research highlights

BIOFUELS

Ejecting nitrogen

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NANCY NEHRING / E+ / GETTY

Producing biofuels from macroalgae is attractive, compared with land-based feedstocks, due to the relative ease of harvest and the decreased possibility for resource conflict with edible crops. However, macroalgae typically contain high concentrations of nitrogen, which must be substantially reduced to produce useable biofuel. To address this issue, Brian Haynes, Moti Herskowitz, Thomas Maschmeyer, Rocky de Nys and colleagues in Australia and Israel demonstrate how the nitrogen content can be minimized at multiple stages of an integrated process to yield a high-quality product for use in transportation fuels.

The researchers grew filamentous green algae under nitrogen starvation conditions to minimize the initial nitrogen content of the biomass. Then, using a hydrothermal liquefaction process, coupled with *in situ* fractionation and the appropriate solvent mix, they were able to produce a biocrude from the biomass with very low nitrogen and sulphur levels. The biocrude was combined with liquid hydrocarbons catalytically synthesized from a mixture of CO_2 and H_2, which could also be produced from biomass. Subjecting the blend to hydrotreatment using a nickel phosphide catalyst removed oxygen and further reduced the nitrogen content. This stage was critical to the success of the final step of the process, hydrocracking and isomerization, which uses catalysts intolerant to high nitrogen concentrations. The final product contained 277 ppm nitrogen and 0.12% oxygen, making it a suitable renewable fuel blend-stock. *JG*

BATTERIES

Oxide analogues

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The performance of batteries depends critically on the properties of the electrodes, therefore enormous efforts have been made to develop improved electrode materials. Many transition metal oxides and lithiated compounds have recently emerged as potential negative electrode materials, although few can meet the criteria of cost, safety, environmental benignity and electrochemical performance simultaneously for practical applications. Richard Dronskowski, Lorenzo Stievano and colleagues in France, Germany, Belgium and the USA have now reported transition metal carbodiimides, $M_x(NCN)_y$ (where M is Fe, Mn, Zn and Cr), as a family of negative electrode materials for lithium and sodium-ion rechargeable batteries with good capacity and cyclability.

The researchers showed that the $M_x(NCN)_y$ compounds behave very similarly to their oxide counterparts: the first discharge occurs at a low voltage plateau with a large irreversible capacity, but importantly, the subsequent charge–discharge processes are reversible. The reversible processes take place through a conversion mechanism in which the transition metal bonds to the NCN groups are replaced by bonds from the Li or Na to the NCN groups, analogous to the mechanism for transition metal oxides. However, owing to the robustness of their structures during charge and discharge, the $M_x(NCN)_y$ compounds exhibit better capacity retention during cycling than that of their oxide counterparts: for example, FeNCN only loses 20% of its capacity after 50 cycles whereas 60% is lost after 25 cycles in the case of FeO. In addition, the carbodiimides also have higher capacities than graphite, a widely used commercial negative electrode material. *CZ*

GAS AND ELECTRICITY INVESTMENTS

A costly uncoupling

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The need for additional flexible electricity generation due to increasing utilization of intermittent renewables, and possible gas disputes between Russia and Ukraine are examples of changes in the electricity market that feed back into the gas market and vice versa. However, the link and the degree of substitutability between natural gas and electricity systems are largely uncharted. Jan Abrell, from ETH Zurich and Hannes Weigt, from the University of Basel close this gap by developing a coupled dynamic model that illustrates how investment decisions in gas and electricity markets show strong interdependence.

The model was applied to a stylized simulation of the European energy markets that included carbon prices and increases in renewable electricity generation. By altering electricity network investment costs, the optimal expansion of power plants and gas pipelines varies considerably. With cheap electricity network costs, cross-border electricity interconnection in Europe increases significantly together with an increase in large gas-plant investment in Poland, encouraged by low gas-transport costs. In the high transmission costs scenario, more gas-fired plants and pipelines are built between Italy and Slovenia, and in other demand hubs, leading to a reduction in the expansion of electricity networks. It emerges that gas and electricity face mutual interdependence, suggesting that efficient investment evaluations should consider the two markets with a holistic approach. *AR*

SILICON SOLAR CELLS

Making contact

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Screen printing of a silver paste followed by rapid heating is an established technique to form metal contacts on the surface of crystalline silicon solar cells. However, the lack of a detailed understanding of the mechanism of contact formation hinders both the optimization of the contact resistance and the development of pastes that are cheaper and non-toxic (these pastes usually contain a lead oxide glass frit). Now, Michael Toney, Maikel van Hest and colleagues at NREL, SLAC National Acceleration Laboratory and Stanford University clarify the contact formation process by performing *in situ* X-ray diffraction during the rapid thermal annealing of screen-printed silver contacts, revealing details of the reaction sequence resulting in the etching of the SiN_x antireflection coating by the paste and the deposition of silver on the underlying silicon surface.

Multiple reactions occurring at different temperature thresholds are involved in the contact formation. Between 500 and 650 °C the etching of SiN_x is caused by lead oxide in the frit and silver subsequently alloys with lead. Above 650 °C silver ions diffuse through the molten frit to reach the silicon surface, where they deposit as metallic particles to form the electrical contact. Silver nanocrystals precipitate in the glass upon cooling, ensuring ohmic conduction between the solidified silver contact and the silver deposited at the silicon. These results are a first step towards the development of pastes that contain cheap, non-toxic elements. *ED*

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