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Case Study on Pesticide Formulation Effect on the Physical Properties of the Chemical.

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Endosulfan EC 35 percent was tested for its surface tension, absolute viscosity and density properties under different concentrations Their corresponding terminal velocities and droplet size formations were determined. It was observed that as the concentration was increased (a) the terminal velocities reduced; (b) the droplet sizes reduced; and (c) surface tension decreased. Absolute viscosity was found to be directly proportional to the change in the concentration. The density of the chemical was not changed by the concentration of the formulation. The effect of concentration on the inertial force was found to be reduced as the concentration increased The influence of viscous force was found to be more dominant than the gravitational force. While the Reynolds number and Froude number were found to vary linearly with the concentration, the Weber number was curvi-linearly correlated.

The density of endosulfan formulation with 34 percent concentration does not differ much from that of water whose density is 1.00 gm/cc, since significant change in density cannot be expected as 0.4 ml or less of the pesticide is mixed with the ether in this case. Out of the three dimensionless numbers considered excepting Froude number, the other two numbers involve the density factor. The influence of density, therefore, can be ascertained only on further studies by incorporation pesticides of varying densities for test with reference to Reynolds and Weber number.

Pesticides like endosulfan, malathion, nuvacron, zolone, rogor and dimecron are used for plant protection. The concentrations at which they are used vary in practice. For instance endosulfan requires 2.0, 3.0 and 4.0 ml of chemicals per litre of water to give concentrations of 0.07, 0.10 and 0.14 per cent respectively. To give similar concentration percentages, the requirements of chemical of dimecron are 0.5, 1.0 and 1.5 ml per litre of water respectively. When the concentrations are varied, the chemicals applied with the aid of a sprayer reach the target with varying terminal velocities, probably due to their variations in physical properties like density, viscosity, and surface tension.

MATERIAL AND METHODS

With a view to examine the interrelations between the physical proper-

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ties and the pesticide formulations, 35 percent EC Endosulfan was used as a test material. Surface tension of different formulations of 0.07, 0.10 and 0.14 percent were determined by "drop method" in which mass of single drop from a burette of known tip diameter was determined. From the following relationship the surface tension was calculated :

$$b = \frac{mg}{3.8r}$$

where m = mass of single drop, gm
r = radius of burette tip, cm
g = acceleration due to gravity, 981 cm/sec^2.

viscosity of these chemicals were determined by observing the time taken by the chemical taken in a burette to permit known volumes of the fluid to pass a horizontally placed capillary tube and by using the following relationship :

$$\mu = \frac{r^4 P g\, h\, t}{8\, LV}$$

where μ = absolute viscosity, gm/cmsec
r = radius of capillary tube, cm
p = density of chemical, gm/cm^3
h = head above the capillary tube, cm
t = time taken between successive equal fall in burette, sec.
L = length of capillary tube, cm
v = volume interval. ml
g = acceleration due to gravity, cm/sec^2

The droplet sizes on the dyed cards were measured with the help of stereoscopic microscope equipped with an ocular reticule. The droplet diameter (D) was calculated from this stain diameter (d) with the help of the following formula :

$$D = 0.318\ (d)^{1.065}\ \text{micron}$$

The terminal velocity of the droplet falling through air due to gravity was determined from the following relationship :

$$v = \frac{2\, r^2\, (e - a)\, g}{4 \mu a}$$

where v = terminal velocity of chemical, cm/sec.
r = droplet radius, cm
e = density of the droplet liquid, gm/cc
a = density of air, gm/cc
g = acceleration due to gravity, 981 cm/sec^2
μ = absolute viscosity of air, gm/cm-sec (183.25 + 10^{-6})

RESULTS AND DISCUSSION :

The results obtained with 35 per cent formulation of endosulfan is presented in Table 1.

TABLE 1 Physical Properties af Endosulfan in Relation to Concentrations and Terminal Velocities.

Concentration percent	Terminal velocity cm/sec	Density gm/cc	Absolute viscosity gm/cm-sec	Surface tension dyne/cm	Droplet cm
0.07	642.9	1.0008	0.83×10^{-2}	70.26	4.90×10^{-6}
0.10	506.1	0.9998	0.88×10^{-2}	62.41	4.34×10^{-6}
0.14	306.1	1.0009	0.95×10^{-2}	52.30	3.38×10^{-6}

It is apparent that as the concentration of the formulation increases, the terminal velocity decreases, probably due to the reduction in droplet size as the concentration increases. While absolute viscosity increases directly as the concentration increases, the surface tension shows inverse proportionality. The change in density due to concentration change is insignificant and variations if any, is within the experimental error. The important physical propererties of the chemical and the terminal velocity of the droplet are influenced by the concentration of the fluid which is again dependent on density, surface tension and absolute viscosity of the fluid. Hence the forces that are to be reckoned within handling such formulations are inertial force, viscous force, gravitational force, and surface tension force. The dimensionless numbers connecting the above forces are :

a) Reynolds number $= \dfrac{\text{Inertia force}}{\text{Viscous force}} = Re$

b) Froude number $= \dfrac{\text{Inertia force}}{\text{Gravitational force}} = Fr$

c) Weber number $= \dfrac{\text{Inertia force}}{\text{Surface tension force}} = We$

Let V = terminal velocity of the fluid, cm/sec
d = mean droplet size, cm
p = density of fluid, gm/cc
σ = surface tension of fluid, dyne/cm
μ = absolute viscosity of fluid; gm/cm-sec.

Then
$$Re = \frac{PVd}{\mu}$$

$$Fr = \frac{V}{\sqrt{gd}}$$

$$We = \frac{PV^2 d}{\sigma}$$

Table 2 gives the results of these dimensionless numbers as affected by the fluid concentrations.

TABLE 2. Concentrations of endosulfan versus dimensionless numbers.

Concentration percent	Reynolds No. $V d \rho / \mu$	Froude No. $V / \sqrt{g d}$	Weber No. $\frac{\rho V^2 d}{\sigma}$
0.07	4.78×10^3	9.927	3.629×10^2
0.10	3.15×10^3	0.776	2.244×10^2
0.14	1.40×10^3	0.544	0.763×10^3

Even though from the table 1, it is inferred that surface tension and viscosity as inversely correlated, it is seen from the data that there ex ists a linear relationship between concentration and other dimensionless numbers except in the case of Weber number. The Reynolds number decreases faster than the Froude number as the concentration increases. This implies that the fluid flow condition influenced by the viscous force from laminar state to turbulent state can be more pronounced as the concentration of the liquid is diluted. In view of the increased atomisation encountered, as the concentration increases, as reflected by the droplet size reduction in table 1, the effect of gravitatinoal force becomes more important as the concentration increases than the effect of inertial force. Thus the concentration of the pesticides reduces the influence of inertial force and increase the effects of viscous, gravitational and surface tension forces. From the figure 1 it can be seen that the influence of surface tension effect is not linearly related to the concentration change. It is to be noted that like the Reynolds number as related to laminar and turbulent flow condition, Froude number is related to wave formation and surface behaviour and Weber number is related to break up of liquid jet and bubble formation. Since the influence of surface tension is film thickness dependent, its importance reduces beyond a critical limit of concentration.