Graphene Visualizes the First Water Adlayers on Mica at Ambient Conditions

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Techniques not suited to study of water in room-temperature

Scanning tunneling microscopy (STM)  atomic force microscopy (AFM)

Need ultra high vacuum  

the capillary menisci formation:

Scanning polarization force microscopy (SPFM) : the lateral resolution of SPFM is relatively low
AFM study of the water adlayer structures on mica under ambient conditions

A difficult water adlayer`s mobility

the use of monolayer graphene sheets (ultrathin coating )
(the standard method of mechanical exfoliation)

tightly seal  Stably fix

A schematic of graphene
Materials

A schematic of graphene

A structure of ordinary ice (~0°C)

muscovite: mica structure

http://www.britannica.com/EBchecked/topic/398688/muscovite
Humidity-dependent experiments

Ambient humidity experiment (RH=36% to 42%):
- Graphene deposite on mica at ambient conditions

Low humidity experiment (RH = 1.8% to 2.1):
- Mica disks : heat in air at 200 °C for 10 min
  - mica surface cleave
  - equilibrate for ~5 min
  - a continuous flow of ultra-high purity argon
- Graphene deposite in glove-bag
high humidity experiment (RH = 89±2%):

Mica disks

↓

chamber
- beaker of water is the center of chamber
- mica surface cleave
- equilibrate for ~5 min

↓

Graphene deposite in chamber
In ambient humidity

(C) AFM image of a monolayer graphene sheet deposited on mica.

- Polygonal shapes
- Island with multiple 120° corners
- Monolayer graphene sheet is folded

- Dotlike thicker areas are surface defects
- Surface defects attract water

The first water adlayer has an icelike structure on the substrate.
In low humidity experiment (RH = 1.8% to 2.1%)

No islandlike structures
- dotlike structures
- surface defects
- no reliably detectable water adsorption on mica surfaces

High density of surface defects
- most islands connect nearby defects
- the importance of defects for water adlayer nucleation

Height of ~0.37 nm indicates single adlayer of water
In high humidity experiment (RH = 89±2%)

- First water adlayer: monolayer graphene with a thickness of 0.7 nm.
- Close-up of the pinholes.
- Image of monolayer graphene deposited on mica with a high density of surface defects.
- Liquidlike structure.
- Bulgelike features.
- Close-up of the second adlayer islands.
- SPFM results: ~120° polygonal shapes.
- Water adlayers grew epitaxially on mica in a layer-by-layer fashion.

- Submonolayers form atomically flat, faceted islands of height $0.37 \pm 0.02$ nm, in agreement with the height of a monolayer of ice.

- In higher relative humidity, the second adlayers also appear icelike, and thicker layers appear liquidlike.

- Surface defects serve as nucleation centers for the formation of both the first and the second adlayers.