Knights of SPACE! Chain mail-inspired material that can hold over 30 times its own weight could be used in astronauts' spacesuits in the future, scientists say

- **The material was developed by experts at the California Institute of Technology**
- **They 3D printed the flexible covering that can hold up to 30 times its own weight**
- **It starts off flexible and can drape over anything, then turn rigid and protective**
- **This could be used in spacesuits and even on spacecraft to protect from rocks**

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A new material inspired by chain mail used in armour worn by medieval knights could be used to create spacesuits of the future, according to its developers.

The material can hold over 30 times its own weight while also being flexible, and was created by experts from the **California** Institute of Technology in Pasadena.

As well as helping astronauts walk on Mars in the future, the 3D printed material may also cover the spacecraft - shielding it from meteorites and other deep space perils.

More down to Earth, it offers extra protection for sports men and women due to its ability to turn from soft and bendable to rigid and back again.

The hi-tech garment also opens the door to a smart exoskeleton that enables paralysed people to walk again, or could provide armour for modern soldiers.

The team hasn't said how much the 3D printed material will cost or even when it will be available for use commercially or in spacecraft.

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Traditional chain mail, as worn by knights in the medieval-era, is made up of a series of linked metal rings.

When put together they are designed to be firm and strong but also pliable, so they can be worn on the body.

It cushioned warriors from arrows and blows from swords, axes, maces and other weapons, while snuggly draping round their body.

The new textile, created in California, is made from plastics rather than fibres or metal, and switches between rigid and soft states as necessary.

Project leader Professor Chiara Daraio says the material is tunable.

'Stiffness changing material may be used in space applications,' he said.

'Indeed, one of our co-authors Dr Doug Hofmann is from NASA's Jet Propulsion Laboratory.

'We think fabrics that can change stiffness on command could be very useful in deployable structures that change shape and size - as protective layers.'

Such devices are used in solar panels and sails on spacecraft.

'When fabricated at different scales, or with different constitutive materials, they could be used as either protective wearables or for emergency shelters,' said Daraio.

In tests, when any pressure was exerted the layers of interlocked particles underwent a phenomenon known as 'jamming transition'.

This profoundly altered the mechanical make-up, transforming the hollow shells from floppy to hard, according to Daraio, who said it could be useful in a range of robotic and medical applications in the future.

HOW IT WORKS: 3D PRINTED CHAIN MAIL-INSPIRED MATERIAL

Structured fabrics, such as woven sheets or chain mail , derive their properties both from the constitutive materials and their geometry.

Their design can target desirable characteristics, such as high impact resistance, thermal regulation, or electrical conductivity.

Once realised, however, the fabrics' properties are usually fixed.

This material is a structured fabric with tunable bending modulus, consisting of three-dimensional particles arranged into layered chain mails.

The chain mails conform to complex shapes, but when pressure is exerted at their boundaries, the particles interlock and the chain mails jam.

'We show that, with small external pressure (about 93 kilopascals), the sheets become more than 25 times stiffer than in their relaxed configuration,' the team wrote.

'This dramatic increase in bending resistance arises because the interlocking particles have high tensile resistance, unlike what is found for loose granular media.'

'Our work provides routes towards lightweight, tunable and adaptive fabrics, with potential applications in wearable exoskeletons, haptic architectures and reconfigurable medical supports.'

The US team 3D printed the chain mail, in which each link was constructed from connecting struts and then put in a sealed plastic bag and pumped out the air.

When the air was removed the resulting pressure increased stiffness by a factor of more than 25, the team discovered.