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INVESTIGATION OF RUTHENIUM-MODIFIED GOLD-BASED PLASMONIC CATALYSTS FOR PHOTOCATALYTIC CO_2 REDUCTION

Streminskaia R.A. (ITMO University)
Scientific advisor – Doctor of Chemical Sciences, Associate Professor P. V. Krivoshapkin (ITMO University)

Introduction. The conversion of CO_2 into useful chemicals, such as methanol, is of great importance in addressing global energy and environmental challenges. Photocatalytic reduction of CO_2, utilizing solar energy, is a promising approach to mitigate climate change while producing valuable fuels. Plasmonic nanocatalysis, which takes advantage of the localized surface plasmon resonance (LSPR) effect in noble metal nanoparticles, shows great promise for boosting light-driven chemical reactions. Among different catalysts studied, gold nanoparticles (AuNPs) stand out because their strong LSPR in the visible range helps generate hot electrons and transfer charge, key processes for catalytic activity. This makes them a promising option for improving the efficiency of photocatalytic CO_2 reduction [1]. However, further optimization is needed to improve the selectivity and stability of plasmonic catalysts. One approach to achieving this is modifying gold nanoparticles with ruthenium (Ru), which can influence the electronic structure and adsorption properties of the catalyst. Ruthenium's ability to facilitate multi-electron transfer processes and activate key intermediates makes it a valuable addition, potentially enhancing the efficiency of CO_2 reduction. This study investigates ruthenium- modified gold nanoparticles supported on amorphous silica as a platform for optimizing the photocatalytic CO_2 reduction process [2].

Main Section. The study focused on gold nanoparticles modified with ruthenium at atomic ratios of 1:100, 1:200, and 1:400, with different nanoparticle loadings ranging from 1% to 20% w/w. The Ru-modified Au nanoparticles were synthesized using a wet-chemical reduction method and deposited onto silica via an impregnation technique. The catalysts were evaluated for their ability to convert CO_2 to methanol under visible light. The highest methanol yield was observed with an Au:Ru ratio of 1:200 and a loading of 10% w/w. This result is attributed to the synergistic effect between the plasmonic Au nanoparticles, which generate hot electrons under light irradiation, and the isolated Ru atoms, which serve as active sites for CO_2 adsorption, activation, and electron-proton transfer. Higher nanoparticle loadings (≥15%) may have reduced catalytic performance, while Au:Ru variations appeared to impact active site availability, with 1:100 causing oversaturation and 1:400 limiting formation.

Conclusion. The results demonstrate that ruthenium doping in gold nanoparticles significantly improves the photocatalytic reduction of CO_2 to methanol. The study provides valuable insights into the optimal Au:Ru ratio and nanoparticle loading, which are crucial for maximizing catalytic efficiency. These findings have implications for the design of advanced catalysts for sustainable CO_2 utilization.

References:

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