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"Surface Treatments for Biological, Chemical and Physical Applications"

Edited by Mehmet Gürsoy and Mustafa Karaman (Selçuk University, Konya, Turkey), Wiley-VCH Verlag GmbH & Co, Weinheim, Germany, 2017, 312 pages, ISBN: 978-3-527-34083-5, £95, €114

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Introduction

"Surface Treatments for Biological, Chemical and Physical Applications" was written to provide an up to date overview of surface modification techniques, with a specific leaning towards applications rather than pure science. The tone of the book strikes a good balance between accessible and technical, and is targeted towards a range of audiences, from undergraduate students to interested individuals. As such, the first three chapters form a basic grounding in surface science and terminology. The later chapters comprise comprehensive reviews of applications of several different surface modification techniques, from chemical separation membranes to biosensors.

The editors, Mehmet Gürsoy and Mustafa Karaman, are both academics in a Chemical Engineering department, though each chapter has a different set of authors from a broad range of disciplines. This is indicative of the applicability and importance of controlled surface modification across several fields. The book is written in good English, and has a well thought out balance of diagrams and text. All diagrams in the book are clear and are related directly to the text.

Surface Science Basics

The first three chapters provide a solid grounding in surface science terminology as well as providing an introduction to the broad range of applicability of controlled surface modification. The first chapter, authored by the editors, is titled 'Surfaces in Nature', presenting surface structures of a number of organisms, as well as attempts to mimic such natural surfaces. Biomimcry, the act of copying or mimicking biological systems, is increasingly being used in the design of high-tech surface structures. The authors neatly sum up the motivation for biomimetics by quoting Da Vinci:

> "Although human genius through various inventions makes instruments corresponding the same ends, it will never discover an invention more beautiful, nor more ready, nor more economical than does nature, because in her inventions nothing is lacking and nothing is superfluous." (1).

Having outlined the broad motivation behind biomimetic surfaces, Chapter 1 continues with several examples from literature, under the title 'Inspiring Natural Surface Structures'. Examples include: self-cleaning, antifouling, fog harvesting,

anti-reflective and adhesive surfaces. In order, these manufactured surfaces were inspired by, or templated from: lotus leaves, shark skin, Namib desert beetles, moth eyes and gecko feet. One interesting observation made by the author is that nature often produces multiple useful functionalities from the same nano- or microstructure, for example gecko foot skin, which exhibits both high adhesion and superhydrophobicity.

The second chapter, 'Chemical and Physical Modification of Surfaces', introduces a range of surface modification techniques, starting with vapour deposition processes before moving on to wet coating techniques, which includes electroplating and dip coating. Each different method is accompanied by clear cartoon schematics, with the underlying physical and chemical processes described well. This chapter is especially useful because it highlights the advantages and limitations of a broad range of surface treatment techniques.

The third and final chapter of surface science basics discusses 'Surface Characterization Techniques'. This, like the previous chapter, takes the form of a list of analytical techniques explained in the context of their usefulness for surface science. That this book is targeted at non-specialists is especially apparent in this chapter, as even routine techniques such as scanning electron microscopy (SEM) and Fourier transform infrared (FTIR) spectroscopy are explained in detail.

Emerging Chemical and Physical Applications

The remaining chapters focus on specific applications of surface modification. The first of these (Chapter 4) is titled 'Surface Modification of Polymeric Membranes for Various Separation Processes', authored by Woei-Jye Lau *et al*. Membranes are here defined as: "a selective barrier between two phases that separate based on the different permeation rates of subjected components". Such interfaces are ideal opportunities for using surface modification to improve for example filtration efficiency, activity and corrosion resistance. This is, in part, due to the separation processes being controlled primarily by the physical and chemical properties of the top layer (the surface) of a membrane. There are many examples given, covering solid-liquid, liquid-liquid and gas-gas separation processes. One example is summarised in **Figure 1**. Zhu *et al*. (2) grafted a zwitterionic polyelectrolyte brush from a

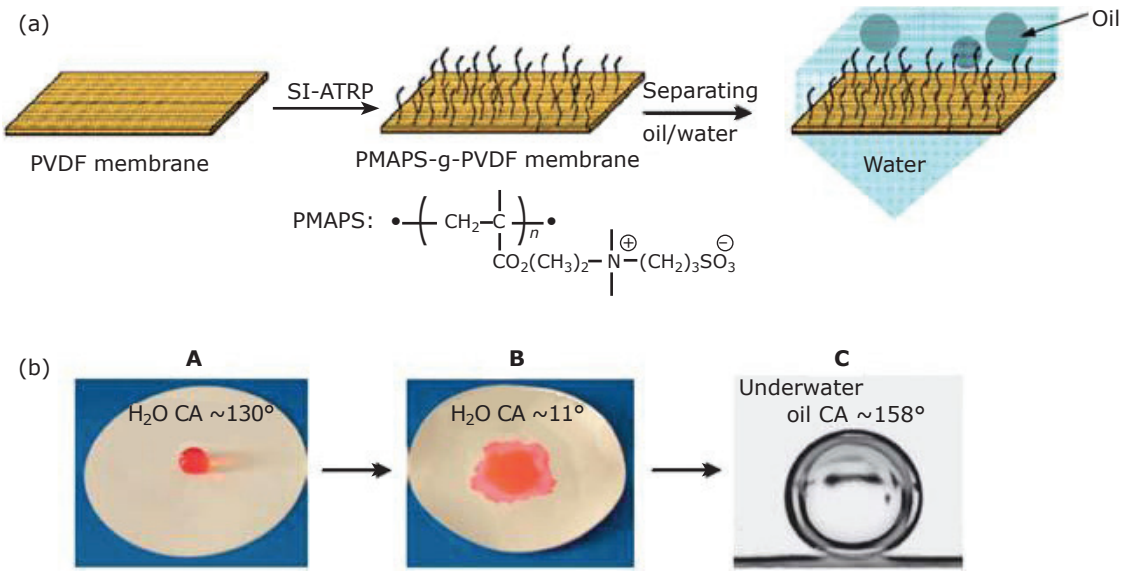


Fig. 1. (a) Schematic illustration of the preparation of poly(3-(N-2-methacryloxyethyl-N,N-dimethyl) ammonatopropanesultone (PMAPS)-grafted poly(vinylidene fluoride) (PMAPS-g-PVDF) membranes for separating dispersed oil from water; (b) water and oil wettability. Photographs of an oil water droplet (3 ml) dropped onto the original PVDF membrane (**A**) and PMAPS-g-PVDF membrane (**B**) and their contact angles. An underwater oil (1,2-dichloroethane) droplet on PMAPS-g-PVDF membrane showing a CA of 158° (**C**). Reproduced from (2). Copyright The Royal Society of Chemistry

poly(vinyldiene fluoride) (PVDF) membrane, with an aim to remove dispersed oil from bulk water. By grafting this brush, they were able to produce a membrane which showed a significantly increased oil filtration, attributed to a high surface energy combined with a low water contact angle.

Chapter 5, authored by Epameinondas Leontidis, reviews the use of Langmuir-Blodgett (LB) films for sensors and in biomedical applications, and then draws comparisons with organic films produced using the layer-by-layer (LbL) method. There is some feeling that LbL methods have supplanted LB-generated films, due, in part, to the ease with which LbL films can be generated. The author outlines the strengths and limitations of both techniques, commenting that they should be considered as complementary rather than as competitors (**Figure 2**).

Chapter 6, 'Surface Modification of Biopolymer-Based Nanoforms and Their Biological Applications', authored by Susana C. M. Fernandes, considers the chemical surface modification of biopolymer-based nanoforms, such as nanocrystalline cellulose and chitin. Cellulose and chitin are the two most abundant biopolymers on earth, with well-known chemistry and the ability to self-assemble into hierarchical structures at several length scales. Unlike other nanomaterials, which can be more dangerous than their larger forms, nancellulose and nanochitin, nanometre crystalline fibrils with diameter ~10 nm, are biodegradable, biocompatible and non-cytotoxic. A selection of different chemical functionalities are discussed, including antimicrobial surfaces and novel composites containing these biomaterials.

Chapter 7 is a relatively short chapter on 'Enzyme-based Biosensors in Food Industry via Surface Modifications', authored by Nilay Gazel and Huseyin B. Yildiz. Enzyme-based biosensors, sensors which use enzymes as part of the detection mechanism for probing biological processes, rely on the immobilisation of enzymes onto a variety of substrates. This chapter outlines a few chemical and physical methods to immobilise these highly selective macromolecules onto several different substrates, from metals and polymers to carbon nanotubes.

The final chapter, Chapter 8, considers 'Heterogeneous Catalysis from the Perspective of Surface Science'. The authors, Aydin Cihanoğlu, Diego Hernán Quiñones-Murillo and Gizem Payer, in keeping with the tone of the book provide a comprehensive grounding in catalysis, as well as

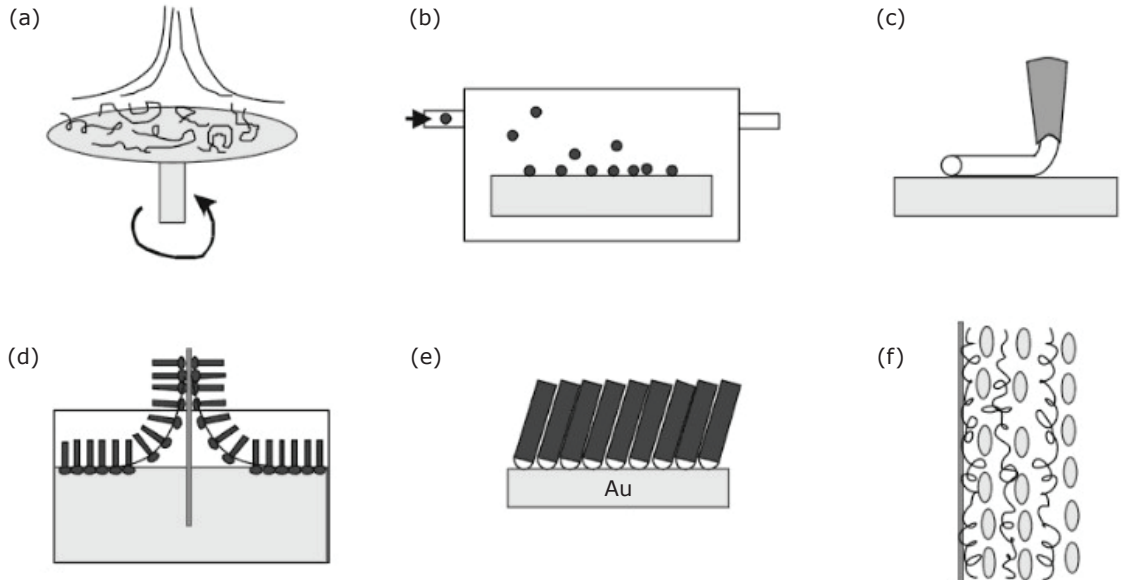
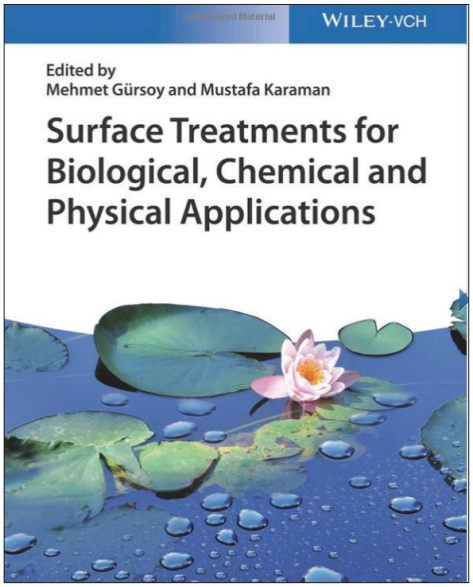


Fig. 2. Various types of technologically important thin organic films: (a) spin-coated films; (b) organic vapour-phase deposited films; (c) inkjet-printed films; (d) Langmuir-Blodgett films; (e) self-assembled monolayers; and (f) layer-by-layer films. Copyright Wiley-VCH Verlag GmbH & Co KGaA. Reproduced with permission

discussing methods of producing and characterising catalytic surfaces. This chapter is a particularly useful overview of catalyst preparation methods, summarising a large number of procedures and characterisation techniques.

Conclusions

The mix of general introduction and applications-focused literature review helps to achieve the intended broad appeal of the book. This book could be used as an accessible introduction to surface science, but could also be a handy reference for a more experienced researcher, with several practical hints and tips. The quality of the writing does vary from chapter to chapter, as one would expect from a research-focused textbook, occasionally drifting into lists of related papers without much further analysis or commentary. On the whole, however, this is a clear, concise and useful introduction to surface science and would be a good addition to the bookshelf for anyone that would want to use surfaces in some way.



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About the Reviewer

Alex de Bruin joined Johnson Matthey in January 2017 as a Research Scientist at Johnson Matthey's Technology Centre, Sonning Common, UK, after completing a PhD in colloid science and nanomaterials at Bristol University, UK. His current research is split between extrusion paste chemistry and fundamentals of washcoat processing, employing a range of surface science techniques to control the rheology of complex fluids.