Development of a novel water-splitting photocatalyst operable across the visible light spectrum

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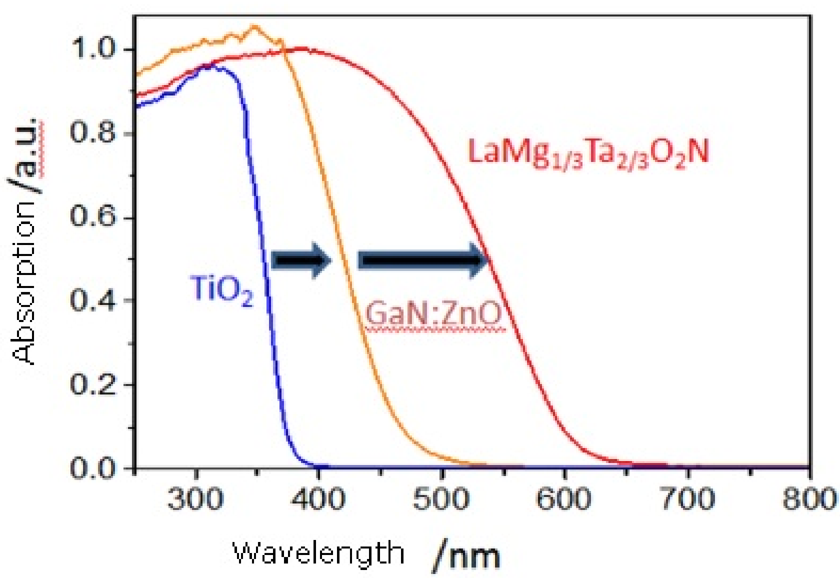

A research group led by Chengsi Pan, Postdoctoral Researcher, and Tsuyoshi Takata, NIMS Special Researcher, at the Global Research Center for Environment and Energy Based on Nanomaterials Science (GREEN; Director-General: Kohei Uosaki) of the National Institute for Materials Science (NIMS; President: Sukekatsu Ushioda), and Kazunari Domen, a professor of the Department of Chemical System Engineering, School of Engineering, The University of Tokyo (President: Junichi Hamada) newly developed a water-splitting photocatalyst that is operable over a wider range of the visible light spectrum than before.

Clean renewable energy can be produced by photocatalytically splitting water into hydrogen and oxygen with solar energy. Most of the conventionally developed water-splitting photocatalysts, however, were only active under UV irradiation, and only a few have been demonstrated to operate under visible light, at up to 500 nm. For making high-efficiency use of solar energy, it was necessary to develop a photocatalyst that can utilize longer wavelength light. To accomplish this, a photocatalyst that is operable under lower-energy light needed to be developed, but since the energy that can be used for the water-splitting reaction would also be smaller, more advanced material design was required, which posed a very difficult challenge.

In this research, a water-splitting photocatalyst that is operable at up to 600nm was developed for the first time, using a transition-metal oxynitride whose electronic structure is suitable for long wavelength absorption. As a development approach, solid solutions were formed between two existing perovskite-type compounds, LaTaON2 and LaMg2/3Ta1/3O3 (La: lanthanum, Ta: tantalum, O: oxygen, N: nitrogen, Mg: magnesium), and electronic structure was adjusted. This made LaMg1/3Ta2/3O2N solid solutions usable for water-splitting reactions by visible light irradiation, but since the degradation of the photocatalyst and the reverse reaction simultaneously occurred, a steady water-splitting reaction could not be achieved. To overcome this problem, the photocatalyst particle surface was covered with a layer of amorphous oxyhydroxide in order to inhibit the degradation of the photocatalyst and reverse reaction, and made the steady water-splitting reaction possible. This oxyhydroxide coating plays a role to control chemical reactions on the photocatalyst surface.

This research result established a new effective method in water-splitting photocatalyst development. Also, by applying this method to other photocatalyst materials, the development of photocatalysts with higher activity can be expected. At present, the quantum yield is still low, and the improvement of the yield is the challenge for the future.

This research was performed jointly with a group led by Yuichi Ikuhara, Professor of the Institute of Engineering Innovation, School of Engineering, The University of Tokyo. Also, this research was supported in part by the Japan Society for the Promotion of Science (JSPS) Grant-in-Aid for Specially Promoted Research, "Development of innovative water splitting photocatalysts based on photocarrier dynamics at solid/liquid interfaces," and projects commissioned by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), "Program for Development of Environmental Technology using Nanotechnology," "Nanotechnology Platform Japan," and "Area of Advanced Environmental Materials, Green Network of Excellence (GRENE): Creation of the Network of Excellence for the Human Resource Development, and Advanced Environmental Materials and Devices toward Environment and Energy Technology."

This research result was published in a science journal of the German Chemical Society,*Angewandte Chemie International Edition*. Also, this research result was appreciated for its importance, and was adopted as the inside cover design of the journal.

More information: "A Complex Perovskite-Type Oxynitride: The First Photocatalyst for Water Splitting Operable at up to 600 nm," *Angewandte Chemie International Edition*, DOI: 10.1002/anie.201410961

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