Global CO_2 emissions exceed 30 billion tons per year, and over the last decade have increased by more than 15%, of which only about 1% is removed annually [1]. CO_2 is one of the main gases responsible for the greenhouse effect. As a result, in recent years the issues related to the reduction of its emissions as well as its processing have become extremely important. Electrochemical conversion is a promising, environmentally friendly method of utilization of carbon dioxide and can be an excellent way of storing energy from renewable sources in the form of hydrocarbons or other chemical compounds of great industrial importance. In the era of growing greenhouse gas emissions, which is the source of climate change, more and more attention is paid to research aimed at the development of stable catalysts that enable selective and efficient CO_2 conversion. Particular attention in the context of electrochemical CO_2 conversion is given to copper. Copper and copper-based catalysts are the most efficient catalysts known for electrochemical CO_2 reduction [2]. It is the only metal on the surface of which CO_2 reduction takes place with the formation of a C=C double bond, leading to the formation of hydrocarbons with a chain length of C_{2+} [3]. A very interesting solution that enables the use of solar energy is the photochemical conversion of CO_2, which has received a lot of attention in recent years. Unfortunately, a very big disadvantage of this method is the low efficiency and conversion rate. The photoelectrochemical method is an ideal solution that guarantees a high conversion rate and efficiency at the same time enables the use of solar energy. Unfortunately, like other methods, it requires the use of an appropriate, stable hybrid metal-semiconductor catalyst on the surface of which the carbon dioxide reduction reaction will run efficiently and selectively - at the same time enabling the production of specific products by controlling the process parameters.

B-doped graphitic carbon nitride (B-g-C_3N_4) is a particularly interesting semiconductor, also used for the photochemical reduction of CO_2 to fuels and other compounds important from the point of view of the chemical industry. It is cheap, easy to synthesize, harmless to the environment and, what is extremely important, it is very stable [1]. Due to its interesting properties, it has received a lot of attention in recent years [4]. The location of its conduction band, in the range of potentials lower than the values of red-ox potentials for the electrochemical reduction of CO_2 to CO, CH_4 and C_2H_4 making it very promising for applications related to photoelectrochemical CO_2 conversion. Taking into account the above, it can be assumed that the partial modification of the surface of copper or its alloys deposited by magnetron sputtering or by an electrochemical method consisting in the electrophoretic deposition of the B-g-C_3N_4 [5] will allow synthesizing materials exhibiting high efficiency and stability in the process photoelectrochemical reduction of CO_2 to hydrocarbons. Additionally, the use of copper alloys with Pd, Ag and Zn instead of pure copper will allow changing the value of the overpotential for electrode reactions responsible for the conversion as well as the sorption properties of the surface concerning CO_2 and CO molecules [6].

The proposed project is devoted to the synthesis and characterization of completely new, not reported previously materials that can have unique properties in the context of carbon dioxide reduction. The main research problem undertaken in the project is the development of a methodology for the fabrication of Cu-(Pd, Ag, Zn)-(B-g-C_3N_4) hybrid composite coatings deposited onto gas diffusion electrodes (GDE) and optimization of their properties towards photoelectrocatalytic reduction of carbon dioxide to hydrocarbons in an electrochemical flow reactor. The analysis of photoelectrocatalytic properties will be preceded by comprehensive studies of the obtained materials in the context of their structural and semiconducting properties, morphology and the ability to generate cathodic photocurrents. The characterized layers will be tested in terms of their selectivity, efficiency and stability in the process of electrochemical conversion of carbon dioxide to hydrocarbons. The layers will be deposited at the surface of gas diffusion electrodes using two alternative methods, making it possible to obtain materials that may differ diametrically in terms of their properties. The first is magnetron sputtering which allows obtaining thin layers of the catalyst with a morphology similar to that of the substrate. The second is an electrochemical method which, depending on the applied electrolysis parameters allows obtaining materials with different degree of surface development, from layers reflecting the morphology of the substrate, through porous layers to structures of a very diverse shape.

It should be emphasized that the literature lacks research on composites which are copper alloys deposited by magnetron sputtering or electrodeposition onto GDE with surface functionalized with electrophoretically deposited B-g-C_3N_4 as well as on the analysis of their physicochemical properties. Essentially important, among others will be analysis of photoelectrocatalytic activity of synthesized materials, including their selectivity, efficiency, as well as its stability in the frame of photoelectrochemical production of hydrocarbons from carbon dioxide.

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