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COMMUNICATIONS

DIELECTRIC CONSTANT DURING EMULSIFICATION

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ABSTRACT

Dielectric constant of emulsions was studied during the process of emulsification. The initial faster rate of increase in dielectric constant was found to decrease progressively until a steady state was attained. The increase in dielectric constant during emulsification was associated with a decrease in globule size. Dielectric constant was found to possess an inverse and linear relation to globule size of the emulsion.

INTRODUCTION

The important step in the manufacture of an emulsion is the process of emulsification, where one liquid is dispersed into another. Any emulsification process, therefore, is required to be designed in such a way that variable physical and chemical parameters are selected and controlled to favor emulsion formation. The applications of certain physicochemical principles in the development of stable dosage forms have been proved to be of advantages.

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Studies from our laboratory have demonstrated the importance of electrical properties in predicting stability of dispersed systems. Reddy[1] studied the dielectric constant (DEC) of emulsions and Panpalia[2] has shown the usefulness of zeta potential of emulsions as promising parameter to study the effect of various formulation factors on the emulsion stability. Labhasetwar *et al.*[3,4] used DEC and zeta potential to study the changes occurring in microcapsules under accelerated storage conditions. In the present investigation DEC of emulsion was studied during the process of emulsification.

MATERIALS AND METHODS

Materials

Liquid paraffin (I.P.), Castor oil (I.P.), Toluene, Polysorbate-80, Triethanolamine Oleate.

Preparation of Emulsion

An internal phase (75 ml) was placed together with 225 ml distilled water in a 500 ml beaker without any added emulgent. This mixture was agitated at a constant speed of 1500 RPM using a mixer (Universal Laboratory Aid, Type 309, Poland). The foaming and aeration during mixing were avoided to a minimum possible extent by selecting the operational position of the stirrer. Similar procedure was adopted when emulsions with emulgents were prepared.

Dielectric Constant Measurement

Since the aim of the present investigation is to understand in-process changes taking place during emulsification, we resorted this study especially to the use of conductive probe (Universal Dielectrometer, Type OH-301, Radelkis, Hungary) by immersing it in the emulsion during emulsification.

Globule Size Measurement

Suitable dilution of the emulsions in distilled water was prepared and the average of 300 globules was determined by conventional microscopic method.

Considering relatively higher aqueous solubility of toluene, water saturated with the internal phase was used as a dilution medium for toluene emulsion.

RESULTS AND DISCUSSION

The changes in the DEC of liquid paraffin emulsions with the emulsification are shown in the Figure 1. The DEC of emulsions increased progressively before attaining a constant DEC. However, the time required for reaching a constant DEC for emulsion without emulgent was about 20 min. whereas the same with polysorbate-80 and triethanolamine oleate was 3 min. and 10 min., respectively.

Surface active agents facilitate the process of emulsification by reducing the interfacial tension. Thus, the faster attainment of constant DEC in the presence of emulgents suggests that DEC conceivably reflects the changes taking place in the emulsion during emulsification. Furthermore, it was observed that the emulsions with emulgents always possessed a higher DEC as compared to the corresponding emulsions without it. The factors responsible for this difference could be the nature and concentration of emulgent, and also the globule size. In order to resolve the role of above said factors, liquid paraffin emulsions were prepared with different concentrations of polysorbate-80. The mixing in each case was continued till the maximum DEC was attained. These emulsions were immediately subjected to globule size measurements. The quantitative estimation of the role of emulgent concentration was carried out by subjecting the solutions of emulgent to the similar treatment. The DEC due to the emulgent was subtracted from the DEC of the corresponding emulsion. The values thus obtained were plotted against the concentration of polysorbate-80 as shown in the Figure 2. This Figure also reveals the relationship between globule size and the concentration of the emulgent. The increase in the concentration of emulgent brought about more or less an exponential increase in the DEC of emulsions. The globule size demonstrated an inverse relation with the concentration of emulgent used.

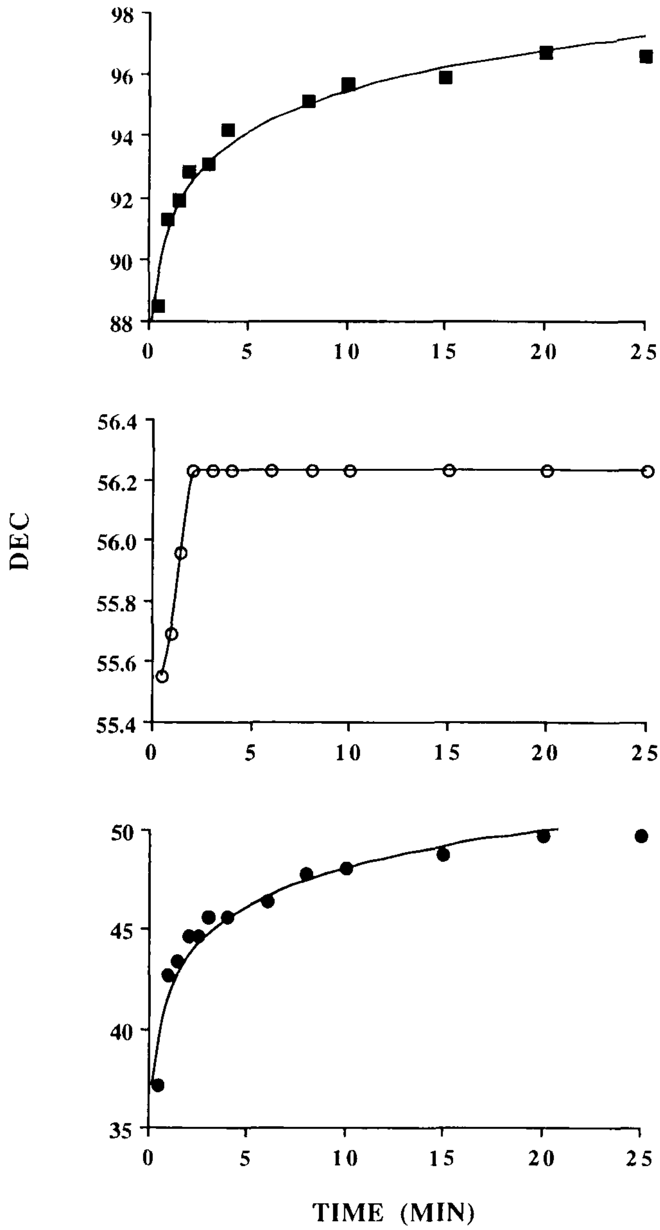

FIGURE 1

The effect of time of agitation on the changes in the DEC of liquid paraffin emulsion. (●), without emulgent; (○), with Polysorbate-80; (■)with Triethanolamine Oleate.

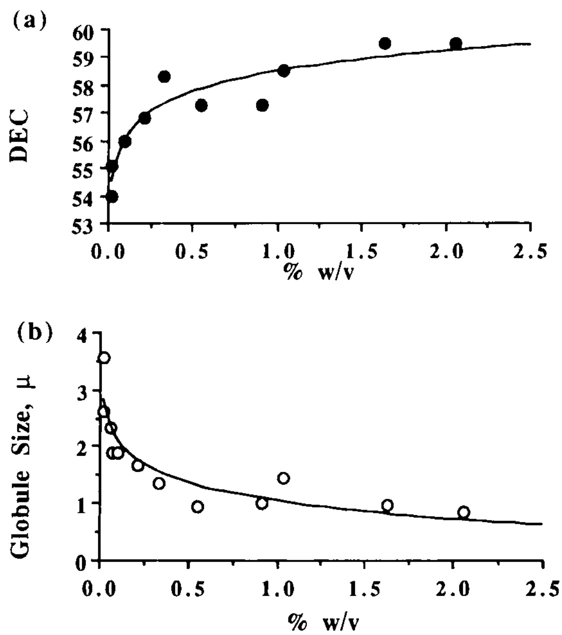

FIGURE 2

DEC and globule size of liquid paraffin emulsions as a function of concentration of polysorbate-80. (a), DEC; (b), globule size.

This indicates that the DEC is an inverse linear function of globule size and when plotted in the Figure 3a showed a good correlation between them (r = 0.856, n=10). A similar relation between DEC and globule size of toluene emulsion could be sought from Figure 3b (r = 0.859, n=8). The relationship between globule size and DEC of emulsion employing castor oil as an internal phase was derived by intermittent removal of emulsion samples and subsequently subjecting them to globule size analysis with emulsification process being in progress (Figure 3c, r = 0.826, n=12).

Although a linear relationship was observed between DEC and globule size in all the emulsions studied, slope values of these plots varied from one internal phase to another (Liquid paraffin emulsion, 1.86; Toluene emulsion,

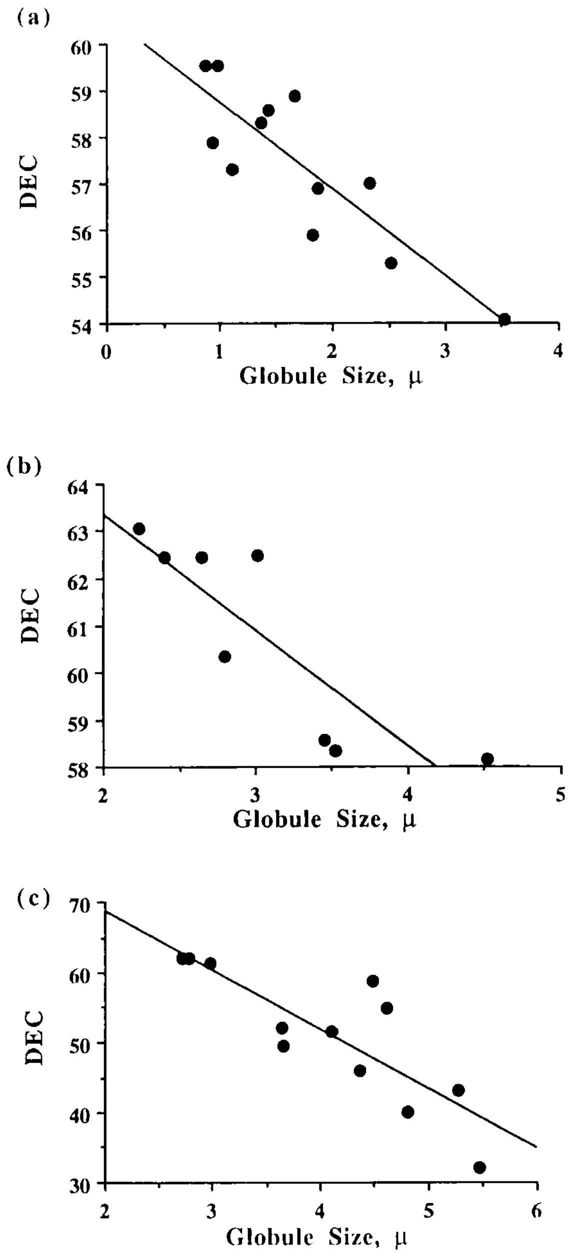

FIGURE 3

Relation between DEC and globule size of emulsions. (a), liquid paraffin emulsion; (b), toluene emulsion; (c), castor oil emulsion.

2.45; Castor oil emulsion, 8.45). This reveals that the DEC is not solely the function of concentration of emulgent and globule size, but also depends on the nature of the emulgent and internal phase. This is possibly due to the variation in the adsorption of emulgent at the interface, affecting double layer polarization, and hence the DEC of the system. The nature of internal phase influencing the stability of emulsions is reported by several researchers.[5] Kaye and Seager[6] studied creaming rate of emulsions through change in the DEC.

From the observations in this study, irrespective of the nature of the internal phase used, globule size showed linear correlation with the DEC of emulsion. Thus, DEC could be a parameter of choice in understanding the efficiency with which emulsification is carried out, mainly without disrupting the system, which is essential at an industrial level.

CONCLUSIONS

DEC depicts the changes occurring during the process of emulsification and could prove to be a useful parameter to study the factors affecting efficiency of emulsification process.

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