localization. This contradiction raises questions about the plasticity of nuclear pore complexes that can be addressed by localizing Nup145p under conditions where nuclear pore complexes are clustered but telomeric silencing is normal.

There are additional caveats. Several conditions have been described^{5,8} in which the foci of telomeric proteins are dispersed, telomeric silencing is lost, yet Y' DNA is still localized to the nuclear periphery. Because Galy and colleagues monitored the localization of Rap1p rather than Y' in the *nup145ΔC* strain, it will be important to establish that telomeric DNA — not just telomeric proteins — are perturbed in the absence of wild-type Nup145p. In addition, to assess the relationship between telomeric silencing and telomere localization, the position of individual telomeres whose silencing status is known must be determined. Finally, conclusions as to the loss of telomeric silencing of the *Δmlp1*, *Δmlp2* and *nup145ΔC* strains should be interpreted with caution as these strains grow slowly in complete media^{9,11}.

Nonetheless, Galy and colleagues provide the first hint of a possible link between telomere localization and nuclear pore complexes. Future experiments with MLps should bring further insights into the connection between telomeric silencing, telomere localization and DNA repair. ■

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1. Galy, V. *et al.* *Nature* **403**, 108–112 (2000).
2. Gottschling, D. E. *et al.* *Cell* **63**, 751–762 (1990).
3. Bourns, B. D., Alexander, M. K., Smith, A. M. & Zakian, V. A. *Mol. Cell. Biol.* **18**, 5600–5608 (1998).
4. Gravel, S. *et al.* *Science* **280**, 741–744 (1998).
5. Gotta, M. *et al.* *J. Cell Biol.* **134**, 1349–1363 (1996).
6. Gotta, M. *et al.* *EMBO J.* **16**, 3243–3255 (1997).
7. Laroche, T. *et al.* *Curr. Biol.* **8**, 653–656 (1998).
8. Martin, S. G. *et al.* *Cell* **97**, 621–633 (1999).
9. Strambio-de-Castillia, C. *et al.* *J. Cell Biol.* **144**, 839–855 (1999).
10. Haber, J. E. *Cell* **97**, 829–832 (1999).
11. Teixeira, M. T. *et al.* *EMBO J.* **16**, 5086–5097 (1997).

Methane combustion

Durable catalysts for cleaner air

Jon G. McCarty

There is great interest in using methane as an alternative to coal and oil, because its high ratio of hydrogen to carbon means it can generate power with fewer greenhouse-gas emissions. But methane combustion requires high temperatures (greater than 1,300 °C) to maintain a stable flame. At these temperatures, noxious emissions of nitrogen oxides that contribute to acid rain and smog become a problem. Catalytic oxides can be used to stabilize 'lean' flames (those with low fuel to air ratio) at much lower temperatures, thereby producing little or no nitrogen oxide pollutants. On page 65 of this issue¹, Zarur and Ying describe the synthesis of promising new catalytic materials that allow methane combustion at 400 °C.

The catalytic reaction of methane and oxygen was examined as long ago as 1817 (before the term catalysis was first coined by Berzelius²) when Humphry Davy and young Michael Faraday investigated the ability of platinum to spontaneously release heat when exposed to mixtures of coal-mine gas and air³. Apart from early work on safety devices for coal mines and the burning of volatile organic vapours, the catalytic oxidation of fuel was not investigated for commercial applications until the mid-1970s when NASA and the Environmental Protection Agency in the United States sought to develop a small ceramic gas turbine as a low-emissions alternative to internal combustion engines for light vehicles⁴. By the early 1980s, catalytic exhaust converters were available to meet new vehicle-emission standards, but the durability and performance of the ceramic gas turbine remained unacceptable, despite progress in the development of catalytic materials.

Attention has since shifted, especially in Japan, to low-emission catalytic and hybrid combustion for stationary electrical-power generation with large-scale (megawatts), natural-gas turbines. Current catalytic combustion devices for small- to medium-scale (0.5- to 15-MW) gas turbine power-generation systems use a very lean mixture of natural gas with compressed air. Our company, Catalytica Combustion Systems, Inc., is developing catalytic combustion technology that is both durable and cost-effective relative to exhaust clean-up. To demonstrate commercial viability, Catalytica has applied this technology to a 1.5-MW gas turbine, which supplies power to the city of Santa Clara, California. To date, the catalyst has run for more than 4,000 hours with very low emissions of nitrogen oxides, carbon monoxide and unburned hydrocarbons (Fig. 1, overleaf). Still, it is fair to say that commercial acceptance of this technology has been slowed by the limited stability of solid-state catalysts.

Catalytic combustion materials have to be hard wearing because they are required to operate for long periods without loss of activity at high temperatures. Noble metal oxides, such as platinum or palladium oxide, are excellent catalysts below 850 °C, but powders of these catalysts suffer from thermal coarsening at higher temperatures. Thermal coarsening is the growth of larger grains of catalyst material through the consumption of smaller grains, which reduces the catalyst surface area and thus its activity. To improve palladium oxide activity at higher operating temperatures the catalyst must be dispersed within a more stable (and typically less active) porous oxide layer (Fig. 1b). This

Reproductive biology

Taking the squeeze off sperm

Non-hormonal contraception is available for males — but, for the moment, only for mice and by targeted gene deletion. The target is the gene encoding a receptor known as P2X₁, which is prominent in smooth-muscle cells of the vas deferens, the ducts that carry sperm from the testicles *en route* to ejaculation. The image here shows a cross-section of vas deferens brimming with P2X₁.

Elsewhere in this issue (*Nature* **403**, 86–89; 2000), K. Mulryan and

colleagues describe the results of knocking out the P2X₁ receptor gene in mice. Females mated with male mice lacking the receptor had a pregnancy rate of only 13.7% against 100% for females mated with normal males.

The cause of the infertility is a much reduced sperm count. Nerve stimulation of vas deferens muscle is largely through P2X₁, and usually results in vas deferens contraction and sperm ejection. In the knockout mice, it seems that the absence of

P2X₁ means that stimulation fails to reach the threshold for normal contraction.

For human contraception, ways of disrupting P2X₁ other than gene deletion would have to be found. A further possible difficulty is that these receptors occur widely elsewhere in the body, and interfering with their function might have side effects. The knockout mice of Mulryan *et al.* showed no obvious abnormalities in behaviour and physiology, however, except for

marginally raised blood pressure.

There is also the other side of the fertility coin. As the authors point out, stimulation of P2X₁ activity might prove fruitful in treating male infertility.

Tim Lincoln

Figure 1 Catalytic combustion technology for gas-turbine applications⁶. a, Fuel and compressed air pass through two catalytic stages, in which catalyst materials limit the temperature rise through each stage. The gas exiting the second stage contains unburned fuel and is sufficiently hot to spontaneously combust in the post-catalyst zone, just before entering the gas turbine. b, An end view of the catalyst honeycomb structure. Thin strips of metal foil are coated with a layer of catalyst and configured to create an array of narrow (1-mm) channels. Fuel in the gas mixture diffuses through the layers where the catalytic oxidation occurs, thereby releasing heat. The heat of combustion is then returned to the flowing gas by convection. Finding catalysts that work at the high temperatures required for methane combustion is not easy. Zarur and Ying¹ have developed a promising catalyst that is more stable at temperatures up to 1,300 °C and could be used in a variety of combustion applications.

prevents active particles meeting and fusing together, thereby preserving the high surface area of the catalyst. The activity of such catalysts can be viewed as the product of their intrinsic ability to oxidize methane (rate per unit surface area of the active phase) and their dispersion (active surface area per unit volume). It is therefore desirable to find materials that combine high activity with greater resistance to thermal coarsening and so maintain high combustion rates.

Oxide catalysts based on non-noble metals, such as perovskites and hexaaluminates, are exceptionally resistant to thermal coarsening, but are difficult to prepare as fine powders. Zarur and Ying¹ have found a way round this problem by combining several state-of-the-art synthesis methods to produce porous powders with high surface area — that is, nanometre particle sizes — and resistance to thermal coarsening at high temperatures. These hexaaluminate powders show an interesting level of activity for methane combustion, but the most important use of these materials may be as a matrix to disperse and isolate small particles of other catalysts that are more prone to coarsening. Indeed, Zarur and Ying¹ disperse grains of a moderately active catalyst, ceria (CeO₂), within a microemulsion of their hexaaluminate oxide powders with interesting results. In this system, the highly dis-

persed and surprisingly efficient ceria catalyst helped sustain methane combustion at temperatures as low as 400 °C.

The dispersed ceria catalyst appears to remain stable and active within the limited conditions and lifetime of laboratory experiments, and is perhaps superior to the transition-metal hexaaluminates studied by Arai and colleagues some ten years ago⁵. The new catalyst is perhaps unique in that ceria, a low-volatility oxide previously thought to have low combustion activity, remains active and highly dispersed within the porous hexaaluminate support after extended exposure to combustion conditions at temperatures as high as 1,300 °C. It remains to be seen if this catalyst possesses the combination of thermal stability and combustion activity necessary to succeed as a commercial catalytic combustion technology. But clearly the ceria-hexaaluminate catalyst, or another of many possible variations prepared using this approach, is worth a closer look.

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1. Zarur, A. J. & Ying, J. Y. *Nature* **403**, 65–67 (2000).
2. Berzelius, J. J. *Ann. Chim.* **61**, 146 (1836).
3. Davy, H. *Phil. Trans. R. Soc.* **107**, 45 (1817).
4. Pfeifferle, W. *J. Energy* **2**, 142–146 (1978).
5. Arai, H. & Machida, M. *Catal. Today* **10**, 81–95 (1991).
6. Dalla Betta, R. A. *Catal. Today* **35**, 129–135 (1997).

Daedalus

Depth of insight

Computed axial X-ray tomography is an expensive and cumbersome way to obtain three-dimensional X-ray data. Daedalus wants to do it by stereo photography. In its optical form, this uses two lenses separated by the distance between the eyes; each takes a photograph. These are then presented to the viewer so that each eye can only see its 'own' photograph. The result is a persuasive and most informative image in depth. The method should work perfectly well with two X-ray sources, or just one stepped quickly sideways between successive exposures.

The snag is that an X-ray image is essentially a shadowgraph. A point source of X-rays throws a shadow of the subject, in all its variations of transparency or opacity, onto a sensitive screen. With two sources, the screen would just sum the two exposures, giving a confused muddle. An X-ray stereography screen will have to hold a separate image for each of the sources.

Daedalus recalls those fine filters made by exposing a sheet of base material to a beam of ionizing particles. Each particle leaves a track through the sheet, dense with dislocations, photoelectrons and so on. A selective solvent etches away these disturbed regions, leaving a tiny tunnel where each particle passed.

So DREADCO chemists are now seeking a polymer or light alloy which can be activated and etched by the passage of X-ray photons. It will be placed behind the subject; in front of him will be two X-ray sources, separated by the width between a human interpreter's eyes. Each X-ray source will riddle the plate with tracks aligned with it, and diverging from it. The interpreter will etch the plate, place it against a bright background, and look at it from such a position that his two eyes are where the X-ray sources were. Each eye will see only the light which converges on it through the tunnels in the plate made by the corresponding X-ray source, and aligned with it. He will see a true stereo X-ray image of the subject.

Cheap and simple, stereo X-radiography will transform routine medical imaging. Each exposure will give far more useful data; many tricky interpretational problems will vanish. It could even provide airports with still more intimate insights into their customers' luggage.

David Jones

The further Inventions of Daedalus (Oxford University Press), 148 past Daedalus columns expanded and illustrated, is now on sale. Special *Nature* offer: m.curtis@nature.com