BIOCOMPOSITE MATERIALS (11)

Biocomposites are composite materials composed of biodegradable matrix and biodegradable natural fibres as reinforcement. The development of biocomposites has attracted great interest due to their environmental benefit and improved performance [50]. Plant-based fibers like flax, jute, sisal and kenaf have been frequently used (Table 8). Most of studies concern biodegradable matrix based on aliphatic polyesters reinforced with various vegetable fillers. With wide-ranging uses from environment-friendly biodegradable composites to biomedical composites for drug/gene delivery, tissue engineering applications and cosmetic orthodontics. They often mimic the structures of the living materials involved in the process in addition to the strengthening properties of the matrix that was used but still providing biocompatibility. Those markets are significantly rising, mainly because of the increase in oil price, and recycling and environment necessities [51].

Bone itself achieves most of its mechanical properties as a natural composite material composed of calcium phosphate ceramics in a highly organized collagen matrix. Composite biomaterials are made with a filler (reinforcement) addition to a matrix material in order to obtain properties that improve every one of the components. This means that the composite materials may have several phases. Some matrix materials may be combined with different types of fillers. Polymers containing particulate fillers are known as particulate composites. The first composite to come into general use, initially made by an orthopedic surgeon, was the plaster of Paris bandage. This has been refined to fiberglass with a polymeric matrix in the current synthetic casting materials. A composite for internal prosthetic applications is based on the addition of chopped carbon fiber to improve the mechanical properties of polyethylene components [52]. Only carbon fiber is being studied for orthopedic applications [53]. Composite structures are typically produced from laminates. A laminate is a thin sheet of composite material in which all the fibers run in one direction and are held together by a thin coating of the polymer matrix material. This laminate is combined with other laminates to form a bulk composite; the properties of this composite vary depending on the orientation of each layer of the laminate [54]. None of these materials are currently in clinical use because of the inability to modify the shapes of the implants intraoperatively to fit the bone; because of liberation of carbon fibers into the adjacent tissues; and because the difficulties of predicting the resorption of polymers in larger loadbearing implants, as opposed to screws and pins, has thus far precluded their use for these larger implants. No doubt, implants in this category will be available in the future, perhaps even containing bone inductive proteins.

TABLE 8 CONSTITUENTS OF BIOMEDICAL COMPOSITES

Particles	Fibers	Matrix
Inorganic	**Polymers**	**Thermosets**
Glass	**Aromatic**	**Epoxy**
Alumina	**Polyamides**	**Polyacrylates**
	(aramids)	**Polymethacrylates**
	UHMWPE	**Polyesters**
	Polyesters **Polyolefins** **PTFE**	**Silicones**
Organic	**Resorbable**	**Thermoplastics**
Polyacrylate	**polymers**	**Polyolefins (PP,**
Polymethacrylate	**Polylactide, and its**	**PE)**
	copolymers with	**UHMWPE**
	polyglycocolide	**Polysulfones**

V. CONCLUDING REMARKS

A biomaterial is any substance (other than drugs), natural or synthetic, that treats, augments, or replaces any tissue, organ, and body function. Biomaterial selection is one of the most challenging issues due to crucial requirements and biocompatibility, so it has been of major interest to material designers in recent years. This review of biomaterials has attempted to demonstrate the very significant progress that has been made with the use of advanced materials within the human body. The present study reviewed the currently used biomaterials; metals, ceramics, polymers, and composite.

Metals are susceptible to degradation by corrosion, a process that can release by-products that may cause adverse biological responses. Ceramics are attractive as biological implants for their biocompatibility. The studies show that alumina with high mechanical strength show minimal or no tissue reaction, nontoxic to tissues and blood compatibility tests were also satisfactory. Carbon with similar mechanical properties of bone is an exciting candidate, for it elicits blood compatibility, no tissue reaction and nontoxicity to cells. The availability of a wide range of polymers significantly influenced the growth of tissue engineering and controlled drug delivery technologies. innovations in the composite material design and fabrication processes are raising the possibility of realizing implants with improved performance. However, for successful application, surgeons must be convinced with the long term durability and reliability of composite biomaterials.

in the past, success of materials in biomedical applications was not so much the outcome of meticulous selection based on biocompatibility criteria but rather the result of serendipity, continuous refinement in fabrication technology, and advances in material surface treatment. in the present and future, election of a biomaterial for a specific application must be based on several criteria. Biocompatibility is the paramount criterion that must be met by every biomaterial. Medical research continues to explore new scientific frontiers for diagnosing, treating, curing, and preventing diseases at the molecular/genetic level. This review should be of value to researchers who are interested in the state of the art of biomaterial evaluation and selection of biomaterials.

TABLE 9 APPLICATION OF COMPOSITE AS IMPLANTS USED IN HUMAN BODY

Applications	Types of materials
Dentistry	**CF/C, SiC/C,CF/Epoxy, GF/Polyester, GF/PC, GF/PP, GF/Nylon, GF/PMMA,UHMWPE/PMMA, cf/pmma, gf/pmma, kf/pmma, Silica/BIS-GMA**
Vascular Grafts	**Cells/PTFE, Cells/PET, PET/Collagen, PET/Gelation, PU/PU-PELA**
Joint replacements	**PET/PHEMA, KF/PMA, KF/PE, cf/ptfe,cf/plla, gf/pu, pet/pu, PTFE/PU, CF/PTFE, CF/C, cf/uhmwpe,uhmwpe/uhmwpe, CF/Epoxy, CF/PS, CF/PEEK, cf/uhmwpe, cf/pe,**
Bone cement	**Bone particles/PMMA, Titanium/PMMA, UHMWPE/PMMA, GF/PMMA, CF/PMMA, Bio-Glass/Bis- GMA**
Bone Replacement Materials	**HA/PHB, HA/PEG-PHB, CF/PTFE, PET/PU, HA/HDPE, HA/PE, Bio-Glass/PE, Bio-Glass/PHB, Bio-Glass/PS, HA/PLA**
Spine Cage, Plate, Rods, Screws, Disc, Finger Joint, Intramedullary Nails, Abdominal wall Prosthesis,	**PET/PU, PET/Collagen, CF/LCP, CF/PEEK, GF/PEEK, CF/Epoxy, CF/PS, Bio-glass/PU, Bio-glass/PS, PET/SR, PET/Hydrogel, CF/UHMWPE**
Silk	**Poly(ether ketones)**
Silk	**Poly(ether ketones)**
Collagen	**Polyesters**
Inorganic	**Inorganic**
Carbon	**Hydroxyapatite**
Glass	**Glass ceramics**
Hydroxyapatite	**Calcium carbonate**
Tricalcium	**ceramics**
Phosphate	**Calcium phosphate ceramics Carbon Steel Titanium Resorbable polymers Polylactide, polyglycolide and their copolymers Polydioxanone**