 DOI: 10.33892/aph.2021.91.270-271

P-54

Space Chemistry, Space Medicinal Chemistry and the SpaceMedChem Consortium – Emerging Tools and Initiatives Towards Advanced Drug Development Methods

FERENC DARVAS[1]; BALÁZS BUCHHOLCZ[1]; GYÖRGY DORMÁN[1]; GERGŐ MEZŐHEGYI[1]

[1] *Innostudio Inc., Záhony u. 7, H-1031 Budapest, Hungary*

Correspondence: ferenc.darvas@innostudio.org

Keywords: *Microgravity, space medicinal chemistry, flow chemistry, SpaceMedChem, drug discovery in space*

1. Introduction: Space chemistry

Have you ever wondered if chemistry is different in space than on the ground?

Chemistry on Earth environment can be performed either in flasks or flow systems. This is not the case under microgravity where the solution in a flask wouldn't mix well and reactions will not be reproducible.

Flow chemistry is an advanced branch of synthetic chemistry and amenable to both automation and synthesis in space and also under harsh conditions. Flow chemistry is performed by mixing two or more liquid/gas reagents under heating or cooling or under pressure in a reactor producing a continuous stream.[1]

Space chemistry is producing chemical transformations (including formulations) in space, mostly via flow chemistry. Space chemistry is relatively new field, which goes back to the mid 2010's. The first scientific conference on the topic was organized by the American Chemical Society (ACS) in San Francisco, CA, USA in 2017.[2] The first summary paper was published in 2017[3]. The most recent review on space chemistry is a book chapter[4].

2. Research areas covered so far

The pharma industry has been profiting from space chemistry and formulation in many ways. Rapid alteration in gene expression in osteoblasts furthermore checking the atrophy tissue metabolism in space helps e.g. the understanding of the ageing process in space and on earth. Better understanding of these phenomena may lead to discovery of novel drugs and therapies.[5] Interestingly, many important response, like musculoskeletal, cardiovascular, immune and other responses to microgravity are similar to the changes experienced at ageing. They are, however, sometimes 10 times faster in space than on Earth.[6]

The exploitation of the advantages of microgravity in protein crystallization is a very rapidly developing area.[7]

Synthetic chemistry experiments performed in microgravity environment have been scarce so far. Until recent years, performing controlled chemical syntheses in space has not been possible due to the lack of an appropriate equipment to do that. In 2019-20, the first flow chemistry platform for synthetic reactions on the ISS was developed by the Beeler Research Group (Boston University) and Space Tango.[8]

3. The SpaceMedChem Consortium and selected results

The real challenge of using synthetic chemistry and formulation development in space is the comparative fine tuning of experiments on orbit with the experiments on Earth and fitting the space experiments properly to the usual drug discovery and development pipeline. This aim is targeted exactly by the SpaceMedChem Consortium.

The Consortium is aiming to solve important, decade long, unsolved drug discovery problems starting on precompetitive levels. An important target is also to create a uniform platform which is synchronizing the drug discovery platforms on orbit and Earth. Participants of the Consortium are from the space community (e.g., service corporations) as well as from the pharmaceutical community, from large to small pharmaceutical corporations, furthermore drug discovery CROs. InnoStudio Inc.[9], one of the pioneers of space chemistry in recent years, is the founding member of the consortium.

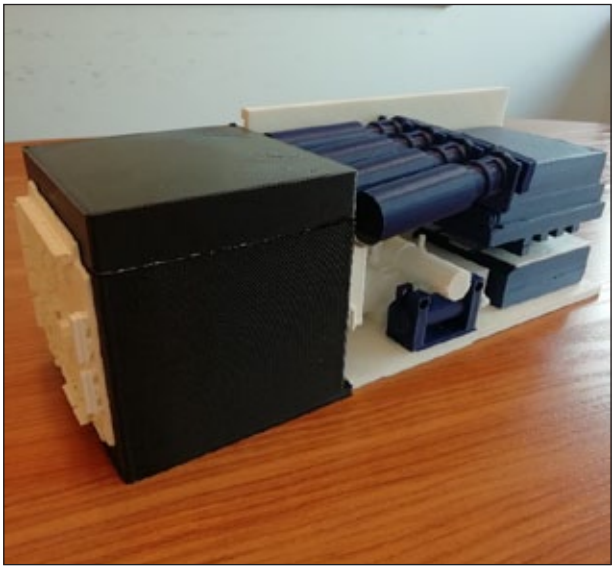

Figure 1 *A 3D printed model of the first flow chemistry instrument targeted to automated and remotely controlled operation on orbit.*

The first and most important result from the SpaceMedChem Consortium is an interesting anti-COVID study related to remdesivir re-formulation under microgravity (for details, see our DDRS 2021 poster "Space medicinal chemistry against SARS-CoV-2: SpaceMedChem – Project 1").

InnoStudio and its sister company Thalesnano have recently developed the first demo equipments of a modular, miniaturized and remotely controllable flow reactor system for space applications and space pharmaceutical manufacturing (***Figure 1***), capable of performing diverse chemical reactions and syntheses, including reactions highly demanded by the pharmaceutical industry. Also, InnoStudio is developing the very first miniaturized reactor with coupled analytical tool that will be able to follow synthesis of a world top 200 medicine in space.

Further result of the SpaceMedChem Consortium is that InnoStudio Inc., in collaboration with Japan Manned Space Systems Corporation (JAMSS), is now organizing the first ever webinar series dedicated to pharmaceutical research and drug discovery in space with speakers from large pharma and space industry corporation will account on their latest results. [10]

4. Conclusions

In recent years, numerous research studies have shown that microgravity and other space effects are promising tools to develop and/or improve pharmaceutical compounds and processes either for space purposes or applications on Earth. We believe that in the coming decade, the enhanced collaboration of the pharmaceutical and space industry, both at national and international level, will offer both novel R&D and commercial opportunities for the development of so far unknown APIs and other compounds of the pharmaceutical research and industry. The present poster summarizes the concept and the latest results of space medicinal chemistry and introduces the SpaceMedChem Consortium as an emerging platform for synchronizing drug discovery related research on orbit and on Earth.

References

1. *Darvas, F., Dormán, Gy., and Hessel, V. ed. (2014). Flow chemistry – Volume 1: Fundamentals. Berlin: De Gruyter.*
2. *The Space Chemistry Symposia series by ACS are ongoing since 2017, the 6th event was held in 2021.*
3. *Jones, R.; Darvas, F. & Janáky, Cs. (2017), Nat. Rev. Chem., 1, 0055.*
4. *Darvas, F. et al. (in press). Space Chemistry – Chemistry related innovations in space, benefits of flow chemistry. In: Hessel, V. (ed.), In-space Manufacturing and Resources. New York, Wiley.*
5. *Braddock, M. (2020), Curr. Drug Discov. Technol., 17(1), 45-56.*
6. *Demontis, G. et al. (2017). Human pathophysiological adaptations to the space environment. Frontiers in physiology, 8, 547.*
7. *Reichert, P. et al. (2019). Pembrolizumab microgravity crystallization experimentation. Npj Microgravity, 5 (1): 1-8.*
8. *https://www.nasa.gov/mission_pages/station/research/experiments/explorer/Investigation.html?#id=8172*
9. *https://innostudio.org*
10. *https://drugdiscoveryinspace.com/*