Global warming resulting from high emission of greenhouse gasses is a phenomenon, that in recent years began to be especially important and dangerous for civilization development due to constantly increasing number of sources of emission of gasses responsible for the greenhouse effect. Global warming negatively influences the non-failure operation of ecosystems and due to glaciers melting, resulting in water volume increase, causing raising of water level in seas and oceans. Large number of negative factors resulting from global warming effect creating necessity of performance of intensified investigations going to development of technologies enabling limitation of emission or neutralization of greenhouses gasses through its conversion to chemical compounds which can be applied in synthesis of other useful chemical compounds or functional materials. Other important problem beyond limitation of CO_2 amount in atmosphere is related to possibilities of its conversion to chemical compounds which can be used as energy carriers. It creates numerous possibilities for its applications in renewable energy storage oriented systems. The proposed project is focused on photoelectrochemical conversion of one of the main greenhouse gasses, CO_2 – strongly absorbing radiation in NIR range – to ethylene.

The main scientific objective of the project is the development of methodology for electrochemical synthesis of binary and ternary composite materials in the Cu-Cu_2O-rGO and Cu-Cu_2O-CNT/CNF systems (rGO – reduced graphene oxide, CNT – carbon nanotubes, CNF – carbon nanofibers) as well as quaternary in the Cu-Cu_2O-rGO-CNT/CNF system. It is expected that synthesized materials will exhibit high catalytic activity towards selective photoelectroreduction of carbon dioxide to ethylene. Moreover, very essential studies related to optimization of electrolysis conditions creating possibilities of synthesis of materials containing high hydrophobic carbon nanostructures which exhibit simultaneously homogenous macroscopic structure will be also undertaken.

Copper is the only metal that exhibits very high selectivity for electrochemical conversion of CO_2 to ethylene [1]. Ren et al. observed similar effect in case of p-type Cu_2O [2]. Reported effects allows on assumption that combination of both materials can be great solution in the frame of light supported electrochemical conversion of carbon dioxide to ethylene. Additionally application of carbon structures: rGO, CNT or CNF as charge transfer mediators can limit photodegradation of Cu_2O, improve its chemical stability [3] and catalytic activity as well as selectivity for electrochemical conversion of CO_2 to ethylene [2]. Presence of highly hydrophobic CNT/CNF phase in Cu matrix may result in a significant improvement of selectivity through limiting adsorption of polar water molecules favoring simultaneously adsorption of nonpolar CO_2 molecules. The current proposal is multithreaded and includes many novel scientific problems which have not been addressed so far, but are still very interesting from scientific point of view. It should be underlined that in the literature, there are no papers devoted to electrochemical synthesis of multicomponent metal-semiconductor composite hybrid materials with incorporated carbon structures and analysis of their physicochemical properties. Essentially important, among others will be analysis of catalytic activity of synthesized materials, including selectivity as well as its efficiency in the frame of photoelectrochemical production of ethylene from carbon dioxide.

[1] Y. Kwon, Y. Lum, E.L. Clark, J.W. Ager, A.T. Bell, ChemElectroChem, 3 (2016) 1012-1019.
[2] D. Ren, Y. Deng, A.D. Handoko, C.S. Chen, S. Malkhandi, B.S. Yeo, ACS Catalysis, 5 (2015) 2814-2821.
[3] P.D. Tran, S.K. Batabyal, S.S. Pramana, J. Barber, L.H. Wong, S.C.J. Loo, Nanoscale, 4 (2012) 3875-3878.