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From Nitrogen Fixation to Water Splitting

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In the nineteenth century, Chile, Bolivian and Peruvian got involved in a war (the Saltpeter War) which led to tens of thousands of casualties for something hard to believe nowadays, the Guano. This mineral is mostly composed of animal excrement and was the major source of nitrogen compounds at that time. Such a war is ridiculous for us nowadays since we can use the Haber-Bosch process to harvest nitrogen compounds by fixing nitrogen gas in the air. This case shows us how chemists make our world peaceful.

From the twentieth century, petroleum has been the major energy source for human society. Since then, the related conflicts never cease. Learning from the lesson of nitrogen fixation, chemists are endeavoring to get hydrogen gas from water driven by renewable solar energy. Among various approaches for solar-driven hydrogen generation, photocatalytic water splitting by particulate photocatalysts is the most promising for large-scale applications. After decades of efforts, two model devices, photocatalyst panels using one kind of photocatalyst[1] and photocatalyst sheets[2] involving two kinds of photocatalysts, were developed for water splitting (see also Fig. 1). However, a technology readiness level investigation from the Royal Society shows that photocatalytic water splitting is still in a basic level and needs knowledge development in academia.[3] For this purpose, we should extend the semiconductor physics to photocatalysts which are usually studied in the viewpoint of catalysts. Recent development on spectroscopy and microscopy has provided a chance for this direction since these tools are powerful for investigating local reaction processes.[4, 5] At the same time, we may apply machine learning to this field.[6] In this way, the study will be less dependent on the expertise of the researchers and we can search the underlying factors that determine the reaction in at low cost.

In the future, our descendant may laugh at the “Fossil Fuel Wars” in this century, just as we did for the “Saltpeter War”. How near this future will be is probably dependent on how well we chemists work on photocatalytic water splitting.

Fig. 1. Photocatalyst panels for large-scale water splitting. 出典: “太陽と CO_2 で化学品をつくる「人工光合成」、今どこまで進んでる」、資源エネルギー庁ウェブサイト (https://www.enecho.meti.go.jp/about/special/johoteikyo/jinkoukougousei2021.html)

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