Plasma-Modified Micropatterned Fluoropolymers for Biomanufacturing Applications

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Abstract: This study employs plasma-enhanced chemical vapour deposition (PECVD) to create functionalized 150- and 100-micron micropatterns on fluoropolymer films, enabling scalable and clinically compatible materials for cell culture applications. These plasma-deposited micropatterns, characterized by SEM and EDS analysis, promote cell adhesion, clustering, and viability. The findings demonstrate the potential of PECVD for advancing biomaterial design and biomanufacturing in clinical-grade settings and stem cell therapies.

1. Introduction

Plasma-enhanced chemical vapour deposition (PECVD) can be used to transform chemically inert fluoropolymer (FEP) films into hydrophilic surfaces functionalized with carboxyl (-COOH) and amine (-NH2) groups, which in turn impacts how extracellular matrix (ECM) proteins adsorb on FEP surfaces. The interactions between these extracellular matrix proteins and cell receptors impact cell adhesion, spreading, and fate decisions [1]. In this study, we explore using plasma-modified 150- and 100-micron micropatterned FEP films as a scalable, biocompatible closed culturing platform. The adhesion and viability of mouse insulinoma 6 (MIN6) cells, as well as the differentiation of stem-cell-derived pancreatic precursors, were investigated on those surfaces [2].

2. Methods

FEP films underwent ammonia pre-treatment and micropatterned plasma polymer deposition under optimized conditions (e.g., RF power: 20-60 W, treatment times: 45 s-5 min) with a combination of ethylene, ammonia and carbon dioxide gases. Fabricated micropatterned films were characterized by Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS). MIN6 cells were seeded at 1×10^5-1.5×10^5 cells/cm² for 5 days, human pluripotent stem cells at 1×10^5 cells/cm² for 4 days, and stem-cell-derived posterior foregut cells 2×10^5 cells/cm² differentiating to pancreatic precursors. Live/dead cell analysis was conducted on MIN 6 cells to confirm adherence and viability. Immunostaining was used to characterize the differentiation of the posterior foregut cells, focusing on the expression of corresponding differentiation transcription factors (PDX1, NKX6.1) and pluripotency markers (Oct3/4).

3. Results and Discussion

Figure 1 A shows the EDS analysis of the oxygen-rich with the main elements being oxygen (O), carbon (C) and nitrogen (N). The analysis confirms the successful oxygen deposition on the surface, represented by the apparent red dots. A similar analysis was done for the nitrogen-rich surface and confirmed the presence of nitrogen in a similar manner as presented for oxygen. Figure 1B shows the live/dead cell analysis of MIN 6 cells on the micropatterns following 5 days of culturing with green and red corresponding to live and dead, respectively. The figure showcases the high viability of cells on the surface

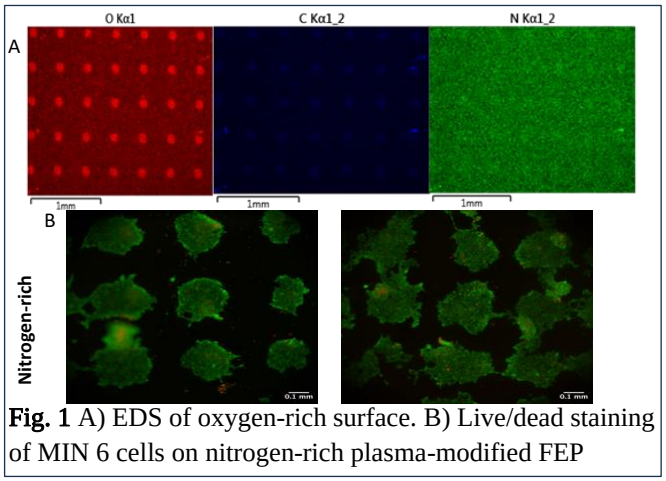

Fig. 1 A) EDS of oxygen-rich surface. B) Live/dead staining of MIN 6 cells on nitrogen-rich plasma-modified FEP

suggesting its applicability as a platform for cell adhesion and viability. The plasma-treated micropatterns provided a hydrophilic surface ideal for extra-cellular matrix (ECM) coating on which stem cell-derived posterior foregut cells were seeded. We are investigating the effect of controlled clustering of cells on those micropatterns and the impact on the differentiation into pancreatic precursor cells.

4. Conclusion

This study demonstrates the applicability of plasma-modified micropatterns as a biocompatible culturing system for scalable biomanufacturing in regenerative medicine and advanced therapeutic material design. This study also highlights the applicability of these surfaces for different cell types and the significance of their clustering in maintaining their viability and differentiation.

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References

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