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The Study of Viscosity of Oil-in-Oil Emulsions with Different Surfactants

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In the present work the viscosity of oil-in-oil emulsions with different surfactants are reported.

INTRODUCTION

The flow properties of emulsions are studied with the viscosity phenomena, which fall within the scope of modern Rheology, which deals with changes in form and physical state which are produced by the application of mechanical stress to a material. A stress is defind as an internal force in matter transmitted per unit area between adjacent layers and is a vector quantity. The viscosity of a concentrated emulsion is a function of the rate of shear and increases asymptotically with the rate of shear. For a given emulsion, for a wide range of the latter, the relation between shearing stress and the rate of shear is linear. The stabilizers producing the best emulsification give emulsions of the lowest limiting relative viscosity. The variation in viscosity at the same concentration is in order of increasing ease of emulsification, the most efficient stabilizer producing emulsions of lowest viscosity.[1–7]

RESULTS AND DISCUSSION

If the stress is parallel to the element, then it is known as tangential stress and is represented as (Γ). When a material is subjected to simple shear by the application of a uniforom and constant shear stress, it undergoes a permanent or non-recoverable deformation. It increases with the duration, not with the applied stress, and it is said that the flow is uniform. The permanent shear is represented by "D" and depends only on the value of Γ. So the viscosity curve is obtained by the ratio of Γ/D at any point, which is termed as the coefficient of viscosity, *i.e.*,

$$\eta = \Gamma/D \qquad \text{(a)}$$

If this viscosity curve is a straight line passing through the origin then η is constant at a given temperature and is said to be normal. Generally, the term 'viscosity' restricts uniform flow but it does not imply that the ratio Γ/D is necessarily constant. For non-uniform flow, the term 'apparent viscosity' is used. Various methods are employed for the measure of viscosity. The methods can be determined by the comparable results for pure liquids and true solutions, discordant values with colloidal and other disperse systems. Therefore, it is desirable that

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For Correspondence: Dr I.P. Pandey, 5 Cross Road, Dehradun-248 001, India viscosity measurements on such a system should be made by a method which allows the rate of shear to be varied and accurately defined.

Dilute two-phase emulsions show a viscosity not greatly exceeding that of water. Viscosity increases rapidly in other emulsions as the volume of dispersed phase increases. In this case, there arises the new factor of the presence of the emulsifying agent because the viscosity of concentrated emulsions is intimately connected with the presence of adsorbed films.

On discussing the viscosity of colloid system, Einstein obtained the equation

$$\eta' = \eta(1 + 2.5\phi) \quad \text{(b)}$$

where η' = mean velocity of the suspension

η = viscosity of liquid medium

$$\phi = \frac{\text{volume of sphere}}{\text{volume of suspension}} = \text{volume of the internal phase}$$

However, many emulsions of technical interest have high volume concentrations of dispersed phase. So, an equation deduced by Hatschek on the assumption that this concentration is at least 50% has received considerable attention. Hatschek concluded that the viscosity varies with the velocity gradient and above a certain velocity gradient reaches a constant value given by the relation.

This equation neglects the viscosity of the internal phase and is given as follows:

$$\eta' = \eta_\theta \frac{1}{1 - 3\phi} \quad \text{(c)}$$

where, η_θ = viscosity of the internal phase

and $$\phi = \frac{(\eta' - \eta_\theta)^3}{(\eta')^3} \quad \text{(d)}$$

Thus the percentage volume of the internal phase is calculated. It was concluded that fine emulsions were more viscous than coarse emulsions at equivalent values of ϕ, the difference increasing as ϕ was increased.

EXPERIMENTAL

Multifoam was used as an anionic surfactant, and chrome lignosulphate and Tween-21 as cationic surfactants. Benzene-ethylene glycol, turpentine oil were used as internal and external phases in preparing the emulsions.

Various different types of emulsions were prepared by taking different concentrations of benzene, turpentine oil and ethylene glycol with different surfactants. Emulsions were prepared in a simple regular electric mixer under the following two conditions:

(a)Different concentrations of benzene, turpentine oil and ethylene glycol with fixed concentrations of surfactants.

(b) Different concentrations of surfactants and fixed ratios of turpentine oil, ethylene glycol and benzene.

Conclusion

Viscosity measurements undoubtedly play an important and remarkable role in the preparation and stabilization of different types of emulsions. The higher viscosity aids emulsification by decreasing mobility of the droplets constituting the dispersed phase, thereby retarding this approach to coalescence, shown in Tables 1–5. Thus by virtue of the hindrance offered to the coalescence of the dispersed globules, the different systems of emulsions are stabilized. So, oil-in-water and alcohol-in-oil emulsions respectively are stabilized by different surfactants.

It was prepared in different oil-in-oil emulsions which stabilized by anionic, cationic and non-ionic surfactants, and studies about the effects of viscosity on the stability of these different emulsions at various temperatures and different concentrations of surfactants were made.

TABLE-1
MEASUREMENT OF VISCOSITY OF BENZENE/ETHYLENE GLYCOL EMULSION IN THE RATIO OF 1:1 AT DIFFERENT TEMPERATURES BY USING ANIONIC SURFACTANT MULTIFORM OF 0.2 g

SL. No.	Temp. (°C)	Viscosity (millipoise)
1	15	275.2
2	20	272.1
3	25	270.0
4	30	268.6
5	35	267.0
6	40	265.2
7	45	263.5
8	50	261.3

TABLE-2
MEASUREMENT OF VISCOSITY OF TURPENTINE OIL/ETHYLENE GLYCOL EMULSION IN THE RATIO OF 1 : 1 AT DIFFERENT TEMPERATURES BY USING SURFACTANT CHROME LIGNOSULPHATE OF 0.2 g

Sl. No.	Temp. (°C)	Viscosity (millipoise)
1	15	270.2
2	20	268.1
3	25	266.0
4	30	264.5
5	35	262.4
6	40	261.1
7	45	260.1
8	50	259.3

TABLE-3
MEASUREMENT OF VISCOSITY OF BENZENE/TURPENTINE OIL EMULSIONS AT DIFFERENT RATIOS WITH 5 mL OF ETHYLENE GLYCOL

Surfacant concentration = 2%, temperature = 20°C

Sl. No.	Oil/Oil Ratio	Multifoam (millipoise)	Chrome lignosulphate (millipoise)	Tween-21 (millipoise)
1	1 : 1	270.10	240.20	290.10
2	1 : 2	271.20	241.20	291.32
3	1 : 3	272.40	242.40	292.50
4	1 : 4	274.00	243.80	294.20
5	1 : 5	275.20	245.00	295.40
6	1 : 6	276.30	246.40	296.50

TABLE-4
MEASUREMENT OF VISCOSITY OF BENZENE/TURPENTINE OIL EMULSION AT DIFFERENT RATIOS WITH 10 mL OF ETHYLENE GLYCOL

Surfacant concentration = 2%, Temperature = 20°C

Sl. No.	Oil/Oil Ratio	Multifoam (millipoise)	Chrome lignosulphate (millipoise)	Tween-21 (millipoise)
1	1 : 1	263.20	234.10	285.00
2	1 : 2	264.50	235.20	286.40
3	1 : 3	265.80	236.00	287.80
4	1 : 4	266.10	237.50	289.00
5	1 : 5	267.10	238.80	290.20
6	1 : 6	268.30	240.00	291.30

TABLE-5
MEASUREMENT OF VISCOSITY OF DIFFERENT EMULSIFIERS (AT 20°C) BY USING ETHYLENE GLYCOL = 5 mL, BENZENE AND TURPENTINE OIL = 5 mL

Sl. No.	Emulsifier conc. (g)	Multifoam (millipoise)	Chrome lignosulphate (millipoise)	Tween-21 (millipoise)
1	0.05	270.00	240.00	290.60
2	0.10	271.10	241.00	292.10
3	0.20	272.40	242.90	293.40
4	0.40	273.80	243.80	295.00
5	0.80	274.80	244.10	296.20
6	1.00	275.90	245.70	297.80

TABLE-VI
MEASUREMENT OF VISCOSITY OF DIFFERENT EMULSIFIERS (AT 20°C) BY USING ETHYLENE GLYCOL = 5 mL, BENZENE AND TURPENTINE OIL = 10 mL

Sl. No.	Emulsifier conc. (g)	Multifoam (millipoise)	Chrome lignosulphate (millipoise)	Tween-21 (millipoise)
1	0.05	245.10	232.20	265.70
2	0.10	246.50	233.40	266.90
3	0.20	247.70	234.80	267.40
4	0.40	248.30	235.90	268.60
5	0.80	249.30	236.80	269.50
6	1.00	250.80	237.80	270.70

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