Study of the Growth Mechanism of Plasma Polymer Films of 2-Methyl-2-Oxazoline

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A serious complication that can arise following the implantation of a medical device is a bacterial infection, potentially leading to implant failure. This issue currently affects approximately 1 to 5% of dental implants. To mitigate this problem, one strategy includes the deposition of a Plasma Polymer Film (PPF) at the implant interface exhibiting antimicrobial properties and promoting cellular adhesion. The plasma polymerization process provides numerous advantages: low environmental impact, excellent layer adhesion on all types of substrates, tuneable physicochemical properties of the coating, industrial scalability, etc. Several studies conducted on oxazoline-based PPF have demonstrated promising preliminary results, particularly in terms of antimicrobial properties and interactions with bone cells, highlighting the potential of plasma polymerization for tailoring the surface properties of implantable devices. However, a lack of understanding of the chemical and physical phenomena involved in the growth of the PPF at a molecular level currently limits the systematic use of these materials in the medical field.

In this context, the objective of this work is to improve the fundamental understanding of the growth mechanism of PPF made from 2-methyl-2-oxazoline. The influence of two experimental parameters has been investigated, namely the power dissipated in the plasma (P_{RF}) and the substrate temperature (Ts).

The analysis of XPS data reveals a decrease in nitrogen and oxygen content with Ts and P_{RF}. This is attributed to the variation of the sticking probabilities of oxygen- and nitrogen-based radicals as a function of the substrate temperature, and an increase in the precursor fragmentation at higher power. FTIR analysis also highlighted the complexity of the process as evidenced by the incorporation within the PPF of chemical functions (e.g., C≡N, C=O, etc.) absent from the chemical structure of the monomer. Based on plasma mass spectrometry data and DFT-based calculations, reaction pathways were proposed to explain the formation of these functional groups.

Peak force QNM and Nano DMA AFM analysis also indicate that the PPF predominantly behaves as a hard elastic material with a Young's modulus of approximately 3 GPa, for all the synthesis conditions. Finally, a suitable experimental window for the synthesis of stable PPF in aqueous solutions, critical for the biological applications, was found paving the way for using the PPF in the medical field.