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Influence of Carbon on Electrochemical Behavior of Nano Molybdenum carbide (Mo_2C)

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Extended Abstract

Transition metal carbides (TMCs) are versatile materials used in wide variety of applications such as high speed drill bits, snow tires, electrical contacts, alloying elements, heating elements and as electro catalysts in fuel cells. The group IV-VI carbides show strong non- stoichiometric character due to the cubic nature of the host metal. This non-stoichiometric but stable nature of these materials exists over a wide range of carbon concentrations and thus can allow for the large concentration of vacancies. TMC's due to their unique band structures find applications as electro catalysts in fuel cells as a replacement of the noble metals such as Pt, Pd, Ru. The non-stoichiometric nature of these compounds results in modification in their electronic band structures and hence influence the catalytic performance as a function of carbon content within the lattice. The surface coating of carbon also improves the catalytic properties of the TMCs. Currently these materials are considered as promising candidates to replace the costly noble metal catalysts in water splitting, fuel cell applications, dye sensitized solar cells (DSCs) and microbial fuel cells (MFCs) etc. The present work highlights the dependence of carbon concentration on electrocatalytic performance of molybdenum carbide (Mo2C), a fascinating and promising candidate for electrochemical water splitting. Nano Mo2C have been synthesized in a specially designed autoclave at relatively low temperature (600°C–800°C). The variation in the stoichiometry of the compounds has been achieved by varying the synthesis parameters (temperature, time and carbon concentration). The lattice carbon content has been calculated with the help of rietveld analysis of the XRD data. The electrochemical studies of nano Mo2C were performed in acidic medium. The high current density was achieved at low potential values. The Linear sweep voltammetry (LSV) measurements were done at scan arte of $2mVs^{-1}$ within a potential range of 0 to -0.3 V. The variation of carbon content within the lattice affects the current density. The cyclic voltammetry (CV) analysis was done in potential range of 0.2 – 0.3V at scan rate of 100 mVs^{-1}. The synthesized sample shows the higher stability and retains the similar current density value after 3000 cycles as shown in Fig. 1. The adherent nature of surface carbon affects the stability of the electrocatalyst, which is highly desirable. The tafel slope estimation shows that synthesized material can be a good substitute to replace costly traditional noble metal electrocatalysts. The electric double layer capacitance (Cdl) and electrochemical impedance spectroscopy (EIS) results suggest that the synthesized material is also suitable for energy storage applications. The EIS plot of Mo2C at different potentials 50 to 550 mV within the frequency range 100 KHz to 300 mHz is shown in Fig. 2. The results reveal the enhancement in charge transfer kinetics due to presence of graphitic carbon coating.

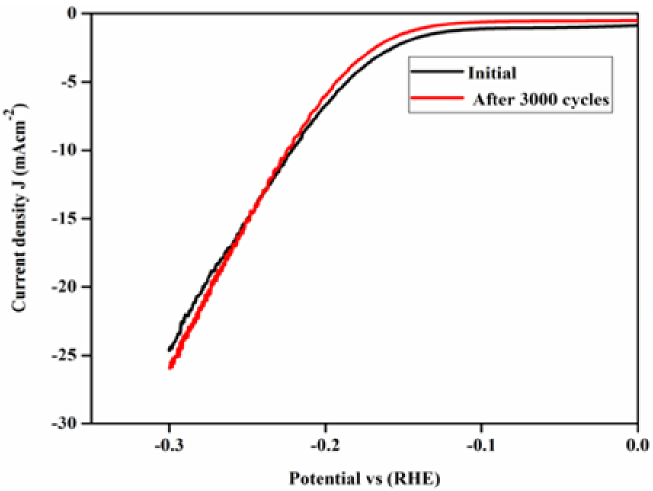

Fig. 1: LSV of Mo_2C before and after 3000 cycles.

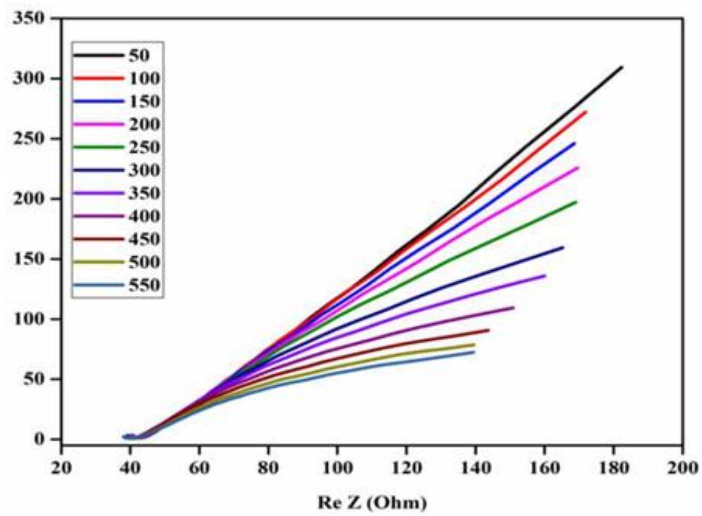

Fig. 2: EIS of Mo_2C from 50 to 550 mV.