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### **Sticky Situations** **Philip Ball**

Why is sticky tape sticky? Why does a toffee apple stick to the paper bag? Surprising though it may seem, these remain unanswered questions. Cyprien Gay and Ludwik Leibler from the CNRS-Elf Atochem laboratory in Levallois-Perret, France, now claim to have cracked the puzzle of what makes a substance tacky.

Although one's intuition is that only rather special substances, like half-dried chewing gum, are sticky, the real question is not what makes them so, but what makes everything else non-sticky. In theory, just about everything should stick together. It costs energy to make a surface. Think how much effort is needed to snap apart a steel bar, because of all the bonds between atoms that need to be broken. So why, if you press the two fractured surfaces back together, doesn't the wound heal up immediately as the naked surface atoms bind together again? According to this argument, you should be able to build a house just by pressing the bricks gently together.

The reason why things don't spontaneously stick to themselves, or to other materials, is that just about all surfaces are rough. Even the smoothest surfaces are generally pitted and grooved on a microscopic scale: look up-close at a sheet of glass and you'll see a mass of tiny scratches, ridges and scars. This means that, if two surfaces are brought into contact, in fact they barely touch at all. Only the largest ridges and bumps will come into contact, and will prop the rest of the surfaces apart. It is like trying to mend a smashed piece of pottery - the bumps never seem to match up on the two surfaces, so you can't get a good join.

This means that the substances can't relieve themselves of their surface energy, because they just can't get it together smoothly enough. But tacky substances are different. They are commonly soft, rubbery or viscous materials, like chewing gum. So if a rough surface is pressed against them, the soft substance can ooze into all the tiny pits and cracks and achieve an intimate union with all of the hard surface.

Yet, say Gay and Leibler in *Physical Review Letters*, even this is not enough to explain the extreme stickiness of some substances. The energy required to pull them apart can be much greater, by a factor of ten thousand, than the surface energy of the resulting free surfaces.

The reason for this, the researchers suggest, is to do with the air bubbles that are created when a hard object is pressed into a soft, tacky medium. Both the hard and the soft surfaces are initially rough, in the sense that they have wavy bumps in their profile. Those in the soft stuff are generally larger than those in the hard material: you can almost see the roughness on the sticky side of adhesive tape, whereas a glass microscope slide looks smooth and shiny to the eye. So when the slide is pressed against the tape, the contact area becomes a mass of bubbles both large and small.

When the glass slide is pulled away from the tape, the bubbles act like suction pads. They get stretched out, and the low air pressure inside the elongating bubbles holds the surfaces together like an array of little sink plungers. As the big bubbles expand, they engulf the little bubbles around their edges and eventually begin to merge with one another. At some point, the whole connected network of big bubbles reaches the edge of the contact area, and sucks in air from outside. This is when you hear the little pop that accompanies the breaking away of the glass slide from the tape - it is like the sound of a plunger as it comes unstuck.

By also taking into account the energy expended in the cracks that pass through the soft material as the bubbles get stretched into necks during pull-away, Gay and Leibler were able to calculate a "tack energy" that agreed well with measurements on typical tacky materials. They were also able to explain why the force required to pull the surfaces apart is initially very high - when the separate bubbles are elongating - but then falls to a constant value when the surfaces are further apart, as the big bubbles merge with one another. And there you have it: a theory of tackiness, or why your posters don't fall off the wall.

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