RSC Advances

Oxygen reduction reaction at MWCNT-modified nanoscale iron(II) tetrasulfophthalocyanine: remarkable performance over platinum and tolerance toward methanol in alkaline medium†

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Abstract

A nanoscale iron(II) tetrasulfophthalocyanine (nanoFeTSPc) catalyst obtained by co-ordinating with hexadecyltrimethylammonium bromide and subsequently anchored onto multi-walled carbon nanotubes (MWCNTs) for oxygen reduction reaction (ORR) has been reported. Two types of MWCNTs, hydroxyl/carboxyl-functionalized (o-MWCNTs) and sulfonate-functionalized (s-MWCNTs) were used as the supporting platforms for the catalysts (nanoFeTSPc-o-MWCNT and nanoFeTSPc-s-MWCNT, only 9 wt% loading of the nanoFeTSPc). The nanoFeTSPc-o-MWCNT gave the best performance towards ORR in terms of high catalytic current density, more positive onset potential (E(subonset)= -0.02 V vs. Ag/AgCl), half-wave potential (E(sub1/2)= -0.32 V vs. Ag/AgCl), and high catalytic rate constant (k- 1.6x10(sup-2) cm s(sup-1)) compared to the nanoFeTSPc-s-MWCNT counterpart or the Pt/XC-72 (80% Pt loading). The ORR performance generally follows this trend: nanoFeTSPc-o-MWCNT > Pt/XC-72 > nanoFeTSPc-s-MWCNT. The MWCNT-modified nanoFeTSPc complexes are much better than observed for the individual components, nanoFeTSPc, o-MWCNT and s-MWCNT. In addition, the nanoFeTSPc-o-MWCNT essentially followed a 4-electron pathway, while the nanoFeTSPc-s-MWCNT followed a 2-electron pathway. The excellent performance of the nanoFeTSPc-o-MWCNT correlates very well with the more homogenous dispersion and higher degree of attachment of the nanoFeTSPc on the surface of the o-MWCNT than on the s-MWCNTs. Unlike Pt/XC-72, the nanoFeTSPc-o-MWCNT exhibited excellent tolerance toward methanol contamination. The excellent ORR activity of the nanoFeTSPc-o-MWCNT at a very low catalyst loading, coupled with its excellent methanol tolerance compared to the commercial platinum, promises to serve as a viable non-noble alternative to the expensive noble metal catalysts (such as Pt and Pd) for alkaline fuel cells.