Effects of Relative Humidity and Temperature on Particle Adhesion Measurements Using Mechanical Surface Energy Tester

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Understanding the dynamics of particle adhesion is crucial in determining powder flow in handling systems, which can be influenced by many factors including environmental humidity and temperature. This study focuses on examining the influence of relative humidity (RH) and temperature on particle adhesion using a mechanical surface energy tester (MSET). The experimental setup allows for precise control of RH and temperature conditions, enabling systematic investigation of their effects on particle adhesion and powder flowability.

The investigation was undertaken using seven pharmaceutical powders varying in particle size, shape, and particle densities. Undertaking a series of tests, different combinations of RH and temperature were applied to the dispersed samples/ surfaces, and the corresponding adhesion forces were measured using the MSET. The results reveal intricate dependencies of particle adhesion on RH and temperature, highlighting the complex interplay between surface properties, environmental conditions, and adhesion forces.

At lower RH levels, adhesion forces tend to increase due to reduced moisture content in the powder, leading to stronger intermolecular interactions between particles and surfaces resulting in more cohesion. Conversely, higher RH levels promote the formation of moisture layers, potentially weakening particle adhesion by lubricating the interface resulting in the free-flowing nature of the materials. Moreover, the results show that temperature variations influence the viscoelastic properties of the contacting materials, further modulating adhesion behaviour.

This study shows the mechanisms underlying particle adhesion in varying environmental conditions. The insights gained can inform further development of strategies for controlling and mitigating particle adhesion in diverse applications, such as manufacturing processes, air quality management, and surface engineering. Additionally, utilization of the MSET offers a robust experimental platform for investigating adhesion phenomena under controlled conditions and predicting the flowability of the powder using a small quantity of the material.

Keywords: Powder Adhesion; Pharmaceutical powders; Powder Flowability; Environment conditions