Considerations When Optimizing Your GC Method: Phase Ratio (β)

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Introduction

Cutbacks in budgets and increased competition have forced labs to improve productivity while decreasing cost. In order to achieve this goal, many labs are optimizing their current GC methods, rather than purchasing new instruments. Fast GC columns are a perfect way to make this happen. Using columns with slightly smaller internal diameter (ID) provides much better resolution allowing runtime to be shortened by as much as 50%.

When changing column dimensions, it is important to consider the affect it will have on the retention characteristics of the column. The Distribution Constant (K) describes the concentration of compound A in the stationary vs. the carrier gas mobile phase (Equation 1). Since a compound is only moving when it has entered the carrier gas, changes in this ratio shift the equilibrium and can affect column retention and selectivity if conditions do not change.

Equation 1: $$K = \frac{[A_m]}{[A_s]} = k\beta$$

A_m = Concentration of the solute in the Mobile Phase
A_s = Concentration of the solute in the Stationary Phase
k = capacity factor
β = Phase Ratio

When looking to optimize column dimensions, it is important to consider phase ratio (β) to ensure that selectivity will remain the same. Phase ratio for a given column is calculated using Equation 2; smaller β values result in greater retention. Chromatographically this means that when using columns of the same ID, the column with a thicker film will have greater retention for a given analyte. Table 1 lists the β values for common IDs and film thicknesses.

Equation 2: $$\beta = \frac{ID}{4 \times d_f}$$

ID = Internal Diameter (µm)
d_f = Film Thickness (µm)

Table 1: Phase ratio (β) value for common columns

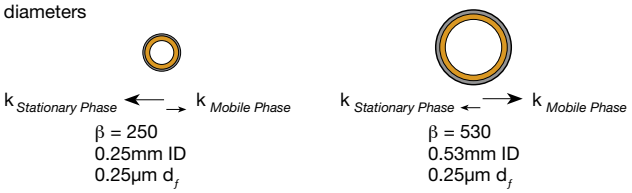
Film Thickness d_f (µm)	Column Diameter (mm)					
	0.10	0.18	0.20	0.25	0.32	0.53
0.10	250	450	500	625	800	1325
0.18	139	250	278	347	444	736
0.25	100	180	200	250	320	530
0.33	—	—	151	—	—	—
0.50	—	90	100	125	160	265
1.00	—	—	50	63	80	133
1.50	—	—	—	42	53	88
3.00	—	—	—	21	27	44
5.00	—	—	—	13	16	27

Increasing Retention (↓)

Increasing Retention (←)

When using columns of two different IDs, the same film thickness does not translate to the same retention characteristics. Figure 1 demonstrates the phase ratio of a 0.25µm film thickness on a 0.53mm and a 0.25mm ID column.

Figure 1: Phase ratio of a 0.25µm film thickness on columns of differing internal diameters



Using phase ratio to our advantage:

The optimum phase ratio depends on the goal of the separation. If analyte retention is low, a column with a low β can be used to increase retention. If column provides good retention, β can be reduced to increase column efficiency and decrease run time.

Let's use the separation of light hydrocarbon impurities found in butane as an example. On a column with a high β such as the Zebron ZB-1 60 meter x 0.32mm x 0.25µm (β = 360) the isomers co-elute due to the lack of interaction with the stationary phase (Figure 2). By using a column with a lower Beta such as the Zebron ZB-1 60 meter x 0.32mm x 3.00µm (β = 27), we are able to achieve separation (Figure 3).

Figure 2: Butane Isomer separation on 60 meter x 0.32mm x 0.25µm (β = 360)

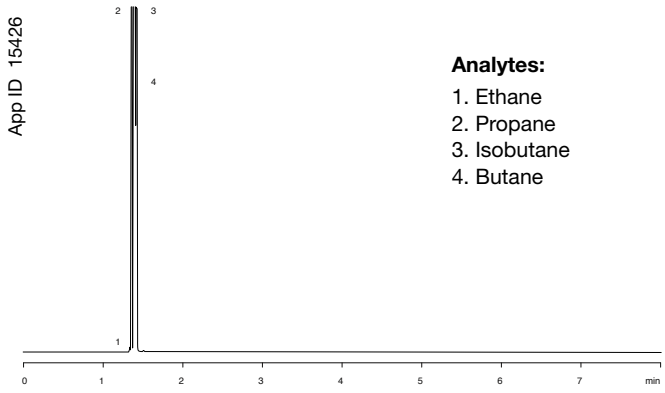
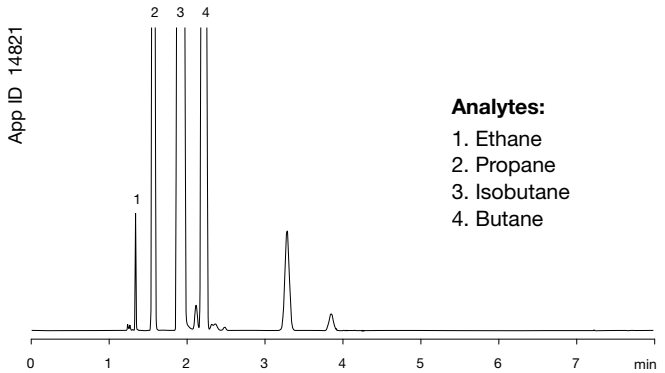


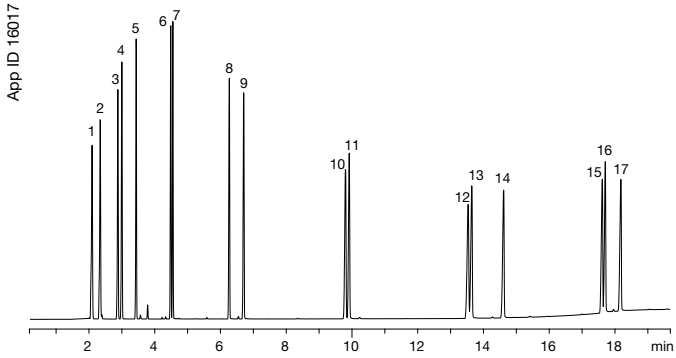
Figure 3: Butane Isomer separation on 60 meter x 0.32mm x 3.00µm (β = 27)



Shortening run times:

The increase in efficiency offered by narrow bore GC columns often improves separation enough to allow the same separation to be done in much less time. Figure 4 shows the separation of 17 priority Polyaromatic Hydrocarbon contaminants using a standard 30 meter x 0.25mm x 0.25µm column (β = 250). By choosing a column with similar phase ratio, but smaller ID the method can be shortened by over 100% while still meeting resolution requirements for key analytes (Figures 5 & 6).

Figure 4: Separation of PAHs on ZB-5ms 30 meter x 0.25mm x 0.25µm (β = 250)



Analytes: (for figures 4-6)

1. Naphthalene
2. 2-Methylnaphthalene
3. Acenaphthalene
4. Acenaphthene
5. Fluorene
6. Phenanthrene
7. Anthracene
8. Fluoranthene
9. Pyrene
10. Benz[a]anthracene
11. Chrysene
12. Benzo[b]fluoranthene
13. Benzo[k]fluoranthene
14. Benzo[a]pyrene
15. Indeno[1,2,3-cd]pyrene
16. Dibenz[a,h]anthracene
17. Benzo[g,h,i]perylene

Figure 5: Separation of PAHs on ZB-5ms 20 meter x 0.18mm x 0.18µm (β = 250)

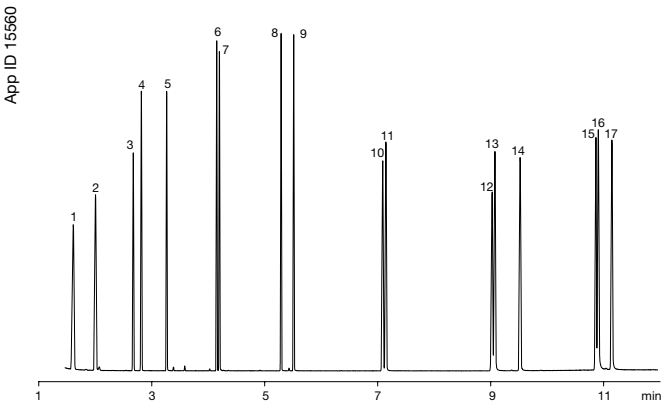
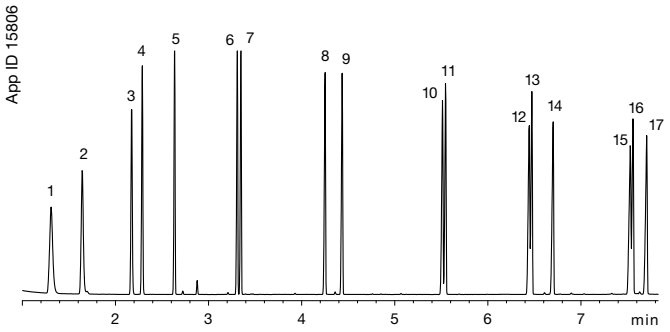


Figure 6: Separation of PAHs on ZB-5ms 10 meter x 0.10mm x 0.10µm (β = 250)



Phase ratio is a critical step in optimizing GC separation. If you would like more information on how it can be used to improve your chromatography, please contact your Phenomenex Technical Consultant.

Ordering Information

Part Number	Description
7KM-G001-11	ZB-1 - 60m x 0.32mm x 0.25µm
7KM-G001-36	ZB-1 - 60m x 0.32mm x 3.00µm
7CB-G010-02	ZB-5ms - 10m x 0.10mm x 0.10µm
7FD-G010-08	ZB-5ms - 20m x 0.18mm x 0.18µm
7HG-G010-11	ZB-5ms - 30m x 0.25mm x 0.25µm

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