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Editorial

Special Issue on Superhydrophobic Coatings for Corrosion and Tribology

Shuncai Wang [1,*] **and Guochen Zhao** [2,*]

[1] National Centre for Advanced Tribology at Southampton (nCATS), University of Southampton, Southampton SO17 1BJ, UK
[2] Shandong Provincial Key Laboratory of High Strength Lightweight Metallic Materials, Advanced Materials Institute, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250014, China
* Correspondence: wangs@soton.ac.uk (S.W.); zhaogch@sdas.org (G.Z.)

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1. Introduction

Superhydrophobicity, showing strong water-repellency, has been widely investigated for many applications, especially in the fields of corrosion protection and antifouling. Water tends to roll off from superhydrophobic surfaces like natural lotus leaves. When a corrosive aqueous solution comes into contact with such a surface, a stable air cushion is formed on the interface between liquid and solid which minimizes the contact area. As a result, the charge transfer of the corrosive reaction is dramatically restrained, resulting in a positively shifted corrosion potential and low corrosion rate. Additionally, the superhydrophobic surface effectively isolates microorganisms from adhering on the surface and thus prevents microbiologically influenced corrosion caused by their metabolites. Thus, the superhydrophobic coatings have potential applications in corrosion protection of marine equipment, medical devices, mechanical components, etc.

However, the lack of mechanical strength and heat resistance prevents the use of these coatings in harsh environments. It is well established that micro-nano hierarchical structures and low surface energy are the two fundamental factors crucial to developing superhydrophobic surfaces, and the superhydrophobicity of these surfaces would be diminished if they were destroyed by abrasion or overheating. The superhydrophobic coatings using wear-resistant inorganic materials are therefore highly sought after. Ceramics are of particular interest due to their high mechanical strength, heat and corrosion resistance. Such superhydrophobic coatings have recently been successfully fabricated using a variety of ceramics and different approaches, and have shown improved wear and tribocorrosion resistance properties.

This special issue is making the best effort to reflect the recent developments in the fabrication of superhydrophobic coatings and their robustness against corrosion and wear resistance. We hope it will stimulate the future research and application.

2. Superhydrophobic Coatings for Corrosion and Tribology

The special issue "Superhydrophobic Coatings for Corrosion and Tribology" was opened in June 2018 and closed in June 2019. During this period of 12 months, there were 19 manuscripts submitted to this special issue, of which 10 were finally accepted. Among the publications, most works focused on the fabrication of superhydrophobic surfaces and applications of corrosion protection, self-cleaning, and oil-water separation. The tribological coatings for corrosion and wear resistance were also included to facilitate other extended functions. The individual work is briefed below:

The paper "Fabrication of Superhydrophobic AA5052 Aluminum Alloy Surface with Improved Corrosion Resistance and Self Cleaning Property" by Zhao et al. presents a method for fabricating superhydrophobic Ni–Co alloy coatings on aluminum surfaces, followed by surface modification with 6-(*N*-allyl-1,1,2,2-tetrahydro-perfluorodecyl) amino-1,3,5-triazine-2,4-dithiol monosodium (AF17N) [1]. The authors discussed the importance of grooves to superhydrophobicity and the effects of AF17N polymeric nanofilm on the corrosion inhibition property using cyclic voltammetry (CV) curves. The coating showed excellent self-cleaning and corrosion-resistance performance with good chemical stability and long-term durability of more than 16 weeks, which is essential for practical applications.

The paper "Effect of Surface Topography and Structural Parameters on the Lubrication Performance of a Water-Lubricated Bearing: Theoretical and Experimental Study" by Xie et al. described theoretical calculations and experiments examining the influence of the surface topography on water-lubricated bearings' lubrication performance [2]. The test data and simulation corresponded well, showing the influences of bushing, eccentricity ratio, bushing deformation, specific pressure, speed, velocity, etc. on the lubrication performance. This work elucidates the lubrication mechanism and is of significance for designing such bearings.

The paper "Effects of Surface Microstructures on Superhydrophobic Properties and Oil-Water Separation Efficiency" by Chen et al. was devoted to increasing the efficiency of oil-water separation by fabricating superhydrophobic copper meshes [3]. Regarding the effects of microstructures of membranes, they found meshes with parabolic morphology to have better separation efficiency than the truncated cone morphology, up to 97.5%, 97.2% and 91% for benzene-water, carbon tetrachloride-water and engine oil-water mixtures, respectively. This work clarified the effects of microstructures relevant to superhydrophobicity which may guide the applications.

The paper "Surfactant-Free Electroless Codeposition of Ni–P–MoS_2/Al_2O_3 Composite Coatings" by Liu et al. presents the tribological performance of electroless surfactant-free Ni–P–MoS_2/Al_2O_3 coatings [4]. The incorporation of Al_2O_3 coated MoS_2 particles obviously improved the wear resistance of such coatings. In the absence of surfactants, compact Ni–P–MoS_2/Al_2O_3 coatings with 7% Al_2O_3 were obtained, which had a low friction coefficient of 0.4 and lower mass loss of wear than Ni–P–MoS_2 coatings.

The paper "Synthesis and Properties of Electrodeposited Ni–Co/WS_2 Nanocomposite Coatings" by He et al focused on the Ni–Co/WS_2 superhydrophobic coatings [5]. The one-pot plated Ni–Co coating had an ultra-low friction coefficient of 0.16 with the embedment of 7.1 wt.% WS_2 lubricants, while also showing excellent superhydrophobicity with a water contact angle of 157°. This work successfully prepared a superhydrophobic surface which possessed self-lubrication, high abrasive resistance and good mechanical properties.

The paper "Super-Hydrophobic Co–Ni Coating with High Abrasion Resistance Prepared by Electrodeposition" by Xue et al. demonstrated the fabrication of Co–Ni superhydrophobic coatings on carbon steel with excellent abrasive resistance and anti-corrosion properties [6]. In their work, the measurement of cyclic voltammograms contributed to determining the appropriate potential for constructing the hierarchical structures of Co–Ni coatings. Modified by 1H,1H,2H,2H-Perfluorooctyltrichlorosilane (PFTEOS), the coating acquired superhydrophobicity with contact angles over 161° and could maintain this kind of property after a 12 m abrasion test. The trapped air on the surface of the coating provided stable corrosion resistance with corrosion rate more than 20 times lower than bare carbon steel.

The paper "Oscillating Magnetic Drop: How to Grade" authored by Goncalves Dos Santos et al. described an alternative method to goniometer-based measurements for evaluating superhydrophobicity: the measurement of the damped-oscillatory motion of a ferrofluid sessile droplet [7]. Through comparing results measured by the two methods, it was found that the damping time of oscillating magnetic drops had a more sensitive response than the traditional one. This method explored by the authors had great significance to grading superhydrophobic surfaces.

The paper "Robust Super-Hydrophobic Coating Prepared by Electrochemical Surface Engineering for Corrosion Protection" by Bi et al. reviewed the recent advances in fabricating robust superhydrophobic surfaces by electrochemical methods, including electrochemical anodization, micro-arc oxidation, electrochemical etching and electrochemical deposition and their corrosion resistance [8]. The wetting principle, corrosion protection mechanism and stability of superhydrophobic coatings were also described in detail, inspiring the fabrication of promising multi-functional coatings for self-healing, slippery liquid-infused porous surface etc.

The paper "Preparation of Superhydrophobic Steel Surfaces with Chemical Stability and Corrosion" by Du et al. presents a simple method for fabricating superhydrophobic surfaces on Q235 steel [9]. The needle-like structures followed by fluorination treatment process exhibited extremely low water affinity (with a water-contact angle of 161°) and high elastic bounce back, resulting in a low-corrosion current which represents about 8.7% of the untreated one. Moreover, such superhydrophobicity could be maintained in various aqueous solutions with different pH values.

The paper "Structure-Property Relationships in Suspension HVOF Nano-TiO_2 Coatings" authored by Zhang et al. shows the effects of microstructure on mechanical properties and wear behavior [10]. By controlling thermal spraying parameters, the stable suspension leads to the formation of quality high-velocity oxygen fuel (HVOF) TiO_2 coatings with the hardness as high as 7.8 GPa and low coefficient of friction and wear rate as low as 0.35 and 0.83 mm^3/Nm, respectively. This work provided good guidance for depositing thermally-sensitive materials such as TiO_2-anatase or hydroxyapatite, with minimal thermal decomposition.

3. Perspectives

Superhydrophobic coatings have attracted extensive attention. Further research may focus on improving the surface stability and robustness. The multiple functional coatings, as published in this special issue, are also highly sought after to achieve both superhydrophobicity and tribocorrosion. A combination of superhydrophobicity and self-lubricated surfaces are another case to broaden their applications in fields of energy, biology, sensor, environment, etc.

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