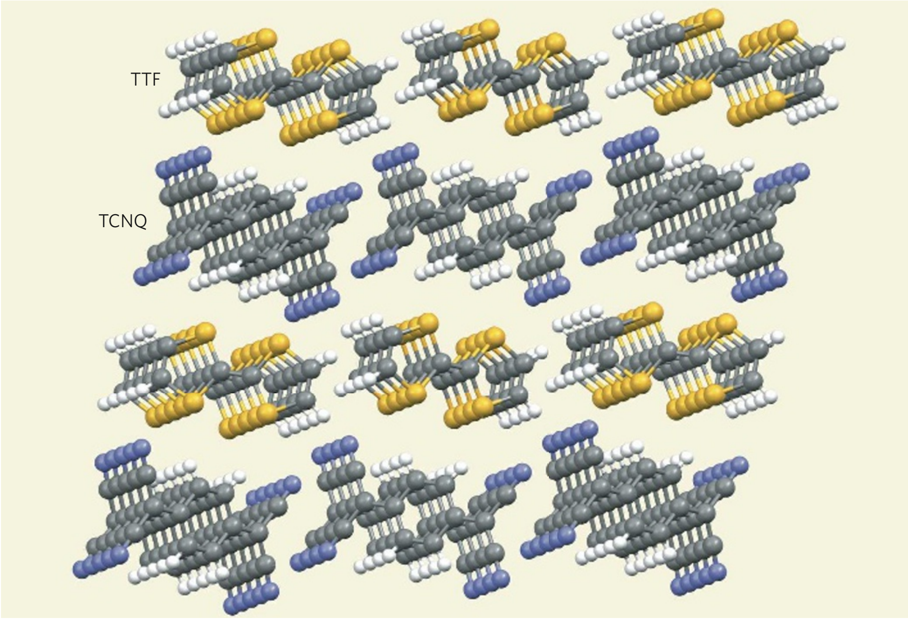

Figure 1 | **Organic crystals in chains.** In a charge-transfer salt, molecules of TTF (tetrathiofulvalene) and TCNQ (7,7,8,8-tetracyanoquinodimethane) line up into orderly chains to form a crystalline structure. They do not interact chemically but exchange charge, so that the solid is highly conductive at room temperature. Alves and colleagues[1] investigated whether a similar charge transfer occurs not only in the solid but at the interface between TTF and TCNQ crystals. Grey, carbon atoms; yellow, sulphur; blue, nitrogen; white, hydrogen. (Reproduced from ref. 1, courtesy of the Cambridge Structural Database.)

occurs independently in the linear arrangements of both molecules (the Peierls transition, which generally afflicts one-dimensional structures), with molecules within the chains alternately moving a bit closer and a bit farther away from each other. The upshot is that conduction of charge along the chains is impeded and the compound turns into an insulator.

In their experiments, Alves *et al.* were entering unknown territory. It was far from obvious how the molecules would behave when the surfaces of TTF and TCNQ crystals were brought into contact, and whether the charge exchange seen in the TTF–TCNQ charge-transfer salts would occur between the surface layers of the two separate crystals. Other questions were whether the surfaces would fit together smoothly enough (any imperfections would trap mobile charges), and whether diffusion of molecules across the interface would mix the two substances, effectively producing a mini charge-transfer salt.

Alves *et al.*[1] found that the TTF and TCNQ crystals are sufficiently smooth and flexible to be combined using a notably simple assembly process: manually, in air, TCNQ was first placed on a soft polymeric substrate and TTF was subsequently laminated on top. The resulting interface between them is highly conductive, indicating that charge transfer across the interface does indeed take place, and that charge trapping at the surfaces is not a big issue. Moreover, having studied about ten devices in detail, the authors found from the temperature dependence that the interfacial layers behave as a true metal. In particular, there is no hint of a Peierls transition and corresponding onset of insulating behaviour at low temperature — showing that the molecules at the surfaces only exchange electrons and holes across the interface and do not cross the boundary themselves.

Remarkably, it seems that a metallic layer is produced at the border between the two insulating solids. Moreover, the tantalizing possibility is that here we have a new kind of electronic system, consisting of two weakly coupled sheets of electrons and holes separated from each other at an intermolecular distance. Unexpected electronic and optical effects may well occur in such a system, for example owing to the formation of an ordered layer of excitons (coupled electron–hole pairs that can emit light), as correlated behaviour between the charge carriers can come into play.

Further study of the nature of the interfacial metallic system is required, but a potentially wide avenue for work on organic electronics has opened up. The obvious attraction is the refreshingly straightforward fabrication method; similar lamination processes have already been used to make a range of organic single-crystal transistors. So far, it has been the electronic properties of the whole device rather than those of the interfaces that have been the focus of attention. But that looks set to change. ■

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50 & 100 YEARS AGO

50 YEARS AGO

The National Science Foundation's report on Government–University Relationships in Federally Sponsored Scientific Research and Development ... directs attention to three major trends [between 1940 and 1958]... In this period Federal support has extended from the agricultural sciences to every field of natural science. Secondly, the period has seen the innovation and expansion of federally owned and financed research centres; and thirdly, in contrast to the relative absence of Federal 'extramural' financial support of research facilities, a significant part of Federal support (265 million dollars in 1957–58) goes for construction or operation of major research facilities.

From *Nature* 21 June 1958.

100 YEARS AGO

La Loi des petits Nombres. By M. Charles Henry. The question discussed by the author may be given in his own words:—

"Est-il possible de prévoir une loi de séquence plus ou moins fragmentaire dans les phénomènes fortuits comme les arrivés de la rouge et de la noire à la roulette?"

He considers that the theory of probabilities is only verified in practice when the number of throws of the ball is indefinitely great, and that new principles are required when the period of play is short. He takes what he terms a psychophysical point of view, and bases his researches on the ultimate vibrations of particles and the musical interval, the fifth —the ratio 3 : 2. He adopts the latter as governing the sequences at roulette without giving any scientific reason whatever.

It is difficult to take the author seriously, but as he pretends in chapter iv. of the work to give rules of play which will enable a player to win at Monte Carlo, it is necessary to inform the reader that the system of M. Henry is not based upon scientific truth, and can have no effect upon his winning or losing.

From *Nature* 18 June 1908.