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Nanotubes strengthen artificial muscles

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BEST known as the ultra-strong material that might one day form the cables of a "[space elevator](#)" capable of raising people into Earth orbit, carbon nanotubes also have a springy side. The discovery that nanotubes keep bouncing back after being compressed repeatedly means this exotic form of carbon may be just the thing to give artificial muscles some extra strength.

Engineers want to build artificial muscles - actuators that change length in response to a stimulus - because they create a smoother, more human-like motion than jerky electric motors or pneumatic devices. Such muscles would be used to power robots, prosthetic limbs and artificial tissue for implantation.

Today's most promising artificial muscles are based on electroactive polymers (EAPs) - plastics that change shape when activated electrically or with chemicals. But they lack mechanical robustness and as a result soon succumb to fatigue and fail. Now engineers led by Victor Pushparaj at the [Rensselaer Polytechnic Institute](#) in Troy, New York, say that carbon nanotubes could toughen up artificial muscles.

To test the nanotubes ability to resist fatigue, the team took a 2-millimetre-square block in which many millions of nanotubes were aligned vertically, and repeatedly compressed it between two steel plates once every 0.75 seconds for over 100 hours. Even after 500,000 compressions, in which the tubes were repeatedly squashed to 75 per cent of their original length, the block kept ping-ponging back almost to its original shape ([Nature Nanotechnology, vol 2, p 417](#)). "The nanotubes buckled in a zig-zag shape but regained their original shapes when the load was released," says Pushparaj. The discovery only applies to large groups of nanotubes: individual nanotubes do not spring back, although it is not yet clear why.


The springiness, and the discovery that it remains even after hundreds of thousands of compressions, is similar to real muscles' ability to return to their original shapes over a lifetime of perpetual extension and contraction. As a result, the researchers are now combining nanotubes with various EAPs - which control when an artificial muscle gets stretched - to improve their resistance to fatigue. Yoseph Bar-Cohen, an artificial muscle engineer at NASA in Pasadena, California, agrees that nanotubes' long fatigue life is "an important property".

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