

Preface

Fouling is the undesirable accumulation of material on a wide variety of objects such as medical devices, ship hulls, pipelines, membranes, as well as what is normally seen in most of the industries (paper manufacturing, food processing, underwater construction, and desalination plants etc.). The fouling material can either be living organisms or non-living substances (inorganic dusts, organic liquids). Fouling can occur almost anywhere and in almost all circumstances, especially where liquids are in contact with other materials, and is economically significant to the marine shipping, resulting in additional functional and monetary costs to various vessels which include reducing their fuel efficiency, increasing dry-dock maintenance costs, and reducing their hull strength and bio-corrosion. Now fouling has become a widespread global problem from land to oceans with both economic and environmental penalties. Fouling by living organisms such as in marine environment is especially problematic and complex: more than 1700 species comprising over 4000 organisms (microorganisms, plants algae, and animals) are responsible for biofouling, which is categorized into microfouling, biofilm formation and bacterial adhesion, macrofouling, and the attachment of larger organisms.

Antifouling is the process of removing or preventing the organism accumulation and growth. Bio-dispersants are usually used to take precautions against biofouling in industrial production processes. In less controlled environments, organisms can be killed or repelled with coatings containing biocides, thermal treatments, or pulses of energy. A variety of antifouling surfaces have been developed to overcome organism settlement, including choosing the surfaces or coating with low friction and low surface energies, creation of slippery antifouling surfaces or building ultra-low fouling polymeric surfaces, creation of various micro/nano structural surfaces similar to the skin of sharks with less anchoring points, and antifouling hydrophilic surfaces (based on zwitterions, such as glycine, betaine, and sulfobetaine) with high hydration that increases the energetic penalty of removing water during the process of attachment of proteins and microorganisms.

Up to now, antifouling technologies have increased drastically in the last decades due to the advancement of bionic science and the longstanding challenge in search of viable and environmentally friendly alternatives of nonfouling surfaces, which is the focus of this book. In this book, we put together the self-cleaning function from

the land to the sea and try to tell readers the difference. For most terrestrial creatures, the hydrophobic surfaces based on surface morphology and chemical composition, which can lead to the self-cleaning for antifouling. The superhydrophobic surface (such as lotus leaves, rose petal, cicada wing, and pattern surface) can repel droplets of water and dust, and the large boundary slip occurs when water flows through the superhydrophobic surface because most of the “liquid-solid shear” is transferred to the “liquid-air shear” at the interface. However, the superhydrophobic surfaces existing on the land are not suitable for the underwater antifouling. Most of the aquatic organisms rather utilize hydrophilicity and softness to keep away the biological growth, such as shark’s and whale’s skin, nacre, etc. These soft surfaces also have drag reduction property due to the decrease of the vortex, the turbulent flow changing to laminar flow at the hydrophilic boundary layer, which also contributes to antifouling.

The book is highly interdisciplinary and covers the fields of nanotechnology, polymer science, surface science, coating technology, hydrodynamics, and marine biology. One area in which considerable research has been performed is self-cleaning and boundary slippage and is discussed in depth in the first and last part of the book. The other chapters are related to antifouling surfaces based on polymer brushes (PEGylated polymers, zwitterionic polymers, bioinspired polymers, and polymers incorporating antimicrobial agents), self-assemble monolayers, or layer-by-layer-assembled films, as well as an emerging research area focusing on micro/nano structural antifouling surfaces. There is also growing knowledge available on novel antifouling coatings and nontoxic green biocides such as ionic liquids and natural products. The future research about green antifouling surfaces should also be toward correlating molecular-level details of the functionalized surface, surface topography, and establishing a fundamental understanding of antifouling and fouling release mechanisms. It also requires to figuring out how mechanical properties of the coating surfaces affect fouling and fouling release and how the chemical composition of the adhesive matrices of organisms takes effect. Moreover, some fundamental work should be done in understanding the relationship between the structure, surface chemical composition, and properties of a coating and its biological performance.

In this book, we aim to provide an overview of antifouling techniques from land to marine environment and from natural to biomimetic technology, which allow readers to understand the antifouling approaches, the existing problems, and its perspectives. The book provides a reference source to scientists from the academic and industrial communities, as well as regulatory authorities.

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From Land to Marine Environment

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