Evaluation of Plasma Effect on the Inner Wall of a Tracheal Stent

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Abstract: In this contribution, we report on surface modification of the inner wall of a Polydimethylsiloxane (PDMS) stent by He atmospheric pressure plasma. The treatment led to incorporation of O atoms, and to decrease in C atoms concentration, while the Si content remained virtually unchanged. However findings suggest modifications in the Si bonding with formation of inorganic silica-like bonds on the PDMS surface.

1. Introduction

Tracheal stenosis is a medical condition characterized by narrowing of the trachea, which leads to significant breathing difficulties. It can occur for various reasons, such as trauma, tumors, inflammatory diseases, and post-intubation injury [1]. Stenosis treatments include surgical insertion of a stent, which remains in the patient's throat to provide a secure airway. Silicone stents like the Montgomery's implant (also called T-tube) have been extensively utilized because they are well tolerated, easy to adjust, and relatively inexpensive. While improving breathing the tracheal stents are prone to biofilm formation, which is the main reason for their replacement.

Recently, cold atmospheric pressure plasma jets have attracted considerable attention because of their antimicrobial properties and the capability of generating plasma inside a small tubes and cavities [2]. Here, we study the effect of plasma jet treatment on the inner wall of a standard T-tube implant in view of future biomedical application.

2. Methods

In this work, we used standard 12-mm-diameter (OD), T-tubes made from medical-grade PDMS polymer. Helium plasma get was generated at the end of 1.0-m-long plastic tube by using the device reported in [3]. This arrangement allows precise and controlled plasma delivery to a targeted area. In this study the plasma jet was introduced inside the T-tube through its horizontal (shorter) branch. Fig. 1 depicts a schematic layout of the experimental setup. Detailed description of the treatment conditions as well as the employed characterization methods can be found in [4]. To evaluate the extent and uniformity of plasma modification effect the stent was cut into many pieces whose surface characteristics were evaluated by Scanning Electron Microscopy (SEM), X-Ray Photoelectron Spectroscopy (XPS), and wettability analysis.

3. Results and Discussion

SEM analysis indicated that the plasma processing induced no significant morphological changes on the polymer surface. However the XPS analyses showed incorporation of O atoms on the PDMS surface, which resulted in an enhancement of material wettability. Space-resolved XPS measurements demonstrated relatively uniform surface modification effect that spans over approximately 7.0 cm along the T-tube horizontal branch. During the plasma treatment the gas temperature inside the T-tube was monitored by a temperature sensor, which measured temperatures well below 40ºC.

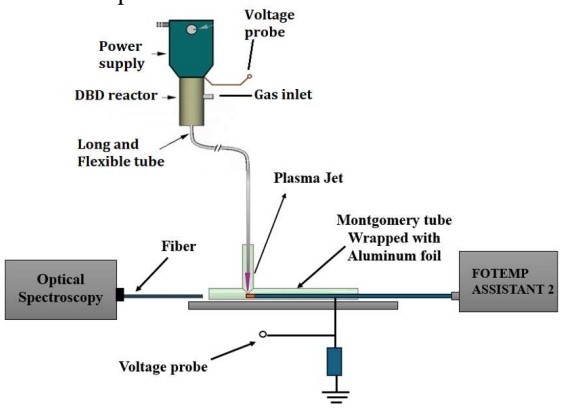

Fig. 1. Experimental setup

4. Conclusion

This study demonstrates that He plasma jet introduced through the T-tube's transversal branch can modify the inner wall surface properties by incorporating O-related groups. The modification effect spans inside the horizontal T-tube branch in a relatively uniform manner. The finding is important for future applications because it demonstrates the feasibility of this approach.

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