

Frontier molecular orbital theory and organic reactions

Frontier Orbitals and Organic Chemical Reactions. By Ian Fleming. Pp. vii+249. (Wiley-Interscience: London and New York, 1976.) £3.95; \$8.50.

ORGANIC CHEMISTS have traditionally used resonance theory and handy 'arrow-pushing' methods of electron book-keeping to rationalise their reactions, or to predict new results. Although organic chemists used Hückel's model to predict stable and unstable cyclic conjugated systems, molecular orbital theory was not generally used as a qualitative predictive tool until Woodward and Hoffmann devised the classic orbital symmetry selection rules for concerted reactions in 1965. Useful in themselves, these rules also profoundly influenced the way organic chemists think about reactions. The work of Evans in the 1930s, of Dewar in the 1950s, and of Fukui in the 1950s and 1960s, was dusted off and assimilated by organic chemists. Fukui proposed in 1952 that the shapes and energies of the frontier molecular orbitals (FMOs)—the highest occupied MO (HOMO) and lowest unoccupied MO (LUMO)—of a molecule were crucial in determining the reactivity of a molecule. Successful applications of this idea to most areas of organic reactivity have led to the reformulation of theories of organic reactivity in terms of approximate quantum mechanical principles.

Fleming's book is the first general introduction to, and review of, the application of FMO theory to organic reactions. The book is unadorned by mathematics, and will be enormously successful in its goal of educating chemists at all levels of preparation in the use of this powerful qualitative theory. Fleming's approach is to show how FMO theory can deal with all of the subjects that fascinate organic chemists—rates, products, and stereoselectivities of reactions. He begins by developing the general idea of MOs and bonding, building up quickly to the valence MOs of ethane. Realistically, one would expect that some more facility than the expected 'familiarity with the concept of a molecular orbital' would be needed by the reader to fully understand this section, but other books are available to fill this need. After this introduction, Salem's and Klopman's treatments of intermolecular interactions, which include interactions other than FMO interactions, are briefly discussed, and the limitations of FMO theory are pointed out. FMO theory is more than an approximation to a full treatment of intermolecular reactions, because it is becoming increasingly apparent that FMO interactions are even more important in transition states that they seem to

be on inspection of isolated reactant orbitals.

Fleming continues with substantial chapters on ionic, pericyclic, radical, and photochemical reactions. Included in these chapters are generalisations about the FMOs of donor, acceptor, and conjugated alkenes, and excellent discussions of aromatic substitutions, ambident reactivity, the HSAB principle, and Woodward-Hoffmann rules. In the desire to make the theory explain everything, Fleming occasionally does a bit of hand-waving. For example, the ambident reactivity of delocalised radicals and anions cannot be fully explained by FMO theory alone, let alone be accurately predicted. I share Fleming's confidence in the theory, but others might be surprised to find him deducing the shapes of FMOs of molecules such as methylmaleic anhydride from products of reactions. The attitude of this book is that FMO theory is incredibly powerful, even if it must occa-

sionally be bent somewhat to fit with experience. Indeed, FMO theory is a MO-based conceptual framework on which the vast experience of organic chemistry can be organised.

I counted six insignificant typographical errors, and only one of any consequence. The calculation of periselectivity of hexatriene dimerisation on p166 is incorrect due to the incorrect placement of summation signs, so that the correct prediction is accidentally made. FMO theory seems to be charmed, indeed!

The book is organised so well, and contains so much factual information, as well as good insight and interesting speculation, that it creates many ideas for research and experimental tests. I heartily recommend the book to chemists interested in understanding organic reactions.

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Spin labels

Spin Labeling Methods in Molecular Biology. By G. I. Likhtenshtein. Translated by Philip S. Shelnitz. Pp. xiii+258. (Wiley-Interscience: New York and London, 1976.) £26; \$39.

ONE can read a translation like this with two purposes in mind. First, one might be hoping to learn about electron spin resonance (ESR) and the way that it can be applied to the problems of molecular biology. Second, one may be reading with the particular purpose of finding out more about the studies by Russian workers, published in less familiar or untranslated journals. This book is generally interesting on both counts.

The approach adopted is very much an empirical one. Theoretical discussion is limited to that absolutely necessary for the interpretation of the experimentally obtained spectra. The first chapter is largely concerned with presenting a series of empirical relationships between spectral shape and the motional parameters for spin labels. This in fact makes a very good introduction to spin labelling for the molecular biologist, since biological studies are very largely empirical, with relatively little necessity (at least at present), for detailed spectral stimulation.

The second chapter is concerned with the double label technique, in which two spin labels are introduced into an enzyme to determine the distance between the two functionally labelled groups. The technique can also be used to determine the distance between a spin label on a protein and a paramag-

netic ion in solution or bound to the protein. The result is, of course, a distance from a spin label group rather than from a group of the native protein, but problems of this kind dog any attempt to use probe molecules to obtain detailed structural information about proteins. All that can be said is that the distances obtained using such techniques agree well with those obtained with native proteins using X-ray diffraction.

The effects of conformational changes on spectra are then described, and a discussion is presented of the importance of the local mobilities detected by ESR for general theories of enzyme activity. Chapters are also included on applications of spin labels to problems of membrane and nucleic acid structure and on the effects of spin labels on nuclear magnetic resonance spectra. Finally, the spin label technique is compared with the possibilities of other probe methods.

All in all, the book provides a very useful guide to the style of spectral interpretation actually used by most molecular biologists. As a translation, it is also fairly successful, although it does contain a few gems. So we read of spin labels being "reduced with great intensity", of spin labels being "implanted" on to proteins and of EPR which "show a fine reaction to the approach of other paramagnetic groups". And how about this for sheer impenetrability: "Nitroxide radicals are reduced to hard to accommodate N-hydroxylamines" (p28).

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