

Materials Science & Engineering Doctoral Defense

Surface Treatment of Transition Metal Dichalcogenides

School for Engineering of Matter, Transport and Energy

Ximo Chu

Advisor: Dr. Qing Hua Wang

abstract

Two-dimensional transition metal dichalcogenides (TMDCs) such as molybdenum disulfide (MoS_2), tungsten disulfide (WS_2), molybdenum diselenide (MoSe_2) and tungsten diselenide (WSe_2) are attractive for use in biotechnology, optical and electronics devices due to their promising and tunable electrical, optical and chemical properties. To fulfill the variety of requirements for different applications, different chemical treatment methods are developed to tune their properties. In this work, plasma treatment, chemical doping and functionalization methods have been applied to tune the properties of TMDCs. First, plasma treatment of TMDCs results in doping and generation of defects, as well as the synthesis of transition metal oxides (TMOs) with rolled layers that have increased surface-to-volume ratio and are promising for electrochemical applications. Second, chemical functionalization is another powerful approach for tuning the properties of TMDCs for use in many applications. To covalently functionalize the basal planes of TMDCs, previous reports begin with harsh treatments like lithium intercalation that disrupt the structure and lead to a phase transformation from semiconducting to metallic. Instead, this work demonstrates the direct covalent functionalization of semiconducting MoS_2 using aryl diazonium salts without lithium treatments. It preserves the structure and semiconducting nature of MoS_2 , results in covalent C-S bonds on basal planes and enables different functional groups to be tethered to the MoS_2 surface via the diazonium salts. The attachment of fluorescent proteins has been used as a demonstration and it suggests future applications in biology and biosensing.

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