My dream is to understand the relationship between dimensionality and properties in molecular materials

Let me explain the origin of my dream.

Graphene, the first 2D material,

revolutionized physics and materials science.

Same composition and structure as graphite,

but instead of having infinite layers, graphene is just an atomic-thick material.

And that changes electronic properties completely.

Going from an infinite-layer material to an atomic-thin material

is called dimensionality reduction.

During my PhD,

I focused on designing 2D molecular materials.

Molecular materials are often composed of two or more molecules.

That allows us to modify components modularly

to understand the structure-property relationship.

Understanding the structure-property relationship

is key for the development of chemistry and materials science.

However, I encountered two significant challenges:

first, most 2D molecular materials are mechanically fragile, making it difficult to access molecular-thin materials;

second, the electronic properties of 2D molecular materials

did not show significant changes upon dimensional reduction.

So, after my PhD, I lost my interest in the topic of 2D materials.

Four years ago, I came to Japan to explore a new research topic

to recover my passion in science,

and joined a metal-organic framework research group,

the topic that has been awarded this year with the Nobel Prize.

During the last period of my research, I realized that metal-organic frameworks

possess properties that have not yet been explored in 2D materials,

particularly porosity and flexibility.

Actually, there are currently no suitable molecular materials

to investigate the effects of dimensionality reduction in porosity and flexibility.

I applied to the Hakubi project to develop the materials that will help me achieve my scientific dream.

In this project, I aim to design 2D porous molecular materials that retain flexibility while overcoming their intrinsic mechanical fragility.

To achieve this,

I draw inspiration from one of the most ubiquitous materials in daily life:

fabrics.

Fabrics are composed of interlaced yarns or threads.

This periodic interlaced architecture offers outstanding mechanical properties,

including robustness, flexibility, durability, and comfort.

They are also highly tunable

structurally, through different fabrication techniques

such as knitting or weaving,

and compositionally, through the use of different fibers.

Tuning the fabrication technique or the composition

allows adjustment of properties such as flexibility, breathability, hydrophobicity, and more.

My proposed strategy is to translate this logic

into molecular materials.

Although we cannot physically interlaced or weave molecules by hand,

we can encode “interlacing points” directly into the self-assembly process of molecules.

By designing two types of molecules as modules,

the interlacing motifs and the junctions,

we can tune both composition and strength along the material,

allowing us to rationalize and ultimately control the structure–mechanical property relationship.

I believe iCeMS is the ideal environment for this project.

It is one of the birthplaces of porous materials,

along with cutting-edge characterization techniques

indispensable to my research.

iCeMS is the suitable place to bring porous materials to the next step.

The end of the Hakubi project,

will lead to a new scientific discipline, “Dynamic 2D materials”,

and, in the future, the materials created during the Hakubi project

will allow us to systematically explore

dimensionality reduction in 2D porous molecular materials.