At-Home Measurement for Hydrophobicity in Surfaces

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July 18, 2020

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Abstract—With the current COVID-19 crisis, the need for a safe way to combat microbial spread is more vital than ever in order to protect the public. This study explores implementation textured, hydrophobic surfaces in public areas as a lasting solution to prevent the spread of bacteria and viruses. It was found that by altering the surface texture of a material by etching microscopic grooves, its hydrophobicity can be increased due to numerous air pockets pushing on water droplets in abrasive surfaces. As many common viruses have hydrophilic tails/arms and propagate easily in water, the implementation of hydrophobic materials to frequently touched surfaces is expected to reduce the transmission of microbes to individuals using the same surface. A series of tests utilizing silicone to fabricate the nano- or micro-patterns of the textured surfaces sandpaper and fine powders on glass were conducted in order to analyze the effectiveness of their hydrophobic surfaces. Key factors that increase hydrophobicity can subsequently be used to modify various surfaces people commonly interact with.

I. INTRODUCTION

Bacteria, germs, and viruses can be found almost everywhere. The average person comes into contact with 60,000 bacteria daily. They survive in air, plants, food, and even human beings. In fact, nearly 90 percent of the human body is composed of germ cells. These specific microbes allow the body to synthesize vitamins and aid digestion, maintaining the body’s immune and digestive system healthy. However, there are various strains of bacteria, germs, and viruses that humans are not immune to yet, such as influenza (flu), norovirus and staphylococcus (staph) [1]. Often the major form of transmission of these infectious microbes is through surfaces. Surfaces such as door knobs, ATM machines, bathroom doors and sinks, shopping carts, phones, and money are known as high contact surfaces because many people come into contact with these surfaces daily. The reason why these surfaces carry so many of these germs is because approximately 1,500 bacteria live per square centimeter of skin on the hand and the surfaces’ hydrophilic properties allow the bacteria to adhere to the surface, later attaching to the epidermis of the skin and entering the human body [2]. Currently, over 50,000 men, women, and children die daily through various infectious diseases and the current SARS CoV-2 pandemic has reached nearly 573,000 deaths worldwide [3,4]. By manufacturing a superhydrophobic surface with a silicone sheet the adhesion of viruses and bacteria can be limited, diminishing the transmission between high traffic surfaces and the human skin.

II. BACKGROUND

A. Surface Properties

Surface science is the study of the interaction between two phases at an interface due to differences in their physical and chemical composition. These interactions can occur between solids and liquids, solids and gases, gases and liquids, or solids and liquids. However, for the purpose of this study, the focus will be on the surface interactions between liquids and solid surfaces with air pockets. The differences between liquid-solid and liquid-air surface interactions are due key differences in their properties, such as degree of hydrophobicity.
or hydrophilicity, friction, viscosity, and the topography of the surface, which includes curvature, roughness, and contact stiffness.

1) Hydrophobicity vs. Hydrophilicity: Hydrophilic surfaces more easily absorb water, while hydrophobic surfaces tend to repel water. The hydrophobic and hydrophilic properties of a surface are most commonly identified by measuring the contact angle of liquid drops. A contact angle is geometrically defined as the angle formed by a liquid at the intersection between the liquid and solid-gas interface. Additionally, the angle is the result of capillary pressure and surface tension between the surfaces as described by the Young-Laplace equation:

\[ \gamma_{SG} = \gamma_{SL} + \gamma_{LG} \cos \theta \]

In this equation, \( \gamma_{SG} \) is the solid-gas surface tension, \( \gamma_{SL} \) is the solid-liquid surface tension, \( \gamma_{LG} \) is the liquid-gas surface tension, and \( \theta \) is the contact angle. The general scientific consensus is that if \( \theta \) is \(<0.5^\circ \) the surface is superhydrophilic; if \( \theta \) is \(<90^\circ \) the surface is hydrophilic; if \( 90^\circ < \theta < 150^\circ \) then the surface is hydrophobic; and if \( \theta >150^\circ \) then the surface is superhydrophobic[5]. However, for the purpose of this experiment, hydrophobic cutoff is \(70^\circ\) rather than \(90^\circ\), as the surfaces fabricated in at-home labs are not flat nor perfectly horizontal, such that at a contact angle of \(>70^\circ\) the water drop may roll off the surface.

Many scientists [6] have studied the surface chemistry of hydrophobicity and how to achieve superhydrophobicity, utilizing models from nature. A prime example of this is the layered texture of shark skin causing it to be antimicrobial, allowing the shark to travel safely through disease-infested zones. The regular alignment of the scales on the shark’s skin also allows the shark to swim with much less friction because the drag is decreased. A model of the shark’s skin was fabricated by a biomedical lab to simulate the effect of the shark’s skin [6]. Figure 1 shows the grooved platelets of a shark’s skin and its imitation in the laboratory. Additionally, plants, such as the lotus leaf, are known to be hydrophobic. The beaded droplets displayed in Figure 2, demonstrate the hydrophobic properties of a lotus leaf. Its cell wall allows the droplets to bead and thereby clean itself when dust is incorporated into the water droplets that roll off the surface.

Our focus will be on the hydrophobic properties of a silicone surface nanoimprinted with the sandpaper’s texture. Specifically, to determine how varying grade sizes of FEPA P-scale sandpaper affect hydrophobicity.

The data collected displays that as the grade of the sandpaper increases the abrasiveness decreases. For example, the coarse grade is (40 to 60 grit), medium is (80 to 120), fine is (150 to 180), very fine is (220 to 240), extra fine is (280 to 320) and super fine is (360 and above).

Thus, the grade of the sandpaper is inversely proportional to the grit size [8]. As the grade increases the grit, or particle size, decreases, creating a smoother, finer surface. These differences in surface roughness that brings about changes in the properties can be characterized by the microscopic features: height, width, and spacing. This is displayed in Figure 3:

In the case of a sandpaper, when the particle size decreases the width and the space between the pillars also decreases and vice versa. Therefore, the density of the pillars is higher, increasing the gaps between them enabling air pockets to fill the space. The smaller spaces decrease the chances of the water to enter the surface and the air pockets push the water droplets causing them to bead on the surface, and increase the hydrophobicity of the surface. In other words, the sandpaper...
with higher grade has greater hydrophobicity. Unfortunately, a relationship between the height and the hydrophobicity could not be reached due to limitations in our at-home lab equipment that gave wide variations in surface textures using the same sandpaper.

2) Surface Topography: The topography of a surface determines the majority of a material’s surface properties. Even though the characteristics of the surface are a result of what is occurring in the nanoscale they can be measured at the macroscale. The topography can be measured utilizing a profilometer or Atomic Force Microscopy (AFM). A stylus profilometer, as shown in Figure 4, utilizes a probe to measure the surface’s height variation or roughness.

![Fig. 4. Basic Elements of a Stylus Profilometer](image)

Atomic Force Microscopy uses a scanning probe microscope with a higher resolution than a profilometer and uses optical scattering. The information collected by the Atomic Force Microscopy is done with a mechanical probe that responds to the surface’s height and chemical structure [12]. A schematic of an AFM measurement is shown in Figure 5.

![Fig. 5. Block Diagram of Atomic Force Microscopy](image)

In summary, the rougher the surface the more hydrophobic it is, and water cannot enter the pits on the surface (e.g., via capillary action or gravity) and will sit on top of the textured surface and tend to bead up. The roughness of the surface has often been modified to increase hydrophobicity, including processes involving the use of lithography, chemical adherents, polishing, grinding, machining and electrical discharging machining. For lithography, a flat surface is drawn with wax, etched with acids, and is repeated multiple times for multiple layers and colors. Machining is translating and cutting the fabricated surface. The electrical discharging machining is the high voltage melting of the particulates on the surface. All of these processes are utilized to change the roughness or texture of the surface physically [14].

B. Viral and Bacterial Structure

A virus forms when multiple viral proteins come to form a viral wall around the RNA that defines the genetic structure of the virus. Most viruses are filled with a nonpolar inner fluid, causing them to be micelles, or shells of lipids with hydrophilic heads. These hydrophilic heads tend to stick out from the viral structure, and allow for the virus to adhere to surfaces that are typically polar (like water in a cell) [15].

1) Viral Adhesion to Cells: When a virus penetrates the body, it attacks the cells in a number of ways. The proteins on the surface of the virus must find receptors on the cell on the cell surface. However, this process requires a very specific interactions between the protein ligand and the cell receptor. One of the ways viruses spread is by being adsorbed onto various surfaces that are often touched by people. In this adsorption step, the same proteins that interact with cell surfaces play a role. The ideas is to eliminate viral transmission by preventing virus proteins, and the virus lipid coatings being adsorbed onto surfaces. Since the virus particles are usually associated with water droplets, if we can prevent water being adsorbed onto the surface, then the virus cannot stick to said surface.

2) Polarization of a Virus: Viruses have polar heads on the outside, allowing them to stick and adhere to water. However, if a surface has no water, or a very little amount, the virus will not attach to it. It would either stay with the host body, become inactive on the surface due to not adhering properly, or simply fall off the surface. As mentioned before, more hydrophobic surfaces are left with less water on them, which also result in less viruses.

III. EXPERIMENTAL PROCEDURE

In order to find the most effective anti-viral surface, several tests were conducted at home using different grits of sandpaper. These materials were useful in producing surfaces for testing in order to determine the level of hydrophobicity from the contact angles of the droplets. Throughout the experiments, the following materials were utilized: a 2.8 fluid oz. tube of advanced water-proof silicone (General Electric Company); sandpaper of grits P80, P100, P120, P150, P180, P220, P320, P400, P1000, P2000, and P3000 on the FEPA scale; syringes
ranging from 1.0mL, 3mL, 5mL, 10mL, and 20.0mL in volume; needles ranging from 14g, 16g, 18g, 20g, 22g, and 25g; and a container of water.

A. Silicone Application

Ideally, the experiment should take place in a clean workspace with controlled humidity room temperature to prevent accumulation of dust and moisture. Sheets of sandpaper (of which each individual sheet measured 9 inches by 11 inches) were cut into small square pieces, about 4 by 4 cm, and laid flat on a workable surface. Slightly larger dimensions can be utilized if the 4cm by 4cm cut-out was deemed to be too small for use.

After each piece has been safely cut out and removed from its original sheet, sufficient amount of silicone was squeezed from the tube. Once the required amount of silicone was deposited, the research participant can then begin to spread out the silicone with their fingers, sheets of printer paper, or cardboard while the silicone is still wet. Additional doses of silicone may be applied in order to make sure there is a thick, uniform level of silicone present on all areas of the sandpaper to imprint each grit as accurately as possible; for best results, the silicone layer should not be less than 1 mm in height. The process continues until the entire square of sandpaper with wet silicone in an even and consistent manner.

When the application of silicone has been successfully completed, the squares with its corresponding layer of silicone should be set aside. The silicone layer should remain undisturbed for a period of time so the silicone can dry properly and preserve the imprints of the sandpaper precisely. The recommended wait time is at least 4 hours before continuing with the experiment in order to ensure a perfectly dry and usable sheet of silicone.

B. Silicone Removal

After waiting for the appropriate amount of time for the silicone to have dried, the silicone was removed with fingernails or a gentle prying implement, such as a knife or tweezers. Starting from the edges allows for the silicone and sandpaper to separate, as the boundary between the two objects can be breached from the outside with the use of force. If one waits too long, the silicon is quite difficult to remove from the sandpaper.

After the initial separation of the silicone and sandpaper at the edges, the process of dividing up the silicone and sandpaper was continued. Working slowly and carefully is imperative for a successful removal; despite the fact that the silicone can stretch and withstand force up until a certain point, pulling too quickly can create tears and rips in the silicone material, resulting in less surface area for testing. Therefore, taking caution to make sure that silicone is not wasted and redoing the experiment in the case of accidental tears were important in this stage. With no errors, the step should result in a layer of silicone imprint and a square piece of sandpaper with nothing on top.

However, some trials have resulted in impossible silicone removals, as certain grits of sandpaper cause too much adhesion with the material, making it difficult to separate with the human hand without tears in the layer. In these circumstances, process A should be redone, but with an additional step of applying a thin layer of oil on the surface of the sandpaper before removing silicone from the tube. The lubricating properties of oil make it easier to remove the silicone without producing incomplete silicone imprints. Aside from this additional instruction, all other steps in process A and B should remain the same.

C. Testing Water Droplets on the Silicone Layers

When the silicone layers have been confirmed to be firm and solid, the step of adding droplets on the surface to measure the hydrophobic properties can begin. The use of a high quality camera would be crucial in this process, as photographs will be used later to determine contact angles. The camera app on a phone would suffice.

A container full of water should be available in order to test droplets on each surface. A syringe of any volume and a needle of any gauge may be used in this process, but the types that were used has be recorded. After a certain syringe and accompanying needle have been chosen, sufficient amount of water from the container was extracted, wiping off any excess fluid from the needle ensures that liquids on the outside do not interfere with the droplet formation.

The syringe and needle should be held over the surface of the textured silicone sheet with its imprinted side on top, in which the contents of the syringe can be expelled in a careful and calculated manner to allow a droplet to form. Once the droplet has reached a large enough size where it can be comfortably seen and photographed, it should be dropped or placed on the silicone sheet. The contact angles were evident.
shown so that its data can be recorded and measured in later steps. The droplet process should be repeated at least five times so that there is sufficient data to be collected. Droplets could be placed in a linear fashion on silicone sheet, or different droplets can be placed on the surface one at a time.

After the droplets have settled on the surface, a camera of some kind was used to produce images for measurements. The lens were held parallel to the surface, so in the resulting image, the top of the surface should not be seen as much as possible. Thus, the bottom of the droplet should appear completely straight in relation to the viewer. Moreover, there was enough lighting in the setting so the droplet is clearly visible. When the preview image seems to satisfy these requirements, the picture should be taken and saved in a safe location where it does not get erased. Multiple retakes may be possible until a competent image is produced.

**D. Data Measurement**

With the compilation of all the images of the droplets, the contact angles were analyzed, as they indicate the level of hydrophobicity of the textured silicone surfaces. The images should be displayed on a digital medium, such as a phone, tablet, or computer screen. Then, a straight line should be drawn at the bottom of each droplet as a base ray of the angle, and another straight line, or arm, should be made tangent to the base of the droplet at both the left and right locations.

After both lines have been drawn to create an angle, a protractor should be held up to the screen to measure the angle inward respective to the droplet, and the angle were measured through the droplet. The origin should coincide with the vertex of the angle, and the protractor was held completely in line with the base ray (which should be the bottom of the droplet). The other arm should point to a corresponding angle on the protractor, of which value could be recorded. The standard unit of each angle should be in degrees.

In order to make sure that there is an abundant amount of data to analyze and inaccuracies are eliminated, each sandpaper grit should have at least three different sets of trials from different individuals. Thus, the data will be less likely to be skewed by the actions of one person. Moreover, due to human error, some of the outlier data points may be excluded. If any of the average contact angles of the silicone sheet seem to be too small or too large, they were considered for removal in order to determine if they are statistical outliers in comparison with the rest of the measurements using standard deviation. If they are found to be outliers, they should be removed from the final data calculations to ensure an accurate depiction of data.

**IV. RESULTS**

The results of the experiment consistently display a positive correlation between the fineness of the imprinted sandpaper and contact angle, and thus hydrophobicity.

**A. Substrate 1: Post-it Notes (The Control)**

Before the hydrophobicity of textured silicone sheet of the sandpapers was measured, silicone molds of Post-It NotesTM were created as control data for the experiment, as Post-It NotesTM provide a relatively smooth surface in comparison to abrasive sandpaper. Data Table 1 shows that the average contact angle for the water droplets was 79.7°.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>WATER DROPLETS ON POST-IT NOTE SILICONE MOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Contact Angle(°)</td>
<td>Standard Deviation(°)</td>
</tr>
<tr>
<td>79.7</td>
<td>5.47</td>
</tr>
</tbody>
</table>

**B. Substrate 2: Silicone Sandpaper Molds**

Figure 9 shows that the average contact angle increases as the particle size decreases. An overall positive correlation can be seen between the sandpaper grade (particle size) and the average contact angle of the water droplets. In general, higher sandpaper grades tend to have smaller particle sizes and lower
sandpaper grades tend to have larger particle sizes. Thus sandpapers with high grades tend to be much more hydrophobic. Upon inspection of the 201.0 µm silicone surface, which is from the lowest sandpaper grade and possesses largest particle size, and the 35.0 µm silicone surface, which is from a higher sandpaper grade, the average contact angles were 58.5° and 93.1°, respectively. There was a 159 percent increase in the average contact angle between the 201.0µm silicone mold and the 35.0µm silicone mold. When observing the 35.0µm silicone mold in comparison to the 10.3µm silicone mold, the contact angles were 93.1° and 100.1°, respectively. There was a 108 percent increase in the average contact angle between the 10.3µm silicone mold and the 35.0µm silicone mold. Upon comparison of the 7.0µm silicone mold and the 10.3µm silicone mold, the average contact angles were 107.5° and 100.1°, respectively. There was a 107 percent increase in the average contact angle between the 7.0µm silicone mold and the 10.3µm silicone mold. Thus, it is determined from the increases of hydrophobicity that lower the size of microscopic features on the surface, water will be more likely to be repelled.

Fig. 9. The graph shows the various contact angles for the water droplets as it is deposited onto surfaces with different particle sizes. *There were no observed contact angles between 0.0° and 55.0°*

C. Substrate 3: Printer Toner

Furthermore, the toner from a printer was tested, which further corroborated the fact that smaller particle sizes produce a much more hydrophobic surface. The toner size is estimated to be 2-7 µm [16], which is smaller than any of the particle sizes of the sandpaper surfaces. According to Data Table 1, the printer toner surface was hydrophobic due to the fact that water had an average of a 130.7° contact angle.

D. Classification of Substrates 1-3

Due to the fact that 201.0 µm silicone mold had the lowest average contact angle, it was the least hydrophobic surface out of all of the sandpapers tested. Since it has a contact angle that was less than 70°, it is considered hydrophilic. To this end, the 141.0µm and the 125.0 µm silicone molds with average contact angles of 66.6° and 64.6° would also be considered hydrophilic. All of the other silicone molds have contact angles that exceed 70°, thus making them hydrophobic. Similarly, the Post-It Note and the printer toner surface are also hydrophobic. Notably, the printer toner was the most hydrophobic surface out of all of the ones tested. With an average contact angle of 130.7°, it is the closest surface to be considered superhydrophobic, and water beads up considerably when dropped on this surface.

E. The Limitations of Sandpaper

By inspecting Figure 9, as the particle sizes exceeding 68 µm approach 0 µm, the data starts to mirror the curve of a square root function which gradually changes at a significantly slower rate than that of the particle size. However, the particle size approaches the limit of 0 µm it seemingly does not reach a contact angle around 150° or greater. This is due to the fact that the manufacturers of sandpaper intend to make their products for smoothing surfaces, and do not create sandpaper for the purpose of it being hydrophobic. The height of the particles in the sandpaper cannot be lower to meet the conditions for the surface to be close to attaining superhydrophobicity. Also, the sandpaper itself is extremely varied and the spacing can be inconsistent which creates less air pockets, thus decreasing the hydrophobicity of the sandpaper.

V. CONCLUSIONS

The characteristics of surface features such as the height, width, and spacing of particles or voids, are key factors that contribute to their hydrophobicity. As the particle size decreased, the horizontal width of each particle decreased and the amount of space between the particles on the horizontal surface decreased. The higher density of particles have more gaps which allows more air pockets to occupy a given area compared to surfaces with lower density of particles. These air pockets serve to push up the water droplets, thus increasing hydrophobicity. Also, since the spacing decreases, it also makes it harder for water molecules to enter these gaps, e.g., via capillary action, which also increases hydrophobicity of the material’s surface. However, in terms of height of the particles,
a precise trend cannot be found due to the varying heights of the sandpaper's particles.

A. Tilt Angle and Gravity

Despite the fact the water droplets on the sandpaper textured silicone sheets did not have average contact angles close to 150°, the sandpaper silicone molding may still prevent the spread of bacteria and viruses, since the contact angles were large for some surfaces. During the experiments, if the textured silicone molding was hydrophobic enough (18.3 µm or lower) then the water droplets were susceptible to the influence of gravity if the silicone molding experienced even the slightest angular displacement. The angle which causes the water droplets to slide off the silicone molding is known as the tilt angle. Typically, the less hydrophobic a surface is, then tilt angle will increase to cause the water droplets slide off, as water particles adhere more strongly to the surface. For example, a 201.0 µm silicone sandpaper mold will require a large angular displacement to have the water droplets slide off, if the force of gravity is strong enough to overcome the hydrophilic nature of the substrate. Conversely, a much more hydrophobic surface such as a 18.3 µm silicone sandpaper molding will require a significantly smaller angular displacement due to the fact that the hydrophobic nature of the substrate gives the water droplets less support, thus allowing gravity to slide the droplet off of the substrate. Therefore, if water particles were placed on curved or tilted surfaces instead of flat ones, then they can roll off instead of staying on the surface.

B. Sources of Error

Given the unique circumstances of the COVID-19 pandemic, the high tech laboratory equipment was not accessible. The contact angles were not measured with the utmost precision since a 60X microscope was not available. To this end, cell phone photographs and a protractor were used to measure the angles, which has a degree of error associated with inaccurate responses of the human eye and human hand. Additionally, the photos that were taken of the water droplets were not all taken at the exact same angle, nor at exactly perpendicular positions. These varying angles produced an artificial tilt on the water droplets which can alter the true contact angle of the water droplet. This could produce larger than usual or smaller than usual contact angles. An uneven silicone layer could have contributed to errors as well. The complete removal of the silicone layer was hard to achieve since tiny remnants of the silicone mold would often stick to the sandpaper. Also, 10 trials were found to be outliers and they were excluded from the data in order to eliminate human error as much as possible. Lastly, elements like human skin cells and dust could have filled up spaces between the grits of sandpaper and on the mold as well.

C. The Trajectory of Silicon Molding

The rudimentary methods of conducting the experiment at home with some success highlights the fact that a silicone mold can be made into a protective layer to prevent the spread of bacteria, viruses, and other germs via contact on objects that people frequently touch in public. Objects such as handrails, elevator buttons, doorknobs, and more can greatly benefit from a silicone molded coating or wrapping. Even after the pandemic, a much more health conscious public may choose to continue the use of the hydrophobic silicone molding of sandpaper or other extremely textured surfaces. With such surfaces, the spread of the COVID-19 virus may slow down considerably and help to protect the public until the release of the vaccine. People can manufacture silicone surfaces at home in the manner of this experiment to sanitize any surface, so that the consequences of this research can promote a safe and viable method for preventing the spread of microbial disease in their everyday lives.
ACKNOWLEDGMENTS

The authors gratefully acknowledge their project mentors, Dr. Sanjeeva Murthy and Dr. Thomas Emge of Rutgers University Department of Chemistry and Chemical Biology. With their efforts, the experimentation process was designed in the comfort of home, and their guidance was useful in formatting the paper and data. Dr. Murthy provided valuable background information on the principles of hydrophobicity. Dr. Emge taught the chemical and biological explanations behind surfaces to demonstrate cell processes and lipid structures. His assignments prompted discussion and inspection into the field of microscopy. Furthermore, the authors would like to express their gratitude to their project liaison, Elizabeth Strother, an undergraduate biomedical engineering student attending Rutgers University; her dedication to the project facilitated the development of this research paper with her consistent attendance in meetings and receptiveness to questions and conversation. Additionally, the authors would like to acknowledge: Dean Jean Patrick Antoine for leading the Governor’s School of Engineering and Technology; Head Counselor Rajas Karajgikar in managing the program; and Research Coordinator Benjamin Lee for regulating the research aspect. They would also like to mention former Dean Ilene Rosen for her past work in maintaining the New Jersey Governor’s School of Engineering and Technology before her retirement.

Finally, the authors would like to express their utmost gratitude to the sponsors for their financial support. Without them, the New Jersey Governor’s School of Engineering and Technology would not be as impactful as it was. Thus, they appreciate the aid from: Rutgers University and Rutgers School of Engineering for providing a summer camp experience; Lockheed Martin, New Jersey Space Grant Consortium, and all other corporate sponsors for their dedication to education; and the New Jersey Governor’s School of Engineering and Technology alumni for their encouragement of STEM learning to the posterity in their continued contributions to the program.

REFERENCES


**APPENDIX**

**TABLE II**

<table>
<thead>
<tr>
<th>Water Droplets on Printer Toner</th>
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<tr>
<td><strong>Average Contact Angle(°)</strong></td>
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<td>130.7°</td>
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**TABLE III**

<table>
<thead>
<tr>
<th>FEPA Sandpaper Grade to Micron Conversion</th>
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<tr>
<td><strong>Sandpaper Grade (FEPA Scale)</strong></td>
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<tr>
<td>P80</td>
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<td>P100</td>
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<tr>
<td>P120</td>
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<td>P3000</td>
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Fig. 11. The figure shows 5 water droplets on the silicone mold of the Post-it note.

Fig. 12. The figure shows 5 water droplets on the 201.0µm silicone mold.

Fig. 13. The figure shows 5 water droplets on the 141.0µm silicone mold.

Fig. 14. The figure shows 5 water droplets on the 125.0µm silicone mold.

Fig. 15. The figure shows 5 water droplets on the 100.0µm silicone mold.

Fig. 16. The figure shows 5 water droplets on the 82.0µm silicone mold.

Fig. 17. The figure shows 5 water droplets on the 68.0µm silicone mold.

Fig. 18. The figure shows 5 water droplets on the 46.2µm silicone mold.

Fig. 19. The figure shows 5 water droplets on the 35.0µm silicone mold.

Fig. 20. The figure shows 2 water droplets on the 18.3µm silicone mold.

Fig. 21. The figure shows 3 water droplets on the 7.0µm silicone mold.
Fig. 22. The figure shows 2 water droplets on a glass surface with toner particles on it, which is estimated to be sized 2-7µm.

Fig. 23. The figure shows 4 water droplets on a talcum surface, which has an estimated particle size of 25.0µm.