

(54) Title of the invention : A multi-interface heterostructure SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>-MoS<sub>2</sub> nanocomposite for water splitting application and a process for the preparation thereof

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(57) Abstract :

In electrochemical water splitting and metal-air energy systems, the noble metal-based catalysts (Pt, RuO<sub>2</sub>, IrO<sub>2</sub>, etc.) are quickly being replaced by electroactive and non-noble metal-based electrocatalysts because of their expensive nature and limited availability. This invention presents a novel bifunctional SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>-MoS<sub>2</sub> multi-interface heterostructure nanocomposite based on non-noble metals. It was synthesised using a straightforward three-step method including hydrothermal and sonochemical techniques, and has a coupled morphology of coral-shaped nanoflowers modified with nanocubes. The SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub> nanocubes was synthesised by sonochemical method followed by calcination process. Firstly a pink-coloured intermediate of CoSn(OH)<sub>6</sub> was formed after 30 minutes of sonication then a two-hour air-based calcination process was carried out in a muffle furnace at 500°C to produce a black precipitate of nanocubes of SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>. These SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub> nanocubes have an average diameter of 380 nm and the shell of these SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub> nanocubes is made by the aggregation of numerous tiny and ultrafine SnO<sub>2</sub> and Co<sub>3</sub>O<sub>4</sub> nanoparticles having an average diameter of 13 nm. Meanwhile MoS<sub>2</sub> coral-shaped nanoflowers was synthesised by a 12 hours long hydrothermal process. Several ultrathin 2D nanosheets, with an average thickness of 35 nm, have been combined and constructed to form these 3D MoS<sub>2</sub> coral-shaped nanoflowers. These MoS<sub>2</sub> nanoflowers have a single unit with an average diameter of 2–3 μm. At last, the SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>-MoS<sub>2</sub> novel nanocomposite was synthesized by a 2 hours long sonication step. Ultimately, this invented SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>-MoS<sub>2</sub> nanocomposite retains both the parental morphologies where the coral shaped MoS<sub>2</sub> nanoflowers are well decorated by SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub> nanocubes. When tested in laboratory, for oxygen evolution reaction (OER) and hydrogen evolution reaction (HER), the overpotentials of 192.3 mV and 204.98 mV at 10 mA/cm<sup>2</sup> and the significantly reduced Tafel slope of 99 mV/dec and 160.24 mV/dec were obtained in 2.0 M KOH and 1.0 M H<sub>2</sub>SO<sub>4</sub> electrolytes respectively. This invented nanocomposite demonstrated high stability over a 24-hour period in both HER and OER. The SnO<sub>2</sub>-Co<sub>3</sub>O<sub>4</sub>-MoS<sub>2</sub> nanocomposite needs a very low cell voltage of 1.45 V to obtain a kinetic current density of 10 mA/cm<sup>2</sup> for the water electrolysis in a 2.0 M KOH alkaline solution also, an outstanding stability of 48 hours was seen which is comparable and even better than most of the earlier reported noble-metal based (Pt, RuO<sub>2</sub>) electrocatalysts. Fig. 1

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