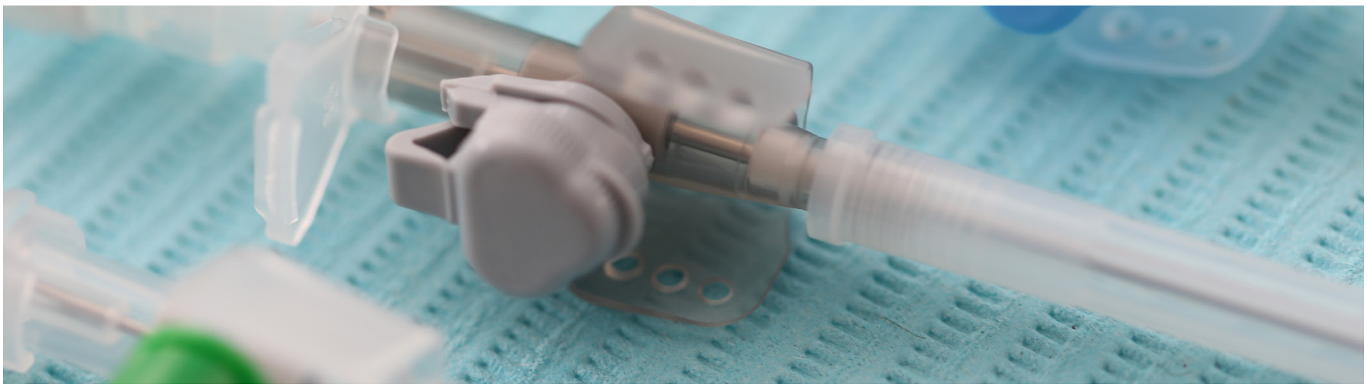
Case study

Evaluation of Biomedical Coating with Contact Angle Measurements



Polymers are widely utilized in medical devices due to their low cost, biological and chemical stability and processability. The polymer material is typically chosen based on its mechanical properties rather than surface chemistry. Surface chemistry, however, plays a significant part in terms of interactions with the human tissue.

One of the properties closely associated with the material-tissue interactions is the wettability of the material. The surface hydrophobicity is linked to poor protein resistance which in turn initiates a thrombosis cascade and bacterial infection [1]. Reduced protein fouling of a surface is likely to reduce both bacterial and mammalian cell adhesion [2]. Hydrophilicity will also help the water to wet the surface better which is especially important in applications like catheters as the water layer present can act as lubricant. Unfortunately, many of the most used polymers are hydrophobic and thus prone to nonspecific protein adsorption.

One commonly used method to modify the surface of the polymer is hydrophilic coatings. Poly(ethylene glycol) (PEG) and poly(ethylene oxide) (PEO) are examples of commonly used coating materials [1].

Hydrophilicity of the material can be determined by water contact angle measurements. Typically, a small, around few microliters drop, is placed on the sample surface, and the contact angle is optically determined. The measurement is very simple to conduct and takes only a few minutes starting from sample placement to the results.

Case study: Hydrogel coating to improve hydrophilicity and lubricity of the urinary catheter

Urinary catheters can be inserted intermittently to drain urine from the bladder when required or, alternatively, remain in place for up to three months. Especially when used intermittently, it is important to ensure good lubricity of the surface as repeated catheterization with poorly lubricated catheters can cause urethral bleeding, trauma, pain, and inflammation as a result of high frictional forces between the biomaterial surface and interfacing tissue.

A common approach to ensure smooth catheterization is to use lubricants such as glycerin and lidocaine gels [3]. Use of a gel lubricant however adds an additional risk of infection with increased handling operations. For this reason, the lubricious hydrophilic coating of the urethral catheter is preferred.

One important requirement for the hydrophilic coating used is that the coating should stay lubricious throughout the procedure to ensure smooth transition through the urinary tract. In addition to increased lubricity, the coating can provide antimicrobial properties to prevent the urinary tract infections commonly associated with catheter use.

Purpose of the study is to evaluate the hydrophilicity of a new coating formulation.

Samples evaluated were polyvinylchloride (PVC) substrates coated with the

hydrogel formulation by a dip coating and UV curing process.

Measurements were performed with Attension Theta optical tensiometer. Static water contact angles were measured by using a 4 ul droplet size. Measurements were performed on both uncoated and coated PVC substrates, previously hydrated for 24 h in dH_2O. Values are reported as the mean standard deviation of five measurements collected 1 – 1.5 sec following droplet placement on ten replicate samples.

Results

Images of a water droplet on uncoated and coated PVC are shown on the right.

The significantly lower contact angles measured for the coated surfaces indicate the increased hydrophilicity, with dH_2O almost completely wetting the surface. The difference in wettability between the two surfaces was due to the hydrophilic functional groups of the coating components. The increased wettability and associated hydration of the coated surface, furthermore, resulted in significantly lower frictional resistance and bacterial colonization than for uncoated PVC. The latter was attributed to the hydration layer formed on the more wettable coated surface, which acts as a barrier to bacterial adhesion.

Further information, including the friction force measurements, can be found in the full paper [4]

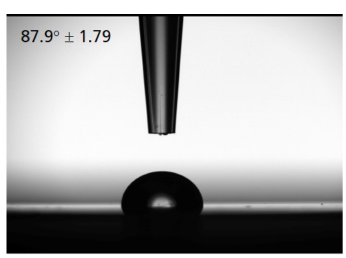
References

[1] B.K.D. Ngo, and M.A. Grunlan, "Protein resistant polymeric biomaterials" ACS Macro Letters 6 (2017) 992.

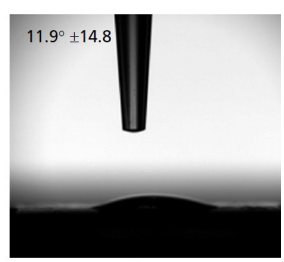
[2] C. Magin, S. Cooper, and A. Brennan, "Non-toxic antifouling strategies", Materials Today 13 (2010) 36.

[3] D. Aygin and E. Usta, "The effect of lubricants used in indwelling bladder catheterization through urethra on procedure-related pain: a literature review", International Journal of Clinical and Experimental Medicine 10 (2017) 1995.

[4] N.J.Irwin, M.G. Bryant, C.P. McCoy, J.L. Trotter, and J.Turner, "Multifunctional, low friction, antimicrobial approach for biomaterial surface enhancement", ACS Applied Bio Materials 3 (2020) 1385.



Uncoated PVC



Coated PVC

Contact us at info@biolinscientific.com

Biolin Scientific
[Progress Together]