

Characterization of Micro-Cartucho Applied to Fluorine-18 Concentration Developing with Ultrashort Laser Pulse

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Introduction and objective: Non-invasive imaging diagnostics using Positron Emission Tomography (PET) is limited by the costs involved in the production of radiopharmaceuticals. In this context, microfluidics has attracted considerable interest from the scientific community [1]. The technique of soft lithography, especially in polydimethylsiloxane (PDMS), is widely used for microfluidic developments. However, PDMS has disadvantages in the use of organic solvents in chemical cross-linking with fluorine-18. The technique of ultrashort pulse laser ablation is capable of developing microfluidic systems in any kind of material. In this work we present the first micro-cartridge developed in optical glass using this technique.

Experimental Procedure: The micro-cartridge was machined onto the surface of a borosilicate optical glass plate (BK7) using an ultrashort laser pulse machining workstation. Subsequently, all structures were characterized using a Zygo 3D optical profilometer. The particle reservoir of the micro-cartridge was filled with Quaternary Methyl Ammonium (QMA) anion exchange resin with particle sizes ranging from 37 μm to 55 μm , which is used in the conventional fluorine-18 trapping and recovery process. An Embedded Supervisory Optical System (ESOS) was used to evaluate the effectiveness of the micro-cartridges in retaining the QMA particles in the reservoir under various water and compressed air flow conditions.

Results and discussion: The particle reservoir and inlet and outlet channels were designed to be 304 μm deep, and profilometry analysis showed an average depth of (307 ± 3) μm . The micropillars were designed to be 312 μm deep with a spacing of 40 μm between structures. Profilometry of the micropillars showed an average depth of (317 ± 10) μm and an average spacing of (38.7 ± 0.8) μm , with a wall tilt angle greater than 83°. The results demonstrate the high quality and precision achieved with the ultrashort laser pulse ablation of the micro-cartridge, with the critical point of machining being the wall tilt angle between the micropillars, which achieved a high slope tilt with a height/width (h/w) ratio above 7. Tests at different flow rates, analyzed by ESOS, showed a high particle retention efficiency of the micropillars, even under extreme conditions of 1000 $\mu\text{L}/\text{min}$ (water) and 10000 mm^3/min (compressed air).

Conclusions: The micro-cartridge developed by ultrashort laser pulse machining in BK7 glass is the first microfluidic system dedicated to the development of radiopharmaceuticals built in this material, with this technique. Thus, both the micro-cartridge and the ultrashort laser pulse ablation can make a significant contribution to the development of radiopharmaceutical and micro-devices in different materials.

References

[1] K. A. Knapp, et al. "The Current Role of Microfluidics in Radiofluorination Chemistry," *Mol. Imaging Biol.*, vol. 22, no. 3, pp. 463–475, 2020.

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