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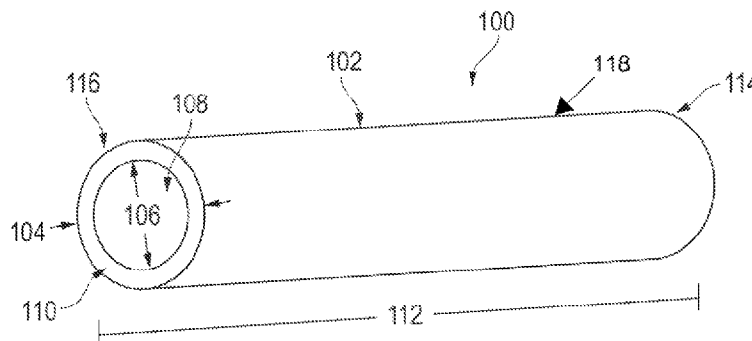


FIGURE 1

(57) Abstract: A peristaltic pump tube (100) includes a silicone composition including a base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material includes a blend of a first silicone elastomer and a second silicone elastomer, wherein the first silicone elastomer has a shore A durometer that is different than a shore A durometer of the second silicone elastomer; wherein the peristaltic pump tube (100) is used with a peristaltic pump at rotator speeds of greater than 600 rotations per minute, and the silicone composition advantageously increases pump life of the peristaltic pump tube (100).



WO 2024/199366 A1

PERISTALTIC PUMP TUBE AND METHOD OF MAKING

TECHNICAL FIELD

This disclosure, in general, relates to a peristaltic pump tube and method of forming
5 the peristaltic pump tube.

BACKGROUND ART

Silicone-based materials are widely used for their properties desired in medical,
pharmaceutical, food, and biological industries. For instance, silicone-based materials
typically are non-toxic, flexible, thermally stable, have low chemical reactivity, and can be
10 produced in a variety of sizes. However, challenges remain with currently available silicone
products. When the silicone product is a peristaltic pump tube, the tube is compressed with
rollers to force the liquid to move. Commercially available silicone tubing has yet to achieve
long service times at high speeds when used with peristaltic pump applications.

The development of high performance tubing that can achieve desirable service times
15 at rotator speeds greater than 600 rpm would be advantageous. More particularly, an
improved silicone-based peristaltic pump tubing is desired.

SUMMARY

In an embodiment, a peristaltic pump tube includes a silicone composition including a
base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone
20 material includes a blend of a first silicone elastomer and a second silicone elastomer,
wherein the first silicone elastomer has a shore A durometer that is different than a shore A
durometer of the second silicone elastomer; wherein the peristaltic pump tube is used with a
peristaltic pump at rotator speeds of greater than 600 rotations per minute (rpm).

In an embodiment, a method of forming a peristaltic pump tube includes: mixing a
25 silicone composition including a base silicone material, an accelerator, a curing agent, and a
catalyst, wherein the base silicone material includes a blend of a first silicone elastomer and a
second silicone elastomer, wherein the first silicone elastomer has a shore A durometer that is
different than a shore A durometer of the second silicone elastomer; and forming the
composition into at least one layer; wherein the peristaltic pump tube is used with a peristaltic
30 pump at rotator speeds of greater than 600 rotations per minute (rpm).

A peristaltic pump tube includes a silicone composition including a base silicone
material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material
comprises a blend of a first silicone elastomer and a second silicone elastomer, wherein the
first silicone elastomer has a shore A durometer that is different than a shore A durometer of

the second silicone elastomer; wherein the peristaltic pump tube has at least one of the following properties: a) a total spallation with particles sized $> 2 \mu\text{m}$ of less than 5 particles/mL, such as less than 4 particles/mL, such as less than 3 particles/mL, such as less than 2 particles/mL after 1000 vial fills when pumped at 300 rpm in a peristaltic pump using distilled water; or b) a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than $1000 \mu\text{m}^2/\text{mL}$, such as less than $800 \mu\text{m}^2/\text{mL}$, such as less than $600 \mu\text{m}^2/\text{mL}$, such as less than $400 \mu\text{m}^2/\text{mL}$, such as less than $200 \mu\text{m}^2/\text{mL}$ after 1000 vial fills when pumped at 300 rpm in a peristaltic pump using distilled water.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The present disclosure may be better understood, and its numerous features and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

FIG. 1 includes an illustration of an exemplary tube.

15 FIG. 2 includes a graphical depiction of tubing life of an exemplary peristaltic pump tube and a comparative peristaltic pump tube.

FIG. 3 includes a graphical depiction of flowrate of an exemplary peristaltic pump tube.

FIG. 4 includes a graphical depiction of compression fatigue of an exemplary peristaltic pump tube and a comparative peristaltic pump tube.

20 FIGS. 5A and 5B include photographs of fracture behavior of an exemplary peristaltic pump tube and a comparative peristaltic pump tube.

The use of the same reference symbols in different drawings indicates similar or identical items.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

25 The following description in combination with the figures is provided to assist in understanding the teachings disclosed herein. The following discussion focuses on specific implementations and embodiments of the teachings. This focus is provided to assist in describing the teachings and should not be interpreted as a limitation on the scope or applicability of the teachings.

30 As used herein, the terms “comprises”, “comprising”, “includes”, “including”, “has”, “having”, or any other variation thereof, are open-ended terms and should be interpreted to mean “including, but not limited to. . .”. These terms encompass the more restrictive terms “consisting essentially of” and “consisting of.” In an embodiment, a method, article, or

apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the
5 following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

Also, the use of “a” or “an” is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the
10 singular also includes the plural, or vice versa, unless it is clear that it is meant otherwise. For example, when a single item is described herein, more than one item may be used in place of a single item. Similarly, where more than one item is described herein, a single item may be substituted for that more than one item.

Unless otherwise defined, all technical and scientific terms used herein have the same
15 meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. The materials, methods, and examples are illustrative only and not intended to be limiting. To the extent not described herein, many details regarding specific materials and processing acts are conventional and may be found in reference books and other sources within the structural arts and corresponding manufacturing arts. Unless indicated otherwise,
20 all measurements are at about 25°C (i.e. room temperature). For instance, values for viscosity are at 25°C, unless indicated otherwise.

In a particular embodiment, a peristaltic pump tube includes a silicone composition. The silicone composition includes a base silicone material, an accelerator, a curing agent, and a catalyst. The silicone composition advantageously increases pump life of the peristaltic
25 pump tube and more particularly, when used at speeds greater than 600 rpms (rotation per minute). In an embodiment, the peristaltic pump tube has an advantageous spallation.

In an embodiment, the silicone composition includes a base silicone material. In a particular embodiment, the base silicone material includes at least one silicone elastomer. In a more particular embodiment, the base silicone material includes a first silicone elastomer and
30 a second silicone elastomer, where the first silicone elastomer has a shore A durometer that is different than a shore A durometer of the second silicone elastomer. For instance, the first silicone elastomer has a shore A durometer of not greater than 50, such as 20 to 50, such as 30 to 50, or even 35 to 45. In an embodiment, the second silicone elastomer has a shore A

durometer of not less than 50, such as 50 to 80, such as 60 to 80, or even 65 to 75. It will be appreciated that the durometer can be within a range between any of the minimum and maximum values noted above.

The at least one silicone elastomer may, for example, include a polyorganosiloxane.

5 Any polyorganosiloxane is envisioned and includes, for instance, a silicon hydride-containing polyalkylsiloxane, a vinyl-containing polyalkylsiloxane, an aryl-containing polyalkylsiloxane, a hydroxy-containing polyalkylsiloxane, a halogen-containing polyalkylsiloxane, or combination thereof. In an embodiment the polyorganosiloxane may include any alkyl group, such as any C1-6 alkyl group or combination thereof. In an embodiment, the
10 polyorganosiloxane may be formed of a precursor, such as dimethylsiloxane, diethylsiloxane, dipropylsiloxane, methylethylsiloxane, methylpropylsiloxane, or combinations thereof. In a particular embodiment, the polyorganosiloxane includes a polydialkylsiloxane, such as polydimethylsiloxane (PDMS). In a particular embodiment, the polyorganosiloxane is a silicon hydride-containing polyalkylsiloxane, such as a silicon hydride-containing
15 polydimethylsiloxane. In a further embodiment, the polyorganosiloxane is a vinyl-containing polyalkylsiloxane, such as a vinyl-containing polydimethylsiloxane. In yet another embodiment, the silicone elastomer is a combination of a silicon hydride-containing polyalkylsiloxane and a vinyl-containing polyalkylsiloxane, such as a combination of silicon hydride-containing polydimethylsiloxane and a vinyl-containing polydimethylsiloxane.

20 In an embodiment, the base silicone material has an aliphatic unsaturated (vinyl) containing ratio of at least 0.01 wt.% and not greater than 5 wt.% based on the total weight% of the base silicone material as measured by H-NMR. In an embodiment, the aliphatic unsaturated containing ratio of the base silicone material is at least 0.03 wt.%, or at least 0.05 wt.%, or at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5 wt.%, or at least 0.7 wt.%, or at
25 least 1 wt.%, or at least 2 wt.%, or not greater than 3 wt.%, or not greater than 1 wt.%, or not greater than 0.7 wt.%, or not greater than 0.5 wt.%, or not greater than 0.3 wt.%, or not greater than 0.1 wt.%, or not greater than 0.05 wt.% based on the total weight% of the base silicone material as measured by H-NMR. In a more particular embodiment and when at least two silicone elastomers are used, the first silicone elastomer has an aliphatic unsaturated
30 containing ratio of at least 0.01% and not greater than 5%, such as 0.01 wt.% to 1 wt.%, or even about 0.05 wt.% to 0.5 wt.% of the first silicone elastomer as measured by H-NMR. In an embodiment, the aliphatic unsaturated containing ratio of the first silicone elastomer is at least 0.03 wt.%, or at least 0.05 wt.%, or at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5

wt.%, or at least 0.7 wt.%, or at least 1 wt.%, or at least 2 wt.%, or not greater than 3 wt.%, or not greater than 1 wt.%, or not greater than 0.7 wt.%, or not greater than 0.5 wt.%, or not greater than 0.3 wt.%, or not greater than 0.1 wt.%, or not greater than 0.05 wt.% of the first silicone elastomer as measured by H-NMR. In a more particular embodiment, the second
5 silicone elastomer has an aliphatic unsaturated containing ratio of at least 0.01% and not greater than 5%, such as 0.05 wt.% to 2 wt.%, or even about 0.05 wt.% to 1 wt.% of the second silicone elastomer as measured by H-NMR. In an embodiment, the aliphatic unsaturated containing ratio of the second silicone elastomer is at least 0.03 wt.%, or at least 0.05 wt.%, or at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5 wt.%, or at least 0.7 wt.%,
10 or at least 1 wt.%, or at least 2 wt.%, or not greater than 3 wt.%, or not greater than 1 wt.%, or not greater than 0.7 wt.%, or not greater than 0.5 wt.%, or not greater than 0.3 wt.%, or not greater than 0.1 wt.%, or not greater than 0.05 wt.% of the second silicone elastomer as measured by H-NMR. It will be appreciated that the ratio can be within a range between any of the minimum and maximum values noted above.

15 In an example, the base silicone material and/or the silicone elastomer may include a halide functional group, a phenyl functional group, or combination thereof. For example, the base silicone material may include fluorosilicone or phenylsilicone. Alternatively, the base silicone material is non-polar and is free of a halide functional group, such as chlorine and fluorine, and of a phenyl functional group.

20 In an embodiment, the base silicone material and/or the silicone elastomer has at least one of the follow properties: a) a number-average molecular weight of 200,000 g/mol to 1,000,000 g/mol, such as at least 200,000 g/mol, or at least 300,000 g/mol, or at least 400,000 g/mol, or at least 500,000 g/mol, or not greater than 1,000,000 g/mol, or not greater than 800,000 g/mol, or not greater than 600,000 g/mol, or not greater than 400,000 g/mol as
25 measured by a gas permeation chromatography (GPC) in THF; b) a weight-average molecular weight of 200,000 g/mol to 1,000,000 g/mol, such as at least 200,000 g/mol, or at least 300,000 g/mol, or at least 400,000 g/mol, or at least 500,000 g/mol, or not greater than 1,000,000 g/mol, or not greater than 800,000 g/mol, or not greater than 600,000 g/mol, or not greater than 400,000 g/mol as measured by a gas permeation chromatography (GPC) in THF;
30 c) a Mooney viscosity of at least 15 and not greater than 60 (ML (1+4) at 100°C), such as at least 25, or at least 35, or at least 45, or not greater than 50, or not greater than 40, or not greater than 30; d) a tensile strength of at least 8 MPa and not greater than 15 Mpa as measured by GB/T 528-2009 type 1, such as at least 9 MPa, or at least 10 MPa, or at least 11

MPa, or at least 12 MPa, or not greater than 13 MPa, or not greater than 12 MPa, or not greater than 11 MPa, or not greater than 10 MPa; e) an elongation of at least 200% and not greater than 900% as measured by GB/T 528-2009 type 1, such as at least 300%, or at least 400%, or at least 500%, or at least 600%, or not greater than 800%, or not greater than 700%,
5 or not greater than 600%, or not greater than 500%; f) a tear strength of at least 10 N/mm and not greater than 45 N/mm as measured by GB/T 528-2009 type 1, such as at least 15 N/mm, or at least 20 N/mm, or at least 25 N/mm, or at least 30 N/mm, or not greater than 40 N/mm, or not greater than 35 N/mm, or not greater than 30 N/mm, or not greater than 25 N/mm; and
10 g) a shore A durometer of 30 to 80, such as 40 to 70, or even 45 to 65 as measured by ASTM D-2240. It will be appreciated that the properties can be within a range between any of the minimum and maximum values noted above. In an embodiment and when the base silicone material includes a first and a second silicone elastomer, the first silicone elastomer has a number average molecular weight, a weight average molecular weight, and Mooney viscosity that is less than the second silicone elastomer. In an embodiment, the first silicone elastomer
15 has an elongation and a tear strength that is greater than the second silicone elastomer.

In an embodiment, the base silicone material is present at not less than 50 wt.%, such as 50 to 99 wt.%, or even 90 to 99 wt.% of the total weight of the silicone composition. In a more particular embodiment, the base silicone material is present at an amount of at least 55 wt.%, or at least 60 wt.%, or at least 65 wt.%, or at least 70 wt.%, or at least 75 wt.%, or at
20 least 80 wt.%, or at least 85 wt.%, or at least 90 wt.%, or not greater than 99 wt.%, or not greater than 97 wt.%, or not greater than 95 wt.%, or not greater than 93 wt.%, or not greater than 90 wt.%, or not greater than 85 wt.%, or not greater than 80 wt.%, or not greater than 75 wt.% of the total weight of the silicone composition. In an embodiment and when the base silicone material includes the first and second silicone elastomer, the first silicone elastomer
25 is present at not less than 50 wt.%, such as 50 to 90 wt.%, or even 50 to 80 wt.% of the total weight of the silicone composition. In a more particular embodiment, the first silicone elastomer is present at an amount of at least 55 wt.%, or at least 60 wt.%, or at least 65 wt.%, or at least 70 wt.%, or at least 75 wt.%, or at least 80 wt.%, or at least 85 wt.%, or at least 90 wt.%, or not greater than 90 wt.%, or not greater than 85 wt.%, or not greater than 80 wt.%,
30 or not greater than 75 wt.%, or not greater than 70 wt.%, or not greater than 65 wt.%, or not greater than 60 wt.%, or not greater than 55 wt.% of the total weight of the silicone composition. Further, the second silicone elastomer is present at not greater than 50 wt.%, such as 1 to 50 wt.%, or even 10 to 40 wt.% of the total weight of the silicone composition. In

a more particular embodiment, the second silicone elastomer is present at an amount of not greater than 50 wt.%, or not greater than 45 wt.%, or not greater than 40 wt.%, or not greater than 35 wt.%, or not greater than 30 wt.%, or not greater than 25 wt.%, or not greater than 20 wt.%, or not greater than 15 wt.%, or at least 1 wt.%, or at least 5 wt.%, or at least 10 wt.%,
5 or at least 15 wt.%, or at least 20 wt.%, or at least 25 wt.%, or at least 30 wt.%, or at least 35 wt.% of the total weight of the silicone composition. It will be appreciated that the amount of silicone elastomer can be within a range between any of the minimum and maximum values noted above.

The silicone elastomer of the base silicone material may include a conventional,
10 commercially prepared silicone formulation. The commercially prepared silicone elastomer typically includes components such as the polyorganosiloxane, a catalyst, a filler, and optional additives. Any reasonable filler and additives are envisioned. Particular embodiments of a commercially available base silicone material includes high consistency rubber (HCR).

15 The silicone composition includes an accelerator. An accelerator typically is a component that may participate in crosslinking and may influence the cured product in chemical structure, properties, and the like. Any accelerator is envisioned. Typically, the accelerator includes a polyalkylsiloxane such as a silicon hydride-containing polyalkylsiloxane, a vinyl-containing polyalkylsiloxane, an aryl-containing polyalkylsiloxane,
20 a hydroxy-containing polyalkylsiloxane, a halogen-containing polyalkylsiloxane, or combination thereof. In an embodiment, the polyalkylsiloxane may include any alkyl group, such as any C1-6 alkyl group or combination thereof. In particular, the accelerator is a polyalkylsiloxane that is different than the polyorganosiloxane of the base silicone material. In an embodiment, the polyalkylsiloxane is terminated with a vinyl group, a methyl group, a
25 hydroxy group, or combination thereof. For instance, the polyalkylsiloxane includes a vinyl-terminated polyalkylsiloxane, a tri-methyl terminated polyalkylsiloxane, a hydroxy-terminated polyalkylsiloxane, or combination thereof. In a more particular embodiment, the polyalkylsiloxane includes a vinyl-terminated polydimethylsilicone, a tri-methyl terminated polydimethylsilicone, a polydimethylsiloxane, a polydiethylsiloxane, a polydipropylsiloxane,
30 a polymethylethylsiloxane, a polymethylpropylsiloxane, a polymethyl hydrosiloxane, a polyethyl hydrogen siloxane, a polyphenylsiloxane, a polymethyl phenylsiloxane, a polymethyl chlorophenyl siloxane, a polyethoxymethylsiloxane, a polymethyl

trifluoropropylsiloxane, a polymethyl vinyl siloxane, a polymethyl hydrosiloxane, or combination thereof.

In an embodiment, the accelerator has a weight-average molecular weight of 200,000 g/mol to 1,000,000 g/mol, such as 200,000 g/mol to 800,000 g/mol, such as 200,000 g/mol to 500,000 g/mol, such as 200,000 g/mol to 400,000 g/mol, or even 200,000 g/mol or even 300,000 g/mol as measured by GPC in THF. In an embodiment, the polyalkylsiloxane of the accelerator has an aliphatic unsaturated containing ratio of at least 0.01% and not greater than 5%, such as 1 wt.% to 5 wt.%, or even about 2 wt.% to 4 wt.% of the polyalkylsiloxane as measured by H-NMR. In an embodiment, the aliphatic unsaturated containing ratio of the polyalkylsiloxane is at least 0.03 wt.%, or at least 0.05 wt.%, or at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5 wt.%, or at least 0.7 wt.%, or at least 1 wt.%, or at least 2 wt.%, or not greater than 3 wt.%, or not greater than 1 wt.%, or not greater than 0.7 wt.%, or not greater than 0.5 wt.%, or not greater than 0.3 wt.%, or not greater than 0.1 wt.%, or not greater than 0.05 wt.% based on the total weight% of the polyalkylsiloxane as measured by H-NMR. The density of the accelerator is at least 0.8 g/cm³ and not greater than 1.5 g/cm³ as measured by GB/T 533-2008 Method A. It will be appreciated that the values can be within a range between any of the minimum and maximum values noted above.

In an example, the polyalkylsiloxane of the accelerator may include a halide functional group, a phenyl functional group, or combination thereof. For example, the polyalkylsiloxane may include fluorosilicone or phenylsilicone. Alternatively, the polyalkylsiloxane is non-polar and is free of a halide functional group, such as chlorine and fluorine, and of a phenyl functional group. Any amount of accelerator is present in the silicone composition. For instance, the accelerator is present at no less than 0.1 wt.%, such as 0.1 to 10 wt.%, or even 1 to 5 wt.% of the total weight of the silicone composition. In a more particular embodiment, the accelerator is present at an amount of at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5 wt.%, or at least 0.7 wt.%, or at least 1.0 wt.%, or at least 1.5 wt.%, or at least 2.0 wt.%, or at least 2.5 wt.%, or not greater than 10 wt.%, or not greater than 9.0 wt.%, or not greater than 8.0 wt.%, or not greater than 7.0 wt.%, or not greater than 6.0 wt.%, or not greater than 5.0 wt.%, or not greater than 4.0 wt.%, or not greater than 3.0 wt.% of the total weight of the silicone composition. It will be appreciated that the amount of accelerator can be within a range between any of the minimum and maximum values noted above.

A curing agent is further included in the silicone composition. A curing agent includes a component that can form a crosslinking structure with the silicone elastomer. Any

reasonable curing agent is envisioned. The curing agent is typically a crosslinker, such as a silicone oil. In a particular embodiment, the oil crosslinker includes a silicon hydride-containing polyalkylsiloxane such as polymethylhydrosiloxane. The curing agent has a molecular weight of at least 20 mPa.s and not greater than 150 mPa.s, such as 20 mPa.s to 5 100 mPa.s, or even 30 mPa.s to 50 mPa.s as measured by HG/T 2363-1992. Further, the curing agent has a hydrogen content (Si-H) of at least 0.01 wt.% and not greater than 2.0 wt.%, such as at least 0.05 wt.%, or at least 0.1 wt.%, or at least 0.3 wt.%, or at least 0.5 wt.%, or at least 1 wt.%, or not greater than 1.5 wt.%, or not greater than 1 wt.%, or not greater than 0.5 wt.%, or not greater than 0.3 wt.%, as measured by chemical titration HG-T 4658-2014.

10 Any amount of curing agent is present that influences the crosslink density, cure speed, and the like. For instance, the curing agent is present at not less than 0.1 wt.%, such as 0.1 to 10 wt.%, or even 3 to 8 wt.% of the total weight of the silicone composition. In a more particular embodiment, the curing agent is present at an amount of at least 0.1 wt.%, or at least 0.5 wt.%, or at least 1.0 wt.%, or at least 1.5 wt.%, or at least 2.0 wt.%, or at least 2.5 wt.%, or at least 15 3.0 wt.%, or at least 3.5 wt.%, or not greater than 10 wt.%, or not greater than 9.0 wt.%, or not greater than 8.0 wt.%, or not greater than 7.0 wt.%, or not greater than 6.0 wt.%, or not greater than 5.0 wt.%, or not greater than 4.0 wt.%, or not greater than 3.0 wt.% of the total weight of the silicone composition. It will be appreciated that the values can be within a range between any of the minimum and maximum values noted above.

20 The silicone composition further includes a catalyst. Typically, the catalyst is present to initiate the crosslinking process. Any catalyst is envisioned depending upon the silicone composition. In an embodiment, a hydrosilylation reaction catalyst may be used. For instance, an exemplary hydrosilylation catalyst is an organometallic complex compound of a transition metal. In an embodiment, the catalyst includes platinum, rhodium, ruthenium, the like, or 25 combinations thereof. In a particular embodiment, the catalyst includes platinum. Further optional catalysts may be used with the hydrosilylation catalyst. Exemplary optional catalysts may include peroxide, tin, or combinations thereof. In an embodiment, the silicone composition further includes a peroxide catalyzed silicone composition. For instance, the catalyst is present at greater than 0.1 wt.%, such as 0.1 to 5 wt.%, or even 1 to 3 wt.% of the 30 total weight of the silicone composition. In a more particular embodiment, the catalyst is present at an amount of at least 0.1 wt.%, or at least 0.5 wt.%, or at least 1.0 wt.%, or at least 1.5 wt.%, or at least 2.0 wt.%, or at least 2.5 wt.%, or at least 3.0 wt.%, or at least 3.5 wt.%, or not greater than 5 wt.%, or not greater than 4.5 wt.%, or not greater than 4.0 wt.%, or not

greater than 3.5 wt.%, or not greater than 3.0 wt.%, or not greater than 2.5 wt.%, or not greater than 2.0 wt.%, or not greater than 1.5 wt.% of the total weight of the silicone composition. It will be appreciated that the amount of catalyst can be within a range between any of the minimum and maximum values noted above.

5 The silicone composition may further include an additive. Any reasonable additive is envisioned. Exemplary additives may include, individually or in combination, a vinyl polymer, a methyl polymer, a hydride, an adhesion promoter, a filler, an initiator, an inhibitor, a colorant, a pigment, a carrier material, an anti-microbial, or any combination thereof. In an embodiment, the silicone composition is substantially free of an additive, such as present at
10 less than 0.1 wt.% of an additive based on the total weight of the silicone composition. In an embodiment, the material content of the peristaltic pump tube is essentially 100% silicone composition. In some embodiments, the silicone composition consists essentially of the respective base silicone material, accelerator, curing agent, and catalyst described above. As used herein, the phrase “consists essentially of” used in connection with the silicone
15 composition precludes the presence of non-silicone polymers that affect the basic and novel characteristics of the silicone composition, although, commonly used processing agents and additives may be used in the silicone composition. In an embodiment, the silicone composition consists of the respective base silicone material, accelerator, curing agent, and catalyst described above.

20 FIG. 1 is a view of an exemplary article, such as a peristaltic pump tube 100 according to an embodiment. In a particular embodiment, the peristaltic pump tube 100 can include a body 102 having an outside diameter 104 and an inner diameter 106. The inner diameter 106 can form an inner surface 108 of the body 102. The inner surface 108 defines a central lumen of the tube. In addition, the body 102 is illustrated as a single layer, the single
25 layer including the silicone composition. The layer can include a thickness 110 that is measured by the difference between the outside diameter 104 and the inner diameter 106.

In a particular embodiment, the outside diameter 104 of the body 102 is about 5 mm to about 150 mm. It will be appreciated that the outside diameter 104 can be within a range between any of the minimum and maximum values noted above. In an embodiment, the inner
30 diameter 106 of the body 102 is about 0.1 mm to about 100 mm. It will be appreciated that the inner diameter 106 can be within a range between any of the minimum and maximum values noted above.

Further, the body 102 can have a length 112, which is a distance between a distal end 114 and a proximal end 116 of the peristaltic pump tube 100. In a further embodiment, the length 112 of the body 102 can be at least about 2 meters, such as at least about 5 meters, such as at least about 10 meters. The length 112 is generally limited by pragmatic concerns, such as storing and transporting long lengths, or by customer demand. Further, the body 102 has a surface 118. The surface 118 can be an outer surface of the tube 100. The surface 118 is typically directly in contact with peristaltic pump rollers of a peristaltic pump.

Although the cross-section of the hollow bore 108 perpendicular to an axial direction of the body 102 in the illustrative embodiment shown in FIG. 1 has a circular shape, the cross-section of the hollow bore 108 perpendicular to the axial direction of the body 102 can have any cross-section shape envisioned.

Although illustrated as a single layer tube, any number of layers is envisioned. For instance, the peristaltic pump tube includes one layer, two layers, three layers, or even a greater number of layers. Typically, the layer has a thickness of at least about 0.05 mm to about 10 mm. It will be appreciated that the thickness of the layer can be within a range between any of the minimum and maximum values noted above. Irrespective of the number of layers present, the outside diameter and inner diameter of the peristaltic pump tube can have any values as defined for the single layer tube 100 defined in FIG. 1. The number of layers is dependent upon the final properties desired for the tube.

In an embodiment, the silicone composition may be formed into a single layer article, a multi-layer article, or can be laminated, coated, or formed on a substrate. Multi-layer articles may include layers such as a polymeric layer, a reinforcing layer, an adhesive layer, a barrier layer, a chemically resistant layer, a metal layer, any combination thereof, and the like. When the peristaltic pump tube includes multiple layers, each of the individual layers of the peristaltic pump tube may be formed by any reasonable means and is dependent upon the material and the configured location of each of the individual layers. Any number of layers is also envisioned. Although primarily described as a peristaltic pump tube, the silicone composition can be formed into any useful shape such as film, sheet, tubing, and the like. The silicone composition may adhere or bond to other substrates including other polymers.

In an embodiment, the silicone composition may be formed by any reasonable means depending upon the final article desired. In an example, at least one silicone layer is provided by any reasonable means. In an embodiment, at least one silicone layer is formed into a tube

by extrusion or injection molding followed by cure such as thermal cure, radiation cure, or combination thereof.

In an exemplary embodiment, the at least one silicone layer is formed by an extrusion system. The extrusion system for the at least one silicone layer typically includes a pumping system and can include a number of devices that can be utilized to form the at least one silicone layer of the peristaltic pump tube. For example, the extrusion system can include a pumping device such as a gear pump, a static mixer, an extruder, a tube die, a thermal cure device, a radiation cure device, a post-processing device, or any combination thereof. The method includes receiving, by an extrusion system, the mixed silicone composition as described above. Any reasonable mixing apparatus is envisioned. In a particular embodiment, the mixing apparatus forms a homogenous mixture of the base silicone material, the accelerator, the curing agent, and the catalyst. In an embodiment, heat may also be applied to the silicone composition. For instance, any reasonable heating temperature for the components of the silicone composition may be used to provide a material that can flow from the pumping system and extruded through the tube die without degradation of the material. For instance, the temperature may be about 10°C to about 70°C. It will be appreciated that the heating temperature can be within a range between any of the minimum and maximum values noted above. Typically, the silicone composition is mixed and pumped, i.e. extruded, through the tube die of the extrusion system.

In an alternative embodiment, the at least one silicone layer is formed by an injection molding system. The injection molding system includes any pumping system to deliver the silicone composition such as pneumatically, hydraulically, gravitationally, mechanically, and the like, or combination thereof. The pumping system delivers the silicone composition to a mold configured in any shape desired for the final article, such as a tube. The pumping system may also include any reasonable mixing apparatus envisioned. In a particular embodiment, the mixing apparatus forms a homogenous mixture of the base silicone material, the accelerator, the curing agent, and the catalyst. Further, the pumping system may include a method of heating any combination of the components of the silicone composition to any temperature envisioned so that it has a desirable viscosity for delivery such that the silicone composition may flow into the mold. The injection molding system may further include a thermal cure device, a radiation cure device, a post-processing device, or any combination thereof.

In an embodiment, the silicone composition is thermally cured. In an embodiment, the thermal curing of the silicone composition can include subjecting the silicone composition to one or more heat sources. In a particular embodiment, the heat source is sufficient to substantially cure the silicone composition. “Substantially cure” as used herein refers to 90% to 100% curing degree, as determined for instance by rheometer data (90% cure means the material reaches 90% of the maximum torque as measured by ASTM D5289). For instance, the level of cure is to provide desirable properties for the final peristaltic pump tube.

In an embodiment, the silicone composition is radiation cured. Any number of applications of radiation energy may be applied with the same or different wavelengths. For example, the extrusion system or injection molding system can include one or more ovens (e.g. infrared (IR) ovens, air ovens), one or more baths (e.g. water baths), or a combination thereof, to cure the silicone composition. The one or more IR ovens can operate at a particular peak wavelength. In certain instances, the peak wavelength of a first IR oven can be different from the peak wavelength of a second IR oven. In an embodiment, the silicone composition can be subjected to a heat treatment for a specified period of time. In a particular embodiment, the silicone composition can be subjected to curing in a first IR oven for a first period of time and then subject to curing in a second IR oven for a second period of time that is different from the first period of time. In one particular embodiment, use is made of a short wavelength IR oven. By short wavelength, it is meant that the peak wavelength is below 4 microns, typically below 3 microns, such as within a range of approximately 0.6 to 2.0 microns, such as 0.8 to 1.8 microns. Generally medium and longer wavelength IR ovens are characterized by a peak wavelength on the order of 4 to 8 microns, or even higher. It will be appreciated that the wavelength can be within a range between any of the minimum and maximum values noted above.

Once the silicone composition is formed, the silicone composition can undergo one or more post processing operations. Any reasonable post processing operations are envisioned. For instance, the silicone composition can be subjected to a post-cure heat treatment, such as a post-curing cycle. Post thermal treatment typically occurs at a temperature of about 40°C to about 200°C. In an embodiment, the post thermal treatment is at a temperature of about 60°C to about 100°C. Typically, the post thermal treatment occurs for a time period of about 5 minutes to about 10 hours, such as about 10 minutes to about 30 minutes, or alternatively about 1 hour to about 4 hours. It will be appreciated that the post thermal treatment temperature and time can be within a range between any of the minimum and maximum

values noted above. In an alternative example, the silicone composition is not subjected to a post thermal treatment. In an example, the silicone article is a tube that can be cut into a number of peristaltic pump tubes having a specified length. In another embodiment, the post processing can include wrapping the peristaltic pump tube into a coil of tubing.

5 The peristaltic pump tube can be sterilized. In an embodiment, the peristaltic pump tube may be sterilized by any method envisioned. For instance, the peristaltic pump tube is sterilized after it is formed. Exemplary sterilization methods include steam, gamma, ethylene oxide, E-beam techniques, combinations thereof, and the like. In a particular embodiment, the peristaltic pump tube is sterilized by gamma irradiation. For instance, the peristaltic pump
10 tube may be gamma sterilized at between about 10 kGy to about 200 kGy. In a particular embodiment, the peristaltic pump tube is sterilized by steam sterilization. In an exemplary embodiment, the peristaltic pump tube is heat-resistant to steam sterilization at temperatures up to about 130°C for a time of up to about 45 minutes. In an embodiment, the peristaltic pump tube is heat resistant to steam sterilization at temperatures of up to about 135°C for a
15 time of up to about 15 minutes. It will be appreciated that the sterilization parameters can be within a range between any of the minimum and maximum values noted above.

 In an embodiment, the peristaltic pump tube has advantageous properties. For instance, the peristaltic pump tube has a desirable life when used in high speed pumping applications, such as at speeds of greater than 600 rotations per minute (rpm), or at least 700
20 rpms, or at least 750 rpms, or at least 800 rpms, or at least 850 rpms, or at least 900 rpms. For instance, the peristaltic pump tube has a tubing life of at least 100 hours, or at least 120 hours, or at least 140 hours, or at least 160 hours, or at least 180 hours, or at least 200 hours at 700 rpm using a pump head test with distilled water. In an embodiment, the peristaltic pump tube has a tubing life of at least 70 hours, or at least 80 hours, or at least 90 hours, or at least 100
25 hours, or at least 110 hours, or at least 120 at 900 rpm using a pump head test with distilled water. In an embodiment, the peristaltic pump tube has a flowrate consistency (R^2) of at least 0.95, or at least 0.97, or at least 0.99 with a pumping speed range from 100 rpm to 900 rpm. In yet another embodiment, the peristaltic pump tube has a flowrate degradation of not greater than 20%, or not greater than 18%, or not greater than 16%, or not greater than 14%,
30 or not greater than 12%, or not greater than 10% before failure. The description of an exemplary peristaltic pump for testing is described in the Examples.

 In an embodiment, the resulting peristaltic pump tube may have further desirable physical and mechanical properties. For instance, the peristaltic pump tube is flexible and

kink-resistant. In particular, the resulting peristaltic pump tube has desirable flexibility. For instance, the silicone composition may advantageously produce low durometer articles. For example, a peristaltic pump tube having a Shore A durometer of between about 20 and about 90, such as between about 35 to about 75 as measured by ASTM D-2240 having desirable mechanical properties may be formed. Such properties are indicative of a flexible material. In an embodiment, the peristaltic pump tube has at least one of the following properties: a) a burst pressure of 0.2 MPa to 1.0 Mpa, such as at least 0.3 MPa, or at least 0.4 MPa, or at least 0.5 MPa, or at least 0.6 MPa, or not greater than 0.9 MPa, or not greater than 0.8 MPa, or not greater than 0.7 MPa, or not greater than 0.6 MPa; b) a tear strength of 30 N/mm to 55 N/mm, such as at least 35 N/mm, or at least 40 N/mm, or at least 45 N/mm, or not greater than 45 N/mm, or not greater than 40 N/mm, or not greater than 35 N/mm as measured by ASTM D624 (Die B); c) an elongation of 300% to 800%, such as at least 350%, or at least 400%, or at least 450%, or at least 500%, or at least 550%, or at least 600%, or not greater than 750%, or not greater than 700%, or not greater than 650%, or not greater than 600%, or not greater than 550%, or not greater than 500%, or not greater than 450%, as measured by ASTM D412 (Die C); d) a tensile strength of 5 MPa to 10 MPa, such as at least 6 MPa, or at least 7 MPa, or at least 8 MPa, or not greater than 9 MPa, or not greater than 8 MPa, or not greater than 7 MPa as measured by ASTM D412 (Die C); e) a compression set of 10% to 40%, such as at least 15%, or at least 20%, or at least 25%, or not greater than 35%, or not greater than 30%, or not greater than 25% as measured by ISO 815-1; and f) a rebound resilience of 30% to 70% such as at least 35%, or at least 40%, or at least 45%, or at least 50%, or not greater than 65%, or not greater than 60%, or not greater than 55%, or not greater than 50% as measured by ISO 4662. It will be appreciated that the values can be within a range between any of the minimum and maximum values noted above.

Further, the peristaltic pump tube may have advantageous properties such as, for example, compression hysteresis, tensile strength, elongation, rupture energy, compression set, burst pressure, or combination thereof. For instance, the peristaltic pump tube may have a compression hysteresis loss of less than 40% from 100,000 cycles to 400,000 cycles at a frequency of 20 hertz and strain range of 20%. In an embodiment, the peristaltic pump tube may have at least one of the following properties at room temperature as measured by ASTM D1708: a) a tensile strength of 5.5 MPa to 9.5 MPa; b) an elongation of 350% to 600% ; c) a rupture energy of greater than 2000 N.mm, or combination thereof. In an embodiment, the peristaltic pump tube may have at least one of the following properties at 60°C as measured

by ASTM D1708: a) a tensile strength of 5.5 MPa to 9.5 MPa; b) an elongation of 275% to 500%; c) a rupture energy of greater than 2000 N.mm, or combination thereof. In yet another embodiment, the peristaltic pump tube may have at least one of the following properties at 60°C with a notched tensile test as measured at a tensile speed of 50 mm/min: a) a tensile strength of 15 MPa to 50 MPa; b) an elongation at break of greater than 400%; c) a rupture energy of at least 500 N.mm, d) a non-linear fracture at break; or combination thereof.

Additionally, the peristaltic pump tube may have a burst pressure of greater than 4.75 bar, or greater than 4.8 bar, or even greater than 4.9 bar as measured by ASTM D1599. In yet another embodiment, the peristaltic pump tube may have a compression set of 4.8% to 5.2%.

In exemplary embodiments, the peristaltic pump tube can be used in a variety of applications. Applications for the peristaltic pump tube are numerous. In particular, the non-toxic nature of the silicone composition makes the peristaltic pump tube useful for any application where toxicity is undesired. For instance, the peristaltic pump tube has potential for FDA, ADCF, USP Class VI, NSF, European Pharmacopoeia compliant, United States Pharmacopoeia (USP) compliant, USP physiochemical compliant, ISO 10993 Standard for evaluating biocompatibility of a medical device, and other regulatory approvals. In a particular embodiment, the silicone composition may be non-cytotoxic, non-hemolytic, non-pyrogenic, animal-derived component-free, non-mutagenic, non-bacteriostatic, non-fungistatic, or any combination thereof.

In an embodiment, the silicone composition is any formed into any reasonable article, such as the peristaltic pump tube, that may be used in applications such as industrial, medical applications, health care, biopharmaceutical, drinking water, food & beverage applications, dairy applications, laboratory applications, FDA applications, laboratory applications, and the like. In an exemplary embodiment, although the article is primarily described as a peristaltic pump tube, the article of the present invention may include any tube envisioned, a connector, a molded part, a septum, an infusion sleeve, a pump diaphragm, a valve, and the like. Any article is envisioned where the physical and mechanical properties of the silicone composition are advantageous.

Many different aspects and embodiments are possible. Some of those aspects and embodiments are described herein. After reading this specification, skilled artisans will appreciate that those aspects and embodiments are only illustrative and do not limit the scope of the present invention. Embodiments may be in accordance with any one or more of the items as listed below.

Embodiment 1. A peristaltic pump tube includes a silicone composition including a base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material includes a blend of a first silicone elastomer and a second silicone elastomer wherein the first silicone elastomer has a shore A durometer that is different than a shore A durometer of the second silicone elastomer; wherein the peristaltic pump tube is used with a peristaltic pump at rotator speeds of greater than 600 rotations per minute (rpm).

Embodiment 2. A method of forming a peristaltic pump tube includes: mixing a silicone composition including a base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material includes a blend of a first silicone elastomer and a second silicone elastomer wherein the first silicone elastomer has a shore A durometer that is different than a shore A durometer of the second silicone elastomer; and forming the composition into at least one layer; wherein the peristaltic pump tube is used with a peristaltic pump at rotator speeds of greater than 600 rotations per minute (rpm).

Embodiment 3. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the first silicone elastomer and the second silicone elastomer includes a polyorganosiloxane.

Embodiment 4. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 3, wherein the polyorganosiloxane includes a silicon hydride-containing polyalkylsiloxane, a vinyl-containing polyalkylsiloxane, an aryl-containing polyalkylsiloxane, a hydroxy-containing polyalkylsiloxane, a halogen-containing polyalkylsiloxane, or combination thereof.

Embodiment 5. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the first silicone elastomer has a shore A durometer of not greater than 50, such as 20 to 50, such as 30 to 50, or even 35 to 45.

Embodiment 6. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 5, wherein the first silicone elastomer is present at not less than 50 wt.%, such as 50 to 90 wt.%, or even 50 to 80 wt.% of the total weight of the silicone composition.

Embodiment 7. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the second silicone elastomer has a shore A durometer of not less than 50, such as 50 to 80, such as 60 to 80, or even 65 to 75.

Embodiment 8. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 7, wherein the second silicone elastomer is present at not greater than 50 wt.%, such as 1 to 50 wt.%, or even 10 to 40 wt.% of the total weight of the silicone composition.

5 Embodiment 9. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the base silicone material has a shore A durometer of 30 to 80, such as 40 to 70, or even 45 to 65.

Embodiment 10. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the base silicone
10 material has a number-average molecular weight of 200,000 g/mol to 1,000,000 g/mol.

Embodiment 11. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the base silicone material has a weight-average molecular weight of 200,000 g/mol to 1,000,000 g/mol.

Embodiment 12. The peristaltic pump tube or the method of forming the peristaltic
15 pump tube in accordance with any of the preceding embodiments, wherein the accelerator includes a polyalkylsiloxane.

Embodiment 13. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 12, wherein the polyalkylsiloxane includes a vinyl-terminated polyalkylsiloxane, a tri-methyl terminated polyalkylsiloxane, a hydroxy-
20 terminated polyalkylsiloxane, or combination thereof.

Embodiment 14. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 12, wherein the accelerator has a weight-average molecular weight of 200,000 g/mol to 1,000,000 g/mol.

Embodiment 15. The peristaltic pump tube or the method of forming the peristaltic
25 pump tube in accordance with embodiment 12, wherein the accelerator is present at not less than 0.1 wt.%, such as 0.1 to 10 wt.%, or even 1 to 5 wt.% of the total weight of the silicone composition.

Embodiment 16. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the curing agent
30 includes a silicon hydride-containing polyalkylsiloxane.

Embodiment 17. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 16, wherein the silicon hydride-containing polyalkylsiloxane includes polymethylhydrosiloxane.

Embodiment 18. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 16, wherein the curing agent is present at not less than 0.1 wt.%, such as 0.1 to 10 wt.%, or even 3 to 8 wt.% of the total weight of the silicone composition.

5 Embodiment 19. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the catalyst includes a hydrosilylation reaction catalyst.

Embodiment 20. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 19, wherein the hydrosilylation reaction catalyst
10 includes a platinum catalyst, a rhodium catalyst, a ruthenium catalyst, or combination thereof.

Embodiment 21. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 19, wherein the catalyst is present at not less than 0.1 wt.%, such as 0.1 to 5 wt.%, or even 1 to 3 wt.% of the total weight of the silicone composition.

15 Embodiment 22. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has an inner surface that defines a central lumen of the tube.

Embodiment 23. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having a compression
20 hysteresis loss of less than 40% from 100,000 cycles to 400,000 cycles at a frequency of 20 hertz and strain range of 20%.

Embodiment 24. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having at least one of the following properties at room temperature as measured by ASTM D1708: a) a tensile strength
25 of 5.5 MPa to 9.5 MPa; b) an elongation of 350% to 600%; c) a rupture energy of greater than 2000 N.mm, or combination thereof.

Embodiment 25. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having at least one of the following properties at 60°C as measured by ASTM D1708: a) a tensile strength of 5.5 MPa
30 to 9.5 MPa; b) an elongation of 275% to 500%; c) a rupture energy of greater than 2000 N.mm, or combination thereof.

Embodiment 26. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having at least one of the

following properties at 60°C with a notched tensile test as measured at a tensile speed of 50 mm/min: a) a tensile strength of 15 MPa to 50 MPa; b) an elongation at break of greater than 400%; c) a rupture energy of at least 500 N.mm, d) a non-linear fracture at break; or combination thereof.

5 Embodiment 27. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having a burst pressure of greater than 4.75 bar, or greater than 4.8 bar, or even greater than 4.9 bar as measured by ASTM D1599.

10 Embodiment 28. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having a compression set of 4.8% to 5.2%.

15 Embodiment 29. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a tubing life of at least 100 hours at 700 rpm using a pump head test with distilled water.

 Embodiment 30. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a tubing life of at least 70 hours at 900 rpm using a pump head test with distilled water.

20 Embodiment 31. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a flowrate consistency (R^2) of at least 0.95 with a pumping speed range from 100 rpm to 900 rpm.

25 Embodiment 32. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a flowrate degradation of not greater than 20% before failure.

 Embodiment 33. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a burst pressure of 0.2 MPa to 1.0 MPa.

30 Embodiment 34. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a tear strength of 30 N/mm to 55 N/mm as measured by ASTM D624 (Die B).

Embodiment 35. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiment, wherein the peristaltic pump tube has an elongation of 300% to 800 as measured by ASTM D412 (Die C).

5 Embodiment 36. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a tensile strength of 5 MPa to 10 MPa as measured by ASTM D412 (Die C).

Embodiment 37. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, wherein the peristaltic pump tube has a compression set of 10% to 40% as measured by ISO 815-1.

10 Embodiment 38. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with any of the preceding embodiments, having an inner diameter of about 0.1 mm to about 100 mm.

Embodiment 39. The peristaltic pump tube or the method of forming the peristaltic pump tube in accordance with embodiment 38, having an outer diameter of about 5 mm to
15 about 150 mm.

Embodiment 40. The method of forming the peristaltic pump tube in accordance with embodiments 2-39, further including curing the peristaltic pump tube.

Embodiment 41. The method of forming the peristaltic pump tube in accordance with embodiment 40, wherein the cured tube has a crosslink density of 90% to 100%.

20 Embodiment 42. A peristaltic pump tube includes a silicone composition including a base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material comprises a blend of a first silicone elastomer and a second silicone elastomer, wherein the first silicone elastomer has a shore A durometer that is different than a shore A
25 durometer of the second silicone elastomer; wherein the peristaltic pump tube has at least one of the following properties: a) a total spallation with particles sized $> 2 \mu\text{m}$ of less than 5 particles/mL, such as less than 4 particles/mL, such as less than 3 particles/mL, such as less than 2 particles/mL after 1000 vial fills when pumped at 300 rpm in a peristaltic pump using distilled water; or b) a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 1000 $\mu\text{m}^2/\text{mL}$, such as less than 800 $\mu\text{m}^2/\text{mL}$, such as less than 600 $\mu\text{m}^2/\text{mL}$, such as less than 400 $\mu\text{m}^2/\text{mL}$, such as less
30 than 200 $\mu\text{m}^2/\text{mL}$ after 1000 vial fills when pumped at 300 rpm in a peristaltic pump using distilled water.

The concepts described herein will be further described in the following examples, which do not limit the scope of the disclosure described in the claims. The following

examples are provided to better disclose and teach processes and compositions of the present invention. They are for illustrative purposes only, and it must be acknowledged that minor variations and changes can be made without materially affecting the spirit and scope of the invention as recited in the claims that follow.

5 EXAMPLES

The following components are provided to form a silicone composition:

Component (A); Base silicone Material – first silicone elastomer

A-1: A polyorganosiloxane with hardness of 40 duro. The tensile strength and elongation of A-1 was 8 to 10 MPa and 700 to 800%, respectively. The tear strength of A-1 was 25-40 N/mm. The vinyl content within the polyorganosiloxane was 0.05 to 0.15 % by weight.

A-2 (Comparison) A polyorganosiloxane with hardness of 40 duro. The tensile strength and elongation of A-2 was 8.5 to 10 MPa and 700 to 800 %, respectively. The tear strength of A-2 was 10 to 20 N/mm. The vinyl content within the polyorganosiloxane is 0.01 to 0.05 % by weight.

Component (B); Base silicone Material – second silicone elastomer

B-1: A polyorganosiloxane with hardness of 70 duro. The tensile strength and elongation of B-1 was 9 to 12 MPa and 300 to 450 %, respectively. The tear strength of B-1 was 15 to 30 N/mm. The vinyl content within the polyorganosiloxane was 0.20 to 1.0 % by weight.

B-2 (Comparison): A polyalkylsiloxane with hardness of 40 duro. The tensile strength and elongation of B-2 was 8 to 10 MPa and 400 to 500 %, respectively. The tear strength of B-2 is 25 to 40 N/mm. The vinyl content within the polyalkylsiloxane was 0.01 to 0.20 % by weight.

Component (C); Accelerator

C-1: A vinyl-containing polyalkylsiloxane with vinyl content of 1 to 5 % by weight.

C-2 (comparison): A vinyl-containing polyalkylsiloxane with vinyl content of 1 to 5 % by weight.

Component (D); Curing agent

D-1: A polymethylhydrosiloxane (PMHS) with Si-H of 0.03 to 0.40 % by weight.

D-2 (comparison): same with D-1, A PMHS with Si-H of 0.03 to 0.04 % by weight.

Component (E); Catalyst

E-1: Platinum catalyst system with Pt atom content of 0.03 to 0.05 % by weight.

E-2 (comparison): same with E-1, Platinum catalyst with Pt atom content of 0.03 to 0.05 % by weight. (ICS-OES)

Compositions of example and comparative example are made by mixing the above component (A) to (E) in the amounts shown in Table 1.

5

Table 1

Composition	Test item	Example 1 (wt.%)	Comparative Example 1 (wt.%)
Component (A)	A-1	65-70 %	65-70 %
	A-2		
Component (B)	B-1	20-25 %	20-25 %
	B-2		
Component (C)	C-1	3-4 %	3-4 %
	C-2		
Component (D)	D-1	4-7 %	4-7 %
	D-2		
Component (E)	E-1	1-2.5 %	1-2.5 %
	E-2		

Two silicone tubing were extruded by following the compositions of example 1 and comparative example 1 as shown in Table 1.

Testing results from both lab tests (FIG. 2) and field tests (Table 2) indicated that new silicone tubing (example 1) presented high tubing life under high pump speed, comparing to the tubing comparative example 1.

10

Table 2. Pump performance of tubing with new composition from field tests

	Test sample	Test item	Test method	Test result
Comparative example 1	Field statistical results of mass production	Tubing life	780 rpm, DI water	50-70 h
Example 1	Trial tubing sample test 1# in 3 duplicates	Tubing life	780 rpm, DI water	230 h
	Trial tubing sample test 2# in 3 duplicates	Tubing life	780 rpm, DI water	276 h
	Trial tubing sample test 3# in 3 duplicates	Tubing life	780 rpm, DI water	264 h
	Trial tubing sample test	Flowrate consistency	Test method as below	Pass
	Trial tubing sample test	Flowrate degradation	780 rpm, 24hrs, flow rate decrease<10%, DI water Test method as below	Pass

The features of the pump were as follows: The peristaltic pump included a pump case, a rotation disc with four copper rollers, and a drive motor. The diameter of the rotation disc was 56 ± 0.2 mm. The four rollers distribute with 90 degree rams on the disc and the diameter of the roller was 8.9 ± 0.1 mm. The minimum distance between the roller and the pump case was 5 ± 0.1 mm. The rotation disc speed could be adjusted in the range of 100 to 1000 rpm.

Test method description: The pump life of the tubing (14.8 mm (OD) and 8.8 mm (ID)) was tested using the pump head defined above with distilled water as media under different rotator speeds. For instance, the tubing pump life was tested under 700 rpm and 900 rpm to determine tubing life. The tubing life was defined as the total running time when water leakage was observed or flow rate degradation was over 25%. A comparison of the tubing life of an exemplary peristaltic pump tube and a comparative tube when tested under 900 rpm can be seen in FIG. 2.

Further, to determine flowrate, it was calculated by measuring the water mass that pumping out by the tubing per unit time under certain pumping speed. The flowrate of tubing under 100, 300, 500, 700, and 900 rpm were tested. The flowrate (g/min) against pump speed (rpm) was plotted and the linear relationship equation was calculated. The R^2 of the linear equation was used to determine the flowrate consistency of tubing under different pump speed and can be seen in FIG. 3. The flowrate degradation was calculated by measuring the water mass that pumping out by the tubing per unit time under certain pumping speed. The

flowrate degradation was determined by measuring the initial flowrate and final measured flowrate under same pump speed. The flowrate degradation was calculated with the following equation:

$$\text{Flowrate degradation} = (1 - \text{Final flowrate}/\text{Initial flowrate}) * 100\%$$

5 Crosslink density

The cross-linked density (V) and critical molecular mass between cross-links (Mc) was measured by the change in the weight of the sample, after swelling in toluene solvent. The samples were then taken from the solution and placed in a previously weighted close container to obtain the weight after being swollen. The cross-linked density was calculated using the Flory-Rehner equation. In an embodiment, the crosslinking density of the exemplary silicone composition was from 90% to 100% as measured by a test method as described.

Burst pressure test:

The burst pressure test was done by continuously increasing the internal hydraulic-pressure of tubing while immersing an exemplary tubing with ID 0.250 inches and OD of 0.375 inches in a controlled-temperature as per ASTM D1599. A comparative and commercialized tube with ID 0.250 inches and OD of 0.375 inches was also tested. Specifically, the data presented was obtained by immersing the tubing in a water bath with an ambient temperature. The highest pressure value during the test on the pressure indicating system constituted the tubing burst pressure value. At least three replicates were done for each tubing to determine the burst pressure. Results can be seen in Table 3.

Table 3. Burst pressure test results

Burst pressure	Exemplary tube	Comparative tube
Test 1	4.94	4.61
Test 2	5.03	4.7
Test 3	5.08	4.66
Average burst pressure (bar)	5.02	4.66
RSD	1.41%	0.97%

As seen in Table 3, the average burst pressure of the exemplary tubing was higher than the comparative tube.

Compression Fatigue

An exemplary tubing and a comparative, commercialized tubing, both with a dimension of ID 0.250 inches and OD of 0.375 inches, were tested. The samples were prepared by cutting 5 cm length tubing and then cutting the tubing along the direction of
 5 longitude so that the width could reach 26 mm, then the cut tubing were placed flat into the testing machine for a sample size of 26 mm in width and 50 mm in length. A cyclic compression test was performed on an Instron 8801 Fatigue Machine with a strain range of 20%, cycles of 400,000 and a frequency of 20 hertz (HZ). The hysteresis results measured from compression fatigue showed the relative hysteresis loss for an exemplary tubing in
 10 comparison to the comparative tube. Results can be seen in FIG. 4. As seen in the figure, the exemplary tubing had lower relative hysteresis after 10,000 cycles.

Tensile Test

Tensile tests were carried out on an Instron 3367 tensile machine according to ASTM D1708. The speed was 50 mm/min with the sample cutting from an exemplary tubing (ID
 15 0.250 inches and OD 0.375inches) and a comparative, commercialized tubing (ID 0.250 inches and OD 0.375inches). Tests were carried out at room temperature (RT) and 60°C between exemplary tubing and comparative tubing. Results can be seen in Table 4.

Table 4. Tensile Test Results

Sample Name	Exemplary Tube		Comparative Tube	
	RT	60°C	RT	60°C
Tensile strength (MPa)	7.57	6.66	9.00	7.39
Elongation at break (%)	445	337	325	272
Rupture energy (N.mm)	3915	2521	2450	1793

20 The rupture energy of the exemplary tubing at room temperature and 60°C were both higher than that of the comparative tubing. For silicone polymers, longer elongation indicates better stretchability of the polymer chains, which is beneficial to de-concentrate the stress at crack tip.

Tensile Notch Test- Crack Propagation

Tensile tests were carried out on an Instron 3367 tensile machine according to ASTM D1708. The speed was 50 mm/min with the sample cutting from an exemplary tubing (ID 0.250 inches and OD 0.375inches) and a comparative, commercialized tubing (ID 0.250 inches and OD 0.375inches). The samples were prepared by cutting 4.5 cm length tubing and then cutting the tubing along the direction of longitude so that the width could reach 26 mm, then the cut tubing were placed flat into the testing machine for a sample size of 26 mm in width and 45 mm in length. A notch was pre-made in the sample with a length of 3 mm by blade. Tests were carried out at room temperature (RT) and 60°C between the exemplary tubing and the comparative tubing. Results can be seen in Table 5.

Table 5. Tensile Notch Test Results

Sample Name	Exemplary Tube		Comparative Tube	
	RT	60°C	RT	60°C
Tensile strength (MPa)	39.54	27.93	43.97	7.79
Elongation at break (%)	878	691	1088	124
Rupture energy (N.mm)	5129	2902	6979	138

The tensile strength in the table is the maximum tensile strength value in the stress-stress curve for this tensile notch test. The rupture energy is the fracture toughness calculated from the value of the integrity area of the stress-strain curve.

The results clearly show that the exemplary tube had higher crack propagation resistance than the commercially available tube under the tensile notch test at 60°C. Notably and as seen in FIGs. 5A and 5B, the exemplary tube had a non-linear fracture (i.e. jagged tear) across the width of the sample at break at 60°C (FIG. 5B) compared to the commercially available tube that exhibited a linear fracture (i.e. straight tear) across the width of the sample at break at 60°C (FIG. 5A).

Tubing Compression Test

An exemplary tube and a comparative, commercialized tube were tested for compression set. The testing included measuring the tubing wall thickness by optical microscopy before the compression set test. The tubings (ID 0.250 inches and OD 0.375 inches) were each placed into a compression fixture (ISO 815). The distance of the two plates

of the fixture were set as 2.4 mm (compressed for 25%) and pressed for 22 hours under 175°C in an oven. The thickness of the wall after compression was then measured via optical microscopy. The compression set (C-set) values were calculated using the wall thickness value before and after compression. Results can be seen in Table 6.

5 Table 6. Compression-set results

Burst pressure	Exemplary tube		Comparative tube	
	Before	After	Before	After
Test 1	1.58	1.55	1.59	1.57
Test 2	1.57	1.55	1.57	1.56
Test 3	1.58	1.57	1.59	1.56
Test 4	1.57	1.55	1.59	1.57
Test 5	1.56	1.57	1.56	1.59
Average wall thickness (mm)	1.58	1.56	1.58	1.56
RSD	0.48%	0.44%	0.72%	0.59%
C-set	4.97%		4.74%	

The compression set showed there was no significant difference observed between the exemplary tube and the comparative tube.

Spallation

Spallation measurement methods include counting particles that come off the tube after 1,000 cycles in recirculated fluid. Exemplary tubes have an ID of 1.6 mm and an OD of 4.8 mm. 25 mL of UltraPure water is run through a FlowCam® 8000 Imaging Flow Cytometer (IFC) as a blank. Tubing is loaded on a Flexicon® PF7 pump. The first 3 vial fills of 1.8 mL is discarded to rinse the tubing of contamination. The test is done without a needle at the end of the tubing. 100mL of water is recirculated through a pump for 1,000 cycles at 300 rpm. The entire flask of 100 mL of recirculated (pumped) water is samples through the IFC at a rate of 5 mL/min and at a magnification of 4x. This is repeated for 1,000 cycles and then another 1,000 cycles, each time with a new 100 mL of UltraPure water. The IFC samples the entire fluid pumped for the first 1,000 cycle, second 1,000 cycle, and third 1,000 cycle of vial fills. The tubing is not touched during the entire test to complete a total cycle of 3,000 vial fills.

Spallation (or particle shedding) typically occurs from the shear compression force in a peristaltic pump that causes the release of particles from tubing. Spallation is represented by

particles/mL (how many larger particles come off the tube in an amount of fluid recirculated) and by area of total spallation/mL ($\mu\text{m}^2/\text{mL}$). These two parameters illustrate both the total particles that are produced in the fluid path by tubing and the relative size of particles. Low particles and low total area is desirable. Tubing is tested as non-irradiated and after gamma
5 irradiation of about 42 kGy.

Exemplary peristaltic pump tubing that is not irradiated has a total spallation with particles sized $> 2 \mu\text{m}$ of less than 5 particles/mL, such as less than 4 particles/mL, such as less than 3 particles/mL, such as less than 2 particles/mL after 1000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is not irradiated has a total spallation
10 with particles sized $> 2 \mu\text{m}$ of less than 5 particles/mL, such as less than 4 particles/mL, such as less than 3 particles/mL, such as less than 2 particles/mL after 2000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is not irradiated has a total spallation with particles sized $> 2 \mu\text{m}$ of less than 5 particles/mL, such as less than 4 particles/mL, such as less than 3 particles/mL, such as less than 2 particles/mL after 3000 vial fills.

Exemplary peristaltic pump tubing that is not irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 1000 $\mu\text{m}^2/\text{mL}$, such as less than 800 $\mu\text{m}^2/\text{mL}$, such as less than 600
15 $\mu\text{m}^2/\text{mL}$, such as less than 400 $\mu\text{m}^2/\text{mL}$, such as less than 200 $\mu\text{m}^2/\text{mL}$ after 1000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is not irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 1000 $\mu\text{m}^2/\text{mL}$, such as less than 800 $\mu\text{m}^2/\text{mL}$, such as less than 600 $\mu\text{m}^2/\text{mL}$, such as less than 400 $\mu\text{m}^2/\text{mL}$, such as less than 200 $\mu\text{m}^2/\text{mL}$ after
20 2000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is not irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 1000 $\mu\text{m}^2/\text{mL}$, such as less than 800 $\mu\text{m}^2/\text{mL}$, such as less than 600 $\mu\text{m}^2/\text{mL}$, such as less than 400 $\mu\text{m}^2/\text{mL}$, such as less than 200 $\mu\text{m}^2/\text{mL}$ after 3000 vial fills.

Exemplary peristaltic pump tubing that is irradiated has a total spallation with particles sized $> 2 \mu\text{m}$ of less than 50 particles/mL, such as less than 40 particles/mL, such as less than 30 particles/mL, such as less than 20 particles/mL after 1000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is irradiated has a total spallation
25 with particles sized $> 2 \mu\text{m}$ of less than 50 particles/mL, such as less than 40 particles/mL, such as less than 30 particles/mL, such as less than 20 particles/mL after 2000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is irradiated has a total spallation with particles sized $> 2 \mu\text{m}$ of less than 50 particles/mL, such as less than 40 particles/mL, such as less than 30 particles/mL, such as less than 20 particles/mL after 3000 vial fills.
30

Exemplary peristaltic pump tubing that is irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 2000 $\mu\text{m}^2/\text{mL}$, such as less than 1800 $\mu\text{m}^2/\text{mL}$, such as less than 1600 $\mu\text{m}^2/\text{mL}$, such as less than 1400 $\mu\text{m}^2/\text{mL}$, such as less than 1200 $\mu\text{m}^2/\text{mL}$, such as less than 1000 $\mu\text{m}^2/\text{mL}$ after 1000 vial fills. In an embodiment, the exemplary peristaltic pump tubing
5 that is irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 2000 $\mu\text{m}^2/\text{mL}$, such as less than 1800 $\mu\text{m}^2/\text{mL}$, such as less than 1600 $\mu\text{m}^2/\text{mL}$, such as less than 1400 $\mu\text{m}^2/\text{mL}$, such as less than 1200 $\mu\text{m}^2/\text{mL}$, such as less than 1000 $\mu\text{m}^2/\text{mL}$ after 2000 vial fills. In an embodiment, the exemplary peristaltic pump tubing that is irradiated has a total spallation area ($\mu\text{m}^2/\text{mL}$) of less than 2000 $\mu\text{m}^2/\text{mL}$, such as less than 1800 $\mu\text{m}^2/\text{mL}$, such as less than
10 1600 $\mu\text{m}^2/\text{mL}$, such as less than 1400 $\mu\text{m}^2/\text{mL}$, such as less than 1200 $\mu\text{m}^2/\text{mL}$, such as less than 1000 $\mu\text{m}^2/\text{mL}$ after 3000 vial fills.

In the foregoing specification, the concepts have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as
15 set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the invention.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems,
20 and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

After reading the specification, skilled artisans will appreciate that certain features are, for clarity, described herein in the context of separate embodiments, may also be provided in
25 combination in a single embodiment. Conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, references to values stated in ranges include each and every value within that range.

WHAT IS CLAIMED IS:

1. A peristaltic pump tube comprises a silicone composition comprising a base silicone material, an accelerator, a curing agent, and a catalyst, wherein the base silicone material comprises a blend of a first silicone elastomer and a second silicone elastomer, wherein the first silicone elastomer has a shore A durometer that is different than a shore A durometer of the second silicone elastomer; wherein the peristaltic pump tube is used with a peristaltic pump at a rotator speed of greater than 600 rotations per minute (rpm).

2. The peristaltic pump tube in accordance with claim 1, wherein the first silicone elastomer and the second silicone elastomer comprises a polyorganosiloxane.

3. The peristaltic pump tube in accordance with claim 2, wherein the polyorganosiloxane comprises a silicon hydride-containing polyalkylsiloxane, a vinyl-containing polyalkylsiloxane, an aryl-containing polyalkylsiloxane, a hydroxy-containing polyalkylsiloxane, a halogen-containing polyalkylsiloxane, or combination thereof.

4. The peristaltic pump tube in accordance with claim 1, wherein the first silicone elastomer has a shore A durometer of not greater than 50, such as 20 to 50, such as 30 to 50, or even 35 to 45.

5. The peristaltic pump tube in accordance with claim 4, wherein the first silicone elastomer is present at not less than 50 wt.%, such as 50 to 90 wt.%, or even 50 to 80 wt.% of the total weight of the silicone composition.

6. The peristaltic pump tube in accordance with claim 1, wherein the second silicone elastomer has a shore A durometer of not less than 50, such as 50 to 80, such as 60 to 80, or even 65 to 75.

7. The peristaltic pump tube in accordance with claim 6, wherein the second silicone elastomer is present at not greater than 50 wt.%, such as 1 to 50 wt.%, or even 10 to 40 wt.% of the total weight of the silicone composition.

8. The peristaltic pump tube in accordance with claim 1, wherein the base silicone material has a shore A durometer of 30 to 80, such as 40 to 70, or even 45 to 65.

9. The peristaltic pump tube in accordance with claim 1, wherein the base silicone material has a number-average molecular weight of 200,000 g/mol to 1,000,000 g/mol.

10. The peristaltic pump tube in accordance with claim 1, wherein the base silicone material has a weight-average molecular weight of 200,000 g/mol to 1,000,000 g/mol.

11. The peristaltic pump tube in accordance with claim 1, wherein the accelerator comprises a polyalkylsiloxane.

12. The peristaltic pump tube in accordance with claim 11, wherein the polyalkylsiloxane comprises a vinyl-terminated polyalkylsiloxane, a tri-methyl terminated polyalkylsiloxane, a hydroxy-terminated polyalkylsiloxane, or combination thereof.

13. The peristaltic pump tube in accordance with claim 1, wherein the curing agent comprises a silicon hydride-containing polyalkylsiloxane.

14. The peristaltic pump tube in accordance with claim 1, wherein the catalyst comprises a hydrosilylation reaction catalyst.

15. The peristaltic pump tube in accordance with claim 1, having a compression hysteresis loss of less than 40% from 100,000 cycles to 400,000 cycles at a frequency of 20 hertz and strain range of 20%.

16. The peristaltic pump tube in accordance with claim 1, having at least one of the following properties at room temperature as measured by ASTM D1708: a) a tensile strength of 5.5 MPa to 9.5 MPa; b) an elongation of 350% to 600%; c) a rupture energy of greater than 2000 N.mm, or combination thereof.

17. The peristaltic pump tube in accordance with claim 1, having at least one of the following properties at 60°C as measured by ASTM D1708: a) a tensile strength of 5.5 MPa to 9.5 MPa; b) an elongation of 275% to 500%; c) a rupture energy of greater than 2000 N.mm, or combination thereof.

18. The peristaltic pump tube in accordance with claim 1, having at least one of the following properties at 60°C with a notched tensile test as measured at a tensile speed of 50 mm/min: a) a tensile strength of 15 MPa to 50 MPa; b) an elongation at break of greater than 400%; c) a rupture energy of at least 500 N.mm; d) a non-linear fracture at break; or combination thereof.

19. The peristaltic pump tube in accordance with claim 1, having a burst pressure of greater than 4.75 bar, or greater than 4.8 bar, or even greater than 4.9 bar as measured by ASTM D1599.

20. The peristaltic pump tube in accordance with claim 1, having a compression set of 4.8% to 5.2%.

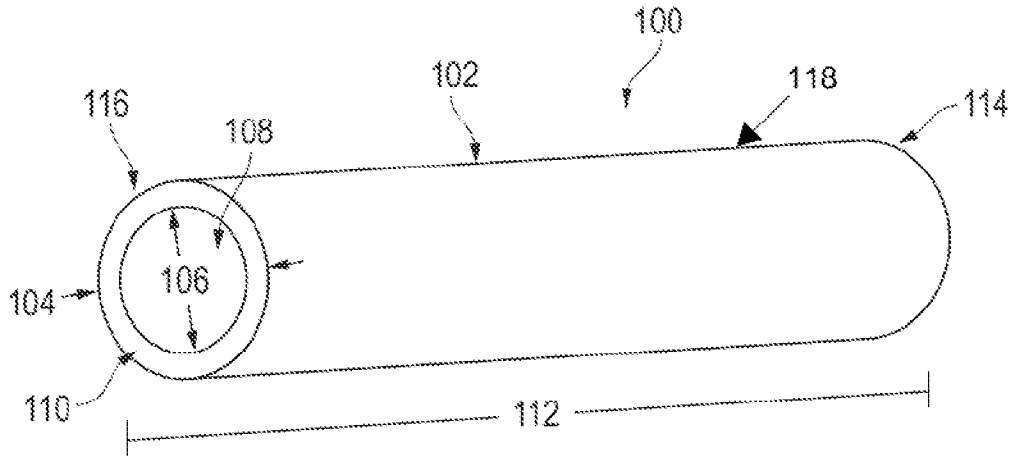


FIGURE 1

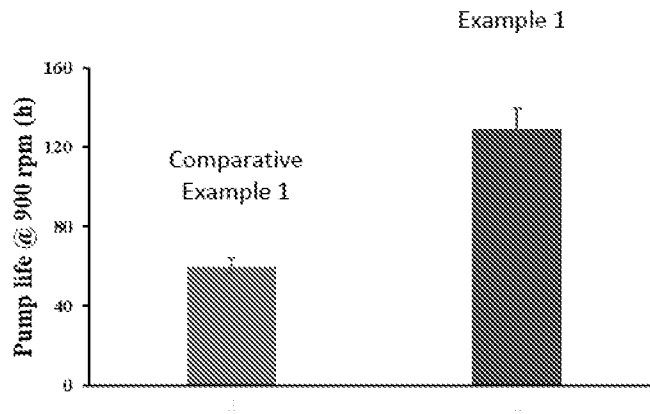


FIGURE 2

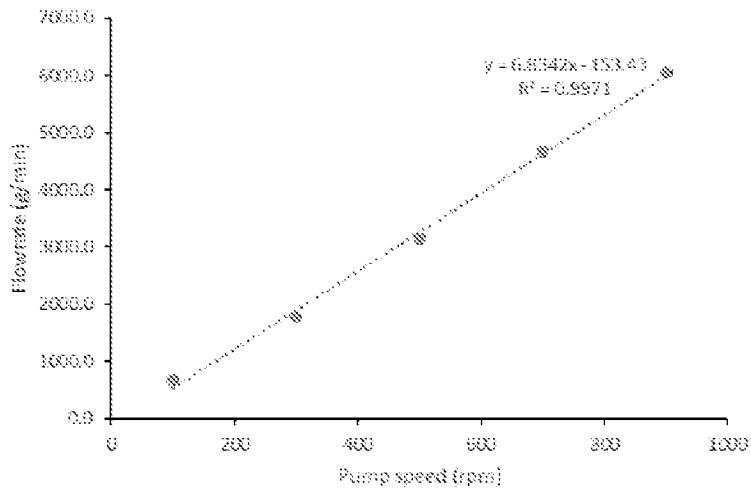


FIGURE 3

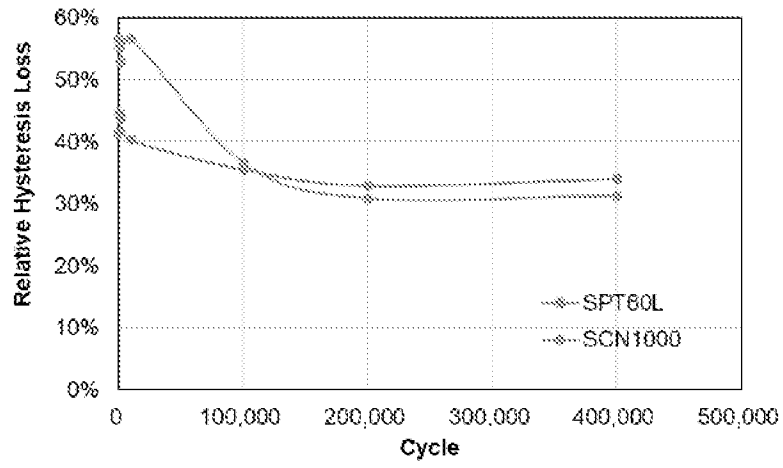


FIGURE 4

4/4

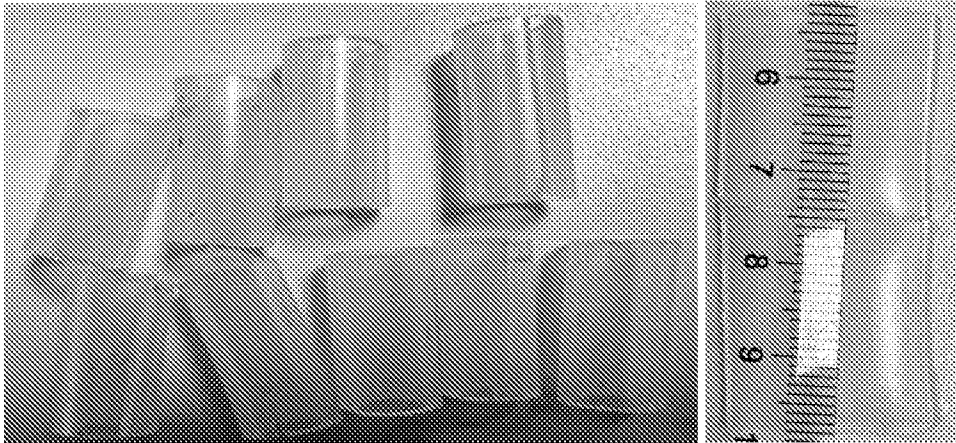


FIGURE 5A

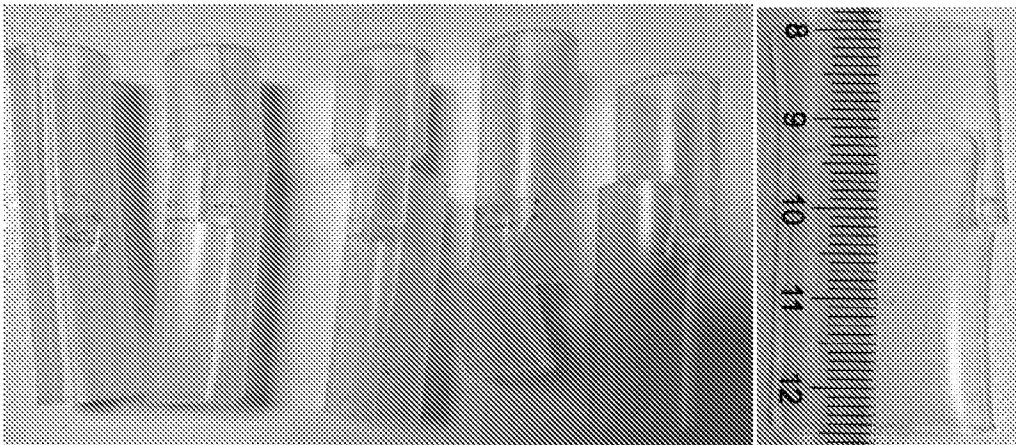


FIGURE 5B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/084461

A. CLASSIFICATION OF SUBJECT MATTER		
F16L9/12(2006.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC:F16L9/+		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
CNTXT,DWPI,ENTXT,ENTXTC,VEN,WPABSC:peristaltic,pump,tube,silicone,composition,accelerator,curing,agent,catalyst,elastomer,hore,speed		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2015252918 A1 (SAINT-GOBAIN PERFORMANCE PLASTICS CORP) 10 September 2015 (2015-09-10) paragraphs [0013]-[0042], figure 1	1-20
A	US 2008293878 A1 (WACKER CHEMIE AG) 27 November 2008 (2008-11-27) the whole document	1-20
A	US 2018080585 A1 (CONTITECH MGW GMBH) 22 March 2018 (2018-03-22) the whole document	1-20
A	US 2020346426 A1 (SAINT-GOBAIN PERFORMANCE PLASTICS CORP) 05 November 2020 (2020-11-05) the whole document	1-20
A	US 2021094253 A1 (SAINT-GOBAIN PERFORMANCE PLASTICS CORP) 01 April 2021 (2021-04-01) the whole document	1-20
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
08 May 2024		23 May 2024
Name and mailing address of the ISA/CN		Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		LI,FuChang Telephone No. (+86) 010-62085524

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2024/084461

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