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Original Article

Bio-Waste-Derived Hydrophobic Coatings: A PDMS-Hair Composite with Enhanced Durability

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Abstract *- The study presents the development and characterization of hydrophobic surfaces for enhanced water repellency using human hair bio-waste material, where the hair particle size is less than 45 µm. A new surface fabrication technique is developed that uses micron-sized hair powder in a PolyDiMethylSiloxane (PDMS) matrix, with particle binding reinforced using stearic acid as a coupling agent. To enhance the durability of the hydrophobic surface, a protective layer of PolyDiMethylSiloxane is deposited on the surface using a custom-designed spraying arrangement. Scanning Electron Microscopy (SEM) and Energy-Dispersive Spectroscopy (EDS) analyses are conducted to investigate the surface topology and chemical composition of the hydrophobic surface. The experimental results reveal a contact angle of 127°, demonstrating the water-repellent nature of the fabricated surface. Moreover, the surface exhibits remarkable robustness and withstands a drop test from a height of 75 mm. Further, the tilting angle test reveals that a water droplet rolls off the surface when the inclination angle exceeds 19°, with leading and lagging contact angles of 120° and 135°, respectively.*

Keywords *- Biological materials, Energy Dispersive Spectroscopy, Scanning Electron Microscopy, Water Contact Angle, Water repellency.*

1. Introduction

Hydrophobic surfaces have attracted considerable attention in recent years owing to their unique properties and wide-ranging potential applications, and have exceptional water-repulsive features [1, 2]. A super hydrophobic surface has a Water Contact Angle (WCA) of 150˚ – 180˚, whereas a hydrophobic surface ensures a WCA of 90˚- 150˚, whereas non-hydrophobic surfaces have a WCA less than 90^0 [3, 4].

Inspired by nature's own hydrophobic surfaces, such as lotus leaves, researchers have been attempting to develop artificial surfaces that mimic the WCA achieved by these natural surfaces. In order to attain hydrophobicity, a surface essentially has an absurd micro-roughness and a low surface energy similar to that of a lotus leaf [5-7].

Researchers have attempted to create durable superhydrophobic surfaces using eco-friendly biological waste materials, including eggshell, bamboo, and coconut shell. Recent focus on hydrophobic surface development has shifted to controlling surface wettability, unlocking potential applications for self-cleaning surface technologies, air water harvesting, and more. There are two predominant methods to fabricate a hydrophobic surface, where one method incorporates controlled roughness in a low surface energy material. The other technique applies a very thin layer of low surface energy material on a rough surface. [8-10].

Jinmei He et al. [11] A superhydrophobic coating was created on a glass slide using a mixture of 2 gm of eggshell particles with irregular shapes and ZnO micro particles, where the mixture was treated with 0.2 gm of stearic acid and ethanol [11]. The author reported that the rough surface structure featuring voids and grooves was key to achieving superhydrophobicity. In an experimental study [12], eggshell particles treated with stearic acid were used with a polymer binder and then coated on a glass substrate using the dip coating method, to obtain a WCA of 151˚- 153˚. Author Panpailin et al. [13] used eggshell micro powder modified with stearic acid and dispersed in polymer binder to achieve a hydrophobic surface on a glass substrate to ensure WCA of 151˚- 153˚.

Mechanical durability is an important concern during the use of superhydrophobic coatings for practical applications. The hydrophobic surface has micron-sized roughness, which may be easily damaged during the wear process, resulting in loss of hydrophobicity. Xiao Gong et al. [14] performed sand abrasion and water drop tests to characterize the mechanical durability of the coating for hydrophobicity on substrates. Post-test, Scanning Electron Microscopy images indicated that PolyDiMethylSiloxane (PDMS) enriches the stability and hydrophobicity of the coating. S. Maryam Shah et al. (2017) [15] fabricated a hydrophobic surface on the glass slides coated with alternate layers of alumina nanoparticles and a thin layer of PDMS solution. The durability of the hydrophobic coating is attributed to the surface roughness due to the presence of Al_2O_3 particles in the PDMS matrix, where the authors reported that after the third layer, the WCA was 165º± 4º.

Certain bio waste, including human hair have inherent hydrophobic nature with a WCA of 120 ˚. There is a need to explore the possibility of improving the WCA by converting the material to micro-sized powder [16, 17]. Preparation of micron size powder is easier and cost-effective than preparation of nano-sized powder. Inorganic materials like metal oxide nanoparticles are used to create a hydrophobic surface by ensuring a rough texture, which reduces the surface energy. Attempts are made to apply such coatings on machines used in electronics and textile engineering [18] (2024).

Fluoro-Ethylene-Propylene (FEP) based hydrophobic coating was implemented on the aluminum substrate by cold-spray process using fumed nano-ceramic and nano-alumina materials. Particle size, substrate temperature, inlet gas temperature, and pressure play a critical role in the particle deposition process and adhesion, which further influences WCA [19]. Authors reported that PolyTetraFluoroEthylene (PTFE) exhibits a superior hydrophobic nature owing to the low surface energy. Wrinkled superhydrophobic surfaces, made up from two forms of PTFE, revealed the durable and excellent hydrophobic properties with WCA of 163 ˚ to 172 ˚ with a lower roll off angle [20, 21]. The hydrophobic nature of the surface made using Cellulose Nano Fibre (CNF) greatly improves after modifying the functional group of CNF with PerFluoroOctylTriEthoxySilane (PFOTES), where the surface revealed WCA of 128 ˚ [22]. Xuelian Zhou [23] reported that modifying cellulose surface with crosslinking agent Methylene Diphenyl diIsocyanate (MDI) resulted in improved hydrophobicity and exhibited WCA up to 137 ˚.

Authors have prepared a self-cleaning hydrophobic nano coating on a glass surface with chemical vapor deposition of TriChloroPerFluoroOctyl-Silane (TCPFOS) [24]. Satish Mahadik et al. [25] developed a sol-gel spray coating method for the fabrication of MethylTrimEthoxySilane (MTES) based hydrophobic coating on various metallic and glass substrates with a WCA of 161 ˚- **170** ˚. Suresh Sagadevan et al. [26] investigated the use of crystalline copper particles of 30-50 nm to achieve a hydrophobic surface. Inherent presence of starch in a bio-degradable material ensures better film-forming ability and biocompatibility. Further, these surfaces can be subjected to processes like cross linking, grafting and condensing reactions to improve the hydrophobic nature [27].

Jaychandra et al. [28] performed an experiment to manufacture bioplastic film from orange peel, with a hydrophobic nature, where WCA was 140^0-150^0. Guo Li et al. [29] reported that nano SiO_2 and TiO_2 nano particles, after being treated with silane, ensure an increase in the surface roughness when used in a coated concrete, thereby resulting in enhanced WCA and reduced water absorption.

Ming Zhang [30] reported that the modified silica particles can be coated on the filter paper by the drop coating method to enhance wettability and create a super hydrophobic surface with WCA 156 ˚.

A comprehensive literature review revealed that the two methods employed for developing hydrophobic surfaces include roughening the surface (i.e. enhancing surface roughness of inherently low-surface-energy materials to amplify hydrophobic properties) and coating of low surface energy material [31, 32].

Plasma etching, plasma polymerization, phase separation, spin coating, spraying, electrospinning, laser texturing, and electrochemical machining methods are primarily used to generate controlled micro-roughness in the surface, which increases the surface energy to ensure a hydrophobic nature. Further nanoparticle deposition, sol-gel, electrochemical, solvothermal, and salinization are the chemical methods to generate hydrophobic surfaces by coating the low-energy material [33, 34].

The above-mentioned methods of surface modification are hindered by several limitations, including high equipment costs, potential substrate damage, complex process control, limited material selectivity, scalability issues, and generates hazardous gases, resulting in safety and environmental concerns, which restrict their widespread adoption and application [35-37].

Techniques used to create rough surfaces, such as dip coating, atomic layer deposition, chemical vapor deposition, and spray coating using Al_2O_3 and SiO_2, are often expensive [38-40]. The plasma polymerization method has additional limitations of reduced film stability, lower reproducibility and difficult process optimization [41]. Eggshell nanoparticles, a bio-based material, have demonstrated exceptional hydrophobicity with contact angles exceeding 150°. However, the synthesis of these nano-powders and the coating process are expensive, and have the challenges of particle aggregation, stability, limiting their widespread adoption. [42]. The particle deposition method involving the use of inorganic alumina and silica nanoparticles in a PDMS matrix faces cost challenges [43].

There is a need to utilize commonly available bio-waste material for the preparation of a hydrophobic material. Further, preparation of nanoparticles from the bio waste material is a costly process, and there should be an attempt to use micron-sized powder for the development of hydrophobic material. A promising approach is to utilize biological materials, like human hair, to create hydrophobic surfaces with enhanced water repellency.

This work explores the possibility of using human hair biological waste, which is widely available, for the preparation of a hydrophobic surface when used in micron-sized powder form. The proposed fabrication method is simple, inexpensive and uses custom-designed devices to fabricate the surface. A hydrophobic surface is prepared on a glass slide, and Scanning Electron Microscopy (SEM) and Energy-Dispersive X-ray Spectroscopy (EDS) are used to study the surface morphology and chemical composition. Detailed analysis of Water Contact Angle (WCA) is discussed with the investigation of the drop test and inclination test effects.

The paper is structured as follows. Section 2 outlines the experimental methods employed to fabricate the hydrophobic surface. Section 3 presents the results and discussion, encompassing hair particle size distribution analysis, surface morphology and chemical analysis of the powder and prepared hydrophobic surface, drop test results, effects of acidic and alkaline environments on the prepared surface, and inclination effect on Water Contact Angle (WCA). Section 4 summarizes the conclusions drawn from the study.

2. Materials and Methods

2.1. Materials

In the present study, human hair biological waste is used for hydrophobic surface preparation. The hairs are collected from an Indian population of the age group 25-40 years in Pune, Maharashtra, India. Human hairs are collected and cleaned to remove dirt and other contaminants. Later, the hairs are washed carefully to remove oil and other chemicals.

The hair samples are then converted to fine powder with less than 45 µm by using the patented process developed by the Institute of Applied Research (IAR), Pune, India. Later, the sieving operation is performed to obtain a sample of hair powder within a 25-45 µm particle size for the hydrophobic surface preparation. Human hair powder, PolyDiMethylSiloxane (PDMS), stearic acid, and ethanol are used for the surface preparation.

The epoxy resin, PDMS (Type-520 grade, Density- 0.965 gm/cm^3) and hardener (Type- HG Grade, Density-0.965 gm/cm^3) are sourced from Asterix Reinforced Ltd., Silvassa, India. The coupling agent (stearic acid) has a density of 0.90 gm/cm^3 and is manufactured by Fisher Scientific Pune, India.

2.2. Fabrication of Hydrophobic Surface/ Preparation of Hydrophobic Film

The hydrophobic surface is deposited on the glass substrate, where the glass substrate was thoroughly cleaned by washing several times with deionized water and alcohol, with air drying to ensure a clean surface. The hydrophobic surface is created in the following three steps.

1. Base layer deposition
2. Hair powder deposition
3. Deposition of protective PDMS layer on the hair powder layer

The details of each step are as follows;

2.2.1. Base Layer Deposition

Initially, the epoxy resin and hardener are mixed with a mass percentage proportion of 70:30, and later the coupling agent (Stearic Acid) is added by 5% of the total mass. The mixture is diluted in 80% ethanol to increase its fluidity so that it can be sprayed easily using an atomizer arrangement. Then the mixture is used to prepare a thin film (≈ 0.05-0.1 mm thickness) using an atomizer arrangement as illustrated in Figure 1 Arrangement in the atomizer comprises of compressed nitrogen flow (Pressure: 4 Bar, flow rate: 42 liter per minute (lpm)) along with a provision to feed the epoxy mixture in the air stream at an angle of 60° to the air flow path. Use of the diluted epoxy mixture makes it possible to be used along the nitrogen stream to get a uniform base layer. The epoxy film was carefully prepared to have a uniform thickness by controlling the horizontal travelling speed of the atomizer (the travelling speed maintained was 60 cm/min).

2.2.2. Hair Powder Deposition

After deposition of the base layer, hair particles are sprayed on the base layer. The arrangement illustrated in Figure 2 is used to spray and embed the hair particles in the base layer, which uses a nitrogen cylinder and a customized spray gun. A photograph of the spraying device is shown in Figure 2. The spray device is provided with pressurized nitrogen (Pressure – 4 Bar, flow rate 42 lpm). The hair powder is contained in the chamber as shown in Figure 3, which comes out with the pressurized nitrogen. The sprayer is moved manually over the base layer at a speed of 3 cm/sec to obtain a uniform distribution of the hair particles. Pressurized flow of the nitrogen gas ensures embedding of the particle inside the base layer, whereas movement of the sprayer ensures uniform particle deposition. After deposition of the hair powder, the specimens are cured in the hot air oven at 80^{o}C (Make- Swan Scientific) for the duration of 30 minutes.

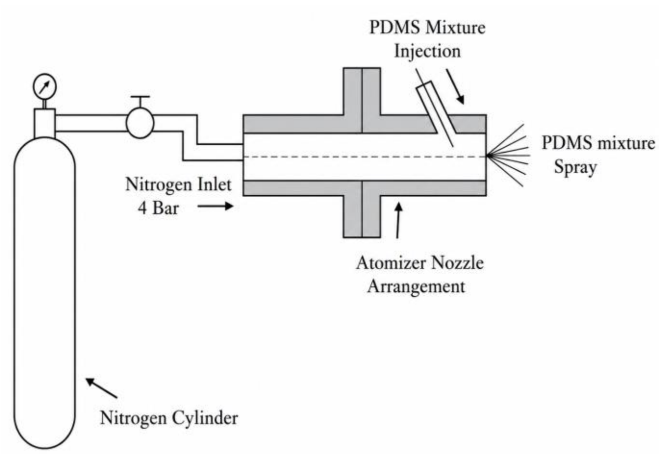

Fig. 1 Arrangement of the atomizer used for making epoxy film

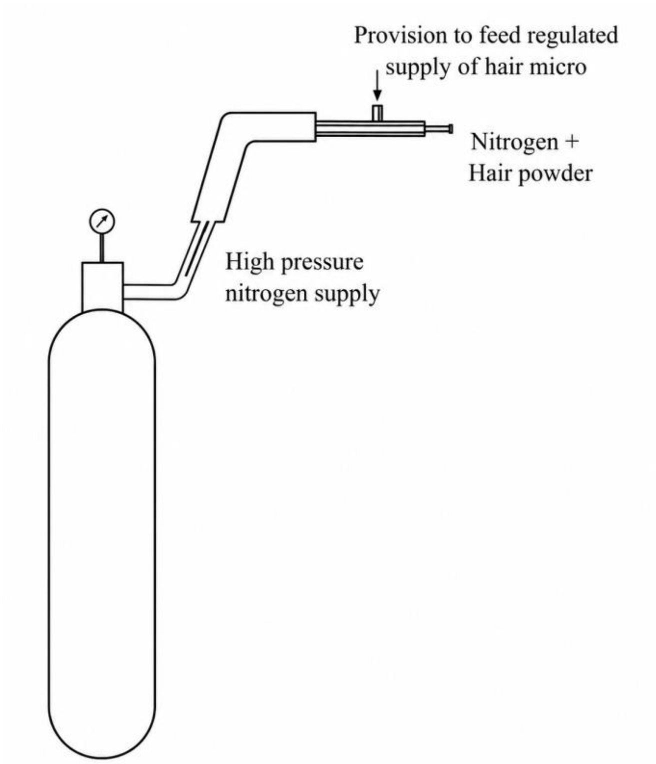

Fig. 2 Arrangement to spray the hair micro powder on the epoxy layer

Fig. 3 Photograph of powder spraying arrangement

2.2.3. Deposition of Protective PDMS Layer on the Hair Powder Layer

Coating of the additional epoxy layer is necessary to ensure the strength and durability of the prepared hydrophobic surface. The arrangement illustrated in Figure 1 is used for spraying the epoxy layer on the hair micro powder, where the epoxy is carried in ethanol (Density-0.79 gm/cm^3 at 20 ˚C with 20:80 mass proportion). Uniform velocity of the atomizer, along with the regulated feeding of epoxy and carrier, is essential to ensure uniform thickness of the epoxy layer over the micro powder. Finally, the specimens were subjected to curing in a furnace at 80°C for a duration of 30 minutes to ensure the strength of the epoxy layer.

Two types of hydrophobic surfaces are prepared during the present study, with the details as follows.

Type I – Surface with a base layer with PDMS and a coupling agent, followed by the hair particles on the layer at the top.
Type II - Surface with base layer, followed by hair powder and a thin PDMS layer at the top

A flow chart for the preparation of the hydrophobic surface is illustrated in Figure 4.

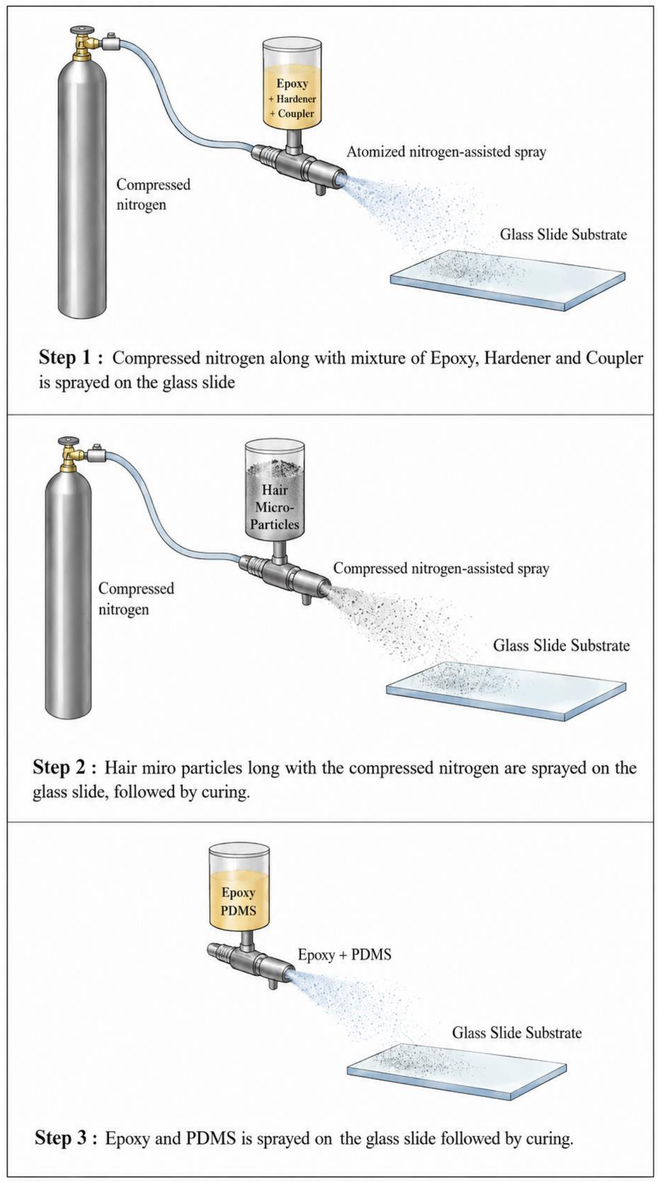

Fig. 4 Flow chart for preparation of the hydrophobic surface

2.3. Morphology Characterization

The surface topographies of the developed hydrophobic surface were investigated by using Scanning Electron Microscope (SEM) (Make- JSM-6360) at the experimentation facility at the Department of Physics, Savitribai Phule Pune University, Pune, India. Energy Dispersive X-Ray Spectroscopy (EDS) is used to study the chemical composition of the coated surface.

2.4. Contact Angle Measurement and Wettability

The wettability of a solid surface is commonly evaluated using the contact angle between the droplet and the interface. When a water drop is added over a solid surface, the droplet will reach an equilibrium state and will no longer spread. The water contact angles of the coated specimens (I and II) were measured using a contact angle goniometer (Rame-Hart Instrument Co., Charotar University of Science and Technology, Gujrat, India 388421). The measurements were taken at various tilt angles, ranging from 0° to 20°, with an interval of 5°. The roll-off angle, defined as the point at which the droplet begins to slide down the inclined surface, was determined for each specimen. The reported contact angle values represent the average of three independent measurements performed on five different samples, all of which were prepared and measured under identical surface conditions. This approach ensures the reliability and reproducibility of the results, providing a robust representation of the surface hydrophobicity. In the measurement process, the volume of each water droplet was carefully controlled and maintained at a consistent 0.33 ml. According to previous studies, the ideal volume for the water droplet is up to 10 μL. Using smaller droplets helps prevent deformation due to gravity, ensuring a more accurate measurement of the contact angle and maintaining the droplet's spherical shape [5].

3. Results and Discussion

Human hairs have a hydrophobic nature, which is attributed to several factors, including particle structure and the presence of lipid layers [16]. Cuticle structure consists of overlapping layers of 0.5 – 1.5 µm wall thickness, which acts as a barrier against water retention. The lipid layers with fatty acids and cholesterol contribute to hydrophobicity. Surface energy of human hairs varies from 20-70 mN/m with a contact angle between $120^{\circ}-150^{\circ}$, which indicates a hydrophobic nature inherent [16, 17]. Hydrophobic behavior of the surface is exhibited due to surface texture as well as chemical nature.

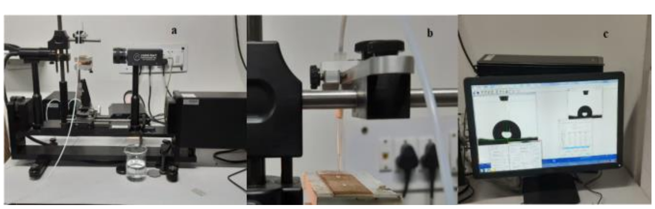

Fig. 5 Photos shot during measurement of contact angle on contact angle goniometer

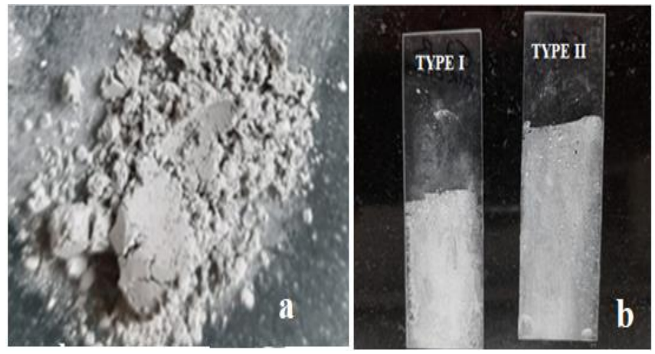

Fig. 6 (a) Human hair micro powder used for the preparation of the hydrophobic surface (b) Photograph of Type I and II Specimen.

In the present work, the hydrophobic nature of human hair is further enhanced by converting it into micro-sized powder. Photographs of the hair powder used to prepare the surface are shown in Figure 6 (a), and specimens I and II are given in Figure 6 (b).

The SEM image shown in Figure 7(a-d) reveals a variation in the hair particle size between 25 and 45 μm, and there is a uniform distribution of different-sized particles. The particles are non-uniform in shape. This is due to the fact that the particles were sieved to below 45 μm in size before using them for the preparation of the hydrophobic surface. Average particle density on the surface is approximately 4000 particles per mm^2.

Morphology of the fabricated surface is a very important factor for hydrophobicity. SEM images of Type I and Type II surfaces with different resolutions are shown in Figure 8 and 9, respectively. The particle shape in the PDMS matrix varies significantly and is quite uniform, with obscure, distinct edges. Distinct edges of the hair particles in the PDMS matrix are attributed to the fact that the hair particles are not very deeply pressed inside the PDMS layer.

The uniformity and smoothness of the base matrix is because the surface was cured at 80ºC, which does not undergo excessive shrinkage during the curing process. The base PDMS matrix is observed to be smooth and uniform without the presence of external material. Further, the hair particles are embedded in the surface and are sprayed uniformly over the surface.

Image of the PDMS-coated hydrophobic surface (Figure 9) reveals that there is no influence of the top PDMS layer on the particle density and placement. The particle's edges are observed to be distinct in a similar manner to the uncoated surface. Appearance in the higher magnification images reveals that the top PDMS layer does not influence penetration of the hair particle inside the base PDMS matrix. The hydrophobic property is attributed to the thin layer of air, entrapped between the surface and the water drop, in addition to the effect of the surface energy of human hair particles.

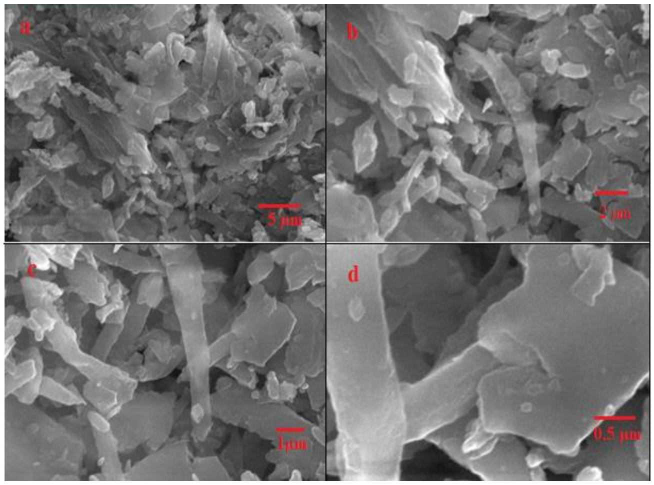

Fig. 7 SEM images of hair micro particles a) 5 µm b) 2 µm c) 1 µm d) 0.5 µm.

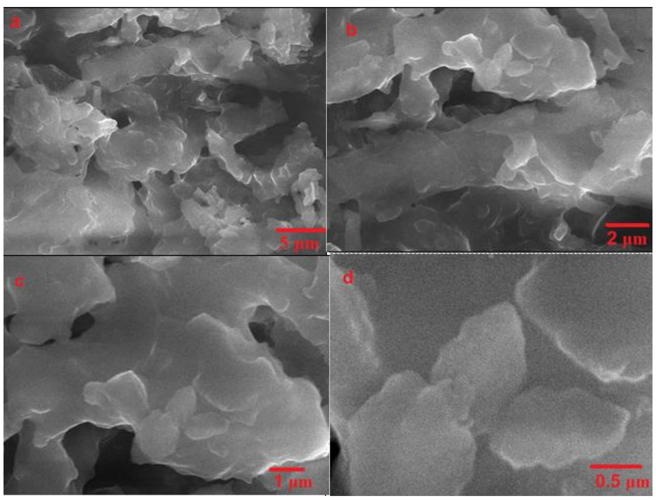

Fig. 8 SEM images of type I surface a) 5 µm b) 2 µm c) 1 µm d) 0.5 µm

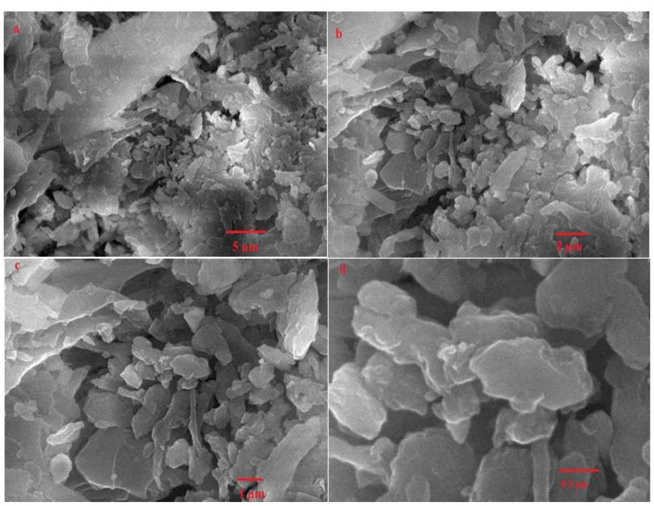

Fig. 9 SEM images of type II surface a) 5 µm b) 2 µm c) 1 µm d) 0.5 µm

Particle size distribution shown in the Figure 10 reveals particle size between 25-45 µm, which results in micro-sized surface texture.

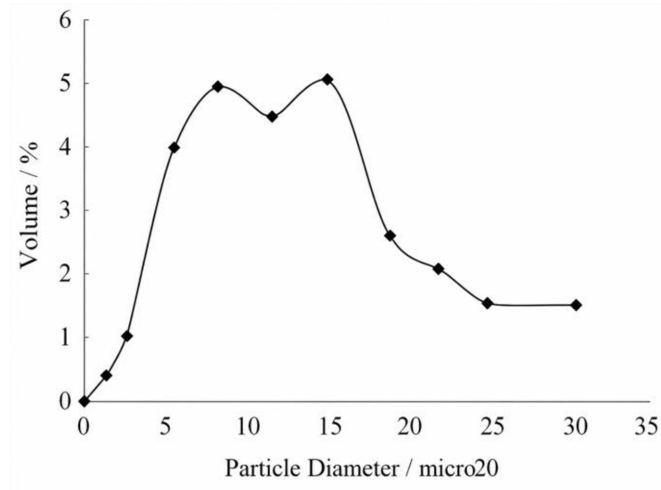

Fig. 10 Volume % vs particle size (Particle size distribution of hair micro-particles)

Results for chemical analysis of the hair powder and hydrophobic surface are shown in Figures 11- 13

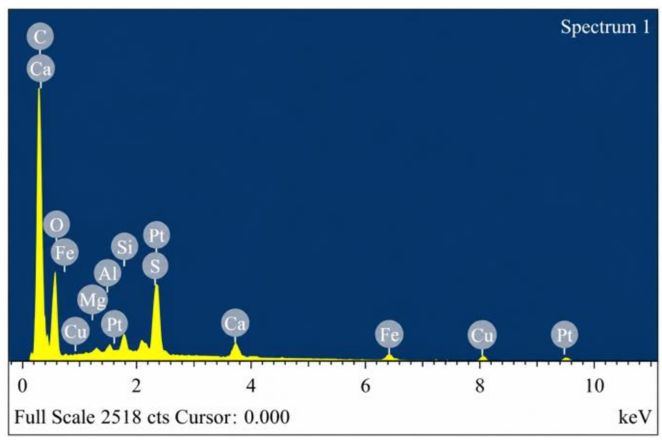

Fig. 11 EDS analysis of hair particles

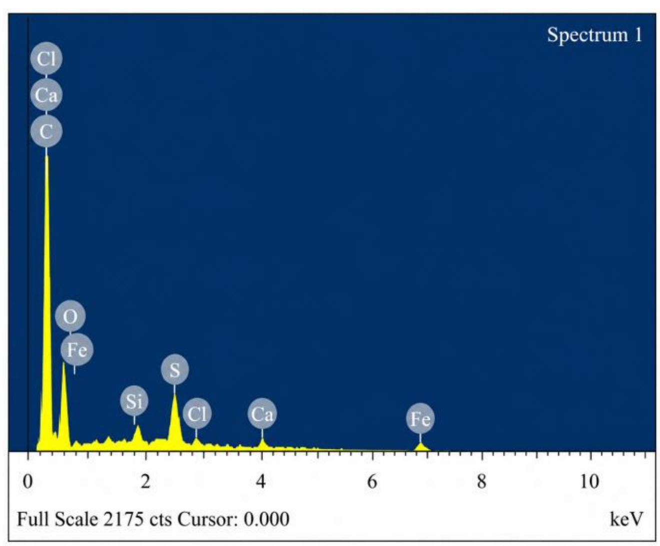

Fig. 12 EDS analysis of Type I hydrophobic surface (without PDMS layer at the top)

EDS analysis for the hair powder shown in Figure 11 reveals the presence of C (65.20 %), O (31%), Si (0.18%), S (2.84%) and Fe (0.18%). The chemical composition results closely matching with the previously reported chemical composition for hair powder [44]. In the case of the hydrophobic surface with a base PDMS layer and particles above the layer (Type I), the composition reveals a mixture of the elements for PDMS and hair powder, with an increase in Fe, O, and Cl that of the hair particles. Finally, the surface with the thin layer of PDMS coating (Type II) results in the presence of C (66.85 %), O (29.58 %), Si (0.66 %), S (1.34%), and Fe (0.61 %). It can be noted that the presence of a thin PDMS layer at the top reduces the chemical elements of S and Fe in the chemical composition measured for the surface with a PDMS layer at the top.

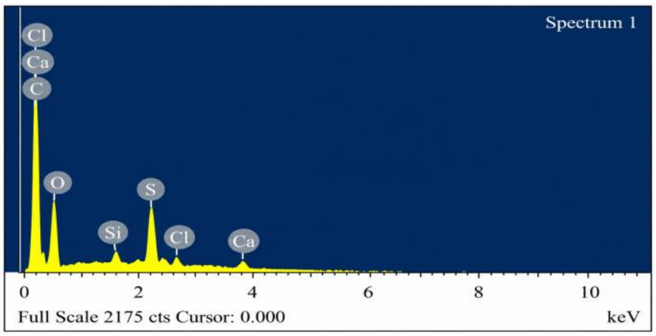

Fig. 13 EDS analysis of Type II hydrophobic surface (with PDMS layer at the top)

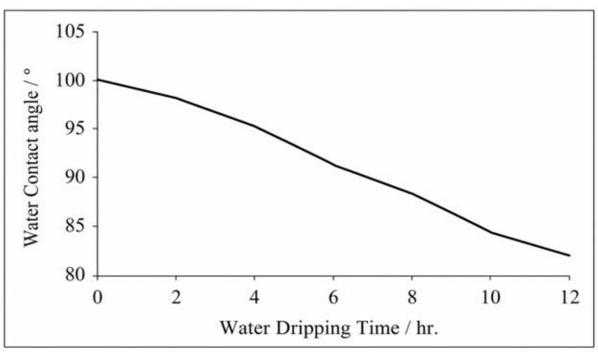

Fig. 14(a) Effect of water dripping on WCA on (a) non-coated surface (Type I)

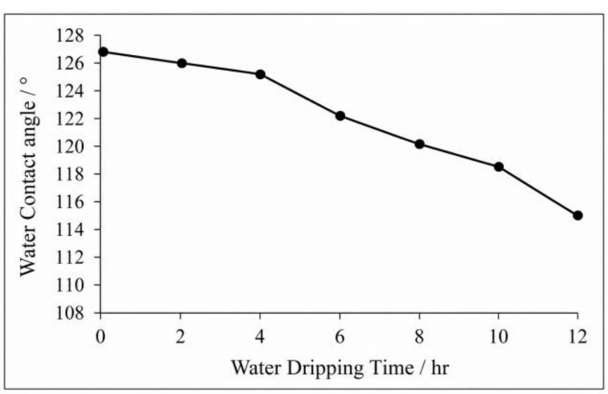

Fig. 14(b) Effect of water dripping on WCA on coated surface (Type II)

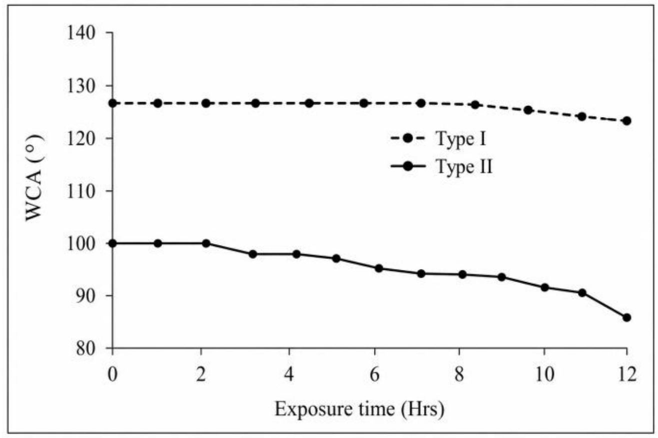

Fig. 15 (a) Effect of acidic environment corrosion on the specimen

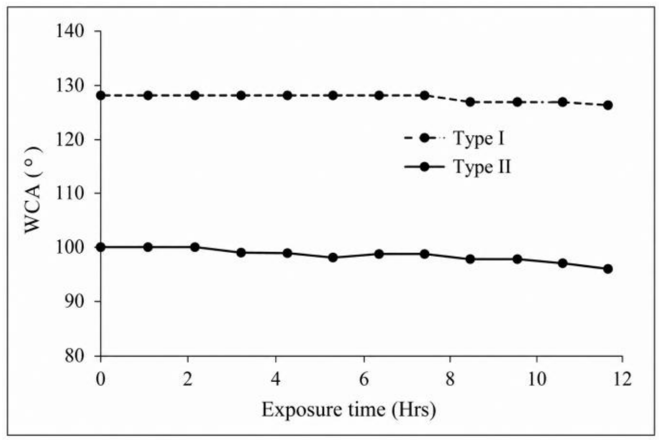

Fig. 15 (b) Effect of alkaline environment corrosion on the specimen

Contact angle measurement for specimens I and II revealed a WCA of 100 ° and 127 °, respectively. Further experiments were conducted with drop testing, where 5 µL of water was dropped on the surface at a rate of two drops per second, to investigate the change in WCA with the exposure time. The results are reported in Figure 14 (a) and 14 (b) for 12 hours test duration. The water contact angle reduces from 100 ° to 82 ° in the case of Type-1 specimens. On the other hand, in the case of Type II specimens, the water contact angle reduces by 12 ° from 127 ° to 115 °. It can be noted that Type II specimens have a thin PDMS layer above the hair particles, which reduces the effect of water dropping in comparison to Type I specimens. However, Type II specimens are able to withstand the drop test and maintain their hydrophobic nature at the end of the test duration of 12 hours.

Investigations are performed to study the effect of acidic and alkaline corrosion on the hydrophobic surface. An acidic solution is prepared with a Ph value of 4.0, and Type I and type II surfaces are dipped in the solution for 12 hours. The results are reported in Figure 15(a), which reveals that in the case of the uncoated Type I specimen, the WCA is not affected for the initial 2 hours. Later, WCA reduces gradually, such that the WCA reduces by 15 ° after 12 hours. On the other hand, Type II specimens coated with the thin layer above the hair powder exhibit no change in WCA for the initial 8 hours. After 12 hours, the WCA was reduced by 4^{o} to 123˚.

Influence of alkaline environment corrosion on the WCA is reported in Figure 15 (b). It can be noted that Type I specimens exhibit a very small change in WCA. On the other hand, type II specimens do not show any change in WCA for the test duration. The findings reported for an acidic environment are in agreement with previous work findings, which have reported that solutions with Ph value of 4 result in mild damage to hair [45, 46]. Damage to hair in an acidic environment is due to breakage of keratin bonds, leading to protein degradation, damage and roughening of hair particles [47-49]. Observations for alkaline solutions are in line with earlier findings, which report that the hair structure is not damaged by alkaline fluids with Ph value of up to 8 [44, 50].

One of the possible uses of a hydrophobic surface is to separate oil and water [51]. In order to check the possible use of the proposed hydrophobic surface for this application, experiments are conducted to check if the developed surface can retain oil and can be used for water filtration. An oil and water mixture was prepared using a mixture of tetrachloromethane and water, added by methyl blue with 2.5 ml quantities each. The mixture was taken in a 5ml syringe and rolled over the hydrophobic surface as shown in Figure 16.

The results showed that water was repelled by the hydrophobic surface and was collected in the beaker, kept below the surface. However, the oil was stuck on the surface, and reduced oil was found in the beaker. In the single cycle, 72% of the oil (tetrachloromethane) was trapped on the hydrophobic surface. After 5 cycles, 83% of the oil was found to be trapped on the surface. These observations for the oleophilic behavior of the surface are in agreement with the earlier reported findings [11].

Fig. 16 Arrangement for the experiment with oil and water mixture

WCA was measured for Types I and II for different tilt angles. The results are reported in Table 1, whereas the images of the water drop for different tilt angles are shown in Figure 17 and 18. Type I surface gives WCA of 100˚ at 0˚ tilt, where the advancing and receding angle is reduced to 92˚ for a 20˚ tilt, and there is roll off for further tilt angle. Type II surface has a WCA of 127˚ where the drop rolls off for a 20˚ tilt. Higher WCA of type II surface is attributed to the presence of micro-scale structures on the surface, surface roughness lowering the drop adhesion, and low surface energy. [52].

Table 1. Effect of tilt angle on WCA

Measured average mean advancing and receding WCA (± 2.5^{o})						
Specimen	**0^{o} Tilt**	**5^{o} Tilt**	**10^{o} Tilt**	**15^{o} Tilt**	**20^{o} Tilt**	**25^{o} Tilt**
Type I	100^{o}	99^{o}	97^{o}	95^{o}	92^{o}	Rolled off
Type II	127^{o}	125^{o}	122^{o}	119^{o}	Rolled off	-

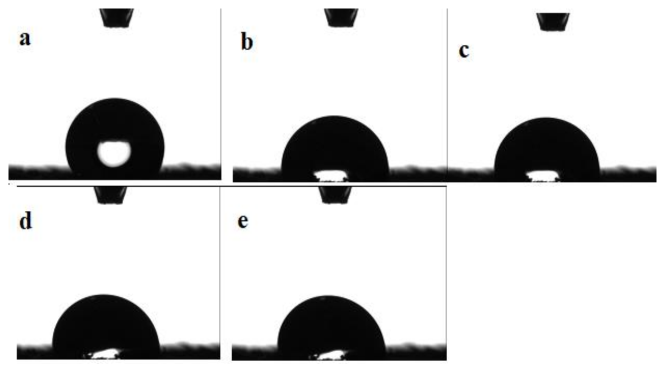

Fig. 17 Representative results for WCA of Type I specimen, (a) 0˚ Tilt angle, (b) 5^{o} Tilt angle, (c) 10^{o} Tilt angle, (d) 15^{o} Tilt angle, (e) 20^{o} Tilt angle.

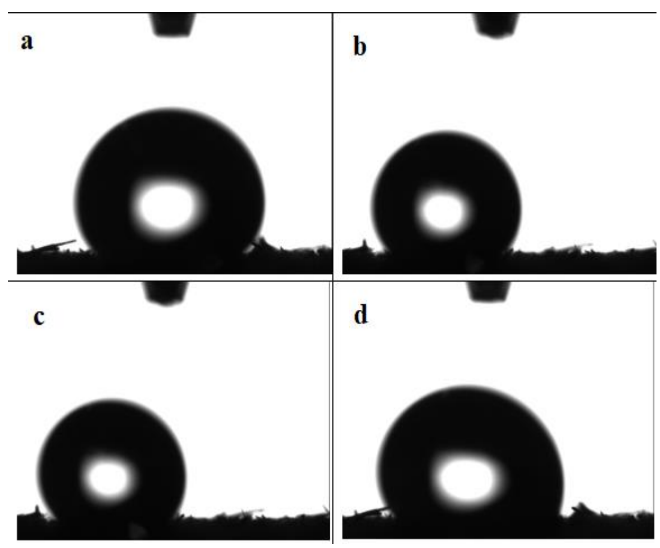

Fig. 18 Representative results for WCA of Type II specimen, (a) 0˚ Tilt angle (b) 5^{o} Tilt angle (c) 10^{o} Tilt angle (d) 15^{o} Tilt angle.

4. Conclusion

The present study proposes a novel method for the preparation of hydrophobic surfaces by using micron-sized human hair powder. Custom arrangements are designed to prepare the hydrophobic surface on a glass substrate with three-layered coatings. Microstructure investigation is performed using SEM analysis, whereas the chemical composition is investigated with EDS analysis. The hydrophobic surface demonstrated a WCA of 125˚, with the surface able to withstand the drop test and alkaline environment corrosion. Leading and lagging WCA are investigated using the tilt test, where the roll-off angle was 19˚. The prepared surface exhibits an oleophilic nature, which makes it possible for its use in the possible application of oil separation from an oil-water mixture.

Conflicts of Interest

"The authors declare that there is no conflict of interest regarding the publication of this paper."

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