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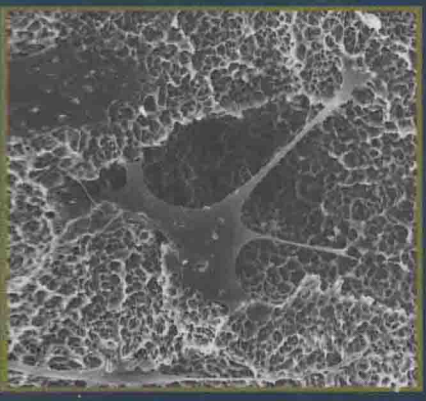

Surface modification of biomaterials

Methods, analysis and applications

Edited by Rachel Williams

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Surface modification of biomaterials

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Preface

Many materials that are used in medical devices are well-established materials used in other areas of manufacturing. They therefore have well-defined properties in terms of both bulk properties and surface characteristics. This has allowed the appropriate choice of materials for specific devices with appropriate functional mechanics. However, frequently these materials do not have the appropriate surface properties essential to control the interaction of the device with the biological environment and thus may lead to clinical failure due to adverse biological responses. This has led to major programmes in surface modification of biomaterials to enhance their biological interactions.

Surface modification of materials is a broad subject with many different considerations. For example, it is necessary to consider the properties of the materials to be modified, the surface characteristics required, the stability of the modifications, the application of the end product and the practicalities of the process. In some instances, surface chemical modification is advocated, whereas in others surface morphological changes are suggested. It is important to consider, however, that the routes to provide surface chemical modifications may also cause surface morphological changes and vice versa. An obvious result from this point is that it is essential to characterise all surfaces after surface modification so that all changes are fully defined. Considering that the biological interactions will be occurring at the atomic and molecular level, it is important to characterise the surface properties right down to the atomic- and nano-scale.

Some surface modification processes are designed to incorporate specific functional groups, for example amine, hydroxyl, or methyl groups, with the aim of influencing the non-specific protein interactions with the surface and thus influencing the cellular interaction. Other techniques are designed to incorporate biological or biomimetic molecules, for example peptides or heparin, with the aim of providing a surface active layer that will interact directly with the cells. For metal surfaces, in particular, there are techniques designed to increase their passivity, such as oxidation, or enhance their bioactivity by coating with ceramics. Careful consideration is needed to choose the correct surface

modification process to produce the surface characteristics required for the particular application and dependent on the properties of the materials being modified.

In this book experts in their fields have provided detailed chapters on a range of surface modification techniques including plasma polymerisation, covalent binding of polyethylene glycol (PEG), heparinisation, peptide functionalisation, oxidation, calcium phosphate deposition and surface topographical modification. In many of these chapters there is practical advice on how to achieve optimised surfaces and a review of the current knowledge on how these influence biological interactions. Furthermore, all chapters provide an insight into future trends in the areas.

Two key chapters (Chapters 8 and 9) have been put together to provide excellent reviews and practical advice on the surface characterisation methods for surface chemistry, structure and morphology. These provide important information on a range of surface characterisation techniques and will help the reader to choose the appropriate technique to use to define the surface properties dependent on the bulk material properties and the modification performed.

The biological response that is required will clearly be dependent on the specific application for which the material is being designed and there may well be more than one route to obtain the required surface characteristics for the specific application. Although it is not possible to cover all application areas, in the second part of this book a range of key applications are addressed by authors with expertise in each area. This includes interactions with blood, soft tissues, nerve cells, stem cells, bone and the control of infection. In each case the authors review the role of surface modification in their specific application area and the performance of those currently under investigation. Furthermore they discuss where they think future trends are likely to take this research.

It is clear from the research presented in this book that some surface modifications are well established and accepted in clinical practice, whereas others are still in the early stages of research. A greater understanding of how specific surface characteristics can be used to optimise the biological interactions with implantable biomaterials has the potential to enhance their clinical performance and demonstrates the importance of this field of research.

Rachel Williams

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Part I

Surface modification techniques