

Science and Technology Group Annual Report FY2020

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1 Introduction

I continued to engage in two independent research projects during FY2020, namely, engineering of catalytic RNAs (ribozymes) and investigations on natural fibers (e.g. Bashofu). Due to COVID-19 I had to change my plan to meet with artisans to discuss traditional production of Bashofu for the Kakenhi project. Instead, we focused on research about Bashofu for everyday use in FY 2020.

2 Activities and Findings

1) Engineering of Catalytic RNAs (as a member of the Nucleic Acid Chemistry and Engineering unit)

Template-directed RNA ligation catalyzed by an RNA enzyme (ribozyme) is a plausible and important reaction that could have been involved in transferring genetic information during prebiotic evolution. We had already selected and characterized an 18-nt catalytic core RNA that catalyzes template-directed regiospecific RNA ligation in 2019¹⁾. To discover RNAs with a smaller catalytic core, we designed RNA libraries composed of shorter RNA sequences and selected interesting sequences through our laboratory selection method coupled with deep sequencing analysis. Surprisingly, we found RNA sequences having as few as 7-nt RNA that catalyze ligation reaction. Furthermore, we analyzed reactions catalyzed by an 8-nt catalytic core at 4 °C which may be relevant to prebiotic environment. In 2021, we will continue experiments in preparation for submitting a manuscript.

¹⁾ Y. Nomura and Y. Yokobayashi, Systematic minimization of RNA ligase ribozyme through large-scale design-synthesis-sequence cycles, *Nucleic Acids Research*, 47, 8950-8960, 2019.

2) Natural fiber projects

A. Bashofu projects (Kakenhi projects)

Improvement of the productivity of high-quality Bashofu fibers

Quality of Bashofu fiber depends on fineness of the fiber which is dependent on the thickness of the secondary cell walls of sclerenchyma fibers cells and vascular bundles in the material plant *Itobasho*. We investigated the correlation using raw materials with Bashofu fibers through micro-structure imaging. We plan to submit the outcome from this research to a scientific journal in FY2021²⁾. Furthermore, we identified several bacterial strains that are expected to decrease cell wall thickness of low-quality fibers in 2020. Basic research such as these will help improve the Bashofu production process.

²⁾ K. Koizumi, T. Sasaki, R. Suwa, Y. Nomura. How do artisans create premium quality Bashofu yarns? -from a plant science perspective. *in preparation*.

Use of Bashofu in our daily lives

Although premium Bashofu for summer kimono is produced from high-quality materials by experienced artisans today, coarse Bashofu was used to make working clothes for the ordinary Okinawans until WWII. Inspired by this history, we extracted Bashofu fibers from low-quality materials through a simple method instead of the sophisticated method practiced by skilled artisans. The fibers were lower in quality compared to those used for the premium Bashofu due to its twisted and thick morphology (right photo). However, with further improvements, our fibers may lead to development of novel environmentally friendly materials for humid summer climate (see 4.

Publications, F. Kakihara et al., submitted)

Single fiber extracted from the facile method (twist and thick). Low-quality materials were used.



One artisan's yarn, made from 18 thin fibers extracted from the traditional method. Good-quality materials were used.



100 % *Citrus depressa* juice (pH 2.5) H₂O 0.75 % citric acid (pH 2.3)



Soaking test (1.5 h at room temperature). *Citrus depressa* sample (2) became lighter in color and softer.

To care for the textiles and the kimonos made of Bashofu, they are traditionally soaked in the acidic solution containing the fruit juice of *Citrus depressa*, a native Okinawan citrus. We experimentally confirmed that a brown piece of used Bashofu became lighter in color and softer after being soaked in the acidic solutions, especially *Citrus depressa* juice (left photo). These results revealed that the acidic solution functions as both finishing and washing agents for Bashofu. Furthermore, we concluded that this method allowed

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Bashofu to be used repeatedly as textile for clothing. The result was published in the annual bulletin of Japan Women's University (see 4. Publications, non peer-reviewed, F. Kakihara et al.). We will scientifically and more specifically analyze what substances in *Citrus depressa* juice contribute to this result.

We also continued the investigation of behavior of moisture transportation in Bashofu fibers to clarify the cooling mechanism of Bashofu (see 4. Presentations). Furthermore, we started a related project with a new collaborator Kato Tech Co. Ltd.. We preliminarily tested cool-touch feeling of Bashofu textiles in a standard condition (20 °C, 65 %RH) and we confirmed that some pieces of Bashofu textiles were considered as cool-touch feeling fabrics because the Q-max* values for those were over 0.1.

*Index of cool-touch feeling calculated by heat flow in a fabric sample. Q-max 0.1 (watts/m², from 30 to 20 °C) is a threshold of cool-touch feeling for fabrics in Japanese Industrial Standards.

B. Others

We continued working on a research project on natural fibers in collaboration with Teijin Frontier Co. Ltd. In this collaboration, we analyze and evaluate natural fibers other than Bashofu.

As an outreach activity we started *Kariyushi* wear project with an Okinawan apparel company Lequio Co. in FY2020. In this project, Bashofu fibers are extracted from *Itobasho* plant (raw) materials with a simple method based on our research. We are now investigating how to make yarns from our fibers to weave a new Bashofu textile.

3 Collaborations

OIST: NACE (Yokobayashi) unit, OIST Imaging Section.

Universities: University of the Ryukyus (Prof. Ryuichi Suwa), Japan Women's University (Department of Clothing).

Industries: Teijin Frontier Co. Ltd, Kato Tech Co. Ltd, Okinawan apparel company Lequio Co.

4 Publications and other output

Publications:

Peer-reviewed: F. Kakihara, K. Koizumi, T. Sasaki and Y. Nomura, Facile extraction of Bashofu fibers, under review to be published, *Journal of Home Economics of Japan*.

Non peer-reviewed: F. Kakihara, C. Mitani and Y. Nomura, Traditional usage of plants for clothing -The traditional washing method for Bashofu-, *Journal of The Graduate School (Human Life Science)*, Japan Women's University, vol 27, 2021, 247-256.

Invited author: Y. Nomura, How does scientific research contribute to the future of traditional Bashofu production? (科学の活用で築く芭蕉布の未来), Japan Greenery Research and Development Center, GREEN AGE. 2020 November, 23-27.

Presentations (2020 annual conferences):

C. Mitani, K. Koizumi, T. Sasaki F. Kakihara, and Y. Nomura, Characterization of Bashofu fibers as materials of summer textiles - behavior of moisture transportation in fibers - (夏季衣料材料としての芭蕉布繊維の特性-水分の保持・乾燥能-), The Japan Research Association for Textile End-Uses.

C. Mitani, F. Kakihara, and Y. Nomura, Characterization of Bashofu textile as summer clothing material, The Japan Society of Home Economics.

C. Mitani, K. Koizumi, T. Sasaki F. Kakihara, and Y. Nomura, Smart textile of the Ryukyu era (琉球時代のスマートテキスタイル), The Society of Fiber Science and Technology.

Grants:

FY 2019-2021: JSPS Kakenhi Kiban C (PI), 19K02308, 4,420,000 yen over 3 years, "Contribution of scientific analysis to Bashofu production".

FY 2020-2022: JSPS Kakenhi Kiban C (Co-PI), 20K02354, 2,860,000 yen over 3 years, "Imaging analysis of high quality Bashofu fibers to make Kimono textile", PI is Dr. K. Koizumi of IMG section.

FY 2020: Teijin Frontier Co. Ltd., 3,000,000 yen, "Collaboration research on natural fiber".