



# HOKKAIDO UNIVERSITY

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| Title               | Study on Swelling Effects on the Structure, Deformation, and Fatigue Behaviors of Anisotropic Bilayer Hydrogel [an abstract of dissertation and a summary of dissertation review] |
| Author(s)           | Begum, Most Laboni                                                                                                                                                                |
| Degree Grantor      | 北海道大学                                                                                                                                                                             |
| Degree Name         | 博士(ソフトマター科学)                                                                                                                                                                      |
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| Type                | doctoral thesis                                                                                                                                                                   |
| File Information    | Most_Laboni_Begum_review.pdf, 審査の要旨                                                                                                                                               |



## Doctoral Dissertation Evaluation Review

Degree requested Doctor of Soft Matter Science      Applicant's name Most Laboni Begum

Examiner :

|                    |                       |                   |
|--------------------|-----------------------|-------------------|
| Chief examiner     | (Professor)           | Jian Ping Gong    |
| Associate examiner | (Professor)           | Takayuki Kurokawa |
| Associate examiner | (Associate Professor) | Tasuku Nakajima   |
| Associate examiner | (Associate Professor) | Li Xiang          |

Title of Doctoral Dissertation

Study on Swelling Effects on the Structure, Deformation, and Fatigue Behaviors of Anisotropic Bilayer Hydrogel  
(異方性二分子膜ハイドロゲルの構造・変形・疲労挙動に及ぼす膨潤の効果)

### Results of Evaluation of the Doctoral Dissertation (Report)

The PDGI/PAAm anisotropic gel is a unique composite material composed of thousands of periodic lamellar bilayer stackings embedded within an elastic polyacrylamide (PAAm) hydrogel matrix. The bilayers, formed from polymerized non-ionic surfactant polydodecyl glyceryl itaconate (PDGI), act as reversible sacrificial bonds, providing the gel with exceptional toughness and self-resilience under monotonic loading through efficient energy dissipation. These distinctive structural and mechanical properties make the PDGI/PAAm gel a promising candidate for applications such as wearable devices and smart sensors. However, long-term usage necessitates a thorough understanding of its fatigue behavior and structural evolution under cyclic loading.

This study presents a comparative investigation of the fatigue behavior of PDGI/PAAm gels in two states: the as-prepared (AP) state and the swollen (WE) state. Both unnotched fatigue damage and notched fatigue fracture under cyclic loading were evaluated. The swelling mechanisms, structural properties, and deformation behavior under monotonic loading were analyzed in both the AP and WE states. Fatigue tests were conducted at varying maximum stretch ratios to assess the gel's long-term mechanical response, focusing on the role of lamellar bilayers. The fatigue and fracture parameters of PDGI/PAAm gels were compared to those of other tough gels from the literature. The findings reveal that embedding rigid PDGI bilayers within the soft PAAm matrix improves tensile strength, fracture energy, and significantly decelerates crack growth above the fatigue threshold. However, the enhancement of the fatigue threshold value is relatively modest. Additionally, the study identified that the unique one-dimensional swelling behavior of the gel weakens interactions within the PDGI bilayers, resulting in slight reductions in tensile strength, fracture energy, and fatigue resistance.

The candidate conducted the first systematic investigation into the fatigue behaviors of PDGI/PAAm gels.

This pioneering study revealed the effects of one-dimensional swelling and highlighted the role of lamellar bilayers in enhancing fatigue resistance. The findings contribute to the fundamental understanding of this material and offer practical knowledge for its design and modification to meet long-term functional application requirements. In recognition of this impactful work, we affirm that the candidate is fully qualified to be awarded the Doctorate of Soft Matter Science from Hokkaido University.