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SUMMARY OF Ph.D. DISSERTATION

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Title

Development of Soret Forced Rayleigh Scattering Method for Mass Diffusion Coefficient Measurement

Abstract

The performance of micro mechanical fluid system strongly depends on the control of diffusion process. Mass diffusion coefficients are needed for the analysis of mass transfer mechanism. However, conventional measurement methods of mass diffusion coefficient cannot be applied to measurement of new materials such as polymer electrolyte membrane and high concentrated polymer solutions. The problems of the conventional methods are convection caused by the formation of initial concentration distribution. For the formation technique of initial concentration distribution, mass transfer induced by the Soret effect is an attractive method to create the molecular migration in liquid. In addition, it can be applied to a molecular manipulation device for micro fluidic technology. Therefore, the purpose of this study is to develop measurement system of the mass diffusion coefficient using the Soret effect and to clarify the applicability to several applications.

Chapter 1 explains the importance of the mass diffusion phenomenon of new devices such as fuel cell and micro fluidic device. The purpose of this study is presented.

In the chapter 2, the Soret forced Rayleigh scattering method (S-FRSM) is proposed as a high speed measurement method of mass diffusion coefficient using the Soret effect. In the principle of this method, interference of two laser beams heats the sample, and the Soret effect induces concentration distribution. The concentration distribution decays exponentially, and the mass diffusion coefficient can be determined by analyzing the time constant of the attenuation process. In this chapter, the principle and development of the measurement apparatus are described.

Chapter 3 explains a theoretical analysis of the systematic effect (systematic error) and a reliable procedure to optimize the measuring conditions in S-FRSM. The uncertainty evaluations based on the GUM present the high reliability of this method. The relative expanded uncertainty of this method is 3~4% or less.

Chapter 4 demonstrates the applicability of the S-FRSM to several applications. Measurement of the polymer electrolyte membrane for fuel cell indicates the applicability of the S-FRSM to in situ diffusion measurement of the polymer membrane. In the experiment of the fullerene solution, the strong π-π interaction between fullerene and *o*-dichlorobenzene is revealed. The result demonstrates the potential of the S-FRSM to be applied for chemical assay. The concentration dependence of diffusion coefficient of CAB (Cellulose acetate butyrate) in MEK (Methyl ethyl ketone, 2-butanone) is successfully revealed. It indicates that the S-FRSM enables a monitoring the chemical engineering process.

Chapter 5 describes an application of the Soret effect to micro fluidic device. For a feasibility study, the experiment to generate the micro scale concentration distribution in 500μm micro channel is conducted. The developed system realizes the molecular movement in the micro channel. From this result, it is concluded that the molecular manipulation device using the Soret effect can be used for the formation technique of the concentration distribution in micro channel devices.

Chapter 6 summarizes the results of this research, and gives the conclusion of this dissertation.