TITLE: **Direct conversion of CO_2 to value-added products (ethanol or aromatics) over bifunctional heterogeneous catalysts in a continuous flow reactor**

Summary: Carbon capture and utilization (CCU) is critical to reducing CO_2 emissions, a major air pollutant, and mitigating global warming. CO_2 as feedstock for chemical processes has attracted great attention since it can reduce the cost and increase the profit for reducing CO_2 emissions. One of the most promising approaches toward CO_2 valorization is hydrogenation of the latter into ethanol or aromatics over bifunctional metal-modified zeolite catalysts comprising redox and acidic sites. Aromatics are the most important bulk chemicals, which can be used to produce polymers (phenolic resins, polystyrene, polyethylene terephthalate fiber, nylon, polycarbonate, films, and resins), while ethanol has been widely used as a solvent, detergent, and disinfectant, which acts as a very useful chemical in both daily life for human beings and industrial production. Currently, ethanol is mainly produced from the fermentation of cellulosic biomass in industry (using high energy input and competing over food supplies), while aromatics mainly derived from petroleum (naphtha) and the synthesis of aromatics from other alternatives are rarely reported.

Research techniques used: The synthesized catalysts will be characterized by Inductively coupled plasma atomic emission spectroscopy (ICP-AES) analysis, N_2 physisorption, Scanning transmission electron microscopy (STEM) - energy dispersive X-ray spectroscopy (EDXS) analysis, Powder X-ray diffraction (XRD) analysis, Scanning electron microscopy (SEM) analysis, NH_3-temperature-programmed desorption (NH_3-TPD) analysis, CO_2-temperature-programmed desorption (CO_2–TPD) analysis, H_2-temperature-programmed reduction (H_2-TPR) analysis, X-ray photoelectron spectroscopy (XPS), Thermogravimetric analysis (TGA), and Pyridine diffuse reflectance infrared Fourier transform spectroscopy (Pyr-DRIFTS). The reaction (CO_2 hydrogenation) will be conducted in an automated laboratory packed-bed microactivity reactor (Microactivity-Reference, PID Eng&Tech) or Microactivity Effi reactor (probably the most advanced worldwide modular laboratory system for measurement of catalytic activity and for the study of the yield and kinetics on chemical reactions). The collected liquid samples will be then analyzed by gas chromatography (GC machines from Agilent, Shimadzu, and Thermo Scientific FOCUS) with FID and MS detectors, while the gas products will be sent to the online micro-GC (Fusion Inficon) with TCD detectors.

The reason why the topic is innovative: Transformation of greenhouse gas CO_2 and renewable H_2 into value-added products is recognized as a promising route to store fluctuating renewable energy. Methods for the hydrogenation of CO_2 into valuable chemicals are in great demand but their development is still challenging. Despite the efforts of the scientific community, no direct synthetic route exists today to synthesize ethanol or aromatics from CO_2 with high productivities and low undesired byproducts selectivity. To overcome these limitations, we will develop a novel bifunctional catalyst with high catalytic activity, stability, and selectivity for ethanol and/or aromatics products.

SUPERVISOR: Dr. Andrii Kostyniuk
SECONDMENT: Le Mans Universite, France and University of Liverpool, UK
SUPERVISOR AT SECONDMENT: Prof. François GOUTENOIRE and Prof. Ivan Kozhevnikov

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA VISOKO ŠOLSTVO, ZNANOST IN INOVACIJE
Masarykova cesta 16, SI - 1000 Ljubljana

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