Impact of nanoparticles on insect attachment ability

Nanomaterials can represent an environmentally sustainable approach to control various insect pests. This study investigates the effects of biogenic and non-biogenic zinc oxide nanoparticles (ZnO-NPs) on the attachment ability of the southern green stink bug, *Nezara viridula* L. (Hemiptera: Pentatomidae), a significant agricultural pest. Experiments were conducted on glass surfaces treated with different concentrations of ZnO-NPs, and the attachment ability of adult males was assessed using traction force measurements. Results demonstrated that both biogenic and non-biogenic ZnO-NPs significantly reduced the insects' attachment, with notable decreases in friction force observed at concentrations of 12.5 mg L^{-1} and above. Scanning electron microscopy (SEM) analyses revealed the aggregation of ZnO-NPs on key attachment structures of *N. viridula*, including pulvilli, hairy pads, and claws, thereby interfering with the mechanical attachment mechanism. These findings were compared with those obtained using three other nanoparticle-based films: kaolin, zeolite, and calcium carbonate. Among the tested materials, ZnO-NPs, kaolin, and zeolite caused a significantly greater reduction in the safety factor than calcium carbonate. Overall, the results highlight the potential of ZnO-NPs—especially biogenic ZnO-NPs synthesized from plant extracts—as natural and eco-friendly agents for impairing insect attachment and reducing pest damage in crops.