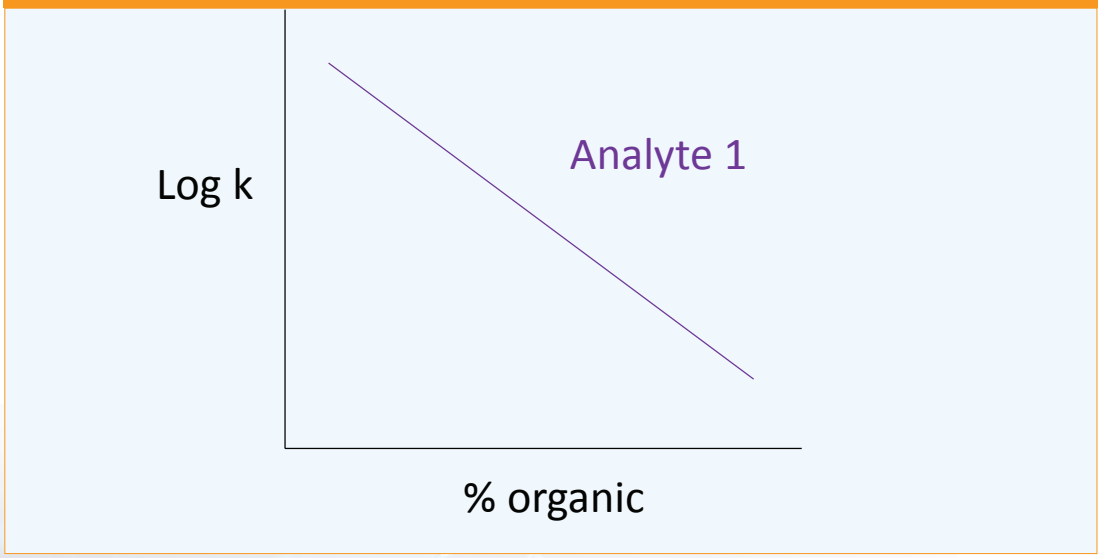
Linear-Solvent-Strength (LSS) Model

The Linear-Solvent-Strength (LSS) model (1) is used to describe the relationship between retention factor (k) and the percentage of the organic solvent (%B) in isocratic reversed-phase liquid chromatography. It is most often represented by Equation (1):

$$\log k = \log k_w - S\varphi \quad (1)$$

k_w is the extrapolated value of k for $\varphi = 0$ or water as the mobile phase. S is a constant for the compound of interest and fixed experimental conditions (other than φ). φ is the %B in decimal form, for example 10% B would be 0.1. A typical plot of log k vs. %B is shown in Figure 1. As the %B increases, the log (retention factor) decreases.

Figure 1: Typical Plot of log k vs. %B



For "regular" samples, the order of elution does not change no matter the %B that is used. These analytes can be homologues or have closely related structures. See Figure 2.

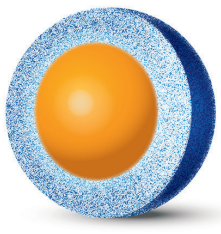


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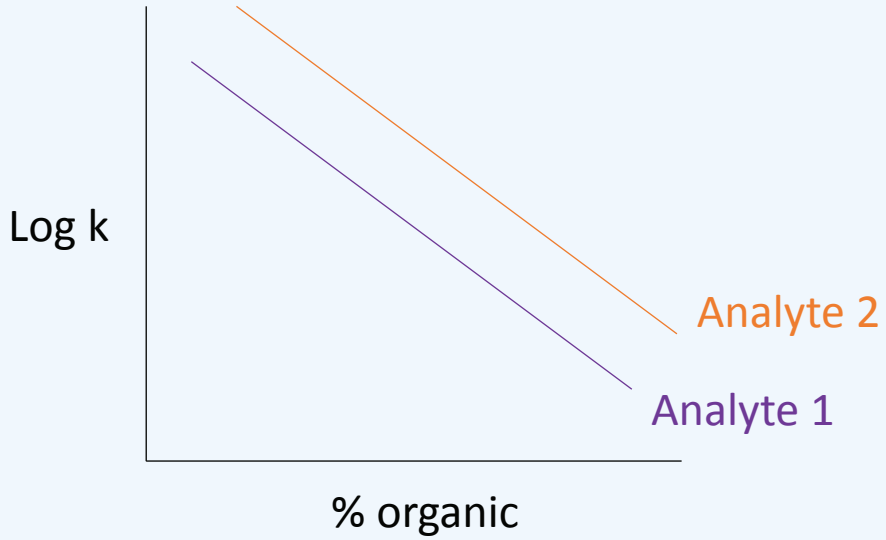
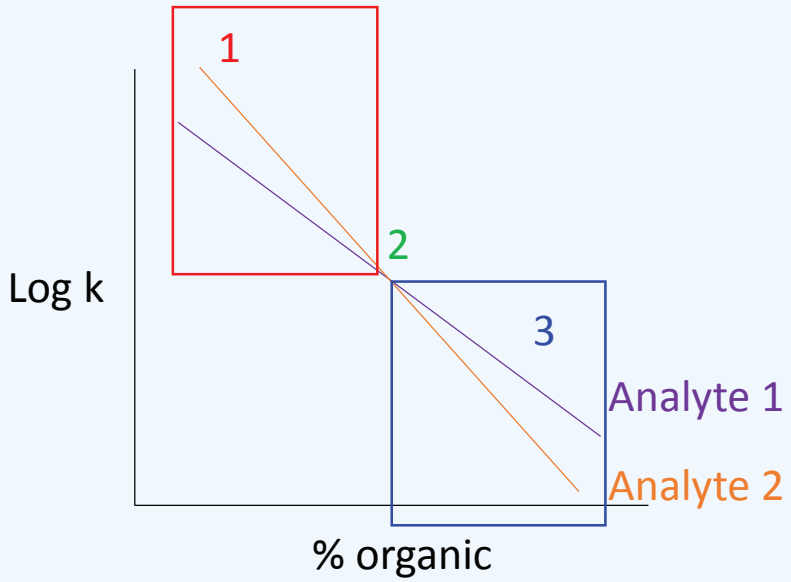
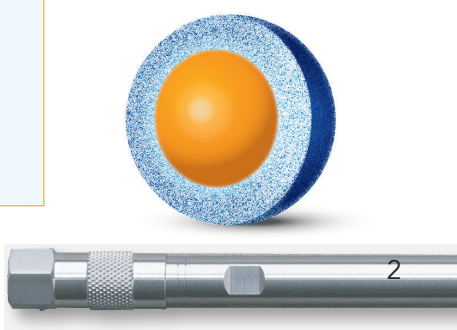
Figure 2: Typical Plot of log k vs. %B for regular samples



For "irregular" samples, the elution order can change as the %B is changed. This type of behavior is observed for samples that are structurally different from each other. An example plot is shown in Figure 3.

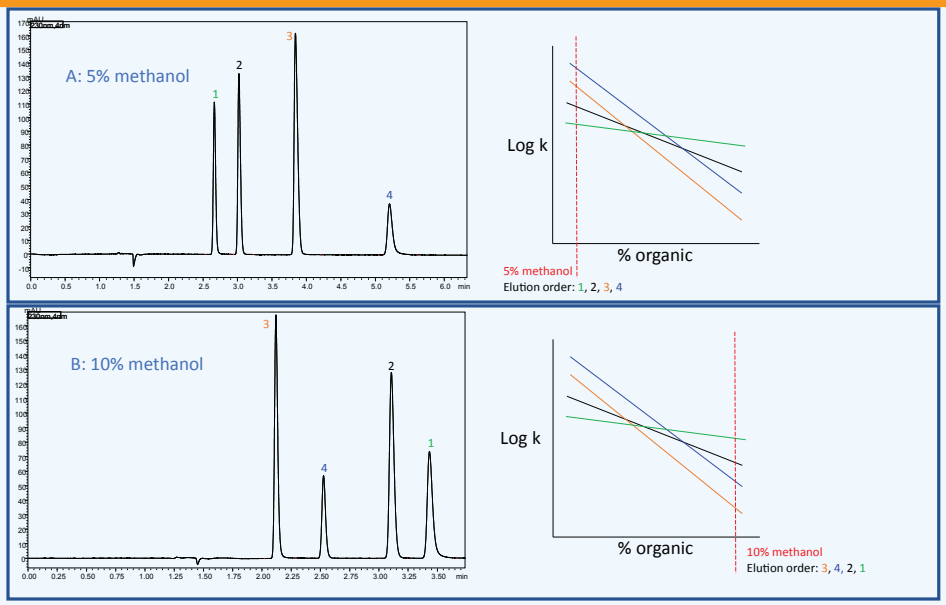
Figure 3: Typical Plot of log k vs. %B for Irregular Samples





In the section labeled 1, analyte 2 (orange trace) has more retention than analyte 1 (purple trace). At the portion of the graph labeled 2, both analytes coelute as a single peak at that %B composition. Finally, in the section labeled 3, analyte 1 is more retained than analyte 2. The LSS model is the basis for chromatographic optimization software and is a powerful tool for method development.
An example using a mix of irregular samples is shown in Figure 4 using a HALO 90 Å AQ-C18, 2.7 µm column.

Figure 4: Effect of changing organic composition from 5% methanol to 10% methanol for a sample composed of 1.Acesulfame, 2. Benzoic acid, 3. Sorbic acid, 4. Saccharin sodium run on a HALO 90 Å AQ-C18, 2.7 µm column.



When 5% methanol is used (Fig. 4A), the elution order is acesulfame, benzoic acid, sorbic acid, and saccharin sodium. The elution order changes when 10% methanol is used (Fig. 4B) so that the acesulfame is the most retained instead of the least retained. See also the comparison of the plots in the right hand side of Figure 4.

An interesting observation that has been made about this particular mix of analytes is that when it is run on a HALO 90 Å AQ-C18, 5 µm column, the elution follows the trend of a "regular" sample. See the comparison of 5% and 10% methanol in Figure 5.

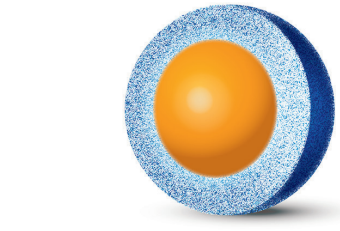
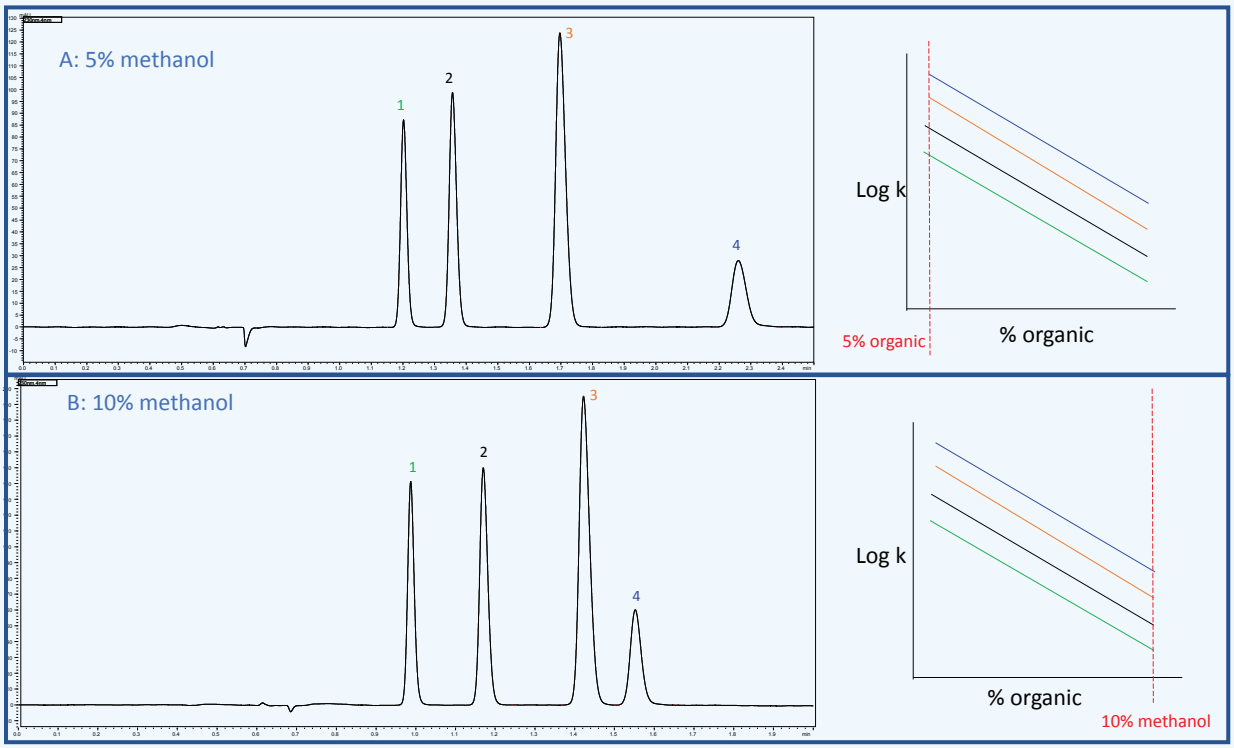
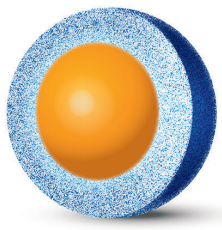
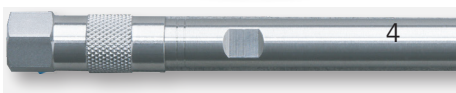


Figure 5: Effect of changing organic composition from 5% methanol to 10% methanol for a sample composed of 1.Acesulfame, 2. Benzoic acid, 3. Sorbic acid, 4. Saccharin sodium run on a HALO 90 Å AQ-C18, 5 µm column.



Using 5% methanol and 10% methanol, the elution order of the four analytes of interest remains the same. However, notice that the selectivity between the sorbic acid and the saccharin sodium has changed. It could be imagined that at a higher concentration of methanol the sorbic acid and the saccharin sodium may begin to coelute, which would indicate a cross over point in their log k vs. % organic plots.





CONCLUSIONS

In summary, the LSS model can be very useful when developing methods. Naturally, challenges arise when samples do not respond equally to changes in mobile phase composition. This is why robust method development along with screening columns of different selectivity is critical for avoiding potential areas of overlap between analyte log k vs % organic plots.

REFERENCE

1. High-Performance Gradient Elution: The Practical Application of the Linear-Solvent-Strength Model, L.R. Snyder and J.W. Dolan, 2007, John Wiley & Sons, Inc.

MAC-MOD Analytical is an authorized distributor of HALO columns.