Abstract

Self-lubricating fastener devices with interlocking rails or interlocking members of a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer are provided. Methods for production of self-lubricating fastener devices and their use in liquid-resistant or liquid-proof articles are also provided. A particular advantage is the ability of the devices to repeatedly reestablish a self-lubricated surface, even after solvent cleaning.

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Related U.S. Application Data

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FIG. 1

THIS SIDE FIXED

DIRECTION PARALLEL TO RAIL

50lbs of force applied in this direction Rh side only over entire 1 x .566 surface
Figure 7: Sliding Pull Force (zipping) at Room Temperature.
SELF-LUBRICATING FASTENERS

CROSS REFERENCE TO RELATED APPLICATION
[0001] This application claims priority to provisional application U.S. Ser. No. 60/974,977, filed Sep. 25, 2007.

BACKGROUND OF THE INVENTION
[0002] The invention relates to interlocking rails or teeth comprised of a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer. The self-lubricating interlocking rails or teeth are used in self-lubricating fastener devices, and in particular waterproof, fastener devices for garments.
[0003] A particular advantage is the elimination of the need to apply a lubricant to the rail at frequent intervals during its lifetime. Some currently commercial devices require lubrication after every ten cycles of the closure. This is inconvenient, time consuming, and can result in contamination of materials in proximity of the device.
[0004] Various sliding clasp fasteners with lubricants have been disclosed. For example, a traditional coil type zipper (coupling elements) and a slider adapted to close the coils have been disclosed.
[0005] In one embodiment, the coils of the fastener are indented in the surface and mechanically roughened during extrusion or after. A lubricant is dissolved in an appropriate solvent and coated onto the coils. The indented surface is suggested to enhance this coating process.
[0006] In another embodiment, a slide fastener is made from a pair of carrier tapes and coupling elements. The coupling elements are either a spiral or continuous coil formed from a filament. A separate cord of an absorbent material soaked in lubricant is positioned adjacent to the coupling elements to reduce friction upon coupling. However, re-application of such lubricants is typically required.
[0007] A slide fastener has also been disclosed with polymer interlocking members injection molded directly onto a zipper tape. To aid in the removal of the polymer interlocking members from the die, an organic mold release agent such as siloxane is added into the polymer extrusion. A decrease in pull force of the zipper with the siloxane present is disclosed. The interlocking members may be rail protrusions, teeth, or lock and key mechanisms.
[0008] Reclosable household storage bags with sliding fastener closures have also been disclosed. For instance in one such bag, the writing surface is created on the household storage bag via a surface roughening or anti-slip agent. A slip agent is then added to the opposing surface of bag in selected areas, to overcome the anti-slip agent in the opposing surface.

SUMMARY OF THE INVENTION
[0009] An aspect of the present invention relates to an interlocking rail for self-lubricating fastener devices. The rail comprises a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.
[0010] Another aspect of the present invention relates to interlocking members for self-lubricating fastener devices. The interlocking members comprise a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer, or alternatively dispersed throughout a region or portion of the polymer.
[0011] Another aspect of the present invention relates to a self-lubricating fastener device comprising at least two interlocking rails wherein at least one of the interlocking rails comprises a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.
[0012] Another aspect of the present invention relates to a self-lubricating fastener device comprising two interlocking rails wherein one of the interlocking rails comprises a polymer and a roughening agent of a slip system additive dispersed throughout the polymer and the other interlocking rail comprises a polymer and a lubricant of the slip system additive dispersed throughout the polymer.
[0013] Another aspect of the present invention relates to a self-lubricating fastener device comprising a plurality of interlocking members, said interlocking members comprising a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.
[0014] Another aspect of the present invention relates to articles such as garments comprising one or more of these self-lubricating fastener devices.
[0015] Yet another aspect of the present invention relates to methods for production of interlocking rails or interlocking members and self-lubricating fastener devices.
[0016] Yet another aspect of the present invention relates to an interlocking rail fastener device that combines high strength and high flexibility.

BRIEF DESCRIPTION OF THE DRAWINGS
[0017] FIG. 1 is a diagram of an exemplary fastener device with self-lubricating interlocking rails of the present invention.
[0018] FIG. 2 is a side view of a different exemplary design of an interlocking rail of the present invention.
[0019] FIG. 3 is a cross-sectional side view of an interlocking rail portion with a rotation preventer.
[0020] FIG. 4 is a graph of strength v. flexibility.
[0021] FIG. 5 is a depiction of rotation preventers.
[0022] FIGS. 6A and 6B is a comparison of the prior art to the present invention.
[0023] FIG. 7 is a comparison of pull force values.

DETAILED DESCRIPTION OF THE INVENTION
[0024] The present invention provides interlocking rails and interlocking members for use in self-lubricating fastener devices.
[0025] By “article” as used herein is meant to include garments, footwear, hardwear, bags, protective garments, enclosures such as chemical and biological protective shelters, and the like.
[0026] By “self-lubricating” as used herein it is meant that separate application and/or re-application of a lubricant to the fastener device to reduce friction of the fastener device is not required.
[0027] By “waterproof” as used herein it is meant any article capable of withstanding a hydrostatic pressure of at least 1.0 psi for a period of at least 1.0 minutes.
[0028] By “liquid-proof” as used herein it is meant any article that will not leak or weep liquid when challenged with a test fluid at a pressure of at least 0.07 bar for a duration of at least 3 minutes. The test fluid is at a minimum water, and ideally can be a range of liquid chemicals.
[0029] By “rotation preventer” as used herein it is meant any means by which the interlocking portions of the rails are
prevented from rotational movements relative to each other (upon external force applied relative to the interlocking surfaces) when the fastener is engaged in a “closed” or “locked” configuration. The rotation preventer keeps the interlocking interface from rotating without adding excessive stiffness to the fastener. For example, FIGS. 1 and 4 depict examples of rotation preventers including, but not limited to, means for preventing rotation, such as protrusions, knobs, thickened areas and other modifications relative to the fastener which prevent rotation.

[0030] An exemplary fastener device with interlocking rails is depicted in FIG. 1.

[0031] As shown in FIG. 1, the fastener device 1 comprises a first rail 2 and a second rail 3 which are fitted to each other via interlocking design by a metal or plastic slider 7 and a stopper which connects the rails at one end. As also shown in FIG. 1, each rail comprises a tongue portion 4 and groove portion 5 for interlocking with the other rail and a flat portion 6 for attachment to an article to be closed with the device.

[0032] In one embodiment of the present invention, the self-lubricating fastener device comprises interlocking rails and one or both rails of the fastener device comprise a polymer and a slip system additive dispersed throughout the polymer. The slip system additive comprises a roughening agent which roughens a surface of the rail and a lubricant which lubricates a surface of the rail. Exemplary articles closed with such fastener devices include, but are not limited to, garments, footwear, bags, gloves, head coverings, protective gear, medical transport enclosures, tents, and storage bags. In an alternative embodiment, one of the rails comprises a polymer and a roughening agent of the slip system additive dispersed throughout the polymer while the other rail comprises a polymer and a lubricant of the slip system additive dispersed throughout the polymer.

[0033] In yet another embodiment, the self-lubricating fastener device comprises two sets of interlocking members and one or both sets of interlocking members of the fastener device comprise a polymer and a slip system additive dispersed throughout the polymer.

[0034] In an alternative embodiment, two sets of interlocking members are used to create a seal. One set of interlocking members comprises a polymer and a roughening agent of the slip system additive dispersed throughout the polymer while the other set of interlocking members comprises a polymer and a lubricant of the slip system additive dispersed throughout the polymer.

[0035] Exemplary polymers for use in these rails and interlocking members of the present invention include, but are not limited to, polyurethanes, thermoplastic polymers, silicones, thermoplastic elastomers or rubbers or the like, polyethylene, polyesters, polypropylenes, polyvinyl chlorides, fluoropolymers, and blends thereof.

[0036] The slip system additive dispersed throughout the polymer comprises a roughening agent which roughens a surface of the rail or interlocking members and a lubricant which lubricates a surface of the rail or interlocking members. In one embodiment, the slip system additive comprises at least one roughening agent with at least one lubricant.

[0037] The roughening agent of the slip system additive roughens the surface of the rail or interlocking members to increase roughness and reduce the contact points between the surfaces allowing the surface to move past each other with less friction, preferably without changing the bulk properties of the polymer. Exemplary roughening agents useful in the slip system additive comprise inorganic materials including, but not limited to silica, aluminums, silicates, diatomaceous earth, or talc. It is to be further understood that roughening agents may be chosen from inorganic or organic materials for the applications taught herein. [0038] The lubricant of the slip system additive reduces friction during closing and opening of a fastener device comprising the rails or sets of interlocking members. Lubricants useful in the present invention are dissolvable in either a polar or non-polar solvent such as alcohol, preferably ethanol, isopropyl alcohol, hexane, methylene chloride, or methyl ethyl ketone, or acetone. Such lubricants tend to appear or reappear at the surface of the polymer and reduce surface friction. Further, preferred lubricants for use in the present invention do not interfere with adherence of the fastener device with a hot melt adhesive. Exemplary lubricants useful in the slip system additive include, but are not limited to, oleamides, stearamides, ethylene bis-oleamides, ethylene bis-stearamides, siloxanes, fluorinated polymers and erucamides, stearyl alcohol, steaeric acid, stearates, and metal salts of stearic acid such as magnesium and calcium, silicones, polytetrafluoroethylene, and the like.

[0039] The slip system additive is dispersed in the polymer at a rate of 0.1 to 20 weight percentage, more preferably at a rate of 2 to 5 weight percentage.

[0040] By “dispersed throughout the polymer” as used herein it is meant that the slip additive agent or a component of the slip additive agent is diffused evenly or unevenly throughout the polymer so that at least a portion of the produced rail or interlocking members contain both polymer and the slip additive agent or a component thereof. Dispersion of the slip additive agent throughout the polymer eliminates the need to coat the polymer and/or re-apply lubricant to the fastener device after use. It is preferred that the slip additive agent is not simply a topical coating or application as those used for mold release. Conventionally, it is an unwanted effect to have such slip additive present in or on final products as they may contribute undesirable qualities.

[0041] In one embodiment, the slip system additive is evenly distributed throughout the polymer and the resulting interlocking rails or interlocking members. For this embodiment, the interlocking rails or interlocking members may be produced by blending of the polymer and slip system additive prior to or during extrusion of the polymer.

[0042] Alternatively, the slip system additive may be dispersed throughout a portion of the polymer and the resulting interlocking rails or interlocking members. For example, a blend of polymer and slip system additive can be co-extruded with polymer without slip system additive so that, for example, the tongue and groove portion of an interlocking rail comprises polymer and slip system additive while the flat tape portion of the interlocking rail comprises polymer without slip system additive.

[0043] In these embodiments, both the lubricant and the roughening agent are included in the portion of the polymer containing the slip system additive.

[0044] In an alternative embodiment of the present invention, the self-lubricating fastener device comprises a first interlocking rail or first set of interlocking members comprising a polymer and the roughening agent of the slip system additive dispersed throughout the polymer of the first rail or first set of interlocking members and a second interlocking rail or second set of interlocking members comprising a poly-
mer and a lubricant of the slip system additive dispersed throughout the polymer of the second rail or second set of interlocking members.

[0045] Also provided in the present invention are methods for production of self-lubricating fastener devices.

[0046] In one embodiment, the method comprises combining or blending a polymer with a slip system additive. The resulting combination or blend is then extruded, injection molded, RTV, spin cast, SLA, SLS, three-dimensional print, CNC or any other suited method for molding the interlocking pieces into interlocking rails or interlocking members of polymer with slip system additive dispersed throughout. These interlocking pieces are then assembled into a self-lubricating fastener device.

[0047] In another embodiment, the method comprises combining or blending a polymer with a slip system additive. The resulting combination or blend is then extruded along with a polymer into interlocking rails or interlocking members, a portion of which comprises polymer with slip system additive dispersed throughout. These interlocking pieces are then assembled into a self-lubricating fastener device.

[0048] In another embodiment, the method comprises combining or blending a polymer with a roughening agent of a slip system additive. The resulting combination or blend is then extruded into a first interlocking rail or first set of interlocking members comprising polymer with roughening agent dispersed throughout. A polymer is also combined or blended with a lubricant of a slip system additive and the resulting combination or blend is extruded into a second interlocking rail or second set of interlocking members comprising polymer with lubricant dispersed throughout. These first and second rails or first and second sets of interlocking members are then assembled into a self-lubricating fastener device.

[0049] The self-lubricating fastener devices of the present invention are liquid-resistant, more preferably liquid-proof. Further, these self-lubricating fastener devices of the present invention exhibit improved strength as well as increased strength to mass ratio, making them stronger and lighter at the same time, as well as increased flexibility, as compared to waterproof fastener samples prepared using a commercially available thermoplastic polyurethane (Bayer Texin 990R) and common profile extrusion process. In order to provide a device that provides high strength and flexibility, it is necessary to provide means to prevent rotation of the interlocking elements relative to themselves during cross-wise tensile loading. In one embodiment, geometrical features are altered to prevent such rotation.

[0050] FIG. 2 shows an aspect of the fastener device 1 which comprises a first rail 2 and a second rail 3 which are able to be fitted to each other via interlocking design by a slider device used to connect or separate the interlocking surfaces. As also shown in FIG. 2, each rail comprises a tongue portion 4 and groove portion 5 for interlocking with the other rail and a flat portion 6 for attachment to an article to be closed with the device. The rotation preventer 30 is also shown as protrusions or thickened areas which resist movement of the tongue portions relative to the groove portions during stress force applications. FIG. 3 shows a fastener device 1 which comprises a first rail 2 and a second rail 3 which are fitted to each other via interlocking design to connect the rails. The rotation preventer 30 is also shown as protrusions or thickened areas which resist movement of the tongue portions relative to the groove portions during stress force applications.

[0052] The necessity for this rotation preventer is depicted in FIGS. 4 and 5. FIG. 5 shows four images numbered 5A through 5D. FIG. 5A depicts a cross-section of a rail at the beginning of a cross-pull test. FIG. 5B is the same depiction, but with overlaid lines A and B. Line A represents the general shape of a portion of the interlock. Line B represents the orientation of another area of the interlock. FIG. 5C is a depiction of a rail cross-section just prior to rail separation. FIG. 5D is the same depiction as FIG. 5C, but with lines A and B again added. Note that line A is considerably straighter in FIG. 5D than it is in FIG. 5B. Also note that line B has an orientation in FIG. 5D that is nearly perpendicular to its orientation in FIG. 5B. For both lines A and B, the changes in shape and orientation are caused by a rotation of certain areas of the interlock. If structural elements can be added that prevent this rotation without an undue loss of in-plane flexural flexibility, the cross-pull strength of the device can be increased while retaining satisfactory flexural flexibility. Alternatively, these elements can be added, and the entire cross-section can be scaled down, so as to create a device with similar strength but improved flexural flexibility.

[0053] FIG. 6A shows a prior art rail profile. FIG. 6B shows the improved rail design of the present invention illustrating that reduction of tooth rotation is accomplished by elimination of unnecessary undercut sizing 100 on reduction of the overhang 200 of the undercut on the tongue portion in conjunction with an increased reinforced area 300. This allows prevention of head rotation relative to the neck portion of the tongue.

[0054] For example, a self-lubricating fastener device of the present invention comprising interlocking rails is able to withstand up to 50 pounds of force applied in the direction depicted in FIG. 1 as measured per ASTM D2061-07. This is known as cross-pull strength measurement. Flexibility, as assessed via a three-point bending method, was also increased. For this assessment, a TA Instruments RSA3 Dynamic Mechanical Analyzer ( DMA) with standard 25 mm span three-point bending fixture was used. Samples were tested as paired rails with a preload of 1.0 g, a max deflection of 1.0 mm and a rate of 0.25 mm/s. The slope of the load-deflection curve between 0.3 and 1.0 mm was used to calculate flexibility. The flexibility is defined as the inverse of the product of the elastic modulus (E) and the second moment of inertia (I), designated (EI)^-1. For three-point bending, (EI)^-1=48y/PL3, where y-deflection, P-load, and L=span=25 mm.

[0055] An interlocking rail of the present application comprises a polymer and a slip system additive dispersed throughout the polymer. The rail has been found to have favorable strength to mass ratios of greater than 2.99 Nm/g. Further, the mass per unit length of the rail has been found to be less than 80 grams per meter as exemplified in the examples.

[0056] Surface roughness was performed using a Zygo New View 5032 optical profilometer, with a 10x objective. Samples were mounted onto a glass slide using carbon tape and placed on a leveled stage for roughness analysis. Three 1.0 mm scans per sample were measured. All data is recorded in microns. The data is fitted to a straight baseline and unfiltered. The reported data is for the direction parallel to the interlocking rail. The average roughness (Ra) reported is the average distance between the surface and the meanline looking at all of the points along the profile. It has been found possible to achieve surface roughness parallel to the rail of greater than 0.3 micrometers Ra.
Thus, the self-lubricating fastener devices of the present invention are particularly useful in production of water-resistant or waterproof articles requiring fastener devices such as garments and bags. The self-lubricating fastener devices of the present invention are useful in joining gloves and socks to chemical and/or biological protective gear as well as in liquid-resistant or liquid-proof garments.

The following non-limiting examples are provided to further illustrate the present invention.

**EXAMPLES**

**Example 1**

**Comparative Waterproof Fastener**

A waterproof fastener sample (CH1351-37-15) was prepared using commercially available thermoplastic polyurethane (Bayer Texin 990R) and common profile extrusion processes. The profile of the resulting rail consisted of a tail section for garment attachment, a transition section, and a twin-mushroom style interlock section (see FIG. 2). The opposing rail sections were identical. Following extrusion, the rails were sprayed with a lubricant by 303 Aerospace Lubricant made by 303 Products Palo Cedro, Calif. then assembled together, and tested. The mass per unit length of the sample was 52 grams/meter. The mean cross-pull strength was 89 Newtons (N). The flexural flexibility was 1421 Newtons/meter (N/m). The strength-mass ratio was 1.70 (Newtonsmeters)/gram or (N/m). The strength-flexibility product was 126943 m. The average surface roughness (Ra) in the extruded direction was 0.24 μm.

**Example 2**

**Comparative Waterproof Fastener**

A waterproof fastener sample (CH1351-37-16) was prepared similarly to that of Comparative Example #1, except that the extrusion speed was adjusted so that the mass per unit length of this sample was 68 grams/meter. The mean cross-pull strength was 100 N. The flexural flexibility was 1388 N·m. The strength-mass ratio was 1.46 Nm/m. The strength-flexibility product was 138337 m². The average surface roughness (Ra) in the extruded direction was 0.28 μm.

**Example 3**

**Waterproof Fastener**

A waterproof fastener sample (CH1351-37-1) was prepared from Estane 58219 resin (available from Lubrizol, Wickliffe, Ohio) blended with Estane Slip System X-4036 using common profile extrusion processes as described in Comparative Example 1. Like Comparative Example 1, the rail profile consisted of a tail section for garment attachment and a transition section. However, the rail comprised a twin-wave style interlock section (see FIG. 3). No additional lubricant was applied to the sample following extrusion. The mass per unit length of the sample was 71 grams/meter. The mean cross-pull strength was 212 N. The flexural flexibility was 1186 N·m. The strength-mass ratio was 2.99 Nm/g. The strength-flexibility product was 251000 m². The average surface roughness (Ra) in the extruded direction was 0.40 μm.

**Example 4**

**Waterproof Fastener**

A waterproof fastener sample (CH1351-37-2) was prepared similarly to that in Example 1, except that the extrusion speed was adjusted so that the mass per unit length of the sample was 47 g/m. The mean cross-pull strength was 143 N. The flexural flexibility was 1800 N·m². The strength-mass ratio was 3.03 Nm/g. The strength-flexibility product was 260000 m². The average surface roughness (Ra) in the extruded direction was 0.40 μm.

**Example 5**

**Waterproof Fastener**

A waterproof fastener sample (CH1351-37-3) was prepared similarly to that in Example 1, except that the extrusion speed was adjusted so that the mass per unit length of the sample was 34 g/m. The mean cross-pull strength was 103 N. The flexural flexibility was 4347 N·m². The strength-mass ratio was 3.01 Nm/g. The strength-flexibility product was 446000 m². The average surface roughness (Ra) in the extruded direction was 0.75 μm.

**Example 6**

**Waterproof Fastener**

A waterproof fastener sample (CH1351-37-5) was prepared similarly to that in Example 1, except that the extrusion speed was adjusted so that the mass per unit length of the sample was 18 g/m. The mean cross-pull strength was 77 N. The flexural flexibility was 8245 N·m². The strength-mass ratio was 4.21 Nm/g. The strength-flexibility product was 638000 m². The average surface roughness (Ra) in the extruded direction was 0.59 μm.

**Example 7**

**Waterproof Fastener**

A sample ZIPLOC® “Big Bags” fastener was evaluated for strength and flexibility. The samples were reassembled so as to be suitable for cross-pull testing. The mean cross-pull strength was 87 N. The flexural flexibility was 3120 N·m². The strength-flexibility product was 271000 m². The sample had a glossy appearance, indicating a very low surface roughness.

**Example 8**

**Waterproof Fastener**

A sample YKK rail fastener (Part No. 5PWH) was evaluated for strength and flexibility. The samples were reassembled so as to be suitable for cross-pull testing. The mean cross-pull strength was 252 N. The flexural flexibility was 515 N·m². The strength-flexibility product was 129780 m². The sample had a glossy appearance, indicating a very low surface roughness.

**Example 9**

The relative strength and flexibility of these Examples 1-8 are depicted in FIG. 4. It can be seen that the invention provides an improvement in combined strength and flexibility represented by the area to the right of the solid line. It is to be noted that gross calculations reported in Examples
1-8 were based upon measured values prior to rounding to the reported nearest whole number.

Example 9
Test Method

[0068] Coefficient of Friction Measurement:

[0069] Coefficient of friction measurements (COF) were made using test method ASTM D1894-06 with a sled speed of 90 inches per minute and a sled load of 600 gram. The sled base measured 2.5 inches by 2.5 inches. The coefficient of friction was measured ten times per test specimen and the averages reported in the result table.

[0070] Coefficient of Friction Measurements after Abrasion:

[0071] Coefficient of friction after abrasion is an important indicator of the longevity of the effect of added lubricants to

a polymer extrusion. Thus, the flat samples prepared for the coefficient of friction measurements were also subjected to Martindale Abrasion Testing using a modified ASTM D4966-98 test method. The modification involved using "0" Emery Cloth as the abrading and doing 100 cycles (1600 movements) with a 12 kPaA load. After each test specimen was abraded according to this protocol, the coefficient of friction was again measured using the COF test method. The after abrasion test results are also shown in the results table.

Example 10
Lubricant Effect

[0072] The effect of lubricant on the coefficient to friction (COF) of flat test specimens the polyurethane material used to make up the rails was determined experimentally. Flat sheet extrusions of a mixture of Estane 58219 and Estane X4036 polyurethane were prepared using standard extrusion conditions as recommended by the resin manufacturer. This master-batch composition was the basis for all subsequent experiments with various lubricant types and levels added. These samples also served as the non-lubricated baseline.

[0073] To determine the effect of both (1) an erucamide blend lubricant (ECM Plastics, Inc., Worcester, Mass., part No. CPU310), and (2) with PTFE micropowder, additional batches of Estane 58219/Estane X4036 were compounded but this time with the lubricant included. These compounded, lubricant-containing batches were then extruded into flat sheets using similar conditions as those used for the non-lubricated control samples.

[0074] Different concentrations of the erucamide blend lubricant and of the PTFE micropowder were evaluated. The initial test specimens were prepared using 0%, 3%, and 6% by weight of erucamide blend lubricant in the base polyurethane polymer. After these data were determined, new set of polyurethane extrusions were prepared with the same levels of lubricant but with the addition of 0%, 3%, and 6% PTFE micropowder (available from Shamrock as T-815 PTFE micropowder) added into the compounded mix used to produce the polymer extrusion.

TABLE 1

<table>
<thead>
<tr>
<th>Coefficient of Friction Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTFE Percentage</td>
</tr>
<tr>
<td>0% weight</td>
</tr>
<tr>
<td>No Abrasion</td>
</tr>
<tr>
<td>Sample A:</td>
</tr>
<tr>
<td>0% weight CPU310 lubricant</td>
</tr>
<tr>
<td>Sample B:</td>
</tr>
<tr>
<td>0% weight CPU310 lubricant</td>
</tr>
<tr>
<td>Sample C:</td>
</tr>
<tr>
<td>6% weight CPU310 lubricant</td>
</tr>
</tbody>
</table>

[0075] Based on Table 1 above, several lubrication conclusions can be reached. The addition of the lubricant lowers the COF of the initial samples with no abrasion. However after abrasion, the COF increases. This increase of COF after abrasion suggests that the lubricant effectiveness is decreasing. In contrast, when the PTFE micropowder is additionally added to a lubricated sample, the COF after abrasion does not increase.

Example 11

[0076] The effect on rail zipper pull force was determined based on Sample B in Table 1. The zipper pull force was measured using a modified ASTM D1876, where the pull rate was 12 inches per second over a range of 14 inches. The average of the pull force readings was reported. Rails with the same composition as Sample B with no PTFE micropowder were compared to rails with the same composition as Sample B with 3% PTFE micropowder added. In order to normalize these data, the results reported are the ratio of pull force for each pull divided by the initial pull force. These results are shown in Fig. 7.

[0077] These results show that without the PTFE micropowder, the pull force increases with the number of test cycle pulls until it plateaus off at about 200 cycles until the
end of the test at 300 cycles. The plateau value shows the pull force in the absence of the PTFE micropowder has more than doubled by about 200 cycles. In contrast, the pull force with the PTFE micropowder present increases slightly up to about 50 cycles and then levels off to about 200 cycles, after which, the pull force begins to decrease. By the end of this 300 cycle test, the final pull force with the PTFE micropowder is essentially the same as the initial pull force.

What is claimed is:

1. A self-lubricating fastener device comprising a polymer and a slip system additive dispersed throughout said polymer.
2. The self-lubricating fastener device of claim 1 comprising an interlocking rail produced from the polymer and slip system additive.
3. The self-lubricating fastener device of claim 1 comprising two interlocking rails produced from the polymer and slip system additive.
4. The self-lubricating fastener device of claim 1 comprising an interlocking set of interlocking members produced from the polymer and slip system additive.
5. The self-lubricating fastener device of claim 1 comprising two interlocking sets of interlocking members produced from the polymer and slip system additive.
6. The self-lubricating fastener device of claim 1 wherein the polymer comprises a polyurethane.
7. The self-lubricating fastener device of claim 1 wherein the slip system additive comprises a roughening agent which roughens at least one surface of the polymer and a lubricant which lubricates at least one surface of the polymer.
8. The self-lubricating fastener device of claim 1 wherein the polymer comprises a thermoplastic polymer with a glass transition temperature (Tg) of at least −49 degrees Fahrenheit.
9. The self-lubricating fastener device of claim 7 wherein the roughening agent is an inorganic material.
10. The self-lubricating fastener device of claim 7 wherein the lubricant is dissolvable in solvent.
11. The self-lubricating fastener device of claim 10 wherein the solvent is an alcohol or acetone.
12. The self-lubricating fastener device of claim 7 wherein the lubricant does not interfere with adherence of the fastener device with a hot melt adhesive.
13. The self-lubricating fastener device of claim 1 wherein the slip system additive is dispersed throughout the polymer at a percentage of 0.1 to 10 percent by weight.
14. The self-lubricating fastener device of claim 1 wherein the slip system additive is dispersed throughout the polymer at a percentage of 10 to 20 percent by weight.
15. The self-lubricating fastener device of claim 1 wherein the slip system additive is blended with the resin at a percentage of 2 to 5 percent by weight.
16. The self-lubricating fastener device of claim 1 wherein the slip system additive is evenly distributed throughout the polymer of the fastener device.
17. The self-lubricating fastener device of claim 1 wherein the slip system additive is unevenly distributed throughout the polymer of the fastener device.
18. The fastener device of claim 1 wherein the polymer and slip system additive are extruded into an interlocking rail or a set of interlocking members of the fastener device.
19. The fastener device of claim 1 which is liquid-resistant.
20. The fastener device of claim 1 which is liquid-proof.
21. An article comprising the fastener device of claim 1 wherein the article is a garment.
22. An interlocking rail for a fastener device, said rail comprising a polymer and a slip system additive dispersed throughout the polymer.
23. An interlocking rail for a fastener device comprising a surface, said surface having a surface roughness parallel to the rail of greater than 0.3 micrometers Ra.
24. An interlocking rail for a fastener device comprising a surface, said surface having a surface roughness parallel to the rail of greater than 0.5 micrometers Ra.
25. The interlocking rail of claim 22 wherein the polymer comprises a polyurethane.
26. The interlocking rail of claim 22 comprising a surface having a surface roughness in the direction parallel to the rail of greater than 0.3 micrometers Ra.
27. The interlocking rail of claim 22 comprising a surface having a surface roughness in the direction parallel to the rail of greater than 0.5 micrometers Ra.
28. The interlocking rail of claim 22 wherein the slip system additive comprises a roughening agent which roughens a surface of the rail and a lubricant which lubricates a surface of the rail.
29. The interlocking rail of claim 28 wherein the roughening agent is an inorganic material.
30. The interlocking rail of claim 1 wherein the device further comprises a rotation preventer.
31. The interlocking rail of claim 30 wherein the solvent is an alcohol or acetone.
32. The interlocking rail of claim 30 wherein the lubricant does not interfere with adherence of the interlocking rail with a hot melt adhesive.
33. The interlocking rail of claim 22 wherein the slip system additive is dispersed in the polymer at a percentage of 0.1 to 10 percent by weight.
34. The interlocking rail of claim 22 wherein the slip system additive is dispersed in the polymer at a percentage of 2 to 5 percent by weight.
35. The interlocking rail of claim 22 wherein the slip system additive is evenly distributed throughout the polymer of the interlocking rail.
36. The interlocking rail of claim 22 wherein the slip system additive is unevenly distributed throughout the polymer of the interlocking rail.
37. The interlocking rail of claim 22 produced by an extrusion process.
38. The interlocking rail of claim 37 wherein the polymer and slip system additive are coextruded with polymer without slip system additive so that a tongue and groove portion of the interlocking rail comprises polymer and slip system additive and a flat tape portion of the interlocking rail comprises polymer without slip system additive.
39. The interlocking rail of claim 22 having a paired flexibility greater than 1400 N·m⁻² and wherein the cross-pull strength in Newtons is greater than 120 minus (0.00814 times the flexibility) (as determined by ASTM D2061-07).
40. The interlocking rail of claim 22 having a paired flexibility less than 1400 N·m⁻² and wherein the cross-pull strength in Newtons is greater than 423 minus 0.216 multiplied by the flexibility as determined by ASTM D2061-07.
41. The interlocking rail of claim 22 comprising at least one feature that prevents rotation of the interlocking elements.
42. A self-lubricating fastener device comprising at least two rails wherein one rail comprises a polymer and a slip system additive dispersed throughout said polymer.
43. A self-lubricating fastener device comprising at least two rails wherein one rail comprises a polymer and a roughening agent dispersed throughout said polymer.

44. A fastener device comprising:
(a) a first interlocking rail with a tongue portion, a groove portion and a tape portion; and
(b) a second interlocking rail with a tongue portion, a groove portion and a tape portion;
wherein the tongue portion of the first interlocking rail interlocks with the groove portion of the second interlocking rail and the tongue portion of the second interlocking rail interlocks with the groove portion of the first interlocking rail; and
wherein at least one of the tongue portions and groove portions of one of the interlocking rails comprises a polymer and a slip system additive dispersed throughout the polymer.

45. A method of forming a self-lubricating fastener comprising the steps of:
(a) combining or blending a polymer with a slip system additive;
(b) extruding the resulting combination or blend into interlocking rails or interlocking members of polymer with slip system additive dispersed throughout; and
(c) assembling the interlocking rails or interlocking members into a self-lubricating fastener.

46. A method of forming a self-lubricating fastener comprising the steps of:
(a) combining or blending a polymer with a slip system additive;
(b) extruding the resulting combination or blend into interlocking rails or interlocking members; and
(c) assembling the interlocking rails or interlocking members into a self-lubricating fastener.

47. A method of forming a self-lubricating fastener comprising the steps of:
(a) combining or blending a polymer with a roughening agent of a slip system additive;
(b) extruding the resulting combination or blend of step (a) into a first interlocking rail or first set of interlocking members comprising polymer with roughening agent dispersed throughout;
(c) combining or blending a polymer with a lubricant of a slip system additive;
(d) extruding the resulting combination or blend of step (c) into a second interlocking rail or second set of interlocking members comprising polymer with lubricant dispersed throughout; and
(e) assembling the first and second rails or first and second sets of interlocking members into a self-lubricating fastener.

48. A device comprising any of the structural features described herein and shown in the drawings forming part of the invention disclosure.

49. An interlocking rail for a fastener device, said rail comprising a polymer and a slip system additive dispersed throughout the polymer and having a strength to mass ratio of greater than 2.99 Nm/g.

50. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 80 grams per meter.

51. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 40 grams per meter.

52. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 20 grams per meter.

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