

A Table of Spectroscopic Data on Fats, Fatty Acids, and Their Esters

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A LARGE number of absorption spectra of oils and fatty acids have been recorded in the literature. Many of them are important as reference curves to be used for analysis or for the detection of impurities. In the following table the naturally occurring lipids are grouped as animal fats and plant oils. The individual fatty acids are ar-

ranged according to degree of unsaturation and the presence or absence of conjugation. Finally, there

Lipid	Reference	Wave Length Range (A)
ANIMAL FATS		
Bovine, blood fat.....	61	2300-2900
Bovine, body fat.....	66	2300
Bovine, milk fat.....	61	2300-2900
Butter acids.....	34	2300-4000
Butter acids.....	9	2300
Butter acids.....	45	2300-2700
Chicken, abdominal fat.....	21	2300-2700
Chicken, egg fat.....	21	2300-2700
Chicken, liver fat.....	17	.....
Cod liver oil.....	27, 28	2300-4400
Cod liver oil.....	23	2200-2900
Cod liver oil.....	22	2300
Cod liver oil.....	19	2500-3900
Cod liver oil.....	20	2800-3400
Cod liver oil.....	68	2500-4000
Cod liver oil.....	67	2300-4000
Cod liver oil.....	70, 71	2200-3400
Cod liver oil.....	73	2400-4000
Cod liver oil.....	65	2300*
Conger eel, liver oil.....	27	2300-4500
Dab, liver oil.....	27	2300-4500
Dogfish, liver oil.....	68	2500-4000
Duck, body fat.....	65	2300
Haddock, liver oil.....	27	2300-4500
Halibut, liver oil.....	34	2300-4000
Halibut, liver oil.....	65	2300-2900
Herring oil.....	53	2400-3100
Human body fat.....	65	2300
Human milk fat.....	61	2300-2900
Lard.....	26	2300-3970
Lard.....	3	2100-2700
Lard.....	41	2200-3200
Ling, liver oil.....	27	2500-4000
Pig, blood fat.....	61	2300-2900
Pig, body fat.....	65	2300
Pig, leaf fat.....	61	2300-2900
Pig, liver fat.....	61	2300-2900
Pollach, liver oil.....	27	2300-4500
Rat, body fat.....	65	2300
Rat, inter-peritoneal fat.....	66	2300-2900
Rat, milk fat.....	61	2300-2900
Rat, subcutaneous fat.....	66	2300-2700
Roach, body fat.....	65	2300-2700
Sardine oil.....	10	2222-4000
Sardine oil.....	22	2300
Sardine oil.....	48	2100-2900
Seal, body fat.....	65	2300-2400
Seal, liver fat.....	68	2500-4000
Shark, liver oil.....	68	2500-4000
Shark, liver oil.....	34	2300-4000
Sheep, body fat.....	65	2300
Skate, liver oil.....	68	2500-4000
Sturgeon, peritoneal fat.....	27	.....
Turbot, liver oil.....	65	2300-2900
Turbot, liver oil.....	27	2300-4500
Whale, liver oil.....	67	2300-4000
Whale oil.....	34	2300-4000
Whale oil.....	53	2400-3100
Whale oil.....	65	2300-2900

Lipid	Reference	Wave Length Range (A)
VEGETABLE OILS		
Arachis oil.....	33	4000-7000
Arachis oil.....	65	2300
Castor oil.....	18	2300-4000
Castor oil.....	33	4000-7000
Castor oil.....	46	2150-3100
Castor oil.....	48	2100-2800
Castor oil esters.....	10	2222-4000
Cocoonut oil.....	3	2100-2700
Cocoonut oil.....	18	2000-4000
Cocoonut oil.....	33	4000-7000
Cocoonut oil.....	61	2300-2900
Cocoonut oil.....	65	2300
Corn oil.....	3	2100-2700
Corn oil.....	19	2500-3900
Corn oil.....	61	2300-2900
Corn oil.....	64	2300-3300
Corn oil.....	77	1700-2500
Corn oil.....	48	2100-2900
Cottonseed oil.....	18	2000-4000
Cottonseed oil.....	34	2300-4000
Cottonseed oil.....	33	4000-7000
Cottonseed oil.....	64	2300-3300
Cottonseed oil.....	65	2300
Linseed oil.....	3	2100-2700
Linseed oil.....	10	2222-4000
Linseed oil.....	22	2300
Linseed oil.....	33	2000-7000
Linseed oil.....	61	2300-2900
Linseed oil.....	63, 64	2300-3300
Linseed oil.....	53	2400-3100
Linseed oil.....	71	2200-3400
Linseed oil.....	48	2100-3200
Linseed oil.....	77	1700-2500
Palm kernel oil.....	65	2300
Palm oil.....	65	2300
Palm oil.....	46	2200-5450
Perilla oil.....	61	2300-2900
Perilla oil.....	48	2100-3500
Poppyseed oil.....	61	2300-2900
Oiticica oil.....	10	2222-4000
Oiticica oil.....	48	2250-3400
Olive oil.....	3	2100-2700
Olive oil.....	18	2000-4000
Olive oil.....	19	2560-3900
Olive oil.....	33	4000-7000
Olive oil.....	34	2300-4000
Olive oil.....	58	2375-4000
Olive oil.....	53	2400-3100
Olive oil.....	61	2300-2900
Olive oil.....	65	2300
Olive oil.....	77	1700-2500
Olive oil.....	48	2130-3100
Rape oil.....	23	2300
Rape oil.....	48	2130-3350
Sesame oil.....	46	2430-3300
Sesame oil.....	33	4000-7000
Soybean oil.....	19	2222-4000
Soybean oil.....	64	2300-3300
Soybean oil.....	65	2300
Soybean oil.....	48	2100-3300
Teaseed oil.....	53	2400-3100
Tung oil.....	66	2300-2700
Tung oil.....	47	2250-3300
Tung oil.....	61	2350-2900
Tung oil.....	48	2250-3500

are listed fats and fatty acids which have been subjected to autoxidation, alkali isomerization, or to other treatments.

The table includes literature references, information on the range of wave lengths, solvents used,

wave lengths of maxima, and their approximate numerical value when known. Those maxima are omitted which are not characteristic of the pure substance but are due to impurities. Infra-red data are not included in this summary.

Acid	Ref.	Wave Length Range	Abs. Max.	E ₁ pct. 1 cm.	Solvent
SATURATED SUBSTANCES					
Formic acid.....	6, 7	2144-3000			Water
Formic acid.....	8	2144-2525			Alcohol and water
Formic acid.....	36	2200-2900			Several
Formic acid.....	56	1832-2285	2060	13.7	Water, alcohol and hexane
Formic acid.....	75	2200-2555			.....
Acetic acid.....	77	1700-2500	2080	6.8	Heptane and iso octane
Acetic acid.....	6, 7	2144-3000			Water
Acetic acid.....	8	2195-2460			Alcohol and water
Acetic acid.....	35	2380-4000			Water
Acetic acid.....	40	2200-2900			Several
Acetic acid.....	36	2200-2500			Hexane
Acetic acid.....	36	2200-2500			Alcohol or hexane
Acetic acid.....	40	2190-2800			Alcohol
Acetic acid.....	54	1850-2350	2050	8.7	Hexane
Acetic acid.....			2050	10.3	Water
Acetic acid.....	55	1845-2165	2040	6.6	Hexane
Acetic acid.....			2050	10.3	Water
Acetic acid.....			2050	8.7	Alcohol
Acetic acid.....					.....
Acetic acid.....	56	2150-2350			Alcohol
Acetic acid.....	61	2300			.....
Acetic acid.....	75	2200-2555			.....
Propionic acid.....	6, 7	2144-3000			Water
Propionic acid.....	8	2195-2480			Water and alcohol
Propionic acid.....	35	2380-6000			Water
Propionic acid.....	37	2480-6000			Vapor
Butyric acid.....	6, 7	2144-3000			Water
Butyric acid.....	37	2480-6000			Vapor
Butyric acid.....	36	2200-2900			Several
Butyric acid.....	61	2300			Alcohol
Butyric acid.....	75	2200-2555			.....
Butyric acid.....	8	2195-2480			Water and alcohol
Butyric acid.....	1	2000-6000			.....
Butyric acid.....	56	1840-2185	2060	5.7	Water, alcohol or hexane
Valeric acid.....	8	2144-2525			Alcohol or water
Valeric acid.....	37	2480-6000			Vapor
Caproic acid.....	61	2300			Alcohol
Caproic acid.....	75	2200-2555			.....
Caprylic acid.....	77	1700-2500	2050	4.7	Heptane
Caprylic acid.....	61	2300			Alcohol
Caprylic acid.....	75	2200-2555			.....
Capric acid.....	61	2300			Alcohol
Capric acid.....	75	2200-2555			.....
Lauric acid.....	36	2480-6000			Several
Lauric acid.....	37	2480-6000			Vapor
Lauric acid.....	61	2300			Alcohol
Lauric acid.....	65	2300			Alcohol or cyclohexane
Lauric acid.....	75	2200-2555			.....
Myristic acid.....	61	2300			Alcohol
Myristic acid.....	65	2300			Alcohol or cyclohexane
Myristic acid.....	75	2200-2555			.....
Myristic acid.....	77	1930-2350	2050	2.0	Heptane
Myristic acid.....	48	2100-2500			.....
Palmitic acid.....	3	2100-2500			Alcohol
Palmitic acid.....	37	2480-6000			Vapors
Palmitic acid.....	48	2100-2500			.....
Palmitic acid.....	56	2030-2428	2120	2.0	Alcohol
Palmitic acid.....	61	2300			Alcohol
Palmitic acid.....	65	2300			Alcohol or cyclohexane
Palmitic acid.....	75	2200-2555			.....
Stearic acid.....	22	2300			Cyclohexane
Stearic acid.....	37	2480-6000			Vapors
Stearic acid.....	60	2100-2500			.....
Stearic acid.....	61	2300			Alcohol
Stearic acid.....	75	2200-2555			.....
Stearic acid.....	48	2100-2500			.....
Stearic acid.....	59	2220-2500			.....
Stearic acid.....	3	2100-2500			Alcohol
Tripalmitin.....	10	2222-4000			Hexane or cyclohexane
Tristearin.....	10	2222-4000			Hexane or cyclohexane
Behenolic acid.....	59	2290-2380			.....
SINGLY UNSATURATED SUBSTANCES					
Elaidic acid.....	46	2270-2840			Hexane
Elaidic acid.....	48	2100-2700			.....
Elaidic acid.....	65	2300			Alcohol or cyclohexane
Elaidic acid.....	77	1700-2500	1860	290	Heptane
Elaidic acid.....	41	2150-2800			Alcohol
Elaidic acid.....	59	2440-2630			.....
Erucic acid.....	65	2300			Alcohol or cyclohexane
Erucic acid.....	59	2220-2500			.....
Oleate, ethyl.....	41	2100-2800			Alcohol
Oleate, ethyl.....	46	2150-3350			Alcohol
Oleate, methyl.....	10	2222-4000			Hexane or cyclohexane
Oleate, methyl.....	24	2379-3479			.....
Oleate, methyl.....	60	2400-3400			.....
Oleate, methyl.....	79	2424-3636			.....
Oleic acid.....	23	2300			Cyclohexane
Oleic acid.....	3	2100-2500			Alcohol
Oleic acid.....	46	2190-3300			Hexane
Oleic acid.....	60	2400-3300			.....
Oleic acid.....	65	2300			Alcohol or cyclohexane
Oleic acid.....	77	1700-3000	1830	257	Heptane
Oleic acid.....	41	2100-3600			Alcohol
Oleic acid.....	48	2100-2600			.....
Ricinolate, methyl.....	46	2350-2950			Hexane
Ricinoleic acid.....	48	2200-2800			.....

Acid	Ref.	Wave Length Range	Abs. Max.	E _{1cm.} 1 pct.	Solvent
DOUBLY UNSATURATED SUBSTANCES					
Linolate, ethyl.....	10	2222-4000			Hexane or cyclohexane
Linolate, ethyl.....	24	2433-3620			.....
Linolate, ethyl.....	77	1700-2500	1900	465	Heptane
Linolate, ethyl.....	42	2200-3500			Alcohol
Linolate, methyl.....	3	2100-2500			Alcohol
Linolate, methyl.....	24	2370-3490			.....
Linolate, methyl.....	60	2300-3300			.....
Linolate, methyl.....	79	2190-3860			.....
Linolate, methyl.....	46	2300-3300			Hexane
Linolelaidic acid.....	44	2150-2300			Alcohol
Linoleic acid.....	46	2190-3300			Hexane or alcohol
Linoleic acid.....	42	2100-3200			.....
Linoleic acid.....	60	2300-3300			.....
Linoleic acid.....	77	1700-2500	1900	656	Heptane
Linoleic acid.....	81	2200-3200			Heptane
Linoleic acid.....	15	2200-3200			Alcohol
Linoleic acid.....	22	2300			Cyclohexane
Linoleic acid.....	48	2100-2900			.....
Linoleic acid.....	46	2200-3000			Hexane
Stearolic acid.....	59	2200-2940			.....
TRIPLY UNSATURATED SUBSTANCES					
Elaidolinolenate, ethyl.....	77	1700-2800	1930	422	Heptane
Elaidolinolenic acid.....	43	2200-3500			Alcohol
Linolenate, ethyl.....	10	2222-4000			Cyclohexane or hexane
Linolenate, ethyl.....	46	2190-3300			Hexane
Linolenate, ethyl.....	71	2300-3300			Alcohol or iso-octane
Linolenate, ethyl.....	77	1700-2500	1860	613	Heptane
Linolenate, ethyl.....	43	2200-4000			Alcohol
Linolenate, methyl.....	3	2100-2500			Alcohol
Linolenate, methyl.....	24	2489-3750			.....
Linolenate, methyl.....	79	2180-3510			.....
Linolenic acid.....	81	2200-3200			Heptane
Linolenic acid.....	48	2100-2500			.....
Linolenic acid, recrystallized.....	77	1700-2500	{ 1730 1960 1730 1860	{ 690 670 860 815	Heptane
Linolenic acid, debrominated.....	77	1700-2500			Heptane
Linolenic acid.....	43	2150-3500			Alcohol
POLYUNSATURATED SUBSTANCES					
Arachidonate, methyl.....	60	2300-2600			Alcohol
Arachidonic acid.....	3	2100-2500			Alcohol
Arachidonic acid.....	77	1700-2800	{ 1760 1960	{ 680 780	Heptane
Arachidonic acid.....	44	2150-3250			Alcohol
Docosahexaenoate, methyl.....	30	2200-3800	{ 2300 2700	{ 36.7 14.5	Alcohol

Substance	Reference	Wave Length Range (Å)
OXIDIZED FATS AND FATTY ACIDS		
Cottonseed oil.....	32	2250-3000
Dogfish liver oil.....	68	2600-3700
Hydrogenated vegetable oil....	32	2250-3000
Lard.....	41, 57	2150-3200
Ling oil.....	27, 31	2500-4000
Linseed oil.....	62	2280-3100
Shark liver oil.....	68	2400-4000
Soy bean oil.....	63	2350-3200
Tung oil.....	10	2300-3300
Oleic acid.....	41, 44	2100-4000
Oleate, ethyl.....	41, 44, 57	2100-4000
Elaidic acid.....	41	2100-4000
9,10-oxidostearic acid.....	41, 57	2200-4000
9,10-diketostearic acid.....	41, 57	2300-4700
9-keto-10-hydroxystearic acid..	41, 57	2300-4800
Linoleic acid.....	42, 44	2150-3700
Linolate, ethyl.....	42, 44, 57	2150-3600
Linolelaidic acid.....	44	2150-2500
10,12-linoleic acid.....	42, 44	2100-4400
Linolenic acid.....	43, 44	2100-4400
Linolenate, ethyl.....	43, 44, 57	2150-4000
Linolenate, ethyl.....	30	2200-3800
Elaidolinolenic acid.....	43, 44	2200-3800
Alpha-eleostearic acid.....	43, 44	2150-4000
Beta-eleostearic acid.....	12	2300-2900
Pseudoeleostearic acid.....	43, 44	2150-3500
Pseudoeleostearate, methyl.....	44	2250-3000
Beta-linolenic acid.....	43	2150-3600
Arachidonate, methyl.....	44	2150-3250
Docosahexaenoate, methyl.....	31	2200-3800
Docosahexaenoate, methyl.....	30	2200-3600

Substance	Reference	Maximum (Å)	E _{1cm.} 1 pct.
ALKALI ISOMERIZED FATTY ACIDS			
Linoleic acid.....	48, 49	2325	580
Linoleic acid.....	4	2340	860
Linoleic acid.....	64	2340	871
Linoleic acid.....	13, 14		
Linolenic acid.....	4	{ 2340 2680	{ 609 532
Linolenic acid.....	64	{ 2340 2680	{ 600 537
Linolenic acid.....	48	2340	1000
Linolenic acid.....	13, 14		
Arachidonic acid.....	4	{ 2340 2680 3010 3160	{ 593 534 258 226
Arachidonic acid.....	13, 14		

Substance	Reference	Wave Length Range (Å)
ALKALI ISOMERIZED FATS AND OILS		
Cod liver acids.....	22	2200-2900
Fish oils.....	27	
Fish liver acids.....	28	
Guinea pig fat.....	2	2300-3300
Hydrogenated vegetable oil.....	5	2300-3400
Lard.....	5	
Lard.....	13, 14	
Marine animal fats.....	65	
Perilla oil.....	13, 14	
Tall oil.....	13, 14	
Tallow.....	13, 14	
Tobacco seed oil.....	13, 14	
Tobacco seed oil.....	76	
Vegetable fats.....	65	

Fatty Acid	Ref.	Wave Length Range (Å)	Abs. Max. (Å)	E ₁ pct. cm.	Solvent
CONJUGATED FATTY ACIDS AND ESTERS					
9,11-linoleic acid.....	46, 47	2150-2900	2300	.....	Hexane
9,11-linoleic acid.....	48	2150-2600	2320	1150	Hexane
9,11-linoleic acid.....	77	1730-2500	2300	1047	Heptane
9,11-linoleic acid.....	51	2000-2500	2370	950	.....
10,12-linoleic acid, m.p. 44°.....	77	1735-2450	{ 1745 1800 2300	{ 120 128 1030	Heptane
10,12-linoleic acid, m.p. 44°.....	16	2150-2700	2300	.....	Alcohol
10,12-linolate, methyl.....	51	2000-2500	2350	1000	.....
10,12-linoleic acid, m.p. 57°.....	77	1760-2060	{ 1780 2300	{ 86.5 1030	Heptane
10,12-linoleic acid, m.p. 57°.....	48	2150-2600	2320	1150	Hexane
10,12-linoleic acid, m.p. 57°.....	42	2125-3000	2300	916	Alcohol
3,5-octadienoic acid.....	38	1800-2500	2300	1700	Alcohol
Alpha-eleostearic acid.....	46	2150-3200	{ 2720 2850	{ 1890 1440	Hexane
(9,11,13-octadecatrienoic acid).					
Alpha-eleostearic acid.....	48	2200-3100	{ 2705 2700	{ 1840	Hexane
Alpha-eleostearic acid.....	25	2580-2830	{ 2820	{	Alcohol
Alpha-eleostearic acid.....	43	2150-3500	{ 2600 2700 2800	{ 1380 1820 1400	Alcohol
Beta-eleostearic acid.....	80	2200-3300	{ 2700 2800	{ 1800 1440	.....
(9,11,13-octadecatrienoic acid)					
Alpha-eleostearic acid.....	48	2200-3100	2680	2150	.....
Beta-eleostearic acid.....	25	2540-2820	{ 2670 2800	{	Alcohol
Beta-eleostearic acid.....	46	2150-3200	{ 2700 2800	{ 1890 1430	Hexane
Pseudo-eleostearic acid.....	48	2250-3100	2680	2150	.....
(10,12,14-octadecatrienoic acid)					
Pseudo-eleostearic acid.....	77	1745-2425	{ 1760 1930 2100	{ 86 79 61	Heptane
Pseudo-eleostearic acid.....	43	2150-3500	{ 2575 2675 2775	{ 1360 1850 1390	Alcohol
Pseudoeleostearate, methyl.....	44	.....	{ 2575 2675 2800	{ 1420 1960 1460	Alcohol
Licanic acid (couepic acid).....	80	2200-3300	{ 2600 2700 2800	{ 1550 1720 1380	.....
(4-keto-9,11,13-octadecatrienoic acid)					
Beta-licanic acid.....	43	2150-3400	{ 2575 2675 2800	{ 1620 2090 1550	Alcohol
Parinaric acid.....	50	2100-3600	{ 2920 3070 3200	{ 1260 1950 1950	Alcohol
(Octadecatetraenoic acid)					
Arachidonic acid, conjugated.....	69	.....	{ 2730 2860 3000 3150	{ 700 1900 2400 2200	Alcohol
CARBONYL-CONJUGATED FATTY ACIDS					
2-pentadecenoic acid.....	16	2100-2280	.....	.....	.....
2-pentadecenoic acid.....	52	2000-2600	2100	1430	.....
2-heptadecenoic acid.....	77	1715-2475	2150	513	Heptane
2-heptadecenoic acid.....	52	2000-2600	2100	1260	.....
Crotonic acid.....	39	2400-3000	.....	.....	.....
Crotonic acid.....	38	1950-2200	2040	1430	Alcohol
Crotonic acid.....	16	2050-2200	2080	1160	.....
Crotonic acid.....	77	1820-2400	2100	1470	Heptane
Sorbic acid.....	37	1900-2900	2540	2250	Alcohol
Octatrienoic acid.....	38	2100-3300	2960	2650	Alcohol
2,4-octadienoic acid.....	38	1800-3000	2700	1860	Alcohol
Decatetraenoic acid.....	38	2300-3700	3280	3000	Alcohol
2-octadecenoic acid.....	46	2200-2670	.....	.....	Hexane
OXIDATION DERIVATIVES OF FATTY ACIDS					
9,10-oxidostearic acid.....	41, 57	2150-3750	.....	.....	Alcohol
9,10-dihydroxystearic acid (low m.p.).....	41, 57	2100-3200	2150	2.9	Alcohol
9,10-dihydroxystearic acid (high m.p.).....	41, 57	2100-3200	2125	2.0	Alcohol
9,10-hydroxyketostearic acid.....	29	2400-3200	.....	.....	Alcohol
9-hydroxy-10-ketostearic acid.....	41, 57	2150-3250	2800	1.9	Alcohol
9-keto-10-hydroxystearic acid.....	41, 57	2150-3200	2825	1.6	Alcohol
9,10-diketostearic acid.....	29	2900-5000	4200	.....	Alcohol
9,10-diketostearic acid.....	41, 57	2200-4800	{ 4725 4250	{ 1.4 0.6	Alcohol

Substance and Treatment	Reference	Wave Length Range (Å)
PROCESSED FATS, OILS, AND FATTY ACIDS		
Castor oil, dehydroxylated.....	10	2200-3500
Cod liver esters, distilled.....	70	2200-3400
Cod liver esters, heated.....	71	2350-2700
Corn oil, alkali refined.....	63	2250-3100
Corn oil, bleached.....	63	2500-3100
Eleostearic acid, irradiated u.v.....	25	2550-2850
Linolate, methyl, bleached.....	63	2250-3100
Linolate, ethyl, bleached.....	46	2250-3250
Linolenate, methyl, distilled.....	71	2350

Substance and Treatment	Reference	Wave Length Range (Å)
Linolenate, ethyl, bleached.....	63	2250-3100
Linseed oil, boiled.....	73	.....
Linseed oil, bleached.....	63	2500-3100
Linseed oil, bodied in vacuo.....	63	2280-3100
Linseed oil, bodied in vacuo.....	10	2200-3300
Linseed methyl esters, heated.....	71	2350
Sesame oil, bleached.....	46	2200-2850
Soy bean oil, bleached.....	63	2500-3100
Soy bean oil, alkali refined.....	63	2250-3100

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The Preparation of Stearic Acid from Castor Oil¹

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SOURCE materials for the preparation of stearic acid are (a) lards and tallow and certain tropical vegetable oils of which it is a prominent component, such as cocoa butter, Borneo tallow, and shea nut butter, and (b) oils rich in C_{18} unsaturated acids. The point of departure for some investigators whose objective had been the preparation of the pure acid is the technical product which presumably would have been prepared from any of these. Guy and Smith (2), for example, sacrificing quantity for quality—the yield was only 4%—by following a laborious procedure involving 24 crystallizations and three distillations succeeded in preparing pure stearic from the "purest" commercial acid. Philipson et al. (3) have presented detailed manipulative procedures,

based on the well known lead salt-alcohol separation of the unsaturated from the saturated acids, for preparing from technical stearic acid the pure product in 40% yield. Our own experiences in the preparation of a stearic acid meeting the requirements of a primary standard for research purposes have emphasized the desirability of making the point of departure of such a preparation a vegetable oil which is not only practically devoid of C_{16} and other saturated acids but is also readily altered by procedures with which those skilled in the techniques of organic syntheses are familiar. Castor oil, a substantial amount of whose fatty acids is ricinoleic, or 12-hydroxy- Δ -9:10-octadecenoic acid, meets these requirements.

By taking advantage of the fact that the glycerides of castor oil are readily saturated by catalytic hydrogenation over Raney nickel and utilizing the relative

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