The world's first cation and anion IEX multimode ODS column

Reversed Phase + Anion Exchange + Cation Exchange

**Scherzo C18 Family**

Simultaneous analysis of both cationic and anionic compounds
ODS + Ion Exchange separation mode
Three kinds of packings with different ion exchange capacities
For polar compounds
Different selectivity from conventional ODS columns
LC-MS compatible without using ion-pair reagents
ODS column consists of C18+anion+cation ligand

Scherzo family columns can operate without adding an ion-pairing reagent which is required for conventional ODS columns. In addition, both anionic and cationic compounds are retained on this column. The hydrophobicity of the Scherzo family is similar to that of a conventional ODS column, so analysis of a compound in combination with a Unison UK-C18 column (conventional ODS phase) will be very effective for method development.

**Three kinds of ODS with different ion exchange capacities**

**Scherzo SS-C18**

- Large amount of strong ionic ligands loaded onto this ODS column.
- Effective for improved retention of zwitterions or weak ionic compounds

**Scherzo SM-C18**

- Weak ionic ligands adequately loaded onto this ODS column.
- Designed for separation of basic/acidic compounds at neutral pH condition

**Scherzo SW-C18**

- Low amount of strong ionic ligands loaded onto this ODS column.
- Effective for strong ionic compound elution or basic compounds with formic acid eluent
**Separation modes of Scherzo C18 columns**

The Scherzo C18 Family, (SS-C18, SM-C18, SW-C18), consists of not only ODS ligands, but also anion ligands and cation ligands. It also provides reversed-phase mode, both ion exchange modes, and normal phase mode.

<table>
<thead>
<tr>
<th>Separation Mode</th>
<th>Stationary Phase</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reversed-Phase</td>
<td>Octadecyl</td>
<td>Increasing organic solvent composition (decreasing porosity of eluent) decreases retention.</td>
</tr>
<tr>
<td>Anion Exchange</td>
<td>Cation</td>
<td>Increasing ionic strength (salt or acid concentration) decreases retention for acidic compounds. Generally, low pH increases retention.</td>
</tr>
<tr>
<td>Cation Exchange</td>
<td>Anion</td>
<td>Increasing salt concentration decreases retention for basic compounds. SM-C18 retains more with increasing pH, while SS-C18 and SW-C18 retain more at lower pH.</td>
</tr>
<tr>
<td>Normal Phase</td>
<td>Anion/Cation</td>
<td>Polar solutes which cannot be retained with 100% aqueous eluent may be retained by using &gt;50% organic solvent composition due to electrostatic interaction.</td>
</tr>
</tbody>
</table>

**Retention properties of Scherzo C18 columns (RP+AX+CX)**

Multi-mode ODS Scherzo C18 columns consist of ODS ligands which have reversed-phase mode, plus anion and cation ligands which have anion/cation exchange modes. Three kinds of Scherzo columns have individual ion exchange capacities to find the best column for target compounds which have different ionic properties. Moreover, hydrophobicity between Scherzo C18 and Unison UK-C18, a conventional ODS, is similar, so these columns can be used as comparisons during method development.

The entire family, all retain both basic compounds (1) and acidic compounds (2). SS-C18 shows largest retention, followed by SM-C18 and then SW-C18. Retention may be affected by compound dissociation and mobile phase pH to provide switched retention.

Non-ionic compounds may be eluted with similar retention between these columns.

**Scherzo SS-C18, SM-C18, SW-C18, 150 x 3 mm**
A: 40 mM ammonium formate
B: 100 mM ammonium formate / acetonitrile = 50 / 50
0 - 100%B (0 - 15 min), 0.4 mL/min, 37 °C, 260 nm

At neutral pH conditions, SW-C18 has the least retention capacity, and SM-C18 and SS-C18 have stronger retention power. These retention differences among the columns will be enhanced under lower initial salt concentration.
Affecting factors for retention on Scherzo C18 columns

- You can find the best HPLC conditions by optimizing ionic strength or pH to improve retention / separation for ionic compounds, which is difficult on a conventional ODS column.
- Not only pH but also ionic strength (concentration of salt or acid) will strongly affect the retention on Scherzo C18 columns.
- This effect is the same as ion-exchange columns.
- Scherzo C18 columns, which have RP + both ion exchange modes, require optimization of organic solvent, pH, and ionic strength.

For the Scherzo multi-mode ODS columns, optimizing the salt concentration is as important as optimizing the organic solvent. In the left figure, retention of both anionic and cationic compounds are decreased when salt concentration is increased. At the same salt concentration, SS-C18, which consists of a large amount of strong ionic ligands, retains strongly. SM-C18, with weak ionic ligands has medium retention. And finally, SW-C18, which has a low amount of strong ionic ligands, shows the lowest retention.

pH is also an important factor for the elution of ionic compounds. Retention will change dramatically between neutral pH (ammonium acetate or formate) and low pH (formic acid) conditions. SS-C18 and SW-C18 consist of strong ionic ligands and retention will be increased under low pH conditions. On the other hand, SM-C18 consists of weak ion ligands which cannot ionize at a low pH - therefore, retention of basic compounds will be decreased due to a decrease in ionization capacity at low pH.

Elution strategies by Scherzo C18 columns

<table>
<thead>
<tr>
<th>Non-ionic hydrophobic solutes</th>
<th>Organic solvent composition should be optimized (similar to conventional ODS). Peak shape is often improved by using 0.1% acetic acid.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ionic hydrophobic solutes</td>
<td>A combination of organic solvent and 20-100mM of salt or acid at optimal pH should be used for separation of both acidic / basic compounds.</td>
</tr>
<tr>
<td>Weak ionic-polar solutes</td>
<td>SS-C18 is often the best choice for weak ionic polar solutes. Ionic strength should be increased for compounds that contain multiple ionic functional groups. Neutral pH conditions are required for mono-carboxylic acid compounds.</td>
</tr>
<tr>
<td>Strong ionic-polar solutes</td>
<td>SW-C18 may be useful when it is difficult to elute on SS-C18 or SM-C18. Strong ionic compounds have strong ionic interaction, so it is recommended to use multiple gradient elutions with ionic strength and organic solvent composition.</td>
</tr>
</tbody>
</table>
Mobile phase preparation for Scherzo C18 columns

Scherzo C18 columns consist of ODS and ionic ligands. At first this new approach is difficult for some users to conceptualize. However, it is easier to think of the columns as an ODS column AND an ion exchange column. The following eluent conditions are a rough guideline:

### Isocratic Elution

- **water / acetonitrile / HCOOH = x / y / 0.1**  \( (x+y = 100) \)  
  - **Acidic pH Eluent**

- **50mM ammonium acetate / acetonitrile = x / y**  \( (x+y = 100) \)  
  - **Neutral pH Eluent**

### Gradient Elution

- **A) water / HCOOH = 100 / 0.1**
- **B) water / acetonitrile / HCOOH = 30 / 70 / 0.5**  
  - **Gradient with Acid and Organic Solvent**

- **A) 10mM ammonium acetate**
- **B) 100mM ammonium acetate / acetonitrile = 30 / 70**  
  - **Gradient with Salt and Organic Solvent**

- **A) water / HCOOH = 100 / 0.1**
- **B) 100mM ammonium formate / acetonitrile = 30 / 70**  
  - **Gradient with pH, Ionic Strength, and Organic Solvent**

### Comparison of Scherzo columns: Optimized on SS-C18 (Neurotransmitter)

Each Scherzo column has different properties and target compounds depending on column choice. SS-C18 has strong ionic ligands and is useful for zwitter-ions, as well as for separating weak ionic compounds.

![Catecholamines](image)

Due to strong ionic ligands, SS-C18 and SW-C18 retain more than SM-C18 which has weak ionic ligands. In particular, SS-C18 will provide an excellent retention performance for very polar ionic compounds. Also, SW-C18, which interacts weakly with these compounds, may be useful for high-throughput analysis.

Formic acid is strictly required at initial conditions due to positive ion of GABA, but dopamine has a stronger interaction under such acidic conditions. Finally, this application is done with a multiple gradient mode using pH, ionic strength, and organic solvent gradients.
Scherzo SS-C18 column applications (Zwitter-ions)

Zwitter-ions which have internal salt generating iso-electric points (pI) are very polar. While it is difficult to retain zwitter-ions on a conventional ODS column, Scherzo SS-C18 provides very effective retention ability.

Figure 5a

150 x 3 mm
Water / Methanol / Formic acid
= 98 / 2 / 0.6
0.4 mL/min, 37 °C, ELSD

Unison UK-C18

Acidic Eluent, Isocratic

Scherzo SS-C18

Figure 5b

150 x 3 mm
pH + Ionic Strength + Organic Solvent, Multiple Gradient

1. creatine phosphate
2. betaine
3. L-carnitine
4. creatine
5. L-theanine
6. L-ornithine

Zwitter-ions, as typified by amino acids are very polar and difficult to retain on conventional ODS columns. SS-C18 which consists of many strong ionic ligands can retain and separate those zwitter-ions easily.

Figure 5a shows that SS-C18 enables sufficient retention/separation due to ionic interaction between positive-charged zwitter-ions under acidic conditions. There are opportunities to get optimized retention when formic acid or organic solvent concentration is changed.

Figure 5b shows an example with multiple gradient elution with pH, ionic strength, and organic solvent. Zwitter ions are ionized to positive under acidic condition, so initial eluent should have low pH conditions. In contrast, ornithine has another amino group which provides a positive charge and becomes a strong cationic compound, so it is difficult to elute under acidic condition. In this case, neutral pH provides weak ionic interaction and pH gradient with increasing of ionic strength and organic solvent is very effective for elution of ornithine.
Scherzo SM-C18 column applications (Salts, Vitamins)

Scherzo SM-C18, consisting of ODS ligands and both weak anion / cation ligands, is useful for a wide range of ionic compounds such as salts, vitamins, acidic / basic compounds, alkaloids etc. It is also offers different selectivity from conventional ODS like Unison UK-C18.

Simultaneous analysis of salt

**Organic Salt**

<table>
<thead>
<tr>
<th>pH 2.5</th>
<th>pH 3.5</th>
<th>pH 3.8</th>
<th>pH 4.2</th>
<th>pH 4.7</th>
<th>pH 4.9</th>
<th>pH 5.4</th>
<th>pH 6.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>6 : 4</td>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>4 : 6</td>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>2 : 8</td>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>1 : 9</td>
</tr>
<tr>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>5 : 95</td>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>2 : 98</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Water-fat soluble vitamins**

**Scherzo SM-C18, 150 x 2 mm**

A: 0.3% HCOOH aq.
B: acetonitrile

<table>
<thead>
<tr>
<th>0-10% B (0-0.2 min)</th>
<th>10-30% B (0.2-8 min)</th>
<th>30-100% B (8-10 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
<td>6 : 4</td>
<td>A: 50mM HCOOH : 50mM HCOONH4</td>
</tr>
</tbody>
</table>

Since water-soluble vitamins are hydrophilic and fatsoluble vitamins are hydrophobic, simultaneous analysis of both types of vitamins is a very difficult issue.

SM-C18 succeeds in this application; gradient elution from acidic pH aqueous conditions to acetonitrile provides sufficient separation of various 15 vitamins. D2 and D3 is also separated. Thiamine (basic compound) and ascorbic acid are both retained as a multi-mode ODS column advantage.

Data provided by Dr. Eric VERETTE, SEDERE S.A.S., France
Scherzo SM-C18 column applications (Separation Selectivity)

Scherzo C18 columns are designed by using the same silica and ODS ligand density as a Unison UK-C18 column. SM-C18 may be effective in changing selectivity when it is difficult to separate impurities on an ODS column.

Scherzo SW-C18, 150 x 3 mm
A: 10 mM CH$_3$COONH$_4$
B: 200 mM CH$_3$COONH$_4$ / ACN = 85 / 15
0-100%B (0-45 min)
0.4 mL/min (10 MPa), 37 °C, ELSD

Scherzo SM-C18 and Unison UK-C18 are designed in such a way that they provide similar retention of non-ionic compounds. In addition, SM-C18 can retain both anionic / cationic compounds under neutral pH conditions. This means that there is an opportunity to improve separation on SM-C18 than on a conventional ODS by only changing columns under the same conditions. This comparison between SM-C18 and UK-C18 helps to determine whether or not an unknown compound is ionic.

Scherzo SW-C18 includes a few amount of strong ionic ligands which is a novel structural idea from traditional ion-exchange columns. This surface structure offers strong ionic compounds elution.

Scherzo SW-C18 has a small amount of strong ionic ligands which is a novel structural idea from traditional ion-exchange columns. This surface structure provides better elution of strong ionic compounds.

siRNA (small interfering RNA), around 21mer base paired double stranded RNA, is getting lots of attention for next generation medicine. But it is very polar and has a lot of phosphoric acids inside, therefore difficult to analyze in RP mode. Figure 7a on SW-C18 shows multiple peaks of commercial siRNA reagents which may include different structural compounds. SW-C18 seems to recognize the different number of nucleic bases (hydrophobic interaction) and phosphoric acids (ionic interaction). SW-C18 may be useful for structure study of siRNA.

SW-C18 can separate not only siRNA, but also ATP or oligo-nucleotides without adding an ion-pairing reagent in the eluent. SW-C18 is applicable for strong ionic compounds like phosphoric compounds because there is a small amount of ionic ligands on the surface of the stationary phase.

Scherzo SW-C18, 150 x 3 mm
A: 10 mM CH$_3$COONH$_4$
B: 200 mM CH$_3$COONH$_4$ / ACN = 85 / 15
0-100%B (0-45 min)
0.4 mL/min (10 MPa), 37 °C, 260 nm
Scherzo SW-C18 column applications (Drugs, Metabolites)

Scherzo SW-C18 will provide excellent performance for basic drug compounds and ionic metabolites between low and neutral pH conditions due to a small amount of strong anionic / cationic ligands. SW-C18 may be useful for DMPK or metabolome studies.

- Various elution conditions for basic drugs

**Basic Compounds**

**[1] Acidic pH Conditions**

A: water /HCOOH = 100 / 0.5
B: ACN /HCOOH = 100 / 1
20-80%B (0-15 min)

**[2] Multiple Conditions**

A: water /HCOOH = 100 /0.1
B: 100mM HCOONH4 /ACN = 50 /50
0-100%B (0-15 min)

**[3] Neutral pH Conditions**

A: 10 mM HCOONH4
B: 100mM HCOONH4 /ACN = 50 /50
0-100%B (0-15 min)

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**Scherzo SW-C18, 150 x 3 mm**

0.4 mL/min (9 MPa), 37 °C, 260 nm

There are three basic ways to analyze basic compounds on Scherzo SW-C18.

[1] Gradient with formic acid + organic solvent concentration will retain basic compounds as strong positive ions. Various cationic compounds are retained with initial / final formic acid concentration.

[2] Gradient between low concentration of formic acid and high concentration of its salt with organic solvent may separate a wide-range of polar and strong cationic compounds.

[3] Gradient with ionic strength at neutral pH and organic solvent is a very useful easy method to analyze both basic and acidic compounds.

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**Product Information**

Spec.: purified porous silica, 3um particle, 13nm pore, ODS+anion+cation ligand

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Column I.D.</th>
<th>Column Length</th>
<th>Guard Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scherzo SS-C18</td>
<td>0.075mm - 0.5mm</td>
<td>10mm, 20mm, 30mm</td>
<td>Guard Holder</td>
</tr>
<tr>
<td>Scherzo SM-C18</td>
<td>1mm, 1.5mm, 2mm, 3mm</td>
<td>50mm, 75mm, 100mm</td>
<td>Cartridge Column</td>
</tr>
<tr>
<td>Scherzo SW-C18</td>
<td>4.6mm, 6mm, 10mm</td>
<td>150mm, 250mm, 500mm</td>
<td></td>
</tr>
</tbody>
</table>