Preface

Friction between mating surfaces generates heat, leading to energy losses and wear. However, this friction and wear can be mitigated by introducing a lubricant between the interacting surfaces. Nanomaterials have gained preference as lubricant additives over traditional organic chemicals due to their small size and fast tribological response. 2D Nanosheets serve a crucial role in lubrication due to their low coefficient of friction and ease of shearing during sliding motion. However, nanosheets encounter certain limitations when used as lubricants, including issues like nanosheet repiling, agglomeration, poor surface adhesion, inadequate dispersibility in base oil, insufficient wear and friction reduction properties, and limited load-carrying capacity. To overcome these challenges, the functionalization of nanosheets is performed. The current study involves the synthesis of various 2D nanosheets and their non-covalent functionalized nanocomposites with other nanomaterials to improve tribological behavior through synergistic effects. The thesis is structured into several main sections, including an Introduction, Experimental procedures, Results & Discussions, Summary, and References.

In **Chapter 1**, introduction, the term "Tribology" was initially introduced in the context of mechanical systems' durability. The concepts of friction, wear, and lubrication were explained, along with a discussion on various types of lubrication, lubricants, and their classification. Additionally, different categories of additives, especially antiwear/antifriction additives, were described. This section also provides a comprehensive literature survey on the application of nanomaterials in tribology, including quantum dots, nanoparticles, nanosphere, and various 2D nanosheets, along with their nanocomposites. The specific problem being addressed in the research is defined in detail. Finally, the aims and objectives of the current investigation are outlined.

Chapter 2 encompasses various instrumentation techniques employed for the characterization of both synthesized lubricant additives and lubricated mating surfaces. These techniques include powder X-ray diffraction (p-XRD), Fourier Transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and high-resolution scanning electron microscopy (HR-SEM), energy-dispersive X-ray spectroscopy (EDX), transmission electron microscopy (TEM) and high-resolution transmission electron microscopy (HR-TEM), electronic absorption spectroscopy (UV/visible), and X-ray photoelectron spectroscopy (XPS).

The chapter also provides details about the base lube paraffin oil (PO) and the test sample (steel balls) used in the experiments. The experimental procedures for the tribological tests, specifically ASTM D4172 and ASTM D5183, are described. Additionally, brief information is given about various essential tribological parameters, such as the coefficient of friction (μ), mean wear scar diameter (MWD), load-carrying capacity, mean wear volume, and frictional power loss.

The conclusions derived from the experimental data and their corresponding outcomes have been discussed in chapters 3 to 5.

Chapter 3 contains the synthesis of methionine functionalized nano lamellar graphene oxide (GO) to produce M-rGO. Additionally, non-covalent functionalization was performed on nano lamellar MoS_2 using lanthanum (7%)-doped yttria nanoparticles, resulting in the formation of the nanocomposite (La-Y_2O_3)-MoS_2. To further enhance the tribological activity, a ternary nanocomposite (La-Y_2O_3)-MoS_2-(M-rGO) was synthesized, incorporating lanthanum-doped yttria nanoparticles, M-rGO, and MoS_2 nanosheets.

The prepared nanoparticle/nanosheets and their nanocomposite were thoroughly characterized and their morphologies were investigated. Subsequently, the tribological performance of these nano additives was assessed. As expected, the ternary nanohybrid exhibited remarkable tribological activity compared to all other tested additives.

Chapter 4 comprises the hydrothermally synthesized bismuth selenide (Bi_2Se_3) nanosheets. To enhance the tribological efficiency, bismuth selenide nanosheets are further reinforced by incorporating lamellar bismuth tungstate (Bi_2WO_6), resulting in a hetero lamellar binary structure Bi_2Se_3/Bi_2WO_6. For the furtherance of efficiency, the bismuth tungstate was nitrogen-doped (N-Bi_2WO_6) and was used to reinforce Bi_2Se_3 nanosheets to obtain hybrid Bi_2Se_3/N-Bi_2WO_6. These were characterized thoroughly, and their tribological activity has been evaluated. Undoubtedly, the hybrid Bi_2Se_3/N-Bi_2WO_6 performed more efficiently than Bi_2Se_3/Bi_2WO_6.

Chapter 5 illustrates the preparation of MnV_2O_6 (MVO) and Co-doped MnV_2O_6 (C-MVO) nanosheets. MOF-derived NiO nanospheres, prepared through a hydrothermal process followed by calcination, were employed to enhance the tribological performance of C-MVO nanosheets through non-covalent functionalization. The prepared additives underwent a comprehensive characterization, and their tribological activity has been assessed. Undoubtedly, the hybrid NiO/C-MVO exhibited superior efficiency compared to all other tested additives.