UNCONVENTIONAL, INTENSIFIED REACTORS IN SPACE EXPLORATION

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Highlights

- Unconventional, intensified reactors play a paramount role in securing human survival in space.
- Due to scarcity of fossil fuels, electricity-based reactor concepts dominate the field.
- More collaboration between experts in space engineering and process intensification is needed to accelerate progress.

This cross-disciplinary lecture focuses on the relevance of chemical reaction engineering and process intensification for space exploration. Both process intensification and space exploration look beyond conventional engineering solutions and address basically the same issues – equipment miniaturization and increased process efficiency. While smaller plant size and higher process efficiency in terrestrial manufacturing are mostly driven by economic or environmental benefits, the very same features in space exploration become a vital necessity.

In such context, I review various concepts of unconventional, intensified reactors to be applied in fully closed, in-flight systems, where humans are isolated from external supplies and are entirely dependent on the resources available onboard at the start of the mission, and in semi-closed systems (on Moon or Mars), where extraction of some raw materials from local environment (regolith or atmosphere) is possible. Processes, that need to be addressed with intensified reactor solutions include CO_2 hydrogenation (Sabatier reaction and RWGS), pyrolysis of methane, oxygen generation from water or regolith, wastewater treatment and propellant generation from Martian atmosphere.

Given the commonality of concepts and approaches, as well as the fact that both process intensification and space engineering address basically the same issues – equipment miniaturization and increased process efficiency, more intensive interactions between both

scientific communities are needed to benefit from cross-fertilization and the exchange of new ideas and experiences.

References

[1] A. I. Stankiewicz and J. A. Hoffman. "Back to the roots: Process intensification in space exploration". *Chemical and Process Engineering: New Frontiers* (2025): e115-e115.