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Durability of Superhydrophobic Candle Soot Layer Deposited on Adhesive Tape

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Abstract:

Superhydrophobic surfaces are difficult to wet as the water drops makes contact angle higher than 150° and quickly roll off the surface on slight tilting. The superhydrophobic coatings can be fabricated by merely controlling the surface roughness and maintaining the low surface energy. We have fabricated the superhydrophobic coating on glass plate through candle soot deposition; however the coating showed poor mechanical stability. Hence, to achieve the durable candle soot based superhydrophobic surface, the adhesive tape was placed on the candle soot deposited glass plate and peeled off. The candle soot was firmly attached on the adhesive tape and the tape served as superhydrophobic surface. The candle soot layer on tape is less fragile as compared to candle soot layer on glass slide. The drop impact test and water jet impact tests confirmed the durability of the superhydrophobic surface.

Keywords: Superhydrophobic, wettability, contact angle, self-cleaning, sliding angle.

1. Introduction:

In nature, many natural surfaces show water repellency with water contact angle greater than 150° and sliding angle less than 10°, such surfaces are known as superhydrophobic. The biological surfaces such as lotus leaf [1], gecko's feet [2], and the wings of butterflies [3] surfaces show water repellent property. Such superhydrophobic surfaces have essential application in scientific research and engineering work. The carbon nanoparticles are available in different form such as carbon black, carbon nanotubes, coke, carbon nanofibres, diamonds, fullerene, glassy carbon, active carbon, and many. The carbon nanoparticles can be easily collected from the candle flame which shows superhydrophobic property without any physical and chemical surface modification. Liang et al [4] have reported that soot collected at tip of candle flame has hydrophilic and oleophilic due to incomplete combustion of wax vapor and those collected from middle of the flame are superhydrophobic and superoleophilic. In Wenzel state [5], the wettability of solid substance is proportional to roughness of solid surface. In Cassie-Baxter state [6] water droplets easily roll off due to trapped air in cavity of nano-and micro-structured rough surface.

When candle soot was directly deposited on glass slide, the candle soot was easily removed with water droplets. Seo et al [7] have fixed the candle soot on paraffin wax surface without any chemical modification and improved durability of candle soot. In such case paraffin wax act as a binder and improved drop impact durability up to a factor of 50, compared to a bare soot coating without a paraffin wax treatment. Xu et al [8] have reported that when candle soot combined with polydimethylsiloxane (CS-PDMS), it showed excellent superhydrophobicity with CA of 160° and the robustness was far better than the pure CS deposited on glass. In the present research work, to achieve the durable candle soot based superhydrophobic surface, the adhesive tape was placed on the candle soot deposited glass plate and peeled off. The candle soot was firmly attached on the adhesive tape and the tape served as superhydrophobic surface. The drop impact test and water jet impact tests confirmed the durability of the superhydrophobic surface.

2. Experimental Section

2.1 Materials: Glass slides (75 mm long × 25 mm wide) were purchased from Polar Industrial Corporation Mumbai (India). Candle (15 cm height × 2 cm diameter) and two sided adhesive tape was purchased from local market.

2.2 Preparation of superhydrophobic candle soot layer on adhesive tape

The preparation of superhydrophobic candle soot layer on adhesive tape is schematically depicted in **Fig. 1**. Candle soot was deposited on glass slide by holding it in the middle of the candle flame for different times (3, 6, 9 and 12 minutes). The adhesive tape was applied on candle soot deposited glass slide and gently pressed to make good contact between tape and glass slide. The tape was slowly peeled off from the glass slide. Adhesive materials on tape act as a binder, which bind soot particles on the surface of tape.

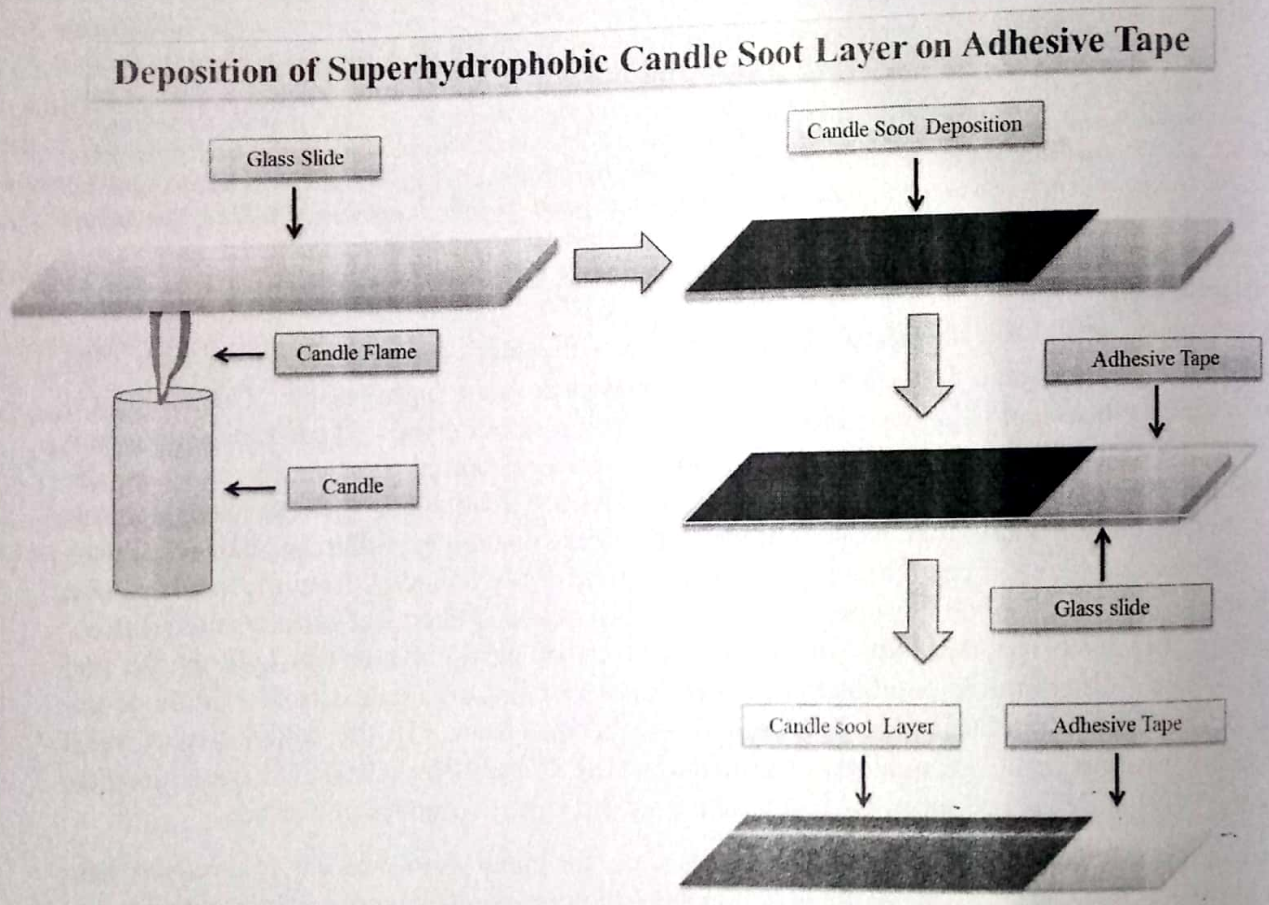

Fig.1: Deposition of superhydrophobic candle soot layer on adhesive tape.

2.3 Characterizations

The wettability like water contact angle and sliding angle were measured by using Contact Angle Meter (Halmarc Co. Ltd.). The durability of the prepared coating has confirmed by water jet impact test and water drop impact test.

3. Results and discussion

3.1 Wettability of the prepared candle soot deposited surface

The adhesive tape was applied on the candle soot deposited glass plate and peeled off slowly to achieve durable candle soot based superhydrophobic surface on adhesive tape. Candle soot deposited adhesive tapes peeled off from the glass slides deposited with candle soot for 3, 6, 9 and 12 minutes (sequentially from left to right) are shown in **Fig. 2**. The appearance of transparent adhesive tapes was turned into black color due to candle soot deposition on the tape.

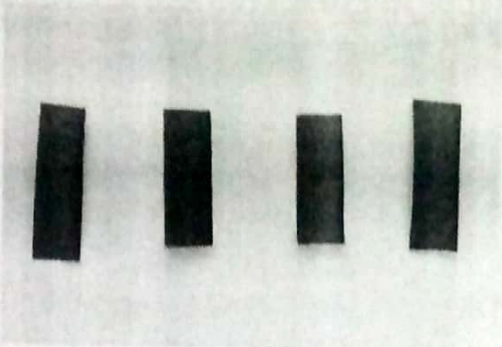

Fig. 2: Candle soot deposited adhesive tapes peeled off from the glass slides deposited with candle soot for 3, 6, 9 and 12 minutes (sequentially from left to right).

The water contact angles were measured on the candle soot deposited adhesive tapes peeled off from the glass slides deposited with candle soot for 3, 6, 9 and 12 minutes. The accurate water contact angle and sliding angle values were reported by measuring contact angles and sliding angles on five different positions on the each sample. All the samples showed water contact angle higher than 153° and sliding angle less than 8°. **Fig. 3** shows the optical photographs of water drops on the candle soot deposited adhesive tapes (peeled off from 12 and 06 minutes candle soot deposited glass plates). No pinning of water drops was observed on the surface and the water drops rolled off freely. While rolling, no candle soot was carried out off the surface as it was observed on candle soot deposited glass plate. The adhesive on the tape acted as a binder which holds carbon soot nanoparticles on the surface.

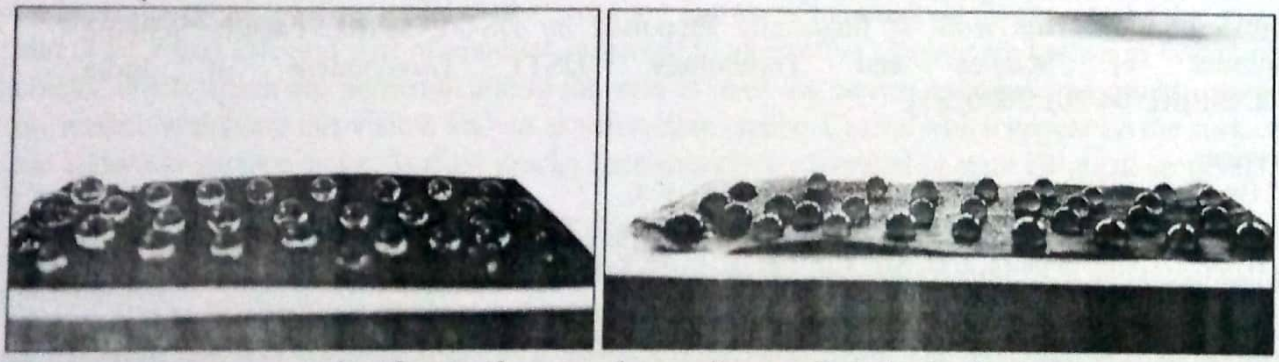

Fig. 3: Optical photographs of water drops on the candle soot deposited adhesive tapes (peeled off from 12 (left) and 06 minutes (right) candle soot deposited glass plates).

3.2 Durability of the superhydrophobic surface

The mechanical durability of the candle soot deposited adhesive tapes was checked by water drop impact test and water jet impact test. In case of candle soot deposited glass plate, the candle soot was washed away by the rolling water drops which were gently kept on the surface. The set up of water drop impact test is as shown in **Fig. 4**. A 500 ml plastic bottle was filled with water and connected to syringe by flexible plastic pipe. The drop falling rate was adjusted to 1 drop / 5sec. The needle to substrate distance was kept nearly 10 cm. The wetting properties of candle soot deposited adhesive tape were checked after every 30 minutes. It was observed that the wetting properties (both static and dynamic angles) of the superhydrophobic surface were intact for almost 2 h of water drop impact test. The contact angle reduced slowly to 127° after 5 h of continuous water drop impact test, which confirms the damage prone to the surface. The water jet impact test was also carried out on candle soot deposited adhesive tapes which confirmed no damage on the surface and water jet was just bounced off the surface.

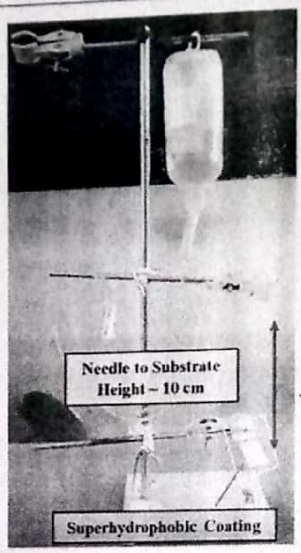

Fig. 4: Set up of water drop impact test.

Conclusion: Simple deposition of hydrophobic candle soot on glass plate showed superhydrophobic wetting properties, however very fragile in nature. We improved the durability of superhydrophobic candle soot layer by simply applying it on the adhesive tape. The candle soot deposited adhesive tapes showed durability against water jet impact test and water drop impact test. The cheap and easily available candle soot can be used to prepare durable superhydrophobic coating and its cost can be greatly reduced.

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