

Gas Chromatography Problem Solving and Troubleshooting

Question:

Our lab uses theoretical plate numbers to evaluate the performance of our capillary columns. Depending on the test sample and conditions, we get different plate numbers for the same column. I am not sure which theoretical plate number to use for the evaluation. Are different theoretical plate numbers for the same column normal, and which number should I use for evaluation purposes?

Answer:

Theoretical plate numbers are influenced by a number of variables. For a specific column, the same GC conditions and compound need to be used when calculating theoretical plate numbers. If not, different values will be obtained for each set of conditions or compound. The different theoretical plate numbers obtained for your evaluations are probably caused by differences in the test conditions. If a specific column's performance is being evaluated and compared, the same oven temperature, carrier gas average linear velocity, and test compound need to be used. The number of theoretical plates is only one measure of a column's performance. There are additional, important column characteristics such as activity and column bleed that should not be neglected when evaluating a column's performance.

Except for unusual circumstances or compound behavior, peak widths increase with retention. Theoretical plate numbers attempt to account for this behavior by relating a peak's width to its retention. When evaluating columns, hydrocarbons are usually preferred for calculating the plate numbers. This is because of their inertness and retention characteristics. Equation 1 is used to calculate the number of theoretical plates (N). The theoretical plates per meter of column (N/m) is often reported, so that columns of different lengths can be more easily compared.

$$N = 5.545 (t_r/W_h)^2 \quad \text{Eq 1}$$

where t_r is the retention time (min) and W_h is the peak width at half height (min).

Peak number	Hydrocarbon	N^*	N/m^\dagger
2	Tridecane	14,082	939
4	Tetradecane	14,736	982
6	Pentadecane	15,740	1049
8	Hexadecane	16,656	1110

* N , number of theoretical plates.
 † N/m , theoretical plates per meter.

It seems that the number of theoretical plates for a column should be the same for all compounds and conditions. In practice, the number of theoretical plates depends on the retention of the peak being used in the calculation. The test mixture chromatogram in Figure 1 contains 4 hydrocarbons. In this case, the theoretical plate number is larger for the later-eluting compounds, even though the same column and analysis is used to generate the data (Table I). If system performance is going to be measured using theoretical plate numbers, the same compound and GC conditions need to be used, otherwise an invalid comparison will be obtained.

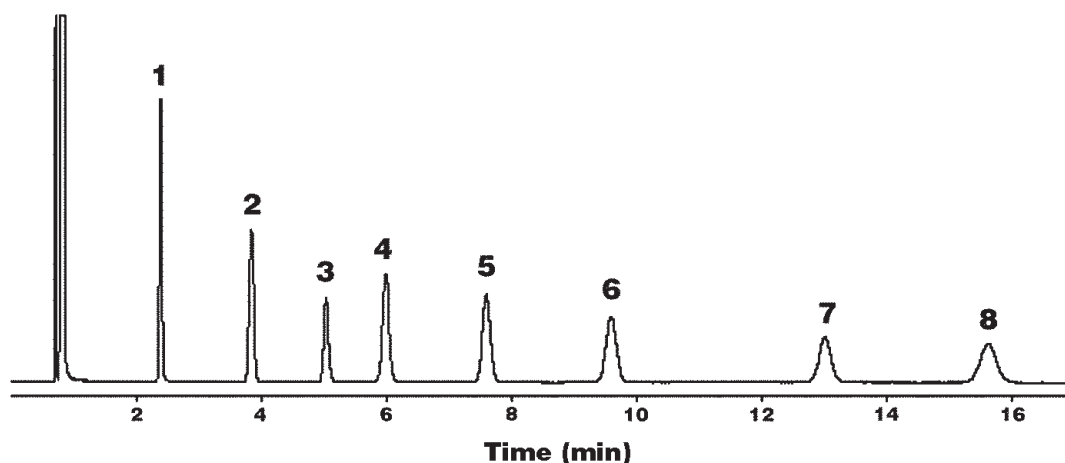


Figure 1. Chromatogram of a test mixture. Chromatographic conditions: column, DB-35 (15 m × 0.53-mm i.d., 1.5- μ m film thickness); split injector, 250°C, 50:1 split ratio; FID detector, 300°C; carrier gas, helium at 35.3 cm/s; column temperature, 135°C. Peaks: 1, benzylamine; 2, tridecane; 3, 4-chlorophenol; 4, tetradecane; 5, 1-undecanol; 6, pentadecane; 7, biphenyl; 8, hexadecane.

Even if the peak retention is the same, the temperature conditions used to obtain the chromatograms are still important. It is fairly easy to obtain theoretical plate numbers that are 4–5 times higher for a temperature program than for isothermal conditions, even though the same compound's retention time differs by less than 0.1 min (1). Also, it is important that the average linear velocities used for each comparison are very similar, because theoretical plate numbers are also dependent on carrier gas conditions.

References

1. D. Rood. *A Practical Guide to the Care, Maintenance and Troubleshooting of Capillary Gas Chromatography Systems*, 3rd ed. Wiley-VCH, Weinheim, Germany, 1999.

The purpose of *Chromatography Problem Solving and Troubleshooting* is to have selected experts answer chromatographic questions in any of the various separation fields (GC, GC–MS, HPLC, TLC, SFC, HPTLC, open column, etc.). If you have questions or problems that you would like answered, please forward these to the *Journal* editorial office with all pertinent details: instrument operating conditions, temperatures, pressures, columns, support materials, liquid phases, carrier gas, mobile phases, detectors, example chromatograms, etc. In addition, if you would like to share your expertise or experience in the form of a particular question accompanied by the answer, please forward to JCS Associate Editor, *Chromatography Problem Solving and Troubleshooting*, P.O. Box 48312, Niles, IL 60714. All questions/answers are reviewed to ensure completeness. The *Journal* reserves the right not to publish submitted questions/answers.

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