Environmentally-benign Electrochemical Method for Formation of Catalytic Metal Nanoparticles in a Chitosan Matrix on a Stainless Steel Electrode

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We have developed a new method (patent pending) for formation of catalytic nanocomposite surfaces, with many potential benefits in energy and biomedical applications (among others). Recent work demonstrates an environmentally-benign process using electrochemistry to create metallic silver nanoparticles and clusters of nanoparticles within a chitosan matrix deposited on a stainless steel (304) electrode surface which in turns proves to be a potential catalytic surface for the oxygen reduction reaction (ORR). An electrochemically-deposited initial layer of chitosan strongly adheres to the passive layer formed on the 304 stainless steel electrodes. A subsequent layer of electrochemically-deposited chitosan forms silver nanoparticles and clusters of nanoparticles in the size range of 10 to 200 nm depending on processing parameters, in situ, rapidly and at room temperature. Our analysis indicates that hydrogen evolution during potentiostatic polarization of the electrode may play a key role in Ag ion reduction.

The overall coating has been shown to possess mechanical cohesiveness, flexibility, and durability (both of the matrix and the nanoparticles contained within). In addition, the method eliminates the need for strong reducing agents which present a safety and environmental hazard. Initial electrochemical analysis shows the surfaces to act as catalysts for the oxygen reduction reaction (ORR) while avoiding oxidation and reduction of the silver itself (which has proved to be a problem in other studies). Further, the surfaces are robust and do not degrade with atmospheric exposure. Infrared and UV-vis spectroscopies, X-ray photoelectron spectroscopy (XPS), synchrotron X-ray absorption techniques (XANES and EXAFS), and electron microscopy have been used to characterize the materials and indicate that chitosan provides protection from environmental degradation (as well as promotes formation of the nanoparticles) while allowing for catalysis and a degree of conductivity.

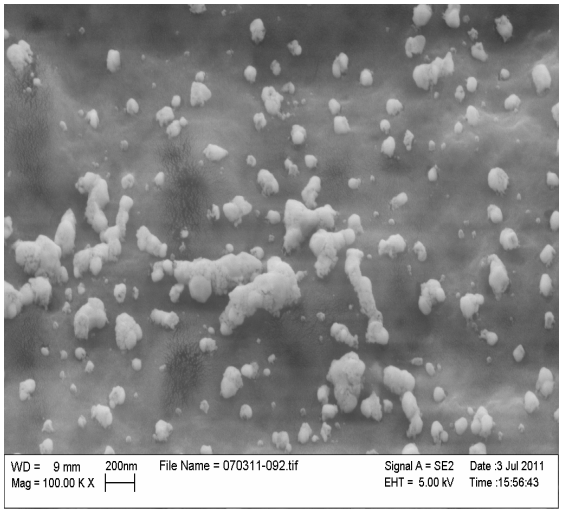

Fig. 1: Ag nanoparticles and clusters formed on a chitosan-304 stainless steel electrode