

Indeed, its very existence also has implications for tackling much broader questions about how intracellular parasites evolved from algae, and whether the single origin of these plastids can be pushed even farther back in time to explain the origin of an even greater diversity of complex algae with red algal plastids, as proposed by the 'chromalveolate hypothesis'^{5,6}.

The discovery of an organism that falls at such an interesting junction in the tree of life happens only rarely, and this little brown ball will surely become the subject of a complete genome analysis soon after the ink of this commentary has dried. When it does, its genome will be a source of clues to many events that defined ancient evolutionary history. ■

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phase, it is extremely difficult for the atoms to move and generate a newly coupled product with the release of carbon monoxide.

Kuzmanich *et al.*³ set out to turn this wisdom on its head by designing a crystalline ketone that would ensure one bond breakage and in doing so make a second unavoidable. Their starting point is diphenylcyclopropenone, a ketone whose central carbonyl forms one corner of a triangular cyclopropene ring with three carbon atoms. The other two corners are connected to two identical phenyl (C₆H₅) rings (Fig. 1a-c).

The authors hypothesized that an initial bond breakage, caused by incident ultraviolet radiation, would release the large strain energy stored in the three-membered cyclopropene ring. Once unleashed, this energy would prevent the molecule from returning to the ground state, stopping the covalent bond from reforming. The energy released would at the same time promote the breaking of the second bond, casting the carbonyl group adrift as carbon monoxide. As a result, single crystals of diphenylcyclopropenone would react to produce solid diphenylacetylene (Fig. 1d).

This is wizardry, albeit of a more conventional chemical type. But a sign of something rather extraordinary was provided by the observation that the crystals took just minutes to crumble: a mark of a very efficient process. To quantify this observation, the authors determined the quantum yield of the reaction — the number of molecules that reacted per photon of incident light.

This is a notoriously difficult measurement owing to the differential scattering of light on

ORGANIC CHEMISTRY

Solid awakening

Leonard R. MacGillivray

Once dismissed as chemical graveyards, organic solids can in fact be manipulated to surprising effect: one example is a crystal designed to embark on a remarkable domino-rally of reactions when bathed in light.

A crystal, the chemistry Nobel laureate Leopold Ruzicka is reported to have said¹, is a chemical cemetery. Molecules in the solid state occupy the most restrictive of quarters: lying just ångströms apart, the lively spontaneity of processes such as conformational change, enjoyed by molecules in solution, is largely forbidden to them. But although some effects of close packing might make molecules in solids relatively inert, this packing does determine important physical properties, such as a crystal's conductivity and reactivity. That fact has animated the field of crystal engineering², which in recent years has made great strides in controlling the properties of organic solids. As a case in point, Kuzmanich *et al.*³, writing in the *Journal of the American Chemical Society*, describe how they have designed an organic solid that has truly remarkable 'chain reactivity'.

Reactions involving molecules are typically unimolecular (with just one player at the starting-gun) or bimolecular (with two). Both types of reaction occur less often in solids than in liquids, but they do occur. Kuzmanich and his colleagues focus on a unimolecular reaction: the photodecarbonylation of a ketone. A ketone is a molecule characterized by a carbonyl (C=O) group, the carbon atom of which forms a covalent bond to a carbon atom in each of two additional organic groups. When light excites such a molecule, the two carbon-carbon single bonds can break, generating reactive fragments known as radicals. If the conditions are right, the radicals combine, releasing the elements of the carbonyl group as carbon monoxide gas.

The breaking of the carbon-carbon bonds is

reversible. In the solid state, this is an essential point: because the atoms of a crystal are locked in position by the lattice, the covalent bonds can easily re-form when the molecule returns to the ground state after the initial excitation⁴. Compared with the situation in the liquid

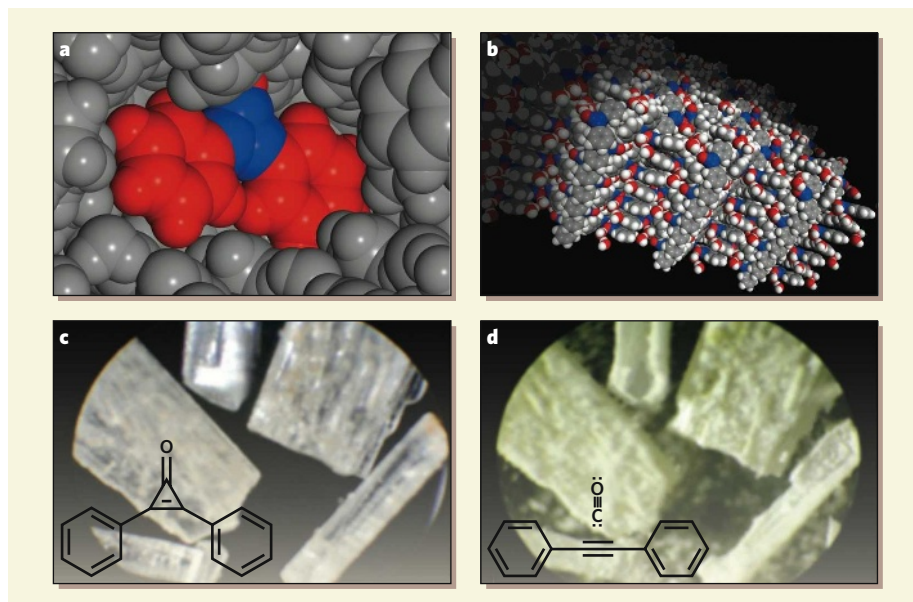


Figure 1 | Excited by light. a, b, These models, derived from X-ray data, show diphenylcyclopropenone monohydrate in close-up (a; blue, cyclopropenone ring; red, phenyl and oxygen; remaining atoms, grey) and in their long-range structure (b; blue, cyclopropenone ring; grey, carbon; red, oxygen; white hydrogen). Nearest-neighbour diphenylcyclopropenones are 4–5 ångströms from each other. c, d, The before and after of Kuzmanich and colleagues' quantum chain reaction¹: photoexcitation breaks a bond in the cyclopropenone ring (central triangle of structure), unleashing the strain energy pent up there. A second bond breaks, releasing carbon monoxide and leaving behind a powder of diphenylacetylene, C₆H₅C≡CC₆H₅.

different parts of a solid sample⁵. The authors turned to nanophysics for an answer to this problem^{6,7}: specifically, the fact that a tiny crystal comparable in size to the wavelength of ultraviolet light (around 200–400 nanometres) can provide an environment homogeneous enough to minimize sample effects. Applying a technique developed by their own group⁷, they used an aqueous nanocrystalline suspension to trap all the photons from the ultraviolet light source. Taking their earlier measurements on a related solid ketone as a reference, they were able to calculate an accurate value for the quantum yield of their new reaction.

That value was 3.3. For one photon to be activating more than one molecule (a quantum yield of 1.0), the reaction must be proceeding through a remarkable quantum chain process⁸, with electronic excitations cycling through the crystal as bonds on different rings open and close. Any energy not used in the chain process probably led to loss of the included water (the crystal was prepared as an aqueous ‘monohydrate’), the crumbling of the crystal, and recrystallization of the acetylene product.

In 1959, in his famous talk ‘There’s plenty of room at the bottom’, Richard Feynman raised what was, in retrospect, an irresistible question⁹: “What would the properties of materials be if we could really arrange the atoms the way we want them?” Answers to this question can, and have, been sought in all states of matter — gas, liquid and solid. By effectively ‘spring-loading’ a molecule so that, when touched by light, it transferred its energy to a nearest neighbour, Kuzmanich *et al.*³ establish a new connection between unimolecular and bimolecular reactivity. We can now start to wonder what further use we might make of the technique; whether, for example, the signal amplification provided by its domino-like behaviour might be useful for sensor-based materials and applications. With our rapidly growing knowledge of the structures and properties of organic solids², Ruzicka’s morgue-like crystals will probably continue to reveal themselves as surprisingly lively places. ■

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EPIDEMIOLOGY

Emerging diseases go global

Mark E. J. Woolhouse

Novel human infections continue to appear all over the world, but the risk is higher in some regions than others. Identification of emerging-disease ‘hotspots’ will help target surveillance work.

The steady stream of outbreaks of new or unexpected infectious diseases is a much-discussed issue in the field of public health^{1,2} and has even acquired its own dedicated scientific journal³. But for many years research has generally taken a case-by-case approach to understanding why new infections emerge. Now, Jones *et al.*⁴ (page 990 of this issue) have published a systematic, quantitative analysis of recent global patterns of disease emergence. Their work provides insight into the ecology of emerging diseases, and has practical implications, providing pointers for the design of international surveillance programmes.

Jones and her colleagues began by collating data on what they call emerging infectious

disease ‘events’ — that is, outbreaks of human disease associated with a new species or variant of an infectious agent (which could be any type of pathogen, from a virus to a parasitic worm). A painstaking review of the literature going back to 1940 turned up more than 300 such events, most of them involving bacteria (Box 1). (The database is published in full as supplementary information to the paper⁴ and is itself a valuable resource.) The authors then quantified variation in the frequency of these events decade by decade across the world, and carried out a series of statistical analyses to look for relationships with other variables, ranging from human population growth to rainfall patterns.

Box 1 | Emerging diseases: the pathogens and the places

In the work discussed here, Jones *et al.*⁴ identified 335 emerging-disease ‘events’ reported worldwide between 1940 and 2004. The pathogens involved could be novel species or strains, including drug-resistant strains, of known species. Just over half of the events were associated with bacteria, as shown in the pie chart.

An example is *Escherichia coli* serotype O157:H7, first reported in the 1970s. This strain of the usually benign *E. coli* group is a food-borne pathogen that can cause fatal renal illness in the young and the elderly. It turned out to be just one type of verocytotoxigenic *E. coli* (VTEC): other VTECs have since been reported in the United States, the United Kingdom, Japan and other, mostly industrialized, countries.

In general, most reports of emerging-disease events come from developed countries; the bar chart shows the five countries with the most reports in red, and selected others in blue. In the United States alone, there have been more than 100 events reported (almost one-third of the total). Examples

are infections with several species of hantavirus (such as Sin Nombre virus), fungal infections in hospital patients (including different species of *Candida*) and a range of bacterial infections acquired from animal reservoirs (for instance, *Bartonella henselae*, the cause of cat-scratch disease). Jones *et al.* suggest

that this pattern reflects reporting bias. Often, the United States or another developed country can be merely the site of discovery of pathogens with wider distributions. This implies that there is still significant under-reporting of emerging infectious diseases from other regions of the world. **M.E.J.W.**

