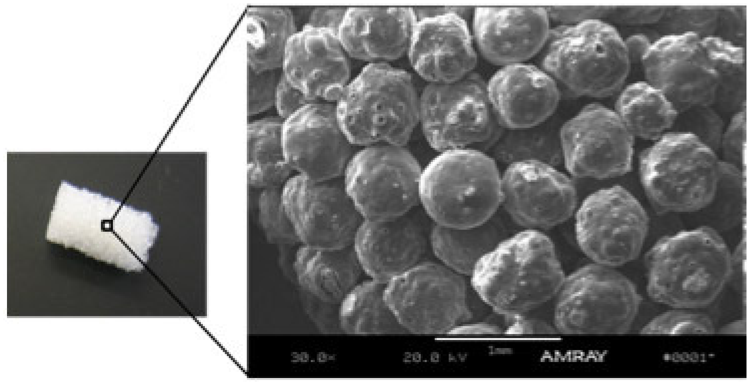
BOTM: March 2008

Biocompatible, Biodegradable Polymers

Polymers are long chains of repeating structural units or molecules known as monomers, and form a class of materials distinct from metals and ceramics. The physical and chemical properties of polymers can vary widely based on several parameters such as the type or types of monomers used to compose the long chains, and the overall length of these monomer chains, also known as the molecular weight. Polymers have been used as biomaterials for various applications such as vascular grafts of both large diameter (polyethylene terephthalate) and small diameter (expanded polytetrafluoroethylene, or Gore-texÂ®), hip and knee implant components (ultrahigh molecular weight polyethylene), and bone cements (polymethylmethacrylate). These materials have shown excellent biocompatibility and are able to exist in the body for long periods of time during which they elicit mild to no immune response. They are, however, nondegradable polymers and will remain in the body until removed and may suffer from undesirable erosion over time. Although this nondegradable design is ideal for implant materials intended to perform a function for an extended period of time, in instances where the erosion of the material is desirable, such as for the release of an encapsulated material (for drug delivery) or to allow the replacement of the material by endogenous tissue (tissue regeneration), degradable polymers are a much more attractive alternative.



Degradable polymers are distinct from nondegradable polymers in that over time the molecular structure breaks down, allowing the polymer to slowly disintegrate or degrade. When used for biological applications like drug delivery or tissue regeneration, these polymers are often designed to degrade hydrolytically (through contact with aqueous solutions like body fluid) over controlled periods of time. Some of the more widely used and most widely studied degradable polymers are within the polyester family of polymers, and include polylactide, polyglycolide, and their co-polymer poly(lactide-co-glycolide). These polymers can exhibit a range of degradation times based on either their molecular weight or their lactide:glycolide ratio (for the copolymer) and therefore have broad appeal in orthopaedic, vascular, and drug delivery applications.

Due to the inherent properties of poly(lactide-co-glycolide), ie. controllable degradation time, biocompatibility, rigidity at body temperature, and relatively low melting point, structures formed from this polymer can take on various shapes and architectures, depending on the particular application. One application that has shown considerable success is that of a three-dimensional scaffold for bone regeneration. Utilizing microspheres that are fused through heat sintering, porous structures have been fabricated that both encourage bone regeneration and provide a mechanical support system during skeletal repair. Combining this material (see figure) with other bone-friendly materials like calcium phosphate (see October 7, 2007 Biomaterial of the Month) has also been found to encourage bone repair. This is only one potential application of degradable polyesters such as poly(lactide-co-glycolide), the limits of which are governed by the physicochemical properties of the polymer and the imagination of the engineer.