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(54) **POLYURETHANE BRISTLES**

(76) Inventors: **Ronald R. Duff**, Shrewsbury, MA (US); **Scott Batson**, Wakefield, MA (US); **Helge Zimmet**, Waltham, MA (US); **Jerry Szczech**, Iowa City, IA (US); **Michael Roberts**, Brookfield, CT (US)

Correspondence Address:
ROBERT C. NABINGER
Fish & Richardson P.C.
225 Franklin Street
Boston, MA 02110-2804 (US)

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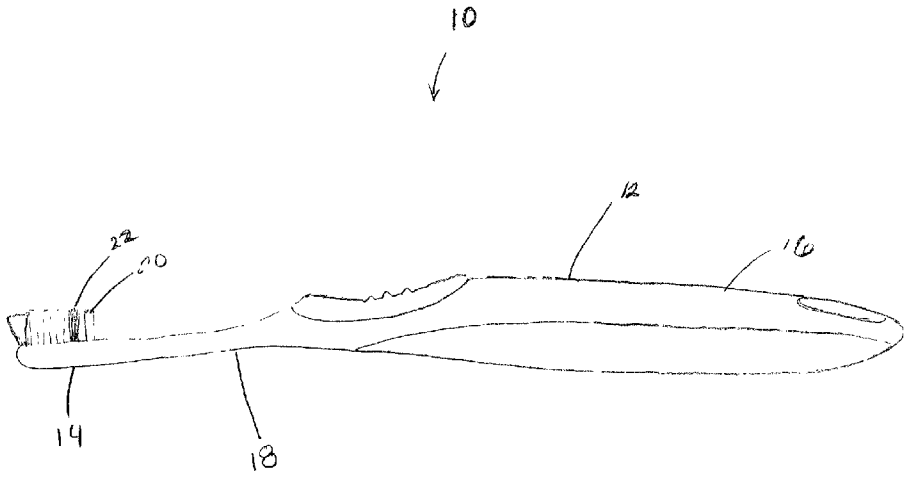
(57) **ABSTRACT**

Oral brushes and bristles for oral brushes are provided. The bristles include a polyurethane and have a relatively high stiffness.



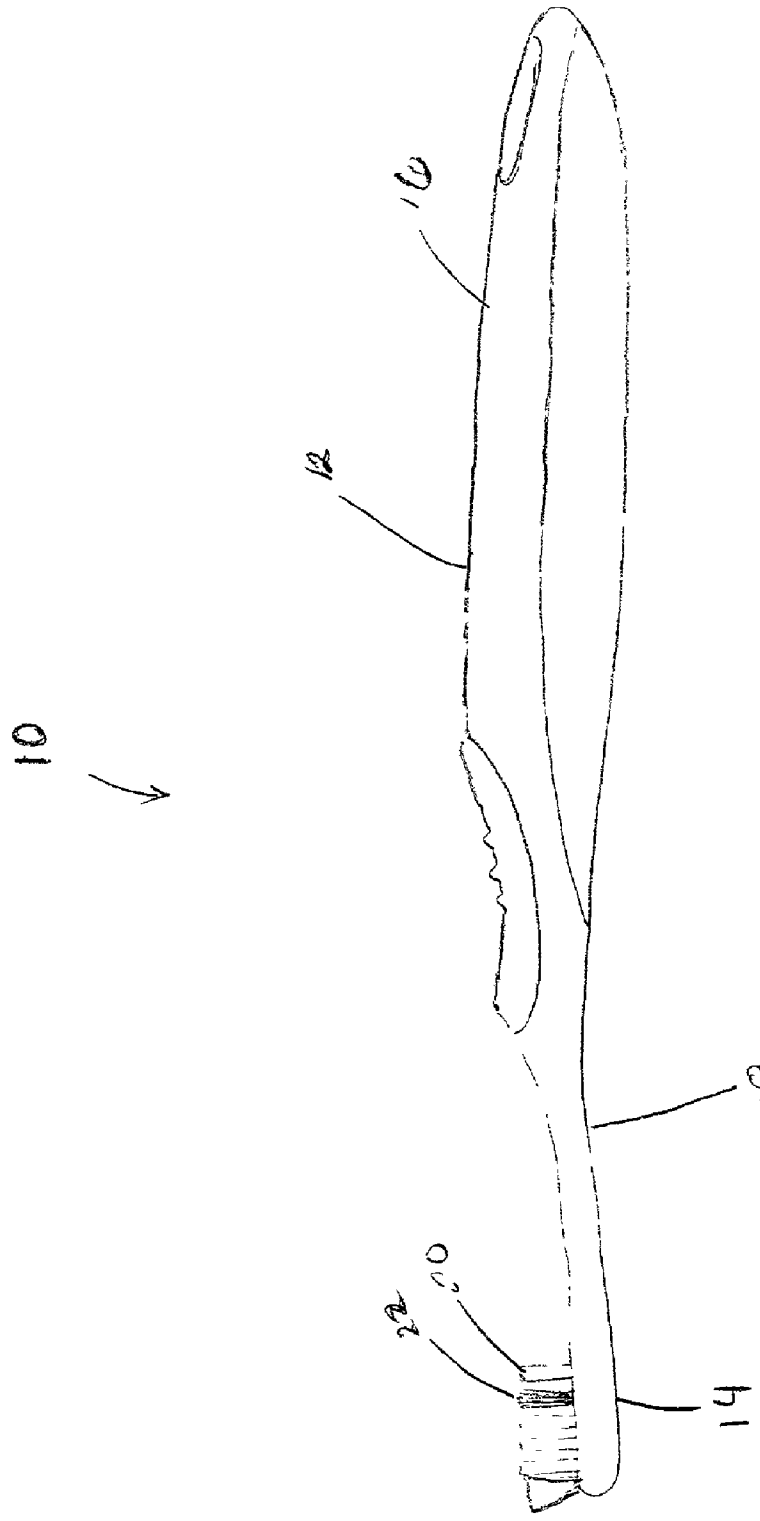


Fig. 1

POLYURETHANE BRISTLES

BACKGROUND OF THE INVENTION

[0001] The invention relates to polyurethane bristles for oral brushes.

[0002] Most humans suffer from tooth decay and/or gingivitis caused by plaque in the mouth. As a result, decreasing the amount of plaque in the mouth has long been the target of persons working in the health care field. A common way of minimizing the number of bacteria is to brush the teeth regularly.

[0003] It is important that the bristles of the toothbrush clean not only the tooth surfaces but also the areas between the teeth (interproximal regions) and between the exposed tooth surface and the gums (gingival margin). These areas are particularly susceptible to tooth decay, and tend to be difficult to clean.

SUMMARY OF THE INVENTION

[0004] The invention relates to oral brushes that provide good cleaning efficacy, particularly of the interproximal regions and gingival margin, and include bristles having excellent stiffness. The stiffness of the bristle material permits the manufacture of bristles having a sufficiently small diameter such that the bristle can effectively penetrate and clean the interproximal regions and gingival margin during brushing of the teeth.

[0005] The bristles are made from a polyurethane that is inherently stiffer than conventional bristle materials (i.e. Nylon 6.12, PBT, etc.), and thus it is possible to reduce the diameter of these bristles while maintaining similar overall brush stiffness. In some implementations the bristle includes a rigid thermoplastic polyurethane having a good balance of stiffness and wear resistance, which results in a durable bristle that can be used repeatedly without loss of stiffness or cleaning performance. By "rigid", we mean that the thermoplastic polyurethane has a flexural modulus of at least 300,000 psi (2100 MPa) tested according to ASTM D-790.

[0006] In general, the invention features oral brushes that include a body having a head and a handle, and a plurality of bristles extending from said head.

[0007] In one aspect, the bristles include a polyurethane and the brush exhibits a stiffness grade of from about 2 to 9 cN/mm^2.

[0008] Some implementations include one or more of the following features. The bristles have an average diameter no greater than about 0.007 inch, more preferably from about 0.004 inch to about 0.007 inch. The brush exhibits a stiffness grade of from about 2 to 6 cN/mm^2. The bristles exhibit a bend recovery of at least about 80%. The bristles exhibit a tensile modulus of at least about 3000 MPa. The bristles include a core and a sheath surrounding the core. The core and/or the sheath may include the polyurethane. The sheath includes an abrasive. The polyurethane includes a rigid thermoplastic polyurethane.

[0009] The oral brush further includes a plurality of second bristles formed of a material other than the polyurethane, e.g., nylon.

[0010] In another aspect, the bristles include a polyurethane and have an average diameter of no greater than about 0.007 in.

[0011] In a further aspect, the bristles include a polyurethane and have a bend recovery of at least 80%, and the brush exhibits a stiffness grade of from about 2 to 9 cN/mm^2.

[0012] The invention also features methods of using these oral brushes to brush an oral cavity of a mammal.

[0013] Other features and advantages of the invention will become apparent from the description of the preferred embodiments and from the claims.

BRIEF DESCRIPTION OF THE DRAWING

[0014] The FIGURE is a perspective view of a toothbrush.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Referring to the FIGURE, an oral brush **10** includes a body **12** that includes a head **14**, a handle **16** and a neck **18** between the head **14** and the handle **16**. Tufts **20** of bristles **22** extend from the head **14**.

[0016] The bristles **22** include a rigid thermoplastic polyurethane. Examples of suitable polyurethanes include ISOPLAST polyurethane filaments available from Dow Chemical under the product designations 300, 301, 301EZ, 302EZ, XUS72514.14, XUS72301.00L and XPR-1818-D73837-021.

[0017] The bristles **22** are of a stiffness such that the brush has a stiffness grade of from about 2 cN/mm^2 to about 9 cN/mm^2, more preferably from about 2 cN/mm^2 to about 6 cN/mm^2, when measured according to ISO 8627.

[0018] Preferred bristles also exhibit a tensile modulus of at least about 3000 MPa, more preferably at least about 4500 MPa, as measured according to ASTM Test Method D2101, and a toughness of at least about 40 MPa, more preferably at least about 50 MPa, as measured according to ASTM Test Method D2101. Preferred bristles exhibit a tensile strength at maximum load of at least 300 MPa, more preferably at least about 480 MPa, as measured according to ASTM Test Method D2101, and an elongation to break of at least about 20%, more preferably at least about 40%, as measured according to ASTM Test Method D2101.

[0019] The bristles exhibit satisfactory bend recovery, i.e., the ability to recover to an original position when bent from the original position by a force. Preferably the bristles exhibit a bend recovery of at least about 80%, more preferably at least about 85-95%, as measured according to the Dupont Mandrel Test Method set forth in the examples below.

[0020] The bristles also exhibit satisfactory wear resistance. Preferably, at the end of the life of the brush (i.e., after 3 months of daily use at normal brushing pressures) the brush will exhibit substantially the same amount of wear (bristle splaying and/or matting) as a similar brush having conventional nylon 6.12 bristles of the same length and diameter will exhibit after the same period of use.

[0021] Preferred bristles have a diameter from about 0.003 inch to about 0.008 inch. Bristles incorporated into manual toothbrushes preferably have a diameter of from about 0.005 in to about 0.007 inch, more preferably about 0.006 inch. Bristles incorporated into electric toothbrushes preferably have a diameter of from about 0.004 in to about 0.006 inch, more preferably 0.005 inch.

[0022] Toothbrushes of the invention can include a combination of polyurethane bristles of different diameters, e.g., bristles of 0.006 inch diameter and bristles of 0.005 inch diameter. The toothbrushes may also contain bristles of one or more diameters made from materials other than polyurethane (i.e. Nylon 6.12, PBT, and/or other bristle materials).

[0023] The bristles can have a variety of different constructions. For example, the bristle can have a concentric sheath/core construction in which the polyurethane is present in the core material, the sheath material, or a combination thereof.

[0024] Bristles having a sheath/core construction can be formed by coextruding two polymer compositions, e.g., an ISOPLAST polymer and a second composition that includes other thermoplastic polyurethanes such as those available under the tradenames PELLETHANE, MORTHANE, TECOTHANE, TECOFLEX, and ELASTOLLAN. The second composition may contain combinations of these polyurethanes and/or other bristle materials.

[0025] In a sheath/core construction, the sheath or core can include an abrasive material, e.g., a filler, to provide a microtexture to the surface or tip of the bristle. The microtexture can aid in cleaning of the tooth surface.

[0026] The sheath can be constructed to wear off of the bristle as a result of use. As the sheath wears away, the underlying core is exposed. The sheath thus serves as a wear indicator. The wear indicator function of the sheath can be enhanced through the incorporation of a coloring agent, e.g., a pigment, dye or combination thereof, in the sheath and/or the core. Preferably the coloring agent of the sheath differs from that of the core. If the sheath and/or core includes a coloring agent, as the sheath wears away a visible color change occurs, which indicates to the user the degree of wear of the brush.

[0027] The bristles can also include a wear indicator, e.g. a dye, which would wear off or leach out during use indicating the wear level of the bristles of the brush.

[0028] The cross section of the bristles can be circular or have a variety of noncircular shapes, e.g., rectangle, square, and triangle. The bristles can be multi-lobular, that is individual bristles can include a number of lobes, i.e., an exterior wall defining a central opening.

[0029] The bristles can also include any number of protrusions. The bristle may have, e.g., one, two, three, four, five, or six protrusions which define a shape, e.g., keyhole, cross, T, Y, X, or a star.

[0030] Production of the Bristle Filament

[0031] The following text describes a preferred method of manufacturing polyurethane filaments using an ISOPLAST polyurethane resin. Other suitable methods may be used.

[0032] Suitable methods generally include one or more drawings steps and one or more annealing steps.

[0033] Polyurethane Resin Preparation

[0034] The polyurethane resin is dried thoroughly prior to extrusion according to the resin manufacturer's recommendations. Preferably the polyurethane resin is dried with dry air in a desiccant-bed-type hopper dryer. Generally, throughout the drying process the dew point of the drying air should be maintained at −20° F. or less, preferably −40° F. Recommended drying temperatures for ISOPLAST resins range from 185-280° F. More specifically, the drying temperatures are 185-195° F. for ISOPLAST 300, 190-200° F. for ISOPLAST XUS72514.14, 200-230° F. for ISOPLAST 301, 301EZ, and XUS72301.00L, 260-280° F. for ISOPLAST 302EZ. Prior to processing the resin should generally be dried to a moisture content of less than 0.1%, preferably less than 0.02%. (See "Drying and processing guidelines for Isoplast resins," Dow Chemical.)

[0035] Filament Production

[0036] The polyurethane resin dried as described above is extruded through an extrusion die to form a filament. Preferably the extrusion die includes a spinneret, as is known in the filament forming art, through which a plurality of filaments are simultaneously extruded.

[0037] Immediately after the extruded polymer melt exits the die, it is cooled, e.g., by air or in a water tank, and solidifies. The filaments are then passed through an oven at a temperature of about 120° C. to about 280° C. (more preferably about 160-220° C.), depending on residence time in the oven and the type of resin that is processed. In this first oven the filaments are stretched as they travel between a first godet (godet #1) and a second drawing godet (godet #2) at a draw rate between 2:1 and 5:1 (more preferably between 2.5:1 and 4:1). The draw rate in this case is defined as the speed of godet #2 relative to the speed of godet #1.

[0038] The filaments are then passed through a second oven at a temperature of about 120° C. to about 280° C. (more preferably about 160-220° C.), depending on residence time in the oven and the type of resin that is processed. As the filaments pass through this second oven they are stretched as they travel between the second godet (godet #2) and a third drawing godet (godet #3) at a draw rate between 2:1 and 5:1 (more preferably between 3:1 and 4:1). The draw rate in this case is defined as the speed of godet #3 relative to the speed of godet #1.

[0039] If the filaments have not been annealed, or have not been fully annealed, during the previous steps, the filaments can be passed through a third oven at a temperature of about 120° C. to about 280° C. (more preferably about 160-220° C.). The temperature will depend on residence time in the oven and the type of resin that is processed. As the filaments pass through this third oven they are stretched as they travel between the second godet (godet #3) and a third drawing godet (godet #4) at a draw rate between 2:1 and 5:1 (more preferably between 3:1 and 4:1). The draw rate in this case is defined as the speed of godet #4 relative to the speed of godet #1. In most cases the draw ratio in the third oven is very similar to the draw ratio in the second oven.

[0040] The filaments are then air cooled, preferably at ambient temperature 20° C.+/−5° C., as they travel from the exit of the last oven to the takeup winder.

EXAMPLE

[0041] Filament samples were made according to the method described above, using the parameters in Table 1 below:

TABLE 1

	Extrusion process parameters						
Sample	ISOPLAST Polymer	Melt temperature	Speed Godet #1	Draw-down ratio godet #2/#1	Draw-down ratio godet #3/#1	Temp. oven #1 radiant heat	Temp. oven #2 radiant heat
1	XUS 72301.00 L	217° C.	90 m/min	3.8:1	3.7:1	220° C.	220° C.
2	XUS 72301.00 L	218° C.	96 m/min	3.55:1	3.5:1	230° C.	200° C.

[0042] The samples were conditioned for 24 hours at 70° F. and 65% relative humidity. They were then tested. The tensile modulus, tensile strength, toughness and elongation at break were tested according to ASTM Test Method D2101. Initial tensile modulus was measured between 0.1% and 0.5% elongation. The bend recovery was tested according to the DuPont Mandrel Test Method.

[0043] The results are shown in Table 2, below:

TABLE 2

	Filament Properties						
Sample	Average diameter	Bend Recovery	Tensile Modulus	Tensile Strength @ 0.2% yield	Tensile Strength @ max. load	Toughness	Elongation @ break
	["]	[%]	[MPa]	[MPa]	[MPa]	[MPa]	[%]
1	0.0061	85.6	4902	59.5	486.2	47.9	52.3
2	0.005	85.5	5353	63.4	341.3	59.4	81.2

[0044] These results indicate that the filaments have good strength and bend recovery even at relatively small diameters, and that the filaments exhibit properties that would render them suitable for use in toothbrush bristles.

[0045] Other embodiments are within the claims. For example, oral brushes that include the above-described polyurethane bristles can also include any number of bristles (single or multi-component) made from any number of other materials including, e.g., nylon, thermoplastic polymers, elastomers, thermoplastic elastomers, and combinations thereof.

What is claimed is:

1. An oral brush comprising:

a body comprising a head and a handle; and

a plurality of bristles extending from said head, said bristles comprising a polyurethane;

wherein the brush exhibits a stiffness grade of from about 2 to 9 cN/mm^2.

2. The oral brush of claim 1, wherein said bristles have a cross-sectional dimension no greater than about 0.007 inch.

3. The oral brush of claim 1, wherein said bristles have a cross-sectional dimension of from about 0.004 inch to about 0.007 inch.

4. The oral brush of claim 1, wherein the brush exhibits a stiffness grade of from about 2 to 6 cN/mm^2.

5. The oral brush of claim 1, wherein said bristles exhibit a bend recovery of at least about 80%.

6. The oral brush of claim 1, wherein said bristles exhibit a tensile modulus of at least about 3000 MPa.

7. The oral brush of claim 1, wherein said bristles comprise a core and a sheath surrounding said core.

8. The oral brush of claim 7, wherein said core includes the polyurethane.

9. The oral brush of claim 7, wherein said sheath includes the polyurethane.

10. The oral brush of claim 7, wherein said sheath further comprises an abrasive.

11. The oral brush of claim 1 wherein said polyurethane comprises a rigid thermoplastic polyurethane.

12. The oral brush of claim 1 further comprising a plurality of second bristles formed of a material other than said polyurethane.

13. The oral brush of claim 12 wherein said second bristles comprise nylon bristles.

14. The oral brush of claim 1 wherein said bristles have a toughness of at least about 40 MPa.

15. The oral brush of claim 14 wherein said bristles have a toughness of at least about 50 MPa.

16. An oral brush comprising:

a body comprising a head and a handle; and

a plurality of bristles extending from said head, said bristles comprising a polyurethane and having an average diameter of no greater than about 0.007 in.

17. The oral brush of claim 16 wherein said bristles have a bend recovery of at least 80%.

18. The oral brush of claim 16 wherein said bristles have an average diameter of 0.006 in. or less.

19. An oral brush comprising:

a head; and

a plurality of bristles extending from said head, said bristles comprising a polyurethane and having a bend recovery of at least 80%,

wherein said brush exhibits a stiffness grade of from about 2 to 9 cN/mm^2.

20. The brush of claim 19, wherein said brush exhibits a stiffness of from about 2 to 6 cN/mm^2.

21. The brush of claim 19, wherein said bristles have an average diameter no greater than about 0.007 inch.

22. The bristle of claim 21, wherein the average diameter of said bristles is from about 0.004 inch to about 0.007 inch.

23. The method of claim 19 wherein said polyurethane comprises a rigid thermoplastic polyurethane.

24. A method of using the oral brush of claim 1, said method comprising brushing an oral cavity of a mammal with said brush.

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