STUDIES ON FUEL CELLS : EFFECT OF SURFACE OXYGEN COMPLEXES OF SUGAR CHARCOALS ON THE ELECTROCHEMICAL REDUCTION OF OXYGEN

A Thesis Submitted
In Fulfilment of the Requirement For the Degree of
DOCTOR OF PHILOSOPHY

BY
G. VASUDEV

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CERTIFICATE

This is to certify that the thesis entitled, "Studies on Fuel Cells: Effect of Surface Oxygen Complexes of Sugar Charcoals on the Electrochemical Reduction of Oxygen" submitted by Shri G. Vasudev to the Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to the best of my knowledge, has reached the requisite standard.

The results contained in this thesis have not been submitted in part or in full to any other University or Institute for the award of any degree or diploma.

N.K. Sandle.

(N.K. SANDLE)
Assistant Professor,
Chemistry Department,
Indian Institute of Technology
New Delhi-110016.

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Abstract

The present work is a study on fuel cells. Carbons which are extensively used in fuel cells as electrode materials, have surface oxygen complexes. The effect of these surface oxygen complexes on the individual electrodes i.e., the anode and the cathode is studied and presented in the thesis in six chapters.

The first chapter summarises the extensive literature available, with a particular emphasis on methanol fuel cells, role of carbons in fuel cells, their electrochemical activity and metal phthalocyanines as catalysts for the electrochemical reduction of oxygen. The literature survey showed that work on single cell fuel cells is scanty and though many workers have carried out research on the identification of surface functional groups on carbons, very few have worked on the effect of these surface complexes on the electrochemical properties. The first chapter also includes the scope of the present work.

The second chapter deals with the experimental techniques used for various investigations. Procedures for the preparation of sugar charcoal samples, metal phthalocyanines, and various measuring techniques are outlined.

In the third chapter, the characterisation of prepared samples are described. IR and ATR studies were carried out for the identification of surface complexes on charcoal samples. Amounts of CO, CO_2, H_2O and H_2 complexes present on the charcoals

were determined. These results were substantiated with base adsorption studies on the charcoal samples with n-butylamine and barium hydroxide solutions. Surface morphology was also studied with the help of scanning electron microscope. The nickel ferrite prepared was also characterised by Curie and Ponderometer methods.

The fourth chapter presents the studies carried out on a demonstrative alcohol-air fuel cell. The fuels were methanol and ethanol and the oxidant was oxygen from air. Platinum and silver electroplated on a copper wire mesh formed the fuel and oxidant electrodes respectively. The temperature coefficient of cell voltage, conductance, current and wattage were measured. Theoretical voltage of the cell was calculated and compared with the experimental results.

The fifth chapter contains the studies carried out on the effect of surface oxygen complexes of sugar charcoal on the half cell potential of carbon-nickel ferrite electrodes. Sugar charcoals having different amounts of oxygen complexes were mixed with nickel ferrite and the half cell potentials of the electrodes made out of these mixtures were measured with respect to a SCE. The results obtained were discussed in terms of surface oxygen complexes and a mechanism was suggested for the adsorption.

In the sixth chapter results obtained for the electrochemical reduction of oxygen are discussed. Metal phthalocyanines (Fe, Co, Ni) were precipitated in different amounts on different

charcoal samples with varying amounts of surface complexes. For comparison platinum was also deposited on different charcoals. The electrochemical reduction of oxygen was studied on these samples and results were discussed with particular emphasis on the effect of surface oxygen complexes. An attempt was made to compare the BET and electrochemical surface areas of sugar charcoal samples.

The seventh chapter consists of the summary of the present work.

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