Second Supplement to Bibliography on Molecular or Short-Path Distillation

SAMUEL S. TODD

Southern Regional Research Laboratory, New Orleans, Louisiana
Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration
U. S. Department of Agriculture

The appearance of numerous publications resulting from the increasing use of molecular or short-path distillation during the past two and one-half years has made it desirable to prepare a supplement to the two previous bibliographies on this subject (31, 29) in order to cover the patent and scientific literature up to December 31, 1942.

The recent development of revolving-plate stills for molecular distillation has increased the efficiency of this form of distillation and extended it to less stable substances (71). Many large units of this type, which employ centrifugal force to spread the distilland, are now used in commercial production of vitamin A (72).

Of the few new applications of molecular distillation the work of Bailey (6) and Hechtman (65) on the distillation of lignin and that of Hurd *et al.* (102, 103, 122) on the separation of sugars may be mentioned. However, the suggested applications of the technique enumerated by Hickman (71) should lead to still greater use, especially in pharmaceutical, biochemical, and related fields of research.

Especially noteworthy are a number of publications of general and review nature, which have appeared in various countries. Withers (161) in Australia and Blasco (14) in Spain have written two of the most recent reviews. Two other brief reviews are by Skishakov (142) in Russia and Dam (26) in Denmark. In Great Britain, Howat (96-100) has published several articles on molecular distillation equipment and its applications to the production of vitamins. Wittka (162) in Germany has published an article containing many designs of molecular stills and an extensive bibliography of articles and patents. A series of papers by Kaufmann and Wolf (116, 117) describe the application of molecular distillation in the field of fats and oils. Their first paper contains 80 patent citations. In the United States, an article of general scope has been published by Embree (56) on the separation of natural components of fats and oils and one by Hickman (71) on the use of high-vacuum stills in pharmaceutical and biochemistry. Abstracts of references listed in previous bibliographies with 58 additions were published by Detwiler (30) in December, 1941. These abstracts are in mimeographed form and are arranged in chronological order. They may be obtained on request from the Northern Regional Research Laboratory, Peoria, Illinois.

The present supplement contains approximately 160 citations on molecular or short-path distillation, including a number of earlier articles and patents which were not listed in the first two bibliographies. In addition, several references on high-vacuum pumps, low-pressure gages, vacuum technique, etc., have been selected from the extensive literature on these subjects.

Where available, the Chemical Abstract (CA) reference has been included with each citation. Patents are indicated with an asterisk and are in groups by the senior patentee following articles by the same senior author. In general, the dates appended to patents include not only the one of final approval or of publication but also the one of application.

MOLECULAR STILLS AND APPLICATIONS

1. Anonymous, Osaka, Japan: Boshoku Zasshischa (1939). Nylon (in Japanese).
2. Allen, W. M., J. Biol. Chem. *98*, 591 (1932). The preparation of progestin. (CA *27*, 530.)
3. *Almquist, H. J., and Klose, A. A. (to Merck and Co.), U. S. 2,280,777, Apr. 28, 1942, appl. Feb. 7, 1940. Product of vitamin K activity. (CA *36*, 5618.)
4. Askew, F. A., Bourdillon, R. B., Bruce, H. M., Jenkins, R. G. C., and Webster, T. A., Proc. Roy. Soc. (London) *107 B*, 76 (1930). Distillation of vitamin D. (CA *24*, 5802.)
5. *Associated Electrical Industries, Ltd., Polish 11,592, Jan. 28, 1930, appl. Aug. 16, 1928. Process and apparatus for vacuum distillation. (Chem. Zentr. *1931, II*, 1237.) (Similar to Brit. 303,078-79, C. R. Burch *et al.*)
6. Bailey, A. J., Paper Trade J. *111*, No. 7, 27 (1940). The heterogeneity of lignin. (CA *34*, 8263.)
7. Bailey, A. J., Ind. Eng. Chem., Anal. Ed. *14*, 177 (1942). Molecular still heads. (CA *36*, 1813.)
8. Baxter, J. G., and Robeson, C. D., J. Am. Chem. Soc. *64*, 2411 (1942). Crystalline vitamine A. (CA *37*, 422.)
9. Baxter, J. G., Robeson, C. D., Taylor, J. D., and Lehman, R. W., Abstracts of papers, 104th Mtg., Am. Chem. Soc. 33M (Sept. 1942). Natural α-, β-, γ-tocopherols and certain esters of physiological interest.
10. Baxter, J. G., Taylor, J. D., and French, K. S., Abstracts of papers, 104th Mtg., Am. Chem. Soc. 14B (Sept. 1942). An assay method for mixtures of tocopherols.
11. *Baxter, J. G., and Jakobsen, J. L. (to Distillation Products, Inc.), U. S. 2,269,243, Jan. 6. 1942, appl. Mar. 8, 1939. Refining animal or vegetable oils containing natural antioxidants. CA *36*, 3060.)
12. Bickford, W. G., Krauczunas, P., and Wheeler, D. H., Oil and Soap *19*, 23 (1942). The reaction of nonconjugated unsaturated fatty esters with maleic anhydride. (CA *36*, 2171.)
13. Bills, C. E., The chemistry of vitamin D. In Am. Med. Assoc. The vitamins: A symposium. ch. 23 (1939). CA *34*, 2424.)
14. Blasco, E., Ion *2*, 753 (1942). Molecular distillation. (CA *37*, 1625.)
15. Bömer, A., and Ebach, K., Z. Untersuch. Lebensm. *55*, 501 (1928). The glycerides of lauric and myristic acids. (CA *23*, 818.)
16. Bomskov, C., Arch. exptl. Path. Pharmakol. *190*, 627 (1938). Biological evaluation and mode of action of vitamin E and the preparation of a highly active vitamin E concentrate. (CA *33*, 8707.)
17. Bradley, T. F., and Johnston, W. B., Ind. Eng. Chem. *33*, 86 (1941). Drying oils and resins. Purification of polymerized methyl linoleate by molecular distillation. (CA *35*, 2736.)
18. Braude, R., Foot, A. S., Henry, K. M., Kon, S. K., Thompson, S. Y., and Mead, T. H., Biochem. J. *35*, 693 (1941). Vitamin A studies with rats and pigs. (CA 35, 8046.)
19. Bruijn, J. A. de, Chem. Weekblad *37*, 249 (1940). Laboratory notes. (CA *34*, 5317.)
20. *Burrows, G., Brit. 523,754, Jul. 22, 1940, appls. Jan. 13, and Dec. 5, 1939. High-vacuum molecular still. (CA *35*, 6163.)
21. Caldwell, K. S., and Hurtley, W. H., J. Chem. Soc. *95*, 853 (1909). The distillation of butter fat, coconut oil, and their fatty acids. (CA *3*, 1821.)
22. Carothers, W. H., Collected papers, on high polymeric substances; ed. by H. Mark and G. S. Whitby (High Polymers, v. 1) N. Y., Interscience Publishers, Inc., 1940. (CA *34*, 7483.)
23. Carothers, W. H., and Hill, J. W., J. Am. Chem. Soc. *55*, 5043 1933). Studies of polymerization and ring formation. XXII. Stereochemistry and mechanism in the formation and stability of large rings. (CA *28*, 743.)
24. Carothers, W. H., and Van Natta, F. J., J. Am. Chem. Soc. *55*, 4714 (1933). Studies of polymerization and ring formation. XVIII. Polyesters from ω-hydroxydecanoic acid. (CA *28*, 105.)
25. Cloetta, M., Arch. exp. Path. Pharm. *88*, 113 (1920). Chemistry and pharmacology of digitoxin and its cleavage products. (CA *15*, 707.)
26. Dam, H., Kem. Maanedsblad *20*, 203 (1939). Short-path distillation.
27. Dam, H., Geiger, A., Glavind, J., Karrer, P., Karrer, W., Rothschild, E., Salomon, H., Helv. Chim. Acta *22*, 310 (1939). Isolation of vitamin K in highly purified form. (CA *33*, 5448.)
28. Dam, H., Glavind, J., Prange, I., and Ottesen, J., Kgl. Danske Videnskab. Selskab. Biol. Medd. *16*, No. 7 (1941). Vitamin E. (CA *36*, 6214.)
29. Detwiler, S. B., Jr., Oil and Soap *17*, 241 (1940). Supplement to bibliography on molecular or short-path distillation. (CA *35*, 2.)

30. Detwiler, S. B., Jr., Abstracts of articles and patents on molecular or short-path distillation. U. S. Dept. Agr., Bur. Agr. Chemistry Eng. ACE-115, 98 pp. (1941). U. S. Reg. Soybean Ind. Prod. Lab., Urbana, Ill. (May be obtained on request from Northern Regional Research Lab., Peoria, Illinois.)
31. Detwiler, S. B., Jr., and Markley, K. S., Oil and Soap *16*, 2 (1939). Bibliography on molecular or short-path distillation. (CA *33*, 1545.)
32. *Dijck, W. J. D. van (to N. V. de Bataafsche Petroleum Maatschappij), Australian 863/31, Mar. 3, 1932, appl. Feb. 23, 1931. Process and apparatus for carrying out distillations under low pressure. (Chem. Zentr. *1932, II*, 3451.) (Similar to Dutch 27,023, N. V. de Bataafsche Petroleum Maatschappij.)
33. *Dijck, W. J. D. van (to N. V. de Bataafsche Petroleum Maatschappij), U. S. 1,950,830, Mar. 13, 1934, appl. Jan. 24, 1931. Distillation of materials under low pressure. (CA *28*, 3498.) (See ref. 32.)
34. *Distillation Products, Inc., Brit. 526,389, Sept. 17, 1940, appl. Mar. 15, 1939. Vitamin compositions. (CA *35*, 7123.) (Similar to U. S. 2,199,995, K. C. D. Hickman.)
35. *Distillation Products, Inc., Brit. 527,381, Oct. 8, 1940, appl. Apr. 11, 1939. Treating animal and vegetable oils for retarding oxidation. (CA *35*, 7224.)
36. *Distillation Products, Inc., Brit. 532,770, Jan. 30, 1941, appl. Sept. 16, 1939. High-vacuum distillation. (CA *36*, 937.) (Cf. ref. 84.)
37. *Distillation Products, Inc., Brit. 538,565, Aug. 8, 1941, appl. Jan. 4, 1940. Apparatus for high-vacuum distillation. (CA *36*, 3403.)
38. *Distillation Products, Inc., Brit. 540,603, Oct. 23, 1941, appl. Apr. 5, 1940. High-vacuum distillation. (CA *36*, 3989.)
39. *Distillation Products, Inc., Fr. 851,427, Jan. 9, 1940, appl. Mar. 9, 1939. Vacuum distillation apparatus. (CA *36*, 1814.) (Cf. Brit. 482,881, Kodak, Ltd.)
40. *Distillation Products, Inc., Hickman, K. C. D., and Hecker, J. C., Brit. 530,367, Dec. 10, 1940, appl. Mar. 9, 1939. High-vacuum unobstructed path still. (CA *35*, 7767.) (Divided out of Brit. 530,371, ref. 41.)
41. *Distillation Products, Inc., Hickman, K. C. D., and Hecker, J. C., Brit. 530,371, Dec. 11, 1940, appl. Mar. 9, 1939. High-vacuum unobstructed path distillation. (CA *35*, 7767.) (Similar to U. S. 2,180,052, K. C. D. Hickman and J. C. Hecker.)
42. Drummond, J. C., Ann. Rev. Biochem. *7*, 335 (1938). The fat-soluble vitamins. (CA *33*, 4649.)
43. Drummond, J. C., Singer, E., and MacWalter, R. J., Biochem. J. *29*, 456 (1935). A study of the unsaponifiable fraction of wheat germ oil with special reference to vitamin E. (CA *29*, 5159.)
44. Drummond, J. C., Singer, E., and MacWalter, R. J., Biochem. J. *29*, 2510 (1935). Further observations on the constituents of the unsaponifiable fraction of wheat germ oil with particular reference to vitamin E. (CA *30*, 3477.)
45. Earle, F. R., and Detwiler, S. B., Jr., Oil and Soap *18*, 117 (1941). Wax constituents of the winterizer press cake of soybean oil. (CA *35*, 5336.)
46. *Eastman Kodak Co., Brit. 523,346, July 12, 1940, appl. Dec. 1, 1938. Removal of gas from organic liquids. (CA *35*, 6161.) (Similar to U. S. 2,180,051, K. C. D. Hickman.)
47. *Eastman Kodak Co., Brit. 524,390, Aug. 6, 1940, appl. Jan. 28, 1939. Vacuum distillation. (CA *35*, 6158.) (Cf. refs. 48, 82.)
48. *Eastman Kodak Co., Brit. 524,439, Aug. 6, 1940, appl. Jan. 28, 1939. Vacuum distillation. (CA *35*, 6158.) (Divided out of Brit. 524,390, ref. 47.)
49. *Eastman Kodak Co., Fr. 49,761, Jul. 17, 1939, appl. Jul. 29, 1938. Apparatus for distilling in vacuo. (CA *36*, 2453.) (2nd. addn. to Fr. 834,937, Eastman Kodak Co.; similar to U. S. 2,180,053, K. C. D. Hickman.)
50. *Eastman Kodak Co., Fr. 823,767, Jan. 26, 1938, appl. Jun. 11, 1937. Products from the distillation of fish oils. (CA *32*, 6088.) (Similar to U. S. 2,169,192, J. G. Baxter.)
51. *Eastman Kodak Co., Fr. 825,973, Mar. 18, 1938, appl. Feb. 6, 1937. Cholane derivatives. (CA *32*, 6263.) (Similar to Brit. 489,623, Eastman Kodak Co.)
52. *Eastman Kodak Co., Fr. 826,474, Mar. 31, 1938, appl. Apr. 17, 1937. Improvements in distillation process. (Chem. Zentr. *1938, II*, 1151). (Similar to U. S. 2,117,802, K. C. D. Hickman.)
53. *Eastman Kodak Co., Fr. 845,957, Sept. 6, 1939, appl. Nov. 14, 1938. Vacuum distillation. (CA *35*, 936.) (Similar to U. S. 2,199,994, K. C. D. Hickman.)
54. *Eastman Kodak Co., Fr. 849,596, Nov. 27, 1939, appl. Jan. 28, 1939. Vacuum-distillation apparatus. (CA *35*, 6840.) (Cf. ref. 82.)
55. Embree, N. D., J. Biol. Chem. *128*, 187 (1939). The occurrence of cyclized vitamin A in fish liver oils. (CA *33*, 3969.)
56. Embree, N. D., Chem. Rev. *29*, 317 (1941). The separation of natural components of fats and oils by molecular distillation. (CA *36*, 1796.)
57. Emerson, O. H., Science *88*, 40 (1938). The chemistry of vitamin E. III. Permanganate oxidation of alpha tocopherol. (CA *32*, 7037.)
58. *Fawcett, E. W. (to Imperial Chemical Industries, Ltd.), U. S. 2,047,196, Jul. 14, 1936, appl. May 9, 1935. Refining crude fats and fatty oils. (CA *30*, 6228.) (Cf. Brit. 438,056, E. W. Fawcett.)
59. Gray, E. LeB., and Cawley, J. D., J. Nutrition *23*, 301 (1942). The state of vitamin A in the liver of the rat. II. the effect of feeding the vitamin over extended periods. (CA *36*, 2895.)
60. Gray, E. LeB., Morgareidge, K., and Cawley, J. D., J. Nutrition *20*, 67, (1940). Intestinal absorption of vitamin A in the normal rat. (CA *34*, 7355.)
61. Haller, H. L., LaForge, F. B., and Sullivan, W. N., J. Econ. Entomol. *35*, 247 (1942). Effect of sesamin and related compounds on the insecticidal action of pyrethrum on houseflies. (CA *36*, 5916.)
62. Haller, H. L., McGovran, E. R., Goodhue, L. D., and Sullivan, W. N., J. Org. Chem. *7*, 183 (1942). The synergistic action of sesamin with pyrethrum insecticides. (CA *36*, 2959.)
63. Hallett, L. T., Ind. Eng. Chem., Anal. Ed. *14*, 956 (1942). A review of organic microchemistry. (CA *37*, 582.)
64. Hannewijk, J., Over, K., Vlodrop, C. van, and Waterman, H. I., Verfkroniek *13*, 162 (1940); Paint Ind. Mag. *56*, 48 (1941). The addition of phenol to fatty oils in the presence of sulfur dioxide and sulfuric acid. (CA *35*, 6136.)
65. Hechtman, J. F., Paper Trade J. *114*, No. 22, 45 (1942). The behavior of some lignin preparations in the molecular still. (CA *36*, 4331.)
66. *Hecker, J. C. (to Distillation Products, Inc.), U. S. 2,269,153, Jan. 6, 1942, appl. Jun. 18, 1940. High-vacuum distillation apparatus. (CA *36*, 2763.)
67. Hickman, K. C. D., J. Optical Soc. Am. *18*, 62 (1929); Chemistry and Industry *48*, 366 (1929). A sublimation mercury still. (CA *23*, 3602.)
68. Hickman, K. C. D., J. Biol. Chem. *128*, Proc. xliii (1939). The nature of vitamin A in fish liver oils, and the need for a new international standard.
69. Hickman, K. C. D., Ind. Eng. Chem. *32*, 1451 (1940). High-vacuum distillation of the steroids. (CA *35*, 275.)
70. Hickman, K. C. D., Synthetic Org. Chemicals, *13*, No. 5 (1941), Pub. by Eastman Kodak Co., Rochester, N. Y.; Am. Perfumer Essent. Oil Rev. *44*, No. 3, 36 (1942. Vacuum distillation in organic research.
71. Hickman, K. C. D., Ind. Eng. Chem., Anal. Ed. *14*, 250 (1942). The high-vacuum still in medicine. (CA *36*, 2682.)
72. Hickman, K. C. D., Chem. Eng. News *20*, 1561 (1942). Molecular distillation. (CA *37*, 1011.)
73. Hickman, K. C. D., Harris, P. L., and Woodside, M. R., Nature *150*, 91 (1942). Interrelationship of vitamins A and E. (CA *36*, 6599.)
74. Hickman, K. C. D., and Mees, G. C., News. Ed. (Am. Chem. Soc.) *19*, 623 (1941). Vitamin A supplies during a national emergency. (CA *35*, 5539.)
75. *Hickman, K. C. D. (to Eastman Kodak Co.), Brit. 521,227, May 15, 1940, appl. Nov. 14, 1938. Vacuum distillation. (CA *36*, 937.) (See ref. 53.)
76. *Hickman, K. C. D. (to Distillation Products, Inc.), Brit. 539,056, Aug. 26, 1941, appl. May. 25, 1940. Vacuum distillation. (CA *36*, 3403.) (See ref. 87.)
77. *Hickman, K. C. D. (to Distillation Products, Inc.), Brit. 539,089, Aug. 27, 1941, appl. Jun. 15, 1940. Extracting vitamin-containing fish oils. (CA *36*, 3634.) (See ref. 88.)
78. *Hickman, K. C. D. (to Eastman Kodak Co.), Ger. 700,764, Dec. 30, 1940, appl. Jul. 6, 1937. High-vacuum distillation. (CA *35*, 7240.) (Similar to Brit. 482,882, Kodak, Ltd. and U. S. 2,117,803, K. C. D. Hickman.)
79. *Hickman, K. C. D. (to Eastman Kodak Co.), U. S. reissue 20,705, Apr. 26, 1938, appl. Mar. 6, 1934, (A reissue of 1,925,559). Extraction of fish oils containing vitamins. (CA *32*, 4813.)
80. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,210,926-27, Aug. 13, 1940, appl. Sept. 5, 1936. Fat-soluble vitamin concentration by distillation. (Process.) (CA *35*, 583, 584 resp.)
81. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,210,928, Aug. 13, 1940, appl. Dec. 16, 1939. Fat-soluble vitamin concentration by distillation. (Apparatus.) (CA *35*, 584.)
82. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,218,240, Oct. 15, 1940, appl. Jan. 28, 1938. Fractional distillations under high vacuum. (CA *35*, 936.) (Cf. ref. 48, 54.)
83. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,221,690, Nov. 12, 1940, appl. Mar. 20, 1937. Therapeutic vitaminic compositions. (CA *35*, 1582.)
84. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,221,691, Nov. 12, 1940, appl. Sept. 28, 1938. Vacuum distillation such as that of vitaminic oils and the like. (CA *35*, 1272.) (Cf. ref. 36.)
85. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,229,173, Jan. 21, 1941, appl. Feb. 9, 1939. Vitamin concentrates from oils such as pollack- or shark-liver oils. (CA *35*, 3037.)
86. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,234,166, Mar. 11, 1941, appl. Nov. 3, 1939. High-vacuum distillation. (CA *35*, 3489.)
87. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,249,526, Jul. 15, 1941, appl. June 9, 1939. Vacuum distillation of vitaminic oils, etc. (CA *35*, 6740.)
88. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,256,392. Sept. 16, 1941, appl. Oct. 14, 1939. Vitaminic fish oils. (CA *36*, 224.)
89. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,298,377, Oct. 13, 1942, appl. Nov. 3, 1939. Vacuum distillation from moving surfaces and apparatus therefor. (CA *37*, 1303.)
90. *Hickman, K. C. D., and Baxter, J. G. (to Distillation Products, Inc.), Brit. 535,100, Mar. 28, 1941, appl. Oct. 14, 1939. Distilling oxidizable substances. (CA *36*, 1215.) (Cf. ref. 91.)
91. *Hickman, K. C. D., and Baxter, J. G. (to Distillation Products, Inc.), U. S. 2,221,692, Nov. 12, 1940, appl. Oct. 15, 1938. Vitamin distillates resistant to oxidation during storage. (CA *35*, 1582.) (Cf. ref. 90.)
92. *Hickman, K. C. D., and Hecker, J. C. (to Distillation Products, Inc.), U. S. 2,249,524, Jul. 15, 1941, appl. Jun. 27, 1939. Improving the taste and odor of vitaminic oils. (CA *35*, 6740.)
93. Hill, J. W., and Carothers, W. H., J. Am. Chem. Soc. *55*, 5023 (1933). Studies of polymerization and ring formation. XIX. Many-membered cyclic anhydrides. (CA *28*, 741.)
94. Hill, J. W., and Carothers, W. A., J. Am. Chem. Soc. *55*, 5031 (1933). Studies of polymerization and ring formation. XX. Many-membered cyclic esters. (CA *28*, 742.)
95. Hill, J. W., and Carothers, W. H., J. Am. Chem. Soc. *57*, 925 (1935). Studies of polymerization and ring formation XXIV. Cyclic and polymeric formals. (CA *29*, 4328.)

96. Howat, D. D., Chem. Age (London) *45*, 309 (1941). Molecular distillation. I. Advances in a new branch of chemical industry. (CA *36*, 5057.)
97. Howat, D. D., Chem. Age (London) *45*, 323 (1941). Molecular distillation. II. Design of condensation pumps. (CA *36*, 5057.)
98. Howat, D. D., Chem. Age (London) *46*, 3 (1942). Molecular distillation. III. Stills, pumps, and other apparatus. (CA *36*, 5057.)
99. Howat, D. D., Chem. Age (London) *46*, 41 (1942). Applications of molecular distillation. I. Commercial production of vitamin A. (CA *36*, 5057.)
100. Howat, D. D., Chem. Age (London) *46*, 53 (1942). Applications of molecular distillation. II. Vitamins D and E. (CA *36*, 5057.)
101. Hulst, L. J. N. van der, Rec. trav. chim. *53*, 672 (1934). Preliminary notes on the application of absorption spectra in oil research: distillation of palm oil. (CA *28*, 4925.)
102. Hurd, C. D., and Liggett, R. W., J. Am. Chem. Soc. *63*, 2659 (1941). Analytical separation of sugars by distillation of their propionates. (CA *36*, 369.)
103. Hurd, C. D., Liggett, R. W., and Gordon, K. M., J. Am. Chem. Soc. *63*, 2656 (1941). Distillation of sugar propionates at low pressures. (CA *36*, 412.)
104. *Imperial Chemical Industries, Ltd., Belgian 406,148, Mar. 28, 1935, appl. Nov. 8, 1934. Drying oil. (Chem. Zentr. *1936, II*, 2822.) (Similar to Brit. 442,000, Imperial Chemical Industries, Ltd.)
105. *Imperial Chemical Industries, Ltd., Belgian 428,704, appl. Jun. 18, 1938. Improvements in vacuum distillation of fats and vegetable oils. (Similar to Brit. 501,194, E. W. Fawcett and Imperial Chemical Industries, Ltd.)
106. *Imperial Chemical Industries, Ltd., Dutch 44.870, Jan. 16, 1939, appl. Oct. 2, 1936. Improvements in and relating to the production of oils rich in vitamins. (Similar to Brit. 464,395, E. W. Fawcett, D. Whittaker and Imperial Chemical Industries, Ltd.)
107. *Imperial Chemical Industries, Ltd., Fr. 770,422, Sept. 13, 1934, appl. Mar. 19, 1934. Margarine and food fats. (CA *29*, 518.)
108. *Imperial Chemical Industries, Ltd., Fr. 773,068, Nov. 10, 1934, appl. May 8, 1934. Distilling solids. (CA *29*, 1287.) (Similar to Brit. 437,895, Imperial Chemical Industries, Ltd.)
109. *Imperial Chemical Industries, Ltd., Fr. 782,731, Jun. 11, 1935, appl. Dec. 14, 1934. Saporific materials. (CA *29*, 7108.) (Similar to Dutch 43,250, H. I. Waterman and C. van Vlodrop.)
110. *Imperial Chemical Industries, Ltd., Fr. 839,496, Apr. 4, 1939, appl. Jun. 18, 1938. Stabilizing fats and fatty oils. (CA *36*, 5372.) (Similar to Brit. 501,194, E. W. Fawcett and Imperial Chemical Industries, Ltd.)
111. *Imperial Chemical Industries, Ltd., Ger. 643,877, Apr. 19, 1937, appl. Jun. 12, 1936. Process and apparatus for carrying out short-path high-vacuum distillation. (Similar to Brit. 458,119, B. E. A. Vigers and Imperial Chemical Industries, Ltd.)
112. *Imperial Chemical Industries, Ltd., Ger. 650,160, Sept. 16, 1937, appl. May 10, 1934. Purifying or separating solids by high-vacuum distillation. (CA *32*, 845.) (Similar to Brit. 437,895 with additional examples, Imperial Chemical Industries, Ltd.)
113. *Imperial Chemical Industries, Ltd., Ger. 680,085, Aug. 25, 1939, appl. Feb. 4, 1936. Stand oil. (CA *36*, 2170.)
114. *Imperial Chemical Industries, Ltd., Swedish 90,721, Nov. 9, 1937, appl. Jun. 12, 1936. Short-path high-vacuum distillation of solid or liquid substances. (Chem. Zentr. *1938, I*, 673.) (Similar to Brit. 458,119, B. E. A. Vigers and Imperial Chemical Industries, Ltd.)
115. Jenaer Glaswerke Schott u. Gen., Jena. Circulars No. 5917, Jul. 1937; No. 6268, Jun. 1938.
116. Kaufmann, H. P., and Wolf. W., Fette u. Seifen *47*, 252 (1940). The use of molecular distillation in the field of fats. I. The distillation of fat acids and the refining of fats. (CA *35*, 4981.)
117. Kaufmann, H. P., and Wolf, W., Fette u. Seifen *48*, 51 (1941). The application of molecular distillation in the fat field. II. The distillation of glycerides. (CA *36*, 1202.)
118. Killeffer, D. H., Sci. Am. *157*, 372 (1937). Pure vitamin A by "molecular distillation."
119. *Kodak, Ltd. (assignee of Eastman Kodak Co.), Brit. 481,189, Mar. 7, 1938, appl. Aug. 5, 1936. Improvements in the manufacture of esters. (CA *32*, 6404.) (Similar to U. S. 2,169,195, K. C. D. Hickman and A. O. Tischer.)
120. *Kodak, Ltd., Brit. 517,214, Jan. 24, 1940, appl. Apr. 20, 1938. Vacuum-distillation of vitamin D-containing substances. (CA *35*, 6741.)
121. Kubias, J., Chem. Obzor *16*, 55 (1941); Chem. Zentr. *1942, I*, 1912. Molecular distillation. (CA *37*, 2961.)
122. Liggett, R. W., Gordon, K. M., and Hurd, C. D., Trans. Illinois State Acad. Sci. *34*, No. 2, 121 (1941). Separation and identification of sugars from mixtures. (CA *36*, 2530.) (See refs. 102, 103.)
123. *Litton, C. V. (25% each to Poniatoff, A. M., and Markel, J. L.), U. S. 2,266,053, Dec. 16, 1941, appl. July 31, 1939. Vacuum distillation of various materials. (CA *36*, 2184.)
124. Loyern, J. A., and Morton, R. A., Biochem. J. *33*, 1734 (1939). The distribution of the fat acids in halibut intestinal oil, with a note on the presence of free fat acids in the intestines of fish. (CA *34*, 3116.)
125. Marberg, C. M., J. Am. Chem. Soc. *60*, 1508 (1938). A semimicro sublimation apparatus. (CA *32*, 5261.)
126. *Metropolitan-Vickers Electrical Co., Ger. 580,213, Jul. 12, 1933, appl. Aug. 26, 1938. Distillation process. (Similar to Brit. 315,186, C. R. Burch, F. E. Bancroft and Associated Electrical Industries, Ltd.)
127. Morse, R. S., Ind. Eng. Chem. *30*, 1039 (1941). Molecular distillation of polymerized drying oils. (CA *35*, 6131.)
128. Müller, R. H., Ind. Eng. Chem. Anal. Ed. *13*, 667 (1941). Instrumental methods of chemical analysis. (CA *35*, 7867.)
129. Nelson, E. M., and Tolle, C. D., Ann. Rev. Biochem. *8*, 415 (1939). Fat-soluble vitamins. Vitamin D. (CA *33*, 6922.)
130. *Ockrent, C., Bennett, N., and Imperial Chemical Industries, Ltd., Brit. 452,659, Aug. 26, 1936, appl. Feb. 26, 1935. Paraffin-wax esters. (CA *31*, 1193.)
131. *Ockrent, C., Bennett, N., and Imperial Chemical Industries, Ltd., Brit. 452,661, Aug. 26, 1936, appl. Feb. 26, 1935. Hydrocarbons and chlorine derivatives; alcohols. (CA *31*, 1195.)
132. *Ockrent, C., Hardie, D. W. F., and Imperial Chemical Industries, Ltd., Brit. 452,660, Aug. 26, 1936, appl. Feb. 26, 1935. Carboxylic acids. (CA *31*, 1193.)
133. *Ockrent, C., and Imperial Chemical Industries, Ltd., Brit. 452,662, Aug. 26, 1936, appl. Feb. 26, 1935. Chlorinated paraffin wax. (CA *31*, 1193.)
134. Quackenbush, F. W., Cox, R. P., and Steenbock, H., J. Biol. Chem. *140*, Proc. civ. (1941). Stabilization of carotene in linoleic ester.
135. Quackenbush, F. W., Cox, R. P., and Steenbock, H., J. Biol. Chem. *145*, 169 (1942). Tocopherol and the stability of carotene. (CA *36*, 7092.)
136. Quackenbush, F. W., Gottlieb, H. L., and Steenbock, H., Ind. Eng. Chem. *33*, 1276 (1941). Distillation of tocopherols from soybean oil. (CA *35*, 7744.)
137. Randall, M., and Doody, T. C., J. Phys. Chem. *43*, 613 (1939). Octrahedral arsenious oxide. (CA *33*, 9077.)
138. Ratcliff, J. D., Barron's *21*, 3 (Jun. 23, 1941). Eastman Kodak's research odyssey.
139. Ray, J. N., Proc. Natl. Inst. Sci. India *5*, 205 (1939). Some recent developments in the study of the constitution of natural products. (CA *34*, 3233.)
140. Robeson, C. D., J. Am. Chem. Soc. *64*, 1487 (1942). Crystalline natural α-tocopherol acetate. (CA *36*, 4508.)
141. Robeson, C. D., and Baxter, J. G., Abstracts of papers, 104th Mtg., Am. Chem. Soc. 14B (Sept. 1942). Vitamin E, an antioxidant in fish liver oils.
142. Skishakov, F. A., Uspekhi Khim. *2*, 358 (1933). Molecular distillation in the organic laboratory. (CA *28*, 461.)
143. Smith, W. H., and Wing, H. J., Rubber Chem. Tech. *12*, 789 (1939). Behavior of rubber hydrocarbon in a molecular still. (CA *34*, 2641.) (A reprint of J. Research Natl. Bur. Standards *22*, 529 (1939.)
144. Spielman, M. A., and Anderson, R. J., J. Biol. Chem. *112*, 759 (1936). The chemistry of the lipids of tubercle bacilli. XLII. Studies on phthioic acid. (CA *30*, 1409.)
145. Tischer, A. O., J. Biol. Chem. *125*, 475 (1938). The nature of vitamin A in cod-liver oil. (CA *32*, 9394.)
146. Van Natta, F. J., Hill, J. W., and Carothers, W. H., J. Am. Chem. Soc. *56*, 455 (1934). Studies of polymerization and ring formation. XXIII. ϵ-caprolactone and its polymers. (CA *28*, 1665.)
147. Vlodrop, V. van, Chem. Weekblad *38*, 150 (1941). Catalytic effect of sulfur dioxide on the conversion of fatty oils. (CA *36*, 5663.)
148. Volmer, M., Z. angew. Chem. *34*, 149 (1921). New high vacuum methods in chemistry. (CA *15*, 2225.)
149. Von Elbe, G., and Scott, B. B., Ind. Eng. Chem., Anal. Ed. *10*, 284 (1938). High-vacuum fractional distillation without gravitational reflux. (CA *32*, 4830.)
150. *Von Elbe, G. J. K., and Scott, B. B., Jr. (to Carnegie Institute of Technology), U. S. 2,198,848, Apr. 30, 1940, appl. Jun. 29, 1936. Method for high-vacuum distillation. (CA *34*, 5704.)
151. *Voorhees, V. (to Standard Oil Co. of Ind.), U. S. 2,224,621, Dec. 10, 1940, appl. Jun. 20, 1938. High-vacuum distillation such as that of heavy high-boiling petroleum and lubricating oils. (CA *35*, 2712.)
152. Waterman, H. I., Chem. Weekblad *30*, 174 (1933). Modern methods of accomplishing hydrogenation, especially in the fat industry.
153. Waterman, H. I., and Elsbach, E. B., Rec. trav. chim. *53*, 730 (1934). The quantitative study of the oxidation of citronellal. (CA *28*, 5405.)
154. Waterman, H. I., Nellensteyn, F. J., and Daamen, N. P. J., Rec. trav. chim. *46*, 509 (1927). Distillation of Java citronella oil in a high vacuum. (CA *21*, 3421.)
155. Waterman, H. I., Over, J., and Tulleners, A. J., Rec. trav. chim. *53*, 699 (1934). Polymerization of isobutene. (CA *28*, 5397.)
156. Waterman, H. I., and Vlodrop, C. van, Rec. trav. chim. *53*, 670 (1934). Differences between biologically active substances before and after isolation from the raw material in which they occur. (CA *28*, 6166.)
157. Waterman, H. I., and Vlodrop, C. van, Molecular or short-path distillation. Paris: Gauthier-Villards 24 pp. (CA *37*, 2256.) (Also, Rev. chim. ind. [Paris] *48*, 314 [1939].)
158. Waterman, H. I., Vlodrop, C. van, and Pfauth, M. J., Verfkroniek *13*, 130 (1940). The "activation" of linseed oil by sulfur dioxide. (CA *34*, 8305.)
159. *Waterman, H. I., Dijk, J. A. van, and Vlodrop, C. van, Ger. 703,149, Mar. 6, 1941, appl. Mar. 21, 1933. Concentrates of vitamins, provitamins and the substances giving the Baudouin test. (CA *36*, 224.) (Cf. Brit. 452,442 and U. S. 2,143,587.)
160. *Waterman, H. I., and Vlodrop, C. van (to Imperial Chemical Industries, Ltd.), Australian 20,902/35, Oct. 31, 1935, appl. Jan. 11, 1935. Flavouring matters, and their application. (Chem. Zentr. *1936, I*, 4227.) (Similar to Dutch 43,250 H. I. Waterman and C. van Vlodrop.)
160a. Wheeler, D. H., Riemenschneider, R. W., and Sando, C. E., J. Biol. Chem. *132*, 687 (1940). Preparation, properties, and thiocyanogen absorption of triolein and trilinolein. (CA *34*, 2331.)
161. Withers, W. F., Australian Chem. Inst. J. and Proc. *9*, 103 (1942). Molecular distillation. (CA *36*, 5389.)
162. Wittka, F., Angew, Chem. *53*, 557 (1940). New methods in organic synthesis. VII. Molecular distillation. (CA *35*, 2849.)
163. Wittka, F., Allgem. Oel- u. Fett-Ztg. *38*, 269 (1941); Chem. Zentr. *1942, I*, 284. Problems of modern fat chemistry and technology. (CA *37*, 2201.)
164. Wittka, F., Allgem. Oel- u. Fett-Ztg. *38*, 318 (1941); Chem. Zentr. *1942, I*, 945. Modern fat chemistry methods. I. Separating glycerides with definite properties from natural fats. (CA *37*, 2201.)
164a. Wittka, F., Allgem. Oel- u. Fette-Ztg. *38*, 435 (1941). Modern fat-chemistry methods. IV. Purpose and aim of refining natural fats. (CA *37*, 3959.)

ACCESSORY APPARATUS AND TECHNIQUE

165. Abbott, F. R., Rev. Sci. Instruments *13*, 187 (1942). The use of fusible alloy in vapor diffusion pumps. (CA *36*, 3398.)
166. *Bancroft, F. E., and Miller, C. W. (to General Electric Co.), U. S. 2,249,450, Jul. 15, 1941, appl. Mar. 8, 1940. Condensation pump suitable for operation with "Apiezon" oil. (CA *35*, 6488.)
167. *Burrows, G., and Metropolitan-Vickers Electrical Co., Ltd., Brit. 475,062, Nov. 12, 1937, appl. May 12, 1936. Diffusion pumps. (CA *32*, 2794.)
168. *Carlson, W. A. (to General Mills, Inc.), U. S. 2,244,939, Jun. 10, 1941, appl. May 9, 1940. Vacuum connection for high-vacuum apparatus. (CA *35*, 5754.)
169. *Distillation Products, Inc., and Hickman, K. C. D., Brit. 531,745, Jan. 9, 1941, appl. Aug. 1, 1939. Cascade diffusion pumps for producing high vacua. (CA *36*, 4.) (Cf. ref. 187.)
170. *Eastman Kodak Co. (to Kodak, Ltd.), Brit. 514,820, Nov. 20, 1939, appl. May 11, 1938. High-vacuum condensation or diffusion pumps. (CA *35*, 4250.)
171. *Embree, N. D. (to Distillation Products, Inc.), U. S. 2,150,676, Mar. 14, 1939, appl. Oct. 8, 1937. High vacuum.
172. Friesen, S. v., Rev. Sci. Instruments *11*, 362 (1940). Large molecular pumps of the disk type. (CA *35*, 345.)
173. Friesen, S. v., Arkiv. Mat. Astron. Fysik *27B*, No. 11, 7 pp. (1940). A vacuum-meter combination for pressures between 1and 10^{-6} mm. Hg. (CA *35*, 2039.)
174. Garner, L. P., Rev. Sci. Instruments *8*, 329 (1937). Machined metal stuffing box seals adapted to high vacuum technique. (CA *31*, 7704.)
175. Hickman, K. C. D., J. Applied Phys. *11*, 303 (1940). Trends in design of fractionating pumps. (CA *34*, 3951.)
176. *Hickman, K. C. D. (to Eastman Kodak Co.), Brit. 513,586, Oct. 17, 1939, appl. Mar. 11, 1938. Producing vacua. (CA *35*, 2041.) (Similar to U. S. 2,150,685, K. C. D. Hickman.)
177. *Hickman, K. C. D. (to Eastman Kodak Co.), Brit. 514,766-67-68, Nov. 16, 1939, appl. May 14, 1938. High-vacuum condensation or diffusion pumps. (CA *35*, 4250.) (Similar to U. S. 2,153,189, K. C. D. Hickman.)
178. *Hickman, K. C. D. (to Distillation Products, Inc.), U. S. 2,206,093, Jul. 2, 1940, appl. Jan. 4, 1939. Vacuum pump. (CA *34*, 7151.)
179. *Hickman, K. C. D., and Baxter, J. G. (to Distillation Products, Inc.), Can. 403,495, Mar. 17, 1942, appl. Sept. 30, 1939. Preservation of glyceride oils and their fractions. (CA *36*, 3692.) (See ref. 180.)
180. *Hickman, K. C. D., and Baxter J. G. (to Distillation Products, Inc.), U. S. 2,282,054, May 5, 1942, appl. Oct. 5, 1938. Preserving glyceridic oils, fats and vitaminic vacuum-distillates from decomposition by oxidation. (CA *36*, 5957.) (See ref. 179.)
181. *Litton, C. V. (to Mackay Radio and Telegraph Co.), U. S. 2,289,845, Jul. 14, 1942, appl. Jan. 12, 1939. High-vacuum pump of the vapor condensation type. (CA *37*, 287.)
182. Lockenvitz, A. E., Rev. Sci. Instruments *8*, 322 (1937). A self-fractionating oil-diffusion pump. (CA *31*, 7704.)
183. Morse, R. S., Rev. Sci. Instruments *11*, 277 (1940). Baffles for oil-diffusion pumps. (CA *34*, 7148.)
184. Morse, R. S., and Bowie, R. M., Rev. Sci. Instruments *11*, 91 (1940). A new-style ionization gage. (CA *34*, 3579.)
185. *Morse, R. S. (to Distillation Products, Inc.), Brit. 537,673, Jul. 1, 1941, appl. Jun. 22, 1940. High-vacuum pumps. (CA *36*, 1820.) (Cf. ref. 187, U. S. 2,245,216.)
186. *Morse, R. S. (to Distillation Products, Inc.), Brit. 539,175, Aug. 29, 1941, appl. Jun. 22, 1940. High-vacuum pumps. (CA *36*, 3402.) (Cf. ref. 187, U. S. 2,245,215.)
187. *Morse, R. S. (to Distillation Products, Inc.), U. S. 2,245,215-16, Jun. 10, 1941, appls. Sept. 29, 1939 and Oct. 11, 1939 resp. High-vacuum pumping apparatus. (CA *35*, 5754.) (Cf. refs. 186 and 185 resp.)
188. Müller, R. H., Ind. Eng. Chem., Anal. Ed. *12*, 571 (1940). American apparatus, instruments and instrumentation. (CA *34*, 7661.)
189. Prausnitz, P. H., Chemicker-Ztg. *63*, 110 (1939). New apparatus out of Jena glass.
190. *Sykes, C., Bancroft, F. E., and Metropolitan-Vickers Electrical Co., Ltd., Brit. 477,013, Dec. 20, 1937, appl. Jun. 20, 1936. Condensation vacuum pumps operating with organic fluid. (CA *32*, 4393.)

Fat Acid Composition of Linseed Oil From Different Varieties of Flaxseed[1]

EDGAR PAGE PAINTER and L. L. NESBITT

Department of Agricultural Chemistry, North Dakota Agricultural Experiment Station, Fargo

The quantity of some chemical constituents in different varieties of the same crop may vary greatly. Plant breeders recognize the importance of production for specific compounds, as well as for total crop yields. Perhaps more emphasis is given to specific compounds in food crops than in a crop like flaxseed which is grown primarily for oil, but here also we find varietal differences.

Plant breeders have relied upon the iodine number as the criterion of the quality of linseed oil. Varietal differences in the iodine number of linseed oils have been repeatedly demonstrated in this laboratory. Dillman and Hopper (1) found the iodine number of oils from Redwing and Linota to average 10 points higher than oils from Rio and Bison when each of the four varieties was grown for several crop years at widely separated locations. Sometimes there is a difference of as much as 20 points between high and low iodine number producing varieties when grown under apparently identical conditions.

Attempts have been made to account for these differences in the iodine number by determining the fat acids of the oil. Gross and Bailey (2) found higher oleic acid and lower linolenic acid in oils from Bison than in oils from Abyssinian. Dillman and Hopper (1) recently reported the composition of a group of oils from Linota, Redwing, Bison and Rio. They found the highest percentage of saturated acids in Rio oils, the highest percentage of oleic acid in Bison oils and higher linolenic acid in Redwing and Linota oils than in Rio and Bison oils. Their results were based on analyses carried out in 1929, 1930, and 1931. Many refinements in thiocyanometric technique, as well as an improved method for the determination of the saturated acids, have been made since the above mentioned work was carried out. The composition of linseed oils, when calculated from empirical thiocyanogen numbers by using modified Kaufmann equations (3, 4, 5), differs greatly from that reported earlier. When calculating the composition of oils for analytical results supplied by the laboratories of Archer-Daniels-Midland Company, Dillman and Hopper (1) chose constants recommended by Riemenschneider, Swift and Sando (6) for 0.1 *N* thiocyanogen solutions.

The properties of a drying oil should depend more upon the fat acid composition than upon the total number of double bonds, as measured by the iodine number. Now that methods for the analysis of an oil like linseed have been improved so that the results appear to be near true values, it would seem that more complete analyses may be necessary for an evaluation of the many available products. The object of the present investigation is to determine whether or not there are varietal differences in the fat acid composition of linseed oil other than those which might be predicted from the iodine number.

A number of linseed oil samples[2] (pressed from finely ground seed) were selected for analysis. The

[1] Published by permission of the Director, N. Dak. Agr. Expt. Station. This work was carried out under Purnell 95, "The Chemistry of Flaxseed."

[2] Many of the flaxseed samples were obtained through the cooperative studies with A. C. Dillman, Associate Agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture. Others were from trials of the Agronomy Department of the North Dakota Station.