SOME CONSTITUENTS OF ESSENTIAL OILS AND THEIR STRUCTURAL RELATIONS.

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One of the most interesting chapters of organic chemistry is that dealing with the constituents of essential oils. For an understanding of these odoriferous principles it is necessary to be familiar with their structure, and, unfortunately, our present system of structure formulas does not allow the author to make an extensive use of them, for they are not only extremely cumbersome to set into type, but also take too much space, and are therefore, as a rule, omitted from the ordinary textbook and dispensatory. Various makeshifts are sometimes employed to present the structure in a rational formula, but these are usually intelligible only to the initiate and meaningless to the less experienced student. At the same time the succession of C's and H's and O's with small and large numerals intermingled and connected by single and double lines, periods, commas, parentheses and bars, offer a splendid opportunity for the printer's devil and as a result there seems to be not a single textbook in which there is not at one place or another a mistake in the printed rational or structural formula.

The purpose of this paper is two-fold: first, to give an outline of the structural relation among the constituents of essential oils; and second, to illustrate by practical application the advantages of structure symbols, the new chemical notation of organic compounds, by which the responsibility of correctness of a structure is placed upon the author. Without structure symbols it would have taken at least eight to ten times more space to represent the 150 compounds of this paper. The structures of the majority of these compounds can hardly be found in the common textbooks, dispensatories or pharmacopoeia, but a knowledge of them is essential for an understanding of the similarities and differences among these compounds.

While at first sight the hieroglyphic characters of the structure symbols seem strange and difficult, they become, on second thought, quite intelligible, simple and more accurate than the conventional formula. No radical change is involved and no new theory or new conception of structure is developed, for the structure symbols are mainly a convenient geometrical device which eliminate the customary symbols C, H, O and N from the structure formula and represent the atoms of these elements by points from which one, two, three, or four lines, respectively, radiate. The key to the whole system is in the very simple diagram at the top of Plate 1. Wherever a line begins or terminates an atom of hydrogen stands, where two lines come together (an angle) oxygen is situated, where three (or five) lines radiate an atom of nitrogen is located, and where four lines come together or two lines cross an atom of carbon is placed.

Each organic compound belongs to a definite type and a definite class. The seven most important types are given in the second line of Plate 1. In these characteristic structure symbols a shaded circle indicates any radical. The first category of types are the hydrocarbons, which may be aliphatic or aromatic. Next come the alcohols and ethers, the aldehydes and ketones, the acids and esters—all are related to each other by having, respectively, one and two radicals (circles) attached; thus, in the ethers, ketones, and esters the hydrogen of the alco-

PLATE I

PLATE II

PLATE III

STRUCTURE SYMBOLS

hol, aldehyde, and acid is replaced by another organic radical (*e. g.*, methyl, ethyl, phenyl, etc.). The type of an organic compound is an indication of its chemical character and reactivity, while the class to which the compound belongs indicates its general structural characteristics. Saturated compounds contain no double bonds, unsaturated have one or more double bonds. Some compounds representative of classes are given at the lower part of Plate 1. Thus the relation of hexamethylene (13) to benzene (17) and the intermediate compounds (14, 15 or 16) is clearly seen, likewise the chemical name of menthane (18) as 1-methyl-4-isopropyl-hexamethylene. It will also be noticed that menthane (18), the mother substance of the terpenes, differs from camphane (19) in that in the first case the propyl group is outside the ring, and in the second case it is inside the ring; in other words, by swinging the isopropyl group 180° around the fourth carbon atom and connecting the eighth with the first carbon atom, a bridge in the hexamethylene ring is formed.

HYDROCARBONS.

The aliphatic hydrocarbons occurring in essential oils may be derived from octane (6 and 20). By attaching to the 2nd and 6th carbon atom a methyl group, 2,6-dimethyl-octane (21) is formed which contains one assymetric carbon atom, indicated by the dot in the structure symbol. An assymetric C atom is formed whenever the four valencies of C are connected to different groups, thus in 21 the sixth or assymetric carbon atom is connected on the left to the large group, on the right to ethyl, above to methyl, below to hydrogen. A double bond between the 2nd and 3rd C gives 2,6-dimethyl-Δ2-octene (22), where Δ indicates the position of the double bond in the now-accepted nomenclature. This compound likewise contains one assymetric C atom. A second double bond between the 5th and 6th C forms 2,6-dimethyl-Δ2,5-octa-diene (23), in which the sixth C atom is no more assymetric, as it is connected by two valencies to the fifth. A third double bond placed between the 7th and 8th C gives Ocymene (24), which occurs in some essential oils and is isomeric with other aliphatic hydrocarbons occurring in essential oils. The relation of this hydrocarbon is graphically shown in the structure symbols 24, 25, 26 and 27; thus, if the fourth CH_2 group is shown by a heavier line (*c*), and the two methyl groups are marked *a* and *b*, then by connecting *a* with *c* pseudocymene (24) is formed, *b* with *c* gives myrcene (25), and *a* and *b* with *c* gives pseudomyrcene (26). By this turning movement of the double bond various isomeric compounds can be explained, *e. g.*, 30 and 34, 31 and 35, 38 and 42, etc.

Ring formation usually takes place by attaching the first to the sixth carbon atom, thus may be derived from the compound 21: menthane (84), from 22: Δ4(8)-terpene (89), from 23: terpinolene (91), and from 24: Δ2,6,4(8)-cymene. Such ring compounds may be monocyclic (terpene group) or dicyclic (camphene group). To the first group belong the following compounds:

Terpanes, $C_{10}H_{20}$, the most common representative is menthane (84) or para-terpane. The methyl and isopropyl group may also be in the meta-position: *m*-terpane (120), and ortho-position: *o*-terpane, of which 125 is a derivative.

Terpenes, $C_{10}H_{18}$, derived from the terpanes by having a double bond, which may be variously located, either inside the ring (85, 86, 87), or between the ring and the methyl carbon atom (88) or the isopropyl-carbon atom (89), or it may

be outside the ring (90). The more prominent representatives of this group are carvomenthene (85) and menthene (87).

Terpadienes, $C_{10}H_{16}$, contain two double bonds which may be located in 20 different ways relative to each other; only four different positions are shown by the symbols 91, 92, 93 and 96, representing terpinolene, phellandrene, limonene, and pseudophellandrene. Of limonene the dextro-rotatory (94) and laevo-rotatory (95) as well as the inactive (93) varieties are shown.

Terpatrienes, $C_{10}H_{14}$, contain three double bonds, of which the most common one is cymene (97). The other possibilities with three double bonds are $\Delta 2,4,6$, $\Delta 2,5,1(7)$, $\Delta 2,4,1(7)$, $\Delta 2,1(7),4(8)$, $\Delta 2,1(7),8(9)$, and $\Delta 2,1(7),8(10)$. Of terpatetraenes, containing four double bonds, there are the two possibilities $\Delta 1,3,5,8(9)$-methyl-propenyl-benzene, and $\Delta 2,5,1(7),4(8)$, which resembles the quinone type.

To the second group the dicyclic compounds belong:

Camphanes, $C_{10}H_{18}$, in which the bridge may connect the first and fourth (133), second and fifth (134), second and fourth (135), third and fourth (136) carbon atom. Of these fenchane (134) is structurally related to *m*-terpane (120) in the same way as camphane (133) is to *p*-terpane (84).

Camphenes, $C_{10}H_{16}$, is a very important class containing a double bond which may be located between the 1st and 7th carbon atom of 134 = alpha-fenchene (138), or 135 = camphene (139), or between the 6th and 1st C atom of 134 = beta-fenchene (141), or of 135 = pinene (142), or of 136 = carene (143), or it may be located between the 5th and 6th C of 133 = bornylene (140), or finally between the 4th and 5th C of 133 = camphanene (144).

A transition between the monocyclic and dicyclic compounds is formed by thujene (126, 127) and sabinene (128), which differ by a different position of the double bond as shown in the structure symbols.

ALCOHOLS AND PHENOLS.

Both types, alcohols and phenols, contain the OH group, which in the latter case is attached to a benzene ring. The uniform ending of these compounds is -OL. Of aliphatic alcohols occurring in essential oils there is octyl alcohol (28), derived from octane (20), rhodinol (30), derived from 22, citronellol (33, 34), derived from 30 by swinging the double bond from the third to the first carbon atom. Of citronellol, the laevo- and dextro-rotatory form is given. Geraniol (31) is derived from 23, and nerol (35) from geraniol by swinging the double bond again. Linalool (32) has the OH group attached to the sixth carbon atom and is thus a tertiary alcohol.

Phenols of importance are phenol (48), anol (49), chavicol (50), charvacrol (51), thymol (52), and methyl-thymol (53). Anol differs from chavicol by attaching the first resp. the second carbon atom of the propenyl group to the benzene ring. Charvacrol differs from thymol, in the position of the hydroxy group, as clearly illustrated in the structure symbol.

Terpanols, $C_{10}H_{20}O$, or monocyclic alcohols of the terpane group contain one hydroxy group which may be located on any of the ten carbon atoms of menthane (84). The most important one is terpan-ol-3 or menthol (99) where the OH group is attached to the third carbon atom.

Terpan-diols, $C_{10}H_{20}O_2$, contain two hydroxy groups of which terpin or terpinol (101, 102) is a representative.

Terpenols, $C_{10}H_{18}O$, are derived from the terpenes and contain one double bond and one hydroxy group. Only three (103, 104, 105) terpenols are given, but from each of the seven terpenes there are nine terpenols, together 49 compounds, possible.

Terpadiene-ols, $C_{10}H_{16}O$, contain two double bonds and one hydroxy group of which there are about 180 possibilities, but the more important ones are pulegol (106) and carveol (108).

Campholes, $C_{10}H_{18}O$, or dicyclic alcohols of the camphane and camphene type are also quite numerous. The more important ones are borneol (146) or borneo-camphor and isoborneol (145), and cineol (150) (eucalyptol, cajeputol) which would belong, strictly speaking, to the ethers.

ETHERS.

The ethers occurring in essential oils belong mainly to the phenyl-ethyl-ether type. Thus anisol (54) or methoxy-benzene is the first representative. Anethol (55) and methyl-chavicol (56) contain the propenyl group. Methyl-eugenol (57) and methyl-isoeugenol (58) contain two methoxy groups, while asarol (59) contains three methoxy groups. Hesperitol (60) contains one methoxy and one hydroxy group, while eugenol (62), isoeugenol (63), chavibetol (64), and betelphenol (65) are all isomeric compounds. Two neighboring methoxy groups attached to the benzene ring may form a secondary pentacycle, thus if in 57 the second methoxy group swings around, and eliminating methane, the structure of safrol (78) a methylene-ether is formed. Isosafrol (79) differs by the attachment of the propenyl group, and myristicine (80) contains another methoxy group, while apiol (81) and iso-apiol (82) contain two additional methoxy groups.

ALDEHYDES.

The aldehydes, like the alcohols, occurring in essential oils, may be aliphatic or aromatic. To the first class belong citronellal (38, 41, 42) and geranial (39, 40, 43), which are derived, respectively, from citronellol (33, 34) and geraniol (31). Of citronellal two forms are possible, the terpinolene form (derived from rhodinol (30)) and the limonene form (derived from 33, 34). Both may be dextro- or laevo-rotatory. Geranial, while not containing an assymetric carbon atom may be of the cis- and trans-type, that is, the methyl group may exchange places with the aldehyde group as shown in structure symbol 39 and 40.

Aromatic aldehydes are derived from benzaldehyde (66). If to benzaldehyde there is attached one hydroxy group in the ortho position: salicyl aldehyde (67); one methoxy group in the para position; anisyl aldehyde (68) or anisic aldehyde; if both: vanillin (69); two methoxy groups: methyl-vanillin (70). Cumic aldehyde (71) is *p*-iso-propylbenzene, and Cinnamaldehyde (72, 73) is phenyl-acryl-aldehyde of which exists a trans- (73) and cis- (74) type. Piperonal or heliotropin (83) is the methylene ether of benzaldehyde.

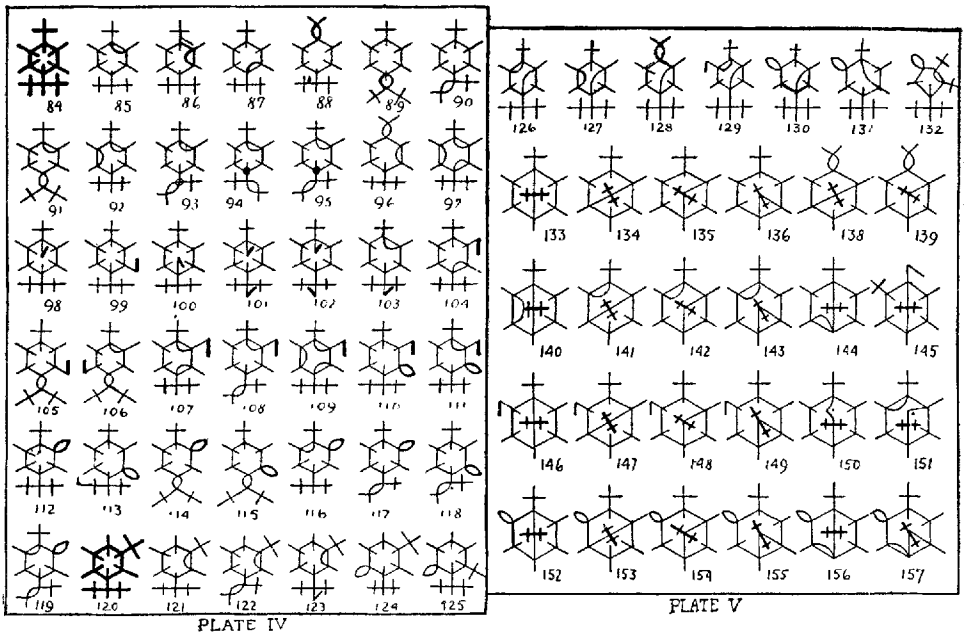
KETONES.

Aliphatic ketones are amyl-methyl-ketone (44) and nonyl-methyl-ketone (45), a derivative of the latter is pseudo-ionone (47) which contains two methyl groups and three double bonds. Ionone (74, 75) and Irone (76) are monocyclic methyl-ketones which differ in the position of the double bond.

Terpan-ones, $C_{10}H_{18}O$, are saturated monocyclic ketones derived from terpane. Thus menthone (113) and tetrahydrocarvone (112) are the more prominent representatives.

Terpen-ones, $C_{10}H_{14}O$, are unsaturated monocyclic ketones containing one double bond of which there are about 18 possibilities. The more important ones are pulegone (115), isopulegone (118), carvotanacetone (116), and dihydrocarvone (117).

Terpadiene-ones, $C_{10}H_{12}O$, contain, as the name indicates, two double bonds, of which there are 12 possibilities. Carvone (119) is terpadiene-one-2 and derived from terpine (91).



STRUCTURE SYMBOLS.

Camphones, $C_{10}H_{16}O$, or camphors, are dicyclic ketones derived from camphane and camphene. Most prominent is camphor (152) or laurel camphor, less in importance are fenchone (153), pinone (154), camphenone (156) which can be derived from 144. In Plate 5 these compounds are so arranged that the corresponding hydrocarbons, alcohols and ketones are placed under each other, as far as this is possible. Thus, in the first four columns there are the corresponding series: 133, 140, 146, 152, 133–140–146–152, 134–141–147–153, 135–142–148–154 and 136–143–149–155, while 144–156 are similarly related.

A comparative study of these tables will undoubtedly be of profit, for it is possible by the use of structure symbols to arrange the compounds in such a way that their similarity and difference can be exposed, which is not possible by using the conventional structure formula, for then one has to read every symbol and letter. The arrangement of the tables is such that from the simple the more complex structure has been derived—some of the characteristic differences have been marked by a heavier type.

The structure symbols are at present still in the experimental stage, but the writer has already compiled a classified list of over 2,000 organic compounds and in so doing he came to the belief that the structure symbols have advantages which are unsurpassed by the conventional formula. In overcoming the initial inconvenience of understanding and using these characters by practical use and application in class-room work and study, much benefit is gained and the conception of organic chemistry and the structures of their compounds greatly facilitated.

PLATE I.

Key to Structure Symbols:

Hydrogen, a point from which one line radiates.
Oxygen, a point from which two lines radiate.
Nitrogen, a point from which three lines radiate.
Carbon, a point from which four lines radiate.

The substances whose structure symbols are shown are:
hydrogen-gas (H_2), water (H_2O), ammonia (NH_3), methane (CH_4).

Types of Organic Compounds:

There are seven important types of organic compounds:
Hydrocarbons, R-H, where R (shaded circle) is any radical.
Alcohols, R-OH and Phenols, if R is a benzene ring.
Ethers, R-O-R.
Aldehydes, R-CHO.
Ketones, R-CO-R.
Acids, R-COOH.
Esters, R-COO-R.

Classes of Organic Compounds:

A. Saturated Aliphatic Compounds:

1 = methane CH_4
2 = ethane C_2H_6
3 = propane C_3H_8
4 = butane C_4H_{10}
5 = isobutane C_4H_{10}

6 = octane C_8H_{18}

B. Unsaturated Aliphatic Compounds:

7 = ethine, acetylen C_2H_4
8 = propine C_3H_6
9 = butine C_4H_8
10 = trans-Δ2-butine C_4H_8
11 = cis-Δ2-butine C_4H_8
12 = 2-methyl-propine C_4H_8

C. Saturated Aromatic Compounds:

13 = hexamethylene, hexahydrobenzene C_6H_{12}
18 = menthane, 1-methyl-4-isopropyl-hexamethylene $C_{10}H_{20}$
19 = camphane, 1-methyl-1(4)-isopropylene-hexamethylene $C_{10}H_{18}$

D. Unsaturated Aromatic Compounds:

14 = tetrahydro-benzene C_6H_{10}
15 = 4,5-dihydro-benzene C_6H_8
16 = 2,5-dihydro-benzene C_6H_8
17 = benzene C_6H_6

PLATE 2.

Aliphatic Hydrocarbons, Alcohols, Aldehydes, and Ketones.

Hydrocarbons:

20. C_8H_{18} = Octane
21. $C_{10}H_{22}$ = 2,6-dimethyl-octane
22. $C_{10}H_{20}$ = 2,6-dimethyl-octene-2
23. $C_{10}H_{18}$ = 2,6-dimethyl-octa-diene-2,6
24. $C_{10}H_{16}$ = Ocymene, 2,6-dimethyl-octa-triene,2,5,7
25. = Pseudocymene, 2,6-dimethyl-octa-triene-1,5,7
26. = Myrcene, 2-methyl-6-vinyl-hepta-diene-2,5
27. = Pseudomyrcene, 2-methyl-6-vinyl-hepta-diene-1,5

Alcohols:

28. $C_8H_{18}O$ = Octyl-alcohol, octan-ol-1 or octan-ol-8
29. $C_{10}H_{22}O$ = 2,6-dimethyl-octan-ol-8
30. $C_{10}H_{20}O$ = Rhodinol, 2,6-dimethyl-octene-2-ol-8
33. = l-Citronellol, 2,6-dimethyl-octane-1-ol-8
34. = d-Citronellol, 2,6-dimethyl-octane-1-ol-8
31. $C_{10}H_{18}O$ = Geraniol, 2,6-dimethyl-octa-diene-2,6-ol-8
32. = Linalool, 2,6-dimethyl-octa-diene,2,7-ol-6
35. = Nerol, 2,6-dimethyl-octa-diene-2,6-ol-8

Aldehydes:

36. $C_8H_{16}O$ = Heptyl-aldehyde, octanal
37. $C_{10}H_{20}O$ = 2,6-dimethyl-heptyl-aldehyde
38. $C_{10}H_{18}O$ = Citronellal (terpinolene form)
41. = Citronellal (limonene form) laevo-
42. = Citronellal (limonene form) dextro-
39. $C_{10}H_{16}O$ = Geranial (terpinolene form) trans-
40. = Geranial (terpinolene form) cis-
43. = Geranial (limonene form)

Ketones:

44. $C_7H_{14}O$ = Amyl-methyl-ketone, hepten-one-2
45. $C_{11}H_{22}O$ = Nonyl-methyl-ketone, Undecan-one-2
46. $C_{13}H_{22}O$ = 2,6-dimethyl-nona-diene-2,6-methyl-ketone
47. $C_{13}H_{20}O$ = Pseudoionone, 2,6-dimethyl-nona-triene-2,6,8-methylketone

PLATE 3.

Aromatic Phenols, Ethers, Aldehydes, and Ketones.

Phenols:

48. C_6H_6O = Phenol, hydroxy-benzene
49. $C_9H_{10}O$ = Anol, *p*-propenyl-phenol, 1-hydroxy-4-propenyl-benzene
50. $C_9H_{10}O$ = Chavicol, *p*-allyl-phenol, 1-hydroxy-4-allyl-benzene
51. $C_{10}H_{14}O$ = Charvacol, 1-methyl-2-hydroxy-4-isopropyl-benzene
52. $C_{10}H_{14}O$ = Thymol, 1-methyl-3-hydroxy-4-isopropyl-benzene, thyme camphor
53. $C_{10}H_{14}O$ = Methyl-thymol, 1,6-dimethyl-3-hydroxy-4-isopropyl-benzene

Ethers:

54. C_7H_8O = Anisol, methyl-phenyl-ether, methoxy-benzene
55. $C_{10}H_{12}O$ = Anethol, *p*-propenyl-anisol, 1-methoxy-4-propenyl-benzene
56. $C_{10}H_{12}O$ = Methyl-chavicol, *p*-isopropyl-benzene, 1-methoxy-4-allyl-benzene
57. $C_{11}H_{14}O_2$ = Methyl-isoeugenol, 1,2-dimethoxy-4-propenyl-benzene
58. $C_{11}H_{14}O_2$ = Methyl-eugenol, 1,2-dimethoxy-4-allyl-benzene
59. $C_{12}H_{16}O_3$ = Asarol, 1,2,5-trimethoxy-allyl-benzene

Phenolic Ethers:

60. $C_9H_{10}O_2$ = Hesperitol, 1-methoxy-2-hydroxy-4-vinyl-benzene
61. $C_9H_{10}O_2$ = Isohesperitol, 1-hydroxy-2-methoxy-4-vinyl-benzene

62. $C_{10}H_{12}O_2$ = Eugenol, 1-methoxy-2-hydroxy-4-allyl-benzene
63. $C_{10}H_{12}O_2$ = Isoeugenol, 1-methoxy-2-hydroxy-4-propenyl-benzene
64. $C_{10}H_{12}O_2$ = Chavibetol, 1-hydroxy-2-methoxy-4-allyl-benzene
65. $C_{10}H_{12}O_2$ = Betelphenol, 1-hydroxy-2-methoxy-4-propenyl-benzene

Aldehydes:

66. C_7H_6O = Benzaldehyde
67. $C_7H_7O_2$ = Salicylaldehyde, *o*-hydroxy-benzaldehyde
68. $C_8H_8O_2$ = Anisaldehyde, *p*-methoxy-benzaldehyde, anisic aldehyde
69. $C_8H_8O_3$ = Vanillin, 3-methoxy-4-hydroxy-benzaldehyde
70. $C_9H_{10}O_3$ = Methyl-vanillin, 3,4-dimethoxy-benzaldehyde
71. $C_{10}H_{12}O$ = Cumic aldehyde, *p*-isopropyl-benzaldehyde
72. C_9H_8O = cis-Cinnamic aldehyde, cis-cinnamaldehyde
73. C_9H_8O = trans-Cinnamic aldehyde, trans-cinnamaldehyde
74. $C_{13}H_{20}O$ = beta-Ionone
75. $C_{13}H_{20}O$ = alpha-Ionone
76. $C_{13}H_{20}O$ = Irone
77. $C_9H_6O_2$ = Coumarine, *a*-benzopyrone

Methylene-ethers:

78. $C_{10}H_{10}O_2$ = Safrol, shikimol, 1,2-methylenedioxy-4-allyl-benzene
79. $C_{10}H_{10}O_2$ = Isosafrol, 1,2-methylenedioxy-4-propenyl-benzene
80. $C_{11}H_{12}O_3$ = Myristicin, 1,2-methylenedioxy-5-methoxy-4-propenyl-benzene
81. $C_{12}H_{14}O_4$ = Apiol, 1,2-methylenedioxy-5,6-dimethoxy-4-propenyl-benzene
82. $C_{12}H_{14}O_4$ = Isoapiol, 1,2-methylenedioxy-5,6-dimethoxy-4-allyl-benzene
83. $C_8H_6O_3$ = Piperonal, Heliotropin, 3,4-dioxy-methylene-benzaldehyde

PLATE 4.

Monocyclic Compounds: Terpene-group.

A. Saturated Hydrocarbons: *Terpanes:*

84. $C_{10}H_{20}$ = Menthane, *p*-terpane, hexahydrocymene, menthonaphthene.

B. Unsaturated Hydrocarbons, 1 Δ, *Terpenes:*

85. $C_{10}H_{18}$ = 1-Terpene, carbomethene
86. $C_{10}H_{18}$ = 2-Terpene
87. $C_{10}H_{18}$ = 3-Terpene, menthane
88. $C_{10}H_{18}$ = 1(7)-Terpene
89. $C_{10}H_{18}$ = 4(8)-Terpene
90. $C_{10}H_{18}$ = 8(9)-Terpene

2 Δ, *Terpadienes:*

91. $C_{10}H_{16}$ = 1,4(8)-terpadiene, perpinolene, terpinene
92. $C_{10}H_{16}$ = 1,5-terpadiene, phellandrene
93. $C_{10}H_{16}$ = 1,8(9)-terpadiene, *i*-limonene
94. $C_{10}H_{16}$ = 1,8(9)-terpadiene, *d*-limonene
95. $C_{10}H_{16}$ = 1,8(19)-terpadiene, *l*-limonene
96. $C_{10}H_{16}$ = 2,1(7)-terpadiene, pseudophellandrene

3 Δ, *Cymenes:*

97. $C_{10}H_{14}$ = Cymene, 1-methyl-4-isopropyl-benzene

A. Saturated Alcohols, 1(OH), *Terpan-ols:*

98. $C_{10}H_{20}O$ = Terpan-ol-1
99. $C_{10}H_{20}O$ = Terpan-ol-3, menthol, mint-camphor
100. $C_{10}H_{20}O$ = Terpan-ol-4, tertiary-menthol

2(OH), *Terpan-diols:*

101. $C_{10}H_{20}O_2$ = Terpan-diol-1.8, cis-terpin, cis-terpinol
102. $C_{10}H_{20}O_2$ = Terpan-diol-1.8, trans-terpin, trans-terpinol

B. Unsaturated Alcohols, 1 Δ, 1(OH), *Terpen-ols:*

103. $C_{10}H_{18}O$ = 1-terpen-ol-8, terpineol
104. $C_{10}H_{18}O$ = 3-terpen-ol-2, tetrahydro-carvacol
105. $C_{10}H_{18}O$ = 4(8)-terpen-ol-3, dihydro-pulegol

2 Δ, 1(OH), *Terpadiene-ols:*

106. $C_{10}H_{16}O$ = 1,4(8)-terpadiene-ol-5, pulegol
107. $C_{10}H_{16}O$ = 1,3-terpadiene-ol-2, dihydrocarvacol
108. $C_{10}H_{16}O$ = 1,8(9)-terpadiene-ol-2, carveol

3 Δ, 1(OH), *Cymols:*

109. $C_{10}H_{14}O$ = carvacol, 2-cymol

Alcohols and Ketones:

110. $C_{10}H_{18}O_2$ = Menthanol, 1-methyl-4-isopropyl-cyclohexanone-3-ol-2
111. $C_{10}H_{16}O_2$ = Buchu-camphor, 1-methyl-4-isopropyl-cyclohexene-1-one-3-ol-2

A. Saturated Ketones—*Terpan-ones:*

112. $C_{10}H_{18}O$ = terpan-one-2, tetrahydrocarvone
113. $C_{10}H_{18}O$ = terpan-one-3, menthone

B. Unsaturated Ketones—1 Δ, *Terpenones:*

114. $C_{10}H_{14}O$ = 4(8)-terpen-one-2
115. $C_{10}H_{14}O$ = 4(8)-terpen-one-3, pulegone
116. $C_{10}H_{14}O$ = 6-terpen-one-2, carvotanacetone
117. $C_{10}H_{14}O$ = 8(9)-terpen-one-2, dihydrocarvone
118. $C_{10}H_{14}O$ = 8(9)-terpen-one-3, isopulegone

2 Δ, *Terpadiene-ones:*

119. $C_{10}H_{12}O$ = 6,8(9)-terpadiene-one-2, carvone

Meta- and Para-Terpanes and Derivatives:

120. $C_{10}H_{20}$ = *m*-terpane, *m*-menthane
121. $C_{10}H_{18}$ = 1-*m*-terpene, carvestrene
122. $C_{10}H_{16}$ = 1,(9)-*m*-terpadiene, sylvestrene
123. $C_{10}H_{18}O$ = 1-meta-terpen-ol-8, carvestrol, 1-meta-menthenol
124. $C_{10}H_{18}O$ = meta-terpenone-4, *m*-menthone
125. $C_{10}H_{18}O$ = ortho-terpenone-3, *o*-menthone

PLATE 5.

Transition from Monocyclic to Dicyclic Compounds:

126. $C_{10}H_{16}$ = alpha-thujene, 2(4),6-terpadiene
127. $C_{10}H_{16}$ = beta-thujene, 2(4),5-terpadiene
128. $C_{10}H_{16}$ = sabinene, 2(4),1(7)-terpadiene
129. $C_{10}H_{16}O$ = a-thujol, 2(4),6-terpadiene-ol-5, thujyl alcohol
130. $C_{10}H_{16}O$ = a-thujone, 2(4)-terpen-one-5
131. $C_{10}H_{18}O$ = b-thujone, 1(3)-terpen-one-5
132. $C_{10}H_{16}O$ = isothujone

Dicyclic Compounds: Camphene Group.

Saturated Hydrocarbons—*anes:*

133. $C_{10}H_{18}$ = Camphane, 1,7,7-trimethyl-bicyclo(1,2,2)heptane
134. $C_{10}H_{18}$ = Fenchane, 2,7,7-trimethyl-bicyclo(1,2,2)heptane
135. $C_{10}H_{18}$ = Pinane, 2,7,7-trimethyl-bicyclo(1,1,3)heptane
136. $C_{10}H_{18}$ = Carane, 3,7,7-trimethyl-bicyclo(0,1,4)heptane

Unsaturated Hydrocarbons—*enes:*

138. $C_{10}H_{16}$ = a-Fenchene
139. $C_{10}H_{16}$ = Camphene
140. $C_{10}H_{16}$ = Bornylene, Borneo-camphor
141. $C_{12}H_{16}$ = b-Fenchene

142. $C_{10}H_{16}$ = Peinne
143. $C_{10}H_{16}$ = Carene
144. $C_{10}H_{16}$ = Camphanene

Alcohols—*oles:*

145. $C_{10}H_{18}O$ = Isoborneol
146. $C_{10}H_{18}O$ = Borneol, Borneo-camphor
147. $C_{10}H_{18}O$ = Fenchol
148. $C_{10}H_{18}O$ = Pinol
149. $C_{10}H_{18}O$ = Carol
150. $C_{10}H_{18}O$ = Cineol, Eucalyptol, Cajeputol
151. $C_{10}H_{18}O$ = Subrerol

Ketones—*ones:*

152. $C_{10}H_{16}O$ = Camphor, laurel camphor
153. $C_{10}H_{16}O$ = Fenchone
154. $C_{10}H_{16}O$ = Pinone
155. $C_{10}H_{16}O$ = Carone
156. $C_{10}H_{16}O$ = Camphenone
157. $C_{10}H_{16}O$ = Eucarone

COLLEGE OF PHYSICIANS AND SURGEONS,
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PURITY STANDARDS FOR ABSORBENT COTTON.

BY A. WAYNE CLARK, R. O. SMITH AND LEROY FORMAN.

Prior to the work of one of us during the years 1909 to 1911 on extraction methods, etc., for impurities in absorbent cotton, little or no work appears to have been done on the subject and no standards suggested. The U. S. Pharmacopoeia VIII, then official, contains only rough standards for absorbency, for acid or alkali and for ash.

Tentative standards used for manufacturing control came into use during the above period. These were published in a monograph issued from this laboratory (1912).

METHOD OF TESTING ABSORBENT COTTON LABORATORY NOTES No. 1, 1912.

Acid or Alkali.—Ten grammes of sample are saturated with 100 Cc. neutral distilled water, the water pressed out and divided into two portions, each of which is placed in a white porcelain dish. To one portion is added three drops phenolphthalein test solution, and to the other portion one drop methyl orange test solution. Neither portion should develop any pink color.

Ash.—Five grammes, on incineration in a weighed platinum crucible, should leave not more than 0.2 percent ash.

Oil and Fatty Matter.—Extract 20 grammes of sample in a narrow percolator with ether until 200 Cc. percolate is secured. The percolate, on evaporation to dryness in a weighed beaker, should leave not more than 0.5 percent residue. A blank test should be made with an equal quantity of the ether used.

Coloring Matter Resins and Soap.—Extract 20 grammes of sample in a narrow percolator with alcohol until 200 Cc. percolate is secured. The percolate should not be of a greenish or bluish tint, and on evaporation to dryness in a weighed beaker should leave not more than 0.5 percent residue. A blank test should be made with an equal quantity of the alcohol used.

Water-soluble Salts and Soap.—Extract 20 grammes of sample in a narrow percolator, with hot distilled water (80° to 90° C.) until 200 Cc. percolate is secured. The percolate should