

Description**Field of the invention**

- 5 This invention relates to a method of forming an improved hydrophilic coating on a non-reactive hydrophilic polymer surface layer by applying an osmolality increasing compound to said non-reactive polymer surface layer to produce a more stable hydrophilic surface as well as medical articles being coated with said improved hydrophilic coating.

Background of the invention

- A hydrophilic coating having a much lower coefficient of friction in wet condition than in dry condition. Thus, the formation of hydrophilic coating on substrates has many applications but in particular is most desirable in many biomedical applications. For example, biomedical applications such as wound drains, catheters, surgical tools and other medical instruments intended to be entered in the body cavities, because the instrument gives a good hand grip in dry condition while simultaneously becoming very slippery when it gets in contact with water-based liquids, and thus can be inserted easily without causing trouble to the patient. Further, an article having a hydrophilic surface coating is desirable to minimize thrombosis, crystal formation, tissue trauma, tissue adhesion to medical instruments, and foreign body reactions. In prior art methods, surfaces have been rendered hydrophilic by such methods as high energy radiation in situ polymerization processes, by grafting, by forming interpolymer network or by direct chemical bonding, for instances by isocyanates or silanes. Such hydrophilic polymer surfaces for medical use are described for instance in GB-A-1 600 963, US-A-4 373 009, US-A-4 459 317, WO-A-83/03977 and EP-A-0 093 093. EP-A-93 093 discloses that such a hydrophilic surface may be treated with iodine to be antibacterial. US-A-3 895 169 discloses treatment of an acidic hydrophilic polymer surface with a base sodium bicarbonate to create a neutralised surface. Extensive studies indicate, however, that the hydrophilic coating can be dried out, thus rendering the article insufficiently hydrophilic.

Description of the invention

- 30 The object of the present invention is to prepare an improved hydrophilic coating on an already hydrophilic polymer surface layer on a substrate. This object of the invention has surprisingly been achieved by applying a solution of an osmolality increasing compound to a non-reactive hydrophilic polymer surface layer and then evaporating the solvent of the solution.

- 35 While experimenting with hydrophilic polymer coatings on various substrates the applicant found that when an article coated with a hydrophilic polymer surface layer is dipped in water it will be well wetted but there is a great risk that the polymer surface lose its water when it comes in contact with e.g. a mucous membrane. This depends on the difference in the osmotic potential between the hydrophilic surface and the mucous membrane. The mucous membrane has a higher osmotic potential that is a higher salt concentration than the hydrophilic surface, which results in that the water goes from the hydrophilic surface layer to the mucous membrane so that the difference in the salt concentration will be counterbalanced.

- According to the invention it has surprisingly been found possible to further reduce the low friction of the hydrophilic surface and to enhance the osmolality of the hydrophilic surface simultaneously by applying a coating of an osmolality increasing compound to the hydrophilic polymer surface layer. Different types of osmolality increasing compounds can be used such as inorganic or organic salts, mono- or disaccharides or sugar alcohols. Examples of such osmolality increasing compounds are glucose, sorbitol, sodium chloride, sodium citrate, sodium benzoate, calcium chloride, potassium chloride, potassium iodide, potassium nitrate. This osmolality increasing compound must be non-toxic. The process has found to be especially useful for sodium chloride. The osmolality increasing compound may be mixed with a polymer and dissolved in water or a lower alcohol, preferably in water to a suitable viscosity. Said solution is applied to the hydrophilic polymer surface layer e.g. by dipping or spraying and then the solvent is evaporated by air drying or by drying at elevated temperature. The added polymer ought to be well compatible with the polymer in the polymer surface layer, preferably the same polymer. The polymer is not a necessary additive to the solution but it enhances the viscosity and by that the reception of the osmolality increasing compound can be controlled. Further, the polymer possesses a lubricating property and a controlled release effect.

The process according to the invention can be used for coating many different types of well-known hydrophilic polymer surfaces, wherein the hydrophilic polymer is selected from polyvinyl compounds, polysaccharides, polyurethanes, polyacrylates or copolymers of vinyl compounds and acrylates or anhy-

driles. Especially polyethyleneoxide, polyvinylpyrrolidone, heparin, dextran, xantan, polyvinyl alcohol, hydroxy propyl cellulose, methyl cellulose, copolymer of vinylpyrrolidone and hydroxy ethylmethyl acrylate or copolymer of polymethylvinyl ether and maleinic acid anhydride. The preferred hydrophilic polymer is polyvinyl pyrrolidone. The polymer surface layer must be made non-reactive for instance by curing.

The substrates may be any polymer material, which are well-known to use and to which the said hydrophilic polymers adhere, such as polyurethanes, latex rubbers, other rubbers, polyvinylchloride, other vinyl polymers, polyesters and polyacrylates.

The hydrophilic surface contains an appreciable amount of partly freely movable polymer chains. Thus it has been shown that some coating can complex-bind a substantial amount of elemental iodine, which is for example the case with free polyvinylpyrrolidone and iodine when a hydrophilic surface of polyvinylpyrrolidone is treated with a KI/I_2 solution. PVP-coated catheters treated with a KI/I_2 solution have a less slippery surface than corresponding untreated surface and such KI_3 -treated catheters dry more quickly.

The claimed invention is a method of forming an improved hydrophilic coating in order to retain the slipperiness for a longer time on a substrate characterized in

- (a) applying a non-reactive hydrophilic polymer surface layer to the substrate;
- (b) applying to the non-reactive hydrophilic surface polymer layer a solution comprising a solvent and above 2% (weight per volume) of an osmolality-increasing compound selected from the group consisting of mono and disaccharides, sugar alcohols, and non-toxic organic and inorganic salts, with the proviso that the osmolality-increasing compound is not a trihalogenide such as KI_3 (KI/I_2); and
- (c) evaporating the solvent, as well as medical articles obtained by said method.

Example.

A trimerized hexamethylene diisocyanate of biuret type (named Desmodur® L 2291; Bayer AG) was dissolved in methylene chloride to a concentration of 8% (weight/volume). A urinary PVC catheter was dipped in this solution during 30 seconds. The catheter was then dried at 70°C during 60 seconds, whereupon it was dipped during 5 seconds in a solution containing 33 g polyvinylpyrrolidone (K25; mean molecular weight 25 000) per 100 ml methylene chloride. This solution also contained 0.33 g triethylene diamine (DABCO®) per 100 ml solution. The catheter was then allowed to dry at ambient temperature during 60 seconds, then cured during 40 minutes at 70°C, cooled to ambient temperature and was then rinsed in water. Such a catheter was dipped in a solution containing 20% (weight/volume) sodium chloride and 5% polyvinylpyrrolidone (PVP) (weight/volume) dissolved in water during 1 hour at 20°C. The catheter was then allowed to dry at 70°C during eight hours. The catheter has a very slippery and adherent surface when wet.

Experimental test

A number of catheters according to the examples were dipped in different solutions comprising osmolality increasing compounds during 10 minutes and were then placed in water during 30 seconds at 23°C and a relative humidity of 49% and then dried at room temperature. The slipperiness was noticed 1 min., 2 min. etc. after already begun drying. The value of slipperiness was noticed in a relative scale, wherein 8 means a very slippery surface and 0 means a dry surface.

This experiment was repeated with a number of corresponding PVP-coated catheters but without the coating of osmolality increasing compound.

Table 1.

PVP-coated catheter treated with following solutions.	Slipperiness after drying				
	0 min	1	2	3	4
Untreated	8	7	5	2	1
20% NaCl + 5% PVP	8	8	8	8	7
15% KCl + 5% PVP	8	8	7	7	6
15% Na citrate + 1% Keltrol®	8	8	8	8	8
15% KI	8	8	7	4	2
15% Glucose + 5% PVP	8	8	8	7	6
30% Sorbitol + 1% Keltrol®	8	8	8	7	7
Keltrol® a xanthan gum; Kelco Co.					

Result

The table 1 shows that the catheters having a coating of a non-toxic, osmolality increasing compound retain their slipperiness for a longer time than the corresponding untreated surfaces i.e. the coated catheters dry more slowly. The osmolality increasing compounds prevent the hydrophilic polymer surface to desiccate.

Thus, catheters applied with an osmolality increasing compound such as sodium chloride according to the invention dry more slowly than corresponding untreated catheters. The sodium chloride treated catheter keeps its slipperiness a much longer time period, which is very desirable.

Medical tests show that the catheters applied with a coating of a osmolality increasing compounds such as sodium chloride are superior both at the insertion and at the removal of the catheter in urethra.

Claims

1. A method of forming an improved hydrophilic coating in order to retain the slipperiness for a longer time on a substrate characterized in
 - (a) applying a non-reactive hydrophilic polymer surface layer to the substrate;
 - (b) applying to the non-reactive hydrophilic surface polymer layer a solution comprising a solvent and above 2% (weight per volume) of an osmolality-increasing compound selected from the group consisting of mono and disaccharides, sugar alcohols, and non-toxic organic and inorganic salts, with the proviso that the osmolality-increasing compound is not a trihalogenide such as KI_3 (KI/I_2); and
 - (c) evaporating the solvent.
2. A method according to claim 1 in which the compound in the solution is selected from the group consisting of glucose, sorbitol, sodium chloride, sodium citrate, sodium benzoate, calcium chloride, potassium chloride, potassium iodide or potassium nitrate.
3. A method according to claim 1 in which the compound in the solution is selected from the group consisting of glucose, sodium chloride, sodium citrate, sodium benzoate, calcium chloride, potassium chloride, potassium iodide or potassium nitrate.
4. A method according to claim 1 in which the solution contains a polymer, preferably the same polymer as in the polymer surface layer.
5. A method according to claim 1-4 in which the solution having 4% to 40% (weight to volume) of sodium chloride.
6. A method according to claim 1 in which the non-reactive hydrophilic polymer surface layer is cured.
7. A method according to claim 1 in which the non-reactive hydrophilic polymer surface layer comprises a polymer selected from the group consisting of polyethyleneoxide, polyvinyl pyrrolidone, polyvinyl compounds, polysaccharides, polyurethanes, polyacrylates or copolymers thereof.



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7. A method according to claim 1 in which the non-reactive hydrophilic polymer surface layer comprises a polymer selected from the group consisting of polyethyleneoxide, polyvinyl pyrrolidone, polyvinyl compounds, polysaccharides, polyurethanes, polyacrylates or copolymers thereof.



8. A method according to claim 1 in which the non-reactive hydrophilic polymer surface layer comprising of polyvinyl pyrrolidone and in applying a solution having 20% (weight/volume) of sodium chloride.
9. A medical article having a very low coefficient of friction when wetted with a water-based liquid which comprises: a substrate, a non-reactive hydrophilic polymer layer on said substrate, and an evaporated coating of a non-toxic organic or inorganic salt other than trihalogenide such as KI_3 (KI/I_2), a mono- or disaccharide or a sugar alcohol on the thus hydrophilic polymer layer.
10. A medical article according to claim 9, in which the evaporated coating consists of glucose, sorbitol, sodium chloride, sodium citrate, sodium benzoate, calcium chloride, potassium chloride, potassium iodide, or potassium nitrate.
11. A medical article according to claim 9, in which the evaporated coating consists of glucose, sodium chloride, sodium citrate, sodium benzoate, calcium chloride, potassium chloride, potassium iodide or potassium nitrate.
12. A medical article according to claim 9 characterized in that it comprises a catheter.
13. A medical article according to claim 12 which is urinary catheter.

Revendications

1. Procédé pour former un revêtement hydrophile amélioré pour retenir plus longtemps le caractère glissant sur un substrat, procédé caractérisé en ce que:
 - (a) on applique une couche de surface polymère hydrophile non réactive sur le substrat ;
 - (b) on applique, sur la couche de surface polymère hydrophile non réactive, une solution comprenant un solvant et plus de 2 % (en poids par volume) d'un composé augmentant l'osmolalité , choisi parmi le groupe comprenant en des mono- et disaccharides ,des sucres-alcools et des sels organiques et minéraux non toxiques ,à la condition que le composé augmentant l'osmolalité ne soit pas un trihalogénure tel que KI_3 (KI/I_2), et
 - (c) on évapore le solvant .
2. Procédé selon la revendication 1 , dans lequel le composé présent dans la solution est choisi parmi le groupe comprenant le glucose , le sorbitol , le chlorure de sodium , le citrate de sodium , le benzoate de sodium , le chlorure de calcium , le chlorure de potassium , l'iodure de potassium ou le nitrate de potassium .
3. Procédé selon la revendication 1 , dans lequel le composé présent dans la solution est choisi parmi le groupe comprenant le glucose , le chlorure de sodium , le citrate de sodium , le benzoate de sodium, le chlorure de calcium , le chlorure de potassium , l'iodure de potassium ou le nitrate de potassium .
4. Procédé selon la revendication 1 , dans lequel la solution contient un polymère ,de préférence le même polymère que dans la couche de surface polymère .
5. Procédé selon l'une des revendications 1 à 4 , dans lequel la solution contient 4 % à 40 % (en poids par volume) de chlorure de sodium.
6. Procédé selon la revendication 1 , dans lequel la couche de surface polymère hydrophile non réactive est durcie .
7. Procédé selon la revendication 1 , dans lequel la couche de surface polymère hydrophile non réactive comprend un polymère choisi parmi le groupe comprenant du poly(oxyde d'éthylène), de la polyvinylpyrrolidone , des composés polyvinyliques , des polysaccharides , des polyuréthannes , des polyacrylates ou leurs copolymères .
8. Procédé selon la revendication 1 , dans lequel la couche de surface polymère hydrophile non réactive comprend de la polyvinylpyrrolidone et l'on applique une solution contenant 20 % (en poids/volume) de chlorure de sodium .



9. Article médical ayant un très bas coefficient de frottement quand il est mouillé par un liquide à base d'eau, qui comprend : un substrat, une couche de polymère hydrophile non réactive sur ledit substrat, et un revêtement évaporé d'un sel minéral ou organique non toxique autre qu'un trihalogénure tel que KI_3 (KI/I_2), un mono- un un disaccharide ou un sucre-alcool sur cette couche de polymère hydrophile.
10. Article médical selon la revendication 9, dans lequel le revêtement évaporé consiste en du glucose, du sorbitol, du chlorure de sodium, du citrate de sodium, du benzoate de sodium, du chlorure de calcium, du chlorure de potassium, de l'iodure de potassium ou du nitrate de potassium.
11. Article médical selon la revendication 9, dans lequel le revêtement évaporé consiste en du glucose, du chlorure de sodium, du citrate de sodium, du benzoate de sodium, du chlorure de calcium, du chlorure de potassium, de l'iodure de potassium ou du nitrate de potassium.
12. Article médical selon la revendication 9, caractérisé en ce qu'il comprend un cathéter.
13. Article médical selon la revendication 12, qui est un cathéter urinaire.

Patentansprüche

1. Verfahren zur Bildung einer verbesserten hydrophilen Beschichtung auf einem Substrat, um die Gleitfähigkeit länger zu erhalten, gekennzeichnet durch
- (a) das Auftragen einer nicht reaktiven hydrophilen Polymeroberflächenschicht auf das Substrat;
- (b) das Auftragen einer ein Lösungsmittel und mehr als 2% (Gew./Vol.) einer Osmolalitäts-erhöhenden Verbindung ausgewählt aus der Gruppe bestehend aus Mono- und Disacchariden, Zuckeralkoholen und nichttoxischen organischen und anorganischen Salzen umfassenden Lösung auf die nicht-reaktive hydrophile Oberflächenpolymerschicht, mit der Maßgabe, daß die Osmolalitäts-erhöhende Verbindung kein Trihalogenid, wie KJ_3 (KJ/I_2) ist; und
- (c) Abdampfen des Lösungsmittels.
2. Verfahren nach Anspruch 1, worin die Verbindung in der Lösung ausgewählt ist aus der Gruppe bestehend aus Glukose, Sorbit, Natriumchlorid, Natriumcitrat, Natriumbenzoat, Calciumchlorid, Kaliumchlorid, Kaliumjodid oder Kaliumnitrat.
3. Verfahren nach Anspruch 1, worin die Verbindung in der Lösung ausgewählt ist aus der Gruppe bestehend aus Glukose, Natriumchlorid, Natriumcitrat, Natriumbenzoat, Calciumchlorid, Kaliumchlorid, Kaliumjodid oder Kaliumnitrat.
4. Verfahren nach Anspruch 1, worin die Lösung ein Polymeres, vorzugsweise dasselbe Polymere wie in der Polymeroberflächenschicht, enthält.
5. Verfahren nach Anspruch 1-4, worin die Lösung 4% bis 40% (Gewicht zu Volumen) Natriumchlorid enthält.
6. Verfahren nach Anspruch 1, worin die nicht-reaktive hydrophile Polymeroberflächenschicht gehärtet ist.
7. Verfahren nach Anspruch 1, worin die nicht-reaktive hydrophile Polymeroberflächenschicht ein Polymeres ausgewählt aus der Gruppe bestehend aus Polyäthylenoxid, Polyvinylpyrrolidon, Polyvinylverbindungen, Polysacchariden, Polyurethanen, Polyacrylaten oder Copolymeren davon umfaßt.
8. Verfahren nach Anspruch 1, worin die nicht-reaktive hydrophile Polymeroberflächenschicht ein Polyvinylpyrrolidon umfaßt und eine Lösung mit 20% (Gew./Vol.) Natriumchlorid aufgetragen wird.
9. Medizinischer Gegenstand mit sehr niedrigem Reibungskoeffizienten bei Benetzung mit einer Flüssigkeit auf Wasserbasis, welcher ein Substrat, eine nicht-reaktive hydrophile Polymerschicht auf dem Substrat und eine aufgedampfte Beschichtung eines nicht-toxischen organischen oder anorganischen Salzes, das kein Trihalogenid, wie KJ_3 (KJ/I_2) ist, eines Mono- oder Disaccharids oder eines Zuckeralkohols auf der so hydrophilen Polymerschicht umfaßt.



10. Medizinischer Gegenstand nach Anspruch 9, worin die aufgedampfte Beschichtung aus Glukose, Sorbit, Natriumchlorid, Natriumcitrat, Natriumbenzoat, Calciumchlorid, Kaliumchlorid, Kaliumjodid oder Kaliumnitrat besteht.
11. Medizinischer Gegenstand nach Anspruch 9, worin die aufgedampfte Beschichtung aus Glukose, Natriumchlorid, Natriumcitrat, Natriumbenzoat, Calciumchlorid, Kaliumchlorid, Kaliumjodid oder Kaliumnitrat besteht.
12. Medizinischer Gegenstand nach Anspruch 9, dadurch gekennzeichnet, daß er einen Kathether umfaßt.
13. Medizinischer Gegenstand nach Anspruch 12, welcher ein Harnkatheter ist.