

This Week's Citation Classic

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Sanders J K M & Williams D H. Tris(dipivalomethanato)europium. A paramagnetic shift reagent for use in nuclear magnetic resonance spectroscopy.

J. Amer. Chem. Soc. 93:641-5, 1971.

[University Chemical Laboratory, Cambridge, England]

The addition of the nuclear magnetic resonance (NMR) shift reagent, $\text{Eu}(\text{DPM})_3$, to lone-pair bearing organic compounds gives striking spectral simplifications by virtue of reversible complexation. The use of this shift reagent enhances the power and versatility of NMR spectroscopy. [The SCI® indicates that this paper has been cited in over 385 publications since 1971.]

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"In 1969, it could be argued that nuclear magnetic resonance (NMR) was on a temporary plateau; Fourier transform techniques and superconducting magnets were not yet routinely available, and many of the world's leading practitioners were still laboring with 100 MHz instruments (for proton resonance). A major problem for such practitioners was the overlap of proton resonances in many common, and even relatively simple, organic molecules.

"The above problem was far from my mind when, during a lecture tour of the Western US in the fall of 1969, I took a short break between a round of visits to various faculty members at the University of California, Los Angeles. During this break, I idly thumbed through a current copy of *Journal of the American Chemical Society*—a personal copy sitting on the desk of an absent faculty member. It was with great excitement that I saw a proton spectrum of cholesterol in which proton resonances had been shifted from the 'methylene envelope' to a region where the signals could be more readily analyzed, thus providing a wealth of new information. The paper incorporating this spectrum was by Hinckley,¹ and the dramatic result had been obtained by addition of a lanthanide chelate, [(pyridine)₂Eu(DPM)₃], to a solution of the steroid.

"Why did I focus on this paper? First, I had been trained as a steroid chemist during my PhD studies on the synthesis of vitamin D. Second, I had shortly before published a book on the proton NMR of steroids,² and was acutely aware of the problems caused by proton resonance overlap. Immediately, I decided to suggest to a new graduate student, Jeremy Sanders, that we should develop further this new technique.

"In a previous *Citation Classic*,³ Sanders described how we removed the pyridine from the initially used reagent, and so obtained a superior shift reagent. We then followed up this work by determining the relative affinities of a range of common monofunctional organic substrates for $\text{Eu}(\text{DPM})_3$. Sanders also related³ how, when this work was submitted for rapid publication, it was rejected. The original manuscript was therefore expanded and submitted as a full paper to *Journal of the American Chemical Society*. This paper, which forms the subject of the present *Citation Classic*, was accepted and became the most-cited 1971 article in the natural sciences for the citation period 1971-1972.⁴

"Why was this paper highly cited? I believe it was because it demonstrated clearly how the analysis of complex proton spectra could be simplified by use of $\text{Eu}(\text{DPM})_3$, and gave to organic chemists the 'feel' of which substrates would bind strongly and which would bind weakly. It is interesting to look back at the paper and note the slightly scruffy appearance of the spectra and figures provided by us. To my mind, it was a credit to the then editors of *Journal of the American Chemical Society* that they allowed us so much space to demonstrate our results pictorially (with evident impact⁴); and to their credit that they gave us relatively rapid publication rather than insisting on cosmetic improvement of the figures. Was it a 'correct' decision that the concise form of the paper was regarded as unsuitable for urgent publication? There are perhaps too many variables to permit a rational discussion of such a question; but in view of the historical facts,⁴ it might be argued that the refereeing process which normally serves us well proved too arbitrary in the case under discussion."

1. Hinckley C C. Paramagnetic shifts in solutions of cholesterol and the dipyrindine adduct of trisdipivalomethanatoeuropium(III). A shift reagent. *J. Amer. Chem. Soc.* 91:5160-2, 1969.
2. Bhacca N S & Williams D H. *Applications of NMR spectroscopy in organic chemistry: illustrations from the steroid field*. San Francisco: Holden-Day, 1964. 198 p.
3. Sanders J K M. *Citation Classic. Commentary on J. Chem. Soc. Chem. Commun.* 7:422-3, 1970. *Current Contents/Physical, Chemical & Earth Sciences* 23(12):20, 22 March 1982.
4. Garfield E. The 25 most cited 1971 papers reveal a great deal about research in 1971. *Essays of an information scientist*. Philadelphia: ISI Press, 1977. Vol. 1. p. 496-9. (Reprinted from: *Current Contents* (44):5-8, 31 October 1973.)