DISINFECTANTS

THEIR VALUES AND USES

W. E. FINCH

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BY

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WITH A FOREWORD BY

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Foreword

IT is rather curious that although the subject of disinfectants and disinfection is not lacking in published research papers and treatises, yet, considering its importance, the number of published textbooks is singularly few. Moreover, when these books attempt a survey of the whole field of disinfection, the author usually adopts the role of editing the existing publications and compiling an account into book form because he lacks personal experience and knowledge of more than a fraction of the total. Such books, valuable as they are, rarely answer the question of the comparative evaluation in practice of those disinfectants which are used in large quantities for the various purposes of general hygiene. For this reason alone, I think this book is almost unique, for the author has spent most of his working life on this very aspect of disinfectants and in manufacturing laboratories, where he has had to work out for himself the details of evaluation, standardization, formulation and the problems of large scale manufacture of the phenolic disinfectants and the active quaternary ammonium compounds. He rightly brings into the picture for comparison the hypochlorites, for these three classes constitute our main armamentaria of disinfectants which can be produced economically for large scale work. He produces a wealth of his own practical experiences and much of a type which has never been published. Thus the extremely important subject of formulation, which constitutes the 'know how' of producing active and stable products, is discussed and he produces for the first time details of the manufacture of Black and White Fluids and the 'Lysol' types. These, to anyone outside a manufacturing establishment, have long been mysterious preparations, variable in composition and activity, and so difficult to standardize. He brings into perspective the synthetic phenolic derivatives such as the Chloroxylenols.

His work on carriers alone makes foolish any attempt to maintain the Rideal-Walker type of test as a general evaluation test, and places it in its right sphere as merely a batch test and, moreover, only remaining in existence as a biological test because of the absence of a suitable chemical method. By reasoning that a simple *in vitro* test using an aqueous suspension of bacteria is merely a sorting test for bactericidal action, he recognizes that environment is important. He thus brings the Chick-Martin test into perspective and evaluates it as a measuring factor. The same reasoning that surfaces must have an effect on disinfectants led him to his work on fabrics and he here again, with his results, opens up another field of research which by producing a 'bactericidal blanket' may make a great contribution to that most urgent of problems, the prevention of cross infection in wards.

The work on the sterilization of skin will be welcomed and, I think, accepted. I have a feeling that this work is timely in that there is a growing anxiety that the extensive use of antibiotics in producing new resistant organisms, is staging a return to, and re-evaluation of the old antiseptics and bactericides in surgical practice.

The methods of assay used by the author are inevitably from his work of the extinction type as in the Rideal-Walker test. For this reason it would not be wise to treat the results as strictly quantitative (I doubt if the author would claim this) but rather as qualitative results indicating trends.

I found the book most stimulating and I feel certain that it will be welcomed by research workers, manufacturers and all those users of disinfectants who take an intelligent and responsible interest in these important products.

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Author's Preface

IN COMMON with all other branches of applied science, recent years have been marked by increased knowledge leading to new techniques in the manufacture and use of disinfectants and antiseptics. While a number of papers and references covering many of the developments that have taken place have appeared in scientific journals and similar publications, little effort has been made to deal with the subject as a whole.

In the present volume an attempt has been made to give a balanced survey of all types of disinfectants and to indicate the uses and limitations of the various groups. It appears to the author that in the past there has been a lack of appreciation of the comparatively narrow range of effectiveness of certain types which has led on some occasions to the making of recommendations for purposes for which a product has not been well suited.

Our knowledge of the problems involved and the behaviour of various organisms under differing conditions is still expanding and it is realized that on this account some of the opinions expressed in this work may be open to some degree of controversy. On the other hand, it is believed that a number of established investigational results, some hitherto unpublished, have been collected together in one cover and if some discussion takes place on the basis of facts presented, nothing but good should result.

My thanks are due to Professor H. Berry, B.Sc., F.P.S., F.R.I.C., Dip. Bact., for the gift and for the loan of many reprints and journals. I am indebted to Mr. P. A. Lincoln, M.Sc., for the loan of numerous reprints and references to the literature on the hypochlorites. To Mr. R. A. Acheson of R. S. Haldane Ltd. I tender thanks for literature on D.C.M.X., while the number of authors who have given or loaned reprints, or who have advised on their work are too numerous to mention here, but to whom I offer my grateful acknowledgments. My colleagues past and present who have helped in numerous ways include S. J. Street, E. A. F. Wright, Mervyn Hicks, A. Rubbra, R. A. Stephenson, and R. J. Binnington, and to them I express thanks.

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CHAPTER ONE

A Brief History of the Practice of Disinfection

Historical Background

ALTHOUGH the ancients knew that putrefaction and decay could be arrested and discovered certain remedies and preventatives for some infections, it was not until Pasteur had demonstrated in 1862 that fermentation was due to the presence of micro-organisms—thus disposing of the theory of the spontaneous generation of life—and Lister in 1863 had proved that aseptic surgery was possible, that sufficient facts had been accumulated to allow of a sound and scientific approach to the problem of disinfection.

Development of Disinfectants

Lister used the carbolic spray in his new surgical technique, but the early methods of comparing disinfectant values soon established that the cresols and higher phenols were more germicidal than phenol. The pioneers of the coal tar disinfectant industry found that efficient disinfectants could be made without prior extraction of the phenols from the tar oils; by dissolving soap, usually rosin soap, in tar oil or creosote it could be made to form stable emulsions in water. These were the original black fluids which were manufactured in the latter half of the nineteenth century.

John Jeyes[1] patented his disinfectant, which was a rosin soap dissolved in creosote, on 7 December 1877; this was, in all probability, the first black disinfectant to be manufactured in Great Britain. Engler and Dieckhoff[2] (1892) reviewed the history of the saponaceous coal tar disinfectants and stated that in 1874 tar oil and soap, about which little was known, was being produced commercially.

In 1887 mixtures of tar oil and soap which would form emulsions in water were mentioned for the first time in chemical journals, while in 1889 Damman[3] patented a method for preparing tar oil in soap solution. The original 'Lysol' was based on this patent by Schulke and Mayr of Hamburg. Engler and Dieckhoff also referred to the increase in water solubility of the cresols by the use of soap, and considered that the tar oil soap mixtures were of two types. The first a solution of tar oils in soap and the second a solution of soap in tar oil; the first, 'Lysol', gave a clear solution in water, and the second, 'Kreolin', an emulsion.

It was later found that the soaps of some fatty oils, notably castor oil, when used with the same tar oils gave appreciably higher germicidal values leading to the development of the modern black coal tar disinfectants.

Damman's disinfectant of 1889 gave clear solutions in water. This, according to the specification, could be made by using a potash soap with linseed oil or colophony and a tar oil of unspecified phenols content. Alcohol was used in the saponification of the soap and could be removed by distillation if desired. Provision was made for halogenation as well as other treatment. The soap content was of the order of 40–50 per cent so that the solution of the product in water would probably be clear even if some hydrocarbons were present. Liquor cresoli saponatus B.P. (1914) was a solution of cresol, which distilled 90 per cent between 195°C. and 205°C., in castor oil soap.

In the early part of the present century there appeared the white fluid, a concentrated emulsified form of tar oils and phenolic homologues (tar acids) which would readily dilute with seawater. Rideal[4] (1903) refers to Izal, which was probably the first white fluid to be produced in the United Kingdom. Its maker, Mr. Worrall, claimed that its most valuable property was its insolubility in water. The germicidal action of dispersions of phenols will be discussed later.

Many germicidal agents were already recognized, which included the hypochlorites which were used in the middle of the nineteenth century against water-borne infection and formaldehyde which was stated by Loew[5] (1886) to be a protoplasmic poison and to damage the cell nucleus of algae. These have been followed at intervals by many others including the chloramines, the substituted and halogenated phenols, the quaternary ammonium compounds, hexachlorophene, phenoxyethanol and chlorhexidine, all of which will be discussed later.

The Development of Bacteriological Testing of Disinfectants

The first attempt to measure the bactericidal activity of disinfecting agents was made by Koch[6] (1881), who used silk threads on which anthrax spores had been dried. Kronig and Paul[7] (1897), after trials with glass beads, used carefully matched and washed stone garnets in order to obtain even distribution of a bacterial spore suspension on their surfaces. These were then dried over calcium chloride at 7°C. for at least twelve hours and then stored away from light. It was assumed that, as the garnets were evenly wetted with the bacterial suspension, each had approximately equal numbers of spores dried on them. The washings from the garnets, after disinfection with mercuric chloride solutions, were plated in agar in petri dishes to observe the colonies developing, to obtain quantitative results.

In 1903 Rideal and Walker[8] published their test which was revised and published by the British Standards Institution[9] in 1934. This technique was a departure from those of Koch and Kronig and Paul in so far as their methods involved the disinfection of surfaces while the Rideal-Walker test measured the value of the agent for disinfecting pure cultures of *Bacterium typhosum*.

Various modifications of the Rideal-Walker test have appeared from time to time of which it is probable that the most important was that published by Chick and Martin[10] in 1908, which although using a pure culture of *Bacterium typhosum* introduced organic contamination as a suspension of dried and ground faeces. This test was modified in 1938 and published as a standard by the British Standards Institution,[11] when the dried faeces was replaced by a standard suspension of yeast.

American modifications of the Rideal-Walker test are the Hygienic Laboratory Test[12] of 1921 which was later superseded by the Foods and Drugs Administration (F.D.A.)[13] test which uses *Bacterium typhosum* but makes provision for a second test organism, *Staphylococcus aureus*; a later modification published by the Association of Official Agricultural Chemists[14] introduces changes of culture media for the types of disinfectant tested. Official approval dilutions based on this test multiplied by twenty are now checked by a Use-Dilution Confirmation test to ensure that they sterilize metallic surfaces on which cultures of *Bacterium cholerae-suis* or *Staphylococcus aureus* have been partially dried.

Needham[15] (1947) used his nephelometer[16] to measure turbidimetrically survivor levels of *Bacterium typhosum* against pure carbolic acid and disinfectant dilutions to obtain a phenol coefficient. The use of a survivor level in place of the positive-negative end point of the Rideal-Walker type test is claimed to give greater reproducibility of results although Berry and Bean[17] (1954) obtained an accurate end point using a complete kill in their technique in which standard drops of culture-disinfectant mixture are quenched at specified intervals with a nutrient broth.

Cousins[18] (1951) compared quaternary ammonium compounds by a method in which whole milk was used as the organic contaminant and *Bacterium coli* the test organism and used a plating technique to determine survivor levels.

The differences in the Rideal-Walker, Chick-Martin, and F.D.A. Tests are listed as follows:

TABLE 1.1

Details of the standard bacteriological techniques for testing disinfectants

Test Organism	RIDEAL-WALKER *B. typhosum* Lister strain N.C.T.C. 781	CHICK-MARTIN *B. typhosum* 'S' strain N.C.T.C. 3390	F.D.A. *B. typhosum* Hopkins strain *S. aureus* Insecticide strain
Culture medium	2% Eupeptone No. 1 2% Lab-lemco 1% salt pH 7·4	1% Eupeptone No. 1 1% Lab-lemco 0·5% salt pH 7·6	1% Armours peptone 0·5% Lemco 0·5% salt pH 6·8
Amount of inoculum	0·2 ml.	0·1 ml. broth culture up to 2·5 ml. with 5% yeast	0·5 ml.
Volume of disinfectant	5 ml.	2.5 ml.	5 ml.
Organic matter	Nil	2·4% (dry weight yeast)	Nil
Method of determining end point	Dilution showing life in 5 min. and no life thereafter	Mean of dilutions which kill and fail to kill in 30 min.	Dilution showing life in 5 min. and none in 10 min.

Specificity of the Newer Disinfectants

Disinfectants generally have their own distinctive properties, particularly in respect of their compatibilities and the types of organism against which they are effective. The coal tar fluids, namely those based on carbolic acid and its homologues, are generally accepted as possessing a wide killing range among the different classes of microorganisms. This non-specificity of bactericidal action is not shared by most of the newer germicidal agents; for example, the substituted phenols generally become increasingly effective against the Gram-positive organisms and decreasingly so against the Gram-negatives as molecular complexity increases beyond a certain level; the quaternary ammonium compounds are more active against the Gram-positives generally although they are effective against the Gram-negative coliform organisms. The last two groups of disinfectants are relatively ineffective against the pseudomonas group of bacteria. Phenoxyethanol is effective against the pseudomonas group while chlorhexidine has a wide bactericidal spectrum that includes this group of organisms. It is certain that the techniques of testing disinfectants which exhibit specificity have not kept pace with their production and that more enlightened methods of testing are necessary to assess their value.

Application of Disinfectants for Particular Uses

A general disinfectant should be non-specific in its germicidal action. This property is possessed, among the more ordinary disinfectants, by those based on the coal tar phenols which are, however, generally toxic and often possess a characteristic odour which may debar them from certain uses in the food industry. The cresols are necrotic to the skin while the higher aromatic hydrocarbons may be carcinogenic; this might prohibit their use as skin disinfectants. The chlor-phenolics are weak in their action against the pseudomonas group, and they should not therefore be used in surgical units where skin grafting is practised. They are relatively bland to the skin and are very effective against the haemolytic streptococci, which makes them eminently suited for use in obstetric practice. Certain types of quaternary ammonium compounds are effective in high dilution against the micro-organisms responsible for food spoilage; furthermore in such dilution they are odourless, tasteless and non-toxic. The Gram-positive pyogenic organisms are rapidly killed by them. They are also strongly adsorbed to certain surfaces, imparting an antibacterial effect that can last for considerable periods. This gives them an almost unique value for laundering.

The uses of some disinfectants are limited by poor solubility or miscibility in hard or saline waters, others are badly inactivated by organic matters.

A disinfectant, while being effective for a particular use may possess refinements or qualities that are not required. These may add unnecessarily to its cost so that a selection from the types of disinfectants available based on consideration of the anticipated conditions of use could effect considerable economy.

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