ELCAT
*NEST ADVENTURE*

*Could the greenhouse gas, carbon dioxide, be used as a raw material in the production of fuels and other useful hydrocarbons?*

# Electrocatalysing a sword into a ploughshare

**In the presence of an electrocatalyst, carbon dioxide can be reduced to useful hydrocarbons. The reaction can take place at room temperature and atmospheric pressure but it is not productive and exploitation is further hampered by rapid deactivation of the catalyst. A consortium of research organisations will explore this reaction and hopes, thereby, to lay the foundations for the advancement of knowledge in the neglected but promising field of electrocatalysed gas-phase reactions.**

The ELCAT project was born of an observation made by the coordinating partner of an electrocatalytic reaction carried out at room temperature and atmospheric pressure. With carbon dioxide confined inside carbon micropores, and electrons and protons allowed to flow to an active catalyst – noble-metal nanoclusters – gaseous carbon dioxide was reduced to a series of hydrocarbons and alcohols. The reaction products were remarkably similar, in fact, to those of the Fischer-Tropsch (FT) process in which synthetic gas is converted to a series of hydrocarbons (alkanes, alkenes and so on) and water.

The FT process requires high temperatures and pressures and gets its carbon from the carbon monoxide, not dioxide, in synthetic gas. The focus of a lot of interest as a potential source of fuels and raw materials, it is already used in some countries to produce a substitute for diesel. One of its drawbacks is the difficulty of controlling the distribution of its products – which hydrocarbons are produced and in what proportions.

A process yielding FT-like products in useful quantities from a reaction not requiring high temperatures and pressures would be highly prized. If it could reduce carbon dioxide, an abundant greenhouse gas, instead of carbon monoxide, it would have outstanding potential. But the electrocatalytic reaction as it stands cannot do these things; not yet, at least. Two difficulties prevent it and the ELCAT consortium's mission boils down essentially to reversing them: the catalyst is quickly deactivated and the reaction's productivity is poor.

## Twin experimental configurations

Scarcely any research has been reported in the scientific literature on gas-phase electrocatalysis, so the consortium is aware that completely disposing of these difficulties inside three years may prove elusive. Even if it does, a secondary goal should lead to valuable information on the feasibility of controlling product distribution. Another should add to what is currently known about the advantages of confining metal nanoparticular catalysts in carbon nanotubes.

The team will work with two experimental configurations. Built around a proton conduction membrane in which protons are generated by catalytic oxidation of hydrogen on the opposite side from the carbon

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*Generating hydrogen from water in a single step is one possible long-term outcome of the research led by the ELCAT project.*

# ELCAT
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### AT A GLANCE

***Official title***
*Electrocatalytic gas-phase conversion of $CO_2$ in confined catalysts*

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dioxide, the first will be operated at temperatures of 50–150°C for good reaction productivity. The second configuration will be similar but have an oxygen-anion-conducting membrane instead. Catalysing the reaction in both configurations, metal nanoparticles stabilised within carbon nanotubes are expected to generate very high local pressures inside the nanotubes. This, the partners believe, is probably an essential ingredient in the production of the FT-like products already observed.

The partners, though only four in number, bring diverse but complementary expertise to the project. One takes on the task of synthesising and characterising the nanotubes; another, that of analysing and characterising the underlying reaction mechanism; and the remaining two, those of testing the reaction in one configuration each.

Because ELCAT is embarking upon exploratory research in a field that, until now, has barely been noticed, any successes the team enjoys have the potential to entice further researchers to join them and open it up further. Indeed, the partners have deliberately kept the consortium small in size and tight-knit, the better to build a base of knowledge quickly.

**If carbon dioxide can be converted into useful fuels at a low temperature, the possibilities are enormous.**

The longer-term outcomes, though naturally difficult to gauge with any confidence, could be considerable in several technological areas. Similarities between the first configuration and proton-exchange-membrane (PEM) fuel cells suggest the possibility of knock-on improvements in the electrodes of PEM fuel cells. Moreover, if knowledge gained from the second configuration turns out to be transferable to the related solid-oxide fuel cell, the result might be capable, further down the line, of generating hydrogen from water in a single step.

Longer-term promise, then, is clearly not restricted to the obvious potential for converting carbon dioxide, a greenhouse gas, into useful fuels and raw materials on a large scale, though this alone would be an extremely handsome reward. Also more niche applications can be considered: Mars atmosphere is mostly composed from $CO_2$ and one of the limitations for the exploration of Mars by humans is the necessity of producing on-site the fuel necessary for the back flight. Knowledge generated within ELCAT project may be used to develop novel devices which can use solar energy, $CO_2$ and $H_2O$ to produce fuels.

SIXTH FRAMEWORK PROGRAMME