

whether or not the droplets will coalesce as they approach one another. If the film is electrically charged, then repulsive forces will contribute to stability.

Separation of an emulsion into its constituent phases is termed *cracking* or *breaking*. It follows that any agent that will destroy the interfacial film will crack the emulsion. Some of the factors that cause an emulsion to crack are:

- the addition of a chemical that is incompatible with the emulsifying agent, thus destroying its emulsifying ability. Examples include surface-active agents of opposite ionic charge, e.g. the addition of cetrimide (cationic) to an emulsion stabilized with sodium oleate (anionic); addition of large ions of opposite charge, e.g. neomycin sulfate (cationic) to aqueous cream (anionic); addition of electrolytes such as calcium and magnesium salts to an emulsion stabilized with anionic surface-active agents
- bacterial growth – protein materials and non-ionic surface-active agents are excellent media for bacterial growth
- temperature change – protein emulsifying agents may be denatured and the solubility characteristics of non-ionic emulsifying agents change with a rise in temperature; heating above 70 °C destroys most emulsions. Freezing will also crack an emulsion; this may be because the ice formed disrupts the interfacial film around the droplets.

Other ways in which an emulsion may show instability are as follows.

Flocculation. Even though a satisfactory interfacial film is present around the oil droplets, secondary minimum flocculation, as described earlier in this chapter under the discussion on the DLVO theory of colloid stability, is likely to occur with most pharmaceutical emulsions. The globules do not coalesce and may be redispersed by shaking. However, due to the closeness of approach of droplets in the floccule, if any weaknesses in the interfacial films occur then coalescence may follow. Flocculation should not be confused with creaming (see below). The former is due to the interaction of attractive and repulsive forces and the latter due to density differences in the two phases. Both may occur.

Phase inversion. As indicated under the section on emulsion type, phase volume ratio is a contributory factor to the type of emulsion formed. Although it

was stated there that stable emulsions containing more than 50% of disperse phase are common, attempts to incorporate excessive amounts of disperse phase may cause cracking of the emulsion or phase inversion (conversion of an o/w emulsion to w/o or vice versa). It can be shown that uniform spheres arranged in the closest packing will occupy 74% of the total volume irrespective of their size. Thus Ostwald suggested that an emulsion which resembles such an arrangement of spheres would have a maximum disperse phase concentration of the same order. Although it is possible to obtain more concentrated emulsions than this, because of the non-uniformity of size of the globules and the possibility of deformation of shape of the globules, there is a tendency for emulsions containing more than about 70% disperse phase to crack or invert.

Further, any additive that alters the HLB of an emulsifying agent may alter the emulsion type; thus addition of a magnesium salt to an emulsion stabilized with sodium oleate will cause the emulsion to crack or invert.

The addition of an electrolyte to anionic and cationic surfactants may suppress their ionization due to the common ion effect and thus a w/o emulsion may result even though normally an o/w emulsion would be produced. For example, pharmacopoeial White Liniment is formed from turpentine oil, ammonium oleate, ammonium chloride and water. With ammonium oleate as emulsifying agent, an o/w emulsion would be expected but the suppression of ionization of the ammonium oleate by the ammonium chloride (the common ion effect), and a relatively large volume of turpentine oil, produce a w/o emulsion.

Emulsions stabilized with non-ionic emulsifying agents such as the polysorbates may invert on heating. This is due to the breaking of the H-bonds responsible for the hydrophilic characteristics of the polysorbate; its HLB value is thus altered and the emulsion inverts.

Creaming. Many emulsions cream on standing. The disperse phase, according to its density relative to that of the continuous phase, rises to the top or sinks to the bottom of the emulsion, forming a layer of more concentrated emulsion. The commonest example is milk, an o/w emulsion, with cream rising to the top of the emulsion.

As mentioned earlier, flocculation may occur as well as creaming but not necessarily so. Droplets of the creamed layer do not coalesce, as may be found by gentle shaking which redistributes the droplets