The MIT have found a way to circumvent this problem by using a silyl linker that does not compromise mechanical strength nor other useful properties of thermoset plastics, but means that they can be recycled. The team has demonstrated proof of principle with the synthesis of a degradable modification of polydicyclopentadiene. At end of life, the polymer can be broken down into a powder and used to remake the polymer. Their theoretical analysis of the process suggests that the same approach would work for other thermoset plastics.

"This work unveils a fundamental design principle that we believe is general to any kind of thermoset with this basic architecture," explains team leader Jeremiah Johnson. Given that thermoset plastics cannot be returned to a liquid state after fabrication, unlike thermoplastics, there were until now completely limited in their re-use or recycling.

The silyl linker in the team's modified pDCPD allows them to retrieve a soluble form of the polymer using fluoride. The new material made from this recycled plastic powered is almost indistinguishable from virgin polymer and in some ways improves on the original thermoset plastic material's properties. "Showing that you can take the degradation products and remake the same thermoset again using the same process is exciting," Johnson enthuses.

Given how much plastic waste we are discarding in the environment the time is ripe for materials scientists and chemists to turn their attention to simple technology that allows us to retrieve even unrecyclable plastics for fabrication into new products. If researchers can find appropriate degradable monomers for other types of modified polymers, we could ultimately have recyclable acrylics, epoxies, and silicones, perhaps even degradable vulcanized rubber.

The new approach could allow car manufacturers and others to address sustainability concerns as well as providing the "raw materials" for recycling plants that are missing out on a vast waste stream when it comes to thermoset plastics.

David Bradley

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Bio-inspiration for making polyenes

A synthetic route to polyenes inspired by nature could open up new applications for these compounds in biomedical research and drug discovery. Given that these compounds have a role in various biological processes, the work might represent a turning point.

Ryan Gilmour of the University of Münster, Germany, and colleagues demonstrated a method for the synthesis of complex polyenes, such as retinoic acid, from simple alkene building blocks. The key to their success was the use of light-activated antenna molecules that facilitate energy transfer catalysis. [Molloy, Schäfer et al., Science (2020) doi: 10.1126/science.abb7235]

"The process provides us with a light-driven, operationally simple solution to a conundrum that has occupied us for a long time," explains team member John Molloy.

The team hoped to start with stereoisomers of their alkene building blocks, a critical move in terms of synthesizing the biological form of retinal, the vitamin A derivative, for instance. Historically, however, alkene geometry although it plays a pivotal role in biological function is underdeveloped as an area within synthesis, particularly when it comes to concatenating different building blocks to form more complex structures with numerous carbon–carbon double bonds along the length of a molecule. There are many approaches available to chemists hoping to make each isomer individually, but these often have poor selectivity and take too many separate reaction steps to be tenable in creating physiologically interesting polyenes.

The team has now shown that by attaching a light-activated unit, they can use light energy to flip the alkene to the appropriate isomer. They describe in detail their strategy for a photocatalytic isomerization of beta-borylacrylate derivatives that "enables access to both geometric isomers of ambiphilic C3 linchpins". Moreover, given that now both ends of the alkene are functionalized they can be extended iteratively to build more sophisticated structures all guided towards the biological form of a molecule like retinal rather than the various non-natural isomers that are possible. The Münster team demonstrated the power of their method in a short, stereocontrolled syntheses of two pharmaceuticals, isotretinoin (an acne treatment) and alitretinoin (an anticancer drug), both based on retinoic acid.

"This platform for the stereocontrolled generation of complex polyenes might prove to be expansive and may facilitate the exploration of these bioactive materials in drug discovery," the team concludes.

David Bradley

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Copper against Covid

Might the addition of copper to facemasks help reduce the risk of catching or spreading the coronavirus that causes the pandemic disease Covid-19?

The debate over whether we should be wearing facemasks is gradually settling on the side of caution. Many researchers have pointed out that we have not adopted facemasks as a strategy to any significant degree for respiratory pathogens previously. However, the current outbreak which at the time of writing has killed more than 600,000 people when outbreaks seems very different with so many people who are asymptomatic able to spread the disease before they know they are a carrier. A simple measure would be to wear a covering over one's nose and mouth to preclude the expulsion of infectious droplets into the air or on to surfaces. Researchers have already shown that a two-ply tightly woven cotton material sandwiching a layer of chiffon or silk to add an electrostatic barrier can reduce the passage of 98 percent of droplets.

Now, researchers at Indiana University Purdue University Indianapolis's Integrated Nanosystems Development Institute think we could add an additional defence to such a mask in the form of metallic copper oxide nanoparticles. Copper has been used throughout history for its germicidal properties although until the discovery of microbes its positive effects on health in this regard were inexplicable. Any virus that impinges on a copper surface will be disabled instantaneously, IUPUI's Mangilal Agarwal points out. He suggests that many consumer-level masks, as opposed to clinical grade masks do not have a sufficiently tight weave. A tighter weave or the addition of other fabric layers can make a mask less comfortable to wear as well as making it harder for the wearer to breathe. Such characteristics will have a negative effect on compliance while facemasks are not mandated through law.

The IUPUI researchers suggest that embedded copper oxide nanoparticles would add a kill layer so even if droplets do travel from one surface of the mask to the other with the attendant risk of infection that would imply, the copper will disable the virus en route. The team has pointedly turned its attention to this application of their earlier work to make lighter, stronger, and cheaper composites with the ultimate aim of offering the general public a wearable alternative to the expensive masks that healthcare workers are often required to wear.

"To make any fabric into a mask or filter, we have to provide the nanostructure, and we can put that nanostructure on a roll-to-roll printing machine with the fibers at nanoscale," Agarwal explains. "We are using electrospinning, using the electric field to spray the nanofibers on to the fabric."

David Bradley

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Nanotech for improved wound healing

In healthy individuals wounds will heal quickly with little intervention. However, in certain disease conditions, such as diabetes, the healing process, which involves migration, proliferation, and differentiation of different types of skin cells, is often compromised. This is a challenging problem in healthcare for those looking after chronically ill patients and post-operative skin cancer patients, as well as environments where antibiotic-resistant strains of pathogenic bacteria and microbial fungi might be present.

Chronic wounds and non-healing wounds can lead to serious issues of infection and tissue death, necrosis, and in extreme cases can require limb amputation.

Writing in the journal Applied Materials Today, a team from the Chinese Academy of Sciences, explain how molybdenum ions have, in laboratory tests, been shown to promote the migration and proliferation of human dermal fibroblasts cells, human umbilical vein endothelial cells, and human hair dermal papilla cells. They hypothesized that a material capable of carrying molybdenum nanoparticles might be used as a dressing that would steadily release these ions into the wound and trigger these cellular processes to accelerate healing where underlying health conditions were otherwise stymieing the natural wound-healing processes.

The team has now developed a novel synthesis of molybdenum sulfide nanoparticles which can be incorporated as clusters into a sodium alginate hydrogel. This material has a porous microstructure and carries within it a uniform distribution of molybdenum nanoparticles. The team has now demonstrated that their nanoparticle-laden hydrogel has a significant effect on promoting new blood vessel growth, angiogenesis, around the wound bed and also leads to regeneration of hair follicles. The tests were carried out on a wound present on an in vivo murine model of diabetes. [Ma et al., Appl. Mater. Today (2020) doi: 10.1016/j.apmt.2020.100735.]

The team also tested the hydrogel on wound healing in a nude mouse model of melanoma where wound healing is compromised by the presence of insidious skin cancer cells. The healing process in this case was improved by a photothermal process as well as the steady release of molybdenum(IV) ions into the wound site.

The team concludes that their nanoparticle-loaded hydrogel "may be one of the promising candidates for disease-impaired wound healing and provides a broad prospect for the development of skin regeneration in the future."

David Bradley

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Scintillating sintering improved

Laser additive manufacturing (LAM) based on laser powder bed fusion (LPBF) can be used to make components with complex shapes layer by layer from a CAD drawing or other digital design. The technique has now been used widely in the fields of aerospace, energy, and medicine. However, despite the precision that is achievable it suffers one critically limiting shortcoming when metal components are to be fabricated: the components can end up region regions of porosity, incompletely fuse, or develop cracks.

Materials scientists from the University of Sheffield have now worked with mechanical engineers from University College London and colleagues at The European Synchrotron, in Grenoble, France, have used ultrafast, in situ X-ray synchrotron imaging to look at the sintering processes that take place in LAM to help them understand why porosity arises. Porosity can lead to insidious weaknesses in safety–critical metallic components.

The team has also looked closely at the melt pool dynamics, keyhole porosity, and how spatter occurs during the fabrication process to clarify how this affects the layers as they are built up to make a component.