Figure 2 One potato. Starches from wheat, banana and plantain are badly damaged by X-rays, so good diffraction patterns have not been obtained from them. But potato starch is tougher, probably because the crystalline layers are thicker, and so its structure can be determined.

regions are usually attributed to branched or irregular sections of the chains, which provide the organism with a means of controlling the stiffness and swelling of the polymer. Nuclear magnetic resonance studies of starch³ have detected amorphous regions which make up 70 per cent of the granule, some within the crystalline regions and the rest in distinct rings of highly branched and wholly amorphous material.

On the basis of electron microscopy, Oostergetel² has postulated a different model for potato starch, based on radiating double spirals of amorphous and crystalline material, like the swirls on a barber's pole, with an 8-nm cylindrical cavity down the centre of each spiral. So far, this model is consistent with, but is not really confirmed by, the new data, and it does seem to be very complex compared with what we might expect from simple polymerization and crystallization processes.

So what of starch as a basis for biodegradable plastic? A decade ago the development of bacterially derived polyhydroxybutyrate as a biodegradable thermoplastic was stalled by the high cost of fermentation and extraction, and that re-ignited interest in starch. Moulded starch golf tees and foamed packing material are already being made.

But the problem, as with most biological polymers, is that its properties are so sensitive to water. Dry starch will not melt but simply dehydrates, cross-links and then burns. Water plasticizes the polymer, allowing it to melt and be processed as a conventional plastic. However, the properties are very sensitive to water content⁴ and this is hard to control at moulding temperatures of 200 °C. In addition, hydrolytic degradation breaks the chains during moulding. As the plasticizing water is lost, a moulded piece of starch is

thus likely to shrink and become brittle. An alternative is to use glycerol in place of water, as it vaporizes less easily⁴, but it might leach out in use, again making the part brittle.

Natural starches differ in their amylopectin/amylose ratio and structure, probably to control the rate of hydrolysis. In reprocessed starch we have not attained a comparable level of control, but these new studies will teach us what kind of structures can be used to control degradation. It would also be valuable to transfer these lessons to biodegradable medical implants — normally made of polylactide or its copolymers with polyglycolide — in which it has proved very difficult to preserve mechanical properties past the first few per cent of the degradation reaction. We would really like a structure that retains its mechanical integrity to the point where much of the polymer has already been degraded and resorbed.

There is also renewed interest in grafting or blending starch with synthetic polymers to provide a combination of biodegradation with better mouldability⁵, but this would increase the cost. Instead, another substance — but one that is similar to starch — may be the answer: polyhydroxybutyrate moulds well and is not very water-sensitive. So perhaps what we are waiting for is a genetically modified corn that makes polyhydroxybutyrate instead of starch. □

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Daedalus

The light rolls in

Squash or deform a crystal of salt, and it will emit light. Many ionic crystals show this effect; the ionic reshuffling of deformation allows defects in the lattice to relax and release their stored energy. A crystal under deformation shines more brightly if it has been loaded with defects beforehand, for example by irradiation.

Daedalus wants to use the effect in a new lamp. He points out that the entire surface of an ionic crystal, at least in vacuum, is made up of defects. Imagine, he says, two ionic rollers rotating in contact, their surfaces being continually brought together and torn apart again. Their surface defects would be continuously healed and recreated. Copious light should be emitted, generated directly from mechanical power.

DREADCO physicists are now exploring the idea. The rollers should ideally be slightly plastic, so that they can deform readily and make intimate contact with each other. The most plastic ionic material is probably silver chloride. So the team is coating rollers with silver chloride and running them against each other in a vacuum, looking for light emission. The rollers are being irradiated and doped with various impurities, to generate excited surface states of the right energy for the colour of luminescence desired.

The 'Rolamp' should be far more efficient than existing lamps. It will be ideal for small hand-cranked torches, emergency beacons, bicycle lamps driven from the wheels, and so on. With little waste heat, it will run much cooler than filament lamps. Photographers and film and TV producers will welcome its coolness and economy, especially on location. Neater still, a Rolamp with an interrupted coating on one roller would emit light in brief flashes, as each active region made contact with the other roller. Synchronized with the camera shutter, it would emit light only when needed, using still less power and giving sharper images of moving objects.

The silver chloride could be doped to give light of any colour; a suitable mixture of dopants would give well-averaged white. But Daedalus likes the idea of distributing the different dopants around the rollers, so that this average is obtained from a rapid repeated sweep through the rainbow. The lamp would then excite our retinal colour sensors in a fast-cycling sequence. The slight time lags between our red, green and blue senses should give us a subtly heightened sense of colour separation.

David Jones