ABSTRACT

Silicates are the most abundant minerals on Earth's crust having a wide range of applications in everyday life. Silicates are biocompatible, sustainable, thermally and chemically stable, and abundant complex oxide found in nature which encourages researchers to harness their untapped potential for innovations in various industries. Silicates due to their biocompatibility and antibacterial properties find applications in cosmetics, pharmaceuticals, and dental implants. They are used in construction materials, glassware, and ceramic dishes. Silicates are also used as anti-caking agents in the food sector, as well as in the cleaning of water. All things considered; silicates are present in many facets of our everyday lives but still underestimated in many growing technologies due to the lack of sufficient research. Exfoliation of Silicates in ultrathin geometry can reveal significant characteristics such as changes in symmetry, potential in bandgap tuning, modification of surface, charge accumulation and transfer properties, spin-orbital coupling, and others.

This thesis focuses on exploring the potential of two-dimensional silicates in energy harvesting and sensing applications. The first chapter provides an overview of the existing literature on 2D layered silicates and highlights the research gap in exfoliating non-layered silicates. The second chapter introduces and investigates a layered natural silicate from a phyllosilicate group called biotite. We discuss the importance of defect and charge transfer mechanisms in energy generation using ultrathin layered silicates. In the next chapters, we also explore the physical and chemical alterations of non-layered silicates upon exfoliation and their utilization in energy generation and gas sensing. Naturally occurring single-chain non-layered silicates (Diopside & Rhodonite) were exfoliated into 2D sheets for the first time and investigated in detail. The final chapter looks at exfoliating non-layered ring silicates and their properties, with a focus on flexible piezoelectric devices and wearable electronics. Throughout the thesis, we examine the physicochemical characteristics of these materials and their potential applications. The thesis showcases the potential of two-dimensional silicates in energy harvesting and sensing applications.

Keywords: two-dimensional silicate, exfoliation, energy harvesting, gas sensing, flexible devices