Development of Photo-Switching Ocean-Degradable Plastics with Edibility

1 −②: Development of photocatalysts with the ON type photo-switching system

7 −②: Creation ＆ strengthening an environment towards social implementation

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Implementing organizations :Japan Advanced Institute of Science and Technology, Kobe University,
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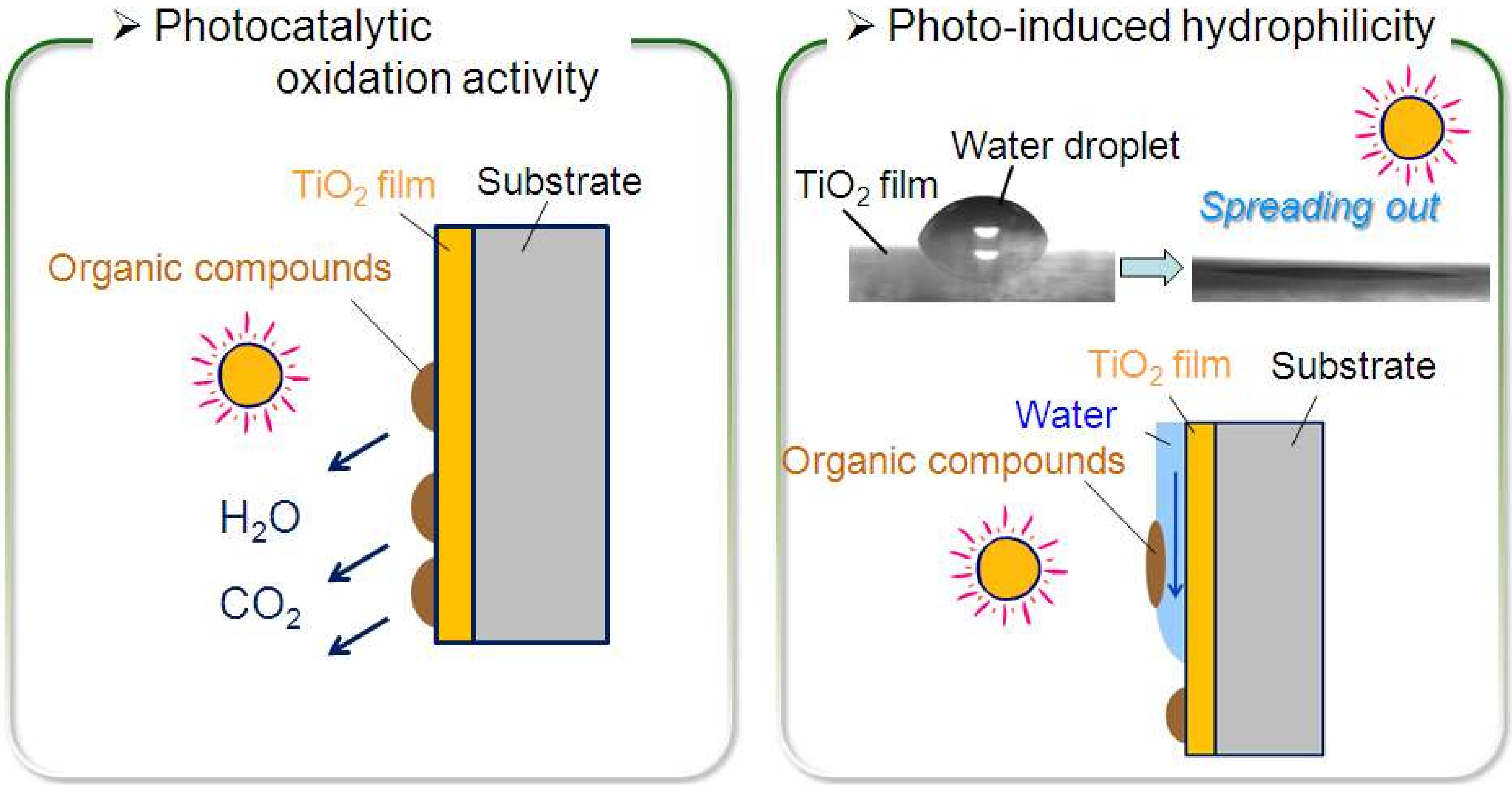
Tokyo University of Agriculture and Technology,
National Institute of Advanced Industrial Science and Technology(AIST),
Osaka Research Institute of Industrial Science and Technology(ORIST).

Function of TiO_2

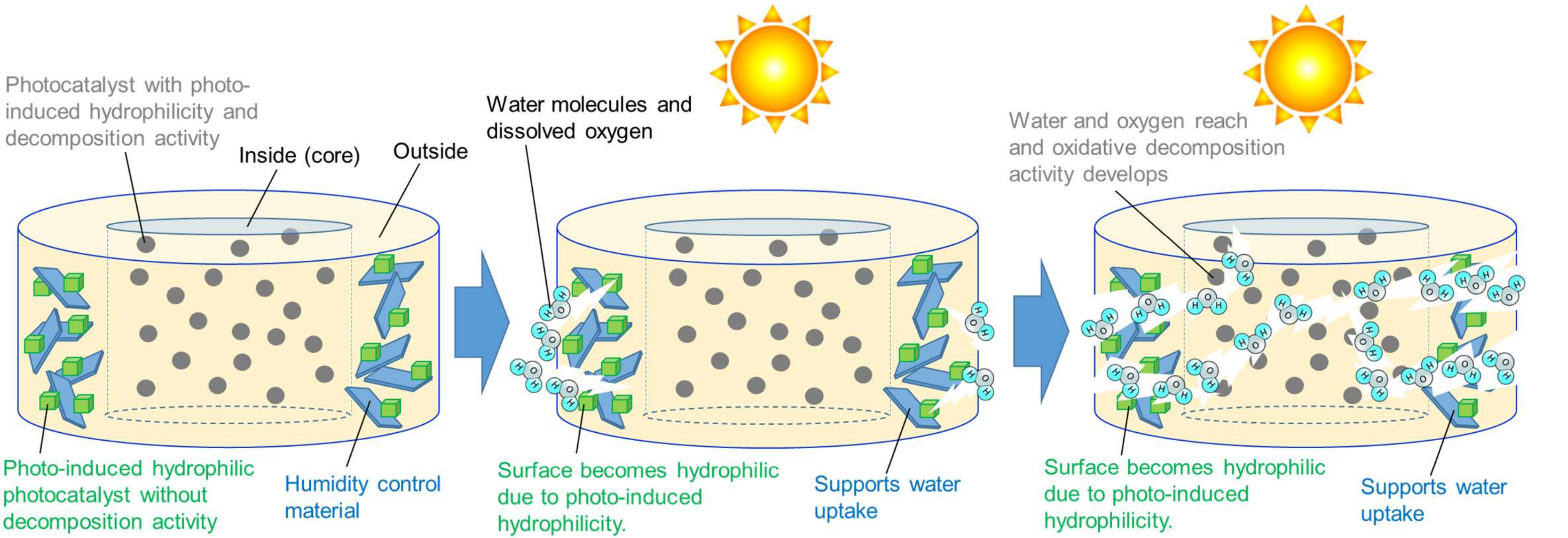


The aim of this project is not the decomposition of polymers by the oxidative decomposition activity of photocatalysts, but the decomposition by photo-switching systems with the photo-induced hydrophilicity.

Final goals（2029）

It does not adversely affect plastics and exhibits photocatalytic activity only when the surface is damaged by physical, chemical or biological stimuli until it goes out to the ocean, and water inside due to the photo-induced super-hydrophilic effect. By making it easier for bacteria to enter, we will clarify the development and mechanism of photocatalysts that cause biodegradation from the inside.

Role of photocatalyst



The effect of photocatalyst is suppressed.
→ Plastic is not decomposed.

When the surface is damaged and the photocatalyst and humidity control material are exposed on the surface, the effect of drawing in water is exhibited.
→ Takes in water and bacteria inside and gradually begins to decompose.

When it goes out to the ocean, the inner photocatalytic oxidative decomposition develops due to the strong sunlight and the water drawn in.
→ Decomposition progresses rapidly due to the synergistic effect of photocatalyst and bacteria

Development items: Materials

1. Photo-induced hydrophilic photocatalyst without decomposition activity

Sodium niobate（$NaNbO_3$）

K. Katsumata *et al.*, *J. Am. Chem. Soc.*, 131 (2009) 3856-3857; *Mater. Sci. Eng. B*, 173 (2010) 267-270; *ACS Appl. Mater. Interfaces*, 2 (2010) 1236-1241.

2. Humidity control material

Layered materials (clay minerals)

K. Katsumata *et al.*, *Appl. Catal. B: Environ.*, 138-139 (2013) 243-252.

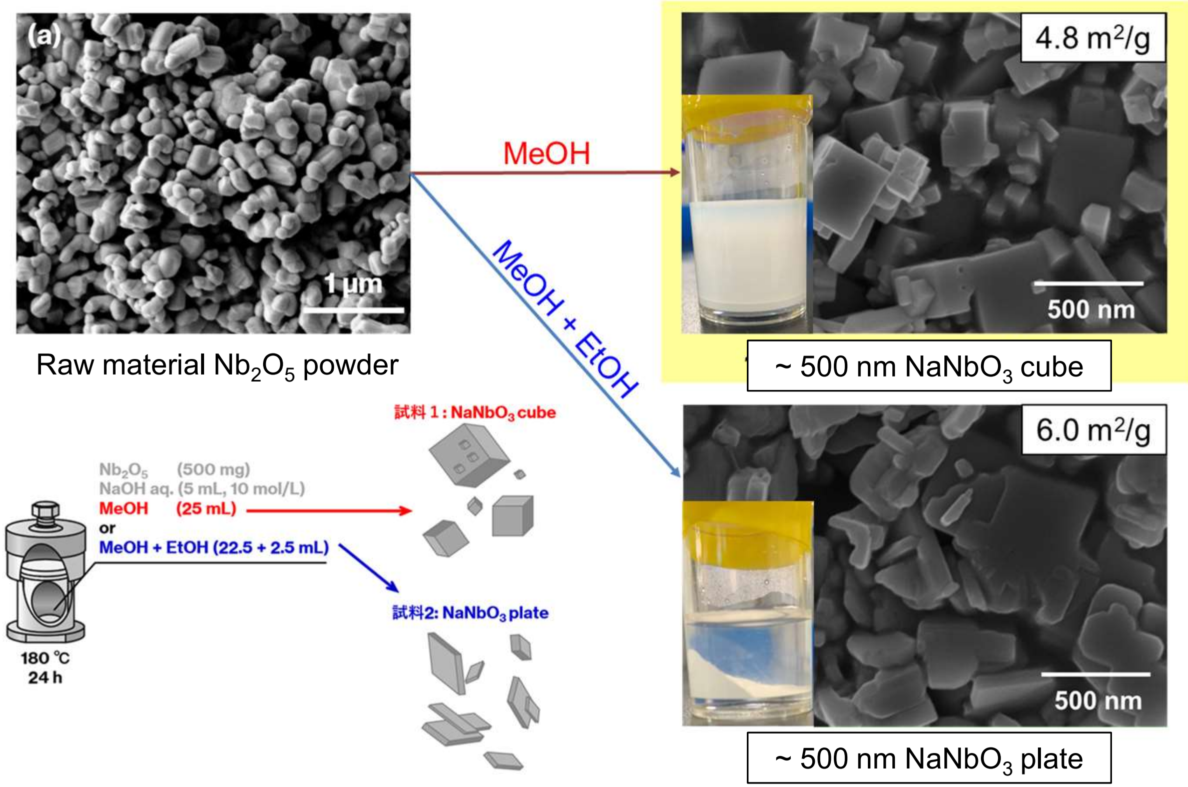
M. Ogawa *et al.*, *Chem. Mater.*, 15 (2003) 3134-3141; *Langmuir*, 25 (2009) 5276-5281; *Ind. Eng. Chem. Res.*, 51 (2012) 14414-14418.

3. Photocatalyst with photo-induced hydrophilicity and decomposition activity

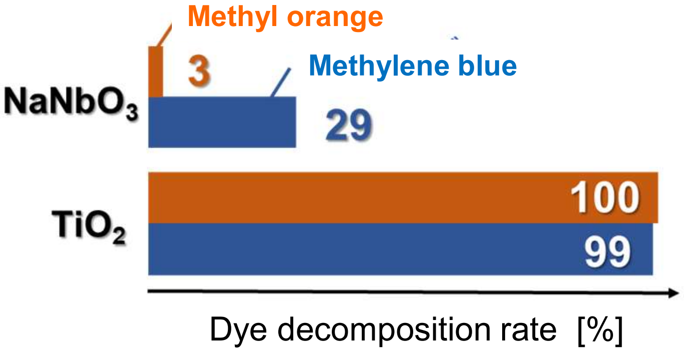
Ultraviolet light responsive type：
TiO_2、ZnO、SrTiO etc.

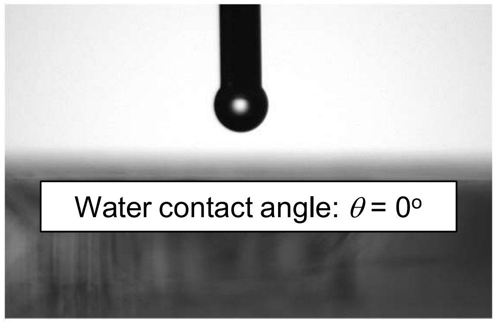
Visible light responsive type：
N_2-TiO_2、Fe-TiO_2、WO_3 etc.

1. Photo-induced hydrophilic photocatalyst without decomposition activity



Succeeded in synthesizing $NaNbO_3$ by directly controlling the particle size and crystal system from a commercially available Nb_2O_5 reagent



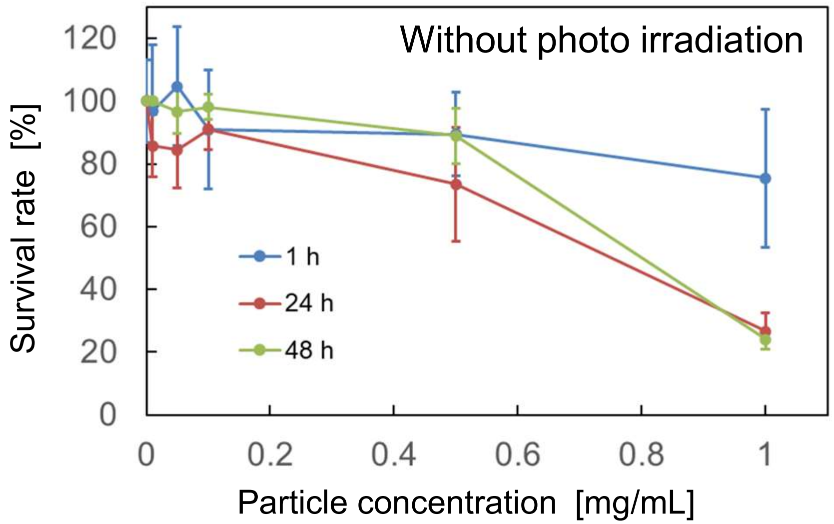


Compared with TiO_2, the synthesized $NaNbO_3$ has lower oxidative decomposition activity and exhibits highly hydrophilicity.

Cytotoxicity test

(Joint research with Prof. Ogino, Kobe University)

The survival rate was 100% when the particle concentration was 0 mg/mL.



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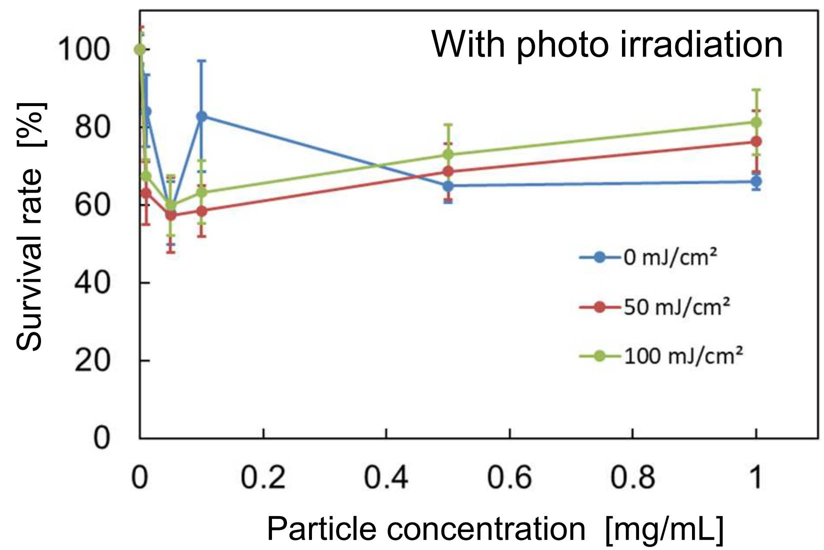
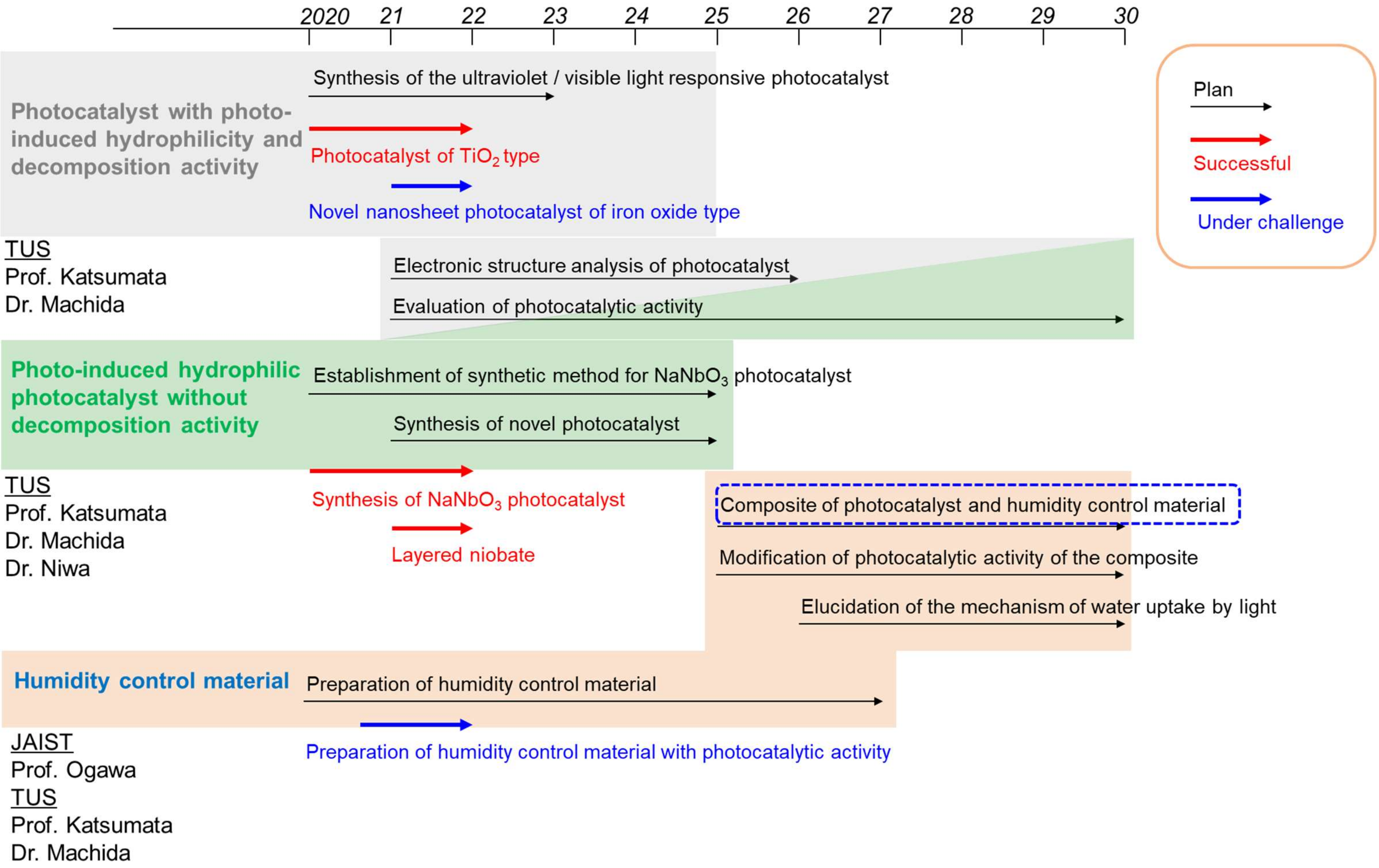


$NaNbO_3$ may have low cytotoxicity with or without light irradiation

R & D plan



2020
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Plan
Successful
Under challenge
Photocatalyst with photo-induced hydrophilicity and decomposition activity
Synthesis of the ultraviolet / visible light responsive photocatalyst
Photocatalyst of TiO_2 type
Novel nanosheet photocatalyst of iron oxide type
TUS
Prof. Katsumata
Dr. Machida
Electronic structure analysis of photocatalyst
Evaluation of photocatalytic activity
Photo-induced hydrophilic photocatalyst without decomposition activity
Establishment of synthetic method for $NaNbO_3$ photocatalyst
Synthesis of novel photocatalyst
Synthesis of $NaNbO_3$ photocatalyst
Layered niobate
TUS
Prof. Katsumata
Dr. Machida
Dr. Niwa
Composite of photocatalyst and humidity control material
Modification of photocatalytic activity of the composite
Elucidation of the mechanism of water uptake by light
Humidity control material
Preparation of humidity control material
Preparation of humidity control material with photocatalytic activity
JAIST
Prof. Ogawa
TUS
Prof. Katsumata
Dr. Machida

Research for commercialization

7-② : Creation ＆ strengthening an environment towards social implementation

✓ Final goals（2029）

・Clarification of applications & development target values

・Building a foundation for the formation of a consortium

✓ Development items & contents

① Recognizing needs and issues for resolving marine plastic and microplastic issues

② Setting the target values for applications and their development

③ Building a foundation for the formation of a consortium

✓ Major achievements at the present time

１． Countermeasure status against marine plastics

・Outflow of plastics to the ocean （2018）: 3.1-12.43 Mt/y

・3 major causes: unmanaged plastic, tire wear, littering

・Regulations and countermeasures against main cause：untouched

２． Application exploration

・Social implementation target in a short period：Coated Fertilizer

・Under joint research between JAIST and a fertilizer manufacturer

３． Building a foundation for the formation of a consortium

・The formation of “The Study Group for Examining the Future of Plastics”

・Design & manage the study group under the concept of “Collective Impact”

・2021: Planning & preparation, 2022: Start with about 10 organizations

MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM