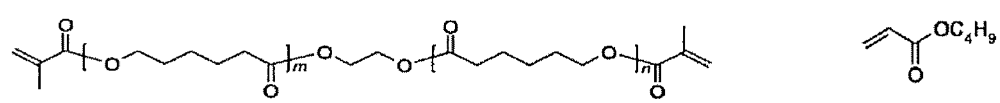
Synthetic Polymers for Biocompatible Biomaterials

J. Kwansima Quansah Materials Literature Seminar September 23, 2004

Scientists define biomaterials as substances other than food and drugs contained in a therapeutic or diagnostic system that are in contact with tissue or biological fluid.[1, 2] Biomaterials are used in a wide variety of applications including implants (e.g. cardiovascular, plastic, reconstructive, dental and neural), controlled drug delivery, and general surgery.[3] Clinicians have generally chosen the materials used in the body, with little to no input by chemists or chemical engineers.[1] This has often led to serious medical complications including infection, and outright rejection of implanted material by the body. Ideal materials for biomaterial applications should be biocompatible.[3,4]

Synthetic polymers present an attractive avenue for biocompatible biomaterials because of their well studied syntheses and modifiable properties.[5, 6] Several synthetic polymers have already been found to be biocompatible- examples include poly(glycolic acid) copolymers as absorbable sutures and poly(urethane) in the artificial heart. Biocompatible polymers can be made into devices directly or incorporated into devices by coating to reduce the chance of rejection upon incorporation into the body. There has been significant development in recent years of shape memory materials, tissue engineering, and coronary stents for use as biocompatible biomaterials.

In 2001, Lendlein and coworkers reported the synthesis of an ABA triblock polymer network based on oligo(ε-caprolactone) segments which showed shape memory properties;[7] that is, this polymer can change its shape in response to external stimuli.[8] Polymeric materials such as this polymer are a good substitute for the traditional metal alloys. Alloys such as Nitinol (Titanium and Nickel) or stainless steel have been used in reconstructions. These alloys have limited use because of their narrow range of mechanical properties and their inability to biodegrade. Using Poly(ε-caprolactone) dimethyacrylate (PCLDMA) and varying n-butylacrylate (structures shown below) as the co-monomer, Lendlein et al. synthesized a very malleable, biocompatible, and biodegradable polymer. Additionally, as the concentration of copolymers can alter the physical and mechanical properties obtained, the polymer can be tuned for different applications.



Poly(ε-caprolactone)dimethyacrylate (PCLDMA) and n-butylacrylate

Tissue replacement problems have been aided by developments in tissue engineering.[5, 9, 10] Skin, bones and cartilage tissue have been engineered using selective cell transplantation on polymer scaffolds. However, an unmet challenge in this field is the regeneration of tissue capable of growing over time (e.g. in concert with the growth of a child). Mooney and coworkers reported a solution by the engineering of a bony tissue with built in growth stimuli from the cell transplantation scaffold.[11] With this, they were able to generate synthetic tissues which show significant growth over time.

Another area of interest is the coronary stent.[12, 13] The use of stents has greatly improved the results of coronary revascularization.[14] However, in-stent restenosis (re-closing) limits their use. Radiation therapy for the treatment of restenosis been considered.[15] Radiation effects associated with treatment as well as cost of the procedure has however hindered further development. Drug eluting stents have also been investigated. Sirolimus is a drug which inhibits the proliferation of cells which lead to restenosis. Morice and coworkers report that by coating the stents with a polymer matrix blended with sirolimus (Schematic of stent is shown in Figure 1 below), a significantly lower occurrence of cardiac events was observed.[16] They report a reduced number of deaths compared to patients with non-sirolimus eluting stents.

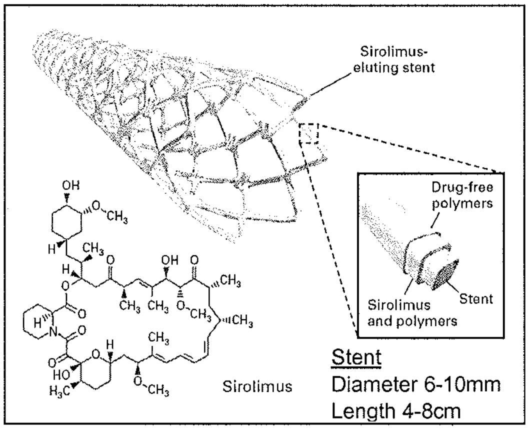


Figure 1: Schematic of the drug eluting stent.

Tremendous steps have been taken in the last decade or so towards solving various healthcare problems by the development of specific biomaterials. Multiple challenges including improved capacity to target specific cells, synthesis of materials more sensitive to biological stimuli, perfection of non-invasive delivery techniques and the development of materials with improved properties still need to be overcome. This field has still numerous unanswered questions and unexplored avenues.

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