Investigation of Static- and Dynamic Friction Behavior of Medical Syringes

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Nowadays, medical products are more important than ever. Syringes are just one example of the status of these products. Sensitive operation of the syringe by the medical staff independent from material and environmental influences ensure a safe use. Therefore, tribological properties play a decisive role in the development and optimization of syringes. For this purpose, a novel test setup has been developed, which allows high sensitivity characterization of static and dynamic operating forces of prefilled/unfilled medical syringes. Furthermore, it can also be shown that sliding speed as well as used fluid have a significant effect on operating forces.

Keywords: tribology, medical syringe, polymers, healthcare

1. Introduction

The past months taught us how indispensable and valuable medical devices are. Especially prefilled syringes are omnipresent in the modern health care system and the number as primary packaging for biopharmaceuticals has increased constantly over the past years [1,2]. They must meet high health and safety standards to ensure safe use. The tribological properties play a decisive role, notably when it comes to their use on patients. This work aims to evaluate the most important tribological parameters, such as coefficient of friction (COF) breakaway forces, and operating forces, on two commercially available syringes using a novel developed test setup. Furthermore, the influence of the used materials, the geometry of the seal, and ambient conditions on operation parameters are investigated.

2. Methods

2.1. Test Equipment

For the investigations, a highly sensitive MCR702 MultiDrive Tribometer (Anton Paar GmbH, AUT) was used, equipped with a newly developed test setup (Figure 1). The temperature was controlled with a CTD180 temperature chamber and the motion was carried out by a linear drive.

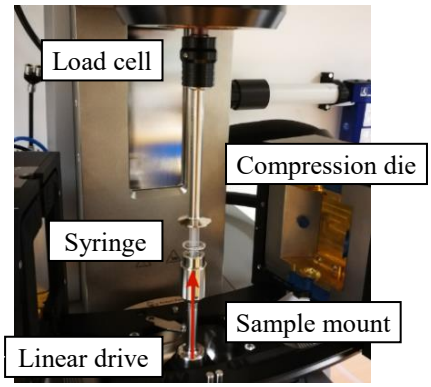

Figure 1: MCR702 MultiDrive with CTD180 temperature chamber and sample mount.

2.2. Testing Conditions

Two commercially available syringes with a glass or plastic cylinder and a rubber seal were examined. The sliding speeds were varied between 10 and 1000 µm/s with different filling media (air, dist. water, NaCl-solution) of the syringe. Additionally, the influence of an elevated temperature (40 °C) on the tribological properties was investigated.

2.3. Results

The results show an increase in the operating forces in the case of sliding velocities (Figure 2) between 10 and 200 µm/s. Especially the static force peak shows a significant increase at higher sliding speeds. This characteristic is also visible in syringes filled with distilled water. However, water acts as a lubricant and thus lowers the general force level and static force peak.

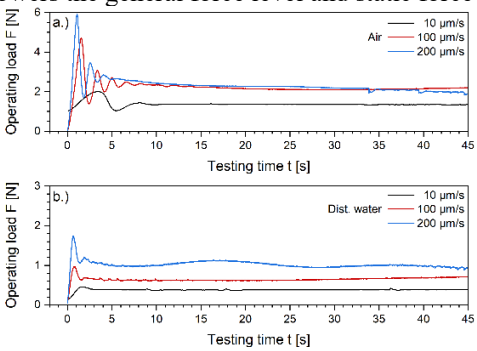

Figure 2: Operating loads over testing time for velocities between 10 and 200 µm/s for syringes filled with a.) air and b.) dist. water.

3. Discussion

A novel test setup for analyzing medical syringes was successfully constructed and implemented. The results show that sliding velocities have a significant influence on operating forces. The used medium also exhibit a considerable influence on the frictional properties and has a friction-reducing effect. The new test setup offers a promising approach to investigate medical syringes from a tribological point of view and opens new opportunities for research and development of this field.

4. References

[1] Werner, B. P. et al., “Silicone Oil-Free Polymer Syringes for the Storage of Therapeutic Proteins” J. Pharm. Sci. 108 (2019) 1148-1160.
[2] Wang, T. et al., “Impact of Surfactants on the Functionality of Prefilled Syringes” J. Pharm. Sci. (2020).