INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Nature-inspired anti-wettable materials—such as superhydrophobic coatings, liquid marbles, patterned interfaces with contrasting wettability, and slippery surfaces—have attracted tremendous interest due to their wide-ranging applications, including self-cleaning, sensing, water harvesting, and environmental remediation. Significant progress has been made in mimicking the functional liquid wettability found in natural systems such as lotus leaves, desert beetles, rice leaves, honeydew, and Nepenthes pitcher plants. Despite these advances, the development of next-generation anti-wettable materials still requires improvements in shelf-life, robustness under harsh environmental conditions, mechanical abrasion resistance, and eco-friendly fabrication methodologies. In this thesis, I report the strategic use of facile chemical reactions—specifically 1,4-conjugate addition and water-based amidation—combined with selected reactive molecules and crystalline polymers to create functional materials and coatings that enable on-demand liquid release, droplet manipulation, antigravity liquid transport, and self-cleaning behavior. The synopsis is organized into six chapters. Chapter 1 provides an overview of bio-inspired liquid wettability, summarizes common strategies for fabricating artificial anti-wetting surfaces, highlights the prevailing challenges in the field, and outlines the objective of this research. Chapter 2 discusses the post-modification of porous and reactive crystalline materials (MOFs) using selected alkyl amines via 1,4-conjugate addition. This modification tunes surface wettability from hydrophobic to superhydrophobic and enables the fabrication of liquid marbles capable of customized, pH-triggered release of encapsulated liquids. Chapter 3 introduces omniphobic capsules (colloidosomes) derived from crystalline, hydrophobic comb-polymers. These capsules effectively prevent liquid loss caused by surface adhesion or evaporation of encapsulated volatile liquids. Chapter 4 describes the fabrication of a chemically reactive superhydrophobic polymeric coating on textiles, creating wettability gradients that enable chemically modulated antigravity water transport. Chapter 5 presents the development of a fully waterborne, highly transparent, abrasion-resistant, and substrate-independent solid slippery–superhydrophobic interface, achieved via an amidation reaction between a thioester and an aminosilane. Chapter 6 concludes with a summary of the research findings and outlines future directions for the continued development of advanced anti-wettability materials.