Evaluation of Six Core Shell Columns Based on Both Separation Behavior and Physical Property

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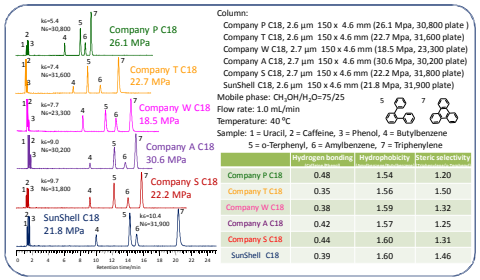
Abstract

A column packed with 2.7 µm core shell particles has been widely used on HPLC and UHPLC, because it showed not only excellent column efficiency but also lower backpressure than sub-2 µm column. More than 10 kinds of core shell column are available in the market. It is said that two types of core shell silica particle are used. One is a mono-layer structure as a porous silica layer like a core shell silica manufactured by Advanced Materials Technology and another is a multi-layer structure like that manufactured by Phenomenex.

In this study, a separation behavior and physical property along with performance matrix of Kinetex C18, Accucore C18, Cortecs C18, PoroShell EC-C18, Ascentis Express C18 and SunShell C18 were evaluated. The evaluation and performance measurements were done using Tanaka Method with reference to retention factor, hydrogen bonding capacity, hydrophobicity and steric selectivity. In addition to peak shapes profile the core shell columns were evaluated for loading capacity of amitriptyline under neutral condition. The stability of the core shell columns under acidic pH1 and basic pH10 conditions at elevated temperatures was evaluated. Apart from physical property such as specific surface area, pore volume, pore diameter along with carbon loading of each C18 packing material, we studied forced degradation of alkyl chains by sintering at 600 degree Celsius for 8 hours. This study revealed significant differences among 6 kinds of core shell C18 in regards to separation behavior, stability and physical properties. This difference can be attributed to diversity of each manufacturing method and bonding technique as well as fully porous silica C18 sorbent matrixes. SunShell C18 showed the largest retention factor and the highest stability despite moderate carbon loading (7%), while the company P C18 core shell column which had the lowest carbon loading and the lowest specific surface area revealed the lowest retention factor and the company A C18 core shell column revealed the lowest stability in regards to chromatographic performance and endurance at elevated Temperature and pH.

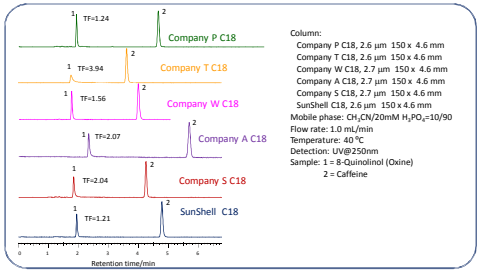
Comparison of Standard Samples



Column:
Company P C18, 2.6 µm 150 x 4.6 mm (26.1 Mpa, 30,800 plate)
Company T C18, 2.6 µm 150 x 4.6 mm (22.7 Mpa, 31,600 plate)
Company W C18, 2.7 µm 150 x 4.6 mm (18.5 Mpa, 23,300 plate)
Company A C18, 2.7 µm 150 x 4.6 mm (30.6 Mpa, 30,200 plate)
Company S C18, 2.7 µm 150 x 4.6 mm (22.2 Mpa, 31,800 plate)
SunShell C18, 2.6 µm 150 x 4.6 mm (21.8 Mpa, 31,900 plate)
Mobile phase: CH_3OH/H_2O=75/25
Flow rate: 1.0 mL/min
Temperature: 40 ºC
Sample: 1 = Uracil, 2 = Caffeine, 3 = Phenol, 4 = Butylbenzene
5 = o-Terphenyl, 6 = Amylbenzene, 7 = Triphenylene

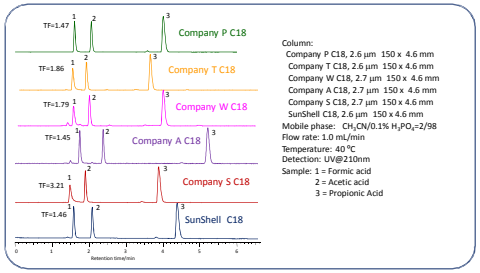
	Hydrogen bonding	Hydrophobicity	Steric selectivity
Company P C18	0.48	1.54	1.20
Company T C18	0.35	1.56	1.50
Company W C18	0.38	1.59	1.32
Company A C18	0.42	1.57	1.25
Company S C18	0.44	1.60	1.31
SunShell C18	0.39	1.60	1.46

Comparison of Oxine,
Metal Chelating Compound



Column:
Company P C18, 2.6 µm 150 x 4.6 mm
Company T C18, 2.6 µm 150 x 4.6 mm
Company W C18, 2.7 µm 150 x 4.6 mm
Company A C18, 2.7 µm 150 x 4.6 mm
Company S C18, 2.7 µm 150 x 4.6 mm
SunShell C18, 2.6 µm 150 x 4.6 mm
Mobile phase: CH_3CN/20mM H_3PO_4=10/90
Flow rate: 1.0 mL/min
Temperature: 40 ºC
Detection: UV@250nm
Sample: 1 = 8-Quinolinol (Oxine)
2 = Caffeine

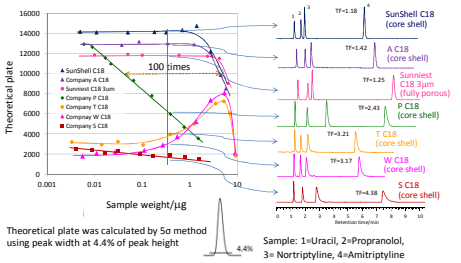
Comparison of Formic Acid



Column:
Company P C18, 2.6 µm 150 x 4.6 mm
Company T C18, 2.6 µm 150 x 4.6 mm
Company W C18, 2.7 µm 150 x 4.6 mm
Company A C18, 2.7 µm 150 x 4.6 mm
Company S C18, 2.7 µm 150 x 4.6 mm
SunShell C18, 2.6 µm 150 x 4.6 mm
Mobile phase: CH_3CN/0.1% H_3PO_4=2/98
Flow rate: 1.0 mL/min
Temperature: 40 ºC
Detection: UV@210nm
Sample: 1 = Formic acid
2 = Acetic acid
3 = Propionic Acid

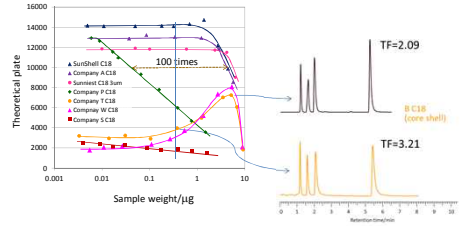
Loading Capacity of Amitriptyline

Mobile phase: Acetonitrile/**20mM phosphate buffer pH7.0**=(60:40)
Column dimension: 150 x 4.6 mm, Flow rate: 1.0 mL/min, Temp.: 40ºC



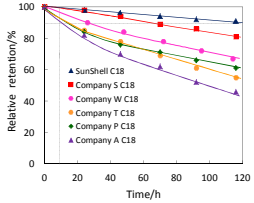
Theoretical plate was calculated by 5σ method using peak width at 4.4% of peak height

Sample: 1=Uracil, 2=Propranolol, 3= Nortriptyline, 4=Amitriptyline



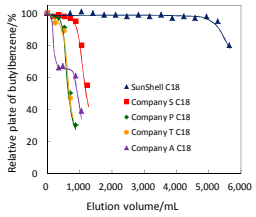
Sample: 1=Uracil, 2=Propranolol, 3= Nortriptyline, 4=Amitriptyline

Stability under pH1 and 10 Conditions



Durable test condition
Column size: 50 x 2.1 mm
Mobile phase: CH_3CN/1.0% TFA, pH1=10/90
Flow rate: 0.4 mL/min
Temperature: 80 ºC

Measurement condition
Column size: 50 x 2.1 mm
Mobile phase: CH_3CN/H_2O=60/40
Flow rate: 0.4 mL/min
Temperature: 40 ºC
Sample: 1 = Uracil
2 = Butylbenzene

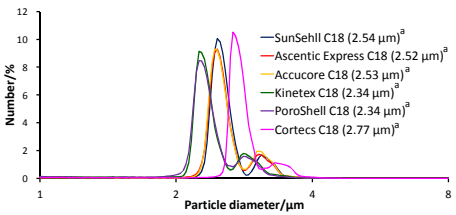


Durable test condition
Column size: 50 x 2.1 mm
Mobile phase:
CH_3OH/20mM Sodium borate/10mM NaOH=30/21/49 (pH10)
Flow rate: 0.4 mL/min
Temperature: 50 ºC

Measurement condition
Column size: 50 x 2.1 mm
Mobile phase: CH_3OH/H_2O=70/30
Flow rate: 0.4 mL/min
Temperature: 40 ºC
Sample: 1 = Butylbenzene

	Acidic condition pH 1	Basic condition pH 10	pH range written in each brochure
SunShell C18	◎	◎	1.5 - 10
Company W C18	△	not tested	2 - 8
Company S C18	○	○	2 - 9
Company A C18	△	△	2 - 9
Company T C18	△	△	1 - 11
Company P C18	△	△	1.5 - 10

Physical Property



*Measured using Beckman Coulter Multisizer 3 after C18 materials were sintered at 600 degree Celsius for 8 hours. The measured value of each sintered core shell silica is considered to be different from that of the original core shell silica.

a. Median particle size

	Carbon loading (%)	Specific surface area [a] (m^2/g)	Pore volume [a] (mL)	Pore diameter [a] (nm)
SunShell C18	7.3 (7)[b]	125 (150)[b]	0.261	8.34 (9)[b]
Company S C18	8.0	133 (150)[b]	0.278	8.20 (9)[b]
Company A C18	8.5 (8)[b]	135 (130)[b]	0.414	12.3 (12)[b]
Company T C18	8.8 (9)[b]	130 (130)[b]	0.273	8.39 (8)[b]
Company W C18	7.3 (6.6)[b]	113	0.264	9.32
Company P C18	4.9 (12 effective carbon loading)[b]	102 (200 effective surface area)[b]	0.237	9.25 (10)[b]

a. Measured after C18 materials were sintered at 600 degree Celsius for 8 hours. The measured value of each sintered core shell silica is considered to be smaller than that of the original core shell silica.
b. Value written in each brochure or literature

Used Column Name

1. Company P C18, 2.6 µm: Kinetex c18
2. Company T C18, 2.6 µm: Accucore C18
3. Company W C18, 2.7 µm: Cortecs C18
4. Company A C18, 2.7 µm: PoroShell C18 EC
5. Company S C18, 2.7 µm: Ascentis Express C18
6. SunShell C18, 2.6 µm

Conclusion

- ✓ The big difference concerning retention, residual silanol groups, metal impurities, loading capacity, stability and particle size among core shell C18s was confirmed as well as fully porous C18s.
- ✓ SunShell showed the longest retention, the most symmetrical peak and the highest stability.
- ✓ Not only the measured value of physical property but also pH range for usage is not as same as a value shown in a brochure and a literature in some cases.