TITLE: Energy storage cycle with carbon free aluminium

Summary: One of the main keys for a climate neutral Europe are technologies for the storage of renewable energies over longer time at an attractive cost and with an acceptable environmental impact. Renewable electricity and heat can be produced cheaply today and short-term storage are available at low cost. However, technologies for storing renewables for longer time-spans of months or seasons are scarce and costly and thus not widely used yet. Unique solution to this challenge, using the conversion of aluminium oxide into aluminium metal by solar energy. Aluminium metal is then upon request used for seasonal heating and power supply of household. This ground-breaking technical solution will enable to store large amounts of energy with an unmatched energy storage density of over 15 MWh/m3 at an attractively low cost. Therefore, with the emerging technology of carbon free reduction of aluminium oxide to aluminium in combination with the release of energy from an aluminium storage vector this project will provide one of the missing pieces of the puzzle for a climate neutral Europe.
During the innovative doctoral program, the candidate will be responsible for introducing state of the art of Al energy storage and production of heat, hydrogen and electricity out of Al metal. In the first phase, the candidate will develop innovative paths of Al interaction with water at different pH, temperature and pressure, analytical procedures for evaluation of resulting materials. The candidate will be also responsible for studying improvements in the field of Al energy storage. In the second phase, the candidate will focus on optimization of reaction kinetic parameters, separation of reactants and products and usage of additives resulting in improved material transformation, product curing, and gas separation. The outcome of the doctoral program will enable proof of concept, reactor development, better quality assurance/control of produced products in accordance with internationally accepted norms and skilled person development.

Research techniques used: Al metal transformation to Al2O3, characteristics of Al2O3 will be investigated by Fourier transform infrared and Raman spectroscopy, differential scanning calorimetry measurements. The surface morphologies of the oxide intermediates and products will be investigated by scanning electron microscopy, atomic force microscopy and transmission electron microscopy. Surface properties will be evaluated by contact angles measurements and surface free energy estimation by tensitometry. Reaction kinetic will be studied by electrochemistry.

The reason why the topic is innovative: The EU aims to be climate-neutral by 2050 – an economy with net-zero greenhouse gas emissions. Therefore, A renewable Al fuel – from wind, solar or hydroelectricity – that is suitable for seasonal storage that does not rely on a carbon source as would be the case for common Power-to-Gas or Power-to-Liquid processes is one of feasible solution achieving vision by EU. Higher standard demands are focused on cheaper and more green energy without impact on environment. Comprehensive development and usage of approaches and easy accessible materials is unavoidable.

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The Scientists4Future Slovenia has received funding from Ministry of Higher Education, Science and Innovation. The project is co-executed by University of Ljubljana.

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