of the immune protein interferon regulatory factor 3 to the nucleus[13], promotes stress responses in an organelle called the endoplasmic reticulum[13] and mediates degradation of immune proteins called MHC proteins[11].

Kee and colleagues' work adds another layer to our understanding of how SARS-CoV-2 interacts with host cells. It will be important to investigate further how Orf8 activity can alter virus infection and spread, and the development of disease in humans. A naturally occurring deletion in the SARS CoV-2 gene encoding Orf8 that was found in 2020 in Singapore was associated with less severe disease[14] and might provide the first hints. It remains unclear whether the decreased severity of this variant was directly linked to changes in histone mimicry, but the association shows that coronavirus accessory proteins can have roles in disease severity.

The study raises questions about virus evolution and adaptation to humans. Most of the proteins in SARS-CoV-2 and the related virus SARS-CoV, which was responsible for a smaller coronavirus pandemic in 2003, are highly evolutionarily conserved, except for Orf3b and Orf8, with the Orf8 protein of SARS-CoV lacking an ARKS motif. By contrast, some SARS-related coronaviruses in bats exhibit the motif. This might indicate that SARS-related coronaviruses are evolving to use an accessory protein and histone mimicry as part of their interference strategies.

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The authors declare no competing interests.
This article was published online on 5 October 2022.

Physical chemistry

Secrets of light-activated catalyst particles revealed

Ulrich Aschauer

The movement of electric charges in light-activated catalyst particles is key to the water-splitting reaction, which could be used to generate hydrogen as a renewable fuel. Such movement has now been observed in exquisite detail. **See p.296**

Renewable energy sources are of great interest for reducing our dependence on fossil fuels. Light-activated catalysts — known as photocatalysts — are promising in this regard, because they convert solar energy to chemical energy that is stored in the bonds of fuel molecules. Progress in this field will require the development of new photocatalytic materials. But future advances will also hinge on an improved understanding of how electric charges are generated and transferred within photocatalyst particles, so that the particles can be rationally tuned for solar-to-fuel conversion. Such insight is challenging to obtain, given the extremely wide range of timescales and length scales involved. On page 296, Chen *et al.*[1] report an impressive advance in the spatio-temporal monitoring of excited charge carriers on single photocatalyst particles; the findings could provide much-needed detail on photocatalytic processes.

The Sun has great potential as a renewable energy source — the solar radiation that strikes Earth in just one hour is equivalent to the amount of energy currently used annually by humans[2]. The only requirement is that the radiation's energy must be converted to a usable form, such as electrical, chemical or thermal energy. Solar cells are commercially available to convert sunlight to electricity, but for some

From the archive

Detecting counterfeit whisky using nuclear technology, and the legendary origins of Scottish boulders.

50 years ago

Some of the most useful ... benefits of nuclear technology have come from the application of activation analysis to forensic problems ... The forensic uses of activation analysis depend mainly on the detection and estimation of trace elements in material gathered from the scene of a crime or from a suspect ... F. W. Lima ... told of studies on counterfeit whisky. The bottles, labels, corks — and even the contents — were not distinguishable chemically from the genuine articles, but the lead foil caps were found, by anomalies in tin and antimony content, to be of local manufacture. The object of the well-planned counterfeiting was to sell Brazilian whisky (of its kind, quite good) as a genuine Scottish product at an inflated price.

From *Nature* 13 October 1972

150 years ago

The first Report of the Committee appointed to collect statistics as to boulders ... contains much that is interesting both to the geologist and archaeologist ... Great numbers of boulders have legends attached to them, one of the commonest being that the boulder was thrown to the spot where it lies by some giant, demon, or even by "Auld Nickie Ben" himself ... [A]lmost invariably, the place from which the legend says the huge stone was thrown, is the nearest spot containing the formation to which the boulder belongs ... [B]oulders differ from the formation on or in which they are found, and in reference to what we have just mentioned, the place from which the giant or devil took his throw is often at a very considerable distance ... For example there is a large conglomerate boulder near the top of a hill, in the island of Edag, one of the Orkneys, which goes under the name of the "Giant's Stone." The legend says it was flung by a giant from the island of Stronsay; now there is no conglomerate rock which could have supplied the boulder in Edag, though there is in Stronsay.

From *Nature* 10 October 1872

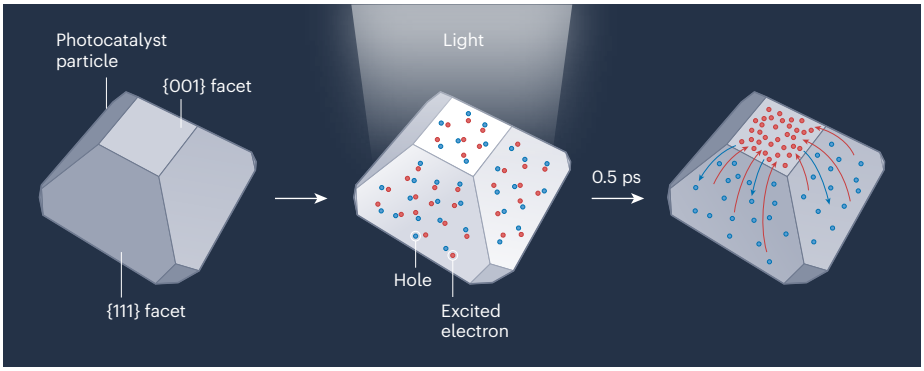

Figure 1 | Rapid charge separation observed in photocatalysts. Light-activated catalysts, known as photocatalysts, can be used to promote a variety of chemical reactions. This requires the separation of electric charges and their transfer to the surfaces of photocatalyst particles. Chen *et al.*[1] report using a combination of techniques to observe charge transfer on single particles of a photocatalyst (cuprous oxide; Cu_2O), across a wide range of timescales and length scales. The particles have two types of facet, known as {001} and {111} facets. Irradiation with light initially produces negatively charged, excited electrons paired with positively charged electron vacancies (known as holes) on all facets. The excited electrons then migrate to the {001} facets, whereas holes accumulate on the {111} facets. The authors observed that this process occurs surprisingly quickly, in less than 1 picosecond (1 ps is 10^{-12} seconds).

applications it is preferable for energy to be stored in the bonds of fuel molecules. This is especially the case for long-distance vehicles, for which refuelling is likely to be much quicker than recharging a battery.

The most desirable strategy for converting sunlight into chemical energy is direct solar-to-fuel photocatalysis. In this process, a semiconductor photocatalyst absorbs sunlight, which excites some of the material's electrons from a low-energy band (the valence band) to a high-energy band (the conduction band). The resulting high-energy electrons can then be transferred from the semiconductor to a molecule adsorbed on the photocatalyst's surface. At the same time, electron vacancies in the valence band, known as holes, can attract electrons from the molecule. This addition and subtraction of electrons allows the photocatalyst to promote complex redox reactions of molecules adsorbed at its surface.

One particularly appealing such reaction is water splitting, which converts water into oxygen and hydrogen. The combustion of hydrogen produces only water as a by-product, thus enabling its use as a fuel in an entirely environmentally neutral conversion cycle. Chen *et al.* investigated particles of cuprous oxide (Cu_2O), which promote water splitting when used in conjunction with a suitable co-catalyst[3].

Crystals of cuprous oxide are bounded by two types of facet, known as {001} and {111} facets, which correspond to distinct planes in the material's crystal lattice (Fig. 1). The authors engineered their particles by altering the ratio of the surface areas of the two facet types, and by controlling the types of lattice defect that form on the different facets. In this way, they produced particles that preferentially accumulate negatively charged electrons on the {001} facets and positively charged holes on the {111} facets when irradiated by light, as revealed by a technique called surface photovoltage microscopy[4] (SPVM). More importantly, these particles contain intrinsic electric fields across the interfaces between the two facet types; such fields are key to the process that separates electrons and holes in photocatalysts after excitation by light[5,6].

The main advance in Chen and colleagues' study is their use of time-resolved measurements to track changes in the electron population on individual facets with high temporal resolution, using a technique known as time-resolved photoemission electron microscopy[7]. The authors observed surprisingly rapid electron transfer from the {111} to the {001} facets after light irradiation: it occurred in less than 1 picosecond (1 ps is 10^{-12} seconds), a time frame that was previously inaccessible to single-particle measurements. This observation suggests that electron transport is only weakly affected by imperfections in the photocatalyst material, and that the electrons encounter very low resistance to their movement. By contrast, using a technique called transient surface photovoltage spectroscopy[8], the authors observed that charge-carrier trapping at surface defects occurs on the microsecond scale. Finally, Chen *et al.* showed that the rate at which hydrogen is generated by the cuprous oxide photocatalysts in the presence of a gold co-catalyst can be directly related to the dynamics of electron and hole transfer in the photocatalysts.

"The combustion of hydrogen produces only water as a by-product, thus enabling its use in an environmentally neutral conversion cycle."

The ability to track electron populations with high resolution in both space and time on a single particle establishes an experimental approach that will extend our understanding of the fundamental microscopic mechanisms underlying photocatalytic function. In particular, being able to resolve electron and hole accumulation with subpicosecond resolution yields unprecedented insight into charge-transfer processes that occur immediately after particles have been excited by light. Previously, measurements could be taken only at microsecond timescales, or after the charge carriers had reached equilibrium (that is, once charge transfer had finished)[9].

Chen and colleagues' approach holds great promise for diagnosing bottlenecks in photocatalytic processes and for determining the success of particle-engineering strategies — such as defect engineering, coating particles with layers of other materials and the addition of co-catalysts — in maximizing the efficiency of hydrogen generation from water splitting. A current limitation of this approach is that it relies on a combination of highly advanced, specialist techniques. But if these methods can be developed into routine and widely available tools, the resulting data will be substantially more valuable for fundamental science than are oxygen or hydrogen production rates, which are currently often reported.

The authors' approach should be readily applicable to photocatalysts other than cuprous oxide, and will therefore allow comparisons of the inner workings of a variety of materials, deepening our understanding of the mechanisms that underlie good photocatalytic performance. Such detailed knowledge of microscopic processes will be indispensable for rational design of the high-performance catalysts needed to make direct solar-to-fuel conversion an economically viable technology.

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The author declares no competing interests.