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Battery waste material catalyses the production of hydrogen peroxide

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Abstract

The waste powder from lithium-ion batteries (LiB) is a useful source of numerous elements, including carbon and metals. Despite having electrical conductivity, a nanostructured shape, and the possibility of metal oxides, this material has never been exploited as an electrocatalyst. The use of LiB waste powder as a catalyst for electrochemical H2O2 generation was demonstrated in this study. The powder was immobilised on a glassy carbon (GC) electrode and assembled at a liquid–liquid interface created by a solution of decamethylferrocene (DMFc) in trifluorotoluene and aqueous perchloric acid in the presence of oxygen. Cyclic voltammetry and a rotating disc electrode (RDE) were used to investigate the electrochemistry, and a 2-electron ORR pathway was confirmed. Colorimetry, UV–vis spectroscopy, and scanning electrochemical microscopy were used to detect H2O2 production at the liquid–liquid interface and DMFc oxidation (SECM). When compared to an unmodified GC, the ORR onset potential is reduced by about 0.3 V when LiB waste powder is used. The waste powder boosts the efficiency of H2O2 generation by around 20 times when constructed at a liquid–liquid interface.

Keywords: *Nanoparticle; Photoelectrochemistry; Electrocatalysis*

Introduction

One of the most important reactions in chemical energy conversion and storage is the oxygen reduction reaction (ORR). The 2-electron ORR creates H2O2 and can be used to produce this molecule in a sustainable manner. Because of its oxidative and bleaching capabilities, H2O2 is in high demand. It's a flexible green oxidant that's frequently utilised in organic chemistry. H2O2 is also frequently utilised as an active ingredient in disinfectants and antiseptics, as well as a taste and odour remover in water. Its use as a fuel and oxidant in fuel cells has recently been established. H2O2 is manufactured commercially via the environmentally dangerous anthraquinone technique.

Carbon-free technologies, such as electrochemical ORR, on the other hand, are more ecologically benign. Electrons can be provided by an external voltage source, photocatalytic oxidation of different hole scavengers, or both. ORR is thermodynamically advantageous in a non-aqueous environment and creates H2O2 in an acidified organic solvent or at the liquid–liquid interface created by an organic solvent and an acidic aqueous solution. In the latter situation, a sacrificial electron donor from the organic phase lowers oxygen in the presence of protons from the aqueous phase. ORR and other biphasic processes, such as interfacial electron transfer, hydrogen evolution, and water oxidation, are sped up by conductive nanoparticles generated/assembled at a liquid–liquid interface, which provides multiple electron routes. We will show how leached lithium battery (LiB) waste powder may be used to boost the efficiency of H2O2 production in a biphasic system, namely at the liquid–liquid and electrode–electrolyte interfaces.

The LiB waste is produced as a byproduct of the process of recovering lithium and transition metals from lithium battery electrodes. Because the waste contains carbon and cobalt traces, it appears to be an excellent candidate for a 2-electron ORR (electro)catalyst. We show here that LiB waste leached with acids for metal removal may be constructed at the liquid–liquid interface created by,,-toluene (TFT) and an acidic aqueous solution. TFT may be used instead of the previously suggested 1,2-dichloroethane for biphasic H2O2 production. Colorimetry, UV–vis spectroscopy, and scanning electrochemical microscopy were used to examine the reaction's development (SECM). Furthermore, we show that the same material put on an electrode surface increases 2-electron ORR in an acidic aqueous solution while significantly lowering overpotential.

Conclusion

In the presence of the strong electron donor DMFc in the organic phase, post-leaching LiB powder assembles at the liquid–

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liquid interface and displays catalytic characteristics towards 2-electron ORR. This suggests that the process is catalysed by more than just noble metal nanoparticles. Furthermore, the results obtained with LiB powder-modified electrodes show 2-electron ORR stoichiometry and a considerable reduction in the overpotential vs glassy carbon in acidic solution. It is still unknown if this catalytic action is caused by the presence of carbon as the major component of LiB waste and/or cobalt oxide. Both materials have previously been shown to catalyse 2-electron ORR. These findings suggest a potential application for the waste left over after transition metal recovery from lithium battery electrodes. The application of these materials for ORR in alkaline solution, as well as the influence of LiB composition, particularly the type of the carbonaceous material, are being studied.