A HOMOGENEOUS CARBON DISULPHIDE EMULSION

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INTRODUCTION

Carbon disulphide, emulsified in water by means of soaps, is now being used throughout the area infested by the Japanese beetle, Popillia japonica Newm., to destroy the immature stages of this insect in the soil. All of these concentrated carbon disulphide-water emulsions tend to stratify into two or more layers of different composition which must be agitated to form homogeneous mixtures.

If a portion of such a concentrated emulsion were diluted without agitation and applied to the soil about the roots of plants, the dilution made from the heavier layer would have an excessive proportion of the insecticide and would be likely to injure the plants, while the dilution made from the lighter layer might not be strong enough to kill the insect. Experience has shown that these concentrated carbon disulphide-water emulsions were not entirely satisfactory, owing to the variability in the concentration of the dispersed phase, and experiments were conducted to make an emulsion of carbon disulphide which would not have this undesirable property.

EXPERIMENTAL WORK

As all of these emulsions contain two immiscible liquids—carbon disulphide and water—it was thought that a more satisfactory concentrated emulsion could be made by substituting for the water some other liquid which is more miscible with carbon disulphide. Very good concentrated mixtures of this type were made by dissolving the carbon disulphide in methyl or ethyl alcohol. The dilute emulsions were made by precipitating the carbon disulphide from the alcoholic solution by the addition of water. This procedure, however, which was used in the case of certain oils by Lewis (6) and by Joshi (5), is effective only when there is a very small proportion of carbon disulphide in the alcoholic mixture. Since it is desirable to have a large proportion of carbon disulphide in these mixtures, it was thought necessary to add a suitable third substance.

Investigators have observed that the addition of 5 per cent methyl alcohol to mixtures of ethyl alcohol and petroleum (7) increased the stability of the mixtures when diluted with water. Transparent homogeneous emulsions can be made by adding glycerol to a solution of calcium olate in carbon tetrachloride (2, p. 30). A solution of a cresol soap (4) has been prepared from linseed oil, potassium hydroxide, alcohol, water, and crude cresol, and a liquid soap with formaldehyde (3) has been prepared from castor oil saponified with alcoholic

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potassium hydroxide, water, and formaldehyde; but, so far as the
writer has been able to determine, no concentrated mixture of carbon
disulphide has been prepared with alcoholic potassium hydroxide and
oleic acid.

The preliminary experiments for determining the nature of the
third substance to be added to the carbon disulphide-alcohol mixture
indicated that a soap is the best addition for increasing its stability
with water. The sodium soap formed from oleic acid and different
proportions of sodium hydroxide were not sufficiently miscible with
carbon disulphide to be satisfactory, but the potassium soaps formed
in the same manner mixed well with carbon disulphide and alcohol.

The next step was to determine the maximum volume of carbon
disulphide and the optimum quantities of alcohol, oleic acid, and
potassium hydroxide to be used. Alcoholic potassium hydroxide was
mixed with U. S. P. oleic and 95 per cent ethyl alcohol, in the propor-
tions of hydroxide 2:9, oleic acid 3:7, and ethyl alcohol 4:6, by volume. This mixture contained about 2 per cent excess of oleic acid over the
quantity required to react with the potassium hydroxide to assure
complete conversion of the potassium to potassium oleate, and thus
prevent the loss of carbon disulphide by the action of potassium alco-
holate, converting it to potassium xanthate. This alcoholic potassium
oleate was mixed with carbon disulphide in the proportions of 1:9, 2:8, 3:7, 4:6, and 5:5, by volume. Although the lower proportions
of the alcoholic potassium oleate gave concentrated mixtures having
the best appearance, there was not sufficient soap to disperse the car-
bon disulphide in water. The mixture 2:8 seemed to have the
minimum proportion of soap necessary to keep the mixture from
disintegrating when diluted with water.

The results having indicated that 70 per cent was near the maximum
proportion of carbon disulphide which should be put into the mixture,
the percentage of excess ethyl alcohol was varied from 0 to 22, and the
corresponding percentage of alcoholic potassium oleate from 30 to 8.
Each of these 70 per cent carbon disulphide emulsions was diluted by
pouring 5 c. c. of water into 5 c. c. of the emulsion, and, after slight
agitation, adding it to a large volume of water. It was not possible
to produce a homogeneous dilution by pouring any of these emulsions
directly into a large volume of water, but it was possible to obtain
such dilutions after the initial dilution obtained by adding an equal
volume of water to the concentrated emulsion. These mixtures
made good dilutions with water, the stability of the dilution being
proportionate to the amount of soap present. The results of these
different mixtures, which are outlined in Table 1, indicate that the
mixture containing 14 per cent ethyl alcohol, 8.56 per cent oleic acid,
and 7.44 per cent potassium alcoholate was the best. Expressed in
other terms, the composition of a liter of the best alcoholic carbon
disulphide emulsion is:

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. P. carbon disulphide</td>
<td>700.00 c. c.</td>
</tr>
<tr>
<td>95 per cent ethyl alcohol</td>
<td>214.40 c. c.</td>
</tr>
<tr>
<td>U. S. P. oleic acid</td>
<td>85.60 c. c.</td>
</tr>
</tbody>
</table>

Alcoholic potassium hydroxide (potassium alcoholate) was prepared by refluxing 100 gm. of U. S. P. potassium hydroxide with 400 c. c. of 95 per cent ethyl alcohol, and, after cooling, filtering the supernatant liquid through a dry filter. The alcoholate was standardized by titrating a diluted aliquot part against 0.1/N hydrochloric acid, using methyl orange as an indicator, and so adjusted with 95 per cent ethyl alcohol as to contain 0.2 gm. of potassium hydroxide per cubic centimeter.
**Table 1.**—Characteristics of insecticidal emulsions and their stability when diluted; composed of 70 per cent of carbon disulphide and various proportions of alcohol, oleic acid, and potassium alcohólate

<table>
<thead>
<tr>
<th>Proportions of—</th>
<th>Characteristics of concentrate</th>
<th>Stability of dilution, 5 :100 of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl alcohol</td>
<td>Oleic acid</td>
<td>Potassium alcohólate</td>
</tr>
<tr>
<td>Per cent</td>
<td>Per cent</td>
<td>Per cent</td>
</tr>
<tr>
<td>0</td>
<td>16.05</td>
<td>13.95</td>
</tr>
<tr>
<td>2</td>
<td>14.98</td>
<td>13.02</td>
</tr>
<tr>
<td>4</td>
<td>13.81</td>
<td>12.09</td>
</tr>
<tr>
<td>6</td>
<td>12.84</td>
<td>11.16</td>
</tr>
<tr>
<td>8</td>
<td>11.77</td>
<td>10.23</td>
</tr>
<tr>
<td>10</td>
<td>10.70</td>
<td>9.30</td>
</tr>
<tr>
<td>12</td>
<td>9.63</td>
<td>8.37</td>
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<tr>
<td>14</td>
<td>8.56</td>
<td>7.44</td>
</tr>
<tr>
<td>16</td>
<td>7.49</td>
<td>6.51</td>
</tr>
<tr>
<td>18</td>
<td>6.42</td>
<td>5.58</td>
</tr>
<tr>
<td>20</td>
<td>5.35</td>
<td>4.65</td>
</tr>
<tr>
<td>22</td>
<td>4.28</td>
<td>3.72</td>
</tr>
</tbody>
</table>

**Addition of Oils or Fatty Acids**

Further experiments were made to determine whether the dispersion of the carbon disulphide in water could be facilitated by the addition of oils or fatty acids to the concentrated emulsion. Mixtures were prepared containing 70 per cent carbon disulphide and different proportions of alcoholic potassium oleate (95 per cent ethyl alcohol, 214 c. c.; U. S. P. oleic acid, 86 c. c.; and U. S. P. potassium hydroxide, 15 gm.), together with coconut oil, cottonseed oil, copaiba oil, linseed oil, olive oil, oleic acid, or lactic acid. It was found that satisfactory concentrated mixtures could be made with coconut oil, cottonseed oil, linseed oil, and olive oil. Of these, the mixture in which 10 per cent of the alcoholic potassium oleate was replaced by cottonseed oil appeared to be the most efficacious in facilitating the dispersion of the carbon disulphide in water. The formula of the carbon disulphide emulsion was therefore modified to be as follows:

- C. P. carbon disulphide: 700 c. c.
- U. S. P. oleic acid: 77 c. c.
- Ethyl alcohol (95 per cent): 193 c. c.
- Cottonseed oil (purified): 30 c. c.
- U. S. P. potassium hydroxide: 13.5 gm.

To prepare a liter of this alcoholic emulsion, dissolve an excess of potassium hydroxide in alcohol; then filter off the insoluble carbonate and, after determining the hydroxide content by titration against a standard acid, add sufficient alcohol to obtain a concentration of 13.5 gm. of potassium hydroxide in 193 c. c. of alcohol; then pour 77 c. c. of oleic acid into each 193 c. c. of the alcoholic potassium hydroxide solution; then add 700 c. c. of carbon disulphide and 30 c. c. of cottonseed oil to each 270 c. c. of the oleic acid-alcoholic solution.

The resulting emulsion is amber colored, transparent, and homogeneous over a relatively long period. It is readily measured in small quantities, and mixes well with water. It must be diluted initially with an equal volume of water before being mixed with the larger quantity of water used in the insecticidal treatment in order to obtain a good dispersion of the carbon disulphide.
SUMMARY

A concentrated carbon disulphide emulsion has been prepared for insecticidal use which is transparent, homogeneous, and readily measured in small quantities. It is necessary to pour an equal volume of water into the emulsion and agitate it before adding it to the larger volume of water used in the insecticidal treatment. The composition of this emulsion is given.

LITERATURE CITED