Oxygen reduction reaction on the "green" silver nanomaterial-coated electrodes

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In this contribution, we focused on application and understanding the activity of silver nanomaterials synthesized via a simple, one-pot eco-friendly process using brewery wastes, as catalysts of oxygen reduction reaction (ORR). The brewery wastes used in our work encompassed wort precipitate (BW5), brewer's spent yeast (BW7), and waste left after filtration (BW9).

Oxygen reduction reaction (ORR) is a significant reaction in biological processes, e.g., in respiration. It also gained importance in the field of energy conversion with development of fuel cells [1]. This reaction proceeds via two main routes in aqueous solutions (*i*) direct four-electron reduction of dioxygen to water or (*ii*) two-step process with two-electron reduction observed at each step. This leads to formation of hydrogen peroxide intermediate. The H_2O oxidation to O_2 and the O_2 reduction to H_2O require very high overpotentials [2]. The best known catalyst of the ORR is platinum. Unfortunately, this metal is rare and expensive. The search for alternative catalysts has led to the devising of several materials that successfully operate as commercial cathodes. However, designing alternative cathode materials is still challenging. To this end, silver nanomaterials gained attention as catalysts for ORR [3], as they are much cheaper than well-known catalytic metals, including platinum, palladium, and gold. Furthermore, the Ag nanomaterials were shown to be attractive alternatives for effective H_2O_2 production, which is important e.g. for wastewater treatment, decomposition of organic materials, textile and paper bleaching, and synthesis reactions.

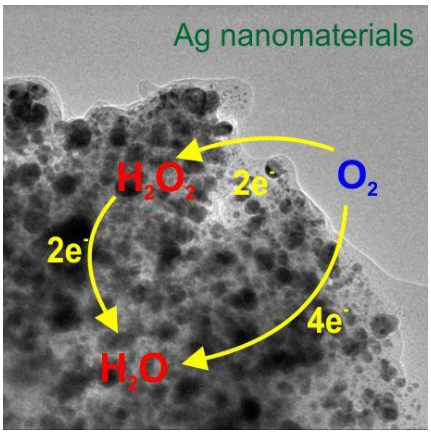

Figure 1: Oxygen reduction reaction on silver nanomaterials synthesized with use of brewer's spent yeast.

Herein, we describe electrochemical studies of a range of silver nanomaterials as catalysts for ORR. The materials synthesized with help of the brewery wastes were composed of Ag, AgCl and Ag_3PO_4 in various proportions depending on synthesis parameters. They formed agglomerated nanocomposites containing nanoparticles (NPs) with sizes 2 - 50 nm.. Voltammetric and rotating ring-disk experiments have shown, that these nanocomposites predominantly facilitated the two-electron ORR, producing H_2O_2. The nanocomposites rich in Ag_3PO_4 having a thin organic coating promoted faster transfer of electrons and improved oxygen adsorption. Furthemore, irradiating the materials with γ-rays influenced importantly the catalytic effectiveness of nanomaterials prepared using BW7 and BW9.

Acknowledgments

The funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No. 711859 and the financial resources awarded by the Polish Ministry of Science and Higher Education in the years 2017–2022, the European Regional Development Fund and Hungary in the frame of the project GINOP-2.2.1-15-2016-00012. the collaboration project between the Polish Academy of Sciences and the Hungarian Academy of Sciences (2020 - 2022), as well as, the NCN grant "Beethoven Classic 3" no. 2018/31/G/ST/02056), are gratefully acknowledged.

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