CC/NUMBER 3
JANUARY 19, 1981

This Week's Citation Classic

van Deemter J J, Zuiderweg F J & Klinkenberg A. Longitudinal diffusion and resistance to mass transfer as causes of nonideality in chromatography. *Chem. Eng. Sci.* 5:271-89, 1956. [Shell Research B.V., Amsterdam, and Shell Internatl. Petroleum Maatschappij B.V., The Netherlands]

The sharpness of separation in a gas-liquid chromatographic column is effected by longitudinal molecular diffusion, slowness to reach absorption equilibrium, and by flow irregularities in channels and across the column. The total effect of all these causes can be described by a simple equation which can be derived from the rigorous mathematical solution by introducing reasonable simplifying assumptions. [The *SCI*® indicates that this paper has been cited over 370 times since 1961.]

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January 7, 1981

"In the early 1950s various scientists and engineers at the Royal/Dutch Shell Laboratory in Amsterdam (The Netherlands) were involved in pioneering work in gas-liquid chromatography. Among them was the late A.I.M. Keulemans, the author of the first book in this field.[1] As a physicist — working in chemical engineering research — I had initially only a side-interest in chromatography. On the other hand I had the conviction that certain chemicai engineering concepts, which had a proven use in packed column processes, could also be applied in chromatography.

"Going through the literature I found that the mathematical description of chromatographic phenomena had already been given by many authors, but that, in the first place, the role of the accepted chemical engineering models had not been properly recognized and, secondly, that the complicated mathematical results had prevented the practical scientists from appreciating the influence of the various factors on the performance of chromatographic columns.

"My colleague Klinkenberg had already found much earlier that under many conditions error functions could be used to describe chromatographic peaks. This idea proved to be very useful for the derivation of simpler formulas. The final result did, however, not present itself automatically. Only after much plotting and cross-plotting did it become evident that peak broadening could be described by a very simple equation.

"My friend Zuiderweg had in the meantime worked on the possibilities of using gas-liquid chromatography for preparative separations. Some basic results of that work were also included in the paper.

"In 1955 I transferred to Houston, Texas, to work for Shell Oil Company on catalytic cracking. Incidentally, the modeling of fluidized beds was partly suggested by concepts of chromatography! During my absence Keulemans wrote his well-known monograph on gas chromatography. When he presented me with a copy, I found out that he had associated my name with the equation on peak sharpness that I had derived. He had not consulted me in advance as he wanted to surprise me.

"The appearance of this book made the 'van Deemter equation' much better known in a relatively short period. The frequent citation has, according to my opinion, also to do with the fact that the equation describes in a simple way the role of the main design parameters of the chromatographic column. It proved extremely useful for both instrument manufacturers, who in the early years tried to conquer good shares of a potentially big market, and for users, who wanted to understand possibilities and limitations of this new analytical tool.

"Many interesting historical comments on the development of chromatography can be found in the reference given below.[2]

"I was one *of* the scientists who received in 1978 the memorial medal, issued by the Academy of Sciences of the USSR, honoring the 75th anniversary of the discovery of chromatography by M.S. Tswett."

1. **Keulemans A I.** *Gas chromatography.* New York: Van Nostrand Reinhold, 1959. 234 p.
2. **Ettre L S A Zlatkis A,** eds. *Seventy-five years of chromatography—an historical dialogue.* New York: Elsevier-North Holland, 1979. 502 p.