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Laser Surface Texturing of Polymers for Biomedical Applications

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Polymers are materials widely used in biomedical science because of their biocompatibility, and good mechanical properties (which, in some cases, are similar to those of human tissues); however, these materials are, in general, chemically and biologically inert. Surface characteristics, such as topography (at the macro-, micro, and nano-scale), surface chemistry, surface energy, charge, or wettability are interrelated properties, and they cooperatively influence the biological performance of materials when used for biomedical applications. They regulate the biological response at the implant/tissue interface (e.g., influencing the cell adhesion, cell orientation, cell motility, etc.). Several surface processing techniques have been explored to modulate these properties for biomedical applications. Despite their potentials, these methods have limitations that prevent their applicability. In this regard, laser-based methods, in particular laser surface texturing (LST), can be an interesting alternative. Different works have showed the potentiality of this technique to control the surface properties of biomedical polymers and enhance their biological performance; however, more research is needed to obtain the desired biological response. This work provides a general overview of the basics and applications of LST for the surface modification of polymers currently used in the clinical practice (e.g., PEEK, UHMWPE, PP, etc.). The modification of roughness, wettability, and their impact on the biological response is addressed to offer new insights on the surface modification of biomedical polymers.

Keywords: laser surface texturing, surface modification, wettability, surface roughness, implants, cell response

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INTRODUCTION

Polymers are organic materials, formed by linking a large number of repeating units called monomers. These materials are widely used in biomedical applications, e.g., in joint replacement components. Typical polymers used in clinical applications include polyetheretherketone (PEEK), ultra-high-molecular-weight polyethylene (UHMWPE), polypropylene (PP), acrylic bone cements (PMMA), or nylon among others. They exhibit excellent mechanical properties for applications such as knee and hip implants, sutures, orthopedic fixation implants (pins, screws, rods, clips, etc.), dental implants, or stents among others. In addition, they have a reduced density as compared to other biomaterials (such as metals or ceramics), and do not interfere and degrade the biological tissue in contact.

Although these materials are biocompatible, and in some cases, have similar mechanical properties to human tissues, they are, in general, chemically and biologically inert. They show