Atomically Structured Electrocatalyst Materials with Increased Stability

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Increasing concerns regarding the global warming and environmental impacts became the main motivation for transition of the energy sector towards renewables. Electrocatalysis plays crucial role in this transition, since environmentally-safe power storing technologies are based on interconversion of chemical and electrical energy [1]. The most promising among them are the storage of renewable energy through the electrochemical reduction of CO_2, electrical storage using battery electric vehicles, production of hydrogen by water electrolysis [2]. The common challenge in the electrochemical devices for energy conversion and storage is the development of active and stable electrocatalyst materials. This is especially important for the electrolyzers and fuel cells that operate in acidic media where due to harsh corrosive environment catalysts containing noble metals such as Pt and Ir are still materials of choice. Limited abundance of Ir and Pt, however, challenges widespread applications of electrochemical devices in the large scale conversion and storage of renewable energy. A lot of research efforts are aimed towards development of the strategies to replace expensive noble metals by cheaper alternatives or at least to reduce their loading without sacrificing efficiency and stability. The rational design of durable catalyst materials with reduced loading of noble metals demands a deep understanding of the interplay between the nature of the active sites, their reactivity and degradation mechanisms at the atomic scale.

In this talk the approaches to reducing loading of Pt and Ir in electrocatalyst materials without sacrificing crucial in electrocatalysis functional properties will be discussed [2-5]. The main focus will be placed on the structure and composition of the topmost atomic layers of the catalysts and their temporal evolution induced by the polarization in the acidic media. By combining advanced electrochemistry methods with atom probe tomography, X-ray photoelectron and X-ray absorption spectroscopies we define active species in these materials and develop strategy for their stabilization at the electrode surface [2-5]. These results provide useful insights on the structure-function relationships in electrocatalysis, which can help to design new active and durable materials with reduced loading of noble metals.

[1] Stamenkovic et. al. Nature materials 2017, 16 (1), 57-69. [2] Kasian et. al. Journal of Physics: Energy 2021, 3 (3), 034006. [3] Lahn et. al. ChemElectroChem 2024, 11(4), e202300399. [4] van der Merwe, ACS Catalysis 2023, 13 (23), 15427-15438. [5] Ruiz Esquius et. al. Journal of the American Chemical Society 2023, 145 (11), 6398-6409.