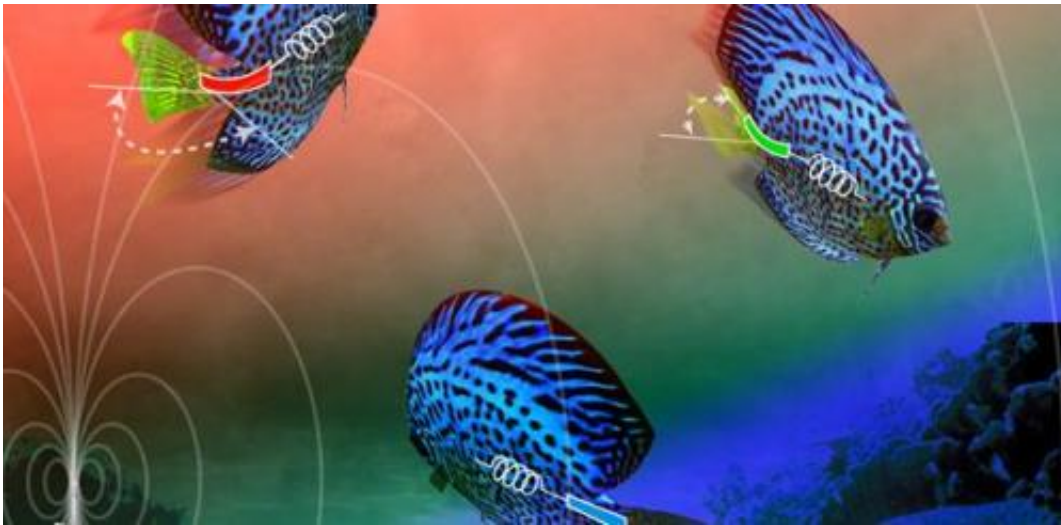# Artificial muscle capable of 'remembering' movements developed

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Artificial fish. Credit: Stoyan Smoukov

Researchers from the University of Cambridge have developed artificial muscles which can learn and recall specific movements, the first time that motion control and memory have been combined in a synthetic material.

The 'muscles', made from smooth plastic, could eventually be used in a wide range of applications where mimicking the movement of natural muscle would be an advantage, such as robotics, aerospace, exoskeletons and biomedical applications.

Although artificial muscles (actuators) and polymers that can remember shapes exist, movement and memory have not yet been incorporated in the same material. Now, University of Cambridge researchers have produced such a material, known as polymeric electro-mechanical memory (EMM). Details are published in the journal *Materials Chemistry C*.

The movement of the [artificial muscle](#) developed by the Cambridge researchers, can be manipulated, stored, read, and restored independently. It can store, learn, and later recall, a variety of different movements.

Muscles are the bundles of cells which make movement in animals possible. There are three different types of muscle in vertebrates such as ourselves: the cardiac muscles of the heart, the involuntary muscles which regulate the movements of organs, such as the intestine and bladder, and the muscles which produce voluntary movement at joints and on the face.

If a movement in voluntary muscle is repeated enough times, a type of muscle 'memory' is developed. For example, a violinist practising the same passage over and over will eventually be able to perform the passage without needing to think about it: the brain develops a procedural memory of the passage, and can quickly instruct the fingers to perform the correct movements. This sort of unconscious movement learned through repetition is known as [muscle memory](#), and is something we use every day: when riding a bicycle, for instance.

Most artificial muscles are made of polymers which change size or shape when they receive an electrical signal. Through a number of mechanisms and stimuli, movement reasonably approximating natural muscles can be reproduced in an artificial material.

"Muscles in animals have the ability to both control motion and develop muscle memory in the same tissue, but reproducing these multiple functions in an artificial muscle has not been possible until now," said Dr Stoyan Smoukov of the Department of Materials Science & Metallurgy, who led the research.

After chemically modifying thin strips of a bendable, commercially-available material which is used in batteries and fuel cells, the researchers then programmed a variety of shapes at different temperatures and taught the artificial muscle to 'remember' the movement associated with each shape. The movements can later be recovered one-by-one, on demand, by going back to the temperature which was used to programme it.

The shape and movement transformations are reversible: the restored states can be cycled thousands of times using low voltage inputs (between one and two volts). These low voltages and the potential biocompatibility of the muscles could lead to bio-implantable devices. The researchers also analysed the dependence of the movement on the amount of mechanical programming, and the mechanism underlying the muscles' behaviour.

Based on the success of the proof-of-concept material they developed, the Cambridge researchers are now developing a general methodology to create muscles which incorporate different types of functionality.

  More information: *Materials Chemistry C*, pubs.rsc.org/en/content/articl … c00904e#!divAbstract

Provided by University of Cambridge