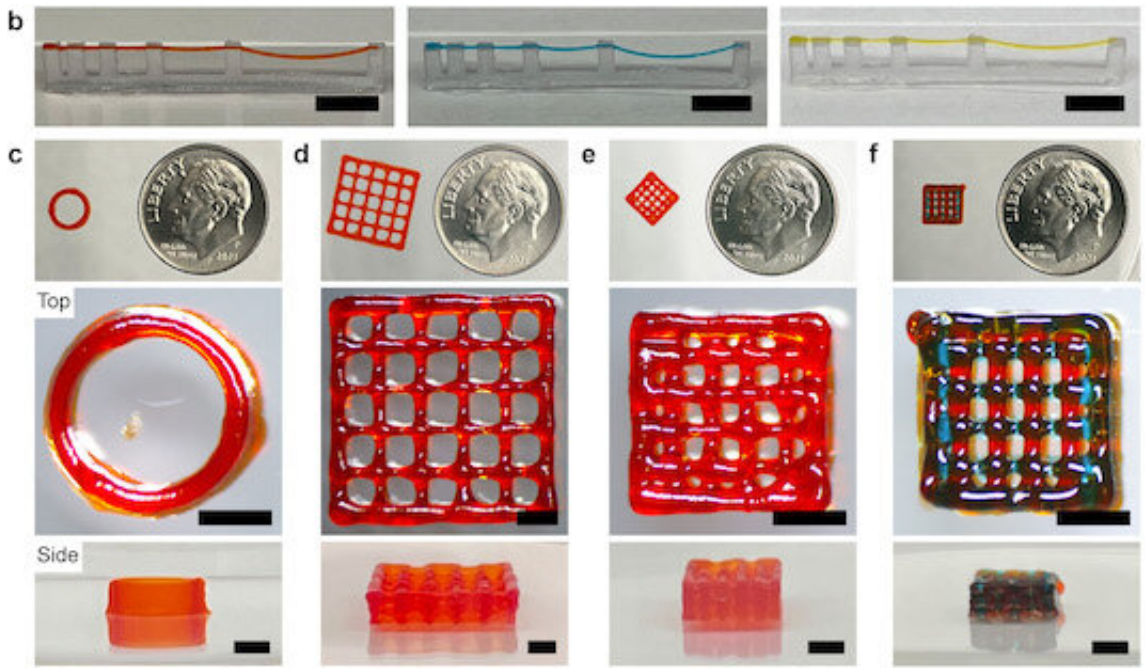
Peptide 3D-printing inks could advance regenerative medicine

February 7 2023, by Silvia Cernea Clark



Structures printed using the peptide-based 3D-printing ink developed by Rice's Hartgerink lab. A dime is included for scale. Credit: Hartgerink lab/Rice University

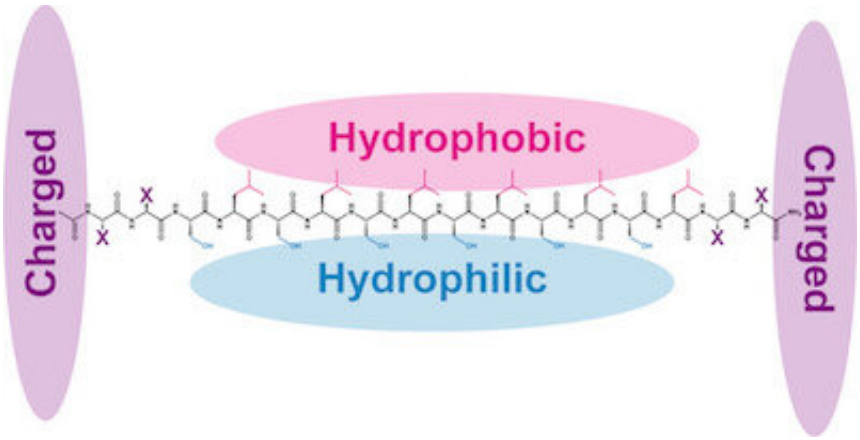
How do you build complex structures for housing cells using a material as soft as Jell-O? Rice University scientists have the answer, and it represents a potential leap forward for regenerative medicine and medical research in general.

Researchers in the lab of Rice's Jeffrey Hartgerink have figured out how to 3D-print the well-defined structures using a self-assembling peptide ink. "Eventually, the goal is to print structures with cells and grow mature tissue in a petri dish. These tissues can then be transplanted to treat injuries, or used to learn about how an illness works and to test drug candidates," said Adam Farsheed, a Rice bioengineering graduate student and lead author of the study, which appeared in *Advanced Materials*.

"There are 20 naturally occurring amino acids that make up proteins in the human body," Farsheed said. "Amino acids can be linked together into larger chains, like Lego blocks. When amino acid chains are longer than 50 amino acids, they are called proteins, but when these chains are shorter than 50 amino acids they are called peptides. In this work, we used peptides as our base material in our 3D-printing inks."

Developed by Hartgerink and collaborators, these "multidomain peptides" are designed to be hydrophobic on one side and hydrophilic on the other. When placed in water, "one of the molecules will flip itself on top of another, creating what we call a hydrophobic sandwich," Farsheed said.

These sandwiches stack onto one another and form long fibers, which then form a hydrogel, a water-based material with a gelatinous texture that can be useful for a wide range of applications such as tissue engineering, soft robotics and wastewater treatment.



The structure of a multidomain peptide used as a building block for a 3D-printing ink by Rice's Hartgerink lab. Credit: Hartgerink lab/Rice University

Multidomain peptides have been used for nerve regeneration, cancer treatment and wound healing, and have been shown to promote high levels of cell infiltration and tissue development when implanted in living organisms.

"We know that the multidomain peptides can safely be implanted in the body," Farsheed said. "But what I was looking to do in this project was to go in a different direction and show that these peptides are a great 3D-printing ink.

"It might be counterintuitive since our material is so soft, but I recognized that our multidomain peptides are an ideal ink candidate because of the way they self-assemble," he continued. "Our material can reassemble after being deformed, similar to how toothpaste forms a nice fiber when pushed out of a tube."

Farsheed's mechanical engineering background allowed him to take an unconventional approach when testing his hypothesis.

"I had more of a brute-force engineering approach where instead of chemically modifying the material to make it more amenable to 3D printing, I tested to see what would happen if I simply added more material," he said. "I increased the concentration about fourfold, and it worked extremely well.

"There have been only a handful of attempts to 3D-print using other self-assembling peptides, and that work is all great, but this is the first time that any self-assembling peptide system has been used to successfully 3D-print such complex structures," Farsheed continued.

The structures were printed with either positively charged or negatively charged multidomain peptides, and immature muscle cells placed on the structures behaved differently depending on the charge. Cells remained balled up on the substrate with a negative charge, while on the positively charged material the cells spread out and began to mature.

"It shows that we can control cell behavior using both structural and chemical complexity," Farsheed said.

Hartgerink is a professor of chemistry and bioengineering and associate chair for undergraduate studies. Farsheed is a bioengineering graduate student and lead author on the study. Additional study co-authors are undergraduate student Adam Thomas and graduate student Brett Pogostin.

More information: Adam C. Farsheed et al, 3D Printing of Self-Assembling Nanofibrous Multidomain Peptide Hydrogels, *Advanced Materials* (2023). DOI: 10.1002/adma.202210378

Provided by Rice University

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