclohexanol and potassium hydrogen sulphate as recommended by Brunel.⁴

Fifteen grams of the tetrahydrobenzene and 7.5 of the diazo-ester were heated in a sealed tube at 130–135° for eight hours. The tetrahydrobenzene was distilled off on the water bath, the residue steam-distilled and the distillate extracted three times with ether. The residue after removal of the ether was distilled and the fraction boiling at 112–115° under a pressure of 11 mm. collected separately. From 25 grams of diazo-ester 8 grams of the bicyclic ester were obtained, a yield considerably higher than that obtained by condensing benzene with ethyl diazoacetate. For the hydrolysis of the ester the following process was adopted:—8 grams of the ester were boiled

¹ Wallach, *Annalen*, 1909, 365, 263.
² *Ber.*, 1901, 34, 990.

³ Wallach, *Annalen*, 1909, 365, 261, 266.
⁴ *Bull. Soc. chim.*, 1905, [111], 33, 270.

Am 2, 214
1925-20-8



on the water bath with 10 grams of potassium hydroxide, 20 cc. of water and 10 cc. of alcohol for two hours, the mixture was then made faintly acid with dilute hydrochloric acid and again just alkaline with dilute sodium carbonate. The alcohol was removed by evaporation on the water bath. The residue was cooled to 0° and oxidized with 1 per cent. permanganate solution until a permanent pink colour was obtained, the hydrated manganese oxide was removed and carefully washed and the clear filtrate acidified with dilute hydrochloric acid. The precipitate (4 grams), which melted at 70° after drying, was crystallised twice from 50 per cent. alcohol and obtained as feathery long needles melting at 97.5–98°.

The yield of acid obtained by hydrolysing the ester with sodium ethoxide was not so good.

0.1012 grs. of the acid required 15.3 cc. of 0.09279 N. sodium hydroxide solution. Equivalent = 140. $C_8H_{12}O_2$ requires 140.

Δ^1 -Tetrahydrobenzoic acid was prepared by Aschan's method of removing hydrogen bromide from α -bromo-hexahydrobenzoic acid.¹ The yield of bromo-acid was 70 per cent. of the theoretical and the yield of crude tetrahydro-acid 80 per cent. of the theoretical.

Δ^2 -Tetrahydrobenzoic acid was obtained by reducing benzoic acid by Aschan's method.²

p-Methylcyclohexylacetic acid, $CHMe\langle\begin{smallmatrix} CH_2 \cdot CH_2 \\ CH_2 \cdot CH_2 \end{smallmatrix}\rangle CH \cdot CH_2CO_2H$.—The method adopted was that due to Hope and Perkin,³ but as they give few details, the following notes may be of value:—A 60 per cent. yield of β -bromo-*p*-methylcyclohexylacetic acid was obtained by treating the corresponding β -hydroxy-acid with aqueous hydrobromic acid saturated at 0°.

10 grams of the bromo-acid were dissolved in 10 cc. of 98 per cent. alcohol together with 5 cc. of glacial acetic acid and a few drops of concentrated hydrochloric acid; 2.1 grams of magnesium turnings were added and the temperature kept below 30°. When all the magnesium had dissolved, the product was steam-distilled and the distillate treated with cold dilute permanganate to destroy any unsaturated acid present. The yield of saturated acid was 4 grams or 57 per cent. of the theoretical.

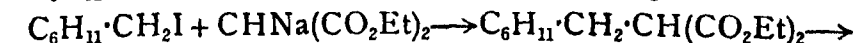
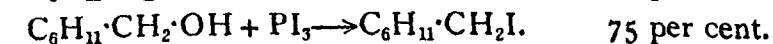
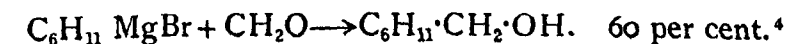
¹ *Annalen*, 1892, 271, 267.

² *Ibid.*, 234.

³ *J. Chem. Soc.*, 1908, 93, 1080.

Δ^2 -Cyclo-hexeneacetic acid, $CH_2\langle\begin{smallmatrix} CH : CH \\ CH_2 \cdot CH_2 \end{smallmatrix}\rangle CH \cdot CH_2 \cdot CO_2H$, was prepared by van Eykmann's method.¹ Tetrahydrobenzene dissolved in its own volume of dry chloroform was treated at 0° with the theoretical quantity of dry bromine in the form of a 20 per cent. chloroform solution. The yield of 1:2-dibromocyclohexane² was 95 per cent. of the theoretical and this was treated in the usual manner with ethyl disodiummalonate (1 mol.) in absolute alcohol, and an 84 per cent. yield of ethyl Δ^2 -cyclohexenemalonate was obtained, boiling at 150–152° under 3 mm. pressure; the dibasic acid melting at 164° was obtained by hydrolysing the ester with alcoholic potash and was decomposed by heating with a free flame for 30 minutes under a pressure of 30 mm. and finally distilled under a pressure of 8 mm. At 105–115° the lactone distilled over and at 125–127° the monobasic acid in a yield of 62 per cent. of the theoretical.

β -Cyclohexylpropionic acid, $C_6H_{11} \cdot CH_2 \cdot CH_2 \cdot CO_2H$.—Zelinsky's method³ was adopted. The yields in the various stages were as follows:—



$C_6H_{11} \cdot CH_2 \cdot CH(CO_2H)_2$, 75 per cent. and in the decomposition of the dibasic to the monobasic acid the yield was nearly theoretical.

Hexahydro-*m*-toluic acid.—Zelinsky's method⁵ was adopted and the yields were similar to those given by this author.

Hexahydro-*p*-toluic acid.—This was prepared from *p*-methylcyclohexyl bromide⁶ by means of magnesium and carbon dioxide in dry ethereal solution. From 40 grams of bromide only 4 grams of transhexahydro-*p*-toluic acid melting at 110° were obtained.⁷

α and β -cyclogeranic acids were prepared by Tiemann's method.⁸

¹ *Chem. Week.*, 1909, 6, 699.

² Baeyer, *Annalen*, 1894, 278, 108.

³ *Ber.*, 1908, 41, 2676.

⁴ *Bull. Soc. chim.*, 1906, [111], 35, 547.

⁵ *Ber.*, 1902, 35, 2689.

⁶ Hope and Perkin, *J. Chem. Soc.*, 1909, 95, 1367.

⁷ Cf. Perkin, *ibid.*, 1911, 99, 536.

⁸ *Ber.* 1893, 26, 2716; 1900, 33, 881.

TABLE XIII.

No.	Acid	Boiling point in degrees Centigrade	Pressure in mm. (unc.)	Melting point in degrees Centigrade	Esterification constant k_1 for 0.1 hydrochloric acid
1	<i>n</i> -Valeric	180-181	685	...	0.268
2	<i>n</i> -Caproic	198-199	685	...	0.267
3	Nonole	245-246	685	...	0.270
4	Decoic	148-150	9	...	0.269
5	Lauric	...	...	43-43.5	0.272
6	Myristic	...	...	53.5	0.269
7	Palmitic	...	...	61-62	0.276
8	Stearic	...	...	68.5-69	0.276
9	Erucic	...	...	32-32.5	0.279
10	Brassicic	...	...	58.5-59	0.273
11	Allylacetic	184-185	683	...	0.274
12	Hydrocinnamic	...	...	47.5	0.321
13	<i>iso</i> Propylacetic	151-152	683	...	0.0518
14	<i>iso</i> Butylacetic	199-201	683	...	0.247
15	<i>iso</i> Amylacetic	205-207	683	...	0.267
16	Methyl- <i>n</i> -propylacetic	190-191	683	...	0.0393
17	Methylallylacetic	188-189	683	...	0.0421
18	Methyl- <i>n</i> -butylacetic	203-205	683	...	0.0345
19	Methylbenzylacetic	150-152	8	...	0.0553
20	Methyl- <i>iso</i> propylacetic	184-186	683	...	0.0110
21	Methyl- <i>iso</i> butylacetic	203-204	683	...	0.0318
22	Ethyl- <i>n</i> -butylacetic	221-222	683	...	0.00283
23	Di- <i>n</i> -propylacetic	219-220	683	...	0.00285
24	<i>cyclo</i> Heptanecarboxylic	137-139	14	...	0.0499
25	<i>bicyclo</i> Heptanecarboxylic	...	...	97.5-98	0.0137
26	<i>cyclo</i> Hexylacetic	230-231	683	...	0.0809
27	<i>cyclo</i> Hexeneacetic	137-138	11	36-37	0.108
28	<i>cyclo</i> Hexylideneacetic	...	...	91.5-92	0.00228
29	<i>p</i> -Methyl <i>cyclo</i> hexylacetic	...	...	71-72	0.0999
30	<i>p</i> -Methyl <i>cyclo</i> hexeneacetic	130-132	10	39-40	0.118
31	<i>p</i> -Methyl <i>cyclo</i> hexylideneacetic	...	...	62-63	0.00234
32	Δ^1 -Tetrahydrobenzoic	238-240	683	...	0.00220
33	Δ^2 -Tetrahydrobenzoic	130-132	30	...	0.0829
34	<i>cyclo</i> Heptatrienecarboxylic	...	...	55-56	0.00184
35	<i>o</i> -Toluic	...	...	102	0.000718
36	<i>m</i> -Toluic	...	...	110	0.00261
37	<i>p</i> -Toluic	...	...	176-177	0.00197
38	Hexahydro- <i>m</i> -toluic	128-130	11	...	0.0827
39	Hexahydro- <i>p</i> -toluic	134-136	15	110	0.0850
40	β - <i>cyclo</i> Hexylpropionic	140-142	10	...	0.141
41	Δ^2 - <i>cyclo</i> Hexeneacetic	125-127	8	...	0.0731
42	Adipic	...	...	149-150	0.301
43	Pimelic	...	...	103	0.282
44	Suberic	...	...	140	0.264
45	α - <i>cyclo</i> Geranic	...	...	93	nil.
46	β - <i>cyclo</i> Geranic	...	...	104-105	nil.

In this table all temperatures given were determined with the aid of short normal thermometers, so that the temperatures given may be taken as corrected temperatures.

In the following tables dealing with the acids 1-44 the various columns 1-5 indicate:—

Column

- 1 = Time in hours.
- 2 = Value of $a-x$ in cc.
- 3 = Percentage conversion into ester.
- 4 = Value of k calculated from the usual equation for a uni-molecular reaction.
- 5 = Value of k_c calculated from equation on p. 89.
- A = Normality of the organic acid.
- B = Normality of the alkali used for titration.
- C = Normality of the hydrogen chloride.
- a = Number of cc. of the alkali required for neutralising the organic acid in 10 cc. of the solution at zero time.¹

1. *n*-Valeric Acid.

A=0.07099 N		C=0.0886 N		A=0.07950 N		C=0.04282 N			
B=0.09279 N		a=7.65		B=0.08738 N		a=9.1			
1	2	3	4	5	1	2	3	4	5
0.1	6.60	13	0.642	0.229	0.20	7.9	13	0.307	0.110
0.2	5.65	26	0.658	0.247	0.50	6.3	30	0.320	0.119
0.3	4.90	35	0.645	0.243	0.75	5.4	40	0.302	0.116
0.5	3.80	50	0.607	0.238	1.00	4.6	49	0.296	0.117
0.9	2.40	68	0.559	0.231	1.50	3.5	61	0.276	0.114
1.5	1.20	84	0.536	0.233	2.00	2.6	71	0.272	0.115

Mean value of k_c = 0.237 = 0.115
Mean value of k_1 = 0.267 = 0.268

¹ In a few cases, marked with an asterisk in the tables 20 cc. were used.

2. *n*-Caproic Acid.

A=0.1272 N B=0.06425 N					A=0.1217 N B=0.06425 N				
C=0.0408 N $\alpha=19.8$					C=0.06646 N $\alpha=18.95$				
1	2	3	4	5	1	2	3	4	5
0.30	16.35	17	0.277	0.103	0.25	14.70	22	0.441	0.168
0.50	14.35	27	0.280	0.108	0.60	10.45	45	0.431	0.179
0.74	12.50	37	0.270	0.109	0.83	8.45	55	0.421	0.183
1.15	9.95	49	0.260	0.110	1.00	7.35	61	0.411	0.183
1.70	7.65	61	0.243	0.109	1.25	6.05	68	0.397	0.182
2.50	5.25	73	0.236	0.110	1.75	4.15	78	0.378	0.180
...	...	...	...	...	2.40	2.65	82	0.356	0.179

Mean value of k_c = 0.108
Mean value of k_1 = 0.265

= 0.179
= 0.269

3. *n*-Nonoic Acid.

A = 0.1838 N B = 0.06425 N					A = 0.09668 N B = 0.06425 N				
C = 0.0395 N $\alpha = 28.60$					C = 0.03534 N $\alpha = 15.05$				
1	2	3	4	5	1	2	3	4	5
0.17	25.6	10	0.281	0.104	0.20	13.30	11	0.268	0.0960
0.40	22.1	22	0.280	0.111	0.57	10.70	28	0.259	0.0985
0.67	19.3	32	0.255	0.106	0.87	9.25	38	0.243	0.0951
1.00	16.8	41	0.231	0.102	1.10	8.10	46	0.244	0.0984
1.40	14.0	51	0.222	0.603	1.40	7.15	52	0.231	0.0948
1.80	11.9	58	0.212	0.103	2.20	4.90	67	0.222	0.0962
...	...	...	...	...	3.33	2.90	80	0.215	0.0985

Mean value of k_c = 0.105
Mean value of k_1 = 0.266

= 0.0968
= 0.274

4. *n*-Decoic Acid.

A = 0.1320 N B = 0.06425 N					A = 0.09548 N B = 0.08718 N				
C = 0.03855 N $\alpha = 20.55$					C = 0.09292 N $\alpha = 10.95$				
1	2	3	4	5	1	2	3	4	5
0.28	17.1	16	0.285	0.106	0.10	9.50	13	0.618	[0.223]
0.50	15.1	26	0.268	0.104	0.25	7.60	30	0.634	0.242
0.75	13.1	36	0.261	0.106	0.45	5.85	46	0.605	0.243
1.08	11.2	45	0.248	0.105	0.70	4.25	61	0.587	0.249
1.42	9.5	53	0.237	0.103	1.00	3.05	72	0.555	0.245
1.83	7.8	62	0.230	0.104	1.50	1.65	84	0.548	0.256
2.33	6.1	70	0.225	0.105	...	...	...	...	...

Mean value of k_c = 0.105
Mean value of k_1 = 0.272

= 0.247
= 0.266

5. *Lauric Acid.*

A = 0.06874 N B = 0.06425 N					A = 0.08095 N B = 0.06425 N				
C = 0.01414 N $\alpha = 10.7$					C = 0.0302 N $\alpha = 12.6$				
1	2	3	4	5	1	2	3	4	5
0.30	9.85	7.9	0.120	[0.422]	0.25	11.0	12.7	0.236	0.0844
0.50	9.45	11.6	0.108	0.0383	0.60	9.3	26.1	0.220	0.0814
1.00	8.40	21.4	0.105	0.0384	1.00	7.7	38.8	0.214	0.0823
1.80	7.10	33.6	0.099	0.0374	1.25	6.9	47.6	0.209	0.0819
2.25	6.30	41.1	0.102	0.0389	1.60	6.1	53.9	0.204	0.0829
3.00	5.45	49.1	0.098	0.0380	2.00	5.0	60.3	0.201	0.0827
4.25	4.25	60.0	0.094	0.0378	...	...	...	...	...

Mean value of k_c = 0.0381
Mean value of k_1 = 0.270

= 0.0826
= 0.0273

6. *Myristic Acid.*

A = 0.09057 N B = 0.06425 N					A = 0.1047 N B = 0.06425 N				
C = 0.0385 N a = 14.1					C = 0.03212 N a = 16.3				
1	2	3	4	5	1	2	3	4	5
0.25	12.10	14	0.266	0.0995	0.17	14.90	8.5	0.234	0.0845
0.42	10.60	24	0.278	0.0994	0.40	13.20	19.0	0.229	0.0868
0.75	9.00	36	0.260	0.100	0.97	10.10	38	0.223	0.0887
1.08	7.55	46	0.250	0.104	1.40	8.25	49	0.211	0.0876
1.33	6.60	53	0.252	0.104	1.75	7.05	56	0.208	0.0885
1.67	5.60	60	0.241	0.104	2.25	5.70	65	0.203	0.0886
1.83	4.40	68	0.231	0.104	3.00	4.25	73	0.195	0.0884

Mean value of k_c = 0.102
Mean value of k_1 = 0.265

= 0.0876
= 0.272

7. *Palmitic Acid.*

A = 0.02891 N B = 0.06425 N					A = 0.02859 N B = 0.06425 N				
C = 0.02212 N a = 4.5					C = 0.04015 N a = 4.45				
1	2	3	4	5	1	2	3	4	5
0.20	4.10	9	0.202	[0.0704]	0.20	3.85	13	0.315	0.110
0.50	3.65	18	0.180	0.0640	0.40	3.35	24	0.308	0.109
0.85	3.20	28	0.174	0.0620	0.60	2.90	34	0.310	0.111
1.20	2.85	36	0.165	0.0593	1.00	2.15	51	0.316	0.115
1.40	2.65	41	0.164	0.0592	1.25	1.85	57	0.305	0.112
2.10	2.05	54	0.164	0.0595	2.50	0.85	80	0.289	0.109

Mean value of k_c = 0.0608
Mean value of k_1 = 0.275

= 0.111
= 0.276

8. *Stearic Acid.*

A = 0.0157 N B = 0.03077 N					A = 0.0185 N B = 0.0355 N				
C = 0.06276 N a = 5.1					C = 0.02308 N a = 5.2				
1	2	3	4	5	1	2	3	4	5
0.1	4.6	10	0.448	[0.156]	0.25	4.60	12	0.213	[0.0740]
0.3	3.6	30	0.504	0.177	0.80	3.70	29	0.185	0.0650
0.5	3.0	41	0.461	0.163	1.25	3.05	41	0.185	0.0658
0.7	2.4	53	0.468	0.166	1.75	2.50	52	0.182	0.0650
0.9	1.9	63	0.477	0.171	2.50	1.90	63	0.175	0.0632
1.5	1.0	80	0.471	0.172	3.50	1.25	73	0.177	0.0646

Mean value of k_c = 0.170
Mean value of k_1 = 0.271

= 0.0647
= 0.280

9. *Erucic Acid.*

A = 0.03918 N B = 0.06425 N					A = 0.04336 N B = 0.06425 N				
C = 0.04318 N a = 6.1					C = 0.07516 N a = 6.75				
1	2	3	4	5	1	2	3	4	5
0.17	5.30	13	0.358	0.126	0.25	4.8	28	0.592	0.214
0.40	4.50	26	0.330	0.118	0.60	2.8	58	0.637	[0.241]
0.70	3.65	40	0.318	0.117	1.00	1.9	72	0.551	0.214
1.00	2.90	52	0.323	0.120	1.20	1.5	77	0.544	0.214
1.30	2.40	60	0.312	0.118	1.80	0.8	88	0.515	0.208
2.00	1.50	72	0.305	0.118	2.50	0.5	92	0.521	0.216

Mean value of k_c = 0.119
Mean value of k_1 = 0.275

= 0.213
= 0.283

10. Brassidic Acid.

A = 0.01296 B = 0.0355 N					C = 0.02165 N a = 7.3*					A = 0.01526 N B = 0.0355 N					C = 0.02165 N a = 4.3				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.50	5.8	20	0.200	[0.0687]	0.25	3.90	9	0.170	0.0589	0.25	3.90	9	0.170	0.0589	0.25	3.90	9	0.170	0.0589
1.25	4.4	39	0.176	0.0616	0.75	3.20	25	0.171	0.0600	0.75	3.20	25	0.171	0.0600	0.75	3.20	25	0.171	0.0600
2.20	3.2	56	0.163	0.0578	1.35	2.55	40	0.168	0.0594	1.35	2.55	40	0.168	0.0594	1.35	2.55	40	0.168	0.0594
2.70	2.6	64	0.166	0.0592	2.10	1.90	55	0.169	0.0602	2.10	1.90	55	0.169	0.0602	2.10	1.90	55	0.169	0.0602
3.25	2.2	69	0.160	0.0573	2.70	1.55	63	0.164	0.0589	2.70	1.55	63	0.164	0.0589	2.70	1.55	63	0.164	0.0589
4.50	1.4	80	0.159	0.0575	3.5	1.10	74	0.169	[0.0612]	3.5	1.10	74	0.169	[0.0612]	3.5	1.10	74	0.169	[0.0612]

Mean value of k_c = 0.0587
Mean value of k_1 = 0.271

= 0.0595
= 0.275

11. Allylacetic Acid.

A = 0.1104 N B = 0.08726 N					C = 0.07575 N a = 12.65					A = 0.1081 N B = 0.08726 N					C = 0.02790 N a = 12.4				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.1	10.05	20	0.589	0.214	0.10	11.8	4.8	0.215	[0.0699]	0.10	11.8	4.8	0.215	[0.0699]	0.10	11.8	4.8	0.215	[0.0699]
0.3	8.55	32	0.567	[0.221]	0.33	10.55	14	0.210	0.0767	0.33	10.55	14	0.210	0.0767	0.33	10.55	14	0.210	0.0767
0.5	6.95	45	0.520	0.213	0.67	9.1	26	0.202	0.0762	0.67	9.1	26	0.202	0.0762	0.67	9.1	26	0.202	0.0762
0.7	5.60	55	0.505	0.212	1.00	7.9	36	0.196	0.0764	1.00	7.9	36	0.196	0.0764	1.00	7.9	36	0.196	0.0764
1.1	3.85	69	0.469	0.211	1.50	6.6	46	0.183	0.0748	1.50	6.6	46	0.183	0.0748	1.50	6.6	46	0.183	0.0748
1.5	2.80	77	0.400	0.205	2.50	5.2	58	0.168	0.0730	2.50	5.2	58	0.168	0.0730	2.50	5.2	58	0.168	0.0730

Mean value of k_c = 0.211
Mean value of k_1 = 0.278

= 0.0754
= 0.270

* 20 cc. of solution used for titrating

12. Hydrocinnamic Acid.

A = 0.09603 N B = 0.09281 N					C = 0.0808 N a = 10.35					A = 0.1206 N B = 0.09348 N					C = 0.0934 a = 12.9				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.1	8.75	15	0.728	0.264	0.1	10.7	17	0.812	0.300	0.1	10.7	17	0.812	0.300	0.1	10.7	17	0.812	0.300
0.2	7.50	27	0.698	0.263	0.2	9.0	30	0.782	0.304	0.2	9.0	30	0.782	0.304	0.2	9.0	30	0.782	0.304
0.4	5.80	43	0.628	0.250	0.3	7.6	41	0.766	0.311	0.3	7.6	41	0.766	0.311	0.3	7.6	41	0.766	0.311
0.7	3.80	63	0.621	0.257	0.5	5.8	55	0.692	0.293	0.5	5.8	55	0.692	0.293	0.5	5.8	55	0.692	0.293
1.0	2.70	73	0.583	0.259	0.7	4.5	63	0.653	0.295	0.7	4.5	63	0.653	0.295	0.7	4.5	63	0.653	0.295
1.4	1.70	83	0.560	0.260	1.4	2.1	83	0.564	[0.280]	1.4	2.1	83	0.564	[0.280]	1.4	2.1	83	0.564	[0.280]

Mean value of k_c = 0.259
Mean value of k_1 = 0.320

= 0.301
= 0.322

13. isoValeric Acid.

A = 0.1494 N B = 0.09279 N					C = 0.09128 N a = 16.1					A = 0.1229 N B = 0.09279 N					C = 0.0385 N a = 13.25				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.5	13.9	13	0.128	0.0471	0.25	12.7	4.6	0.0736	[0.0258]	0.25	12.7	4.6	0.0736	[0.0258]	0.25	12.7	4.6	0.0736	[0.0258]
1.0	12.2	24	0.120	0.0468	1.00	11.65	12	0.0558	0.0202	1.00	11.65	12	0.0558	0.0202	1.00	11.65	12	0.0558	0.0202
2.0	9.7	39	0.113	0.0462	2.00	10.35	21	0.0537	0.0203	2.00	10.35	21	0.0537	0.0203	2.00	10.35	21	0.0537	0.0203
3.5	6.8	57	0.107	0.0491	3.50	8.85	33	0.0500	0.0198	3.50	8.85	33	0.0500	0.0198	3.50	8.85	33	0.0500	0.0198
5.0	5.2	67	0.098	0.0475	5.00	7.65	42	0.0477	0.0196	5.00	7.65	42	0.0477	0.0196	5.00	7.65	42	0.0477	0.0196
7.0	3.6	77	0.093	0.0475	6.00	6.95	47	0.0467	0.0196	6.00	6.95	47	0.0467	0.0196	6.00	6.95	47	0.0467	0.0196

Mean value of k_c = 0.0473
Mean value of k_1 = 0.0518

= 0.0199
= 0.0517

14. isoButylacetic Acid.

A = 0.09603 N B = 0.09281 N					C = 0.1109 N a = 10.35					A = 0.05475 N B = 0.09281 N					C = 0.0689 N a = 5.9				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.25	7.05	31	0.666	[0.255]	0.1	5.30	10	0.466	0.164	0.1	5.30	10	0.466	0.164	0.1	5.30	10	0.466	0.164
0.50	4.85	53	0.658	0.271	0.3	4.20	28	0.492	0.180	0.3	4.20	28	0.492	0.180	0.3	4.20	28	0.492	0.180
0.75	3.70	64	0.595	[0.255]	0.6	3.15	46	0.454	0.172	0.6	3.15	46	0.454	0.172	0.6	3.15	46	0.454	0.172
0.90	2.95	71	0.606	0.267	1.1	1.90	67	0.438	0.177	1.1	1.90	67	0.438	0.177	1.1	1.90	67	0.438	0.177
1.00	2.50	75	0.617	0.277	1.5	1.40	76	0.417	0.168	1.5	1.40	76	0.417	0.168	1.5	1.40	76	0.417	0.168
1.50	1.45	85	0.579	0.267	3.3	0.30	94	0.393	0.169	3.3	0.30	94	0.393	0.169	3.3	0.30	94	0.393	0.169

Mean value of k_c = 0.271 = 0.172
Mean value of k_1 = 0.244 = 0.249

15. isoAmylacetic Acid.

A = 0.08760 N B = 0.08718 N					C = 0.0777 N a = 10.05					A = 0.09763 N B = 0.08718 N					C = 0.0425 N a = 11.2				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.1	8.65	13	0.650	[0.234]	0.1	8.65	13	0.650	0.113	0.2	9.70	13	0.312	0.113	0.2	9.70	13	0.312	0.113
0.2	7.75	22	0.563	0.208	0.2	7.75	22	0.563	0.112	0.4	8.50	24	0.302	0.112	0.4	8.50	24	0.302	0.112
0.4	6.10	39	0.542	0.211	0.4	6.10	39	0.542	0.114	0.7	7.00	37	0.292	0.114	0.7	7.00	37	0.292	0.114
0.6	4.90	51	0.519	0.210	0.6	4.90	51	0.519	0.113	1.0	5.90	47	0.278	0.113	1.0	5.90	47	0.278	0.113
0.8	3.85	61	0.518	0.217	0.8	3.85	61	0.518	0.111	1.5	4.55	59	0.261	0.111	1.5	4.55	59	0.261	0.111
1.1	3.05	69	0.471	0.202	1.1	3.05	69	0.471	0.111	2.5	2.70	75	0.247	0.111	2.5	2.70	75	0.247	0.111

Mean value of k_c = 0.210 = 0.112
Mean value of k_1 = 0.270 = 0.264

16. Methyl-n-propylacetic Acid.

A = 0.1256 N B = 0.1004 N					C = 0.0930 N a = 25.03*					A = 0.1187 N B = 0.1004 N					C = 0.09565 N a = 23.65 *				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1	19.58	21	0.1066	[0.0403]	1	19.58	21	0.1066	[0.0403]	1	18.40	22	0.1090	[0.0411]	1	18.40	22	0.1090	[0.0411]
2	16.08	35	0.0961	0.0385	2	16.08	35	0.0961	0.0385	2	15.00	36	0.0987	0.0394	2	15.00	36	0.0987	0.0394
3	13.58	45	0.0883	0.0371	3	13.58	45	0.0883	0.0371	3	12.45	47	0.0928	0.0387	3	12.45	47	0.0928	0.0387
4	11.48	54	0.0846	0.0367	4	11.48	54	0.0846	0.0367	4	10.55	55	0.0876	0.0378	4	10.55	55	0.0876	0.0378
5	9.88	60	0.0807	0.0360	5	9.88	60	0.0807	0.0360	5	8.95	62	0.0844	0.0375	5	8.95	62	0.0844	0.0375
6	8.58	65	0.0777	0.0354	6	8.58	65	0.0777	0.0354	6	7.70	67	0.0812	0.0369	6	7.70	67	0.0812	0.0369
8	6.48	74	0.0736	0.0349	8	6.48	74	0.0736	0.0349	8	5.85	73	0.0758	0.0358	8	5.85	73	0.0758	0.0358

Mean value of k_c = 0.0364 = 0.0377
Mean value of k_1 = 0.0391 = 0.0394

17. Methylallylacetic Acid.

A = 0.1308 N B = 0.09281 N					C = 0.1058 N a = 14.1					A = 0.08886 N B = 0.09354 N					C = 0.1098 N a = 9.5				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.40	12.60	10	0.122	0.0441	0.40	12.60	10	0.122	0.0441	0.5	8.15	14	0.133	0.0478	0.5	8.15	14	0.133	0.0478
1.10	10.50	25	0.116	0.0448	1.10	10.50	25	0.116	0.0448	1.0	7.2	24	0.120	0.0446	1.0	7.2	24	0.120	0.0446
1.70	9.00	31	0.115	0.0463	1.70	9.00	31	0.115	0.0463	1.5	6.3	33	0.119	0.0455	1.5	6.3	33	0.119	0.0455
2.35	7.80	44	0.109	0.0460	2.35	7.80	44	0.109	0.0460	2.0	5.5	42	0.118	0.0466	2.0	5.5	42	0.118	0.0466
3.60	6.05	57	0.102	0.0452	3.60	6.05	57	0.102	0.0452	3.0	4.4	53	0.111	0.0454	3.0	4.4	53	0.111	0.0454
4.50	5.10	63	0.098	0.0450	4.50	5.10	63	0.098	0.0450	4.5	3.1	66	0.108	0.0461	4.5	3.1	66	0.108	0.0461
6.00	4.10	70	0.089	0.0423	6.00	4.10	70	0.089	0.0423	...	...	...	...	...	...	...	...	...	...

Mean value of k_c = 0.0448 = 0.0460
Mean value of k_1 = 0.0423 = 0.0419

* 20 cc. solution used for titrating.

18. Methyl-n-butylacetic Acid.

A = 0.1079 N B = 0.06425 N					C = 0.09637 N $\alpha = 16.8$					A = 0.06725 N B = 0.1004 N					C = 0.1013 N $\alpha = 13.4^*$				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1.00	13.70	18	0.0854	[0.0308]	1.0	10.65	20	0.0999	0.0361	1.0	10.65	20	0.0999	0.0361	1.0	10.65	20	0.0999	0.0361
2.00	11.40	32	0.0842	0.0321	2.0	8.45	36	0.1001	[0.0376]	2.0	8.45	36	0.1001	[0.0376]	2.0	8.45	36	0.1001	[0.0376]
3.00	9.50	44	0.0825	0.0334	3.00	7.10	47	0.0919	0.0353	3.0	7.10	47	0.0919	0.0353	3.0	7.10	47	0.0919	0.0353
4.25	7.70	54	0.0796	0.0335	4.25	5.25	60	0.0814	[0.0325]	4.25	5.25	60	0.0814	[0.0325]	4.25	5.25	60	0.0814	[0.0325]
5.00	6.80	59	0.0785	0.0338	5.00	3.45	74	0.0843	0.0350	5.0	3.45	74	0.0843	0.0350	5.0	3.45	74	0.0843	0.0350
7.00	5.05	69	0.0745	0.0335	7.00	2.55	80	0.0806	0.0340	7.0	2.55	80	0.0806	0.0340	7.0	2.55	80	0.0806	0.0340
9.00	3.90	76	0.0705	0.0326	9.00	1.95	84	0.0706	0.0345	9.0	1.95	84	0.0706	0.0345	9.0	1.95	84	0.0706	0.0345
Mean value of k_c					= 0.0332					= 0.0350					= 0.0332				
Mean value of k_1					= 0.0344					= 0.0345					= 0.0344				

19. Methylbenzylacetic Acid.

A = 0.1086 N B = 0.09279 N					C = 0.0897 N $\alpha = 11.7$					A = 0.1494 N B = 0.09279 N					C = 0.0837 N $\alpha = 16.1$				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.4	10.5	10	0.118	[0.0421]	0.2	15	6.8	0.154	[0.0547]	0.2	15	6.8	0.154	[0.0547]	0.2	15	6.8	0.154	[0.0547]
1.0	8.6	26	0.134	0.0507	0.5	13.9	13	0.128	0.0471	0.5	13.9	13	0.128	0.0471	0.5	13.9	13	0.128	0.0471
1.6	7.8	33	0.125	[0.0429]	1.0	12.2	24	0.121	0.0468	1.0	12.2	24	0.121	0.0468	1.0	12.2	24	0.121	0.0468
2.1	6.6	43	0.118	0.0480	2.0	9.7	39	0.110	0.0462	2.0	9.7	39	0.110	0.0462	2.0	9.7	39	0.110	0.0462
3.0	5.3	54	0.114	0.0484	3.4	6.8	57	0.110	[0.0505]	3.4	6.8	57	0.110	[0.0505]	3.4	6.8	57	0.110	[0.0505]
5.0	3.4	62	0.107	0.0485	5.0	5.2	68	0.098	0.0473	5.0	5.2	68	0.098	0.0473	5.0	5.2	68	0.098	0.0473
...	...	...	...	...	7.0	3.6	77	0.070	0.0475	7.0	3.6	77	0.070	0.0475	7.0	3.6	77	0.070	0.0475
Mean value of k_c					= 0.0488					= 0.0470					= 0.0488				
Mean value of k_1					= 0.0544					= 0.0561					= 0.0544				

* 20 cc. of solution used for titrating.

20. Methylisopropylacetic Acid.

A = 0.1136 N B = 0.08738 N					C = 0.1183 N $\alpha = 13.0$					A = 0.1199 N B = 0.08718 N					C = 0.0681 N $\alpha = 13.75$				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2.0	11.1	14	0.0343	0.0126	1.0	13.10	4.7	0.0210	0.00742	1.0	13.10	4.7	0.0210	0.00742	1.0	13.10	4.7	0.0210	0.00742
4.0	9.4	27	0.0352	0.0135	2.5	12.35	10	0.0186	[0.00676]	2.5	12.35	10	0.0186	[0.00676]	2.5	12.35	10	0.0186	[0.00676]
6.6	7.9	30	0.0329	0.0131	6.0	11.55	16	0.0126	[0.00465]	6.0	11.55	16	0.0126	[0.00465]	6.0	11.55	16	0.0126	[0.00465]
9.0	6.6	49	0.0327	0.0132	10.0	8.95	34	0.0186	0.00742	10.0	8.95	34	0.0186	0.00742	10.0	8.95	34	0.0186	0.00742
13.0	5.2	60	0.0306	0.0133	15.0	7.45	45	0.0177	0.00740	15.0	7.45	45	0.0177	0.00740	15.0	7.45	45	0.0177	0.00740
23.0	3.2	75	0.0261	0.0123	20.0	6.20	55	0.0172	0.00745	20.0	6.20	55	0.0172	0.00745	20.0	6.20	55	0.0172	0.00745
Mean value of k_c					= 0.0130					= 0.0130					= 0.00742				
Mean value of k_1					= 0.0110					= 0.0110					= 0.0109				

21. Methylisobutylacetic Acid.

A = 0.09928 N B = 0.09279 N					C = 0.1030 N $\alpha = 10.7$					A = 0.09371 N B = 0.09279 N					C = 0.1013 N $\alpha = 10.1$				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.7	9.20	14	0.0939	0.0335	0.6	8.90	11	0.0915	0.0329	0.6	8.90	11	0.0915	0.0329	0.6	8.90	11	0.0915	0.0329
1.2	8.40	21	0.0875	0.0326	1.2	7.85	22	0.0911	0.0337	1.2	7.85	22	0.0911	0.0337	1.2	7.85	22	0.0911	0.0337
2.2	7.00	34	0.0837	0.0324	2.0	6.70	33	0.0891	0.0341	2.0	6.70	33	0.0891	0.0341	2.0	6.70	33	0.0891	0.0341
3.0	6.25	41	0.0777	0.0309	3.0	5.80	42	0.0803	0.0317	3.0	5.80	42	0.0803	0.0317	3.0	5.80	42	0.0803	0.0317
4.5	4.80	55	0.0773	0.0324	3.8	5.10	49	0.0780	0.0316	3.8	5.10	49	0.0780	0.0316	3.8	5.10	49	0.0780	0.0316
6.0	3.80	64	0.0749	0.0323	5.5	3.90	61	0.0751	0.0317	5.5	3.90	61	0.0751	0.0317	5.5	3.90	61	0.0751	0.0317
Mean value of k_c					= 0.0324					= 0.0324					= 0.0326				
Mean value of k_1					= 0.0314					= 0.0314					= 0.0322				

22. Ethyl-n-butylacetic Acid.

A=0.1702 N B=0.1004 N					C=0.2510 N a=16.95					A=0.1004 N B=0.1004 N					C=0.1815 N a=10.0				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4	14.10	17	0.0200	[0.00759]	7.58	7.55	25	0.0166	[0.00609]	7.58	7.55	25	0.0166	[0.00609]	7.58	7.55	25	0.0166	[0.00609]
8	12.30	21	0.0174	0.00702	18.66	5.75	42	0.0129	0.00515	18.66	5.75	42	0.0129	0.00515	18.66	5.75	42	0.0129	0.00515
12	10.65	37	0.0167	0.00710	27.00	4.65	53	0.0123	0.00510	27.00	4.65	53	0.0123	0.00510	27.00	4.65	53	0.0123	0.00510
24	7.35	56	0.0151	0.00713	43.00	3.15	68	0.0119	0.00510	43.00	3.15	68	0.0119	0.00510	43.00	3.15	68	0.0119	0.00510
32	5.95	64	0.0142	0.00703	70.00	1.65	83	0.0115	0.00525	70.00	1.65	83	0.0115	0.00525	70.00	1.65	83	0.0115	0.00525

Mean value of k_c = 0.00797Mean value of k_1 = 0.00282

= 0.00515

= 0.00283

23. Dipropylacetic Acid.

A=0.1131 N B=0.1004 N					C=0.1729 N a=22.55*					A=0.1772 N B=0.1004 N					C=0.1835 N a=17.65				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
7.00	18.40	17	0.0126	0.00467	6.00	14.85	15	0.0125	[0.00472]	6.00	14.85	15	0.0125	[0.00472]	6.00	14.85	15	0.0125	[0.00472]
13.75	15.05	33	0.0122	0.00500	17.25	10.95	37	0.0121	0.00515	17.25	10.95	37	0.0121	0.00515	17.25	10.95	37	0.0121	0.00515
23.00	12.00	46	0.0119	0.00492	24.00	9.05	54	0.0121	0.00551	24.00	9.05	54	0.0121	0.00551	24.00	9.05	54	0.0121	0.00551
30.00	10.05	55	0.0117	0.00500	30.20	8.05	60	0.0112	0.00531	30.20	8.05	60	0.0112	0.00531	30.20	8.05	60	0.0112	0.00531
37.00	8.75	61	0.0110	0.00486	41.25	6.35	64	0.0103	0.00516	41.25	6.35	64	0.0103	0.00516	41.25	6.35	64	0.0103	0.00516
48.00	7.05	68	0.0106	0.00475	50.00	5.45	60	0.0102	0.00525	50.00	5.45	60	0.0102	0.00525	50.00	5.45	60	0.0102	0.00525

Mean value of k_c = 0.00487Mean value of k_1 = 0.00281

= 0.00528

= 0.00288

* 20 cc. of solution used for titrating.

24. cycloHeptanecarboxylic Acid.

A=0.07484 N B=0.09354 N					C=0.09354 N a=8.0					A=0.08886 N B=0.09354					C=0.09354 N a=9.5				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.5	6.9	13	0.128	0.0460	0.5	8.15	14	0.133	0.0479	0.5	8.15	14	0.133	0.0479	0.5	8.15	14	0.133	0.0479
1.0	6.0	25	0.125	0.0460	1.0	7.20	24	0.120	0.0447	1.0	7.20	24	0.120	0.0447	1.0	7.20	24	0.120	0.0447
1.5	5.1	36	0.130	0.0490	1.5	6.30	33	0.119	0.0455	1.5	6.30	33	0.119	0.0455	1.5	6.30	33	0.119	0.0455
2.0	4.5	43	0.124	0.0483	2.0	5.50	42	0.118	0.0466	2.0	5.50	42	0.118	0.0466	2.0	5.50	42	0.118	0.0466
3.0	3.6	55	0.115	0.0461	3.0	4.40	53	0.111	0.0454	3.0	4.40	53	0.111	0.0454	3.0	4.40	53	0.111	0.0454
4.5	2.4	70	0.121	0.0480	4.5	3.10	67	0.108	0.0461	4.5	3.10	67	0.108	0.0461	4.5	3.10	67	0.108	0.0461
6.0	1.7	78	0.112	0.0482	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Mean value of k_c = 0.0473Mean value of k_1 = 0.0506

= 0.0460

= 0.0491

25. bicycloHeptanecarboxylic Acid.

A=0.07377 N B=0.09279 N					C=0.1109 N a=7.95					A=0.1116 N B=0.09279 N					C=0.2610 N a=12.0				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3	6.05	23	0.0401	0.0145	0.2	11.4	5	0.1115	[0.0393]	0.2	11.4	5	0.1115	[0.0393]	0.2	11.4	5	0.1115	[0.0393]
5	4.90	38	0.0420	0.0149	0.6	10.4	13	0.1036	0.0377	0.6	10.4	13	0.1036	0.0377	0.6	10.4	13	0.1036	0.0377
7	4.25	46	0.0385	0.0151	1.1	9.4	22	0.0964	0.0361	1.1	9.4	22	0.0964	0.0361	1.1	9.4	22	0.0964	0.0361
10	3.35	57	0.0375	0.0150	1.9	8.0	33	0.0926	0.0362	1.9	8.0	33	0.0926	0.0362	1.9	8.0	33	0.0926	0.0362
22	1.35	83	0.0350	0.0152	3.8	5.7	63	0.0851	0.0359	3.8	5.7	63	0.0851	0.0359	3.8	5.7	63	0.0851	0.0359
30	0.75	90	0.0341	0.0153	6.5	3.7	69	0.0786	0.0355	6.5	3.7	69	0.0786	0.0355	6.5	3.7	69	0.0786	0.0355

Mean value of k_c = 0.0150Mean value of k_1 = 0.0135

= 0.0363

= 0.0139

26. cycloHexylacetic Acid.

A = 0.1199 N B = 0.08718 N					C = 0.0929 N a = 13.75					A = 0.1173 N B = 0.08718 N					C = 0.09337 N a = 13.45				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.10	13.10	4.7	0.210	0.0739	0.25	11.85	11	0.220	0.0794	0.25	11.85	11	0.220	0.0794	0.25	11.85	11	0.220	0.0794
0.25	12.35	10	0.186	[0.0673]	0.50	10.05	25	0.251	[0.0966]	0.50	10.05	25	0.251	[0.0966]	0.50	10.05	25	0.251	[0.0966]
0.40	11.55	16	0.191	0.0697	1.00	8.70	35	0.189	0.0751	1.00	8.70	35	0.189	0.0751	1.00	8.70	35	0.189	0.0751
1.00	8.95	34	0.186	0.0743	1.50	7.10	47	0.185	0.0768	1.50	7.10	47	0.185	0.0768	1.50	7.10	47	0.185	0.0768
1.50	7.45	45	0.177	0.0739	2.00	5.90	56	0.178	0.0772	2.00	5.90	56	0.178	0.0772	2.00	5.90	56	0.178	0.0772
2.00	6.20	55	0.172	0.0750	2.75	4.40	67	0.177	0.0800	2.75	4.40	67	0.177	0.0800	2.75	4.40	67	0.177	0.0800
...	...	...	...	...	4.25	2.90	78	0.157	0.0753	4.25	2.90	78	0.157	0.0753	4.25	2.90	78	0.157	0.0753

Mean value of k_c = 0.0734
Mean value of k_1 = 0.0790

= 0.0773
= 0.0828

27. cycloHexeneacetic Acid.

A = 0.09874 N B = 0.08738 N					C = 0.1013 N a = 11.3					A = 0.1126 N B = 0.8738 N					C = 0.1084 N a = 12.9				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.17	10.0	14	0.312	0.112	0.2	11.1	13	0.325	0.119	0.2	11.1	13	0.325	0.119	0.2	11.1	13	0.325	0.119
0.40	8.6	26	0.296	0.111	0.4	9.4	27	0.344	0.131	0.4	9.4	27	0.344	0.131	0.4	9.4	27	0.344	0.131
0.70	7.2	38	0.279	0.109	0.7	7.9	38	0.304	0.122	0.7	7.9	38	0.304	0.122	0.7	7.9	38	0.304	0.122
1.00	6.2	47	0.261	0.105	1.0	6.6	48	0.291	0.121	1.0	6.6	48	0.291	0.121	1.0	6.6	48	0.291	0.121
1.50	4.8	59	0.248	0.104	1.5	5.2	59	0.263	0.114	1.5	5.2	59	0.263	0.114	1.5	5.2	59	0.263	0.114
2.20	3.3	71	0.243	0.107	3.0	3.2	75	0.201	0.094	3.0	3.2	75	0.201	0.094	3.0	3.2	75	0.201	0.094

Mean value of k_c = 0.108
Mean value of k_1 = 0.107

= 0.117
= 0.108

28. cycloHexylideneacetic Acid.

A = 0.1054 N B = 0.08718 N					C = 0.2504 N a = 12.1					A = 0.1064 N B = 0.08718 N					C = 0.1920 N a = 12.2				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
9	10.8	10	0.0164	0.00591	3.25	11.1	9	0.0126	0.00451	3.25	11.1	9	0.0126	0.00451	3.25	11.1	9	0.0126	0.00451
7	9.4	22	0.0159	0.00585	7	10	18	0.0123	0.00454	7	10	18	0.0123	0.00454	7	10	18	0.0123	0.00454
11	8.4	30	0.0144	0.00554	11	9.15	25	0.0113	0.00429	11	9.15	25	0.0113	0.00429	11	9.15	25	0.0113	0.00429
22	6.1	49	0.0135	0.00558	22	7.1	41	0.0107	0.00429	22	7.1	41	0.0107	0.00429	22	7.1	41	0.0107	0.00429
31	4.6	61	0.0132	0.00585	30	5.9	51	0.0105	0.00439	30	5.9	51	0.0105	0.00439	30	5.9	51	0.0105	0.00439
47	3.1	74	0.0126	0.00573	71	2.8	77	0.0090	0.00416	71	2.8	77	0.0090	0.00416	71	2.8	77	0.0090	0.00416
72	1.8	85	0.0114	0.00551	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Mean value of k_c = 0.00571
Mean value of k_1 = 0.00228

= 0.00436
= 0.00227

29. p-Methylcyclohexylacetic Acid.

A = 0.09535 N B = 0.09348 N					C = 0.08863 N a = 10.2					A = 0.1019 N B = 0.09348 N					C = 0.09135 N a = 10.9				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.2	9.20	10	0.224	0.0798	0.2	9.8	10	0.231	0.0823	0.2	9.8	10	0.231	0.0823	0.2	9.8	10	0.231	0.0823
0.4	8.30	18	0.224	0.0821	0.5	8.5	22	0.216	0.0804	0.5	8.5	22	0.216	0.0804	0.5	8.5	22	0.216	0.0804
0.9	6.70	33	0.203	0.0781	0.9	7.0	35	0.214	0.0837	0.9	7.0	35	0.214	0.0837	0.9	7.0	35	0.214	0.0837
1.6	5.05	50	0.191	0.0777	1.4	5.6	48	0.207	0.0844	1.4	5.6	48	0.207	0.0844	1.4	5.6	48	0.207	0.0844
2.5	3.60	64	0.181	0.0775	2.2	4.1	62	0.193	0.0830	2.2	4.1	62	0.193	0.0830	2.2	4.1	62	0.193	0.0830
3.5	2.50	74	0.177	0.0780	3.5	2.5	77	0.183	0.0835	3.5	2.5	77	0.183	0.0835	3.5	2.5	77	0.183	0.0835

Mean value of k_c = 0.0789
Mean value of k_1 = 0.0890

= 0.0829
= 0.0898

30. *p*-Methylcyclohexeneacetic Acid.

A = 0.1013 N B = 0.08738 N					C = 0.1013 N a = 11.6					A = 0.09949 N B = 0.08738 N					C = 0.1013 N a = 11.1				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.25	9.60	17	0.329	0.120	0.2	9.50	14	0.338	0.124	0.2	9.50	14	0.338	0.124	0.2	9.50	14	0.338	0.124
0.50	8.05	30	0.317	0.120	0.4	8.20	26	0.328	0.126	0.4	8.20	26	0.328	0.126	0.4	8.20	26	0.328	0.126
1.00	5.90	48	0.294	0.120	0.7	6.70	39	0.313	0.125	0.7	6.70	39	0.313	0.125	0.7	6.70	39	0.313	0.125
1.50	4.50	60	0.274	0.118	1.0	5.60	49	0.297	0.123	1.0	5.60	49	0.297	0.123	1.0	5.60	49	0.297	0.123
2.00	3.40	70	0.266	0.118	1.5	4.40	60	0.268	0.115	1.5	4.40	60	0.268	0.115	1.5	4.40	60	0.268	0.115
3.00	2.20	80	0.240	0.112	2.0	3.35	69	0.260	0.116	2.0	3.35	69	0.260	0.116	2.0	3.35	69	0.260	0.116

Mean value of k_c = 0.118
Mean value of k_1 = 0.117

= 0.121
= 0.119

31. *p*-Methylcyclohexylideneacetic Acid.

A = 0.09249 N B = 0.08718 N					C = 0.1920 N a = 10.6					A = 0.09598 N B = 0.08718 N					C = 0.1920 N a = 11.0				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4	9.4	11	0.0130	0.00467	3	9.85	10	0.0160	[0.00592]	3	9.85	10	0.0160	[0.00592]	3	9.85	10	0.0160	[0.00592]
8	8.4	20	0.0127	0.00465	7	8.95	18	0.0129	0.00470	7	8.95	18	0.0129	0.00470	7	8.95	18	0.0129	0.00470
22	6.2	41	0.0114	0.00417	11	8.20	25	0.0117	0.00435	11	8.20	25	0.0117	0.00435	11	8.20	25	0.0117	0.00435
33	4.6	56	0.0113	0.00455	22	6.10	44	0.0115	0.00464	22	6.10	44	0.0115	0.00464	22	6.10	44	0.0115	0.00464
48	3.3	66	0.0105	0.00459	30	5.25	52	0.0107	0.00439	30	5.25	52	0.0107	0.00439	30	5.25	52	0.0107	0.00439
72	2.1	80	0.0099	0.00442	51	3.50	68	0.0099	0.00424	51	3.50	68	0.0099	0.00424	51	3.50	68	0.0099	0.00424
...	...	...	...	...	72	2.70	75	0.0098	[0.00380]	72	2.70	75	0.0098	[0.00380]	72	2.70	75	0.0098	[0.00380]

Mean value of k_c = 0.00451
Mean value of k_1 = 0.00235

= 0.00447
= 0.00232

32. Δ^1 -Tetrahydrobenzoic Acid.

A = 0.1038 N B = 0.09348 N					C = 0.1197 N a = 11.1					A = 0.1720 N B = 0.09348 N					C = 0.1197 N a = 18.4				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
10	9.5	14	0.00676	[0.00245]	10	15.5	15	0.00745	[0.00281]	10	15.5	15	0.00745	[0.00281]	10	15.5	15	0.00745	[0.00281]
20	8.1	27	0.00684	0.00259	20	13.5	26	0.00673	0.00270	20	13.5	26	0.00673	0.00270	20	13.5	26	0.00673	0.00270
30	7.0	36	0.00667	0.00262	30	11.9	35	0.00631	0.00266	30	11.9	35	0.00631	0.00266	30	11.9	35	0.00631	0.00266
61	4.7	57	0.00612	0.00259	40	10.5	42	0.00609	0.00267	40	10.5	42	0.00609	0.00267	40	10.5	42	0.00609	0.00267
110	2.6	76	0.00573	0.00263	50	9.6	47	0.00565	0.00254	50	9.6	47	0.00565	0.00254	50	9.6	47	0.00565	0.00254
152	1.6	85	0.00561	0.00265	100	5.5	70	0.00524	0.00268	100	5.5	70	0.00524	0.00268	100	5.5	70	0.00524	0.00268

Mean value of k_c = 0.00262
Mean value of k_1 = 0.00219

= 0.00265
= 0.00221

33. Δ^2 -Tetrahydrobenzoic Acid.

A = 0.1395 N B = 0.09363 N					C = 0.0975 N a = 14.9					A = 0.1374 N B = 0.09348 N					C = 0.0975 N a = 14.7				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.25	13.2	11	0.210	[0.0766]	0.2	13.30	9.5	0.217	0.0782	0.2	13.30	9.5	0.217	0.0782	0.2	13.30	9.5	0.217	0.0782
0.60	11.2	24	0.206	0.0800	0.4	12.20	17	0.202	[0.0754]	0.4	12.20	17	0.202	[0.0754]	0.4	12.20	17	0.202	[0.0754]
0.90	9.8	34	0.202	0.0817	0.8	10.00	31	0.209	0.0836	0.8	10.00	31	0.209	0.0836	0.8	10.00	31	0.209	0.0836
1.30	8.4	43	0.191	0.0806	1.1	8.95	39	0.196	0.0808	1.1	8.95	39	0.196	0.0808	1.1	8.95	39	0.196	0.0808
1.90	6.7	55	0.182	0.0814	1.5	7.55	48	0.192	0.0832	1.5	7.55	48	0.192	0.0832	1.5	7.55	48	0.192	0.0832
2.30	5.8	61	0.178	0.0817	2.0	6.50	55	0.177	0.0789	2.0	6.50	55	0.177	0.0789	2.0	6.50	55	0.177	0.0789
3.40	4.1	72	0.164	0.0801	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Mean value of k_c = 0.0809
Mean value of k_1 = 0.0829

= 0.0809
= 0.0829

34. *β*-cycloHeptatrienecarboxylic Acid.

A = 0.09372 N B = 0.09279 N					C = 0.2210 N a = 10.1					A = 0.08351 N B = 0.09279 N					C = 0.2210 N a = 9.0				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	8.8	13	0.0120	0.00430	6	7.7	14	0.0113	0.00406	16	6.0	33	0.0110	0.00417	34	4.2	53	0.0097	0.00392
10	7.9	22	0.0108	0.00394	16	6.0	33	0.0110	0.00417	46	3.1	66	0.0101	0.00423	70	2.1	77	0.0090	0.00394
30	5.1	49	0.0099	0.00400	46	3.1	66	0.0101	0.00423	70	2.1	77	0.0090	0.00394	105	1.0	89	0.0091	0.00413
40	4.2	58	0.0095	0.00398	70	2.1	77	0.0090	0.00394										
72	2.3	77	0.0090	0.00400															
100	1.4	86	0.0086	0.00401															

Mean value of k_c = 0.00404
Mean value of k_1 = 0.00183

35. *o*-Toluic Acid.

A = 0.1021 N B = 0.09279 N					C = 0.1485 N a = 11.0					A = 0.09001 N B = 0.09279 N					C = 0.1485 N a = 9.7				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
24	9.40	14	0.00284	0.00103	24	8.30	14	0.00282	0.00102	49	6.95	28	0.00295	0.00111	73	6.00	38	0.00285	0.00111
47	8.10	26	0.00283	0.00106	49	6.95	28	0.00295	0.00111	119	4.70	51	0.00264	0.00107	144	4.10	57	0.00259	0.00107
74	6.95	36	0.00269	0.00105	73	6.00	38	0.00285	0.00111	216	2.70	72	0.00257	0.00112	264	2.20	77	0.00244	0.00109
96	6.10	44	0.00266	0.00108	119	4.70	51	0.00264	0.00107										
120	5.40	50	0.00257	0.00106	144	4.10	57	0.00259	0.00107										
200	3.70	66	0.00236	0.00104	216	2.70	72	0.00257	0.00112										
...	...	...	...	...	264	2.20	77	0.00244	0.00109										

Mean value of k_c = 0.00105
Mean value of k_1 = 0.000710

36. *m*-Toluic Acid.

A = 0.09835 N B = 0.09279 N					C = 0.02002 N a = 10.6					A = 0.1048 N B = 0.09279 N					C = 0.2877 N a = 11.3				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4	9.35	11	0.0136	[0.00489]	4	9.35	11	0.0136	[0.00489]	1.5	10.5	7	0.0212	0.00753	10	7.70	27	0.0138	0.00523
10	7.70	27	0.0138	0.00523	10	7.70	27	0.0138	0.00523	12.0	6.8	39	0.0184	0.00743	25	5.10	51	0.0127	0.00523
25	5.10	51	0.0127	0.00523	25	5.10	51	0.0127	0.00523	27.0	3.8	66	0.0175	0.00771	30	4.40	58	0.0127	0.00536
30	4.40	58	0.0127	0.00536	30	4.40	58	0.0127	0.00536	38.0	2.8	75	0.0159	0.00729	36	3.80	64	0.0123	0.00516
36	3.80	64	0.0123	0.00516	36	3.80	64	0.0123	0.00516	46.0	2.1	81	0.0158	0.00747	53	2.50	76	0.0118	0.00536
53	2.50	76	0.0118	0.00536	53	2.50	76	0.0118	0.00536	...	...	...	...	...	62	2.10	80	0.0113	0.00521
62	2.10	80	0.0113	0.00521	62	2.10	80	0.0113	0.00521										

Mean value of k_c = 0.00526
Mean value of k_1 = 0.00263

37. *p*-Toluic Acid.

A = 0.1267 N B = 0.09279 N					C = 0.1485 N a = 13.65					A = 0.1011 N B = 0.09279 N					C = 0.04463 N a = 10.9				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
5	12.4	9	0.0083	0.00299	5	12.4	9	0.0083	0.00299	24	9.5	12	0.00248	0.000897	21	9.5	30	0.0075	0.00294
21	9.5	30	0.0075	0.00294	21	9.5	30	0.0075	0.00294	95	6.7	38	0.00222	0.000876	33	7.9	42	0.0072	0.00297
33	7.9	42	0.0072	0.00297	33	7.9	42	0.0072	0.00297	119	6.0	44	0.00217	0.000877	45	6.7	50	0.0068	0.00294
45	6.7	50	0.0068	0.00294	45	6.7	50	0.0068	0.00294	160	5.0	54	0.00211	0.000880	70	4.9	64	0.0063	0.00289
70	4.9	64	0.0063	0.00289	70	4.9	64	0.0063	0.00289	216	4.0	63	0.00201	0.000869	94	3.8	72	0.0059	0.00279
94	3.8	72	0.0059	0.00279	94	3.8	72	0.0059	0.00279	...	...	...	...	...	118	3.0	78	0.0057	0.00279
118	3.0	78	0.0057	0.00279	118	3.0	78	0.0057	0.00279										

Mean value of k_c = 0.00290
Mean value of k_1 = 0.00195

38. Hexahydro-m-toluic Acid.

A = 0.1113 N B = 0.09348 N					C = 0.0888 N a = 11.9					A = 0.1337 N B = 0.09348 N					C = 0.09556 N a = 14.3				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.2	10.9	8.4	0.191	[0.0679]	0.4	12.0	16	0.190	[0.0706]	0.4	12.0	16	0.190	[0.0706]	0.4	12.0	16	0.190	[0.0706]
0.5	9.5	20	0.196	0.0729	0.5	11.3	21	0.204	0.0775	0.5	11.3	21	0.204	0.0775	0.5	11.3	21	0.204	0.0775
0.7	8.8	26	0.187	0.0712	1.0	9.1	37	0.196	0.0796	1.0	9.1	37	0.196	0.0796	1.0	9.1	37	0.196	0.0796
1.1	7.4	37	0.187	0.746	1.7	7.0	52	0.182	0.0791	1.7	7.0	52	0.182	0.0791	1.7	7.0	52	0.182	0.0791
2.0	5.4	54	0.172	0.728	2.1	6.0	59	0.180	0.0803	2.1	6.0	59	0.180	0.0803	2.1	6.0	59	0.180	0.0803
3.0	3.8	68	0.166	0.742	3.4	3.9	74	0.166	0.0798	3.4	3.9	74	0.166	0.0798	3.4	3.9	74	0.166	0.0798

Mean value of k_c = 0.0731
Mean value of k_1 = 0.0823

= 0.0793
= 0.0830

39. Hexahydro-p-toluic Acid.

A = 0.1113 N B = 0.09348 N					C = 0.1009 N a = 11.9					A = 0.09627 N B = 0.09348 N					C = 0.09348 N a = 10.3				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.20	10.6	10	0.251	0.0903	0.2	9.30	9.7	0.222	0.0789	0.2	9.30	9.7	0.222	0.0789	0.2	9.30	9.7	0.222	0.0789
0.40	9.6	19	0.233	0.0864	0.4	8.40	18	0.221	0.0810	0.4	8.40	18	0.221	0.0810	0.4	8.40	18	0.221	0.0810
0.75	8.1	31	0.222	0.0866	0.9	6.75	34	0.204	0.0776	0.9	6.75	34	0.204	0.0776	0.9	6.75	34	0.204	0.0776
1.00	7.2	39	0.218	0.0874	1.6	5.10	50	0.191	0.0778	1.6	5.10	50	0.191	0.0778	1.6	5.10	50	0.191	0.0778
1.50	5.8	51	0.208	0.0872	2.4	3.60	65	0.190	0.0816	2.4	3.60	65	0.190	0.0816	2.4	3.60	65	0.190	0.0816
2.00	4.9	58	0.192	0.0832	3.3	2.60	74	0.181	0.0809	3.3	2.60	74	0.181	0.0809	3.3	2.60	74	0.181	0.0809
3.00	3.4	71	0.181	0.0826	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Mean value of k_c = 0.0857
Mean value of k_1 = 0.0849

= 0.0796
= 0.0851

40. β -cycloHexylpropionic Acid.

A = 0.1214 N B = 0.09348 N					C = 0.0811 N a = 13.0					A = 0.0888 N B = 0.09348 N					C = 0.1430 N a = 9.5				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.2	11.1	15	0.343	[0.126]	0.10	8.3	13	0.586	0.210	0.10	8.3	13	0.586	0.210	0.10	8.3	13	0.586	0.210
0.5	9.4	28	0.281	0.109	0.20	7.4	20	0.542	0.200	0.20	7.4	20	0.542	0.200	0.20	7.4	20	0.542	0.200
0.8	7.9	39	0.270	0.109	0.35	6.2	35	0.529	0.203	0.35	6.2	35	0.529	0.203	0.35	6.2	35	0.529	0.203
1.1	6.6	49	0.267	0.113	0.50	5.3	44	0.507	0.200	0.50	5.3	44	0.507	0.200	0.50	5.3	44	0.507	0.200
1.5	5.2	60	0.265	0.117	0.70	4.1	57	0.521	0.214	0.70	4.1	57	0.521	0.214	0.70	4.1	57	0.521	0.214
2.5	3.2	75	0.243	0.116	1.10	2.9	70	0.468	0.202	1.10	2.9	70	0.468	0.202	1.10	2.9	70	0.468	0.202

Mean value of k_c = 0.113
Mean value of k_1 = 0.139

= 0.205
= 0.143

41. Δ^2 cycloHexeneacetic Acid.

A = 0.1225 N B = 0.09279 N					C = 0.2070 N a = 13.2					A = 0.1117 N B = 0.09348 N					C = 0.09743 N a = 11.95				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.2	11.0	16	0.396	0.146	0.20	10.8	9.6	0.202	[0.0788]	0.20	10.8	9.6	0.202	[0.0788]	0.20	10.8	9.6	0.202	[0.0788]
0.4	9.1	31	0.404	0.158	0.45	9.8	17	0.195	0.0714	0.45	9.8	17	0.195	0.0714	0.45	9.8	17	0.195	0.0714
0.6	7.9	40	0.372	0.151	0.80	8.5	28	0.185	0.0712	0.80	8.5	28	0.185	0.0712	0.80	8.5	28	0.185	0.0712
0.9	6.3	52	0.357	0.153	1.60	6.4	46	0.170	0.0697	1.60	6.4	46	0.170	0.0697	1.60	6.4	46	0.170	0.0697
1.4	4.4	66	0.341	0.155	2.00	5.5	53	0.168	0.0714	2.00	5.5	53	0.168	0.0714	2.00	5.5	53	0.168	0.0714
1.9	3.3	75	0.317	0.151	4.00	2.9	75	0.153	0.0715	4.00	2.9	75	0.153	0.0715	4.00	2.9	75	0.153	0.0715

Mean value of k_c = 0.152
Mean value of k_1 = 0.0734

= 0.0710
= 0.0728

42. Adipic Acid.

A = 0.1206 N B = 0.09348 N					C = 0.1009 N a = 12.9					A = 0.09545 N B = 0.08718 N					C = 0.0804 N a = 10.95				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.1	10.7	17	0.812	0.300	0.10	9.50	13	0.617	0.223	0.10	9.50	13	0.617	0.223	0.10	9.50	13	0.617	0.223
0.2	9.0	30	0.782	0.305	0.25	7.60	30	0.634	0.242	0.25	7.60	30	0.634	0.242	0.25	7.60	30	0.634	0.242
0.3	7.6	41	0.766	0.312	0.45	5.85	46	0.605	0.243	0.45	5.85	46	0.605	0.243	0.45	5.85	46	0.605	0.243
0.5	5.8	55	0.694	0.300	0.70	4.25	61	0.587	0.249	0.70	4.25	61	0.587	0.249	0.70	4.25	61	0.587	0.249
0.7	4.5	65	0.653	0.295	1.00	3.05	72	0.555	0.245	1.00	3.05	72	0.555	0.245	1.00	3.05	72	0.555	0.245
1.3	2.1	83	0.606	0.300	1.50	1.65	84	0.548	0.256	1.50	1.65	84	0.548	0.256	1.50	1.65	84	0.548	0.256

Mean value of k_c = 0.302
Mean value of k_1 = 0.300

= 0.243
= 0.302

43. Pimelic Acid.

A = 0.1337 N B = 0.09348 N					C = 0.0488 N a = 14.3					A = 0.08786 N B = 0.09348 N					C = 0.0989 N a = 9.4				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.20	12.0	16	0.381	0.141	0.10	7.9	15	0.755	0.273	0.10	7.9	15	0.755	0.273	0.10	7.9	15	0.755	0.273
0.30	11.1	22	0.367	0.140	0.20	6.7	29	0.736	0.276	0.20	6.7	29	0.736	0.276	0.20	6.7	29	0.736	0.276
0.60	9.1	36	0.327	0.133	0.30	5.7	39	0.724	0.281	0.30	5.7	39	0.724	0.281	0.30	5.7	39	0.724	0.281
0.75	8.1	43	0.329	0.138	0.40	4.9	47	0.707	0.281	0.40	4.9	47	0.707	0.281	0.40	4.9	47	0.707	0.281
0.95	7.0	51	0.310	0.142	0.65	3.5	62	0.651	0.276	0.65	3.5	62	0.651	0.276	0.65	3.5	62	0.651	0.276
1.50	5.3	62	0.287	0.132	1.00	2.2	76	0.631	0.278	1.00	2.2	76	0.631	0.278	1.00	2.2	76	0.631	0.278

Mean value of k_c = 0.138
Mean value of k_1 = 0.283

44. Suberic Acid.

A = 0.1194 N B = 0.08718 N					C = 0.09337 N a = 13.7					A = 0.07932 N B = 0.08718 N					C = 0.04345 a = 9.1				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0.1	11.70	14	0.685	0.251	0.20	7.9	13	0.307	0.110	0.20	7.9	13	0.307	0.110	0.20	7.9	13	0.307	0.110
0.2	10.05	22	0.673	0.259	0.50	6.3	30	0.319	0.120	0.50	6.3	30	0.319	0.120	0.50	6.3	30	0.319	0.120
0.4	7.80	41	0.612	0.251	0.75	5.4	40	0.302	0.116	0.75	5.4	40	0.302	0.116	0.75	5.4	40	0.302	0.116
0.7	5.60	59	0.555	0.244	1.00	4.6	49	0.296	0.117	1.00	4.6	49	0.296	0.117	1.00	4.6	49	0.296	0.117
1.0	4.10	70	0.524	0.241	1.50	3.5	61	0.278	0.114	1.50	3.5	61	0.278	0.114	1.50	3.5	61	0.278	0.114
1.4	2.70	80	0.504	0.244	2.00	2.6	71	0.272	0.115	2.00	2.6	71	0.272	0.115	2.00	2.6	71	0.272	0.115

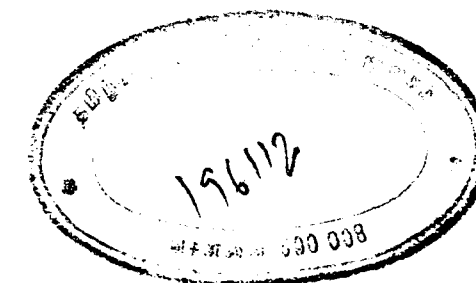
Mean value of k_c = 0.247
Mean value of k_1 = 0.264

= 0.115
= 0.264

In conclusion we wish to thank Dr. H. E. Watson and Messrs. P. Ramaswami Ayyar and B. Sanjiva Rao for helping in revising the calculations.

Department of General and Organic Chemistry,
Indian Institute of Science,
Bangalore.

[Accepted, 4-4-25.]



22.2.25
22.2.25-80-8

- Part III.—The Retting of Coconut Husk for the Production of Coir, by Gilbert J. Fowler and F. Marsden. Price, Re. 1.
- Part IV.—Reactions of Chromates at High Temperatures. Part I. The Synthesis and Decomposition of Calcium, Sodium and Magnesium Chromates in Air, by M. Raman Nayar, H. E. Watson and J. J. Sudborough. Price, Re. 1.
- Part V.—Oil from Mimosa Hexandra: Rayan Oil, by C. K. Patel. Price, As. 12.
- Part VI.—The Relation Between the Iodine Values and Refractive Indices of Hardened Oils. Part II, by H. E. Watson and J. J. Sudborough. Price, As. 12.
- Part VII.—Contributions to the Scientific Study of the Lac Industry. Parts I—VIII, by Gilbert J. Fowler, S. Mahdihassan and M. Sreenivasaya. Price, Rs. 3.
- Part VIII.—I. The Systematic Nomenclature of Polycyclic Carbon Systems, by J. J. Sudborough. II. Polycyclic and Cage Systems of Carbon Compounds, by J. J. Sudborough and P. Ramaswami Ayyar. III. The Systematic Nomenclature of Heterocyclic Compounds including Polycyclic Structures, by J. J. Sudborough. Price, Rs. 4.
- Part IX.—The Use of Mixed Catalysts in the Hydrogenation of Oils, by C. K. Patel. Price, As. 12.
- Part X.—Condensation of Aromatic Amines with Chloroform or Carbon Tetrachloride in the Presence of Finely Divided Copper, by R. C. Shah. Price, Re. 1.
- Part XI.—I. Notes on Bixin, by K. Venkataraman. II. An Alkaloid from Annona Squamosa Leaves, by N. Trimurti. Price, As. 12.
- Part XII.—Iodine as a Catalyst in Reactions Involving Elimination of Hydrogen Halides, by R. D. Desai. Price, Re. 1.
- Part XIII.—Studies Relating to the Symbiosis of Seeds and Bacteria, by Gilbert J. Fowler and Miss R. K. Christie. Price, Rs. 1-8-0.
- Part XIV.—The Bio-Genesis of Mahua Oil, by Gilbert J. Fowler and Talwar Dinanath. Price, Re. 1.
- Part XV.—Contributions to the Scientific Study of the Lac Industry. Parts IX—X, by Gilbert J. Fowler, S. Mahdihassan and M. Sreenivasaya. Price, As. 12.

VOLUME VIII (A)—(1925).

- Part I.—The Photochemical Oxidation of Aromatic Hydrocarbons. I, by J. J. Sudborough, H. E. Watson and B. T. Narayanan. Price, As. 8.
- Part II.—Kachi-Grass Oil, by Bijoor Sanjiva Rao and J. J. Sudborough. Price, Re. 1.
- Part III.—Argemone Oil, by S. Narayana Iyer, J. J. Sudborough and P. Ramaswami Ayyar. Price, As. 12.
- Part IV.—Essential Oil of Cyperus Rotundus, by B. Sanjiva Rao, P. B. Panicker and J. J. Sudborough. Price, As. 8.
- Part V.—Dehydration of Rectified Spirit by means of Anhydrous Calcium Chloride, by J. J. Sudborough and P. Ramaswami Ayyar. Price, As. 8.
- Part VI.—The Hydrolysis of the Amides of $\alpha\beta$ -Unsaturated Acids and of their Saturated Analogues, by A. R. Yathiraja and J. J. Sudborough. Price, Re. 1.
- Part VII.—I. Studies Relating to the Acetone-Producing Organisms, by Gilbert J. Fowler and V. Subramanyan. II. Mahua Flowers as Raw Material for the Acetone-Fermentation Process, by A. G. Gokhale. Price, Re. 1.
- Part VIII.—Studies in Esterification, by B. V. Bhide and J. J. Sudborough. Price, Rs. 1-8-0.