

WET FRICTION MATERIAL FOR HAIR REMOVAL DEVICES

FIELD OF THE INVENTION

5 The invention generally relates to materials for hair removal devices, more particularly to materials for hair removal devices that have a high coefficient of friction when wet and low tack when dry.

BACKGROUND OF THE INVENTION

10 Hair removal devices typically include thermoplastic polymers to engage a skin surface of a user. For example, fins on a wet shaving razor or grip portions on a handle of a hair removal device include thermoplastic polymers to improve engagement of a skin surface with the hair removal device. Known thermoplastic polymers for hair removal devices, however, may be slippery when the devices are wet during typical hair removal environments. This results in
15 slippage and/or poor engagement of the thermoplastic polymer with the skin surface. In addition, with respect to grip portions of hair removal devices, users often have to apply extra effort to grip the devices.

 Current approaches may increase the coefficient of friction when wet, but these approaches, however, do not improve a user's perception of gripping the hair removal devices or
20 engaging a user's skin with the thermoplastic polymers. For example, in one approach, the thermoplastic polymer can have a higher coefficient of friction, but such approaches may also have higher tack or perception of stickiness to a user, which may be uncomfortable and undesirable. In addition, current approaches have issues manufacturing thermoplastic polymers that adhere to substrates of hair removal devices, such as for injection molded thermoplastic
25 elastomers adhering to substrates of hair removal devices.

 What is needed, then, is a wet friction material suitable for a hair removal device that preferably is stable and durable, and has a high coefficient of friction when wet and low tack when dry, which would improve engagement of the hair removal device with a user's skin, e.g., for secure grip of a handle portion, potentially without discomfort. What is also needed is a wet
30 friction material that can preferably adhere to a substrate of a hair removal device for injection molded polymers, such as injection molded thermoplastic elastomers.

SUMMARY OF THE INVENTION

In one aspect, the invention relates to a hair removal device comprising a thermoplastic elastomer disposed on a portion of the hair removal device and one or more projections extending from the thermoplastic elastomer. The thermoplastic elastomer is polar and hydrophilic.

The foregoing aspect can comprise one or more of the following embodiments. The thermoplastic elastomer can define one or more pores to facilitate removal of water. The thermoplastic elastomer can have a coefficient of friction of in a range of about 2.0 to about 3.5 when wet with water, a tack force of about 3 g to about 12 g when dry, and/or a Shore A hardness of about 35 to about 50. The one or more projections can comprise at least two projections, and/or at least one groove can be formed between the at least two projections. The one or more projections can be integrally formed with the thermoplastic elastomer, for example, by injection molding, such as two step injection molding. The portion of the hair removal device comprises at least one of a grip portion of the hair removal device and a fin on a guard of the hair removal device.

In another aspect, the invention relates to a hair removal device comprising a thermoplastic elastomer disposed on at least a portion of the hair removal device and the thermoplastic elastomer defining one or more pores to facilitate removal of water when wet. The thermoplastic elastomer is polar and hydrophilic.

This aspect can comprise one or more of the following embodiments. The thermoplastic elastomer can have a coefficient of friction of in a range of about 2.0 to about 3.5 when wet with water, a tack force of about 3 g to about 12 g when dry, and/or a Shore A hardness of about 35 to about 50. The hair removal device can also comprise one or more projections, such as at least two projections, extending from the thermoplastic elastomer, and/or at least one groove can be formed between at least two projections. The one or more projections can be integrally formed with the thermoplastic elastomer, for example, by injection molding, such as by two step injection molding. The portion of the hair removal device can comprise at least one of a grip portion of the hair removal device and a fin on a guard of the hair removal device.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present invention, as well as the invention itself, can be more fully understood from the following description of the various embodiments, when read together with the accompanying drawings, in which:

FIG. 1 is a schematic perspective view of a known material for a hair removal device when wet;

FIG. 2 is a schematic perspective view of a wet friction material on a portion of a hair removal device in accordance with an embodiment of the invention when wet;

5 FIG. 3 is a chart illustrating the coefficient of friction of the known material of FIG. 1 and a wet friction material according to an embodiment of the invention when wet;

FIG. 4 is a chart illustrating properties of stiffness, coefficient of friction when dry, coefficient of friction when wet, surface energy, and peel strength for wet friction materials in accordance with embodiments of the invention relative to the known material of FIG. 1;

10 FIG. 5 is a chart illustrating properties of tack and coefficient of friction when wet for the known material of FIG. 1 and a wet friction material according to an embodiment of the invention;

FIG. 6 is a schematic perspective view of a textured surface in accordance with an embodiment of the invention;

15 FIG. 7 is a schematic perspective view of another textured surface in accordance with an embodiment of the invention;

FIG. 8 is a schematic perspective view of yet another textured surface in accordance with an embodiment of the invention; and

20 FIGS. 9A and 9B are schematic perspective views of textured surfaces according to embodiments of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Except as otherwise noted, the articles “a,” “an,” and “the” mean “one or more.”

25 As used herein, “hair removal devices” comprise any apparatus or device intended to remove hair, such as a razor (manual or powered) for dry or wet shaving, epilator, electric shaver, and combinations thereof.

Referring to FIG. 1, a known hair removal device 10 comprises a known thermoplastic elastomer 12 disposed on a portion of the hair removal device 10. In an embodiment, the known thermoplastic elastomer 12 is disposed on a substrate 14 of the hair removal device 10 in which
30 the substrate 14 can be formed from a variety of materials, such as polymers (e.g., thermoplastic polymers, polypropylene, polyethylene, etc.), plastic, metal (e.g., diecast metal), etc. The known thermoplastic elastomer 12 is a black, high flow rate polypropylene-based thermoplastic elastomer with a hardness of Shore 35A. The known thermoplastic elastomer 12 is of the

styrenic multi-block copolymer family, specifically elastomers based on styrene-ethylene-butylene-styrene. The known thermoplastic elastomer 12 is further compounded with mineral oil, calcium carbonate, and silica, and contains heat stabilizers and antioxidants. The known thermoplastic elastomer 12 is injection molded and disposed on the substrate 14. The known
5 thermoplastic elastomer 12 may have low surface energy and/or hydrophobic properties such that water on the known thermoplastic elastomer 12 beads when the known thermoplastic elastomer 12 is wet with water.

Referring now to FIG. 2, a hair removal device 20 comprises a wet friction material 22 disposed on, formed on, and/or formed with a portion of the hair removal device 20. The portion
10 of the hair removal device 20 that includes the wet friction material 22 comprises any skin-engaging portion of the hair removal device 20, such as a grip portion (e.g., any portion that a user grips) and/or the guard portion of the razor (e.g., fins on the guard). The wet friction material 22 is disposed on a substrate 24 of the hair removal device 20 in which the substrate 14 can be formed from a variety of materials, such as polymers (e.g., thermoplastic polymers,
15 polypropylene, polyethylene, etc.), plastic, metal (e.g., diecast metal), etc. Additionally or alternatively, the wet friction material 22 can be formed on or formed with the substrate 24. The wet friction material 22 is preferably injection molded and optionally molded with the substrate 24 in a two-stage injection molded process, for example, in embodiments in which the substrate 24 is optionally a thermoplastic polymer, such as a thermoplastic elastomer. Nonlimiting
20 examples of suitable injection molded polymers for hair removal devices include U.S. Patent No. 7,197,825 and 7,669,335 and U.S. Patent Application Publication No. 2010/0005669.

The wet friction material 22 has a high coefficient of friction when wet, e.g., higher coefficient of friction when wet compared to the known thermoplastic elastomer 12. The coefficient of friction is high for the wet friction material 22 when wet in aqueous environments,
25 including water and lubricious materials (e.g., skin preparations such as foams, gels, soaps, etc.). Furthermore, the wet friction material 22 may have a higher surface compliance than that of the known thermoplastic elastomer 12, but preferably with low tack. For example, users can securely grip the wet friction material 22, e.g., resulting in improved comfort and control, when wet and not be uncomfortably grippy or sticky when dry. In an embodiment, the wet friction
30 material 22 is polar and hydrophilic. Additionally or alternatively, the wet friction material 22 has high surface energy (e.g., perhaps via a sufficiently low contact angle) so that wettability of the wet friction material 22 is improved and so that water beads are minimized or non-existent when the wet friction material 22 is wet with water. Without intending to be bound by any

theory, it is believed that preventing water (or other lubricious materials) from beading and improving wettability (e.g., promoting surfacing wetting) may each or both serve to thin the amount of water that a user must penetrate to engage the skin to the wet friction material 22.

The wet friction material 22 comprises a polymer, preferably a thermoplastic polymer, and even more preferably a thermoplastic elastomer. Nonlimiting examples of suitable thermoplastic elastomers are described in U.S. Patent Nos. 5,314,940, 5,670,263, 6,610,382, and 6,904,615, U.S. Patent Application Publication Nos. 2002/0114920 and 2011/0143112. For example, suitable classes of elastomers may comprise hydrated styrene block copolymers (e.g., styrene ethylene butylenes (SEBS and styrene butadiene styrene (SBS), anionic triblock copolymers, polyolefin-based thermoplastic elastomers, thermoplastic elastomers based on halogen-containing polyolefins, thermoplastic elastomers based on dynamically vulcanized elastomer-thermoplastic blends, thermoplastic polyether ester or polyester based elastomers, thermoplastic elastomers based on polyamides or polyimides, ionomeric thermoplastic elastomers, partially or fully hydrogenated styrene butadiene styrene block copolymers, hydrogenated block copolymers in thermoplastic elastomer interpenetrating polymer networks, thermoplastic elastomers by carbocationic polymerization, polymer blends containing styrene/hydrogenated butadiene block copolymers, block polymers such as polystyrene materials with elastomeric segments, and polyacrylate-based thermoplastic elastomers. Examples of elastomers may include natural rubber, butyl rubber, EPDM rubber, silicone rubber such as polydimethyl siloxane, polyisoprene, polypropylene, polybutadiene, polyurethane, ethylene/propylene/diene terpolymer elastomers, chloroprene rubber, styrene-butadiene copolymers (random or block), styrene-isoprene copolymers (random or block), acrylonitrile-butadiene copolymers, mixtures thereof and copolymers thereof. The block copolymers may be linear, radial or star configurations and may be diblock (AB) or triblock (ABA) copolymers or mixtures thereof. Blends or combinations of these elastomers with each other or with modifying non-elastomers are also contemplated. Elastomers may be available from Arkema Inc., Philadelphia, Pennsylvania (e.g., Pebax® 2533); E.I. DuPont de Nemours & Co., Wilmington, Delaware (e.g., Zytel® 2158L); Kraton Polymers U.S. LLC, Houston, Texas; and Kraiburg TPE Corp., Duluth, Georgia.

Additionally or alternatively, the wet friction material 22 is a composite structure, such as a thermoplastic elastomer modified with additives, fillers, and/or rubber mixtures or modifiers. Suitable composite structures, additives, and/or fillers are described in U.S. Patent No. 3,972,528. For examples, additives may be one or more of the following additives: paraffinic white oils,

inorganic bulking agents, ether ester plasticizers, sulfurized mineral oil, alkenyl amide, styrol, polystyrol, petrolatum, polyisobutylene, polybutene, styrene, elastomeric styrene, ethylene, butylene, aqueous carboxylated synthetic polymer having a minimum film-forming temperature (MFFT) (e.g., 10 degrees Celsius or below), low MFFT synthetic polymer reinforced during
5 manufacturing by co-agglomeration with polystyrene, combinations thereof, or any other suitable additive to achieve a wet friction material 22 that has a high coefficient of friction when wet and low tack when dry. Additionally or alternatively, fillers may be one or more if the following fillers: clay treated with lignin sulfonate, pulverized fragments of foamed melamine resin, porous granulated aluminum oxide powder, diatomaceous earth, silica, acrylonitrile pulp,
10 granular filler having a surface area of about 35 m²/g to about 410 m²/g, clay (about 5 parts by weight to about 30 parts by weight), aluminum hydroxide, hollow aluminum oxide particle, dibutylphthalate (applied on carbon fiber base material) that has been hardened, fired, and carbonized), vulcanized rubber particles, aramid fiber, waste ash, ethylene vinyl acetate, polyethelyene, rubber, elastomer, hollow carbonate, alumina, carbide, carborundum, diamond
15 powder, white carbon (about 15 percentage by weight to about 80 percentage by weight), ceramic fiber (about 5 percentage by weight to about 50 percentage by weight), combinations thereof, or any other suitable filler to achieve a wet friction material 22 that has a high coefficient of friction when wet and low tack when dry. The quantity of any additives and/or fillers is controlled such that tensile strength is maintained at an acceptable level with adhesion to a substrate also being
20 maintained at an acceptable level.

FIG. 3 illustrates differences of the coefficient of friction of the known thermoplastic elastomer 12 and a wet friction material A, according to an embodiment of the invention, when wet with water. The known thermoplastic elastomer 12 has a coefficient of friction when wet with water of about 1.2 to about 1.6, e.g., about 1.4. In comparison, wet friction material A
25 preferably has a coefficient of friction when wet with water of about 2.8, about twice that of known elastomer 12.

FIG. 4 shows various properties of wet friction materials B and C, in accordance with various embodiments of the invention, normalized to the known thermoplastic elastomer 12. Generally, hardness of wet friction materials B and C is preferably about the same as the known
30 thermoplastic elastomer 12, though optionally the hardness of wet friction materials may be greater than or less than the known thermoplastic elastomer 12. In an embodiment of the invention, hardness of a wet friction material can be in the range of about 1 times to about 1.5 times that of the known thermoplastic elastomer 12. For example, the hardness of a wet friction

material can be in a range of Shore A hardness of about 5 to about 95, preferably about 30 to about 60, and even more preferably about 35 to about 53. The coefficient of friction when dry for wet friction materials B and C can be greater than known thermoplastic elastomer 12, for example, in the range of about 1.5 times to about 3.5 times that of the known thermoplastic elastomer 12, preferably about 1.8 times that of the known thermoplastic elastomer 12. For example, the coefficient of friction when dry for the known thermoplastic elastomer 12 is about 1.5 and the coefficient of friction when dry for wet friction materials can be in a range of about 2.0 to about 5.3, preferably about 2.4 to about 3.0. In various embodiments, the coefficient of friction when wet with water for wet friction materials B and C can be in a range of about 1.2 times to about 3.8 times that of the known thermoplastic elastomer 12, preferably about 2.2 times that of the known thermoplastic elastomer 12. For example, the coefficient of friction when wet with water for the known thermoplastic elastomer 12 is about 1.3 and the coefficient of friction when wet with water for wet friction materials can be in a range of about 1.4 to about 5.0, preferably about 1.9 to about 2.8. In addition, the surface energies of wet friction materials B and C can be greater than the known thermoplastic elastomer 12 in the range of about 1 times to about 2.0 times that of the known thermoplastic elastomer 12, preferably about 1.25 times that of the known thermoplastic elastomer 12. For example, surface energy of the known thermoplastic elastomer is about 26 mJ/m^2 , and surface energies of wet friction materials can be in a range of about 25 mJ/m^2 to about 52 mJ/m^2 , preferably about 27 mJ/m^2 to about 34 mJ/m^2 . Peel strengths, which relate to strength of an adhesive bond, e.g., to a substrate, of wet friction materials B and C can also be greater than the known thermoplastic elastomer 12, for example, in the range of about 1 times to about 2.5 times that of the known thermoplastic elastomer 12, preferably about 1.5 times that of the known thermoplastic elastomer 12.

FIG. 5 illustrates tack force and coefficient of friction of wet properties for the known thermoplastic elastomer 12 and another wet friction material D, in an embodiment of the invention. Tack is a characteristic of a material to form an immediate cohesive adherence to a contacting surface. Therefore, tack force is the measure of resistance of the material to separate from the contacting surface. Preferably, the tack force of the wet friction material D is similar to that of the known thermoplastic elastomer 12, though the tack force of wet friction materials can be greater than or lesser than the known thermoplastic elastomer 12. In an embodiment, the tack force of the known thermoplastic elastomer 12 is in a range of about 1 g to about 10 g, preferably about 3 g to about 8 g. The tack force of the wet friction material D is in a range of about 1 g to about 25 g, preferably about 3 g to about 12 g. In alternative embodiments, the tack force of a

wet friction material in accordance with an embodiment of the invention can be much higher than that of the known thermoplastic elastomer 12. For example, the tack force of a wet friction material can be in a range of about 200 g to about 700 g, preferably about 300 g to about 500 g. The coefficient of friction when wet with water of the wet friction material D is higher than that of the known thermoplastic elastomer 12. Generally, the coefficient of friction when wet for the known thermoplastic elastomer 12 is about 1.2 to about 1.6. The coefficient of friction when wet with water for the wet friction material D is preferably in a range of about 2.1 to about 3.2, and even more preferably about 2.4 to about 2.8. In an embodiment, the coefficient of friction for the known thermoplastic elastomer 12 when wet with lubricious material, for example, using about 2 g of Gillette® Series Sensitive Skin Shave Gel (available from The Gillette Co., Boston, Massachusetts) is about 0.275. The coefficient of friction when wet with lubricious material, for example, using about 2 g of Gillette® Series Sensitive Skin Shave Gel, wet friction materials according to embodiments of the invention is preferably in a range of about 0.28 to about 2.0, and even more preferably about 0.29 to about 0.5.

Referring now to FIGS. 6 through 9B, various embodiments of wet friction materials of the present invention can optionally include projections or textured patterns extending from the wet friction material to improve engagement of the wet friction material with a skin. The projections and textured patterns can also break the surface tension of the water (or lubricious material) or be exposed above the water (or lubricious material) for engagement with skin. In one embodiment, a textured pattern 30 can be similar to that of a fingerprint pattern with nonlinear shapes, concave and/or convex curvatures, and intersecting lines. In another embodiment, projections 32 can have a generally rectangular shape, such that a cross-section of each of the projections 32 is generally square. By “generally rectangular” the projections 32 include non-rectangular elements, e.g., ridges, protrusions, or recesses, and/or may include regions along its length that are not rectangular, such as tapered and/or flared ends due to manufacturing and design considerations. In yet another embodiment, projections 34 can be generally cylindrical, such that a cross section of the each of the projections 34 can be generally circular. By “generally cylindrical” the projections 34 include non-cylindrical elements, e.g., ridges, protrusions, or recesses, and/or may include regions along its length that are not cylindrical, such as tapered and/or flared ends due to manufacturing and design considerations. In still another embodiment, projections 36, 38 can be generally knurled, such that a cross-section of each of the projections 36, 38 can be generally diamond-shaped. The projections can form any geometric, polygonal, arcuate shape, or combinations thereof. For example, as depicted

in FIG. 9B, the projections can include a combination of a knurled pattern 38 and arcuate ridges 40. In an embodiment, the projections and/or the textured patterns are integrally formed with the wet friction material. Additionally or alternatively, the projections and/or textured patterns can be configured and shaped to form channels for fluid removal. The channels can be grooves
5 formed between the projections. In an additional or alternative embodiment, the channels can define pores to remove/wick fluid away from the wet friction material by absorbing fluids, e.g., via an absorbent layer beneath the wet friction material, or by allowing the fluid to drain underneath the wet friction material. In various embodiments, without intending to be bound by any theory, it is believed that a range of percentage ratios of the distance between projections (D)
10 over the height of the projections (H) promote pleasant sensory touch, preferably in a range of about 25% to about 75%, even more preferably about 60%. Further, it is believed that the less feedback of the projection on the skin surface, such as a fingertip, provides a more comfortable feeling. For example, the less feedback of the projection, that is a larger surface area to touch the skin, is more comfortable; in contrast, the higher feedback of the projection, that is a smaller
15 surface area or a sharper edge, to touch a skin is less comfortable.

TEST PROCEDURE FOR MEASURING PROPERTIES

HARDNESS

20 Hardness of materials is tested at room temperature and at 36 degrees Celsius using Shore A Durometer Instron Model 9130-35 (available from Instron, Norwood, Massachusetts) according to ASTM 2240-00.

COEFFICIENT OF FRICTION WHEN DRY AND WHEN WET

25 Coefficient of friction for each material to be tested is measured using a MTT175 tensile tester (available from Dia-stron Limited, Broomall, Pennsylvania) in which a skin mimic preparation is dragged across the material to be tested. The coefficient of friction for each material is tested when dry, wet with water, or in the presence of various lubricious materials (e.g., foams, gels, non-aerosols). To mimic skin, a polyurethane textured pad is prepared.
30 Nonlimiting examples of skin mimic preparations and polyurethane textured pads are described in U.S. Patent Application Publication Nos. 2007/0128255 and 2009/0212454. A sled/probe is used in which the surface is polished stainless steel. The skin mimic is attached to the sled/probe surface via double-sided tape or clips. The material to be tested is attached to the stage below the

sled/probe surface with preferably double-sided tape and optionally clips. If heat is used, the water bath to warm the platform of the MTT175 tester is set to 39 +/- 1 degrees Celsius and water is circulated. The sled/probe with the skin mimic is mounted to the floating parallelogram cradle of the tester, which is connected to a load cell. The angle of the sled/probe with the skin mimic is set so that the skin mimic surface is flat against the stage, which is attached to the material to be tested, with an approximate angle of about 35 degrees. The parallelogram cradle is leveled to be flat. Downward force can be adjusted by moving weights along a threaded shaft in which the downward force is adjusted to about 175 gm to about 230 gm. If shave preparations (e.g., lubricious materials) are used, lather is generated by applying the shave preparation to the material to be tested, lathering by hand for about 30 seconds to about 60 seconds. For gels, 2.5 +/- 0.7 grams of gel is applied. For foams, 3.0 +/- 0.7 grams of foam is applied. A draw down bar can be used to level the surface of the shave preparation, set at about 2 mm, across the skin mimic. Before performing the tests, the load cells are zeroed. To run the test measuring the coefficient of friction, software associated with the MTT175 tester is used and set at about 2000 gmf load cell with a displacement of about 60 mm and a speed of about 1500 mm/min at room temperature. Of the displacement, a smaller range of displacement is analyzed, such as about 110 mm to about 150 mm. A force of about 226 g is applied in which the force is calibrated with a Mettler-Toldeo Balance Serial No. 114020837 (available from Mettler-Toledo, Inc., Columbus, Ohio). When measuring the coefficient of friction when wet, about 1 mL of room temperature tap water under the probe is used. About one to about three strokes are completed for each test and about three tests completed for each material. To perform another test, a new material is used. The skin mimic on the test head is washed with water and an alcohol wipe, then blotted dry with a paper towel. Alternatively, the skin mimic is replaced. The test head is dried before use.

To maximize reliability of data, at least three different operators perform the tests with a relative standard deviation of about less than 20% for the first stroke data over three separate tests – each operator over a period of three separate days. For each operator, the relative standard deviation is about less than 20%.

TACK

Tack information for each material is measured using a TA.XT*Plus* Texture Analyzer and its associated software (available from Texture Technologies Corporation, Scarsdale, New York). Skin mimic, as prepared as described above, is attached to the round probe end of the Texture

Analyzer instrument via double-sided tape and the material to be tested is attached to the metal stage of the Texture Analyzer instrument, which is below the Tack probe, via double-sided tape. The instrument is calibrated such that the height is set at 10 mm and the force is set using a 2000 g weight. Each cycle of testing includes probe contact with the material to be tested for about 5
5 seconds. The probe contact is then pulled away at about 5 mm/second. The probe contacts the material to be tested a second time for about 5 seconds and is then pulled away at about 1 mm/second. Optionally, to maximize good, repeatable contact of the probe with the material to be tested, the probe contacts the material for the second time after about a 5 second delay.

After a cycle of testing is complete, the skin mimic is washed with alcohol and is blotted
10 dry with a paper towel. The material to be tested is replaced with a fresh, new material and repeated for a total of at least three cycles of sampling per material.

To maximize reliability of data, at least three different operators perform the tests with a relative standard deviation of about less than 50%, preferably about less than 20%, over three separate tests – each operator over a period of three separate days.

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SURFACE ENERGY

Contact angle measurements is used to determine the surface energy of the materials to be tested in which the contact angle depends on the compatibility between the surface properties of the wetting liquid and the material to be tested. Surface energy is calculated from Young's
20 equation in measures of energy per unit area (mJ/m^2). Contact angle measurements utilize a Contact Angle and Surface Tension instrument (available from First Ten Angstroms, Portsmouth, Virginia), such as FTA200, with FTA video 2.0 software in which the instrument includes a camera that can capture many frames per second, a pump to dispense drops from syringes, and a stage to place the sample while frames are collected. To set up the test, the lighting is adjusted so
25 that there is a white background and a dark drop and the focus is adjusted.

The material to be tested is placed below the syringe and leveled. The syringe is filled with a first liquid such that no bubbles remain. The program is initiated and run such that the instrument drops the liquid and takes measurements of contact angle. Two solvents are used, specifically diiodomethane and water. Owens-Wendt regression analysis is conducted to obtain
30 surface energy measurements based on these two solvents.

It should be understood that every maximum numerical limitation given throughout this specification includes every lower numerical limitation, as if such lower numerical limitations

were expressly written herein. Every minimum numerical limitation given throughout this specification includes every higher numerical limitation, as if such higher numerical limitations were expressly written herein. Every numerical range given throughout this specification includes every narrower numerical range that falls within such broader numerical range, as if
5 such narrower numerical ranges were all expressly written herein.

All parts, ratios, and percentages herein, in the Specification, Examples, and Claims, are by weight and all numerical limits are used with the normal degree of accuracy afforded by the art, unless otherwise specified.

The dimensions and values disclosed herein are not to be understood as being strictly
10 limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm.”

Every document cited herein, including any cross referenced or related patent or
15 application is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning
20 or definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is
25 therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

CLAIMS

What is claimed is:

1. A hair removal device (10) comprising:
a thermoplastic elastomer (12) disposed on a portion of the hair removal device (10); and
one or more projections (32) extending from the thermoplastic elastomer (12),
wherein the thermoplastic elastomer (12) is polar and hydrophilic.
- 5 2. The hair removal device of claim 1, wherein the thermoplastic elastomer defines one or more pores to facilitate removal of water.
3. The hair removal device of claim 1, wherein the one or more projections comprises at least two projections and at least one groove can be formed between the at least two projections.
4. The hair removal device of claim 1, wherein the one or more projections are integrally
10 formed with the thermoplastic elastomer.
5. The hair removal of claim 4, wherein the one or more projections are integrally formed with the thermoplastic elastomer by injection molding.
6. The hair removal device of claim 5, wherein the one or more projections are integrally formed with the thermoplastic elastomer by two step injection molding.
- 15 7. The hair removal device of claim 1, wherein the portion of the hair removal device comprises at least one of a grip portion of the hair removal device and a fin on a guard of the hair removal device.
8. A hair removal device comprising:
a thermoplastic elastomer disposed on at least a portion of the hair removal device, the
20 thermoplastic elastomer defining one or more pores to facilitate removal of water when wet,
wherein the thermoplastic elastomer is polar and hydrophilic.

9. The hair removal device of claim 8 further comprising one or more projections extending from the thermoplastic elastomer.
10. The hair removal device of claim 9, wherein the one or more projections is at least two projections.
- 5 11. The hair removal device of claim 10 further comprising at least one groove formed between the at least two projections.
12. The hair removal device of claim 9, wherein the one or more projections are integrally formed with the thermoplastic elastomer.
- 10 13. The hair removal device of claim 11, wherein the one or more projections are integrally formed with the thermoplastic elastomer by injection molding.
14. The hair removal device of claim 12, wherein the one or more projections are integrally formed with the thermoplastic elastomer by two step injection molding.
- 15 15. The hair removal device of claim 8, wherein the portion of the hair removal device comprises at least one of a grip portion of the hair removal device and a fin on a guard of the hair removal device.