The aim of this project is preparation, characterization and catalytic application of new effective mono (Au, Cu) and bimetallic (Au-Cu) catalysts deposited on $Nb_2O_5$, ZnO and CuO, and mixed oxides ($NbZnO_x$, $NbCuO_x$, $ZnCuO_x$, $NbZnCuO_x$) in low temperature liquid phase oxidation of methanol, glycerol, and benzyl alcohol with the use of oxygen or hydrogen peroxide as oxidants.

The characterization techniques applied in the project were so selected as to make it possible to secure information necessary to determine the influence of chemical composition of catalysts (qualitative and quantitative), location of copper (in the structure of the supports or on the surface of catalysts), similarities and differences in the interaction of the surfaces of catalysts with alcohols of diverse nature (aromatic vs aliphatic) and of different number of hydroxyl groups (methanol/benzyl alcohol vs glycerol), kind of oxidant (oxygen or hydrogen peroxide), and methodology of oxidation reaction (autoclave, reactors: microwave, batch, photocatallytic with UV light) on the activity and selectivity of prepared catalysts. This will facilitate investigation of pathways of alcohols oxidation reactions achieved using gold catalysts, as well as the determination of the impact of individual catalyst components and conditions of carrying out reactions for effectiveness of liquid phase oxidation of alcohols.

The motivation to use gold as active phase of catalysts for liquid phase oxidation reactions is fact that gold, when compared to other metals like Pt and Pd, exhibits higher resistance to deactivation in the presence of oxygen and other chemical compounds, as well as lower ability to C-C bond cleavage, which promotes higher selectivity to desirable products of oxidation. Another strong argument that can be made for the use of gold catalysts in this project is fact that factors affecting the activity and selectivity of these materials in liquid phase oxidation of alcohols are not well known and require further study. Niobium pentaoxide, copper oxide, and zinc oxide will be used in this project due to their strong interaction with gold, resulting in enhancing of catalytic activity of this noble metal. Moreover, these metal oxides also exhibit different acid-base properties of surfaces, which make it possible to investigate the influence of this parameter on activity and selectivity of gold catalysts in oxidation of alcohols. The use of mixed oxides instead of metal oxides as supports for gold catalysts could enhance the activity and selectivity of these systems by combining the properties of each component, and by generation of new active sites on the surface of mixed oxides.

Numerous value-added reagents for chemical industry such as aldehydes, ketones, acids, or esters may be produced as a result of oxidation of alcohols. These components are widely used in the manufacture of plastics, detergents, food additives, pharmaceuticals, perfumes, and cosmetics. Conventional liquid phase oxidation processes are performed using toxic and hazardous reagents like $KMnO_4$, in addition, they generate a lot of wastes and by-products, or by using homogeneous catalysts whose application is limited due to such disadvantages as low stability of catalysts, corrosivity, and difficulties of separation of catalysts from reaction mixture. Catalytic oxidation with the use of oxygen or hydrogen peroxides as oxidants in the presence of heterogeneous catalysts should constitute an alternative for the above mentioned processes. To date, many active and selective heterogeneous catalysts for gas phase oxidation of alcohols have been obtained. However, these processes require high temperatures, high temperatures translate to high energy and other costs. An example is gas phase oxidation of methanol to formaldehyde carried out using silver-based catalysts at the temperature of between 550 and 750°C, or by using iron-molybdenum mixed oxides at temperature in the range: 350 – 450°C. However, to date, there is no active and selective heterogeneous catalyst for low temperature liquid phase oxidation of alcohols. Research studies to solve this problem are currently being carried out in many laboratories all over the world. The proposed project also fits to this trend and includes both classical catalytic oxidation using oxygen or hydrogen peroxide, as well as photocatalytic oxidation.

The research proposed in this project could lead to synthesis of active and selective catalyst for low temperature liquid phase oxidation of alcohols but may also contribute to enhancement of fundamental knowledge on catalytic oxidation reactions using gold catalysts and environmentally benign oxidants such as oxygen or hydrogen peroxide.