*Asian Journal of Chemistry* Vol. 12, No. 1 (2000), 255–258

# Physico-Chemical Factors Affecting the Formation of Emulsion

I.P. PANDEY*, KANCHAN SHARMA and T.S. RAWAT
*Oil Extraction and Environmental Research Laboratory*
*Chemistry Department*
*D.A.V. (P.G.) College, Dehradun-248 001, India*

The interfacial tension was regarded as a very important factor in determining the stability and the particle size of emulsions. It is now recognized that the work done in creating new interfaces is only a part of the interfacial tension promoting the disruption of the bulk interfaces, but the real importance of the emulsifier lies in the profound changes, especially of the electrical double layers, near the interfaces. The change in the interfacial tension is a readily measurable manifestation of the changes that have taken place in the nature of the interface.

## INTRODUCTION

In the techniques of emulsion preparation, generally considered as breaking up liquid into fine droplets, in actual practice, various refinements were necessary. Having used brute force to break up the interface, gentle persuasion is added to give the finishing touches to the emulsions. There are a number of properties of emulsions over which the technologists were wanted to have control. The more important terms are concentrations, stability, particle size and viscosity of the emulsions. Sometimes, other properties like the dielectric strength, electrical conductivity and colour may be specified[1].

## RESULTS AND DISCUSSION

The interfacial tension was regarded as a very important factor in determining the stability and the particle size of emulsions. It was argued that a large value of interfacial tension means a large energy input to create new surfaces and was hence was unfavourable to be the reduction of interfacial tension brought about by them. It is now recognized that the work done in creating new interfaces is only a part of the interfacial tension promoting the disruption of the bulk interfaces, but the real importance of the emulsifier lies in the profound changes, specially of the electrical double layers, near the interfaces. The electrical double layer controls the stability of the emulsion by hindering the coagulation of the particles. It also decides whether oil-in-water or water-in-oil emulsion would be formed. The change in the interfacial tension is a readily measurable manifestation of the changes that have taken place in the nature of the interface.

---

*For correspondence*: Dr I.P. Pandey, 5 Cross Road, Dehradun-248 01, India

A large number of emulsifier have been prepared to suit the requirements of the variety of systems. Becher (in the year 1957) has listed over 800 commercial products and the list is by no means complete. The emulsifier stabilizes the droplets once they are formed. Depending upon which type of droplet is stabilized, *i.e.*, water droplets in the oil phase, oil droplets in the water phase, one gets water-in-oil (w/o) or oil-in-water (o/w) emulsions. For this purpose, an emulsifier could be characterized by a number specifying the hydrophil-lyophil balance (HLB). If the HLB number is in the range 3–6, water-in-oil emulsion is produced. An emulsion with an HLB number 8–13 gives oil-in-water emulsion[2, 3].

The emulsifier influences the process of disrupting the interface to form droplets through its effect upon the interfacial tension and to a slight extent, upon the viscosity of the phase. The interfacial tension decreases very rapidly as the concentration of emulsifier is increased from zero, but soon tends to attain a limiting low value of interfacial tension favourable to emulsification[4].

Thus, as the emulsifier concentration is increased, the emulsions are easily formed and are stable; the particle becomes smaller in size. But the increase of emulsifier concentration beyond an optimum value neither improves the stability nor gives finer droplets.[5]

In industrial practice the amount of emulsifier used is governed by its cost. The minimum amount which can be used with reasonably satisfactory results is employed in the formulation of the emulsion. Approximate value of this optimum concentration of the emulsifier can be calculated from the total interfacial area of the emulsions, the thickness, the surface layer and the critical micelle concentration. Emulsions through homogenizer followed by initial mixing can be connected in stability. On the other hand, the agent-in-oil method usually results in uniform emulsions, with an average droplet diameter of about 0.5 μ, which probably represents the most stable type of emulsion. In all cases, where soaps are employed as emulsifying agents, the nascent soap formation method is the most preferred method. Olive oil emulsion is stabilized with sodium oleate. It has been reported that a stable emulsion depends upon the particle size present. The agent-in-oil method usually results in uniform emulsion as compared to all the above emulsions because this method of emulsification produces an average droplet diameter of about 0.5 μ.

## EXPERIMENTAL

Olive oil *ca.* 10%, sodium oleate *ca.* 0.5% and water *ca.* 89.5%.

The mixing technique is at least as important as the mode of addition of materials in defining the final particle size distribution. All the emulsions are prepared by different methods of preparation:

| | |
|---|---|
| Emulsion-I: | Prepared by agent-in-water method, by using simple mixing with a high speed mixer. |
| Emulsion-II: | Prepared by agent-in-water method, by using homogenization mixing. |
| Emulsion-III: | Prepared by the nascent soap method formation with simple mixing. |

Emulsion-IV: Prepared by the nascent soap method but with mixing and homogenization.

Emulsion-V: Prepared by the agent-in-water method, in which oil and water phases were added individually to the homogenizer.

Emulsion-VI: As in emulsion V, after another pass.

Emulsion-VII: Prepared by nascent soap formation of the soap, with the individual phases fed to the homogenizer.

Emulsion-VIII: Prepared by an additional pass through the equipment.

The particle size distribution of olive oil-in-water emulsion as a function of different types of agitation is reported in Table-1.

A number of olive oil-in-water emulsions with sodium oleate emulsifier showing the broad particle size ranges obtained with different mixing techniques, as a function of emulsifier concentration, has also been reported in Tables 1 and 2.

TABLE-1
PARTICLE SIZE DISTRIBUTION AS A FUNCTION OF AGITATION

| Type of agitation | Particle size range (micron) | | |
|---|---|---|---|
| | 1% Sodium oleate | 5% Sodium oleate | 10% Sodium oleate |
| Propeller | No emulsion | 3–8 | 2–5 |
| Turbine | 2–9 | 2–4 | 2–4 |
| Colloid mill | 6–9 | 4–7 | 3–5 |
| Homogenizer | 1–3 | 1–3 | 1–3 |

TABLE-2
TECHNIQUE OF EMULSIFICATION PARTICLE SIZE DISTRIBUTION
FOR OLIVE OIL EMULSIONS

| Size range of particles (microns) | Per cent of emulsion particles in range | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII |
| 0–1 | 47.5 | 71.8 | 68.5 | 80.7 | 80.8 | 87.7 | 88.6 | 97.3 |
| 1–2 | 41.1 | 26.4 | 28.4 | 17.1 | 18.1 | 11.6 | 10.7 | 2.5 |
| 2–3 | 7.4 | 1.4 | 2.0 | 2.0 | 0.8 | 0.7 | 0.5 | 0.2 |
| 3–4 | 2.1 | 0.3 | 0.5 | 0.2 | 0.2 | — | 0.1 | — |
| 4–5 | 0.1 | — | 0.1 | — | 0.1 | — | — | — |
| 5–6 | 0.7 | 0.1 | 0.3 | — | — | — | — | — |
| 6–7 | 0.1 | — | — | — | — | — | — | — |
| 7–8 | 0.6 | — | 0.1 | — | — | — | — | — |
| 8–9 | 0.1 | — | — | — | — | — | — | — |
| 9–10 | 0.2 | — | — | — | — | — | — | — |
| 10–11 | — | — | — | — | — | — | — | — |
| 11–12 | 0.1 | — | — | — | — | — | — | — |

## Conclusion

The results indicated that the radii of the droplets in the emulsion decrease with increasing stirrer speed and with increased emulsifying time and depends on the composition of the emulsifying agent.

## ACKNOWLEDGEMENTS

The authors are thankful to Principal and Head of the Department of Chemistry DAV (PG) College, Dehradun, for providing necessary facilities to carry out the experimental work for this research paper.

## REFERENCES

1. A.T. Florence, T.K. Law, T.F. Svitova and V. Yu Lobanove, Physical Chemistry of Colloids and Interfaces in Oil Production, Paris, p.133 (1985).
2. T. Braja Kumar and I.P. Pandey, *Asian J. Chem.*, **6**, 692 (1994).
3. G.P. Gladden, *J. Inst. of Pet.*, **58**, 564 (1972).
4. J. Reisberg and T.M. Doscher, *Prod. Monthly,* **21**, 43 (1956).
5. V.B. Menon, A.D. Nikolov and D.T. Wasan, *J. Colloid Interface Sci.*, **24,** 121 (1987).

(*Received*: 5 September 1999; *Accepted*: 18 October 1999) AJC-1883