

Wednesday Evening, December 11, 2024

Thin Films and Surface Modification

Room Naupaka Salon 4 - Session TF1-WeE

Thin Films - Properties

Moderator: Tetsuhide Shimizu, Tokyo Metropolitan University

5:40pm TF1-WeE-1 Superlubricity: Toward Design of Zero-Friction and Zero-Wear Materials, *Diana Berman*, University of North Texas **INVITED**

Friction and wear-related failures remain the greatest problems in today's moving mechanical components, from microelectromechanical devices to automotive assemblies and to biological systems. The critical need to reduce and eliminate the tribological failures constitutes the necessity for continuous search of novel materials and lubrication solutions. In this presentation, we overview recent advances in establishing the fundamental understanding of materials interactions at sliding interfaces and use this knowledge as a guide to developing nanomaterials solutions that enhance reliability and efficiency of tribological systems. We evaluate tribological performance of 2D materials, including graphene, molybdenum disulfide, and MXene, and demonstrate realization of superlubricity regime at macroscale. To extend the lifetime of the tribological materials, we demonstrate tribochemically-driven self-replenishment of materials inside the contact interfaces, thus enabling a zero-wear sliding regime.

Overall, the findings have not only allowed us to solve some long-standing puzzles, but could also open a new avenue for the development of new concepts and design strategies for next generation of tribologically efficient materials systems.

6:20pm TF1-WeE-3 Langmuir Monolayer Studies of First-Generation Photoswitchable DASA Surfactants, *H. Kaur*, University of Saskatchewan, Canada; *S. Sumat, S. Murphy*, University of Regina, Canada; **Matthew Paige**, University of Saskatchewan, Canada

Donor-Acceptor Stenhouse Adducts (DASAs) are photochromic molecules that can be isomerized with visible light between a coloured, linear triene form to a colourless cyclic form. These compounds have garnered considerable interest for a variety of light-based applications in the field of photopharmacology and related fields. In this work, we have synthesized several first-generation DASAs with a barbituric acid-based acceptor and a dialkyl amine donor, and investigated how the chemical structure of the DASA affects fundamental structural properties of Langmuir films they form. The DASAs form stable monolayer films at the air-water interface and exhibit a classical LE-LC phase transition at room temperature. Photoillumination leads to a significant alteration in film packing, along with spectroscopic changes consistent with successful isomerization between triene and cyclic form. Film morphology at the air-water interface is also significantly impacted by the photoisomerization process, as assessed by *in situ* Brewster Angle Microscopy. We have also explored the ability to deposit films as both monolayers and multilayers onto solid substrates and characterized the deposition process efficiency and resulting film structures using a variety of techniques. Time allowing, the structure and orientation of the DASA headgroup at the air-water interface will be discussed in context of appropriate molecular modeling calculations.

6:40pm TF1-WeE-4 Precise Synthesis of Covalent Organic Framework Thin Films, *Dong Wang*, Institute of Chemistry, Chinese Academy of Sciences, China

The exotic properties associated with graphene and other 2D layered inorganic materials have attracted great interests from a variety of research fields. Two-dimensional covalent organic frameworks (2D COFs), which are covalently constructed from planar aromatic building blocks based on the principles of reticular chemistry, are a class of porous crystalline material with the highly ordered porous architectures and pre-designable electronic skeletons. 2D COFs feature the extended conjugation within a 2D layer and periodically columnar arrays aligned with an atomic precision in vertical direction, which is hardly achievable in other molecular architectures. In this context, high crystallinity and closely eclipsed stacking alignment of aromatic moieties render 2D COF as an ideal platform for charge carrier transport. With the improved crystallinity and controllable orientation, substrate supported 2D COF film would enable fabrication of advanced architectures for electronic devices, which however remains unexplored so far.

Herein, we report the on surface synthesis of high quality 2D COF thin film. We have developed a general method for constructing COF monolayers and thin films on substrate surfaces based on gas-solid and liquid-solid interfacial reactions. We proposed a method to improve 2D polymer

orderliness by remotely modulating the molecular conformation through the effect of steric hindrance. We developed a chemical vapor deposition method, and prepared highly ordered 2D polymer films with controllable number of layers by modulating the kinetic process of the reaction. We further demonstrate that it is possible to fabricate COF thin film for optoelectronic device. Two types of field-effect transistors with horizontal and vertical structures were constructed by directly growing COF films on the surfaces of hexagonal phase boron nitride and monolayer graphene, respectively, and their in-plane transverse charge transport properties and electronic properties in the π - π stacking direction were investigated. We have constructed COF-based electrochromic devices, and the highly ordered structure of COF significantly enhances their performance such as response speed.

[1] Q. Hao, Z.-J. Li, C. Lu, S. Bing; Y.-W. Zhong, L.-J. Wan, D. Wang. *J. Am. Chem. Soc.* 2019, 141, 19831-19838.

[2] Q. Hao, Z.-J. Li, B. Bai, X. Zhang, Y.-W. Zhong, L.-J. Wan, D. Wang. *Angew. Chem. Int. Ed.* 2021, 60, 12498-12503.

[3] X.-R. Ren, B. Bai, Q. Zhang, Q. Hao, Y. Guo, L.-J. Wan, D. Wang. *J. Am. Chem. Soc.* 2022, 144, 2488-2494.

[4] Q. Hao, X.-R. Ren, Y. Chen, C. Zhao, J. Xu, D. Wang, H. Liu. *Nat. Commun.* 2023, 14, 578.

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