The Hydrophobic Durability Characteristics of Butterfly Wing Surfaces after Freezing Cycles Towards the Design of Natured Inspired Anti-icing Surfaces

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Abstract

Frost formation on solid surfaces is ubiquitous in nature when the water vapor droplets contact surfaces with low temperature. The protocol is for carrying out the frost on the butterfly wing surface and analyzing the hydrophobic durability mechanism of butterfly wing surface. The protocol has been tested on ten different kinds of the butterfly species, *Papilio maackii, Gonepteryx mahaguru, Papilio xuthus, Vanessa cardui, Pieris napi, Argynnis paphia, PierisrapaeLinne, Parnassius glacialis, Mimathyma nycteis, Danaus genutia.*

Citation: Tingkun Chen,Qian Cong,Yingchun Qi,Jingfu Jin,Kwang-Leong Choy The Hydrophobic Durability Characteristics of Butterfly Wing Surfaces after Freezing Cycles Towards the Design of Natured Inspired Anti-icing Surfaces. **protocols.io**

dx.doi.org/10.17504/protocols.io.i2mcgc6

Published: 01 Aug 2017

Guidelines

The frosting process on wing surface of different butterfly species are observed by using self-designed microscopic observation and recording apparatus.

Atomic force microscopy (AFM) is used to observe the microstructure of butterfly wing surface, and measure the distance between the adjacent longitudinal ribs.

The contact angle of butterfly wing surface is measured by adopting the contact angle measurement system (OCA 30-2).

Before start

The microscopic observation and recording apparatus should be carried out many times of freezing test to testify the stability of cooling surface temperature.

Use a solution with a stock time of less than 3 months.

Protocol

Purchasing the butterfly specimens and classification

Step 1.

(1) Purchase the required butterfly specimens from Yunnan Aegean Sea Butterfly.

The seller has completed the initial distinction and classification of the specimens.

(2) Depend on 《Convention on International Trade in Endangered Species of Wild Fauna and Flora》and 《Series of the National Zoological Museum of China for wilding Ecology and Conservation-Butterflies》to determine the purchased butterfly specimens are not the protected insects.

(3) According to the 《Systematic Butterfly Names of the World》, 《Series of the National Zoological Museum of China for wilding Ecology and Conservation-Butterflies》and 《Classification and Identification of Chinese Butterflies》 to complete the final distinction and classification by adopting systematic taxonomy.

(4) Place the purchased the butterfly specimens into a glass box that the air flow inside.

Purchase other experiment supplies

Step 2.

(1) Purchase the copper plate with the thickness of 0.5mm from Xingye Copper International Group Limited.

(2) Purchase the ether and acetone from Beijing Chemincal Works.

(3) Purchase the water from Tianjin Pharmaceuticals Group Co. Ltd., China.

(4) Purchase the thermal conductor adhesive tape and grease from 3M corporation.

Fabricated the copper sheets

Step 3.

(1) Manufacture the copper sheets with a diameter of 6mm by using the slicing tool.

(2) Prohibit the edge of copper sheets with flanging.

(3) Avoid the surface of copper sheet from scratching.

Fabricated the specimen of butterfly wing

Step 4.

(1) Minimize the suffering to anaesthetize the butterfly specimen by using ether.

(2) Cut the butterfly wing with scaple.

Clean the copper

Step 5.

(1) Put the copper sheets in an acetone ultrasonic bath for 5min and a deionized water ultrasonic bath for anther 5min.

(2) Dry in an oven at 60 ℃.

Prepare the experimental samples

Step 6.

(1) Paste the butterfly wing specimens on the copper sheet by using the 3M 8810 thermal conductor adhesive tape.

(2) Observe the flatness of the butterfly wing specimens on the copper sheet by using the horizontal microscope.

(3) Remove the impurities from the experimental sample surface by using the dry nitrogen.

Evaluate the surface properties without frosting

Step 7.

(1) Observe the surface morphology of the different butterfly wings by using the AFM.

(2) Repeated measure the contact angle of different butterfly wing by using the contact angle measurement system (OCA 20).

Amount: *μl*

Frosting/defrosting cycles test

Step 8.

(1) Adjust the experimental apparatus to determined temperature and humidity.

(2) Record the frosting process on surface of different samples by using observation device.

(3) Use the dry nitrogen to clean the sample after each experiment.

(4) Observe the micro-structure by adopting AFM.

(5) Measure the contact angle of the butterfly wing surface by using OCA20.

Amount: *μl*

Notes:

The operational temperature of the OCA20 must below the 25 ℃.

Warnings

Avoid cutting during the preparation of the sample process.

Avoid inhalation of acetone and ether.