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The Materials Science of Superheroes

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While materials scientists don't typically consult comic books when selecting research topics, innovations first introduced in superhero adventures as fiction can sometimes find their way off the comic book page and into reality. As amazing as the Fantastic Four's powers is the fact that their costumes are undamaged when the Human Torch flames on or Mr. Fantastic stretches his elastic body. In shape memory materials, an external force or torque induces a structural change that is reversed upon warming. Smart fabrics used in hiking clothing expand at low temperatures, while other materials increase their porosity at higher temperatures, allowing body heat and water vapor to escape. Some polymers can be stretched to over twice their normal dimensions and return to their original state when annealed, a feature appreciated by Mr. Fantastic. In order to keep track of the Invisible Woman, the Fantastic Four's arch nemesis Dr. Doom employed sensors in the eye-slits of his armored face-plate, using the same physics underlying night vision goggles. Certain forms of blindness may be treated using an artificial retina consisting of silicon microelectrode arrays, surgically attached to the back of the eye, that transmit a voltage to the optic nerve proportional to the incident visible light intensity (one of the few positive applications of Dr. Doom's scheming). Spider-Man's wall crawling ability has been ascribed to the same van der Waals attractive force that gecko lizards employ through the millions of microscopic hairs on their toes. Scientists have recently developed "gecko tape," consisting of arrays of fibers that provide a strong enough attraction to support a modest weight. Before this tape is able to support a person, however, major materials constraints must be overcome (if this product ever becomes commercially available, I for one will never wait for the elevator again!) All this, and the chemical composition of Captain America's shield, will be discussed.