Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2024, Vol. 6, No 1, Suppl. 1, Article ID 1874, 1 Page

Infinite Science Publishing

Abstract

Plasma technology for surface modification of 3D printed medical devices

K. Hain[1, 2*], M. Jänsch[1], K. Nagel[1], T. Neubert[1], and K. Lachmann[1, 2]

[1] *Fraunhofer Institute for Surface Engineering and Thin Films IST, Braunschweig, Germany*
[2] *Technical University of Braunschweig, PVZ Central of Pharmaceutical Engineering, Braunschweig, Germany*
[*] *Corresponding author, email: kevin.hain@ist.fraunhofer.de*

Additive manufacturing has become a versatile tool in medical engineering over the last decade. For medical applications the interaction of the device surface and the surrounding medium is crucial. Depending on the application adhesive or anti-adhesive properties can be necessary.

Cell adhesion to implants is determined by surface chemistry and topography. These can be tailored by plasma-based processes. This allows surface modification from the gas phase, even on complex geometries. In this paper, we would like to give an overview on the advances of different plasma-based treating technologies for medical applications. Focusing on cold plasma at atmospheric pressure, the combination of treatment and 3D-printing is demonstrated. We will present the current state of the art of different plasma sources to be integrated in fused deposition modelling (FDM). Main goals of plasma treatment of polymers deposited by FDM, are the improvement of the wetting behavior, cell adhesion and the adhesion of different materials combined in the printing process.

A distinction can be made between surface functionalization and coating. In the first case, the plasma interacts directly with material surface and generates functional groups there, like oxygen-based groups. This change in surface chemistry has a great influence on the wettability and adhesion and can be used in the treatment of complex FDM-printed structures as potential bone scaffolds in the regenerative medicine [1,2].

In a coating process a suitable film-forming agent has to be added to the process gas. This allows a more specific surface chemistry, like application of thiol, amine or epoxy groups. For example, this could be used as an effective way to optimize protein attachment and adsorption on printed materials [3], or as a substitute for agarose- and dextran-based beads used in chromatography applications and instead use FDM-printed structures that are specifically coated to bind the proteins required for the process.

Author's statement

Conflict of interest: Authors state no conflict of interest. Animal models: No animal experiments where part of the study. Informed consent: Informed consent has been obtained from all individuals included in this study. Ethical approval: No experiments related to humans where part of this study.

Research funding: Parts of the mentioned study where funded by the Federal Ministry of Education and Research (BMBF).

References

[1] M. Nakagawa, F. Teraoka, S. Fujimoto, Y. Hamada, H. Kibayashi and J. Takahashi, Improvement of cell adhesion on poly(L-lactide) by atmospheric plasma treatment, J. Biomed. Mater. Res. 77A, pp. 112-118, Apr. 2006
[2] M. Wang, P, Favi, X. Cheng, N.H. Golshan, K.S. Ziemer, M. Keidar and T.J. Webster, Cold atmospheric plasma (CAP) surface nanomodified 3D printed polylactic acid (PLA) scaffolds for bone regeneration, Acta Biomaterialia 46, pp. 256-265, Dec. 2016
[3] M. Cámara-Torres, R. Sinha, P. Scopece, T. Neubert, K. Lachmann, A. Patelli, C. Mota and L. Moroni, Tuning Cell Behavior on 3D Scaffolds Fabricated by Atmospheric Plasma-Assisted Additive Manufacturing, ACS Appl. Mater. Interfaces 13, 3, pp. 3631–3644, Jan. 2021

DOI: 10.18416/AMMM.2024.24091874