The influence of gold and copper on activity and selectivity of Nb\textsubscript{2}O\textsubscript{5} in photocatalytic methanol oxidation

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In recent years a lot of attention has been paid to development of active and selective catalysts for photocatalytic methanol oxidation. So far, detailed studies on this reaction allowed the investigation of the mechanism of photocatalytic process and to determine the factors affecting the catalyst activity and selectivity [1]. Our studies are part of these efforts due to investigation of the influence of gold and copper, as well as gold-copper interaction on the photocatalytic activity of semiconductors. The selection of Nb\textsubscript{2}O\textsubscript{5} as a model support resulted from its high Brønsted acidity that is important factor for the attainment of high selectivity towards the most valuable products, e.g. dimethoxymethane [2]. The studies included synthesis of mono (Au, Cu) and bimetallic (Au-Cu) photocatalysts supported on Nb\textsubscript{2}O\textsubscript{5}. Copper was deposited by wet impregnation, while for the deposition of gold two different approaches were applied, i.e. deposition-reduction (DR) and grafting with (3-Aminopropyl)trimethoxysilane (APTMS). The catalysts prepared were characterized with ICP-OES, XRD, N\textsubscript{2}-adsorption/desorption, UV-vis, XPS, STEM-EDX, and in situ adsorption of pyridine and methanol. Photocatalytic activity of materials was studied in operando system under the irradiation with different light sources (monochromatic UV light, \(\lambda = 365\) nm; polychromatic UV light with different intensity and polychromatic visible light, \(\lambda > 390\) nm).

The results of photocatalytic activity of materials are shown in Fig. 1. From among all the catalyst prepared the highest activity in methanol photooxidation under polychromatic UV irradiation showed unmodified Nb\textsubscript{2}O\textsubscript{5}. The method of gold deposition has not affected the catalyst activity, but had significant impact on products distribution. Deposition of gold by anchoring allowed obtainment a high selectivity to dimethoxymethane, while deposition of gold by deposition-reduction led to the formation of \(\text{CO}_2\) as the main product. It was observed that copper-containing catalysts (Cu/Nb\textsubscript{2}O\textsubscript{5} and AuCu/Nb\textsubscript{2}O\textsubscript{5}) exhibited the lowest activity in MeOH oxidation under UV irradiation. Very interesting phenomenon was observed under visible light irradiation. From among all the catalysts prepared the highest activity was observed for bimetallic Au-Cu catalysts, while Cu/Nb\textsubscript{2}O\textsubscript{5} and Au/Nb\textsubscript{2}O\textsubscript{5} were almost inactive. The detailed analyses of relationship between the activity and selectivity of catalysts and their surface and physicochemical properties are the main issue of our presentation.

Acknowledgements
We are grateful to the National Science Center in Poland (project no. 2016/21/N/ST5/00533) and Erasmus+ exchange program for the financial support of this work.

References

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