

Retention Mechanism in Reversed-Phase Liquid Chromatography: A Molecular Perspective

Jake L. Rafferty¹, Ling Zhang¹, J. Ilja Siepmann^{1,*}, Mark R. Schure²

¹Departments of Chemistry and of Chemical Engineering and Material Science,
University of Minnesota, 207 Pleasant Street SE, Minneapolis, MN 55455-0431, USA

²Theoretical Separation Science Laboratory, Rohm and Haas Company,
727 Norristown Road, P.O. Box 0904, Spring House, PA 19477-0904, USA

Abstract

A detailed, molecular-level understanding of the retention mechanism in reversed-phase liquid chromatography (RPLC) has eluded analytical chemists for decades. Through validated, particle-based Monte Carlo simulations of a model RPLC system consisting of dimethyloctadecyl silanes at a coverage of $2.9 \mu\text{mol}/\text{m}^2$ on an explicit silica substrate with unprotected residual silanols in contact with a water/methanol mobile phase, we show that the molecular-level retention processes for non-polar and polar analytes, such as alkanes and alcohols, are much more complex than what has been previously deduced from thermodynamic and theoretical arguments. In contrast to some previous assumptions, the simulations indicate that both partitioning and adsorption play a key role in the separation process and that the stationary phase in RPLC behaves substantially different from a bulk hydrocarbon phase. The retention of non-polar methylene segments is dominated by lipophilic interactions with the retentive phase, while solvophilic interactions are more important for the retention of the polar hydroxyl group.

*To whom correspondence should be addressed. E-mail: siepmann@chem.umn.edu