

Development of 3D Printed Micro Gas Chromatography Columns for Harsh Planetary Environments

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1. Overview

Gas chromatography (GC) plays a crucial role in space missions, including those to Venus, Mars, the Moon, and the International Space Station (ISS). GCs are categorized into wall-coated open tubular (WCOT), porous-layer open tubular (PLOT), and packed capillary columns, each serving specific purposes. While WCOT GCs are well-suited for analyzing complex volatile organic compounds primarily found on Earth, PLOT and packed columns offer enhanced separation of light gasses found on other planets. This research evaluated the performance of 3D-printed titanium PLOT-style GC columns with varying internal channel diameters, emphasizing their suitability for harsh planetary environments. The evaluation encompassed pressure versus flow testing and integration with a thermal conductivity detector (TCD) for robust sample injection analysis. An Agilent commercial GC system was used for gas sample injection which allowed for robust separation analysis. Confocal microscopy and Scanning Electron Microscopy (SEM) were utilized to image the internal channel cross-sections of the columns, facilitating accurate assessment of surface roughness. Future endeavors involve comprehensive testing to optimize the separation capabilities of the 3D-printed PLOT columns, focusing on fine-tuning the stationary phase and exploring the potential incorporation of a heating element.

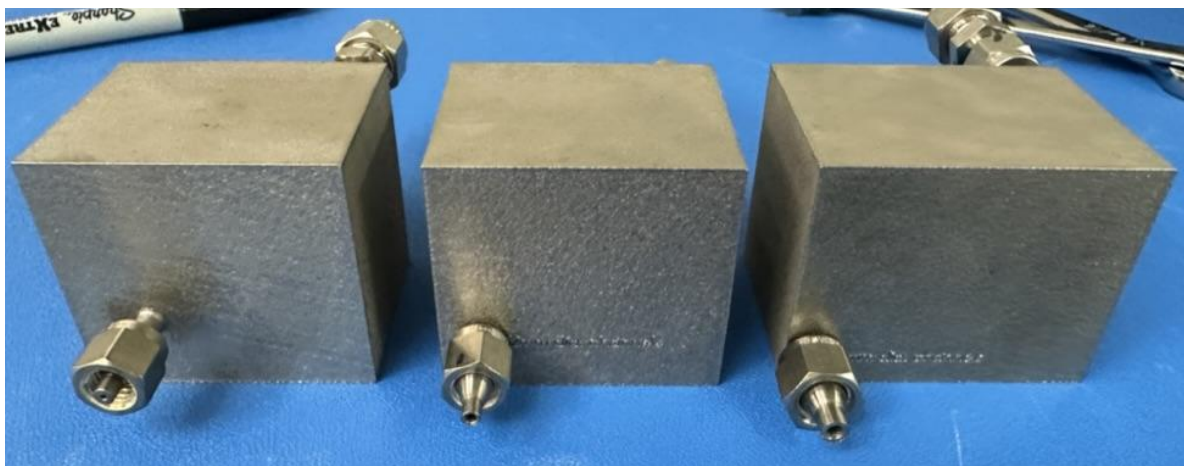


Figure 1. The 3D-printed titanium PLOT columns with 1mm, 2mm, and 3mm (left to right) inner channel diameters. These were tested for their separation capabilities and efficiency.



Figure 2. Setting up the titanium 3D-printed PLOT column into the system with the TCD for sample injection analysis.



Figure 3. Preparing to enter the clean room to take SEM and confocal microscope images of the titanium PLOT column's internal channel for surface roughness analysis.

2. Impact

The internship experience at NASA Jet Propulsion Laboratory (JPL) provided an exceptional opportunity to explore aerospace and scientific research, leading to profound insights and skill development. During my time at JPL, the exposure to the wide variety of research projects and the ability to partake in cutting-edge research solidified my aspiration to pursue a career in research and academia. Witnessing the practical application of scientific projects and technology in space exploration heightened my interest in the field. Additionally, the internship had a significant influence on my academic trajectory. It exposed me to subjects I thoroughly enjoy, such as instrumental analysis and engineering. Consequently, I have decided to take relevant courses during my undergraduate studies to deepen my knowledge in these areas and prepare for advanced research. Moreover, during the internship, I recognized the importance of programming skills in scientific research. As a result, I have enrolled in a programming course and have been actively learning on my own, knowing that these skills will be invaluable in my future academic and research pursuits.

The networking opportunities provided by the internship played a vital role in shaping my academic and career aspirations. Interacting with accomplished scientists and researchers at JPL allowed me to establish valuable connections within the scientific community. These connections taught me about various graduate schools and research opportunities aligned with my specific interests and skills. The experience of working alongside experts in biochemistry and aerospace motivated me to pursue a Ph.D. in biochemistry, focusing on space-related applications. The encouragement and advice from my mentors at JPL bolstered my confidence to strive for higher education and research excellence. The entire internship experience has deepened my passion for research and solidified my determination to pursue a PhD in biochemistry with the hopes of becoming a scientific researcher in the future.