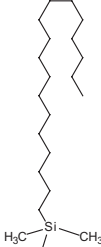
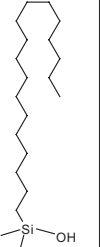
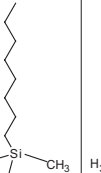
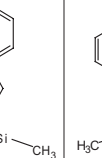
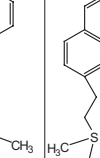
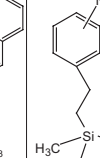
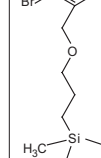
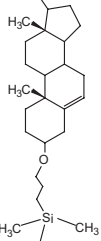
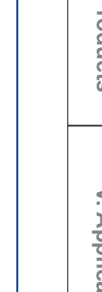


7. Selectivity of Packing Materials in Reversed Phase Liquid Chromatography

Introduction

Reversed phase chromatography is the most commonly used method of HPLC, because of the high theoretical plate number, excellent separation characteristics, reproducibility, and ease of use. Columns packed with octadecyl group bonded type silica gel (C₁₈, ODS) are the most widely used reversed phase chromatography. However, C₁₈ columns provide insufficient separation for compounds similar in hydrophobicity because the main separation mechanism of C₁₈ column is based on hydrophobic interaction. It may improve separation of compounds with similar hydrophobicity by using longer columns, changing mobile phases or changing temperature. However, in many cases, it is probably most effective to use different packing materials which retain compounds base on a secondary interaction in addition to hydrophobic interaction. At Nacalai, we offer a variety of COSMOSIL reversed phase packing materials. Summary of these packing materials and their respective retention mechanism are in Table 1. Retention of compounds in each stationary phase depends on summation of the interactions. Therefore, comprehension of each interaction leads to selection of an appropriate column.

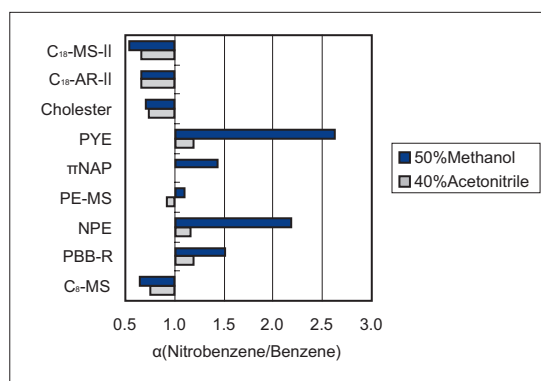
Table1. Stationary phase and interaction of packing materials

Packing Material	C ₁₈ -MS-II	C ₁₈ -AR-II	C ₈ -MS	PE-MS	πNAP	PYE	NPE	PBB-R	Cholester
Silica Gel	High Purity Porous Spherical Silica								
Average Particle Size	5 μm								
Average Pore Size	approx. 120 Å								
Specific Surface Area	approx. 300 m ² /g								
Bonded Phase									
	Octadecyl Group	Octadecyl Group	Octyl Group	Phenylethyl Group	Naphthylethyl Group	Pyrenylethyl Group	Nitrophenylethyl Group	Pentabromobenzyl Group	Cholesteryl Group
Bonding Type	Monomeric	Polymeric	Monomeric	Monomeric	Monomeric	Monomeric	Monomeric	Monomeric	Monomeric
Main Interaction	Hydrophobic Interaction	Hydrophobic Interaction	Hydrophobic Interaction	Hydrophobic Interaction	Hydrophobic Interaction	Hydrophobic Interaction π-π Interaction Dispersion Force Charge-transfer Interaction	Hydrophobic Interaction π-π Interaction Dipole-dipole Interaction	Hydrophobic Interaction Dispersion Force Interaction	Hydrophobic Interaction Molecular Shape Selectivity
End-capping Treatment	Near-perfect Treatment								
Carbon Load	approx. 16%	approx. 17%	approx. 10%	approx. 10%	approx. 11%	approx. 18%	approx. 9%	approx. 8%	approx. 20%

1) Selectivity for Polar Functional Group

Selectivity

Selectivity for polar functional group is evaluated based on the separation of benzene, nitrobenzene, which has a nitro group, and anisole, which has a methoxy group. The chromatograms below show separation of the three compounds on four COSMOSIL columns: C₁₈-MS-II, PE-MS, πNAP and PYE. Elution order on the C₁₈ column is as following: nitrobenzene, anisole and benzene. Elution orders on the aromatic columns are reversed. Separation on the C₁₈ column is based on hydrophobic interaction only. On the other hand, the packing materials on the other three columns have aromatic rings and reverse the elution order by π-π interaction.

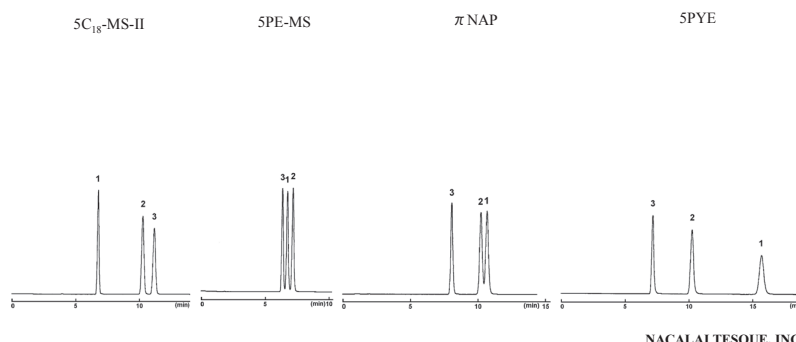
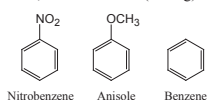


The graph of selectivity for polar functional group is shown below. Among nine COSMOSIL columns, PYE and NPE columns have the highest selectivity factors for polar groups. As to mobile phases, methanol is more effective than acetonitrile for separation using π-π interaction.

Selectivity for Polar Functional Group

Column: 4.6mm I.D.-150mm
 Column size: 4.6mm I.D.-150mm
 Mobile phase: Methanol / H₂O = 50/50
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: 1; Nitrobenzene (0.13 μg)
 2; Anisole (1.5 μg)
 3; Benzene (4.0 μg)



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Application

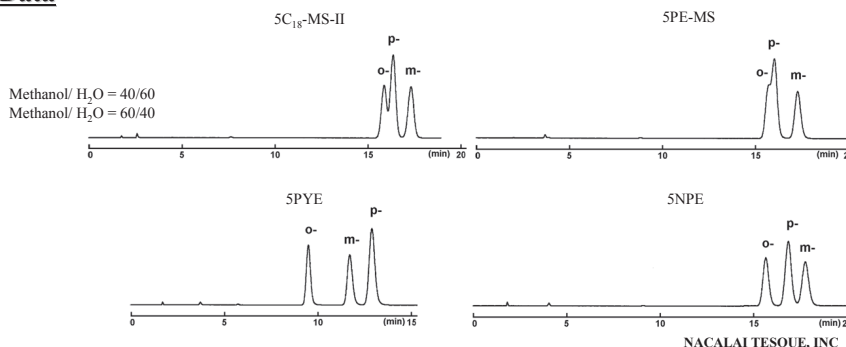
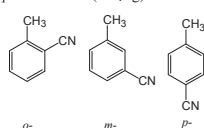
• Separation of Tolunitrile Position Isomers

Tolunitriles have three position isomers. It is difficult to separate ortho and para isomers by C₁₈ or PE-MS column because of lack of poor π-π interaction. On the other hand, the isomers are well separated on PYE or NPE column which has strong π-π interaction.

COSMOSIL Application Data

Column: 4.6mm I.D.-150mm
 Column size: 4.6mm I.D.-150mm
 Mobile phase: 5C₁₈-MS-II, 5PE-MS, 5NPE
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: o-Tolunitrile (2.0 μg)
 m-Tolunitrile (2.0 μg)
 p-Tolunitrile (1.0 μg)

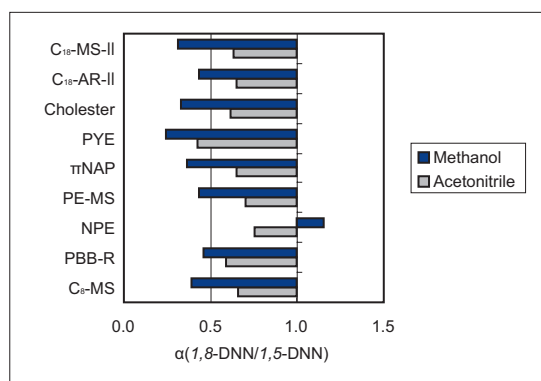


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2) Selectivity for Dipole

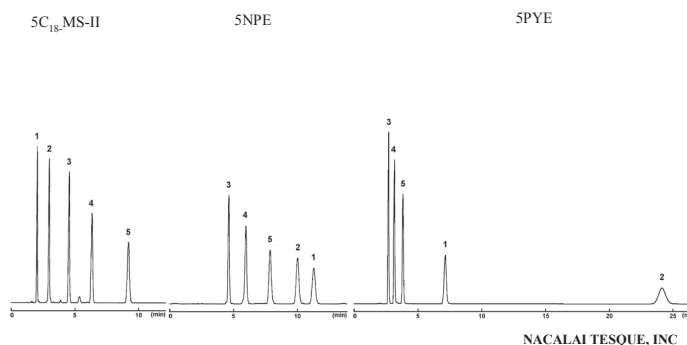
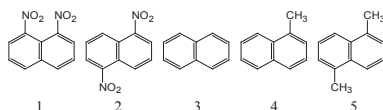
Selectivity

Selectivity for dipole is evaluated based on the separation of 1,5-dinitronaphthalene and 1,8-dinitronaphthalene. Dinitronaphthalenes (peak 1 and 2) were strongly retained on PYE and NPE because of π - π interaction compared with dimethylnaphthalenes. However, there is a slight difference between these two columns. While 1,5-dinitronaphthalene (peak 2) was preferentially retained on PYE, 1,8-dinitronaphthalene (peak 1) was retained longer on NPE. The results with NPE indicate the presence of strong dipole-dipole interaction. The two nitro group dipoles in 1,8-dinitronaphthalene are aligned for a much greater dipolar coupling with the bonded nitrophenyl group in NPE than 1,5-dinitronaphthalene.



Selectivity for Dipole

Column size: 4.6mm I.D.-150mm
 Mobile phase: C₁₈-MS-II Methanol / H₂O = 80/20
 NPE Methanol / H₂O = 70/30
 PYE Methanol / H₂O = 90/10
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm
 Sample: 1; 1,8-Dinitronaphthalene(1,8-DNN) (0.21 μg)
 2; 1,5-Dinitronaphthalene(1,5-DNN) (0.11 μg)
 3; Naphthalene (0.25 μg)
 4; 1-Methylnaphthalene (0.35 μg)
 5; 1,5-Dimethylnaphthalene (0.42 μg)



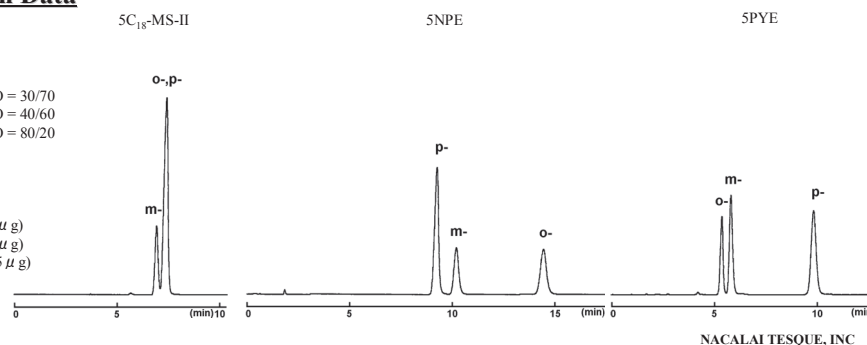
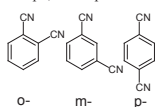
Application

• Separation of Phthalonitrile Position Isomers

Phthalonitriles have three position isomers. NPE or PYE completely separates these compounds due to π - π interaction. Furthermore, NPE strongly retains o-phthalonitrile due to dipole-dipole interaction.

COSMOSIL Application Data

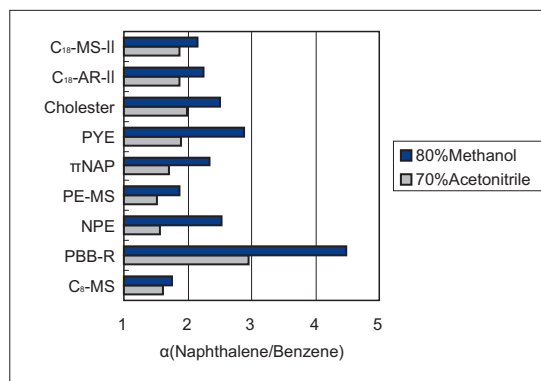
Column:
 Column size: 4.6mm I.D.-150mm
 Mobile phase: 5C₁₈-MS-II Methanol / H₂O = 30/70
 5NPE Methanol / H₂O = 40/60
 5PYE Methanol / H₂O = 80/20
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm
 Sample: o-; Phthalonitrile (0.3 μg)
 m-; Isophthalonitrile (3.0 μg)
 p-; Terephthalonitrile (0.15 μg)



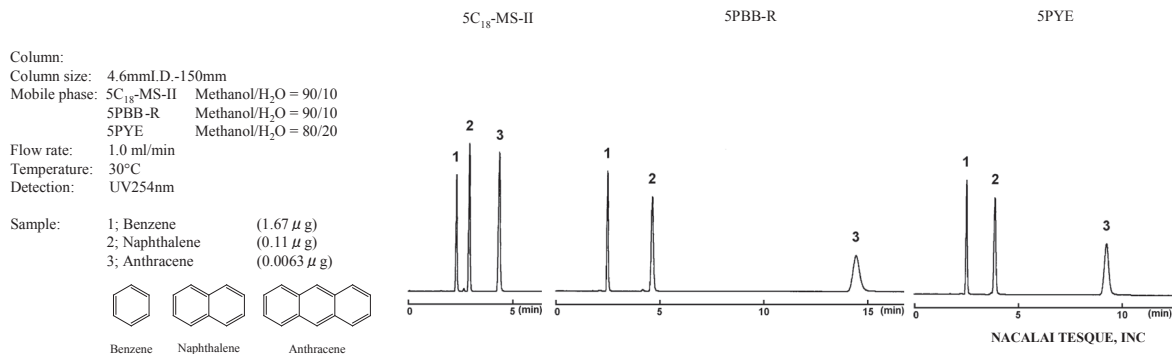
3) Selectivity for Polyaromatic Compounds

Selectivity

Selectivity for polyaromatic compounds is evaluated based on the separation of benzene, naphthalene and anthracene. The elution orders in all columns are the same : benzene, naphthalene and anthracene. Retention increases in all columns with increasing number of aromatic rings. In addition, highly dispersive packing materials such as PBB and PYE show much stronger retention for polyaromatic compounds due to dispersion interaction.



Selectivity for Polyaromatic Compounds

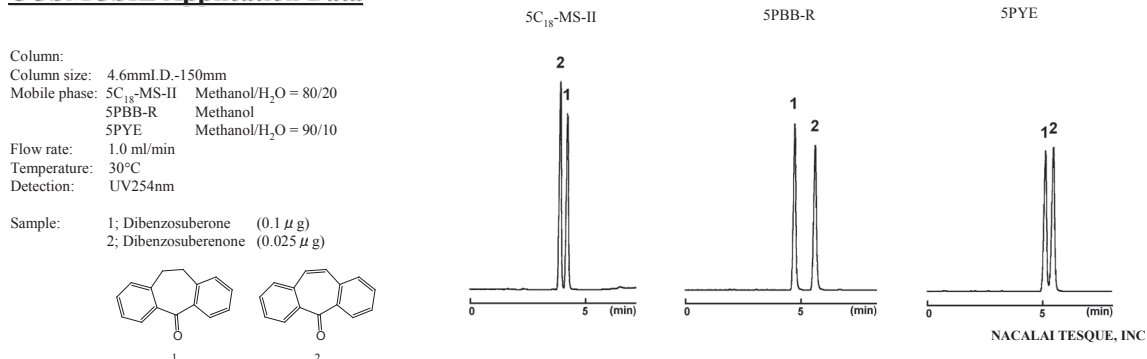


Application

• Separation of Dibenzosuberone and Dibenzosuberone

C₁₈ retains dibenzosuberone (peak 1) longer than dibenzosuberone (peak 2). On the other hand, PBB-R and PYE retain dibenzosuberone (peak 2), which has a π-electron conjugated system, longer than dibenzosuberone (peak 1).

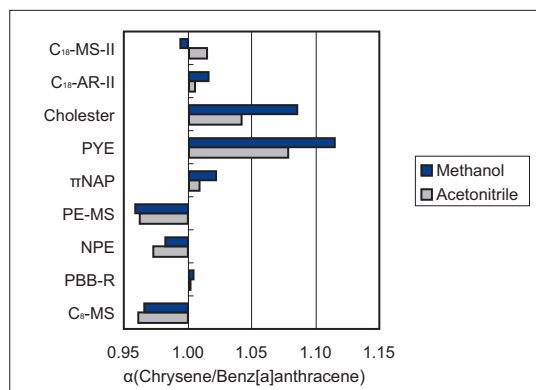
COSMOSIL Application Data



4) Selectivity for Molecular Shape

Selectivity

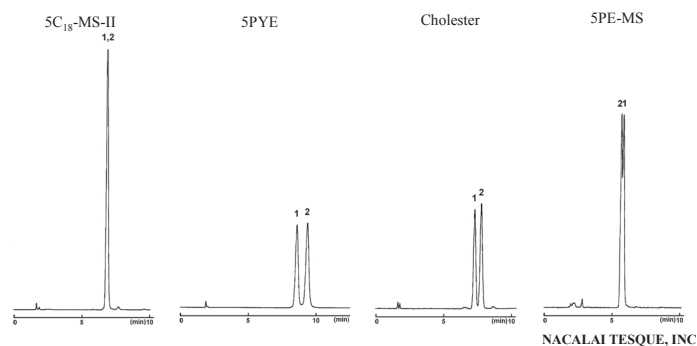
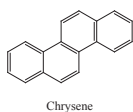
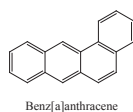
Selectivity for Molecular Shape is evaluated based on the separation of chrysene and benz[a]anthracene. The isomers of two polyaromatic hydrocarbons, which consist of four benzene rings, are difficult to separate because of the similar hydrophobicity or aromaticity. However, PYE and Cholesterol columns, which recognize molecular shape, enable them to separate chrysene and benz[a]anthracene.



Selectivity for Molecular Shape

Column: 4.6mm I.D.-150mm
 Mobile phase: 5C₁₈-MS-II, 5PYE Methanol / H₂O = 90/10
 Cholesterol Methanol
 5PE-MS Methanol / H₂O = 80/20
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: 1; Tetraphene [Benz[a]anthracene] (0.04 μg)
 2; Chrysene (0.04 μg)



Application

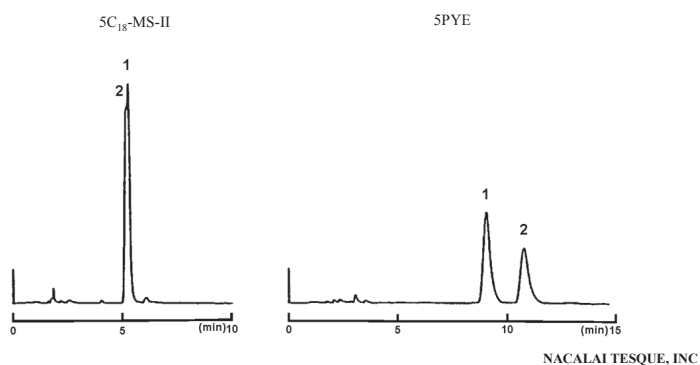
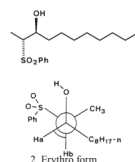
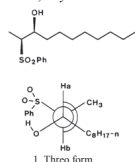
• Separation of Diastereomers (*threo*- and *erythro*-)

C₁₈ cannot separate the *threo* and *erythro* forms. On the other hand, PYE retains the planar *erythro* form longer than the *threo* form.

COSMOSIL Application Data

Column: 4.6mm I.D.-150mm
 Mobile phase: Methanol / H₂O = 80/20
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

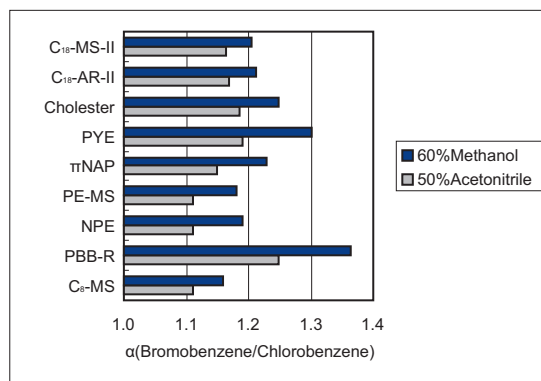
Sample: 1; *Threo* form
 2; *Erythro* form



5) Selectivity for Halides

Selectivity

Selectivity for halides is evaluated based on the separation of chlorobenzene and bromobenzene. PBB-R shows the highest selectivity factor due to dispersion interaction of the five bromine atoms.

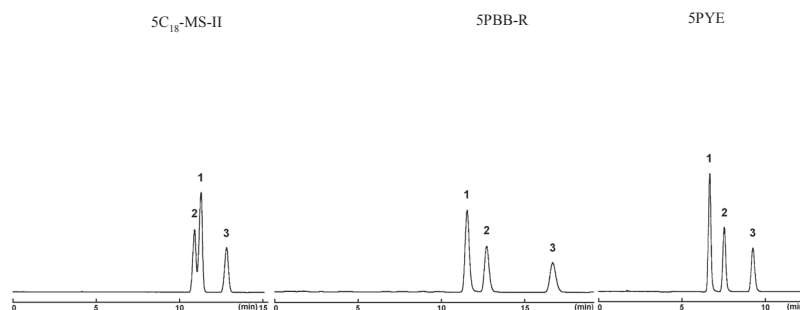
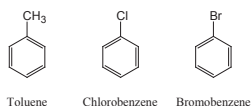


Application

Selectivity for Halide

Column: 4.6mm I.D. - 150mm
 Mobile phase: Methanol/ H₂O = 60/40
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: 1; Toluene (3.3 μg)
 2; Chlorobenzene (3.3 μg)
 3; Bromobenzene (3.3 μg)



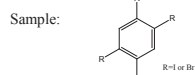
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● Separation of Halogen Exchange Reaction Products

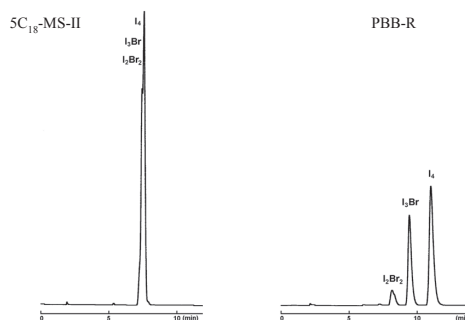
PYE and PBB-R retain dispersed iodine atom longer than bromine atom. As a result, PYE and PBB-R can separate the complicated bromine and iodine compounds that C₁₈ cannot separate.

COSMOSIL Application Data

Column: 4.6mm I.D. - 150mm
 Mobile phase: 5C₁₈-MS-II Methanol/ H₂O = 90/10
 PBB-R Methanol
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm



Sample courtesy of Dr.H.Yamamoto,RIKEN



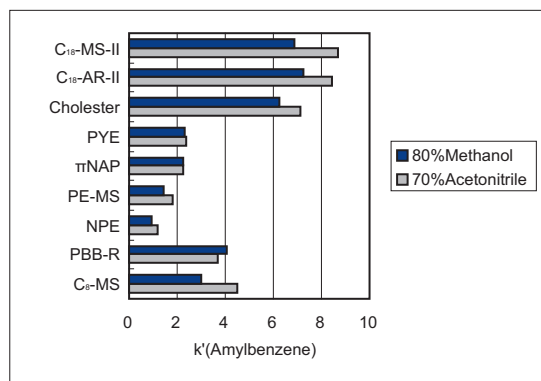
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6) Selectivity for Hydrophobicity

Selectivity

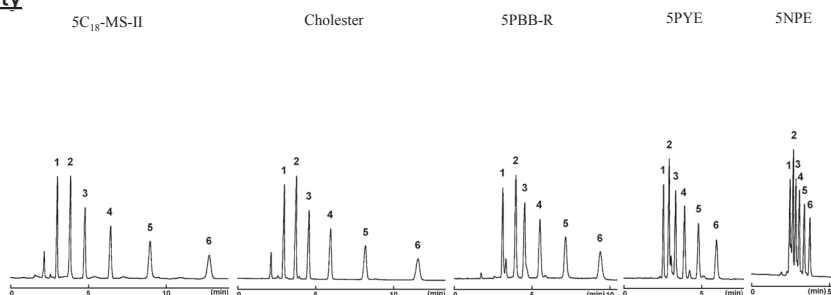
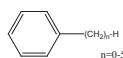
Selectivity for hydrophobicity is evaluated based on the separation of alkylbenzenes. Two C₁₈ and Cholesterol show similar high selectivity for hydrophobicity. Other columns show less hydrophobic selectivity than C₁₈.



Selectivity for Hydrophobicity

Column: 5C₁₈-MS-II
 Column size: 4.6mm I.D. - 150mm
 Mobile phase: Methanol/H₂O = 80/20
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: 1; Benzene (1.67 μg)
 2; Toluene (1.67 μg)
 3; Ethylbenzene (1.67 μg)
 4; Propylbenzene (1.67 μg)
 5; Butylbenzene (1.67 μg)
 6; Amylbenzene (1.67 μg)



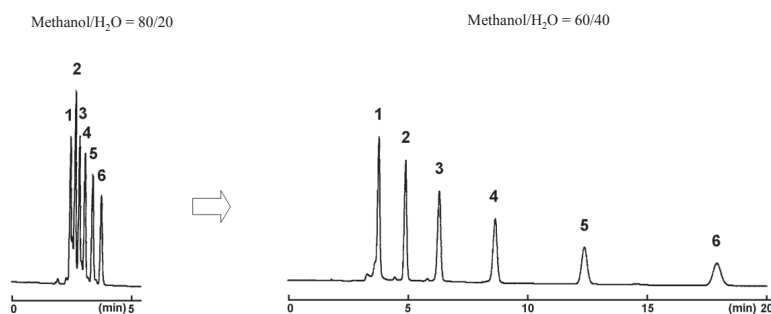
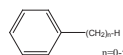
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Lower concentration of organic solvent in mobile phase leads to much retention in reversed phase chromatography. In case of NPE, when methanol concentration is reduced to 60%, the retention times increase to those similar to C₁₈ with 80% methanol.

Adjustment of Retention

Column: 5NPE
 Column size: 4.6mm I.D. - 150mm
 Mobile phase: Methanol/H₂O = 80/20
 Flow rate: 1.0 ml/min
 Temperature: 30°C
 Detection: UV254nm

Sample: 1; Benzene (1.67 μg)
 2; Toluene (1.67 μg)
 3; Ethylbenzene (1.67 μg)
 4; Propylbenzene (1.67 μg)
 5; Butylbenzene (1.67 μg)
 6; Amylbenzene (1.67 μg)



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