CALIFORNIA STATE SCIENCE FAIR
2010 PROJECT SUMMARY

Name(s)
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Project Number
S1910

Project Title
Characterization and Optimization of the Bonding Forces of a Novel Silicon Nanowire Gecko Biomimetic Adhesive

Abstract

Objectives/Goals

The method by which geckos climb smooth vertical walls confounded scientists for over 100 years, until the discovery in 2000, that gecko feet are coated with millions of tiny hairs several nanometers in diameter. When a gecko foot is pressed to a surface the pliability of the tiny hairs permits them to draw close enough to the opposing surface to activate intermolecular bonding forces, allowing the gecko to adhere. In this project the bonding properties of a silicon nano-wire biomimetic gecko adhesives were characterized and its bonding forces optimized.

Methods/Materials

In this project five sets of experiments were completed in order to:

Determine the impact of moisture on the adhesion mechanisms of a gecko setae mimicking silicon nano-wire surface.

Discover if there is a correlation between the adhesion strength of silicon nano-wires and the surface energy of the opposing substrate.

Determine if the adhesion of a silicon nano-wire covered surface to biological surfaces is sufficient for use in medical applications.

Investigate the reusability of the nano-wire surface.

Become the first human to hang on a wall using a nano-fiber based dry adhesive.

Results

It was found that capillarity forces caused by water evaporating off of the silicon nano-wires increased adhesion force by a factor of almost 7x compared to applying the nano-wire surface dry. It was also determined that as the contact angle of a surface increases, the strength of adhesion to the silicon nano-wire surface decreases. On a smooth wetted low contact angle glass surface , adhesion forces above 10 N/cm2 were measured, greater than the adhesive force of most geckos. Adhesion forces of the silicon nano-wires to biological surfaces such as cow intestine and pig skin were found to be high enough to fail cohesively.

Conclusions/Discussion

Silicon Nano-wire surfaces can adhere to biological samples with forces high enough to cause cohesive failure of the tissue, making medical applications for targeted drug delivery or bandages and clamps that stick to moist biological tissue feasible. Also, based on optimized bonding conditions determined during the course of this study, the first documented suspension of a human from a vertical wall using nano-fiber adhesion was successfully demonstrated.

Summary Statement

In this project the bonding properties of a silicon nano-wire biomimetic gecko adhesives were characterized and its bonding forces optimized in order to determine the feasibility of the surfaces use in medical applications.

Help Received

Nanosys, Inc. provided materials and equipment ; Dr. Hugh Daniels and Dr. Wally Parce gave advice