PHOSPHATE DEPOSITS IN NEW GUINEA.

By R. C. Hutchinson.

Department of Agriculture, Rabaul.

Introduction.

The most important fertilizer constituents are nitrogen, phosphoric acid and potash. The constituents most lacking in New Guinea soils are potash and phosphoric acid. This has been proved directly by chemical analyses and indirectly by the remarkable results which follow the use of potassic and phosphoric fertilizers on some plantations.

Nearly all phosphoric and potassic fertilizers employed in this Territory are imported from Australia at a cost which makes their use uneconomical except on the most remunerative crops. This is greatly retarding agriculture in this Territory, where fertilizers are badly needed and would certainly be supplied more freely if their cost were not so high. One way of overcoming the difficulty would be to find local sources of these constituents from which cheap supplies could be obtained. No local source of potash of commercial importance is known, but there are several sources of phosphoric acid, the two principal being the rock on certain islands and bat guano.

Rock Phosphate.

In 1905, the Germans first discovered rock phosphate in New Guinea. About five years later, Mole Island, a unit of the Purdy Group, was worked for phosphate under the New Guinea Protectorate, but when Nauru became the important source of this commodity, the Purdy Islands' deposit was practically ignored. In 1909, the Hanseatic Pacific Expedition, led by Dr. Georg Friederiei, investigated a number of islands for phosphate deposits sufficiently large to be worked. A number of hitherto geologically unknown islands, and also some islands previously examined, were visited. The summarized results of the findings of this expedition for islands within the Territory of New Guinea are given in Tables 1 and 2. In 1929, the British Phosphate Commissioners sent Mr. K. M. Fennell to New Guinea to investigate the phosphate deposits. Some of his conclusions are tabulated in Tables 1 and 2 and others will be referred to later.

In New Guinea, there are two groups of islands on which phosphate rock exists. One group, situated in the north-western corner of the Territory, consists of Wuvulu (Maty), Aua (Durour) and Manu (Allison) Islands and the other group, known as the Purdy Islands, is situated to the south-west of the Island of Manus.

Wuvulu Island is about 5 miles in length and 2½ miles in breadth at its widest part. The island is surrounded by a coral reef and there is no sheltered anchorage. The phosphate deposit, which is nearly all rock, is situated in the south-west corner of the island and is scattered over an area of about an acre. It is difficult to estimate the quantity as it is covered with dense jungle which is difficult to penetrate.

About 20 miles from Wuvulu is Aua Island, which is about 3 miles in length and about 1 mile in breadth at its widest part. It is surrounded by a coral reef which is about 50 yards wide in the south and from 300 to 400 yards wide in the north. There is no protected anchorage. A phosphate deposit is situated about ¼ mile inland on the south-east section of the island. It is about 1,000 yards in length, varies from 30 to 150 yards in breadth and is from 6 to 8 feet deep. It is nearly all rock, with a little alluvial which appears more like ordinary soil than phosphate. The deposit is intermixed with broken coral-rock, sand and mud and is covered with a thick growth of ferns and creepers. The exposed phosphate is covered with a coating of moss. Fennell (1929) estimated the quantity at not more than 80,000 tons. In 1911, the Germans prospected the island for phosphate and their sample pits are still to be seen.

Manu Island is about 37 miles north-east of Aua and has an area of 62 acres. It is only 4 feet above sea-level and the deposit of phosphate is small. There is no protected anchorage.

The Purdy Islands consist of five islands—Mole, Mouse, Rat, North Bat and South Bat—the relative positions of which are shown in Figure 1. Rat Island is the smallest of the group, being only about $^1/_{10}$th acre in area. The sizes of the other islands are given in Table 3. These areas were determined from a compass survey conducted by the author. This group of islands is more centrally situated with regard to the rest of the Territory than the preceding, and there is a well-protected anchorage between North Bat and South Bat Islands.

In general, the Purdy Islands are built up, as shown in Figure V. Surrounding each island is a flat coral reef, part of which is just above water at low tide. The width of this reef varies from about 2 chains at the narrowest parts on Mole and Mouse Islands to over ¼ mile at the widest parts on the Bat Islands. Each island is surrounded by a coarse, white beach of coral origin, behind which there is a sand embankment rising about 6 feet above high-water mark. The islands are saucer-shaped, being about 2 feet above high-water level in the centre. In wet weather, the centres are inclined to be swampy. On all the islands there are coco-nuts, vines and ferns growing and on some islands miscellaneous shrubs and trees.

On Mole and Mouse Islands, the phosphate is to be found in the low-lying centres of the islands (*see* Figures II. and IV.), where it is generally to be found, a few inches below the surface, as lumps of rock weighing 2 to 10 lb. On Mole Island, a stack of at least 400 tons of phosphate is to be found on the western end of the island. This phosphate was collected when the island was being worked by the Germans. It is illustrated in Figure A, where it is seen to be almost covered with small ferns.

On each of the Bat Islands, the phosphate deposits extend out into the sea on one side (*see* Figure III.). This suggests that, in recent years, these islands have moved closer together, thus laying bare phosphatic rock which was originally in the centres of the islands. The beach outcrop on North Bat Island is illustrated in Figure B.

The thickness of the phosphate layers varies greatly. In some places it is possible to sink a 4-in. hole without striking any phosphate, while in other places it runs to a depth of 3 feet. This irregularity of depth is to be found on all the islands and the mean depth of phosphate calculated from 32 determinations was 5 inches. In estimating the total amount of phosphate in Table 3, the depth has been taken as 3 inches, so that the estimation is a very conservative one.

The phosphate was light in weight, very porous and light to medium brown in colour. It was very heterogeneous in composition and small white particles of shell and coral were distinctly visible to the naked eye. In general appearance, the phosphate from the Purdy Islands greatly resembles samples of phosphate inspected by the author from the other phosphate islands—Wuvulu, Manu and Aua.

Samples of phosphate were collected from each of the Purdy Islands and later analysed. The results of these analyses, conducted on the air-dried samples, are given in Table 4. For comparison, the compositions of other Pacific island phosphates are given in Table 5. These figures were taken from "Corallogene Phosphat-Inseln Austral-Oceaniens" by Carl Elschner.

Comparing the results in Tables 4 and 5 it will be seen that the Purdy Islands' phosphate, and probably the phosphate from the other New Guinea islands, is not of high quality. It is very porous, readily absorbs water and contains a large proportion of organic matter. It is probably of a much later date than the deposits on Nauru and the other islands mentioned in Table 5. The rock contains a considerable quantity of lime which indicates that the phosphate is in the form of calcium phosphate. Calculating the phosphate as tricalcium phosphate for comparison, it will be seen that the New Guinea rock is considerably lower in this constituent than rock from the islands mentioned in Table 5.

Bat Guano.

Bat guano, generally consisting of the excrement of several types of bats, is to be found on the floors of caves in many parts of New Guinea. The entrances to these caves are generally situated in places difficult of acccess and, although a great many caves are known, there are undoubtedly a large number which have not yet been discovered.

Recently the author visited a large limestone cave at Kaut on the west coast of New Ireland which, according to all accounts, is one of the largest guano caves yet discovered in New Guinea. The entrance to the cave is on the face of a cliff about 70 feet above sea level. Close to the base of the cliff is an excellent schooner anchorage and the guano could probably be loaded straight into the ship by means of a flying fox, although a considerable reduction in weight would result if the guano were first dried.

The cave consisted of an outer chamber which was in semi-darkness, a large inner chamber in complete darkness and a number of small grottoes. The cave penetrated the cliff for nearly a quarter of a mile and contained many pools of crystal clear water and some very fine stalactites and stalagmites. It was inhabited by large numbers of bats varying in length from 2 to 10 inches, rats, snakes and insects. The guano, which was very moist and slippery, varied in colour from black to light brown and in places was several feet deep. The irregular depth of the guano was due to the unevenness of the cave floor which, in places, penetrated the guano. It is estimated that the cave contains from 5,000-10,000 tons of guano. Numerous samples were collected from different parts of the cave and at different depths. The minimum and maximum figures obtained are given in Table 6.

Several years ago a large bat cave inhabited by a small variety of bat was discovered in the Madang District. A sample was collected from the surface of the guano and sent to the Imperial Institute for analysis. The results are given in Table 6.

In Table 7, the composition of bat guano from the Federated Malay States and cave earth from Mozambique is given for comparison.

In the Kaut caves, the composition of the guano in the outer chamber consists of about 16 per cent. phosphoric acid and 26 per cent. lime which indicates that most of the phosphate is in the form of calcium phosphate. This guano compares very favorably with the best guano from the Federated Malay States. Guano from other parts of the cave, although containing as much as 43 per cent. phosphoric acid, was very low in lime, generally containing 1-2 per cent., which indicates that the phosphoric acid is present as phosphates of iron and alumina and not as calcium phosphate. The Madang guano contains considerably less phosphoric acid, a large proportion of which exists as phosphates of metals other than calcium, probably those of iron and alumina.

In the guano from both caves, the percentages of potash and nitrogen are low. It may be remarked, also, that the nitrogen content of bat guano is largely derived from undigested parts, such as the wings of insects, and is unavailable for plant nutrition. The total percentages of nitrogen, therefore, cannot be regarded as being entirely of immediate manurial value.

The guano in the two caves mentioned above is probably typical of the guano in most caves in this Territory.

Summary.

In New Guinea there are deposits of low-grade rock phosphate amounting to at least 100,000 tons and numerous bat caves, some of which contain large deposits of guano.

It is not considered that the quantity or quality of the phosphatic rock or guano is sufficient to consider the exportation of these commodities, but they contain sufficient phosphoric acid, either in a form suitable for direct application or in a form which can be readily made available, to meet local agricultural requirements for many years to come.

TABLE 1.—PLACES UNSUCCESSFULLY SEARCHED FOR PHOSPHATE WORTH WORKING.

Place.	District.	Investigator.	Remarks.
Alim Island	Manus	Friederiei (1909)	Formed of coral lime
Anir Island	New Ireland	Friederiei (1909)	
Baluan Island	Manus	Friederiei (1909)	Formed of eruptive rock
Buka Island	Kieta	Friederiei (1909)	
Dylup Plantation	Madang	Fennell (1929)	Traces of P_2O_5
Keule Island	Sepik	Friederiei (1909)	
Kilinailau Islands	Kieta	Friederiei (1909)	
Liebliche Islands	New Britain	Friederiei (1909)	Composed of coral lime
Lou Island	Manus	Friederiei (1909)	Formed of eruptive rock
Mait Island	New Ireland	Friederiei (1909)	
Nissan Island	Kieta	Friederiei (1909)	
Nuguria Islands	Kieta	Friederiei (1909)	
Nukumanu Islands	Kieta	Friederiei (1909)	
Pak Island	Manus	Friederiei (1909)	Formed of coral lime
Simberi Island	New Ireland	Friederiei (1909)	
Tabar Island	New Ireland	Friederiei (1909)	
Talele Islands	New Britain	Germans (1905) Fennell (1929)	Limestone containing .21 per cent. P_2O_5
Tanga Islands	New Ireland	Friederiei (1909)	
Taku Islands	Kieta	Friederiei (1909)	
Tendanye Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Valif Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Viai Island	Sepik	Friederiei (1909)	Formed of andesitic eruptive rock
Other small islands adjacent to St. Matthias, Emirau, Tench and Lihir Islands	New Ireland	Friederiei (1909)	

TABLE 2.—ISLANDS VISITED BUT NOT THOROUGHLY INVESTIGATED FOR PHOSPHATE.

Island.	District.	Investigator.	Remarks.
Emirau ..	New Ireland ..	Fennell (1929)	Phosphate deposits unlikely
Komuli Group ..	Manus ..	Fennell (1929)	Of both volcanic and coral formation; phosphate unlikely
Manus ..	Manus ..	Fennell (1929)	No indications of phosphate
Maron ..	Manus ..	Fennell (1929)	Volcanic formation; rugged; no indication of phosphate
Massau ..	New Ireland ..	Fennell (1929)	Phosphate deposits unlikely
Ninigo Group— Awin, Longan, Mal, Pelleluhu, Sumasuma	Manus ..	Fennell (1929)	Low, sandy flat islands of coral formation; no indications of phosphate
Ndruval ..	Manus ..	Fennell (1929)	Coral formation; no indications of phosphate
Pak	Manus ..	Fennell (1929)	Coral formation; no indications of phosphate
Ponam ..	Manus ..	Fennell (1929)	Coral formation; low, sandy; phosphate deposits unlikely
Salami ..	Manus ..	Fennell (1929)	Coral formation; low, sandy; phosphate deposits unlikely
Salien ..	Manus ..	Fennell (1929)	Coral formation; very low, marshy; phosphate deposits unlikely
Sici Liu ..	Manus ..	Fennell (1929)	Coral formation; low, sandy; phosphate deposits unlikely
Sici Mandarin ..	Manus ..	Fennell (1929)	Coral formation; low, sandy, marshy; phosphate deposits unlikely
Tingwon Group	New Ireland ..	Fennell (1929)	Coral formation; low, sandy, marshy; phosphate deposits unlikely

TABLE 3.—APPROXIMATE QUANTITY OF PHOSPHATE ON PURDY ISLANDS.

Island.	Total Area.	Area of Phosphate.	Volume of Phosphate.	Specific Gravity.	Approximate Weight of Phosphate.
	Sq. yds.	Sq. yds.	Cub. yds.		Tons.
Mole	298,800	101,700	8,490	1.6	10,200
Mouse	166,900	46,800	3,900	1.7	5,000
North Bat	54,600	21,200	1,770	1.8	2,400
South Bat	201,200	88,000	7,330	1.7	9,400
Total	721,500	257,700	21,475	..	27,000

TABLE 4.—COMPOSITION OF PURDY ISLANDS' PHOSPHATE.

Constituent.	Mole.	Mouse.	North Bat.	South Bat.	Mean.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	8.9	5.7	5.9	7.2	6.9
Loss on ignition	24.6	32.9	26.4	26.6	27.6
Insoluble matter	0.15	0.27	0.14	0.21	0.19
Lime	52.2	53.2	49.7	50.5	51.4
Phosphoric acid	11.7	11.2	10.4	10.0	10.8
Tri-calcium phosphate* ..	25.6	24.5	22.7	21.8	23.7

* = all P_2O_5 reckoned as $Ca_3P_2O_8$.

TABLE 5.—COMPOSITION OF OTHER PACIFIC ISLAND PHOSPHATES.

Constituent.	Nauru.				Ocean.		
	1.	2.	3.	Mean.	1.*	2.*	Mean.*
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	1.94	1.70	2.95	2.20	..	..	..
Loss on ignition ..	2.90	3.30	3.74	3.31	3.70	3.62	3.66
Lime	52.46	52.47	51.39	52.11	..	..	..
Phosphoric acid ..	38.79	38.72	38.46	38.66	..	..	..
Tri-calcium phosphate ..	..	84.60‡	..	84.60‡	85.90‡	85.30	..

Constituent.	Fais.			Makatea.			Angaur 1.†
	1.†	2.†	Mean.†	1.*	2.*	Mean.*	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Moisture	2.08	..	2.08	1.40	..	1.40	1.20
Loss on ignition ..	..	1.90	1.90	3.05	2.90	2.98	..
Lime	49.88	52.70	51.29	53.70	53.58	53.64	51.52
Phosphoric acid ..	37.03	38.20	37.62	37.88	38.68	38.28	39.66
Tri-calcium phosphate ..	80.93‡	83.47‡	82.20‡	82.76‡	..	82.76‡	86.76‡

* = dried at 100° C. † = probably dried at 100° C. ‡ = all P_2O_5 reckoned as $Ca_3P_2O_8$.

TABLE 6.—COMPOSITION OF BAT GUANO FROM TWO NEW GUINEA CAVES.

Constituent.	Kaut.*		Madang.†
	Maximum.	Minimum.	
	Per cent.	Per cent.	Per cent.
Moisture	21.5	14.3	..
Loss on ignition	38.2	8.4	..
Insoluble in HCl.	11.2	7.3	..
Soluble in HCl.	62.1	38.3	..
Phosphoric acid	43.1	14.6	8.9
Lime	26.2	1.3	4.3
Potash	4.1	0.2	0.9
Nitrogen	3.2	0.1	3.7

* Estimated on air-dried sample. † Probably estimated on air-dried sample.

TABLE 7.—COMPOSITION OF BAT GUANO FROM FEDERATED MALAY STATES AND MOZAMBIQUE.

(ANALYSES BY THE IMPERIAL INSTITUTE.)

Constituent.	Bat Guano, Federated Malay States.				Cave Earth, Mozambique.
	1.	2.	3.	4.	
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Phosphoric acid	17.52	8.60	10.86	14.17	10.92
Lime	22.27	1.81	1.86	2.32	2.42
Potash	2.01	1.12	0.88	0.88	0.35
Nitrogen..	2.47	0.81	1.52	0.84	0.81

Figure A.—Phosphate Stack on Mole Island.

Figure B.—Phosphate Outcrop on North Bat Island.

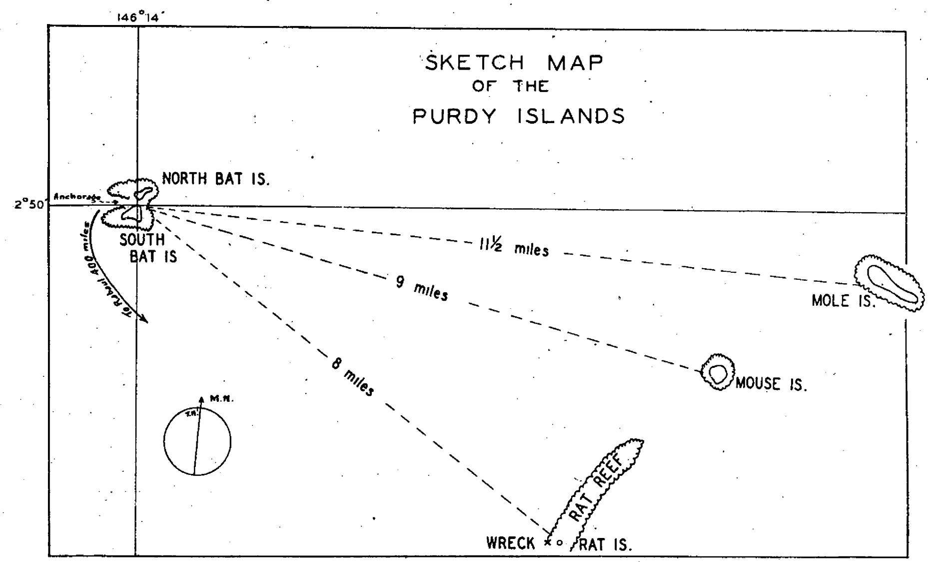

Figure I.

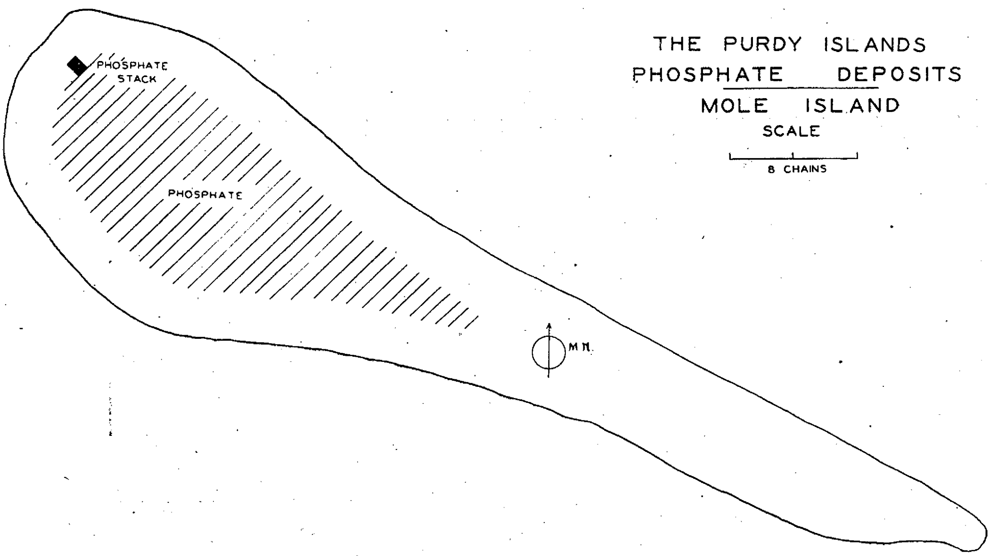

Figure II.

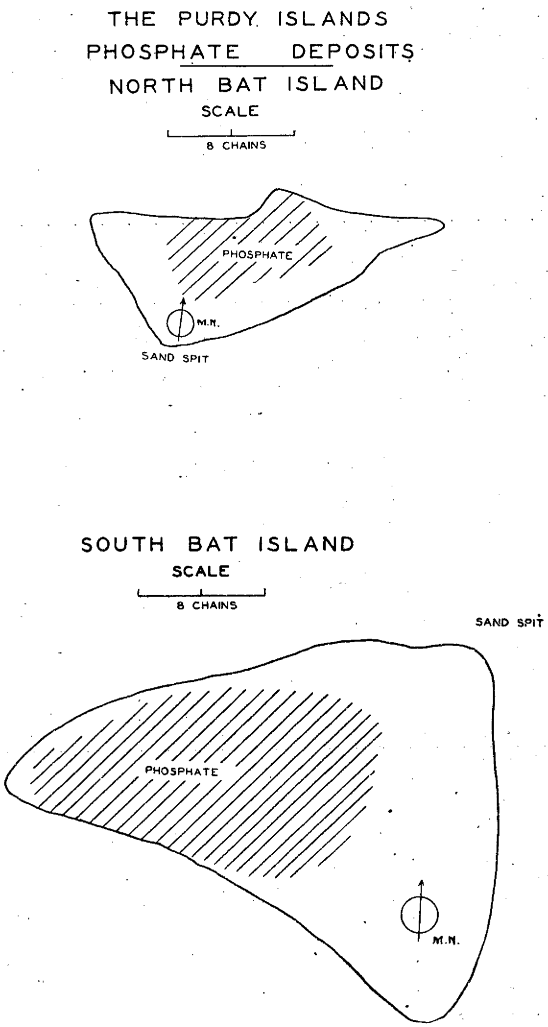
THE PURDY ISLANDS
PHOSPHATE DEPOSITS
NORTH BAT ISLAND
SCALE
8 CHAINS
PHOSPHATE
M.N.
SAND SPIT
SOUTH BAT ISLAND
SCALE
8 CHAINS
SAND SPIT
PHOSPHATE
M.N.

Figure III.

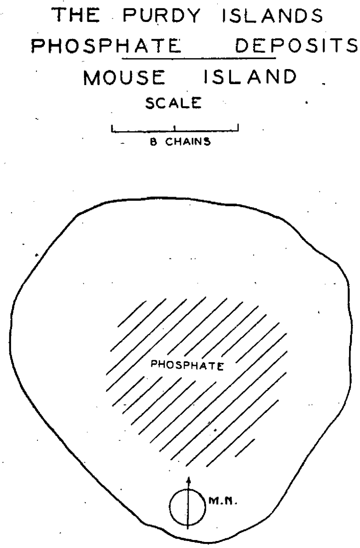

Figure IV.

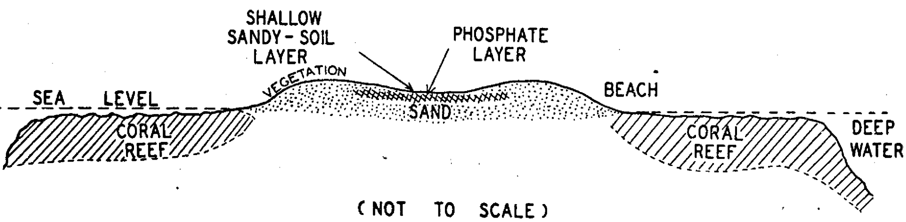

Figure V.

THE CONVERSION OF COCO-NUT OIL INTO A SOLID CRYSTALLINE MASS.

While engaged in the study of thermal decomposition of coco-nut oil, J. Banzon (*The Philippine Agriculturist,* Vol. XXVI., No. 5, p. 399) observed that a particular catalyst had the unique property of converting coco-nut oil into a crystalline solid mass.

The process is the simple distillation of coco-nut oil with ferric oxide or finely divided iron. The distillate thus obtained is dark-yellowish with a bluish fluorescence. On cooling, it sets to a crystalline greenish-yellow mass, which may be purified by repeated washings with methylated spirits.

The purified product is a light, white, crystalline powder, tasteless, and with a faint odour similar to stearic acid. It melts sharply at 55° C., to a clear transparent, colourless liquid, and solidifies to a hard, rather brittle, crystalline solid. Owing to its close resemblance to paraffin, this solid may possibly be used interchangeably with the latter, as, for example, in candle-making.