

NASA TECH BRIEF



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Carbon Offers Advantages as Implant Material in Human Body

Evidence from several sources indicates that a number of high-purity, high-strength carbon or graphite composites which have been developed for aerospace applications are chemically, biologically, and physically compatible with the fluids and tissues in the human body. In addition to their high strength and long-term biocompatibility, these materials can be readily fabricated into complex configurations and are amenable to several of the commonly used sterilization techniques. Because of these characteristics, the aerospace carbonaceous materials are proposed as surgical implants to correct various pathological conditions in the body resulting from disease or injury.

An example of the possible medical use of the carbonaceous materials would be as *cosmetic and protective bone replacements* in the skull, face, and hands. In present practice, stainless steel (or other metal) replacements are prepared as inlays and secured to the adjacent bone by pins or screws. However, stainless steel has been found to degrade substantially with time from chemical and galvanic corrosion. This results in reduced strength of the replacement and probable toxic reaction of the host tissues to the corrosion products. The carbonaceous materials could be advantageously substituted directly for metals in this application. Other suggested uses of the carbonaceous materials in the body are outlined below.

Implantable Splints. Such splints are generally beams or elongated plates attached directly to the damaged bone by pins or screws. They extend sufficiently beyond the damaged area to carry the full loading from the undamaged area on one side of the fracture to the undamaged area on the other side. This arrangement permits the damaged area to repair itself without being displaced or disturbed by the body

activity. While it is desirable to leave the splints in permanently, the degradation of the metals presently used is found to make their eventual removal often mandatory. In some cases, it has been found necessary to remove them even before healing is completed, either because of the toxicity of the corrosion products or the decline of structural integrity in the splint. Substitution of carbonaceous materials for metals promises to alleviate these problems.

Myoelectric Probes. These devices are implanted in the desired muscle tissue to pick up (or introduce) the small electrical signal (picowatts to nanowatts) by which the nervous system instructs the muscle to perform. In medical research they are used to study the phenomena of motor control and reactions to various stimuli. In rehabilitation, attempts are being made to utilize the naturally occurring myoelectric signals to control externally powered prosthetic devices. The apparent galvanic inertness of the carbons indicates that they should be very desirable materials for this application when implanted to provide a percutaneous electrical conductor. Flexibility of the carbon filaments or small-diameter rods would permit normal motion of the body member without disturbing the implant.

Epithelial Bone Extensions. The orthopedic concept involved is based on the premise that bone can be induced to grow to an inorganic member designed to pick up mechanical loads external to the body and transfer them directly into the skeletal structure. Materials that have been investigated to date are corrosion-resistant metals and high-strength ceramics. Success has been very limited because of corrosion problems and rejection of these materials by the body tissues. The carbon materials show promising potential for this application.

(continued overleaf)

Circulatory Bypass Implants. In hemodialysis and other treatments of the bloodstream, it is desirable to implant a bypass connection permanently into an artery and the corresponding vein so that the blood may be circulated through auxiliary equipment outside the body and returned to the normal bloodstream after treatment. Materials presently used for this purpose are stainless steels and various polymers. The steels lack long-term biocompatibility, and the polymers are not sufficiently durable, so that the implants must be replaced more frequently than is desirable. The improved biocompatibility expected from the substitution of the carbon materials, coupled with their high physical strength, indicates their attractiveness for this application.

Implantable Prosthetics. The preferred materials presently used for anatomical joint replacement (e.g., for hip joints) are type 316 stainless steel, certain titanium alloys, and in some cases, ultrahard materials, such as stellite. Degradation of these materials is principally attributable to low-rate galvanic action with the body fluids, which results in surface, intergranular, or massive corrosion and consequent loss of structural integrity of the metals. In some cases, the corrosion products are also toxic to the host organism. In almost all cases, mobility of the joint decreases because of substantially increased friction. The structural properties of certain aerospace carbons closely approximate those of type 316 stainless steel, and in addition these carbons provide self-lubrication on bearing surfaces. These carbons therefore appear to

offer excellent potential as replacements for anatomical joints.

Replacement Heart Valves. One of the most widely used replacement heart valves is the Starr-Edwards design, a simple ball-in-cage check valve. Some recent reported failures of this valve, are apparently due to deterioration of the ball by a very slow chemical reaction with the bloodstream. Vitreous carbon spheres can be produced in a variety of sizes to very precise dimensions and with polished surfaces. By making them hollow, their normal specific gravity can be matched to the bloodstream to provide neutral buoyancy, thus reducing inertial effects. This material is heat-sterilizable and is apparently unaffected by the conditions encountered in the body.

Note:

This information is presented as a concept only. Questions may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
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