Abstract #2263, 224th ECS Meeting, © 2013 The Electrochemical Society

Utilisation of flexible nano-structured PEDOT electropolymerised from ionic liquids for one step (4-electron) oxygen reduction reaction

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As energy is a crucial element in human development, the demand for energy is skyrocketing since the rapid advances in technology and the imminent transformation from fossil fuels to alternative renewable green energy sources. The urge to develop new energy devices to keep up with such evolution and cover the increasing demand for energy has become crucial. Such devices should be light, durable and able to store (e.g. metal-air batteries) or generate a high amount of energy (e.g. fuel cells) with respect to their mass and volume.

Usually, fuel cells utilise noble metals as catalysts that are dispersed on high surface area carbon cathode, such as platinum and platinum composites. In particular such active materials are required to promote the sluggish oxygen reduction reaction (ORR) and generally give high current density for the reaction[1] but on the other hand, these materials are expensive and their composite electrodes exhibit poor mechanical stability[2]. Alternatively, a cheap and mechanically robust conducting polymer such as PEDOT has shown to be a good competitor to platinum as its effective ability for oxygen reduction has been demonstrated by Winther-Jensen et al[3]. Later studies[4] showed that the ORR can proceed at PEDOT via two pathways; a 4-electron process where the oxygen is reduced in one direct step into hydroxide or two consecutive 2-electrons steps where oxygen undergoes reduction first through a hydrogen peroxide anion intermediate and then to hydroxide in alkaline conditions. The morphology of the PEDOT film and the counter ion involved in polymerisation are said to be the factors that determine which pathway the ORR will take.

In this work, PEDOT is electropolymerised from ionic liquids onto flexible carbon cloths with different thicknesses and tested in both alkaline and acidic media for the ORR. Different techniques were used in order to examine the catalytic behaviour of the PEDOT films; (1) rotating disc electrode (RDE) to determine the number of transferred electrons during the ORR and (2) scanning electrochemical microscopy (SECM) to detect the presence of peroxide that may be produced through the ORR over the PEDOT film. Also, SEM is used to examine the morphology of the resultant PEDOT layer on the carbon cloth. The results collected from these techniques indicate the direct step for ORR over thick PEDOT however, thin PEDOT films showed the less favoured pathway with 2 consecutive ORR steps and the presence of peroxide intermediates.

References

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