common type non-ionics while on cotton the efficiency seems to be poorer at the lower concentrations but at use concentrations again to be comparable with other type non-ionics.

The sudsing characteristics of the wax acid non-ionics were observed in launderometer tests as well as in many of the empirical shaking tests. In most instances the amount of suds formed was small and not too lasting.

## Conclusion

Non-ionic synthetic detergents having detergent properties similar to those of alkyl phenol polyethylene glycol ethers and alkyl mercapto polyethylene glycol ethers can be prepared by reacting the optimum quantity of ethylene oxide with the composite crude fatty acids made by the air oxidation of low melting chemical grade paraffin wax.

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# Testing of Drying Oils. II. Evaluation of Natural and Synthetic Oils*

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IN a previous paper Bolley and Gallagher (1) have described in detail a method for the preliminary examination of drying oils. This method has been used by the National Lead Company's Research Laboratory for the evaluation of a large number of oils. It is the purpose of this paper to present some of the data obtained during the evaluation program.

Since this is a preliminary evaluation which is to be completed in a relatively short time, the scheme does not include exposure tests. The object is to characterize the oils to determine their probable application; final evaluation must await exposure tests. Accelerated exposure tests were not included since these have been found to be unreliable in many cases.

One test has been added to the evaluation program as previously described. This is the determination of flash point according to the standard A.S.T.M. Method D92-33 and was included when it was noticed that some synthetic oils had relatively low flash points. A comparison of the data presented in this paper with the previously published method will disclose that not all of the tests have been reported. Although all the tests were actually run on the oils, it seemed desirable to eliminate the results of lesser interest and significance in order to keep the already lengthy tables of data to a minimum.

The following oils, referred to in the abreviated form used in the tables, were tested:

G Bodied Linseed—An alkali refined, bleached, and refrigerated linseed oil heat bodied to a G viscosity.

Conjugated Linseed—A refined linseed oil catalytically treated to contain 8.1% conjugated linoleic isomer and 0.5% conjugated linolenic isomer.

Linseed Penta.—Technical pentaerythritol esterified with nearly equivalent amounts of linseed oil fatty acids.

Dehydrated Castor—Regular commercial unbodied dehydrated castor oil.

Fatty Tall Oil—Tall oil processed to remove a large amount of the rosin acids and the fatty acid concentrate esterified with technical pentaerythritol.

G Bodied Soybean—Refined soybean oil heat bodied to a G viscosity.

Conjugated Soybean—A refined soybean oil catalytically treated to contain 10.1% conjugated linoleic isomer and 1.2% conjugated linolenic isomer.

Soybean Penta.—Technical pentaerythritol esterified with nearly equivalent amounts of soybean oil fatty acids.

Soybean Mannitol—One mol. of mannitol esterified with four mols. of soybean oil fatty acids.

Soybean Sorbitol—One mol. of sorbitol esterified with four mols. of soybean oil fatty acids.

Q Bodied Linseed—An alkali refined, bleached, and refrigerated linseed oil heat bodied to a Q viscosity.

Linseed Polypenta.—Technical polypentaerythritol esterified with nearly equivalent amounts of linseed oil fatty acids.

Linseed Mannitol—One mol. of mannitol esterified with four mols. of linseed oil fatty acids.

Linseed Sorbitol—One mol. of sorbitol esterified with four mols. of linseed oil fatty acids.

TABLE I

Chemical Constants

| | Visc. | Color | Appearance | Odor | Acid Value | Sap. Value | Acetyl Value | Iodine Value | % Unsap. | % Ash | Ref. Index | Specific Gravity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G Bodied Linseed | G | 6 | Clear | Normal | 2.1 | 189.0 | 5.4 | 165.0 | 1.43 | 0.000 | 1.4841 | 0.9430 |
| Conjugated Linseed | F | 7 | Clear | Bodied Oil | 3.3 | 190.7 | 7.4 | 154.7 | 1.20 | 0.000 | 1.4838 | 0.9431 |
| Linseed Penta | I— | 12— | Clear | Bodied Oil | 4.0 | 180.9 | 28.4 | 155.6 | 1.99 | 0.000 | 1.4850 | 0.9524 |
| Dehydrated Castor | H+ | 6 | Clear | Normal | 8.5 | 198.3 | 1.6 | 137.3 | 0.96 | 0.000 | 1.4820 | 0.9377 |
| Fatty Tall Oil | J— | 10 | Clear | Fatty | 6.7 | 170.8 | 3.6 | 133.1 | 4.80 | 0.055 | 1.4861 | 0.9490 |
| G Bodied Soybean | F | 5+ | Clear | Normal | 2.2 | 189.6 | 5.0 | 119.0 | 1.15 | 0.000 | 1.4765 | 0.9358 |
| Conjugated Soybean | G | 6 | Clear | Normal | 3.2 | 192.3 | 3.4 | 118.5 | 0.92 | 0.000 | 1.4771 | 0.9356 |
| Soybean Penta | H+ | 12 | Clear | Normal | 3.3 | 185.9 | 52.2 | 125.1 | 1.00 | 0.000 | 1.4796 | 0.9475 |
| Soybean Mannitol | G | 7— | Clear | Normal | 29.5 | 183.2 | 3.1 | 112.1 | 0.71 | 0.000 | 1.4774 | 0.9402 |
| Soybean Sorbitol | F | 6 | Clear | Normal | 16.5 | 185.1 | 7.8 | 119.6 | 0.80 | 0.020 | 1.4775 | 0.9463 |
| Q Bodied Linseed | U | 5 | Clear | Bodied Oil | 5.9 | 192.2 | 6.9 | 141.4 | 1.06 | 0.000 | 1.4858 | 0.9585 |
| Linseed Polypenta | Q | 11+ | Clear | Bodied Oil | 1.6 | 181.2 | 45.3 | 154.3 | 1.54 | 0.006 | 1.4852 | 0.9592 |
| Linseed Mannitol | T | 10 | Clear | Normal | 31.3 | 179.7 | 7.3 | 131.8 | 2.05 | 0.000 | 1.4862 | 0.9654 |
| Linseed Sorbitol | P | 9 | Clear | Bodied Oil | 18.2 | 185.0 | 8.0 | 146.8 | 1.63 | 0.018 | 1.4857 | 0.9606 |
| Soybean Polypenta | P | 10 | Clear | Bodied Oil | 1.2 | 177.0 | 37.4 | 129.8 | 0.89 | 0.013 | 1.4819 | 0.9553 |
| Soybean Maleic Glyc | Q | 8 | Clear | Normal | 6.3 | 212.6 | 37.5 | 120.1 | 0.14 | 0.000 | 1.4800 | 0.9592 |
| Soybean Maleic Penta | S— | 9 | Clear | Normal | 14.5 | 221.0 | 24.1 | 120.5 | 1.63 | 0.005 | 1.4806 | 0.9614 |
| Z2 Bodied Linseed | Z2 | 6 | Clear | Bodied Oil | 6.6 | 194.0 | 4.8 | 123.8 | 1.54 | 0.000 | 1.4890 | 0.9664 |
| Linseed Maleic Glyc | Z1+ | 7— | Clear | Acrid | 7.9 | 211.8 | 23.4 | 138.0 | 1.05 | 0.014 | 1.4879 | 0.9763 |
| Linseed Maleic Penta | Z2+ | 7 | Clear | Acrid | 11.8 | 212.8 | 24.8 | 155.5 | 0.98 | 0.000 | 1.4872 | 0.9731 |

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* Presented at 22nd annual fall meeting, American Oil Chemists' Society, Nov. 15-17, 1948, New York City.

TABLE II

Oil and Oil Film Tests

| | Bodying Test | | | Drying Test | | Sward Hard. 48 Hr. | Flash Point °F. | Resin Compatibility | | Reactivity (zinc oxide) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minutes at 307°C. | | Color at Z2 | Set to Touch Hr. | Dryness 48 Hr. | | | Urea Formaldehyde | Mod. Alkyd. | Orig. Visc. Sec. | % Increase | |
| | Z2 | Gel. | | | | | | | | | 24 Hr. | 1 Week |
| G Bodied Linseed | 138 | 253 | 9— | 3¾ | 9+ | 3 | 565 | I | C | 166.0 | —11.5 | —22.9 |
| Conjugated Linseed | 105 | 199 | 8 | 2¾ | 9 | 3 | 530 | I | C | 154.0 | — 2.6 | —26.5 |
| Linseed Penta | 72 | 120 | 13 | 2½ | 9+ | 3 | 495 | C | I | 208.0 | 3.9 | —24.5 |
| Dehydrated Castor | 65 | 111 | 8 | 1¾ | 9+ | 2 | 460 | C | C | 110.0 | 60.0 | 60.0 |
| Fatty Tall Oil | 165 | 420+ | 15 | 4 | 9— | 3 | ...... | I | I | 112.0 | 28.3 | 54.8 |
| G Bodied Soybean | 312 | 480+ | 11+ | 8 | 8+ | 3 | 555 | I | I | 145.0 | — 9.0 | —33.8 |
| Conjugated Soybean | 260 | 450 | 11+ | 7 | 8— | 3 | 530 | I | C | 190.0 | 19.0 | —29.5 |
| Soybean Penta | 120 | 195 | 14+ | 3¾ | 9+ | 4 | 540 | C | C | 207.0 | —27.0 | —45.4 |
| Soybean Mannitol | 147 | 275 | 18 | 4 | 8 | 1 | 435 | C | C | 34.0 | 0 | 0 |
| Soybean Sorbitol | 225 | 348 | 18+ | 3 | 9— | 4 | 465 | C | C | 38.0 | 57.9 | 1150.0 |
| Q Bodied Linseed | 102 | 221 | 9 | 3½ | 9 | 2 | 565 | I | C | 69.6 | 13.5 | 44.7 |
| Linseed Polypenta | 48 | 83 | 13 | 1¼ | 9 | 3 | 515 | I | I | 49.4 | — 1.8 | — 7.9 |
| Linseed Mannitol | 38 | 120 | 14 | 3 | 8 | 2 | 450 | C | C | 104.0 | 70.0 | 70.0 |
| Linseed Sorbitol | 45 | 120 | 18— | 2½ | 9 | 2 | 470 | I | C | 153.0 | Livered | Livered |
| Soybean Polypenta | 73 | 123 | 13 | 2¼ | 9 | 3 | 530 | I | I | 60.0 | —10.8 | —14.0 |
| Soybean Maleic Glyc | 150 | 257 | 11+ | 5 | 9 | 4 | 480 | C | C | 87.0 | 77.0 | 84.0 |
| Soybean Maleic Penta | 76 | 130 | 13 | 6 | 10— | 5 | 535 | C | C | 55.5 | — 3.1 | — 9.2 |
| Z2 Bodied Linseed | ...... | 126 | .... | 3⅓ | 9 | 2 | 530 | I | I | 110.0 | 81.0 | 96.0 |
| Linseed Maleic Glyc | ...... | 58 | .... | 2½ | 10— | 2 | 520 | I | C | 52.0 | 104.0 | 144.0 |
| Linseed Maleic Penta | ...... | 16 | .... | 2 | 10— | 4 | 470 | I | C | 109.0 | 292.0 | 787.0 |

Soybean Polypenta.—Technical polypentaerythritol esterified with nearly equivalent amounts of soybean oil fatty acids.

Soy. Maleic Glyc.—A soybean oil adduct made with 5% maleic anhydride and esterified with a near equivalent amount of glycerine.

Soy. Maleic Penta.—A soybean oil adduct made with 5% maleic anhydride and esterified with a near equivalent amount of technical pentaerythritol.

Z2 Bodied Linseed—An alkali refined, bleached, and refrigerated linseed oil heat bodied to Z2 viscosity.

Lin. Maleic Glyc.—A linseed oil adduct made with 5% maleic anhydride and esterified with a near equivalent of glycerine.

Lin. Maleic Penta.—A linseed oil adduct made with 5% maleic anhydride and esterified with a near equivalent of technical pentaerythritol.

The bodied linseed, bodied soybean, and dehydrated castor oils are included for the purpose of providing comparison controls for the synthetic and modified oils. Only one soybean oil control was used because in most cases the synthetic oils based on soybean fatty acids have performance characteristics which approximate or surpass those of linseed oil.

The analytical constants of the various oils are listed in Table I. Upon examination it will be seen that they merely serve to characterize the oils and do not predict performance characteristics. The first four tests—viscosity, color, appearance, and odor—are purely physical in nature and describe the outward appearance of the oils. The term "normal" as used to describe the odor of an oil refers to a faint, bland, fatty odor such as that of a good quality alkali refined linseed oil. With synthetic esters such as are being discussed in this paper, the acid value and acetyl value show the degree of completion attained in esterification. It will be noticed that the mannitol and sorbitol esters have an excess of acid while the pentaerythritol and polypentaerythritol esters and the maleic treated oils contain some unreacted hydroxyl groups. The maleic treated oils also display a characteristically high saponification value (over 210). Because a certain amount of heat bodying always occurs during esterification, the iodine value of a synthetic ester is not such a reliable indication of quality as it is with the natural glycerides. The unsaponifiable and ash content of Fatty Tall Oil is much higher than that of the other oils as might be expected. The last two constants, refractive index and specific grav-

TABLE III

Oil and Oil Film Tests

| | Film Solubility | | | | | | Cold Water Resistance | | Hot Water Resistance | | Alkali Resist. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water | | Hexane | Acetone | Alcohol Benzene | | Time to Whiten Hr. | Time to Fail Hr. | Time to Whiten Min. | Failure | Time to Fail Min. |
| | Per Cent | Acid Value | Per Cent | Per Cent | Per Cent | Acid Value | | | | | |
| G Bodied Linseed | 9.4 | 193.9 | 20.2 | 44.7 | 48.8 | 104.2 | 140 | 140 | 35 | Dull | 32 |
| Conjugated Linseed | 11.2 | 212.1 | 21.8 | 64.6 | 71.2 | 94.0 | ...... | 24 | 9 | Broken blisters | 11 |
| Linseed Penta | 10.8 | 164.0 | 18.1 | 34.4 | 37.2 | 116.4 | ...... | 24 | 8 | Dull, sl. white | 8 |
| Dehydrated Castor | 16.7 | 178.8 | 22.4 | 80.4 | 86.5 | 132.0 | ...... | 16 | 5 | Film removed | 9 |
| Fatty Tall Oil | 14.9 | 128.0 | 24.4 | 75.0 | 88.4 | 100.4 | 18 | 42 | 1 | Broken blisters | 90 |
| G Bodied Soybean | 15.9 | 118.4 | 31.1 | 97.7 | 98.2 | 89.7 | ...... | 16 | 5 | Soft, dull, sl. white | 56 |
| Conjugated Soybean | 18.4 | 144.2 | 34.2 | 98.2 | 98.7 | 93.7 | 16 | 16 | 45 | White, dull | 100 |
| Soybean Penta | 10.2 | 182.0 | 23.8 | 56.2 | 60.8 | 111.9 | ...... | 16 | 5 | Soft, dull, sl. white | 34 |
| Soybean Mannitol | 16.7 | 207.8 | 28.0 | 94.0 | 95.5 | 120.5 | 16 | 16 | 7 | Film removed | 9 |
| Soybean Sorbitol | 12.8 | 211.8 | 30.1 | 91.0 | 92.3 | 103.3 | ...... | 16 | 7 | Film removed | 14 |
| Q Bodied Linseed | 9.7 | 178.0 | 17.0 | 42.4 | 46.9 | 101.8 | 141 | 142 | 36 | Dull | 34 |
| Linseed Polypenta | 12.8 | 149.7 | 9.9 | 17.8 | 18.0 | 141.2 | 190 | 190 | .... | Broken blisters | 2 |
| Linseed Mannitol | 12.3 | 195.0 | 20.9 | 49.6 | 56.4 | 113.9 | 24 | 40 | 10 | Soft, white, dull | 5 |
| Linseed Sorbitol | 11.4 | 171.5 | 17.4 | 38.0 | 41.1 | 120.4 | ...... | 16 | 7 | White, dull, v. soft | 11 |
| Soybean Polypenta | 10.2 | 120.8 | 10.5 | 20.4 | 22.4 | 169.8 | 190 | 190 | .... | Broken blisters | 2 |
| Soybean Maleic Glyc | 9.2 | 187.5 | 21.6 | 40.5 | 43.4 | 120.8 | ...... | 16 | 7 | Pass | 14 |
| Soybean Maleic Penta | 6.6 | 357.5 | 20.5 | 35.0 | 37.5 | 152.1 | ...... | Pass 192 | .... | Pass | 17 |
| Z2 Bodied Linseed | 6.3 | 194.6 | 18.0 | 40.0 | 46.5 | 96.6 | 144 | 144 | 40 | Dull | 35 |
| Linseed Maleic Glyc | 7.7 | 224.3 | 16.6 | 34.2 | 39.1 | 101.5 | ...... | 40 | 40 | Dull | 9 |
| Linseed Maleic Penta | 10.3 | 187.0 | 18.2 | 36.7 | 40.0 | 112.9 | ...... | 40 | 40 | Pass | 5 |

TABLE IV

Bakelite BR 254 Varnishes

| | Cooking Time Min. | Cooking Loss % | Visc. | Acid Value | Kauri Red. Pass % | Drying Test | | | Sward Hardness | Cold Water Resist. Time to Fail Hr. | Hot Water Resistance Failure | Alkali Resist. Time to Fail. Hr. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Set to Touch Min. | Dust Free Min. | Dryness 48 Hr. | | | | |
| G Bodied Linseed | 150 | 10.0 | E | 17.9 | 130 | 30 | 50 | 9+ | 7 | >168 | Dull | 46 |
| Conjugated Linseed | 120 | 10.0 | D | 15.3 | 220 | 21 | 30 | 9 | 5 | >168 | White,dull | 19 |
| Linseed Penta | 135 | 6.1 | D | 19.4 | 150 | 25 | 58 | 9 | 4 | >192 | Pass | 114 |
| Dehydrated Castor | 86 | 9.2 | E | 22.7 | 220 | 20 | 28 | 10 | 7 | >168 | Pass | 66 |
| Fatty Tall Oil | ...... | ...... | .... | ...... | ...... | .... | .... | .... | .... | ...... | ............ | .... |
| G Bodied Soybean | 285 | 13.1 | D | 13.2 | 140 | 30 | 50 | 9 | 4 | >192 | Pass | 40 |
| Conjugated Soybean | 285 | 12.6 | D | 13.6 | 170 | 25 | 35 | 9 | 2 | 190 | Soft, dull | 4 |
| Soybean Penta | 150 | 6.1 | D— | 15.1 | 230 | 20 | 65 | 8+ | 2 | >192 | Pass | 66 |
| Soybean Mannitol | 195 | 15.0 | D— | 22.0 | 140 | 23 | 60 | 9+ | 4 | 190 | Pass | 19 |
| Soybean Sorbitol | 190 | 15.0 | D | 17.0 | 140 | 28 | 45 | 9 | 4 | >192 | Pass | 27 |
| Q Bodied Linseed | 155 | 8.2 | D+ | 18.7 | 160 | 41 | 61 | 10— | 4 | >168 | Pass | 4 |
| Linseed Polypenta | 31 | 3.7 | D+ | 21.8 | 180 | 28 | 330 | 10— | 7 | >192 | Broken blisters | 288 |
| Linseed Mannitol | 120 | 12.6 | E+ | 28.2 | 120 | 43 | 53 | 10 | 11 | 190 | Pass | 19 |
| Linseed Sorbitol | 95 | 9.7 | D+ | 24.3 | 90 | 20 | 40 | 10— | 14 | >192 | Soft, white, dull | 40 |
| Soybean Polypenta | 60 | 4.4 | D | 20.0 | 190 | 30 | 340 | 9 | 3 | >192 | Broken blisters | 288 |
| Soybean Maleic Glyc | 165 | 7.6 | D | 20.6 | 150 | 25 | 60 | 10— | 6 | 196 | Soft, dull | 4 |
| Soybean Maleic Penta | 47 | 8.0 | D— | 28.8 | 90 | 75 | 328 | 10— | 10 | >192 | Pass | 4 |
| Z2 Bodied Linseed | 60 | 4.2 | D | 27.6 | 130 | 253 | 430 | 7+ | 6 | >168 | Broken blisters | 27 |
| Linseed Maleic Glyc | ...... | ...... | .... | ...... | ...... | .... | .... | .... | .... | ...... | ............ | .... |
| Linseed Maleic Penta | ...... | ...... | .... | ...... | ...... | .... | .... | .... | .... | ...... | ............ | .... |

ity, are of a purely physical nature and vary more with the viscosity of the oil than with its composition.

Table II lists some of the performance characteristics of the oils and oil films. An examination of the results of the bodying test shows that the polypentaerythritol esters are much faster bodying than the other synthetic esters. The pentaerythritol esters are next and the mannitol and sorbitol esters are the slowest bodying. Soybean Sorbitol is much slower bodying than Soybean Mannitol, but no such difference occurs with the corresponding linseed esters. The sorbitol and mannitol esters also produce much darker bodied oils than the other synthetic oils. The maleic treated oils which have been esterified with pentaerythritol are much faster bodying than those esterified with glycerine. Most of the oils have about the same flash and fire points, except for the sorbitol and mannitol esters which are much lower. The drying times of the synthetic esters follow the same order as the bodying rates and all are faster than the corresponding natural glycerides. The fastest drying time is shown by the polypentaerythritol esters, followed by pentaerythritol, sorbitol, and mannitol in that order. None of the synthetic oils dried a great deal harder than the natural glycerides and the mannitol and sorbitol esters were somewhat softer. Resin compatibility is not a particularly important test from a performance standpoint. It is intended only to discover any unusual compatibility characteristics of the oils which might be made the basis of some novel practical applications.

Oil and oil film properties are continued in Table III. The film solubility test is designed to give an insight into the film structure. The amount of low molecular weight, water soluble materials produced is approximately the same for all oils. Variations between the oils become apparent in the amounts of slightly higher molecular weight, hexane soluble products and become most apparent in the acetone and alcohol-benzene soluble fractions. The last two solvents appear to remove not only the decomposition products but also uncombined and loosely bound oil molecules. The amount of material which is soluble in acetone or alcohol-benzene varies directly with the

TABLE V

Amberol 801 Varnishes

| | Cooking Time Min. | Cooking Loss % | Visc. | Acid Value | Kauri Red. Pass % | Drying Test | | | Sward Hard. 48 Hr. | Cold Water Resist. Time to Fail Hr. | Hot Water Resist. Failure | Alkali Resist. Time to Fail Min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Set to Touch Min. | Dust Free Min. | Dryness 48 Hr. | | | | |
| G Bodied Linseed | 58 | 1.1 | D | 11.9 | 90 | 133 | 140 | 10 | 43 | >168 | Pass | 40 |
| Conjugated Linseed | 104 | 1.1 | F+ | 11.0 | 100 | 60 | 74 | 10 | 6 | 114 | Dull | 20 |
| Linseed Penta | 68 | 3.2 | E+ | 9.2 | 100 | 58 | 84 | 10 | 21 | >120 | Pass | 32 |
| Dehydrated Castor | 43 | 1.8 | F+ | 11.4 | 130 | 56 | 76 | 10 | 6 | 190 | Soft, dull | 15 |
| Fatty Tall Oil | .... | .... | .... | ...... | ...... | ...... | ...... | .... | .... | ...... | ............ | .... |
| G Bodied Soybean | 128 | 2.9 | F | 11.7 | 190 | 61 | 87 | 9 | 6 | >120 | Pass | 30 |
| Conjugated Soybean | 95 | 1.8 | E | 10.0 | 140 | 63 | 81 | 9 | 2 | 114 | Soft, dull | 36 |
| Soybean Penta | 67 | 2.1 | F | 8.8 | 90 | 75 | 105 | 9+ | 12 | >112 | White, dull | 80 |
| Soybean Mannitol | 26 | 1.3 | D | 12.3 | 70 | 75 | 105 | 9+ | 17 | 112 | White, dull | 34 |
| Soybean Sorbitol | 80 | 1.6 | D | 14.4 | 70 | 75 | 105 | 10— | 17 | 112 | Dull | 27 |
| Q Bodied Linseed | 58 | 1.1 | D | 11.9 | 90 | 133 | 140 | 10 | 43 | >168 | Pass | 40 |
| Linseed Polypenta | ....* | ....* | ....* | ......* | ......* | ......* | ......* | ....* | ....* | ......* | ............* | ....* |
| Linseed Mannitol | 75 | 4.2 | D+ | 16.2 | 80 | 62 | 77 | 10 | 17 | 114 | Very dull | 37 |
| Linseed Sorbitol | 69 | 4.3 | F+ | 13.4 | 40 | 70 | 100 | 10 | 18 | >112 | White, dull | 32 |
| Soybean Polypenta | ....* | ....* | ....* | ......* | ......* | ......* | ......* | ....* | ....* | ......* | ............* | ....* |
| Soybean Maleic Glyc | 36 | 3.2 | D+ | 11.7 | 120 | 58 | 89 | 10 | 8 | >120 | Pass | 15 |
| Soybean Maleic Penta | 0 | 1.3 | D— | 15.3 | 50 | 140 | 246 | 10— | 10 | >192 | Pass | 50 |
| Z2 Bodied Linseed | 58 | 1.1 | D | 11.9 | 90 | 133 | 140 | 10 | 43 | >168 | Pass | 40 |
| Linseed Maleic Glyc | 25 | 1.3 | F | 13.6 | 100 | 57 | 77 | 10 | 9 | 190 | Soft, dull | 20 |
| Linseed Maleic Penta | 28 | 3.9 | E | 15.5 | 80 | 65 | 85 | 10 | 12 | 190 | Soft, dull | 14 |

* Incompatible.

TABLE VI

Limed Rosin Varnishes

| | Cooking Time Min. | Cooking Loss % | * Visc. | Acid Value | Kauri Red. Pass % | Drying Test | | | Sward Hard. 48 Hr. | Cold Water Resist. Time to Fail Hr. | Hot Water Resistance Failure | Alkali Resist. Time to Fail Min. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Set to Touch Min. | Dust Free Min. | Dryness 48 Hr. | | | | |
| G Bodied Linseed | 105 | 6.1 | D+ | 18.3 | 90 | 120 | 180 | 9+ | 36 | 48 | White, dull | 25 |
| Conjugated Linseed | 75 | 6.9 | E | 14.5 | 100 | 53 | 100 | 10— | 16 | 43 | Broken blisters | 6 |
| Linseed Penta | 30 | 2.9 | D+ | 16.4 | 90 | 45 | 115 | 10— | 14 | 112 | Blistered | 62 |
| Dehydrated Castor | 75 | 6.8 | F | 18.4 | 100 | 58 | 120 | 10— | 11 | 43 | White, dull | 12 |
| Fatty Tall Oil | ...... | ...... | .... | ...... | ...... | ...... | ...... | .... | .... | ...... | ........... | .... |
| G Bodied Soybean | 195 | 8.4 | E | 16.8 | 200 | 56 | 216 | 8+ | 3 | 43 | White, dull | 7 |
| Conjugated Soybean | 75 | 6.1 | D | 15.3 | 120 | 47 | 100 | 9 | 6 | 43 | Film removed | 4 |
| Soybean Penta | 115 | 5.0 | E | 13.7 | 130 | 75 | 105 | 10— | 10 | 39 | White, dull | 41 |
| Soybean Mannitol | 115 | 11.8 | D+ | 17.1 | 90 | 70 | 100 | 10— | 16 | 64 | White, dull | 10 |
| Soybean Sorbitol | 125 | 13.7 | E | 18.7 | 110 | 75 | 105 | 10— | 14 | 24 | White, dull | 13 |
| Q Bodied Linseed | 105 | 6.1 | D+ | 18.3 | 90 | 120 | 180 | 9+ | 36 | 48 | White, dull | 25 |
| Linseed Polypenta | 35 | 6.4 | D+ | 16.6 | 90 | 46 | 338 | 10 | 11 | 19 | Broken blisters | 5 |
| Linseed Mannitol | 100 | 10.0 | E+ | 27.2 | 80 | 52 | 72 | 10 | 18 | 120 | Dull | 1 |
| Linseed Sorbitol | 90 | 11.8 | F | 22.8 | 60 | 85 | 115 | 10— | 21 | 64 | White, dull | 22 |
| Soybean Polypenta | 48 | 5.3 | E+ | 15.4 | 100 | 87 | 348 | 9 | 7 | 19 | Broken blisters | 5 |
| Soybean Maleic Glyc | ......* | ......* | ....* | ......* | ......* | ......* | ......* | ....* | ....* | ......* | ...........* | ......* |
| Soybean Maleic Penta | 67 | 11.6 | D— | 12.0 | 70 | 140 | 246 | 10 | 13 | >192 | Broken blisters | 157 |
| Z2 Bodied Linseed | 105 | 6.1 | D+ | 18.3 | 90 | 120 | 180 | 9+ | 36 | 48 | White, dull | 25 |
| Linseed Maleic Glyc | ......* | ......* | ....* | ......* | ......* | ......* | ......* | ....* | ....* | ......* | ...........* | ......* |
| Linseed Maleic Penta | 50 | 8.2 | D | 11.3 | 80 | 42 | 62 | 10 | 18 | 47 | Broken blisters | 20 |

* Incompatible.

functionality of the alcohol and the unsaturation present in the fatty acids and, with alcohol-benzene, ranges from a low of 18.0% for Linseed Polypentaerythritol to a high of 98.2% for G Bodied Soybean. It may be remarked that the hexahydric alcohols, mannitol and sorbitol, exhibit greater solubility than the tetrahydric pentaerythritol, but it must be remembered that mannitol and sorbitol both lose water with the formation of inner ethers at esterification temperatures, so that their actual functionality is usually less than four. In most cases the reactivity of the oils with zinc oxide was quite satisfactory, only the sorbitol esters and Linseed Maleic Pentaerythritol showed excessively large increases in viscosity. The polypentaerythritol esters showed the greatest resistance to cold and hot water, followed by pentaerythritol, mannitol, and sorbitol in that order. The soybean maleic oils had slightly better cold and hot water resistance than the linseed maleic oils. No particular trend can be noticed in the results of the alkali resistance tests.

Table IV shows the characteristics of varnishes made from the various oils and a pure phenolic resin, Bakelite BR 254. The polypentaerythritol esters gave the fastest cooking times, followed by the pentaerythritol, sorbitol, and mannitol esters in that order. Soybean Maleic Pentaerythritol was faster cooking than Soybean Polypentaerythritol while Soybean Maleic Glycerine required about the same time as Soybean Pentaerythritol. No varnishes were made with the linseed maleic oils because these oils both had Z2 viscosities while the resin requires a lower viscosity oil for good results. Most of the oils had excellent Kauri reduction values, only two of them, Linseed Sorbitol and Soybean Maleic Pentaerythritol, failing as low as 100%. The various esters do not produce any great differences in the drying times of the varnishes made from them, but the varnishes made with sorbitol

TABLE VII

Paint Tests

| | Application | | Consistency | | Drying Odor | Dry to Touch | | | Hardness | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S.P. | M.P. | 1 Day | 7 Days | | Hours at 77°F. | Hours at 40°F. | Min. at 230°F. | I Day | | 3 days | |
| | | | M.P. | M.P. | M.P. | M.P. | M.P. | M.P. | S.P. | M.P. | S.P. | M.P. |
| G Bodied Linseed | Good | Good | 183 | 180 | Mod. | 6½ | 42 | 6½ | V. soft | Soft | Hard | Hard |
| Conjugated Linseed | V. good | V. good | 195 | 198 | Mod. | 6¼ | 50 | 14 | Soft | Firm | Soft | Hard |
| Linseed Penta | Good | Good | 219 | 220 | Mod. | 4½ | 26 | 7½ | Soft | Firm | Firm | V. hard |
| Dehydrated Castor | Good | Good | 260 | 260 | Mod. | 3½ | 26 | 10 | Firm | Hard | Hard | V. hard |
| Fatty Tall Oil | Good | Good | 204 | 208 | Mod. | 8+ | ....* | 25 | Soft | Soft | Firm | Hard |
| G Bodied Soybean | Good | Good | 186 | 184 | Mod. | 8+ | ....* | 19 | Soft | Soft | Soft | Firm |
| Conjugated Soybean | V. good | Good | 197 | 207 | Mod. | 8+ | ....* | 15 | V. soft | Soft | Soft | Firm |
| Soybean Penta | Good | Good | 205 | 212 | Mod. | 4½ | 42 | 10 | V. soft | Firm | Firm | Hard |
| Soybean Mannitol | Bad | Poor | 700+ | 700+ | Mod. | 7¼ | 42 | 21 | V. soft | Firm | Soft | Hard |
| Soybean Sorbitol | Fair | Fair | 700+ | 700+ | Mod. | 7¾ | 42 | 17 | Soft | Firm | Hard | Hard |
| Q Bodied Linseed | Fair | Good | 381 | 400 | Slight | 6 | 26 | 6 | Soft | Soft | Hard | Hard |
| Linseed Polypenta | Good | Fair | 230 | 220 | Strong | 3½ | 18 | 6 | Firm | Firm | Hard | Hard |
| Linseed Mannitol | Fair | Poor | 700+ | 700+ | Mod. | 4¾ | 26 | 12 | Soft | Soft | Hard | Firm |
| Linseed Sorbitol | Poor | Fair | 408 | 401 | Slight | 5¾ | 26 | 6½ | V. soft | Soft | Firm | Hard |
| Soybean Polypenta | Good | Fair | 230 | 225 | Strong | 3½ | 18 | 6 | Hard | Hard | Hard | V. hard |
| Soybean Maleic Glyc | Good | Fair | 310 | 339 | Mod. | 5¼ | ....* | 6½ | Soft | Firm | Firm | Hard |
| Soybean Maleic Penta | Good | Fair | 275 | 302 | Mod. | 5½ | 50 | 7 | Soft | Firm | Hard | Hard |
| Z2 Bodied Linseed | V. good | V. good | 205 | 215 | Slight | 4½ | 42 | 7 | Soft | Hard | Firm | Hard |
| Linseed Maleic Glyc | Good | V. good | 288 | 309 | Mod. | 3¼ | 42 | 4 | Firm | Hard | Hard | V. hard |
| Linseed Maleic Penta | Good | V. good | 248 | 268 | Mod. | 2¾ | 26 | 3½ | Firm | Hard | V. hard | Hard |

* Didn't dry.

esters produced the hardest films, followed by mannitol, polypentaerythritol, and pentaerythritol. Both of the soybean maleic oils produced harder films than the soybean esters. The cold water and hot water resistances of the varnishes were generally good. Both of the polypentaerythritol ester varnishes failed in hot water resistance because of broken blisters but showed no sign of whitening. The alkali resistance of the polypentaerythritol ester varnishes was outstanding, followed by pentaerythritol, sorbitol, and mannitol in decreasing order. The soybean maleic varnishes had less alkali resistance than any of the varnishes made with soybean esters.

Table V shows the characteristics of varnishes made from various oils and a rosin-maleic resin, Amberol 801. All the oils were bodied to Z2 viscosity before cooking these varnishes. For this reason it was only necessary to prepare one varnish for the three bodied linseed oils. The maleic treated oils were the fastest cooking group. Most of the esters required approximately the same cooking times, the exceptions being the polypentaerythritols, which were incompatible, and Soybean Mannitol, which had a much shorter cooking time than the other esters. All of the varnishes made with synthetic oils dried rapidly and produced hard films. The pentaerythritol esters produced about the best results, but were not greatly superior to the other esters. Soybean Maleic Pentaerythritol produced a varnish that remained slightly tacky but was as hard as those made with the other soybean base synthetic oils. The soybean maleic oils and Linseed Pentaerythritol produced varnishes having excellent cold water and hot water resistances. The Soybean Pentaerythritol and Soybean Maleic Pentaerythritol varnishes had excellent alkali resistance. The other synthetic oils produced varnishes whose alkali resistances were not quite as good as that of the Z2 Bodied Linseed varnish.

Table VI shows the characteristics of varnishes made from the various oils and 4% Limed Rosin. All the oils were bodied to Z2 viscosity before cooking these varnishes and, as with the Amberol 801 varnishes, only one varnish was necessary for the various bodied linseed oils. Linseed Maleic Glycerine and Soybean Maleic Glycerine were incompatible with Limed Rosin. Linseed Polypentaerythritol and Linseed Pentaerythritol are much faster cooking than the other linseed base synthetic oils, and Soybean Polypentaerythritol is much faster than the other soybean base oils. The varnishes made with the synthetic oils dried faster than those made with the natural oils and those based on soybean oil also dried harder than the varnish made with G Bodied Soybean. The polypentaerythritol esters produced varnishes having less cold water but more hot water resistance than those made with the natural oils, while the other synthetic oils tended to produce greater cold water and about equal hot water resistances. The greatest alkali resistances were produced by the varnishes made with the pentaerythritol esters and Soybean Maleic Pentaerythritol.

Table VII lists some of the properties of paints made with the oils. Two paints were made with each oil, one a single pigment type using zinc sulfide as the sole pigment and the other a mixed pigment paint. The application test, which includes appearance, brushing, leveling, and gloss records a master painter's opinion of the handling qualities of the paints. Most of the paints had fair to good consistencies but those of paints made with the sorbitol and mannitol esters are excessively high. The drying times of the paints corresponded to the drying times of the oils from which they were made. The paints made with polypentaerythritol esters were the fastest drying, followed by those made with pentaerythritol, sorbitol, and mannitol esters in that order. All of the paints made with synthetic oils dried faster than those made with the corresponding natural oils.

Table VIII lists some further characteristics of the paints. The results of the after yellowing, water permeability, and flexibility tests do not show any pronounced trends. In general, the films of paints made with the synthetic oils had less elongation than those of the paints made with natural oils. The two maleic glycerine oils seem to have a tendency to promote brittleness. All of the linseed base synthetic oils produced greater tensile strength than bodied linseed oil of the same viscosities. The two linseed maleic oils produced greater tensile strength in one formulation and less in another. In the mixed pig-

TABLE VIII

Paint Tests

| | Water Permeability M.P. | Flexibility M.P. | Elongation Stripped Film | | Adhesion S.P. | Tensile Strength of of Stripped Film | | Taber Abrasion M.P. | Shear Hardness M.P. | 60° Gloss M.P. | Daylight Reflect. M.P. | After Yellowing M.P. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | S.P. | M.P. | | S.P. | M.P. | | | | | |
| G Bodied Linseed | 0.57 | 28+ | 34.0 | 8.0 | Fair | 5.0 | 20.0 | 339 | 500 | 35.5 | 81.0 | Considerable |
| Conjugated Linseed | 0.63 | 28+ | 34.0 | 6.0 | V. poor | 8.0 | 27.0 | 344 | 405 | 45.5 | 80.3 | Slight |
| Linseed Penta | 0.59 | 28+ | 18.0 | 5.0 | Poor | 20.0 | 37.0 | 200 | 583 | 26.0 | 81.0 | V. Slight |
| Dehydrated Castor | 0.64 | 28+ | 25.5 | 9.0 | Poor | 14.7 | 38.7 | 264 | 428 | 36.2 | 81.0 | V. Slight |
| Fatty Tall Oil | 0.54 | 28+ | 25.5 | 3.1 | Fair | 11.0 | 16.3 | 310 | 637 | 29.3 | 80.0 | Slight |
| G Bodied Soybean | 0.52 | 28+ | 84.0 | 8.0 | Fair | 0.0 | 9.0 | 724 | 234 | 30.5 | 81.7 | Slight |
| Conjugated Soybean | 0.76 | 28+ | 80.0 | 7.0 | Fair | 0.0 | 0.0 | 930 | 182 | 34.0 | 80.6 | V. Slight |
| Soybean Penta | 0.94 | 16.0 | 12.5 | 5.0 | Fair | 11.0 | 30.0 | 399 | 373 | 14.5 | 83.0 | Slight |
| Soybean Mannitol | 0.55 | 18.0 | 60.0 | 3.0 | Fair | 0.0 | 10.0 | 395 | 278 | 18.3 | 80.8 | None |
| Soybean Sorbitol | 0.53 | 19.0 | 39.0 | 3.0 | Good | 8.0 | 18.0 | 331 | 396 | 17.7 | 82.9 | V. Slight |
| Q Bodied Linseed | 0.57 | 28+ | 24.0 | 7.0 | Good | 13.0 | 32.0 | 254 | 145 | 69.0 | 80.2 | V. Slight |
| Linseed Polypenta | 0.54 | 20.0 | 6.0 | 1.5 | Good | 33.3 | 58.7 | 215 | 625 | 27.0 | 82.3 | Considerable |
| Linseed Mannitol | 0.50 | 28+ | 36.0 | 4.0 | Fair | 12.0 | 30.0 | 216 | 595 | 27.0 | 81.0 | V. slight |
| Linseed Sorbitol | 0.49 | 14.0 | 21.0 | 4.0 | Good | 18.0 | 48.0 | 199 | 524 | 32.5 | 78.8 | V. slight |
| Soybean Polypenta | 0.56 | 25.0 | 10.5 | 1.5* | Good | 25.5 | 36.9 | 227 | 645 | 27.5 | 83.3 | Slight |
| Soybean Maleic Glyc | 0.63 | 14.0 | 17.0 | 3.0* | V. poor | 0.0 | 25.0 | 370 | 362 | 46.0 | 78.5 | None |
| Soybean Maleic Penta | 0.67 | 28+ | 12.5 | 6.0 | Poor | 30.8 | 40.9 | 320 | 1000 | 30.4 | 81.2 | V. Slight |
| Z2 Bodied Linseed | 0.45 | 16.0 | 32.0 | 2.0 | Good | 19.0 | 29.0 | 236 | 536 | 13.0 | 81.5 | None |
| Linseed Maleic Glyc | 0.52 | 13.0 | 18.0 | 2.0 | Poor | 14.0 | 38.0 | 218 | 597 | 15.7 | 82.0 | Slight |
| Linseed Maleic Penta | 0.53 | 12.0 | 16.0 | 0.0* | Poor | 28.0 | 22.0 | 250 | 730 | 12.5 | 82.1 | Slight |

* Brittle.

ment paints, the soybean synthetics produced greater tensile strength than G Bodied Soybean, while in the single pigment paints there was in several cases no difference. The paints made with Soybean Maleic Pentaerythritol and the two polypentaerythritol esters had tensile strengths which were much superior to those of the paints made with natural oils. Conjugated Soybean did not have any tensile strength in either formulation. Abrasion resistance was not determined on the single pigment paints because they were too soft. Abrasion resistance of paints made with the various oils showed only that most of the synthetics were better than the corresponding natural oils. Conjugated Soybean, however, had less abrasion resistance than G Bodied Soybean. In most cases the shear and Sward hardnesses of the paints made with synthetic oils were greater than those of the paints made with the natural oils. Soybean Maleic Pentaerythritol and the two polypentaerythritol esters produced particularly hard films. Gloss measurements on the paint films show no particular trends.

Daylight reflectance is a measure of the whiteness of the paints and also shows no particular trends.

In a following paper it is intended to present a method whereby the experimental data gathered under this evaluation scheme may be condensed and correlated for convenience in reference and comparison.

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# ☆ ☆ ☆ ABSTRACTS ☆ ☆ ☆

## Oils and Fats

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CHEMICAL TREATMENTS OF SEEDS TO PREVENT HEATING AND DETERIORATION DURING STORAGE. A. M. Altschul (So. Reg. Res. Lab., New Orleans, La.). *Cotton Gin & Oil Mill Press,* Jan. 8, 1949. Forty-eight chemicals which inhibit heating and deterioration of seeds during storage are recorded. Mixtures of 2 chemicals were more efficient than either one used alone.

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ALCOHOLS BY SODIUM REDUCTION. A STAFF-INDUSTRY COLLABORATIVE REPORT. M. L. Kastens and H. Peddicord. *Ind. & Eng. Chem. 41,* 438-46(1949).

UNSATURATED LONG-CHAIN ALIPHATIC ESTERS. CATALYTIC OXIDATION. T. M. Patrick and W. S. Emerson (Monsanto Chem. Co., Dayton, Ohio). *Ind. Eng. Chem. 41,* 636-41(1949). The liquid-phase air oxidation of the Me esters of tall oil fatty acids is described. In order to develop a technic for the method, oxidation of Et oleate and of oleic acid was studied in some detail. Oxidative scission was expected to take place at or near the double bonds to yield mono- and dicarboxylic acids. Large amounts of high molecular weight by-products, in addition to the expected scission products, were formed in these oxidations. The identified products comprised most of the members of the homologous series from caproic to palmitic acid and from suberic to undecanedioic acid, inclusive.

THE NITROGENOUS CONSTITUENTS OF THE TISSUE LIPIDES. I. THE EXTRACTION, PURIFICATION, AND HYDROLYSIS OF TISSUE LIPIDES. J. M. McKibbin and W. E. Taylor (Syracuse Univ. College Med.). *J. Biol. Chem. 178,* 17-27(1949). A technic for the determination of total lipide nitrogen is described. The amounts of nitrogen, phosphorus, and choline present in lipide extracts of 9 tissues from several dogs are presented.

THE NITROGENOUS CONSTITUENTS OF THE TISSUE LIPIDES. II. THE DETERMINATION OF SPHINGOSINE IN TISSUE LIPIDE EXTRACTS. J. M. McKibbin and W. E. Taylor (Syracuse Univ.). *J. Biol. Chem. 178,* 29-35 (1949). A method is described for an approximate determination of sphingosine in whole lipide extracts which have been freed of non-lipide impurities. The method is based on a chloroform extraction of the aqueous lipide hydrolysate which is both specific and relatively quantitative for sphingosine. Sphingosine is then determined on the chloroform extract as nitrogen.

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