Prussian Blue for information storage

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In the family of Prussian blue, there is a compound that can act as a switch: it is not magnetic at the outset, but it can become magnetized by the effect of light and return to its initial state by heating. Researchers of the Institute of Molecular Chemistry and Materials of Orsay (CNRS/University of Paris XI) and the Laboratory of Inorganic Chemistry and Molecular Materials (CNRS/University of Paris VI) showed that this change of state is due to the collective modification of the position of the atoms, induced by light.

Such compounds, which can memorize binary information, could be used as storage bits for future computers. This work was presented in the journal *Angewandte Chemie International Edition* (after the online publication of January 9, 2007).

In the field of computers, society's demand for capacity to store information is increasing exponentially and has led to the development of the nanosciences: storing ever larger quantities of information in volumes as small as possible and as rapidly as possible. The first hard disk, the RAMAC, built by IBM in 1954, weighed one ton and stored five megabytes. In today's portable computers and MP3 readers, the hard disks store several gigabytes and weigh only a few hundred or even a few dozen grams.

To further miniaturize these devices and to give users greater freedom, many chemists are making new switchable materials, i.e. ones that can switch from one state (OFF = 0) to another (ON = 1) by the effect of an outside impulse (variation of temperature, pressure, light, magnetic or electrical impulse), keeping the memory of the state in which they were found. The chemists of the two teams hope in this way to succeed in storing information on the scale of a few atoms.

They are working on Prussian blue. By replacing some of the atoms or iron with cobalt, they transform this pigment known since ancient times into a compound that can act as a switch: illuminated by a red light at low temperature (-150°C), this compound shifts from a non-magnetic state (OFF) to a magnetic state (ON) in a way that is stable over time. If it is heated, it returns to the OFF state. This change of state is due to the transfer of an electron from the cobalt to the iron (and vice-versa), by absorption of light or thermal energy.

Today, using synchrotron radiation, chemists have observed a collective modification of the position of the atoms in space, induced by the shift of the electron from one atom to the other. When the electron goes from the iron atom (OFF state) to the cobalt atom (ON state) due to the red light, the three-dimensional links between the cobalt, nitrogen, carbon and iron atoms, which were initially bent, become linear. This structural modification is responsible for the existence of this magnetic state and its stability over time.

This knowledge on the atomic scale of the mechanisms associated with ON/OFF switching is an essential first step for chemists towards imagining materials that could be used by industry to store information on the scale of a few atoms.

These new compounds perfectly reproduce the storage function of traditional components. As it will soon be impossible to reduce the size of the current components without having them lose their memory functions, chemists are dreaming up materials that could take over and meet society's demand for miniaturized information storage.

Source: CNRS