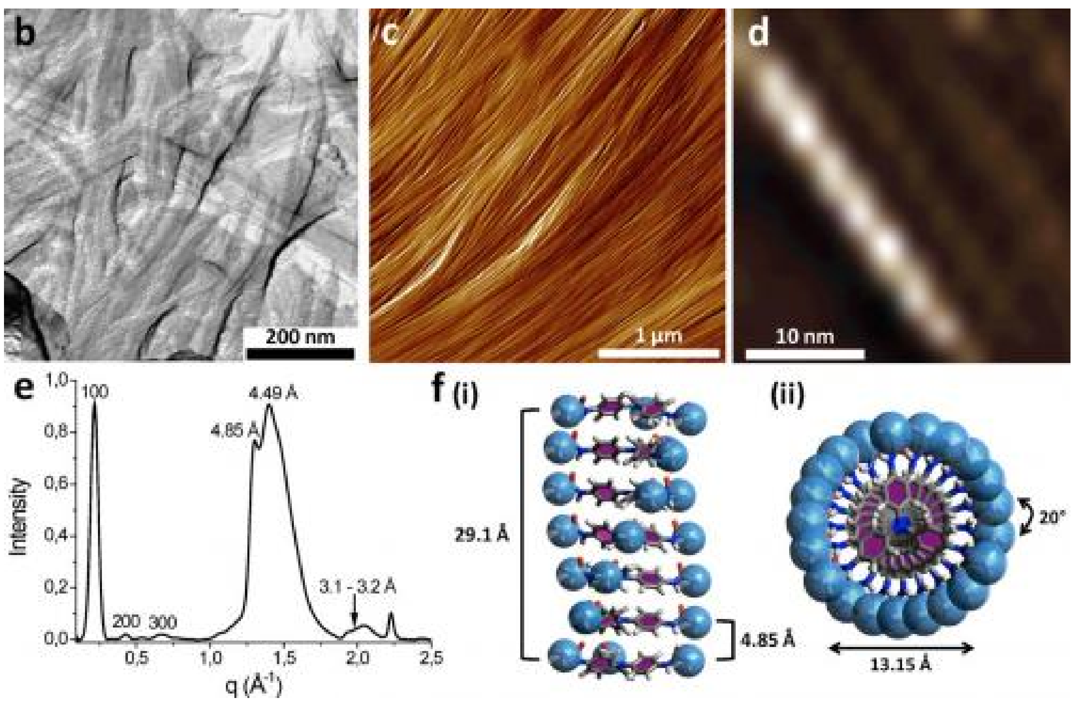
Highly conductive organic metal looks promising for disposable electronic devices

August 19 2014, by Lisa Zyga



(b-d) Images of the organic metal, TATA, are shown with different imaging techniques. (e) X-ray scattering of a thin film of TATA. (f) Side view (i) and top view (ii) of the proposed stacking structure of TATA. Credit: Armao, et al. ©2014 American Chemical Society

(Phys.org) —Although organic materials are often used as semiconductors, such as in organic LEDs and organic transistors, organic materials that have an electrical conductivity as high as that of metals are still very scarce. One problem with developing organic metals is that there is a tradeoff in terms of their crystalline structure: a high crystallinity is required for high conductivity, but is detrimental to the materials' processability.

Now in a new paper published in the *Journal of the American Chemical Society*, researchers Joseph J. Armao, IV, et al., at the University of Strasbourg in France, have demonstrated a way to overcome this problem by developing a new class of organic materials that are highly conductive yet very soft and flexible. When irradiated with a light pulse, the material reorganizes its molecules to correct structural defects. The new material can therefore be assembled with low crystallinity and then transformed via a light pulse into a material with high electrical conductivity.

"Historically, electronic devices have been developed with inorganic materials such as doped silicon, copper, silver, etc.," Nicolas Giuseppone, professor at the University of Strasbourg, told *Phys.org*. "These materials come from limited natural resources which are expensive to extract and process before even being suitable for manufacturing. Additionally, a big problem we have is electronic waste, as many of the inorganic materials used in electronics are quite toxic for the environment, and recycling these materials is difficult and expensive. Organic metals provide an alternative material which is cheaper, easier to produce, and environmentally friendly. In addition to replacing inorganic materials in the electronic devices we currently use, we may be able to create devices with novel properties and architectures through a combination of synthetic modification (at the molecular level) as well as control over the supramolecular organization (at the bulk level)."

The new material is a one-dimensional supramolecular polymer composed of stacks of molecular units called tris-amide triarylamines (TATA). Although these organic nanowires may originally suffer from the same structural defects as other organic materials, the application of a relatively low-energy light pulse can correct misalignments of the TATA stacks, essentially giving the polymers the ability to self-heal.

The results showed that light irradiation increased the conductivities of the suparmolecular polymers by up to four orders of magnitude, reflecting the effectiveness of the photoinduced supramolecular self-optimization. The study marks the first demonstration of supramolecular polymers that achieve electronic, magnetic, and optical signatures similar to those measured in the best conjugated polymers.

"I would say the greatest significance is (a) the ability to demonstrate metallic properties in a supramolecular system without the need to crystallize the material or resort to other processing techniques, (b) the demonstration that supramolecular systems, i.e. ensembles of molecules which are non-covalently bound, can possess characteristics found in conjugated polymers, (c) the ability to remotely trigger the healing mechanism and doping process with light, which creates a responsive material, and (d) the demonstration of a novel error correction mechanism driven by supramolecular polaron diffusion (charge-transfer interactions) within the assembled structures," Giuseppone said.

Highly conductive organic metals could have a variety of novel applications in organic electronics due to their advantages of being lightweight, low cost, and disposable. Applications include transparent electrodes, printed electronic circuits, thermoelectric materials, and memory devices.

"Future research plans include both applications of these materials in devices as well as further research into their fundamental properties," Giuseppone said. "In terms of applications, we are working towards incorporation of these organic assemblies as metallic interconnects for electronic circuitry, testing the efficacy of these materials in solar cells as well as trying to develop means for controlled vertical device architecture. Our fundamental work involves manipulation of optical and plasmonic fields as well as further elucidation and control over the conduction properties."

More information: Joseph J. Armao, IV, et al. "Healable Supramolecular Polymers as Organic Metals." *Journal of the American Chemical Society*. DOI: 10.1021/ja5044006