XPS studies of copper oxides as catalysts for hydrogen generation

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Hydrogen has appeared as an alternative fuel to replace fossil-fuel-based energy sources. Hydrogen is abundant but finding it in a free state is impossible. Due to its highly reactive nature, hydrogen does not exist freely. Green hydrogen can only be produced from electrolysis and other electrochemical reactions. Conversion of electricity or solar energy into chemical fuels via water splitting is a great challenge and the design of highly efficient and low-cost catalysts for hydrogen evolution reaction (HER) has attracted great attention [1]. In the current research, electropolished copper was anodized in 1.0 M NaOH, using a potentiostat and a 3-electrode system in order to form nanoneedles. The major novelty in the research was the application of electrolyte additives, enhancing the formation of the nanostructured passive oxide layer. Potassium permanganate, $KMnO_4$ was used as an oxidation booster during anodizing. Application of even 10^{-4} M $KMnO_4$ in 1.0 M NaOH was found to be advantageous for the nanostructured formation. The obtained materials were found to be promising for photoelectrochemical water splitting. Preliminary research reveals that thanks to the composition and morphology of the oxide efficient H_2 generation is possible. Figures 1 and 2 show detailed XPS spectra of Cu2p 3/2 and O1s, respectively. As can be seen from Fig. 1, Cu2p 3/2 spectrum on the lower binding energy side can be described by one peak which according to peak shape, binding energy position of 934.6 eV and position of modified Auger parameter (not shown here), can be subscribed to Cu(II) signal of $Cu(OH)_2$ which is furthermore supported by the presence of several shake-up signals above 938 eV on the left-hand side of the spectrum, which are only characteristic of the copper in 2+ oxidation state. This finding is additionally supported be O1s spectrum in Fig. 2 which generally can be described by one peak from the hydroxyl group.

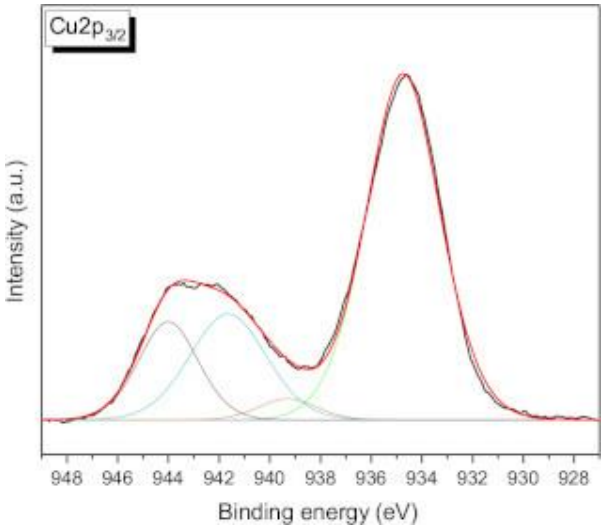

Figure 1. XPS spectrum of Cu 2p 3/2 in CuO

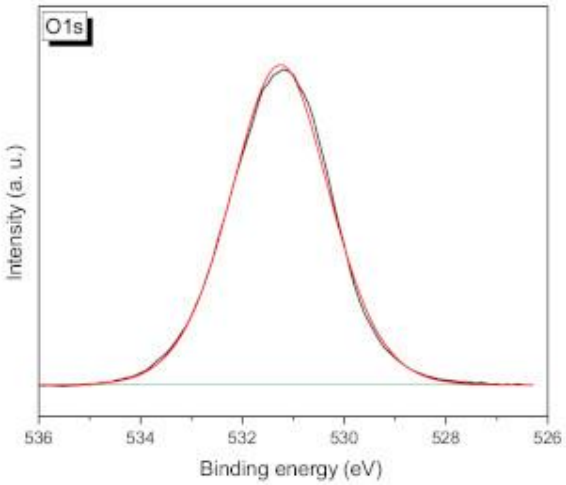

Figure 2. XPS spectrum of O1s in CuO

References

[1] S. Saedy, N. Hiemstra, D. Benz, H. Van Bui, M. Nolan, J. Ruud van Omme Dual promotional effect of CuxO clusters grown with atomic layer deposition on TiO2 for photocatalytic hydrogen production. Catal. Sci. Technol., 2022, 12, 4511

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