COLLABORATIVE DOCTORAL PARTNERSHIPS – CALL 2020

THEMATIC FIELD 10: Non-power nuclear and radiological technologies to achieve the SDGs 2030 Agenda

JRC RESEARCH AREA DESCRIPTION

Nuclear and radiological technologies play an important role in vital areas outside the nuclear energy sector, such as medicine, industry, research and environment, providing numerous benefits to the EU citizens. Non-power nuclear and radiological technologies are among the priorities of JRC, supporting the needs of EU-Member States with its unique array of infrastructures, knowledge base and staff competence.

JRC.G supports the: development of advanced and innovative materials test methodologies; novel approach using nanotechnologies to produce the medical radioisotopes; radiation measurements and instrumentation; fundamental understanding of radiation-induced changes in materials and their emulation; and the cross-fertilization of nuclear and non-nuclear technologies. Innovation is also promoted through the validation of accelerated test methods in representative environments.

JRC.G carries out pre-normative research into the miniaturization of testing methods requiring significantly reduced amounts of material only, thereby raising efficiency and cost-effectiveness. In this context qualification of new micromechanical test methodologies for mechanical property assessment as nanoindentation, microcompression, membrane bulge and microtensile testing are techniques that are explored in conjunction with the assessment of the impact of multiple effects as e.g. radiation fields and environments. The assessment of irradiation-induced changes in materials is supported through the qualification of novel monitoring techniques and instrumentation as the validation of thermoelectric potential measurements (Seebeck effect) for online monitoring of materials modification due to radiation.

To promote the basic understanding of the relationship between the performance of a material and its microstructural properties, JRC.G carries out underpinning analytical modelling and numerical simulation. Numerical modelling of materials changes when exposed to a radiation field as e.g. rate kinetics of defect populations (point defects, dislocation loops, precipitates, voids) are key to develop improved equivalence scheme to compare different radiation fields.

The development of novel, more effective and cheaper methods for treating widespread diseases contributes to achieving the goal of economically sustainable high-level healthcare. The efforts of JRC.G in this area aim at advancing the application of radionuclides to theranostics, a novel field of medicine combining targeted diagnostic tests and targeted therapies. In the medium-term programme, focus will be put on the use of alpha particle emitters for cancer therapies.

Targeted cancer therapy using alpha-emitting radionuclides has shown remarkable benefit to patients in clinical trials. The radionuclides Ac-225 and Bi-213 used in these studies have been produced by natural decay and chemical separation from their precursor Th-229. However, worldwide stocks of Th-229 are very limited. On the other hand, based on the large number of cancer patients who could potentially be treated by targeted alpha therapy, the amount of produced radionuclides must be scaled up significantly. In order to meet this expected demand for Ac-225 and Bi-213, alternative production schemes are being considered. JRC.G is investigating several production paths for Ac-225, which share as a common feature the irradiation of custom-produced targets at accelerator facilities: (1) Low-energy proton irradiation of a Ra-226 target at a cyclotron facility; (2) Neutron irradiation of a Ra-226 target at a neutron facility such as GELINA at JRC Geel; (3) Spallation of a thorium or uranium target at an on-line isotope separator facility such as MEDICIS/CERN. In the framework of a CDP project, the fabrication of solid radium target by electrodeposition, the design and construction of a liquid radium target, or the study of nanostructured thorium and uranium targets will be studied. Following the irradiation of such targets at appropriate accelerator facilities, the produced radionuclides will be quantitatively analysed in order to extract crucial cross-section and yield information

Radioisotope power is a key enabling technology for robotic space missions into the outer solar system or to the dark side of planetary bodies. Since 2015, JRC supports the development of Radioisotope power sources (RPS) for future space missions in the frame of a cooperation with the European Space Agency's (ESA). The work encompasses a variety of activities such as exploring alternative fuel options for radioisotope heater (RHU) and radioisotope thermal generator (RTG) units, encapsulation of power sources using refractory metal alloys, safety assessment of the consequences of re-entry accidents, development of new, actinide-based, thermo-electric materials with high merit factor. In addition JRC is studying ultra-high temperature ceramics that may have applications in (aero)space vehicles as thermal protection shields, and structures for ultra-high-speed flying objects. In this research, we will use the JRC infrastructure (hot-cell laboratory, minor actinide laboratory) and a broad range of unique instruments for actinide materials synthesis and characterization.

JRC.G performs research on: developing and improving analytical methods applicable to nuclear materials on bulk and on particle samples; exploiting information from inhomogeneous materials; studying the potential application of techniques such as retrospective dosimetry, surface profilometry, 3D reconstruction for nuclear forensics; developing and improving interpretational techniques (including Artificial Intelligence methods); and investigating potential correlations in multi-variate data sets (including Artificial Intelligence methods).

MAIN POLICY FIELDS

Sustainable Development Goals 2030

Goal 3: Good health and well-being for people

"Ensure healthy lives and promote well-being for all at all ages."

Goal 8: Decent work and economic growth

"Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all."

Goal 9: Industry, Innovation, and Infrastructure

"Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation."

Goal 12: Ensure sustainable consumption and production patterns

"Urgent action is needed to ensure that current material needs do not lead to the over-extraction of resources or to the degradation of environmental resources, and should include policies that improve resource efficiency, reduce waste and mainstream sustainability practices across all sectors of the economy"

European Commission Priorities

Promoting the European way of life (Protecting public health and Security)

Stronger Europe in the World (Space and Economy)

JRC WP Key orientations for the JRC WP 2019-2020

Key orientation 1.5.1 – Health

Key orientation 1.7.a – Research and innovation policies

Key orientation 1.8.b – Alternative fuels

Key orientation 3.2.b – Energy security

Key orientation 3.3 – Safe and secure use of nuclear energy

Key orientation 3.3.f – Development of knowledge management, training and education

Key orientation 3.3.g – Development of nuclear science applications and use of radioisotopes

Key orientation 4.1.b – Space strategy

Key orientation 9.1.2 – Global nuclear safety and security

Concrete fields

Contribution to the development of novel, effective and cheaper methods for treating widespread diseases, in order to make **high-level healthcare widely available and economically sustainable** in the scenario of an ageing society.

Support to the future **Knowledge Centre on Cancer** in its task of connecting the **Europe's Beating Cancer Action Plan** (lead by DG SANTE) with the new **Mission on Cancer** (lead by RTD), support Member States actions and strengthen EU approach on **cancer control and care**.

Support to the **European space policy,** the **European space industry** and the **European Space Agency's** efforts to develop **European radioisotope power sources (RPS),** thereby enabling independent European space missions into the outer solar system in the future, not only allowing a very new class of missions, but also enhancing significantly the reliability and cost efficiency of the power systems.

LINKS / URL WEBSITES

- https://ec.europa.eu/jrc/en/research-topic/medical-applications-radionuclides-and-targeted-alpha-therapy
- https://ec.europa.eu/jrc/en/research-facility/properties-actinide-materials-under-extreme-conditions-pamec-laboratory
- https://ec.europa.eu/jrc/en/research-facility/minor-actinide-laboratory
- https://ec.europa.eu/jrc/en/research-facility/fuel-and-materials-research-fmr-laboratory
- https://ec.europa.eu/euratom/observatory_radioisotopes.html and links on this webpage
- https://ec.europa.eu/jrc/en/research-facility/linear-electron-accelerator-facility
- https://ec.europa.eu/jrc/en/research-facility/tandem-accelerator-based-fast-neutron-source
- http://youbenefit.spaceflight.esa.int/esa-innovation-exchange-radioisotope/
- https://www.cosmos.esa.int/web/ulysses/rtg
- https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/Landing_on_the_Moon_and_returning_home_Heracles

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- Altstadt, E., Houska, M., Simonovski, I., Bruchhausen, M., Holmstrom, S., Lacalle, R. *On the estimation of ultimate tensile stress from small punch testing*, Int. J. Mech. Sci. 2018, 136, 85–93.
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- F. Bruchertseifer *et al. Targeted alpha therapy with bismuth-213 and actinium-225: Meeting future demand*. J. Labelled Comp. Radiopharm. **62** (2019) 794. https://doi.org/10.1002/jlcr.3792
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- L. Biasetto *et al., Morphological and functional effects of graphene on the synthesis of uranium carbide for isotopes production targets,* Scientific Reports **8** *(2018) 8272.*
- D. Salvato *et al., Spark plasma sintering of fine uranium carbide powder,* Ceramic International, **43** (2017) 866-869
- Qaim S.M., *Nuclear data for production and medical application of radionuclides: Present status and future needs*, Nucl Med Biol. **44,** 31 (2017)
- Mondelaers W., Schillebeeckx P., GELINA, *a Neutron Time-of-Flight Facility for High-Resolution Neutron Data Measurements*, Notiziario Neutroni e Luce di Sincrotrone, Research Infrastructures vol. II no. 2 (2006)
- Oberstedt S., et al., *High precision measurements on fission-fragment de-excitation*, Rad. Phys. Chem. **140**, 458 (2017)