Self-Healing Hydrogel Polymer Using Ambient Carbon Dioxide Fixation
Technology #20907

Applications

This invention generates material hydrogels that grow and self-repair using atmospheric carbon dioxide and sunlight. Such materials are of interest to the transportation and construction industries as both will benefit from materials with self-repairing and carbon dioxide fixing properties.

Problem Addressed

Materials which can self-repair to correct damage have increased lifetimes and resistance against fatigue and acute mechanical stress. Current research to develop synthetic materials with self-repairing properties require one or more external stimuli (heating, pH, mechanical stress, UV light) to be initiated. These materials are therefore not self-sustaining. Materials that can autonomously detect and respond to damage are ideal but have only recently been introduced, each having sufficient limitations to preclude mass-scale application and commercialization. This invention creates a novel class of self-sustaining materials which can autonomously grow, repair and strengthen through carbon dioxide fixation in the presence of sunlight.

Technology

Utilizing embedded, extracted chloroplasts, this invention creates a novel class of materials which can grow, repair, and strengthen using atmospheric carbon dioxide and solar energy. Isolated chloroplasts are placed on graphene oxide film, functionalized with immobilized glucose oxidase. The film is then immersed in a buffer such as 3-aminopropyl methacrylamide (APMA). The presence of ambient light and atmospheric carbon dioxide for 18 hours at room temperature results in the formation of a hydrogel around the chloroplasts. Glucose exported from chloroplasts is converted to gluconolactone by the action of the enzyme glucose oxidase and reacted under relatively mild conditions with APMA to generate the polymer matrix. The matrix embedded with chloroplasts swells in water and continually grows, strengthens, and self-repairs using atmospheric carbon dioxide fixation and ambient light. Water absorption and swelling can increase the hydrogel weight 115-fold in 48 hours. When a gluconolactone solution is added to the interface of two physically separated hydrogels, the result is the formation of extensively repaired gels which can sustain stringent deformation.

A next generation material is also developed in which the function of chloroplasts is replaced with semiconducting photocatalysts like titanium dioxide or graphitic carbon nitrides. In these materials, the photocatalyst directs carbon dioxide reduction to formaldehyde. Domains performing this chemistry under ambient conditions can then be coupled into a material with differing pH to generate trioxane polymerized with a boron trifluoride or boron trifluoride diethyl etherate initiator.
Advantages

- Infinitely self-sustaining, self-repairing hydrogel that fixes carbon dioxide in the presence of sunlight
- Carbon dioxide fixation using chloroplasts or semiconducting photocatalysts

Categories For This Invention:

- Materials
- Polymers (Materials)
- Life Sciences
- Biomaterials
- Composites

Intellectual Property:

Materials exhibiting biomimetic carbon fixation and self-repair
US Patent Pending

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Publications:

Polymethacrylamide and Carbon Composites that Grow, Strengthen, and Self-Repair using Ambient Carbon Dioxide Fixation
Advanced Materials
October, 2018, 1804037

External Links:

Strano Lab
https://srg.mit.edu/
“Self-healing material can build itself from carbon in the air,” MIT News, 2018