Chapter 46
Bioinspired Materials and Biocompatibility

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ABSTRACT

Material science and engineering are the sources of divergent emerging technologies, since all the modifications and developments are being made to reach a novel biomaterial to fulfill the requirements of biomedical applications, the first important feature is the biocompatibility of the new advanced material. In this chapter, the general biocompatibility concept, test systems to determine biocompatibility, examples of bioinspired materials and their altered biocompatibility and future expectations from these novel bioinspired materials will be discussed.

INTRODUCTION

Biomaterials have many different definitions; the most common definition is that they are the natural or synthetic materials used to replace part of a living system or to function in intimate contact with living tissue. Thus, utmost important feature of the biomaterials is biocompatibility. A medical device need to meet biocompatibility requirements, generally as defined by International Organization for Standardization (ISO). According to these standards, a medical device must be nontoxic, nonthrombogenic, noncarcinogenic, nonantigenic, and nonmutagenic. As biomaterials have various definitions, biocompatibility also has several definitions regarding to in which part of the body they are implanted, for how long they are implanted and for what purpose they are implanted. But in any case, enhancing biocompatibility of the implant is increasingly important concern in medical applications. A commonly held approach is mimicking nature of the tissue in implantation area for enhancing host cell attachment, mitigating inflammation, mitigating thrombus and hence enhanced biocompatibility.

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Bioinspired (or biomimicked) materials are materials inspired on biological systems in the simplest term. These materials can be defined as bioinspired according to two different approaches. In traditional approach, using synthetic materials, in other more current approach, produces performances mimicking biological materials; using bioinspired processes at the molecular level produces new materials and structures. Biomimetism and bioinspiration are useful tools for design and production of innovative medical devices. There approaches can provide several benefits to materials; (1) structural benefits such as hierarchical structure and lightness, (2) functional benefits such as biocompatibility and adhesiveness, (3) benefits in processing such as biodegradation. Bioinspired materials are gaining importance due to the advancements in material sciences hence the biocompatibility features of these advanced novel biomaterials should be discussed extensively. Bioinspired materials can be derived from natural resources as well as they can be synthetic. Some mostly used natural biomaterials which are extensively found in the body can be listed as; collagen, elastin, hyaluronic acid and fibrin. Others from natural resources are alginate, chitosan, silk and bacterial cellulose.

The bioinspired materials are designed to be used as scaffolds to mimic the complex native structures for tissue repair and regeneration. There are innumerable combinations of two or more materials to fulfill the requirements of the scaffolds as a novel scaffold must bear multiple features. Using genetically engineered natural biomaterials are promising as many features could be manipulated through the need. Also decellularized tissues are used for allografts and xenografts as scaffolds.

BACKGROUND

Biocompatibility is a complex concept related to reliability and performance of implanted materials. An agreement on the definition of biocompatibility, which is the first component of this concept, was achieved in the Chester Consensus Conference, 1986. Williams gave the definition of biocompatibility, which is widely used in the biomaterials community today. This useful definition was "Biocompatibility is the ability of a material to perform with an appropriate host response in a specific application." (Williams, 1987; Ratner et al., 2004). This accepted definition emphasizes that, there is not absolute suitability of one material for applications and all materials initiate a host response in some way.

Implanted devices in living tissue are able to consist of only biomaterial component or both of biomaterial component and biological component (proteins and cells) (Anderson, 2001). Implanted biomaterials initiate generally inflammatory and foreign body reaction in the body. Implanted tissue engineered devices, including both biomaterial, biological components, activate host defense systems including the inflammatory response, also known as the innate immune system, and immune response, which is considered as acquired or adaptive immune system. (Anderson, 2007). In this case, inflammatory and immune responses must be evaluated together for overall safety and efficacy of the tissue-engineered device.

When a material is implanted within living tissues, the response will change over time, depending on the material characteristics, including physical characteristics and biostability, and it may change with the different circumstances within the body. The response against to the implanted devices changes depending upon time (1), location (2) and controlling factors (3) (Williams, 2012).

Levels of host response are very important as well as the response of the host against the implant. There are three levels of response that can be grouped:

1. Local response

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