The Time For Thermochromics

A house that changes color to white when it is hot, will reflect more sunlight and require less air conditioning.

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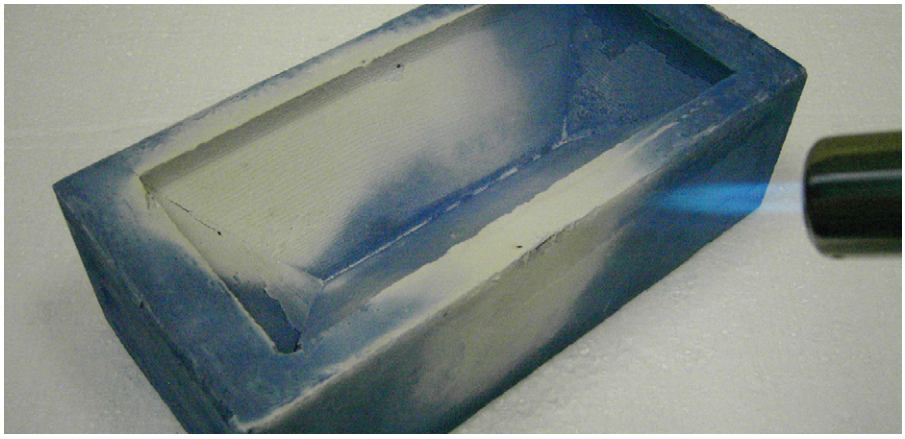
There is a moment in everybody's life when someone bounces up to them bearing a coffee mug with some sort of cartoon on the side of it, such as a picture of a golfer, complete with a jolly looking dog, a putting green and a red flag. The person is invariably grinning and proceeds to pour you a cup of coffee, the act of which causes the picture on the side of the mug to change, the trousers of the golfer, for instance, might suddenly disappear revealing his cheeky bottom. This is your cue to laugh and be amazed at the same time, but you are unable to do so because you are no longer three years old, so you stand there with an awkward smile on your face. For a materials scientist these moments can spark a crisis of confidence akin to seeing your favourite sportsman reduced to advertising breakfast cereals on TV. This is because thermochromic pigments – the origin of the cartoon transformation – are just that, a superstar of the materials world reduced to slumming it as a hot beverage side-show.

Thermochromic materials started to emerge from the laboratory in the 1960's about the same time of the first digital watches, and were based on the same display technologies, liquid crystals. Instead of using an electric current to control the type of crystal structure, heat is utilised, which changes the equilibrium spacing between the aligned sheets of molecules. This changes which wavelengths of light are strongly diffracted, and thus the perceived color of the material. Containing and protecting the liquid crystals was the tricky bit, but as soon as micro-encapsulation came along, the technology took off, and a range of thermochromic inks, papers and dyes became possible. This initiated a burst of interest in thermochromism, and soon other families of molecules were discovered to exhibit the property, Leuco dyes being the most popular. The problem was that no-one really had a good idea what to do with them. Things that changed color unexpectedly were fun everyone agreed, and so the thermochromic t-shirt was born. Possibly the only t-shirt style in the history of fashion that no-one, however attractive, has ever looked good wearing, emphasising as it does the prestigious heat produced by armpits. The thermochromic bikini shared a similar fate. The amusing mugs came next, and then everyone pretty much gave up on this clever technology.



A thermochromic brick that changes color with tempearture, produced by the Materials Library, King's College London.

Its not easy to understand why useful things like thermochromic baths which warn you visually when you are about to put your child or elderly relative into a scolding hot water did not take off. Recently, designers and artists have started to play with thermochromic pigments into conjunction with phase change materials, using them to design multi-sensory walls and interfaces. These may bring the seasonal color changes we see in nature to the urban environment. Thus it may not just be trees that change color in the autumn, but also houses and streets.

The interesting thing about these developments is not just their aesthetic appeal, but also their environmental impact. A house that changes color to white when it is hot, will reflect more sunlight and require less air conditioning. It is such environmental considerations that are pushing forward thermochromic research, in particular as coatings for 'switchable glass'. In this case the transition is designed to be spectrally selective, affecting only the infra-red transparency of glass, letting heat through in the winter to take advantage of passive solar heating and blocking it in the summer. Given that forty percent of the energy consumption of developed economies is consumed in heating and cooling of buildings, such coatings look like they could play an important role in the fight against Global Warming. However given the limp enthusiasm most governments have for energy efficiency, presumably because it does not promote consumption, it may be that such thermochromic glass coatings will have a hard time establishing themselves. An active campaign to promote energy efficiency materials to the public might be the way forward, but please, can it not involve the production of any more novelty coffee mugs.