

# Study of the Diluted Polydispersed Double Emulsions Stability

Cristina Stoian<sup>\*</sup>, Gheorghe Zgherea<sup>\*</sup>, Mihaela Olteanu<sup>\*\*</sup>, Sandu Peretz<sup>\*\*\*</sup>

<sup>\*</sup>„Dunărea de Jos” University of Galați, 111 str. Domneasca, 800201 Galați  
e-mail: cstoian@ugal.ro

<sup>\*\*</sup>University of Bucharest, 4-12 Regina Elisabeta Blvd, Bucharest

<sup>\*\*\*</sup>Institute of Physical Chemistry "I.G. Murgulescu", 202 Spl. Independenței, Bucharest

## Abstract

*The goal of this work consists of studying stability of polydispersed double emulsions. In the experiments performed, the reverse emulsion corpuscles were diluted in the aqueous phase ( $\phi \leq 30\%$ ). The kinetic evolution of Span 80 / SDS (lipophilic surfactant / hydrophilic surfactant) - type double emulsions was traced by using a NaCl solution as internal aqueous phase and a glucose solution, isotonic to the saline one, as external aqueous phase, while the oily phase was toluene. The kinetic evolution of the double emulsions was traced by conductance measurement of the external aqueous phase. It has been ascertained by conductometric method that speeds of the passing at NaCl towards outside increases with added SDS quantity. The release experimental values fit well the first order kinetic equation in for SDS concentration bigger than 1 CCM and the naught order for SDS concentration smaller than 1 CCM.*

**Key words:** kinetic release, double emulsion

## Introduction

Double emulsions are multiple emulsions - type disperses mediums. These emulsions have many applications [1]. In food industry they are used to obtain the foods with a high period of stability provided that olphactive and flavor demand are preserved [2]. Also, they are used in pharmaceutical industry to obtain the formulations with retard effects or sensitive in gastric juice [3].

They are obtained by dispersing a reverse emulsion into an aqueous phase (direct double emulsion W/O/W) [4] or a direct emulsion into an oily phase (reverse double emulsion O/W/O).

The obtained direct double emulsion was formed by reverse emulsion corpuscles dispersed into an external aqueous phase, in presence of a hydrophile surfactant [5]. The reverse emulsion corpuscles were formed by internal aqueous phase drops dispersed into an oily phase, using a lipophile surfactant.

These systems are destroyed by passing an aqueous phase from the reverse emulsion corpuscle interior to the aqueous phase outside them [6].

## Materials and Methods

In this work the direct double emulsions were prepared in two stages [4]. During the first stage, the water-in-oil emulsion was prepared, in Ultraturax, in the presence of Span 80 like surfactant lipophilic. The water-in-oil emulsion obtained (tab. 1.) was polydisperse.

**Table 1.** Composition of reverse emulsion

| Phase         | Materials           | Composition |
|---------------|---------------------|-------------|
| Aqueous phase | NaCl solution 0,4 M | 20%v.       |
| Oil phase     | Toluene             | 80%v.       |
| Surfactant    | Span 80             | 2%wt.       |

The emulsion reverses thus realized was dispersed in the external aqueous phase, in Ultraturax. The prepared emulsion double direct this manner (tab. 2.) was polydisperse.

**Table 2.** Composition of directe double emulsion

| Phase                  |                        | Materials                 | Composition      |       |
|------------------------|------------------------|---------------------------|------------------|-------|
| Reverse emulsion       | Internal aqueous phase | NaCl solution 0,4 M       | 20%v.            | 10%v. |
|                        | Oil phase              | Toluene                   | 80%v.            |       |
|                        | Lipophilic surfactant  | Span 80                   | 2%wt.            |       |
| External aqueous phase |                        | Glucose solution 10,5%wt. | 90%v.            |       |
| Hydrophilic surfactant |                        | SDS                       | 0,5 CCM<br>5 CCM |       |

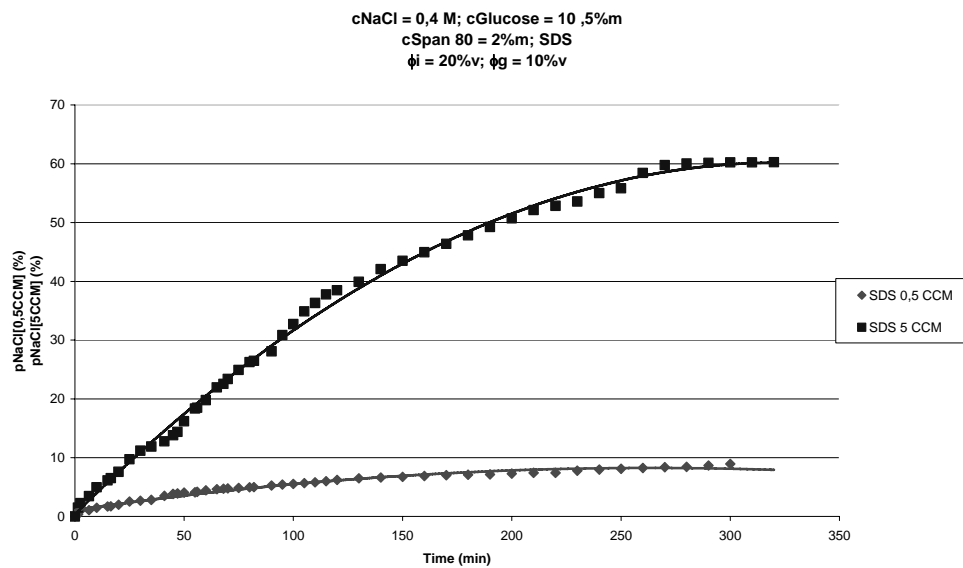
The aspect of the emulsions was observed by optical microscopy [7]. The evolution of the direct double emulsions was followed by conductometry [8]. For that, the NaCl concentration, at the beginning introduced into the aqueous phase interns, was measured in the external aqueous phase. For this goal, a conductometer Radelkis was used. The experimental data, expressed in values of the electric conductance of the external aqueous phase, it's transformed in percentages of salt released from the aqueous phase interns using the calibration curves.

## Results and Discussion

By optical microscopy it's established that the prepared dispersed systems are polydisperse double emulsions. By dilution Briggs [9] it's established that these double emulsions are oil-in-water emulsions.

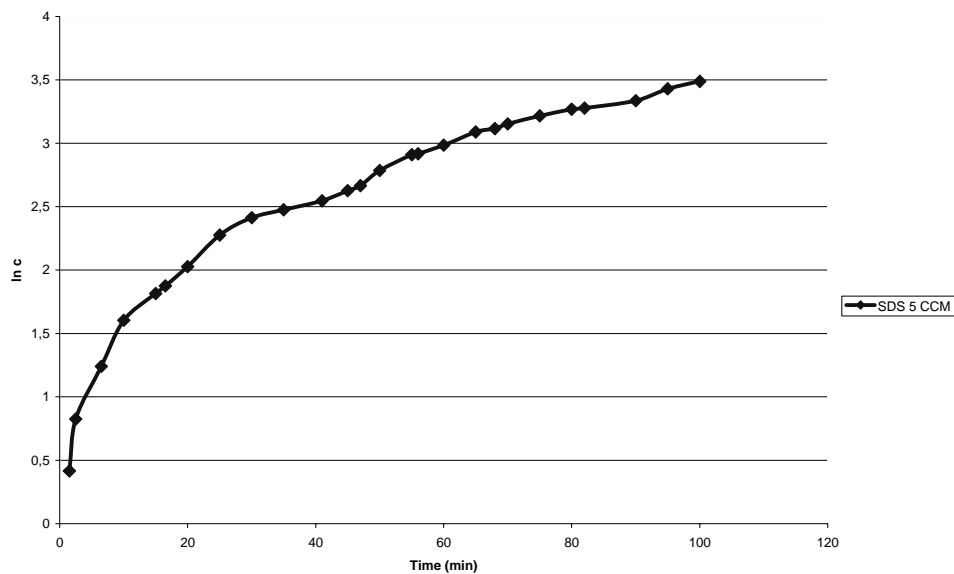
By microscopy it's ascertained that the globules of the emulsion become empty, therefore the direct double emulsion changes in a direct primary emulsion. Like continuation, the passage of salt in the external aqueous phase takes place by a mechanism of coalescence. This process is very complex [10], taking place via the internal coalescence of the droplets and the coalescence of the droplets with the walls of the globules the container.

By measuring the variation of the NaCl concentration in the external aqueous phase in time, the curves of the fig. 1. are obtained. The polydisperse double emulsions having contents of SDS equal to 0,5 CCM behave different from the polydisperse double emulsions having contents of SDS equal to 5 CCM.



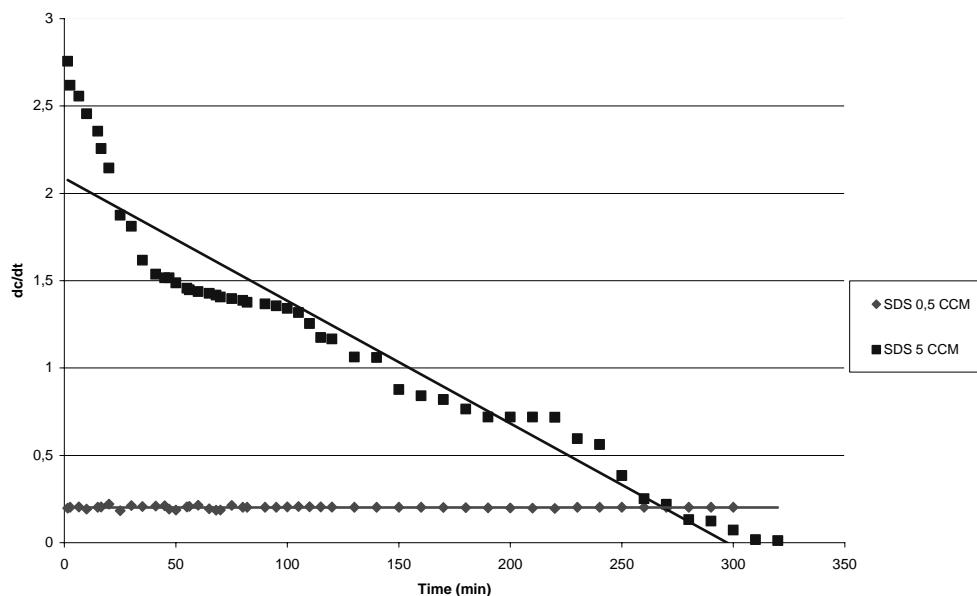
**Fig. 1.** Kinetics of destruction of the polydisperse diluted double emulsions containing the surfactants system Span 80/SDS and the phases NaCl solution/toluene/glucose solution

In the double emulsions with contents of SDS equal to 0,5 CCM are held a process of evolution which respects kinetics of order zero (fig. 2.), unlike the double emulsions containing the SDS in concentration of 5 CCM.



**Fig.2.** Escape velocity of salt in the polydisperse diluted double emulsions containing the surfactants system Span 80/SDS and the phases NaCl solution/toluene/glucose solution

The curve of the fig. 3. (where the dependence of the logarithm of the concentration of the released salt of time is traced) indicates that, in the systems in which the concentration of SDS is 5 CCM, the destruction of the double emulsions takes place after first order kinetics.



**Fig. 3.** Variation of the concentration logarithm of the released salt in the polydisperse diluted double emulsions containing the surfactants system Span 80/SDS and the phases: NaCl solution /toluene/glucose solution when the concentration in SDS is 5 CCM

By using these graphs, the constants speed and times characteristic were given (tab. 3.).

**Table 3.** Constants speed and half-time for the destruction of the emulsions doubles diluted polydisperse

| No. | Concentration of Span 80(%) | Concentration of SDS (CCM) | Reaction order | k                              |         | $\tau_{1/2}$ (min) |
|-----|-----------------------------|----------------------------|----------------|--------------------------------|---------|--------------------|
|     |                             |                            |                | UM                             | Value   |                    |
| 1   | 2                           | 0,5                        | 0              | $(10^3 \cdot \% / \text{min})$ | 21,5053 | 60,0002            |
| 2   | 2                           | 5                          | 1              | $(10^3 \text{ min}^{-1})$      | 20      | 34,6574            |

## Conclusions

The destruction of the polydisperse diluted direct double emulsions stabilized by the surfactant micromolecular ones takes place by a mechanism of coalescence. The time of destruction is much shorter than in the case of the monodisperse double emulsions [11]. That indicates that the destruction of the double emulsions also takes place by other mechanisms, like the ripening of Ostwald. This last process can proceed, as well, on the level of the droplets that on the level of the globules, because all are polydisperse. Because the systems are polydisperse, they can be destroyed by the growth of the interactions of déplétions. That determines the aggregation of the particles. From the macroscopic point of view, it's noted a process of creaming, which follows the aggregation of the particles and the coalescence of the globules.

The kinetics of destruction of the polydisperse diluted double emulsions varies according to the concentration of surfactant hydrophilic. To the concentrations smaller than 1 CCM, the destruction follows kinetics of a nature equal to zero, while with the concentrations larger than 1 the CCM evolution of the double emulsions takes place after kinetics of first order.

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## Studiul stabilității emulsiilor duble diluate polidisperse

### Rezumat

Scopul acestei lucrări este de a studia stabilitatea emulsiilor duble polidisperse. În experimentele efectuate globulele de emulsie inversă erau diluate în faza apoasă ( $\phi \leq 30\%$ ). Evoluția cinetică a emulsiilor duble de tipul Span 80 /SDS (surfactant lipofil / surfactant hidrofîl) a fost trasată folosind o soluție de NaCl ca fază apoasă internă și o soluție de glucoză, izotonică cu soluția salină, ca fază apoasă externă, în condițiile în care faza uleioasă o constituia toluenul. Evoluția cinetică a emulsiilor duble a fost trasată pe baza măsurării conductanței electrice a fazei apoase externe. Prin metoda conductometrică s-a stabilit că viteza de trecere a NaCl în exterior crește la mărirea concentrației de SDS. Valorile experimentale ale procesului de eliberare a sării urmează o cinetică de ordinul întâi atunci când concentrația SDS este mai mare decât 1 CCM și o cinetică de ordinul zero când concentrația SDS este mai mică decât 1 CCM.