

CEIPEX BUT TOPIC 4

Položka / Field	Obsah / Content
CEIPEX RESEARCH TOPIC LEVEL 1	Advanced Nano & Micro technologies
CEIPEX RESEARCH TOPIC LEVEL 2	Future energy
NAME OF THE RESEARCH GROUP	Future Energy & Innovation Lab (RG-1-18)
SUPERVISOR	Prof. Martin Pumera
PROPOSED RESEARCH TOPIC TITLE	Single-Atom Catalysts for Sustainable Ammonia Production
RESEARCH TOPIC DESCRIPTION	Single-Atom Catalysts for Sustainable Ammonia Production This research topic aims to develop efficient catalysts for producing ammonia using electricity, with the long-term goal of powering the process with renewable energy. The research will investigate how individual metal atoms anchored on suitable materials can promote ammonia formation. The central idea is to control the chemical environment surrounding each metal atom. By changing the type, number, and arrangement of neighbouring atoms, researchers will tune how the catalyst interacts with reactants and directs the reaction towards ammonia. Suitable supporting materials may include carbon-based structures, two-dimensional materials, and metal–organic frameworks. Particular attention will be given to accessible metals, such as iron and copper, and to maintaining their stability during operation. The research will focus on electrochemical conversion of nitrate into ammonia, connecting the recovery of nitrogen from contaminated water with the production of a valuable chemical. Experimental studies will combine materials synthesis, structural characterization, and electrochemical testing to identify which atomic arrangements deliver the best performance. Computer modelling may help explain reaction pathways and guide catalyst design. Key challenges include improving ammonia yield, limiting unwanted reactions, preventing metal atoms from clustering or leaching, and achieving reliable performance over extended operation. Ammonia measurements will be verified through complementary analytical methods and appropriate control experiments. The expected outcomes are improved catalysts and clear design principles linking atomic structure to catalytic performance. These advances will support the development of practical technologies for nitrogen recovery and ammonia production, with potential applications in energy storage and for electric mobility.
KEYWORDS	carbon-free energy carrier, hydrogen, catalysis, electrochemistry

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INTERDISCIPLINARY DIMENSION	The topic connects directly with CEITEC's Advanced Materials and Advanced Nano and Microtechnologies research areas, offering opportunities to combine catalyst development with surface engineering and atomic-scale characterization. The project could also benefit from [CEITEC Nano](https://nano.ceitec.cz/) facilities for electron microscopy, surface analysis, and structural characterization. These capabilities would support verification of metal-atom dispersion and investigation of structural changes during electrochemical operation, helping explain catalyst performance and degradation.
WEBPAGE OF THE RESEARCH GROUP	https://www.ceitec.eu/future-energy-and-innovation/rg322/about-us