Chapter 2

Overview of Biomaterials Classification, Properties, and Biomedical Applications

Imade Armadi
https://orcid.org/0009-0003-3063-5058
Cadi Ayyad University, Marrakech, Morocco

Adil El Housseini
https://orcid.org/0009-0007-9294-2685
Ibn Zohr University, Marrakech, Morocco

Samia Elouali
Cadi Ayyad University; University of Mons, Marrakech, Morocco

Souad Loqman
Cadi Ayyad University, Marrakech, Morocco

Abdessamad Abana
Cadi Ayyad University, Marrakech, Morocco

Anass Belbachir
https://orcid.org/0009-0002-4828-0251
Cadi Ayyad University, Marrakech, Morocco

ABSTRACT

Biomaterials have attracted growing interest in the biomedical field thanks to their unique ability to interact with biological systems and make a significant contribution to advances in medicine, tissue engineering and sustainable technologies. Their importance lies in their dual potential: improving patients' quality of life while reducing their impact on the environment. This chapter first presents a detailed classification of biomaterials, distinguishing between natural, synthetic and hybrid categories. Next, the key properties of biomaterials are explored, showing their role in biocompatibility, durability and clinical performance. These fundamental characteristics directly influence the choice of biomaterials for a variety of applications.

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In addition, this chapter highlights the diversity of current biomaterial applications, while discussing the persistent challenges and limitations encountered in their design and use. Finally, future prospects are discussed, including the emergence of personalized biomaterials, which could revolutionize biomedical technologies.

INTRODUCTION

From prehistoric times to the mid-19th century, the era of modern medicine, the word biomaterials has attracted the interest of scientific researchers, evolving over time in line with technological advances and scientific knowledge. (Cohen, 1967), was one of the first to propose a definition of biomaterials. For him, they are defined as any material used as an implant. This concept, though elementary, laid the foundations for a line of thinking that was to become progressively more refined. In 1974, the first approach was enriched by integrating the word inert substance, so that the definition of biomaterials is a systematically and pharmacologically inert substance designed to be implanted or incorporated into a living system (Marin et al., 2020). A few years later, the definition was redefined, this time emphasizing the importance of biomedical function. It therefore refers to a substance of synthetic or natural origin, which can be used for a given period of time, as a whole or as part of a system that treats, augments or replaces a tissue, organ or function of the body (Nitesh R. Patel & Piyush P. Gohil, 2012). In 1987, Professor David Franklyn Williams proposed a more systematic approach, incorporating the notion of non-viability into the definition, for what takes the form of a non-viable material used in a medical device, intended to interact with biological systems (Williams DF, 1987). It took until 1991, at the “Consensus Conference”, to get the most complete definition, accepted today by the scientific community. Biomaterials are therefore any substance or combination of substances, other than drugs, of synthetic or natural origin, which can be used for a given period of time, which partially or totally augment or replace a tissue, organ or function of the body, in order to maintain or improve the individual's quality of life. This definition takes into account the concept of improving quality of life (Marin et al., 2020). Thus, the progressive evolution of the definition of biomaterials reflects their growing role in scientific research and their multiple applications. Today, biomaterials are no longer considered simply as biological substitutes, but as key elements of biomedical innovation. The evolution of their definition has been accompanied at the same time by a diversification of their classification, notably according to their origin (natural or synthetic), their structure (polymers, metals, ceramics, composites) and their function (mechanical support, biological interface, tissue regeneration, etc.) (Agrawal et al., 2023). This multifactorial approach enables us to better adapt to the specific requirements of each