[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF NEVADA]

ESSENTIAL OILS IN DESERT PLANTS
I. PHYSICAL CONSTANTS

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In the semi-arid regions of western United States there is in most localities a stunted growth of plants referred to in general terms as sage-brush, but in reality composed of many widely differing species. The leaves and twigs of most of these plants when crushed have distinct and characteristic odors which indicate the presence of essential oils. Samples of a number of these plants have been collected and steam distilled for the purpose of detecting the presence of essential oils and determining their physical and chemical properties.

Specimens of these various desert plants collected at random, when steam distilled, usually yield from 0.05 to 0.5 of one per cent. of essential oil. The frequent occurrence of these oils has led one of us,[1] in a paper read before the American Association for the Advancement of Science, to suggest that, due to their diathermous properties, they serve, as experiments indicated, as a protection against rapid temperature changes for the plants and also suppress the rapid evaporation of water.

Tests made upon *Artemisia tridentata* prove that the oil exists only in the leaves and young shoots and that the percentage of oil shows a general increase from early spring until late summer. Leaves and twigs of *Chrysothamnus nauseosus* collected from parts of the same plants each month of the year show that the amount of oil varies from 0.04% during May and June to 0.23% in July, 0.39% in August and 0.83% in September. During the winter, when the leaves have fallen, the twigs contained 0.22%. A sample of *Graveolens nauseosus Mohavensis* grown in the botanical gardens at Berkeley, California,[2] yielded a smaller percentage of oil than the same variety growing in the more arid districts of Nevada.

The cause of these variations is undetermined; it may be due to the stage of development and maturity of the plants, or the increase of the oil during the driest season of the year may be a method of drought resistance developed by the plant.

Among the native plants of the semi-arid regions of the United States, essential oil has been observed in *Artemisia cana*,[3] *Artemisia frigida*, *Artemisia Leudoviciana*, *Artemisia caudata*,[4] and *Ramona stachyoides*.[5]

[1] Adams, *Am. Perfumer*, 17, 348 (1922).

[2] Supplied by L. A. Waitzinger.

[3] Whittelsey, A New Occurrence of *l*-Camphor, "Otto Wallach's Festschrift," Göttingen, 1909, pp. 668–70.

[4] Frank Rabak, "On Several New Artemisia Oils," *Pharmaceutical Review*, 24, 324–325 (1906).

[5] Frank Rabak, "Wild Volatile Oil Plants and Their Economic Importance,"

Volatile oil was found by us in the following plants: 1. *Artemisia tridentata typica*, leaves, flowers, and small twigs collected in various localities near Reno, Nevada, at various seasons of the year yielded when distilled from 0.3 to 0.92% of an oil, the first fraction colorless and the last distinctly green. It turns light yellow upon standing. The odor is that of the green plant, strong and very characteristic, and the taste is persistent and camphor-like. The vapors of the oil are tear-producing.

2. *Gutierrezia sarothrae*[6] collected in September, 1922, near Wedekin Mine, Washoe County, Nevada. The oil from the entire top of the plant is light yellow in color and has a mild but somewhat unpleasant odor.

3. *Juniperus Utahensis*,[7] leaves and small twigs collected in October, 1923, from trees growing eight miles north of Reno, Nevada, gave on distillation a mobile, colorless oil.

4. *Salvia lanceolata*,[7] called "purple sage" because of its clusters of small, purple flowers. Leaves, flowers and small branches collected from the rock bluffs along the west shore of Pyramid Lake, Nevada, in June, 1920, and another sample from near Chloride Cliff on the eastern rim of Death Valley, California, May 14, 1926, yielded a clear, strongly fragrant oil.

5. *Thamnosma* (probably *Texanum*) collected from near the Lahontan Dam in Churchill County, Nevada, April, 1916. The shrub is almost leafless and the small thorny branches cut into short pieces and distilled yielded a colorless, fragrant oil.

6. *Tetrademia glabrata*, "spring rabbit brush,"[8] collected in May, 1915, among the hills northeast of Reno gave on distillation of the flowers, leaves and small branches an ill-smelling oil which darkens readily and grows viscous when allowed to stand for a few days.

7. *Chrysothamnus graveolens*,[9] tops of plants in flower collected in September, 1915, near the Station Farm, Reno, Nevada, yielded on distillation a colorless oil which soon changed to a light yellow color and when purified consists chiefly of dipentene. The yield varies from 0.04 to 0.85%, depending on the season of the year in which the plants are gathered.

8. *Chrysothamnus viscidiflorens elegans*[6] collected on the flanks of Slide Mountain, near Franktown, Nevada, October, 1924. The tops when distilled yielded a colorless, ill-smelling oil.

9. *Chrysothamnus nauseosus graphalodes*[10] yielded a light yellow, ill-smelling oil.

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[6] Identified by L. A. Waitzinger of the U. S. Bureau of Plant Industry.

[7] Identified by P. A. Lehenbauer of the University of Nevada.

[8] Identified by N. F. Peterson, Botanist, Nevada Agricultural Experiment Station.

[9] Identified by S. B. Doten, Director, Nevada Agricultural Experiment Station.

[10] Collected February, 1924, by L. A. Waitzinger at Benton, California, near the Nevada-California state line.

10. *Chrysothamnus nauseosus viridulens.*[10] The smooth, green stems when distilled yielded a yellow oil which became viscous on standing.

11. *Chrysothamnus nauseosus hololeucus.*[10] The white stems of this plant yielded a dark yellow, pleasant-smelling oil.

12. *Chrysothamnus nauseosus Mohavensis,* collected from the botanical gardens at Berkeley, California, March, 1924, yielded a clear, colorless oil with a disagreeable odor.

The distillations were carried out by placing the samples in a wire basket which fitted closely into a tin-lined copper still and passing in steam under a pressure of ten pounds. The distillation was continued for three to four hours. The light oil which floated on the surface was drawn off and purified in each case by a second steam distillation. No attempt was made to extract the oil which remained dissolved in the condensed water. In all cases, therefore, the per cent. of oil present in the specimen is somewhat greater than that recovered. When freshly distilled and dried in contact with potassium carbonate the various oils have the following physical constants.

TABLE I

PHYSICAL CONSTANTS OF THE OILS

	Name	Essential oil in plant, %	Sp. g. (18°)	B. p., °C. (642–647 mm.)	Sp. rotation, $^{20}_{D}$	N^{20}_{D}	Iodine no. (Hübl method)
1.	*Artemisia tridentata typica*	0.92	0.9052	173.5	− 8.54	1.4689	168.0
2.	*Gutierrezia sarothrae*	.33	.8678	157.5	+36.49	1.4741	304.4
3.	*Juniperus Utahensis*	..	.8879	163.5	+56.36	1.4715	224.7
4.	*Salvia lanceolata*	.32	.9254	185.5	+ 2.35	1.4771	110.9
5.	*Thamnosma Texanum*	.05	.9593	128.0	+57.67	1.4737	119.4
6.	*Tetrademia glabrata*	.12	.8522	163.0	.....	1.4756	189.6
7.	*Chrysothamnus graveolens*	.85	.8746	169.5	− 1.62	1.4842	184.1
8.	*Chrysothamnus viscidiflorens elegans*	..	.8549	162.0	+20.67	1.4797	325.3
9.	*Chrysothamnus nauseosus graphalodes*	.49	.8651	159.0	.....	1.5080	...
10.	*Chrysothamnus nauseosus viridulens*	.17	.9045	...	.....	1.5008	...
11.	*Chrysothamnus nauseosus hololeucus*	.18	.9797	160.5	.....	1.5399	...
12.	*Chrysothamnus nauseosus Mohavensis*	.16	.8924	126.0	.....	1.4971	...

These oils, being mixtures, do not have very definite boiling points. There was no pressure correction made; the temperature at which the liquid in a flask to which a reflux condenser was attached freely boiled at the local barometric pressure was recorded as the boiling point.

The specific rotation and refractive index of the freshly distilled oil are recorded. Our observations show that these constants are subject to change when the oils are kept for some time, especially when exposed to light and air.

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