Yu. V. Pleskov and V. Yu. Filinovskii

THE ROTATING DISC ELECTRODE*

Reviewed by B. N. Kabanov

In Yu. V. Pleskov and V. Yu. Filinovskii's monograph, the basic theoretical principles of the rotating disc electrode are set forth, and voluminous experimental data are systematically analyzed. Owing to a number of technical peculiarities, the rotating disc electrode has now become one of the principal tools for studying the kinetics of electrochemical reactions on solid surfaces. The theory of the method, which has been developed chiefly by Soviet scientists, rests on modern concepts of hydrodynamics and of mass transfer theory. The number of publications concerned with various applications of the rotating disc electrode exceeds 700. However, these publications are scattered in the form of papers in numerous journals. The appearance of a book which summarizes the information on the rotating disc electrode is therefore very timely.

The book consists of nine chapters and an appendix. Fundamental aspects from hydrodynamics which are required in order to build up the quantitative theory of mass transfer are set forth in the first chapter. Hydrodynamic theory is used in the second chapter to calculate the rate of transport of material. Given here are the basic relations describing the rate of mass transfer under laminary and turbulent conditions, and the rate of mass transfer is analyzed as a function of flow parameters. The problem of the overall rate of a reaction composed of a mass transfer step and of the proper heterogeneous conversion step is discussed in the third chapter. Procedures are discussed with which one can exclude the influence of the step of mass transfer to the reaction surface and which serve to determine the reaction rate constant and reaction order. A special section is devoted to the kinetics of heterogeneous conversions on an inhomogeneous surface. The contents of the fourth chapter, where current passage in a cell with rotating disc electrode is considered, touch upon a wide range of problems at the electrochemical plane. Here, the relatively new electrochemical problem of the structure of the nonequilibrium electric double layer at the disc electrode is analyzed besides general problems such as that of examining the physical situation in the passage of electrical current. Transient processes at the rotating disc are discussed in Chap. 5. Original results obtained by the authors are presented here in significant proportion. These results are of interest in view of the increasing importance of nonstationary methods of electrochemical measurements. Chapter 6 is concerned with the study of mass transfer processes accompanied by chemical conversions of the substances being transferred. It is shown how the rotating disc can be used to measure the rate constants of chemical bulk reactions. Chapter 7 is a broad survey of applications of the rotating-disc method. Problems of electropolishing, the anodic dissolution and corrosion of metals, the dissolution of nonmetals as well as of convective diffusion in systems where the solution properties depend on local electrolyte concentration are considered in particular. Chapter 8 contains theoretical and experimental data on the rotating disc electrode with ring. This modification of the disc electrode is most promising in electrochemical investigations. Interesting information was obtained on the mechanism of the oxygen ionization reaction, which is important in theoretical and applied respects. The most recent achievements are also discussed in this chapter: the rotating disc with sectioned ring, the method of titration in the diffusion layer, etc. Finally, the currently known designs of rotating-disc assemblies are described in Chap. 9.

One must record when summarizing the impressions from a perusal of the book that it is logically written and that the material is clearly exposed. A qualitative description of the resulting effects precedes

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the deduction of the mathematical relations. Each section contains information on an experimental test of the theory and terminates with a survey of experimental data. Literature data are critically discussed. It is also a virtue of the book that frequently the authors employ the rotating disc as an illustrative example to describe current methods of theoretical macrokinetics and for the use of these methods in studying the laws of convective mass transfer. For this reason the book should prove useful not only to electrochemists but also to a wider audience of physical chemists and chemical engineers.

In our opinion, the book is not free from certain defects. For instance, its excessive burden of detailed exposition of secondary questions, of bibliographic and handbook data seems unnecessary. It would have been more correct in each chapter somehow to single out the material of fundamental importance (physical fundamentals, the mathematical statement of the problem, the discussion of the most important results) and to relegate nonfundamental questions (intermediate computations in the solution of equations, the detailed description of experimental techniques,and the like) to a secondary plane.

In the perusal of the book one must also keep in mind that the rotating-disc method develops continuously and very intensely, so that some problems which in the book are examined from the position of qualitative or semiquantitative concepts have now already been studied exactly quantitatively by using numerical methods and fast computers. This applies, for example, to the method of calculating kinetic and catalytic currents (Chap. 6) and to the simplified discussion of the effect of chemical reactions when presenting the method of the disc electrode with ring (Chap. 8).

On the whole the book positively deserves a high rating. It will prove to be of great help both to the specialists using the rotating-disc method and to electrochemists studying new electrochemical tools and techniques.