

## Book Review

### **Carbon-13 NMR Spectroscopy of Biological Systems, edited by Nicolau Beckmann**

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The discovery of NMR by Bloch and Purcell 50 years ago using samples of water and paraffin yielded narrow and broad proton resonance signals, foreshadowing a multitude of applications applicable to both liquid and solid states. In the intervening years NMR spectroscopy has matured to include the utilization of a variety of magnetically active nuclei. Carbon-13 NMR spectroscopy initially experienced a surge of applications involving the structural elucidation of organic compounds, which subsequently migrated into systems of biological interest. The monograph edited by Nicolau Beckmann aims to introduce a broad readership to both the methodological aspects of as well as the motivation for the application of  $^{13}\text{C}$  NMR spectroscopy to problems of biological relevance, spanning the range from structural elucidation of biological molecules in the liquid and solid states to the investigation of the biochemical basis of metabolic pathways. The preface states that topics have been chosen and delivered at a level appropriate to the training of a broad audience including biochemists, biophysicists, chemists, medical doctors, molecular biologists, and physicists. This monograph is organized along conventional lines, beginning with a comprehensive, though brief, overview tracing the development of  $^{13}\text{C}$  NMR spectroscopy; followed by chapters written by acknowledged experts devoted to the methodology and applications of  $^{13}\text{C}$  NMR in liquids, the measurement of internuclear distances in biologically relevant solids, the study of fatty acids and lipid bilayers; and concluded by two chapters devoted to metabolic studies in animals and humans using  $^{13}\text{C}$  NMR spectroscopy.

The introductory chapter is a cogent review highlighting the key developments in  $^{13}\text{C}$  NMR spectroscopy that have brought this technique to prominence. A nice aspect is the inclusion of many references of historical interest. Nonetheless, this reviewer was struck by the absence of references to contemporary NMR texts at the introductory level, especially given the goal of introducing  $^{13}\text{C}$  NMR to a broad audience. The texts of Farrar and Sanders & Hunter come to mind in this context. In a similar vein, chapter 2 provides a detailed analysis of contemporary pulse sequences used in modern  $^{13}\text{C}$  NMR spectroscopy utilizing the elegant compact description afforded by product operator formalism. Whereas such a treatment carries with it many advantages, particularly for the more sophisticated reader, the use of product operator formalism is likely to intimidate the newcomer. Reference to a beginning discussion of product operator formalism would have brought additional

strength to this chapter, as would have reference to one of the several computational aids for working out the behavior of pulse sequences using product operator formalism considerations (e.g., the *Mathematica* toolbox developed by J. W. Shriver, *J. Magn. Reson.* 94:612–616 (1991)). This reviewer is not convinced that product operator formalism is necessary to conceptually understand and profitably employ NMR pulse sequences in research, although for the more advanced reader it does in unequivocal terms describe spin system behavior occurring at each stage of the pulse sequence. Pulse sequences of relevance to modern  $^{13}\text{C}$  NMR spectroscopy are rigorously analyzed; also included is a particularly useful summary table. Limitations and advantages of each of the major pulse sequences are presented enabling the reader to better comprehend their utility. The discussion of  $^{13}\text{C}$  relaxation is brief, as is that of the use of scalar coupling constants. The discussion in chapter 3 is aimed at the measurement of internuclear distances in biological solids by  $^{13}\text{C}$  magic angle spinning, which relies on through space spin dipolar coupling of selected spin 1/2 labeled sites. The theoretical bases of rotational-echo, double resonance; rotational resonance; transfer-echo, double resonance; and rotary-resonance recoupling experiments are clearly and authoritatively presented. Applications to different biological problems are presented in a concise and lucid manner. The general reader is likely to have much less appreciation for experiments using solids rather than liquids so a discussion devoted to experimental implementation, including hardware requirements, would have been a useful addition. The chapter devoted to the interaction of fatty acids with phospholipid bilayers, plasma lipoproteins, and proteins is nicely developed and clearly presented with well thought out concluding remarks. The final two chapters, 5 and 6, are devoted to  $^{13}\text{C}$  magnetic resonance spectroscopy (MRS) of animals and humans with emphasis on the elucidation of metabolic pathways under both normal and pathophysiological conditions. An especially nice aspect to the introduction of chapter 5 is the integration of  $^{13}\text{C}$  MRS concepts into the conceptual framework of metabolic research. Included is a discussion of mathematical models and experimental design. Such considerations are vital if MRS studies are to be taken beyond a superficial level. Following this introduction is an overview of  $^{13}\text{C}$  MRS metabolic studies involving animals. All of the major organs are presented: liver, heart, brain, kidney, etc. These are very detailed, and often the reader can not discern what metabolic

information is merely confirmed, what is challenged, and what is new information. Such delineation would have been especially useful, particularly for the uninitiated reader. This reviewer found the concluding remarks somewhat superfluous and vague. More rewarding would have been a summary discussion describing significantly new aspects of metabolism as revealed by  $^{13}\text{C}$  MRS, and how these findings altered our perception of fundamental metabolic processes. The final chapter continues the discussion of metabolism except that it documents instead human studies. A nice feature of this chapter is the introduction, which exposes the reader to a comprehensive discussion of some of the methodological considerations involving radiofrequency coils, decoupling, signal acquisition, spatial localization schemes, and quantification of

metabolite levels. Metabolic studies involving major organs, body fluids, and isolated tissues in both normal and disease states are presented.

Overall this is a useful book and is likely to appeal to the reader who wants a broad, though comprehensive view of how  $^{13}\text{C}$  NMR spectroscopy can be profitably used in many aspects of biological research. The novice reader will derive considerably more benefits by reading this book in conjunction with an introductory text. I would certainly use and recommend this monograph as supplementary reading to an introductory course on biological NMR spectroscopy aimed at the beginning graduate level. Despite minor reservations this monograph is strongly recommended to readers, both novice and advanced.