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Toward fixing damaged hearts through tissue engineering

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In the U.S., someone suffers a heart attack every 34 seconds—their heart is starved of oxygen and suffers irreparable damage. Engineering new heart tissue in the laboratory that could eventually be implanted into patients could help, and scientists are reporting a promising approach tested with rat cells. They published their results on growing cardiac muscle using a scaffold containing carbon nanofibers in the ACS journal *Biomacromolecules*.

Gordana Vunjak-Novakovic, Rui L. Reis, Ana Martins and colleagues point out that when damaged, adult heart tissue can't heal itself very well. The only way to fix an injured heart is with a transplant. But within the past decade, interest in regenerating just the lost tissue has surged. The trick is to find materials that, among other things, are nontoxic, won't get attacked by the body's immune system and allow for muscle cells to pass the electrical signals necessary for the heart to beat. Previous research has found that chitosan, which is obtained from shrimp and other crustacean shells, nearly fits the bill. In lab tests, scientists have used it as a scaffold for growing heart cells. But it doesn't transmit electrical signals well. Vunjak-Novakovic's team decided to build on the chitosan development and coax it to function more like a real heart.

To the chitosan, they added carbon nanofibers, which can conduct electricity, and grew neonatal rat heart cells on the resulting scaffold. After two weeks, cells had filled all the pores and showed far better metabolic and electrical activity than with a chitosan scaffold alone. The cells on the chitosan/carbon scaffold also expressed cardiac genes at higher levels.

More information: "Electrically Conductive Chitosan/Carbon Scaffolds for Cardiac Tissue Engineering" *Biomacromolecules*, Just Accepted Manuscript. DOI: 10.1021/bm401679q

Abstract
In this work carbon nanofibers were used as doping material to develop a highly conductive chitosan-based composite material. Scaffolds based on chitosan only and chitosan/carbon composites were prepared by precipitation. Carbon nanofibers were homogeneously dispersed throughout the chitosan matrix, and the composite scaffold was highly porous with fully interconnected pores. Chitosan/carbon scaffolds had elastic modulus of 28.1 ± 3.3 KPa, similar to that measured for rat myocardium, and excellent electrical properties, with conductivity of 0.25 ± 0.09 S/m. The scaffolds were seeded with neonatal rat heart cells and cultured for up to 14 days, without electrical stimulation. After 14 days of culture, the scaffold pores throughout the construct volume were filled with cells. The metabolic activity of cells in chitosan/carbon constructs was significantly higher as compared to cells in chitosan scaffolds. The incorporation of carbon nanofibers also led to increased expression of cardiac-specific genes involved in muscle contraction and electrical coupling. This study demonstrates that the incorporation of carbon nanofibers into porous chitosan scaffolds improved the properties of cardiac tissue constructs, presumably through enhanced transmission of electrical signals between the cells.

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