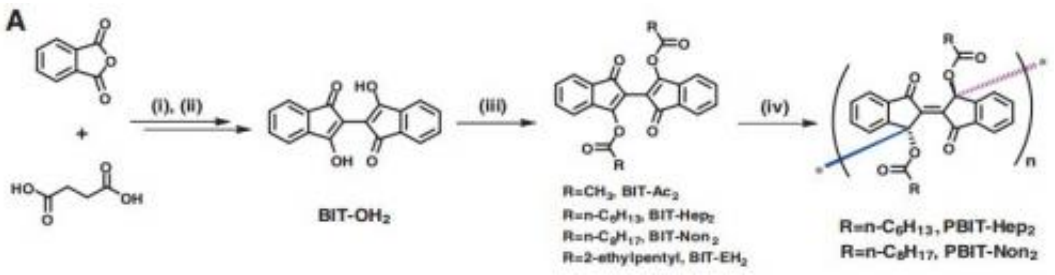
Researchers develop new kind of polymers that can be created using solid-state polymerization of organic dye molecules

January 17 2014, by Bob Yirka



Synthetic route to monomers and polymers. Reaction conditions: (i) melting reaction, potassium acetate, 220°C, 2 hours; (ii) methanol, sodium, 60°C, 30 min; (iii) acyl chloride, triethyl amine, dichloromethane, 0°C to room temperature, 3 hours; and (iv) where ħ is Planck's constant, n is the frequency, and l is the wavelength of the photon's radiation, ħn, l ~ 500 nm. Credit: *Science* 17 January 2014: Vol. 343 no. 6168 pp. 272-277 DOI: 10.1126/science.1245875

(Phys.org) —A team of researchers made up materials scientists and chemists from several institutions in California has developed a new group of polymers that can be caused to come about using solid-state polymerization of organic dye molecules. In their paper published in the journal *Science*, the team describes how their technique allows for using ordinary light to create long strand polymers via crystals of molecular diyne monomers.

In this new effort the team of researchers has found a way to develop a

class of polymers that arise from the interior crystalline molecules of a family of dyes. Such crystals are organized as monomers in their native state and because of their highly ordered structure are useful for creating polymers—strands are created by stitching the monomers together.

To create the polymers, the crystalline dyes are submerged in a solution of micro- or nanocrystalline aggregates. The reaction that occurs when light (which provides the energy for the system) is introduced causes the development of polymers on the outermost exposed monomers—by connecting them together. Doing so results in a loss of color which allows light to pass through to the next layer of monomers, allowing for the development of additional polymers which remain connected to the first layer. The process continues until all of the monomers have been reached. The end result is a crystal that is entirely colorless with polymers connecting all of the monomers together in long strands.

The researchers report that the entire reaction is reversible by exposing the crystal to high temperatures. They also report that they were able to remove individual strands of the polymer (or bundles of them) they created from the crystal using the "scotch tape" method. They note that one benefit of creating polymers using their technique is that it allows for creating polymer strands of virtually any length (bound only by the length of the original crystal) all of which are generally narrow.

The technique developed by the researchers should be applicable for use in other applications for creating other types of polymers, perhaps creating a whole new class. How such polymers would be used is still not clear, however, though stress applications come to mind as the researchers report that if a single strand breaks, color returns, highlighting the flaw.

More information: Single-Crystal Linear Polymers Through Visible Light–Triggered Topochemical Quantitative Polymerization, *Science* 17

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Abstract

One of the challenges in polymer science has been to prepare large-polymer single crystals. We demonstrate a visible light–triggered quantitative topochemical polymerization reaction based on a conjugated dye molecule. Macroscopic-size, high-quality polymer single crystals are obtained. Polymerization is not limited to single crystals, but can also be achieved in highly concentrated solution or semicrystalline thin films. In addition, we show that the polymer decomposes to monomer upon thermolysis, which indicates that the polymerization-depolymerization process is reversible. The physical properties of the polymer crystals enable us to isolate single-polymer strands via mechanical exfoliation, which makes it possible to study individual, long polymer chains.