Dielectric Spectroscopy Study on Vesicles of CTAB/SDBS System

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Abstract: Amphiphilic molecules can form into different structures, such as micelle, microemulsion, vesicle, liposome, liquid crystals, and so on by self-associating. The Dielectric Spectroscopy (DS) method has been applied to the systems of micelle and microemulsion successfully. For the first time the author put the method to the system of vesicle of CTAB/SDBS. The experiments show clear dielectric relaxation and the results were discussed primarily.

Keywords: Dielectric spectroscopy, vesicle, macroscopic relaxation time.

Introduction

When the cationic and anionic surfactants in which the total carbon number is equal to or greater than 20 are mixed, then the vesicles can form spontaneously due to the strong interactions or by sonication[1]. Vesicle is of bilayer structure containing a closed aqueous room, resembling the structure of a real cell. So it seems to be imperative to study the membrane mimicry system like vesicle in order to understand the structure and functions of real cells further. In addition, it can also be used as drug deliveries and microreactors, *etc*. Accordingly the study on vesicle has theoretical and practical values.

The DS method, which is based on the theory of interfacial polarization, is suitable for the vesicle system because of its heterogenecity[2]. It can give the important parameters about structure, dynamic properties and electronic properties of the investigated system. Through a certain mathematical model and theoretical analysis on the dielectric spectroscopy, then the information on the system can be gotten. The dielectric measurements only need a very little perturbation (5mv, a.c.), so it is non-destructive to the system. This is very advantageous to probing the interior structure of the system. By now the DS method has been accepted in the systems of micelle[3], microemulsion[4] and biological cell[5] and so on. Now the study on vesicle is still mainly in the stage of synthesis and applications. The present work investigates its physical chemical properties in view of dielectric firstly. This is significant to further detect the inner information on vesicles and to further expand the application range and values of the DS method.

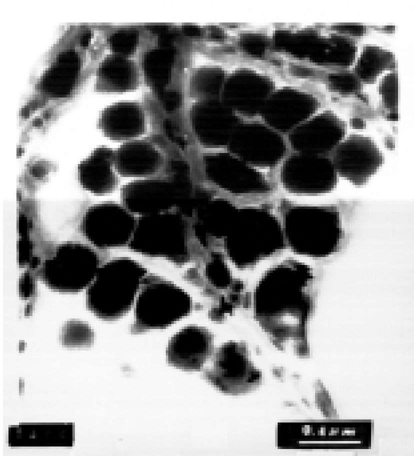
Experimental

Chemicals: cetyltrimethyl ammonium bromide **CTAB**, A.R.; sodium dodecyl benzene sulfonate **SDBS**, A. R.; NaOH, A. R.; double distilled water.

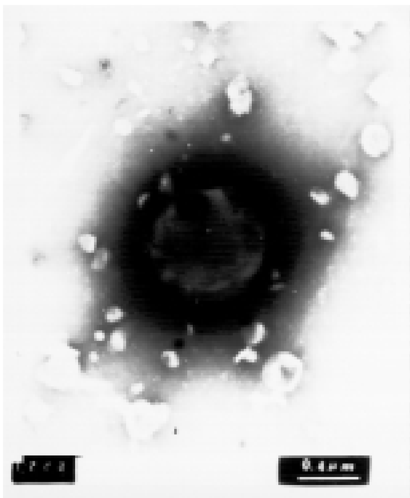
Instruments: HP4192A LF Impedance analyzer; HITACHI H-300 Electron Microscope.

Figure 1 The TEM pictures of negatively stained vesicles

(a) In 0.008mol/L solution



(b) In 0.002mol/L solution



Observations of TEM: In order to verify that the vesicles have formed, the TEM observations were done by negative stained method on HITACHI H-300 Electron Microscope.

Dielectric measurements: According to references[6,7], the vesicle solutions were prepared in different concentrations (The concentration is limited in one phase range.). The dielectric measurements were performed in frequency range 5~10^7Hz. The influence of concentration on the system was measured and the dependency on time and temperature were monitor.

Figure 2 Conductivity dependency on frequency

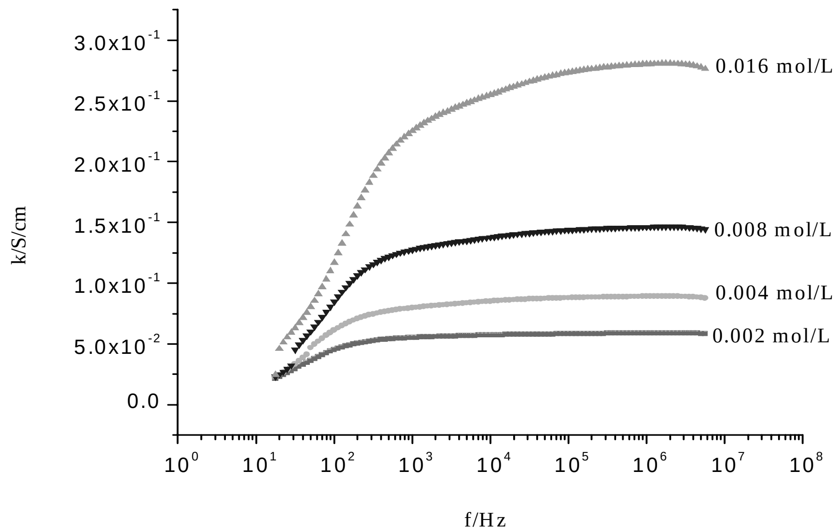
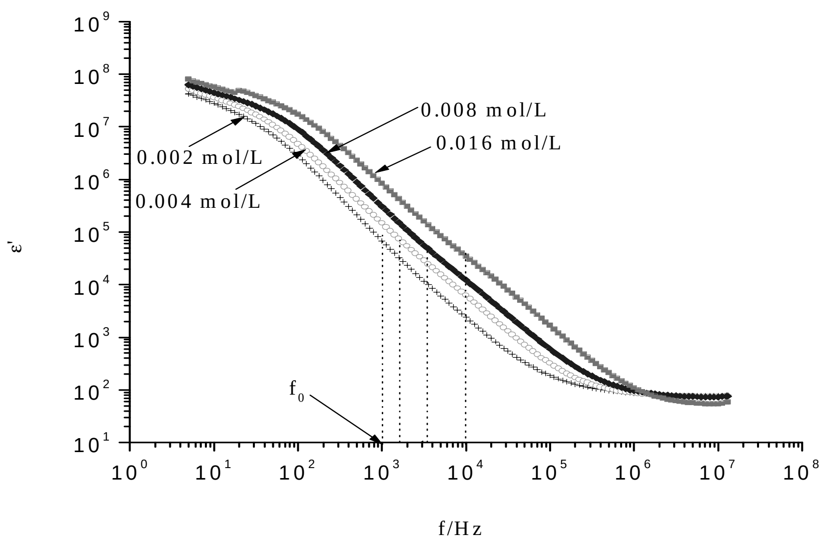


Figure 3 Permittivity dependency on frequency



Results and discussion

From **Figure 1**, it can be concluded that the vesicles have formed. In a solution with more surfactants (a), the number of vesicles is more than that of (b), but the size of vesicle is smaller than that of (b). This is due to the more amount of water in the interior of vesicle in the solution with less surfactants. In **Figure 1 b**, the irregular white dot may be caused by the heterogenecity of sample staining but not vesicles.

The dielectric relaxation is often accompanied with the decrease of relative dielectric constant ε and the increase of conductivity κ of the system. **Figure 2** and **Figure 3** indicate that the dielectric constant and conductivity both have clear dielectric dispersions. The relaxation strength increased with the increase of surfactant concentration. This was more manifest in the conductivity dependency on frequency which maybe caused by the movements of the counterions around the vesicles. It must be noted that so large ε, reaching 10^8, is very rare in the dielectric measurements. So the results of the system provide us an interesting subject. It can be estimated that more surfactants there were in the system, the greater the density of vesicles was and the smaller the vesicles were. **Figure 3** shows the characteristic relaxation frequency f_0 (the frequency when the relaxation strength arrives at half) enlarges with the increase of concentration and the macroscopic relaxation time τ ($\tau = 1/2\pi f_0$) diminishes. The macroscopic relaxation time is the indicator of the change of dipole environment and often used to depict the dynamic characteristics of the systems.

Meanwhile, the changes dependent on time and temperature were also pursued and the results indicate that the system can be stable in certain temperature and time ranges. If the system has changed, then the dielectric spectroscopy, which reflects the interior structure of the system, would have changed. However, no change has been observed in the experemental results. This is in agreement with reference[6,7] and illuminates the stability of the system.

Further dielectric analysis, such as the microstructure of vesicle, the amount of water in the interior of vesicle, the permeability of vesicle, the dynamic properties, *etc*. is still in process.

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