SHIMADZU
Excellence in science

Theory and Key Principles Series

Gas Chromatography (GC)

Session 2 – GC Columns

Introduction

Welcome to Shimadzu's Gas Chromatography Theory and Key Principles Series!

Presenter

Andrew Clissold

GC/GCMS
Business
Manager

Theory & Key Principles Series – GC

– *Introduction to Gas Chromatography **

– GC Columns

– The Split/Splitless Inlet

– Advanced Liquid Injection Techniques

– Alternatives to Liquid Injection

– Choices of Detectors for GC

– Processing GC Data

– Maintenance & Troubleshooting

** Now available on demand at www.shimadzu.co.uk/webinars*

Introduction to gas chromatography

In this presentation:

- Different types of GC columns
  - Packed & capillary
- The different column dimensions and their relevance
  - Length, internal diameter & film thickness
- Column phases and polarity
  - Non-polar, mid-polar & polar
  - Different phase materials
- Temperature ranges

SHIMADZU
Excellence in science

Types of columns

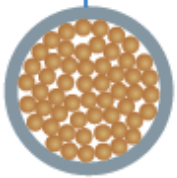
Types of columns

GC Columns

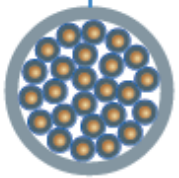
- packed column
- porous solid
- porous solid coated w/liquid stationary phase
- Capillary column
- liquid stationary phase
- porous solid support
- porous solid support w/liquid stationary phrase

Packed

Capillary (Open Tubular)

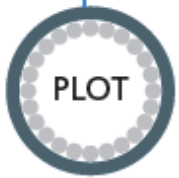


Porous Solid

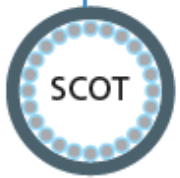


Liquid-Coated Solid

Wall-Coated Open Tubular

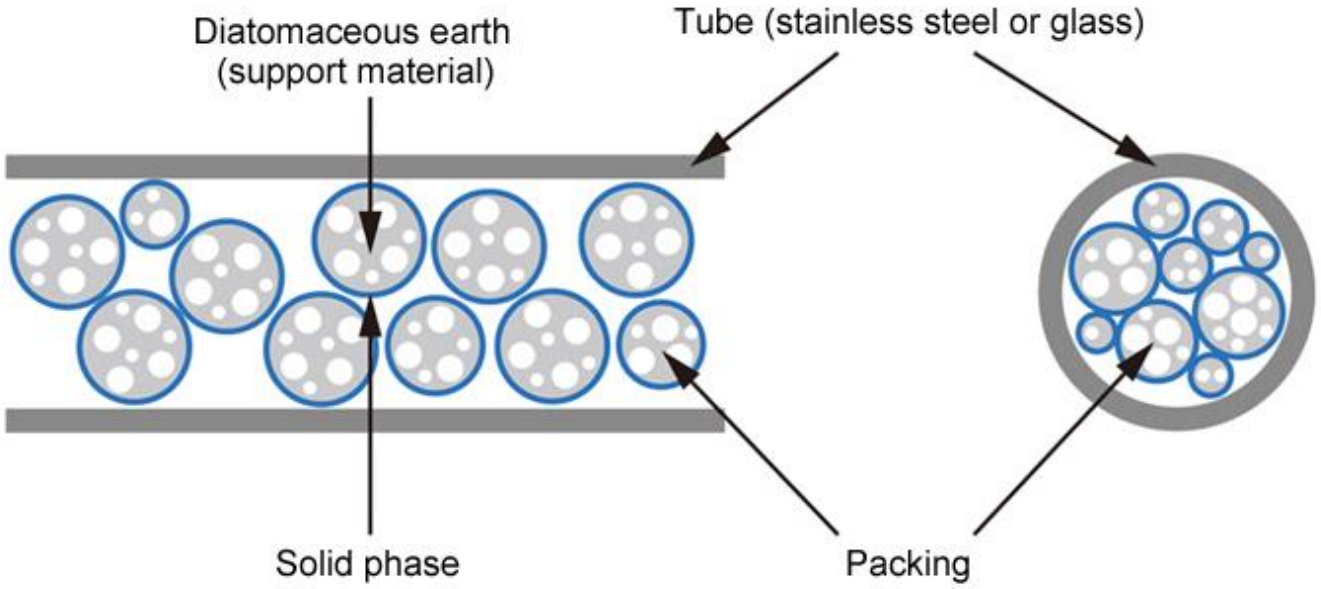


Porous-Layer Open Tubular



Support-Coated Open Tubular

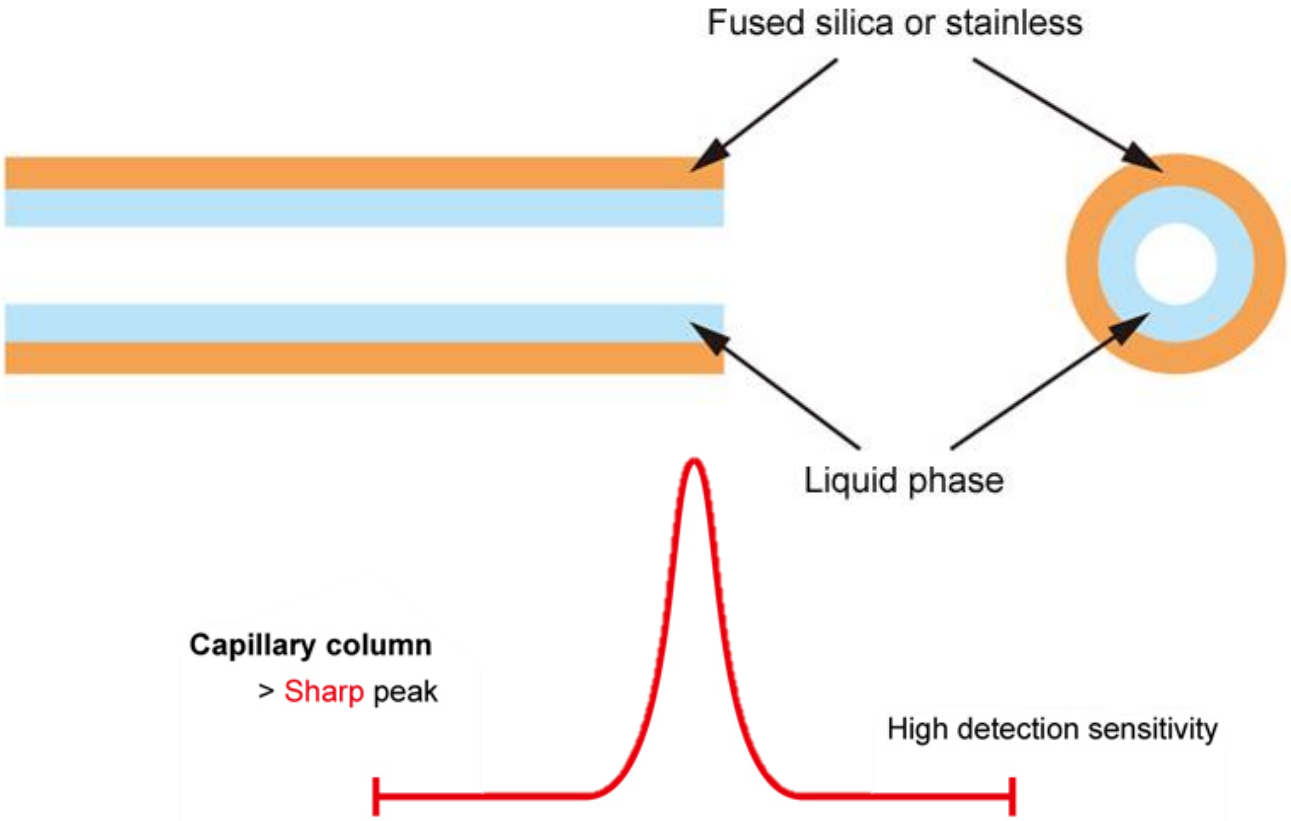
Packed columns



Packed column
> Broad peak

Low detection sensitivity

Capillary columns



Capillary columns

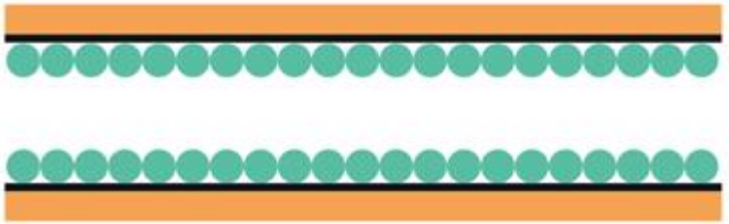
Wall Coated Open Tubular (WCOT)

Lined with liquid phase or a chemical bonding layer

Most common in modern GC applications

Porous Layer Open Tubular (PLOT)

Lined with immobilised porous polymer or alumina, etc.

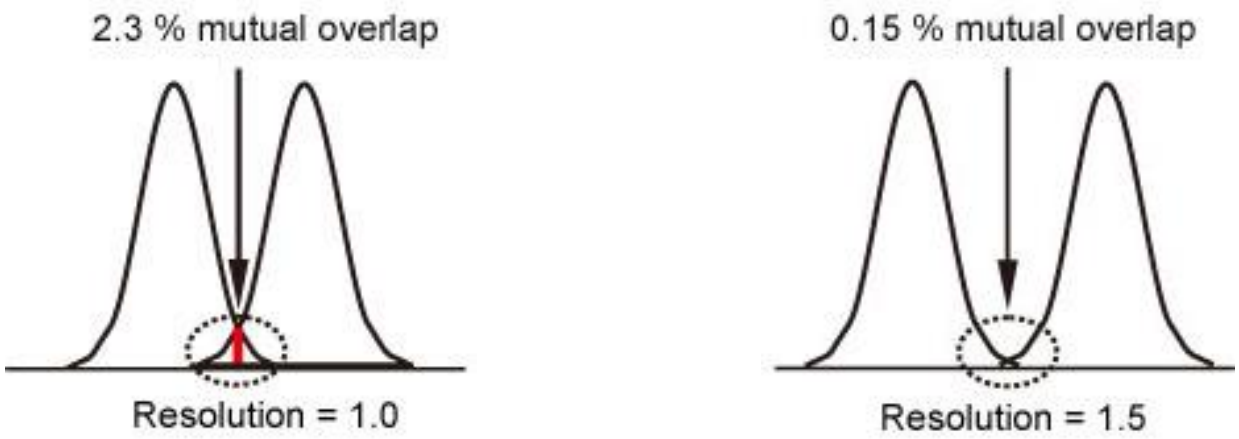


Resolution

The main difference between packed and capillary column chromatography is **resolution**.

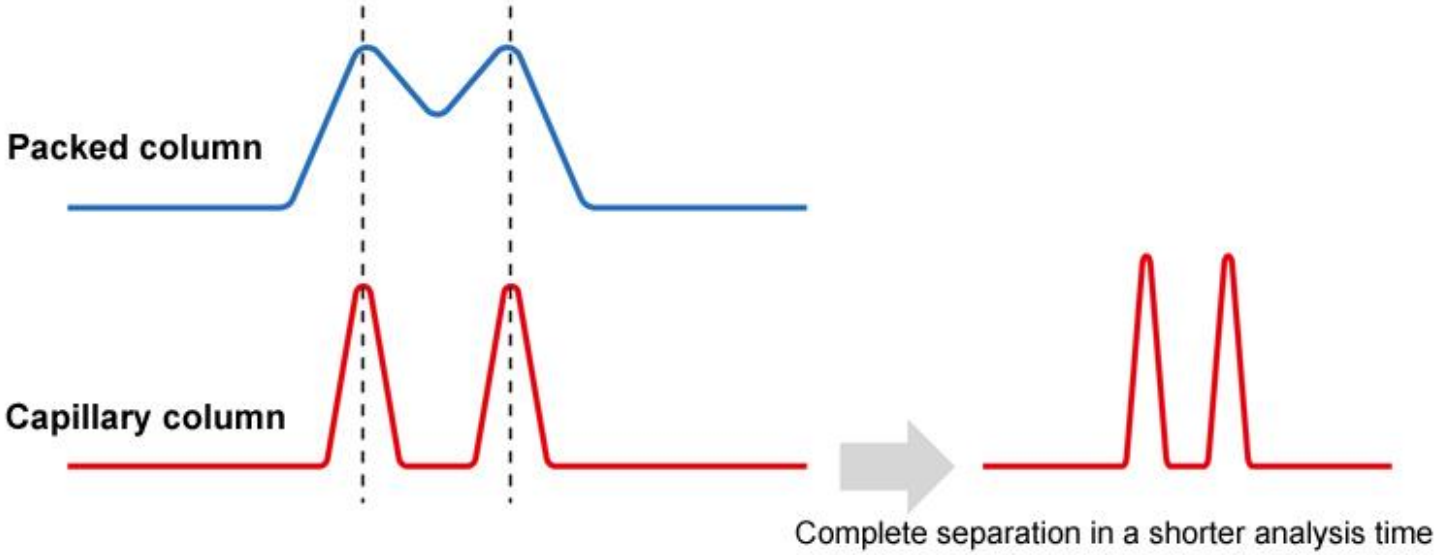
This is a **measure of separation** between two components on a chromatographic system.

The more separated two peaks are, the greater the resolution.



Benefits of capillary columns

Resolution can be >10x higher than packed columns
This means we can separate components on column efficiency rather than selectivity
Fewer stationary phase chemisties are required



SHIMADZU
Excellence in science

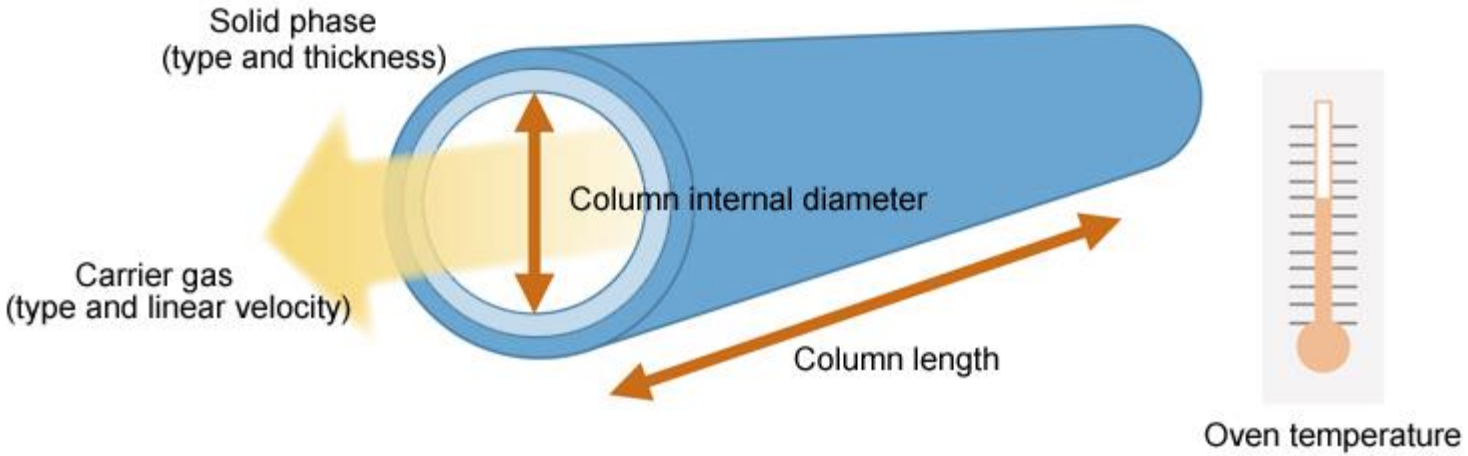
Capillary column properties

Capillary columns

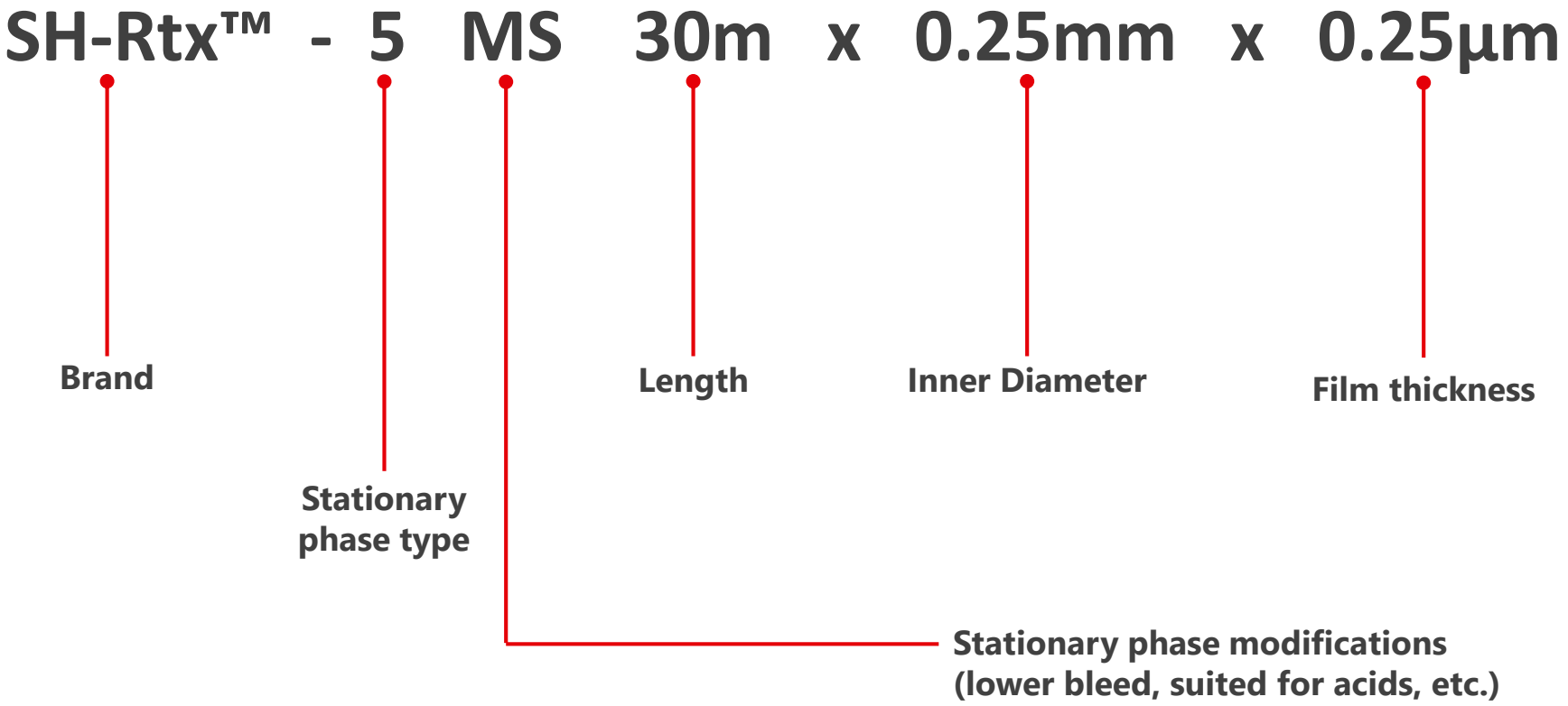
4 Key Properties

Length(m)
Internal diameter (mm)
Film thickness (µm) of stationary phase
Solid phase chemistry

These parameters, combined with **carrier gas** (type and speed) and **oven temperature** determine the separation of components



How to identify capillary columns



SHIMADZU
Excellence in science

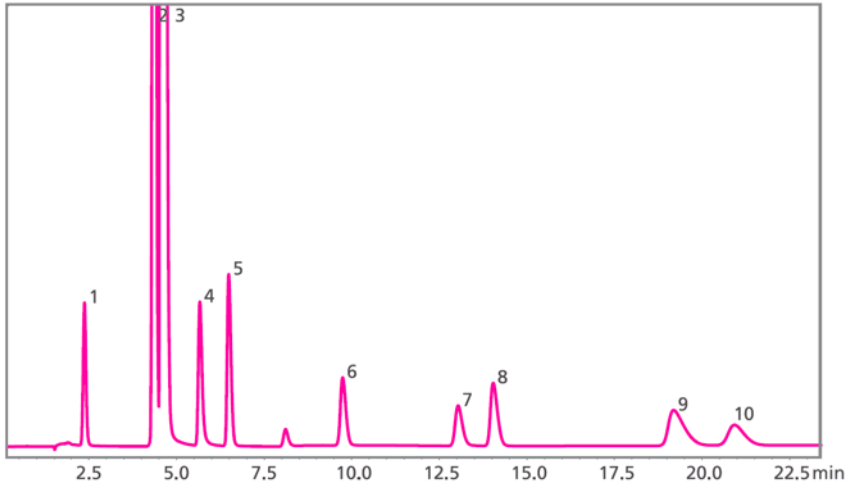
Dimensions

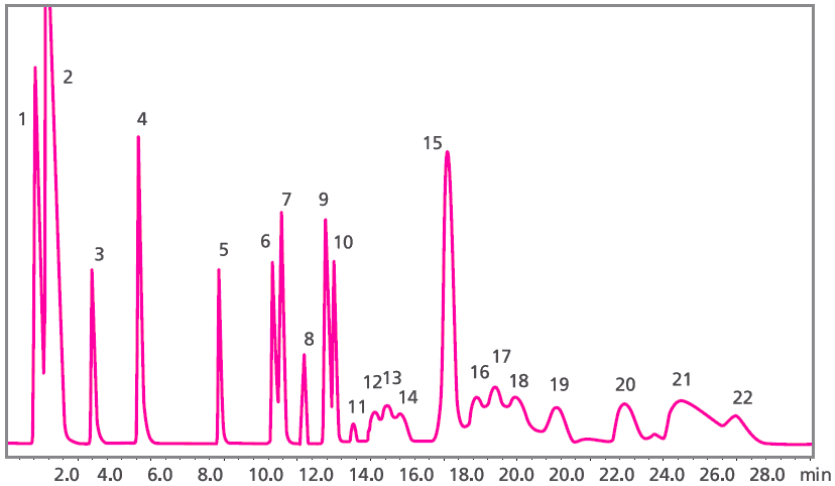
Column dimensions

Length

Whilst increasing column length increases separating power (resolution), it is not a linear relationship! A column that is 2x longer will not have 2x resolution.

But, the longer a column is, the more time compounds spend inside. Long retention times cause compounds to broaden, reducing sensitivity & peak separation.





Column dimensions

> Broad peak

Low detection sensitivity

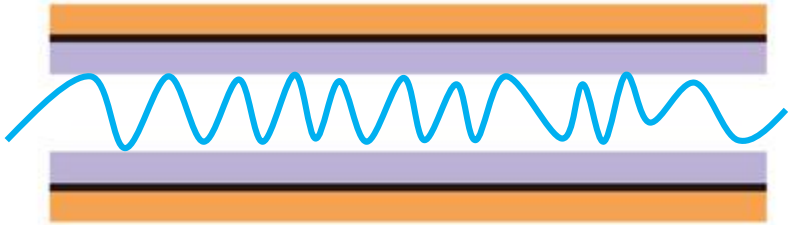
> Sharp peak

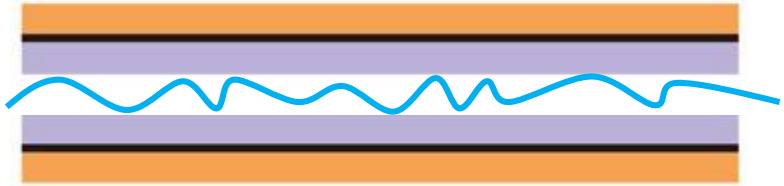
High detection sensitivity

Column dimensions

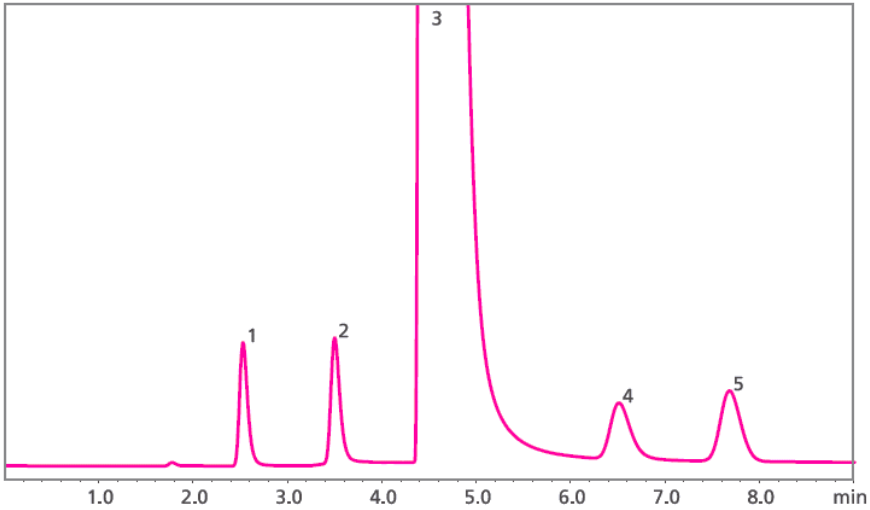
Internal diameter

A narrower internal diameter gives sharper peaks, therefore better resolution and sensitivity.





But, a narrower column reduces the amount of sample that can be effectively separated! Injecting too much of a single compound causes **column overload**.



Column dimensions

Film thickness

Thicker films will retain compounds longer, so thick films are good for very volatile compounds. Equally, a thin film will have a lower retention, so is ideal for very high-boiling components.

Common dimensions

Length	Internal Diameter	Film Thickness	Application
30m	**0.25mm**	**0.25um**	**Most common dimensions, suitable for 90% of applications.**
30m	0.32mm	1.4um	Analysis of very volatile organics in waste water.
15m	0.25mm	0.1um	Analysis of high-boiling phthalates in electrical components
10m	0.1mm	0.1um	Fast GC applications (for higher sampler throughput)

SHIMADZU
Excellence in science

Stationary phase chemistry

Stationary phase chemistry

Capillary column chemistry is usually measured based on its polarity.

Columns are largely described as being polar, mid-polar or non-polar/a-polar.

Like Dissolves Like

Analysis of non-polar compounds	→	Non-polar column
Analysis of polar compounds	→	Strongly polar column

What do the numbers mean?

Roughly speaking, a larger number equates to a higher polarity column

i.e. **Rtx-1** is non-polar **Rtx-5** is largely non-polar **Rtx-35** is mid-polar **Rtx-Wax** is polar

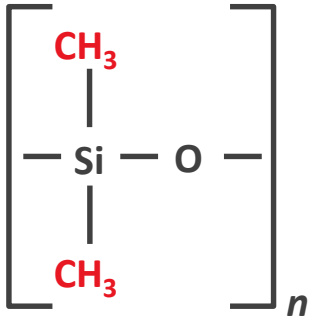
Stationary phases

Type of Solid Phase	Polarity	Separation Characteristics	Application	Temp Ramge (approx.)
Dimethyl polysiloxane	Non-polar	Boiling point order	Petroleum, solvents, high boiling-point compounds	-60 to 360 °C
Phenylmethyl polysiloxane	Non-polar to Mid-polar	Phenyl groups retain aromatic compounds	Perfumes, environmental compounds, aromatic compounds	-60 to 340 °C
Cyanopropyl phenol	Mid-polar to Strongly-polar	Effective separation of oxygenates and isomers	Agricultural chemicals, PCBs, oxygenates *not suited to some detectors (NPDs)	-20 to 280 °C
Trifluoropropyl methyl polysiloxane	Mid-polar to Strongly-polar	Specifically retains halogenated compounds	Halogenated compounds, polar compounds, solvents	-20 to 340 °C
Polyethylene glycol	Strongly polar	Strong retention of polar compounds	Polar compounds, solvents, perfumes, fatty acid methyl esters (FAMEs)	40 to 250 °C

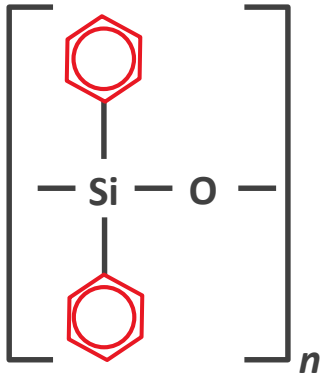
Stationary phases

Polysiloxane phases

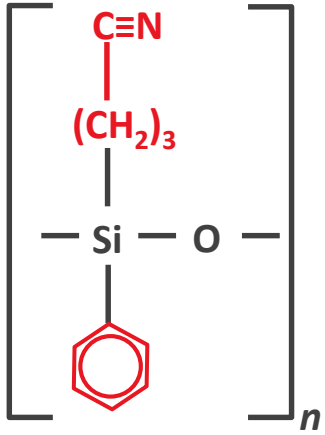
Dimethyl-



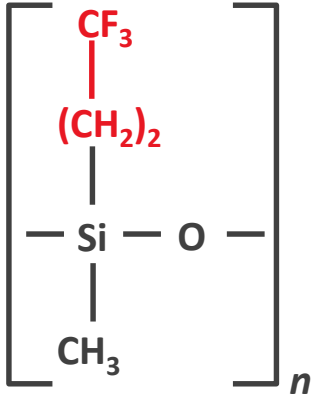
Phenylmethyl-



Cyanopropyl phenyl-

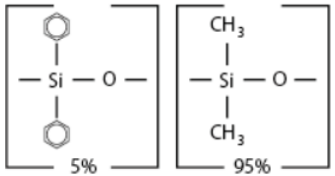


Trifluoropropyl methyl-

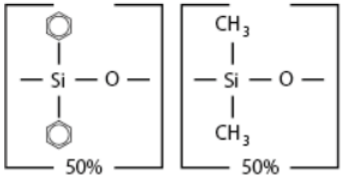


Polysiloxane columns often feature a mixture of the building blocks above:

Rtx-5

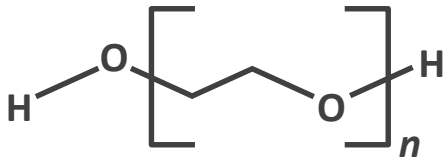


Rtx-17



Special phases

Polyethylene glycol



Temperature considerations

All columns have temperature limits to prevent damage. The details of the limits are on the column box.

Where two temperature limits are stated, these refer to the **isothermal** and **programmed** limits.

Overheating a column causes stationary phase damage, increasing **column bleed** and reducing separation performance.

As columns age, the column bleed starts to increase. **Conditioning** can improve things, but eventually columns have to be replaced.

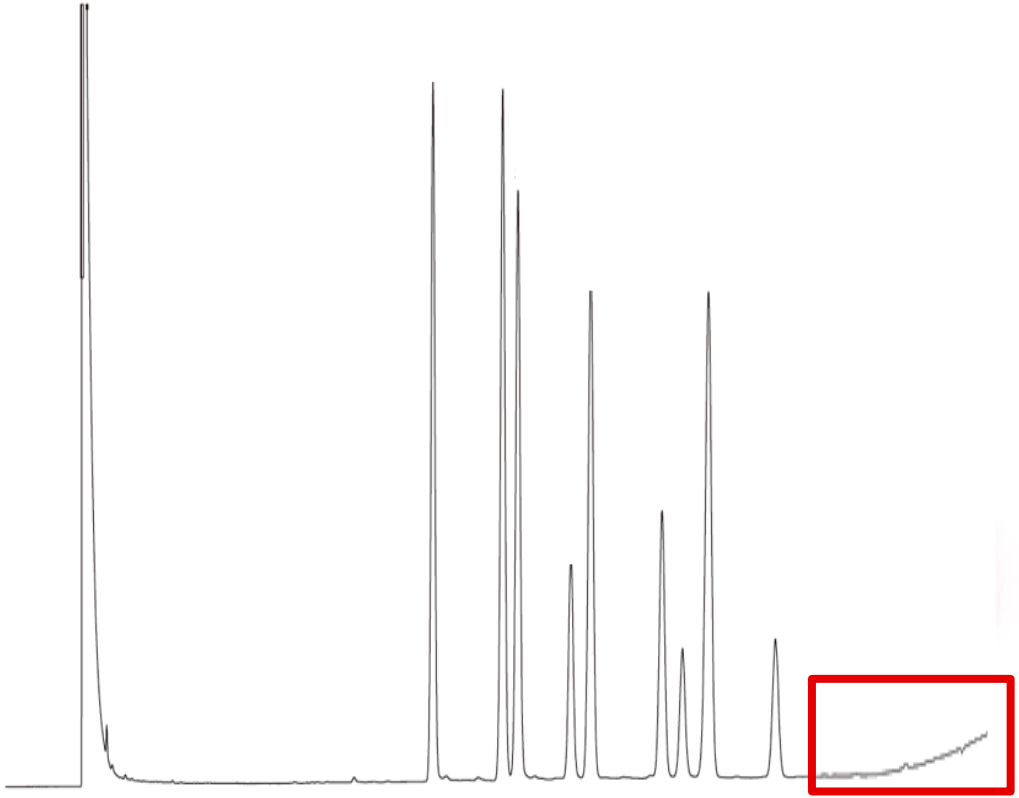
Temperature considerations

All columns have temperature limits to prevent damage. The details of the limits are on the column box.

Where two temperature limits are stated, these refer to the **isothermal** and **programmed** limits.

Overheating a column causes stationary phase damage, increasing **column bleed** and reducing separation performance.

As columns age, the column bleed starts to increase. **Conditioning** can improve things, but eventually columns have to be replaced.



SHIMADZU
Excellence in science

Summary

Summary

- **We can categorise GC columns into two types: packed and capillary (or open tubular)**
  - Packed columns contain a packing material made of a porous solid or a liquid-coated solid
  - Capillary columns are hollow tubes with coatings supported on the inside wall of the column

- **Capillary columns, specifically WCOT, are utilised far more in modern systems as they give a higher resolution**

- **Capillary columns have 4 key properties:**
  - Length – *doubling the length gives small improvements in separating power, but increases run-time*
  - Inner diameter – *a narrower i.d. provides a much higher resolution but can hold less sample*
  - Film thickness – *a thicker film retains compounds for longer, so is good for analysis of more volatile compounds*
  - Phase chemistry – *the make-up of the inner-coating defines how compounds will separate*

- **Phases for WCOT columns are described based on their polarity, from non-polar to polar.**
  - A more polar phase often has a lower maximum temperature, so choosing a suitable phase can be tricky
  - These are a wide range of column phases available – use literature examples to help guide your choice!

Next time

The next session will be on…

The Split/Splitless Inlet

This will cover:

- *The difficulties of getting a sample onto the analytical column*
- *The different method parameters and what they all mean*
- *Why using split mode is the easiest & best option*
- *How and when to use splitless mode*

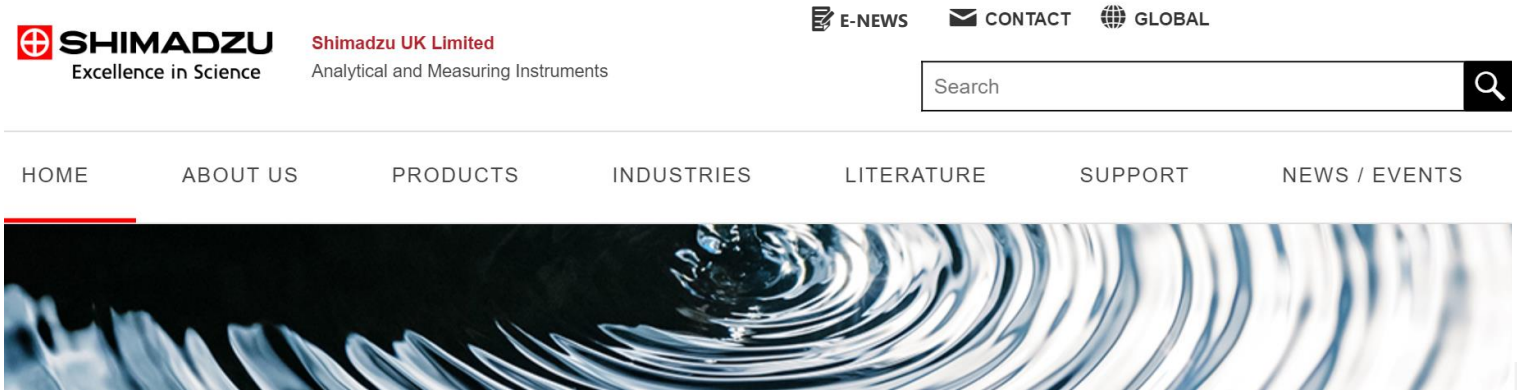
Shimadzu UK e-News

Join our e-News mailing list today!

Benefits of joining:

- Be entered into our prize draws & competitions
- Find out about our latest webinars, workshops & events
- Receive exciting information about the latest analytical technology & application notes

Look for the link in our follow-up email or go to www.shimadzu.co.uk and click on e-News



Shimadzu UK webinars

Please visit our website to check out our other webinar sessions that are open for registration or are available on demand:

www.shimadzu.co.uk/webinars

Please send any questions to gc@shimadzu.co.uk

SHIMADZU

Excellence in Science

Contact Details

www.shimadzu.co.uk *info@shimadzu.co.uk* *01908 552209*

@ShimadzuUK *Shimadzu UK Limited*