HOKKAIDO UNIVERSITY

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学 位 論 文 審 査 の 要 旨
Doctoral Dissertation Evaluation Review

博士の専攻分野の名称　博士（生命科学）　　氏　名
Degree requested: Doctor of （Life Science）　　Name: Honglei Guo

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学 位 論 文 題 名
Title of Doctoral Dissertation

Establishment of Microelectrode Technique for
Detecting the Spatial Distribution of Electric Potential in Hydrogels
（ハイドロゲル内部における電位の空間分布を計測するための微小電極法の構築）

博士学位論文審査等の結果について（報告）
Results of Evaluation of the Doctoral Dissertation (Report)

Over the past few decades, polyelectrolyte hydrogels have drawn much attention due to their unique properties, for example, the high water holding ability, the ionic exchange ability, the ion-strength sensitivity, and the mechano-electrical effect. To predict those properties of polyelectrolyte gels, understanding of the electric potential of hydrogel is required. Although there are some theoretical studies on the potential of polyelectrolyte gels, due to lacking of the reliable experimental approaches on measuring the electrochemical properties of polyelectrolytes, this field had no prominent progress for the past few decades.

In this thesis, the author, for the first time, succeeded in quantitatively measure the spatial distribution of Donnan potential of polyelectrolyte hydrogels by adopting microelectrode technique. Compared to electrolyte solution, there are many difficulties to apply the microelectrode technique to hydrogels due to the solid-like properties in macro-scale and liquid-like properties in micro-scale of the hydrogels. Given the solid-like nature of the hydrogels, the difficulty of applying MET is how to make a good contact of the microelectrode to the hydrogel. This problem was considered in this thesis by reducing crack length and wall thickness of glass capillary. By using microelectrodes with a thin wall thickness and small diameter, the Donnan potential of brittle polyelectrolyte gel was found to be accurately measured. Meanwhile, for ductile DN gel, the electric potential was found to be independent of the diameter and wall thickness of microelectrodes. Based on this study, the potential of polyelectrolyte hydrogel can be accurately measured by using ductile hydrogel, and the crack advancing in brittle polyelectrolyte gel can be ignored if one can prepare hydrogel based on DN concept. Additionally, the author has succeeded in apply the MET to study various polyelectrolyte hydrogels and their internal structure. From the spatial distribution of potential, the micro-structure of hydrogels both in bulk and near the surface, the thickness of ultra-thin hydrogels, and the heterogeneous layered structure of composite gels, can be determined accurately.

The author is the first to provide the profound basic consideration of the applicability and the limitations of the MET method to hydrogels. The experimental results are strongly supported by the theoretical consideration. The MET established in this work provides a powerful tool to directly characterize the spatial distribution of electric potential of hydrogels. Such a work will considerably merit the further development of this field.

Therefore, the author is qualified to be granted the Doctorate of Life Science from Hokkaido University.