

**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
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**to the
DEPARTMENT OF CHEMISTRY
INDIAN INSTITUTE OF TECHNOLOGY, DELHI
FEBRUARY, 1981**

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.

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ACKNOWLEDGEMENTS

The "philosophy" that I learned pursuing the "Doctor of Philosophy" is that research is never a one man act. Scores of people directly or indirectly were involved in my research programme and, thank God, every one had facilitated me in my pursuit. I feel that I am lucky in this respect, and I bow to all of them, with a deep sense of gratitude.

First and the foremost among them is my thesis Supervisor, Dr.N.K.Sandle, Assistant Professor, for his heuristic approach, for allowing complete freedom of work, for initiating me into this "research culture " and for warm heartedness.

To Prof.R.P.Gandhi, Head, Chemistry Department for his unfailing help in every aspect, for providing me with all the facilities in the department and for tidying up my messy and sloppy english.

To Prof. (Mrs). P. Vasudevan for lending me a helping hand, when I badly needed it and for patiently going through the manuscript and for her excellent remarks.

To Profs. J.C. Ahluwalia and R.D.Dua, former Heads of department, for their help in the earlier stages of my work.

To Prof.M.S.Sodha and S.S.Mathur, Centre for Energy Studies, for their financial help.

To Drs. Siva Prasad, Satish Nanda, Prasad, Xavier and Nirupam, for going through the manuscript and for their useful comments.

To my colleagues, Dubo, Mishra, Jasra, Thakur, Rao, Reddy and a host of others.

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To all my dear friends, Shashi, Shankar, Sarma, Shilpi, Neeraj, Ravi, Krishnan, Shankar, Reddy, Seshu and Sivudu, who comforted, prodded, cajoled and helped me in my personal and professional life and who always tried to keep my "Spirits" high and elevating them, whenever, I was in frustrating moods and also, without their active involvement, this work would have been completed much earlier.

A special thanks to Dr. N.S. Manyam, with whom I shared some of the best evenings of my life and for his never to ending help.

To Messrs. Mannan, Shingal and Bani Singh, of glass blowing workshop for their ungrudging cooperation.

To N.L. Arora, the master draftsman, who could transform scientific figures into artistic figures.

To Jagdish Kumar Lohia, for typing my unreadable manuscripts and for not only using his fingers (which all typists do) but also more importantly, using his brains to eliminate the lapses I committed in the collation work.

To my mother, who always prayed for me.

To my father, who could put up, with a smile, all my idiosyncrasies.

To Mr. K.V.R. Moorthy, my sister and their three darling sons, who made me feel at home in a place far away from home.

(iii)

To all my brothers, Shyamanna, Ramana, Raja, Prabha, Gopi and Giri, who always tried to keep me away from mundane affairs and helped me do my research without distraction.

To my youngest sister, Gita and Mr. Gopinath, who always had something nice to say about me.

G. Vasudev
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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, CO₂, H₂O and H₂ complexes present on the charcoals

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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

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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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