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Vanadium doped TiO_2 as a novel support material for anode electro catalyst in polymer electrolyte membrane water electrolysers

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Growing concerns about global warming and energy security demand the expansion of renewable energy sources as viable alternatives to fossil-fuel-based technologies, in conjunction with improved energy storage options. In many of the innovative approaches to address these challenges, the production of hydrogen in various (photo)-electrolysis systems plays a pivotal role. To produce hydrogen using renewable energies, water electrolysis is a fundamental and flexible approach because of its compatibility with all types of electricity generation[1]. The state-of-the-art technology of water electrolysis is based on a solid polymer electrolyte(SPE). In comparison to the traditional device using alkaline solutions, SPE water electrolysis is more efficient in energy conversion and safer in application. However, the major drawback of the SPE is the need for electro catalysts based on platinum group metals. This especially concerns the anode, where so far only iridium based electro catalysts are known to withstand the severe conditions that occur at the anode during the oxygen evolution reaction (OER) [2]. Unfortunately, iridium is not only expensive, but also scarce, being about 50 times less abundant than platinum. Consequently, it is crucial to reduce the amount of IrO_2 in polymer electrolyte membrane water electrolysers if this technology is to become more widely used. One method is to disperse the precious metal nanoparticles on a support in order to maximize the specific surface area and enhance the specific mass activity of the catalysts.

In the present work, we report a novel support material for anode electro catalyst in SPE. Although it's bed electrical conductivity, TiO_2 is interesting to evaluate as catalyst support material due to its high stability at high potential in hydrous, acidic environment. So vanadium element is doped in TiO_2, which can introduce defects to give the non-stoichiometric oxide compositions $Ti_{(1-x)}V_xO_{2+\delta}$. The oxide compositions will exhibit a high electrical conductivity at room temperature. Further more, Mesoporous vanadium doped TiO_2 supports were prepared through modified Evaporation-Induced Self-Assembly (EISA)[3], which the specific surface area can be achieved at 137 m^2/g. The electro catalysts with varying content of IrO_2 were prepared, using a modified version of the Adams fusion method.

The X-ray diffraction (XRD) patterns of the synthesized electro catalysts samples are depicted in Fig.1. The samples TiO_2 and $Ti_{70}V_{30}O_{2+\delta}$, which were prepared by EISA and Adams fusion method, show a mixed phase with predominantly anatase phase peaks comparable with rutile phase. The small shift observed in the XRD peaks comparable with TiO_2 and $Ti_{70}V_{30}O_2$, which may be attributed to the incorporation of V inside the titania lattice. No other peaks from possible impurities/surface vanadium are detected.

The cyclic voltammograms of the IrO_2-based electro catalysts has been shown in Fig.2. A reliable, generally accepted electrochemical method of determining the active area, as it has for example been established for platinum, has not yet been found for iridium oxide. In the potential region between 0.5 and 1.5 V, the anodic and cathodic parts of the voltammograms for IrO_2 display a high degree of symmetry. The predominant influence of IrO_2 on the voltammetric response of the electrode is indicated by the anodic-to-cathodic charge ratio (Qa/Qc) being close to unity. However, a low degree of symmetry are displayed for the support loading 40wt.% IrO_2 and 20wt.% IrO_2. They are in agreement with the work of Polonsky et al. [4], who observed that the charge ratios of the electro catalysts increased when the content of the IrO_2 was reduced below 50 wt.%. These results indicate enhanced interaction of the support with the electrolyte. The CV of $40IrO_2/Ti_{70}V_{30}O_{2+\delta}$ shows larger active area than IrO_2 and $40IrO_2/TiO_2$. The present results demonstrate that $Ti_{70}V_{30}O_{2+\delta}$ may be a potential support for anode electro catalyst in SPE.

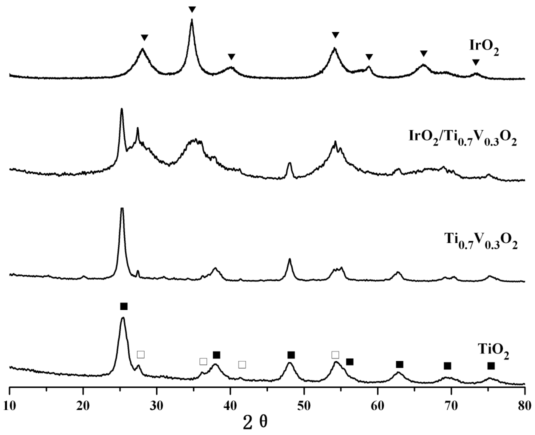

Fig.1 XRD patterns of of electro catalysts. ■ Anatase, □ Rutile, ▼ IrO_2.

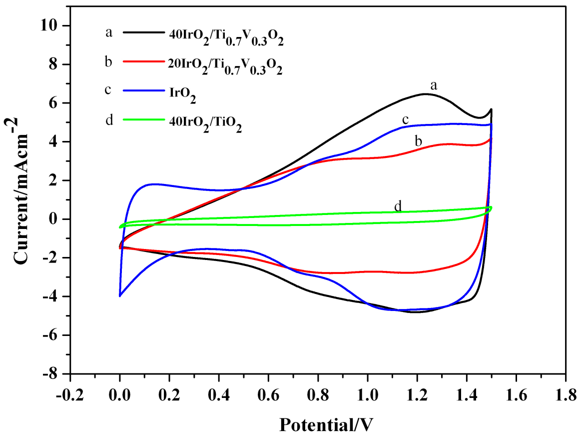

Fig.2 Cyclic voltammetry of electro catalysts in N_2-saturated 0.1M $HClO_4$ solution.

References

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