Materials science

A film worth watching

Keeping cool without costing the Earth

ABOUT 6% of the electricity generated in America is used to power air-conditioning systems that cool homes and offices. As countries such as Brazil, China and India grow richer, they will surely do likewise. Not only is that expensive for customers, it also raises emissions of greenhouse gases in the form both of carbon dioxide from burning power-station fuel and of the hydrofluorocarbons air conditioners use as refrigerants.

As they describe in a paper in this week's *Science*, Ronggui Yang and Xiaobo Yin of the University of Colorado, in Boulder, have a possible alternative to all this. They have invented a film that can cool buildings without the use of refrigerants and, remarkably, without drawing any power to do so. Better yet, this film can be made using standard roll-to-roll manufacturing methods at a cost of around 50 cents a square metre.

The new film works by a process called radiative cooling. This takes advantage of that fact that Earth's atmosphere allows certain wavelengths of heat-carrying infrared radiation to escape into space unimpeded. Convert unwanted heat into infrared of the correct wavelength, then, and you can dump it into the cosmos with no come back.

Dr Yang and Dr Yin are not the first to try to cool buildings in this way. Shanhui Fan and his colleagues at Stanford University, in California, demonstrated a device that used the principle in 2014. Their material, though, consisted of seven alternating layers of hafnium dioxide and silicon dioxide of varying thicknesses, laid onto a wafer made of silicon. This would be difficult and expensive to manufacture in bulk.

Dr Yang's and Dr Yin's film, by contrast, was made of polymethylpentene, a commercially available, transparent plastic sold under the brand name TPX. Into this they mixed tiny glass beads. They then drew the result out into sheets about 50 millionths of a metre (microns) thick, and silvered those sheets on one side. When laid out on a roof, the silver side is underneath. Incident sunlight is thus reflected back through the plastic, which stops it heating the building below.

Preventing something warming up is not, though, the same as cooling it. The key to doing this is the glass beads. Temperature maintenance is not a static process. All objects both absorb and emit heat all the time, and the emissions are generally in the form of infrared radiation. In the case of the beads, the wavelength of this radiation is determined by their diameter. Handily, those with a diameter of about eight microns emit predominantly at wavelengths which pass straight through the infrared "window" in the atmosphere. Since the source of the heat that turns into this infrared is, in part, the building below, the effect is to cool the building.

That cooling effect, 93 watts per square metre in direct sunlight, and more at night, is potent. The team estimates that 20 square metres of their film, placed atop an average American house, would be enough to keep the internal temperature at 20°C on a day when it was 37°C outside.

To regulate the amount of cooling, any practical system involving the film would probably need water pipes to carry heat to it from the building's interior. Manipulating the flow rate through these pipes as the outside temperature varied would keep the building's temperature steady. Unlike the cooling system itself, these pumps would need power to operate. But not much of it. Other than that, all the work is done by the huge temperature difference, about 290°C, between the surface of the Earth and that of outer space. ■

Pollination

Where the bee sucks

Plans for artificial pollinators are afoot

IT IS, in one way, the ultimate drone. In another, though, it is the antithesis of what a drone should be. Drones are supposed to laze around in the hive while their sisters collect nectar and pollinate flowers. But pollination is this drone's very reason for existing.

The drone in question is the brainchild of Eijiro Miyako, of the National Institute of Advanced Industrial Science and Technology, in Tsukuba, Japan. It is the first attempt by an engineer to deal with what many perceive as an impending agricultural crisis. Pollinating insects in general, and bees in particular, are falling in numbers. The reasons why are obscure. But some fear certain crops will become scarcer and more expensive as a result. Attempts to boost the number of natural pollinators have so far failed. Perhaps, thinks Dr Miyako, it is time to build some artificial ones instead.

His pollinator-bot does not, it must be said, look much like a bee. It is a modified version of a commercially available robot quadcopter, 42mm across. (By comparison, a honeybee worker is about 15mm long.) But the modifications mean it can, indeed, pollinate flowers. Specifically—and crucially—Dr Miyako has armed it with paintbrush hairs that are covered in a special gel sticky enough to pick pollen up, but not so sticky that it holds on to that pollen when it brushes up against something else.

Previous attempts to build artificial pollinators have failed to manage this. Dr Miyako, though, has succeeded. Experiments flying the drone up to lily and tulip flowers, so that the gel-laden hairs come into contact with both the pollen-bearing anthers and the pollen-receiving stigmata of those flowers, show that the drone can indeed carry pollen from flower to flower in the way an insect would—though he has yet to confirm that seeds result from this pollination.

At the moment, Dr Miyako's drones have to be guided to their targets by a human operator. The next stage will be to fit them with vision that lets them recognise flowers by themselves. Fortunately, visual-recognition software is sufficiently developed that this should not be too hard. In future, when you are walking through an orchard in bloom, listen out for the humming of the drones as well as the buzzing of the bees.