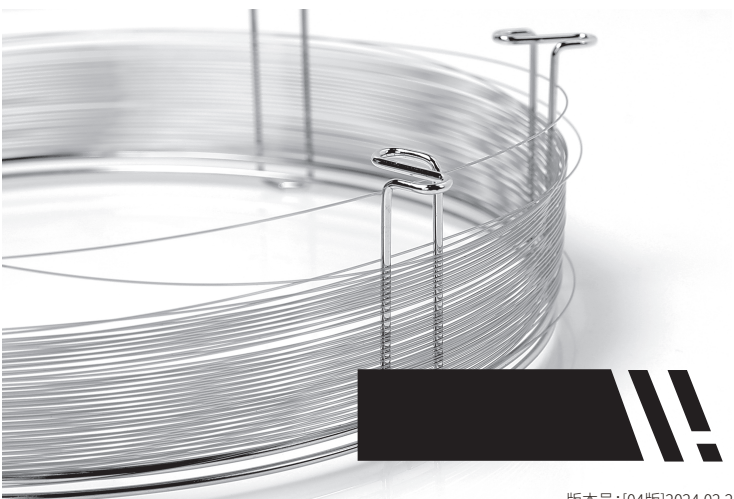
welch
月旭科技

Welchrom®

GC Column



版本号：[04版]2024.02.23

welch
月旭科技

本册说明

本手册为GC色谱柱的中英文说明书，包括以下内容：

1. 色谱柱的身份确认
2. 色谱柱的安装
3. 色谱柱的保存
4. 色谱柱的正确使用
5. 常见问题分析
6. 色谱柱的选择

色谱柱的身份确认

为了保证每一支色谱柱的质量，Welch公司出售的每一支色谱柱都有唯一的身份编码，根据此编码，我公司可以将质量问题确定到个人，为了保障您的利益，收到色谱柱时，请完成以下程序:

1. 仔细查看包装盒是否完好，与自己请购的色谱柱是否一致;
2. 盒内是否有质量检验报告及检验人员签名;
3. 色谱柱表面有无刮痕，避免用硬物刮伤柱体;
4.色谱柱柱体是否有Welch公司色谱柱的身份铭牌，并仔细对照包装盒与色谱柱铭牌上的型号和编号是否一致。

色谱柱的安装

一根好的气相色谱柱，由于安装不当，可能会造成理论塔板数降低，峰形增宽或拖尾，灵敏度降低等问题。毛细管色谱柱由于柱体积很小，载气流量很小，微小的死体积便会对色谱峰有较大的影响。将毛细管色谱柱连接到进样器和检测器时，不同公司的仪器均有严格要求，在安装时应特别注意。

安装前的检查:

1.检查气瓶压力以确保有足够的载气、尾吹气和燃气，载气的纯度不低于99.999%;
2.清洁进样口，必要时更换进样口的密封垫圈、衬管和隔垫;
3.检查检测器密封垫圈，必要时更换，如有必要，清洗或更换检测器喷嘴;
4.仔细检测柱子是否有破损或断裂。

毛细管色谱柱的安装

步骤1: 将螺母和卡套装在柱子上，并将色谱柱两端口小心切平

分别从两端轻轻地将毛细管柱从柱架上绕出半圈，在色谱柱的两端装上相应的螺母和卡套，之后将毛细管柱悬挂在柱温箱的柱架上,色谱柱支架的支撑部分应总是朝向着柱箱门。安装好螺母和卡套后，将色谱柱的两端口切掉3-5cm并用放大镜进行检查，以确认切口和管壁成直角，并且没有残留的碎屑，没有毛边或不平的切割面。

推荐切割工具:钻石或人造钻石割刀、蓝宝石切割工具、陶瓷片
不使用:剪刀、锉刀

步骤2:将毛细管色谱柱连于进样口上

通常情况,色谱柱的顶端应保持在进样口衬管的中下部,当进样针穿过隔垫完全插入进样口后,如果针尖与衬管中的色谱柱顶端相差1-2cm,是较为理想的状态。

从色谱柱架上取出需要连接的足够的长度,并按步骤2切割柱子,连接到进样口。避免用力弯曲压挤毛细柱,并小心不要让标记牌等有锋利边缘的物品与色谱柱接触磨擦,以防柱身断裂或受损。将色谱柱正确地嵌入进样口后,用手把连接螺母拧上,用手拧紧后用扳手再拧1/4-1/2圈,这样当加压时色谱柱不会从接头脱落出来。

步骤3:接通载气

载气必须为高纯氮气(或氦气、氢气),纯度达99.999%,使用极性柱时(如INOWAX,PEG-20M,FFAP等),最好载气加脱氧管进一步脱氧,这样可延长柱子的使用寿命。

当色谱柱与进样口连接好后,接通载气。调节柱前压力以得到合适的载气流速。将色谱柱的另一端(空端),插入装有己烷的样品瓶中,正常情况下,我们可以看见瓶中稳定持续的气泡。如果没有气泡,就要重新检查一下载气装置和流量控制器等是否安装完全或设置正确,并检测一下整个气路有无泄漏。等所有问题解决后,将色谱柱端口从瓶中取出,擦试干净,保证柱端口无溶剂残留,再进行下一步安装。

毛细管柱头压力近似值(psi)

柱温:20°C;　载气:氦气;　线速度:30cm/s;　液膜厚度: 0.25μm

柱长/m	柱内径 I.D.（mm）						
	0.05	0.10	0.18	0.25	0.32	0.45	0.53
10	110	27	7.3	3.8	2.3	1.2	0.8
15	--	54	--	5.7	3.4	1.7	1.3
20	--	--	15	--	--	--	--
25	--	--	--	10	5.8	2.9	2.1
30	--	--	--	12	6.9	3.5	2.5
40	--	--	32	--	--	--	--
50	--	--	--	21	12	5.8	4.2
60	--	--	--	25	15	7.0	5.0
100	--	--	--	42	25	12	8.6

注:psi为平方英寸磅表压,换算为标准单位的近似值为1psi=6894.76pa

步骤4:将色谱柱连于检测器上

其安装和所需注意的事项与以上色谱柱与进样口联接(步骤3)部分所讲述的大致相同,一般色谱柱末端要高于尾吹点。

步骤5:进行气体检漏

在色谱柱加热前,要对GC系统进行检漏。

注意:进样口和检测器端的安装距离请参照色谱仪说明书。

色谱柱的保存

长期保存(色谱柱从柱温箱中取出):

将色谱柱存放在原包装盒内,用合适的密封垫封住色谱柱的两端,避免水分和化学挥发物的污染。

色谱柱的正确使用

毛细管柱的寿命与使用载气的纯度、水蒸气含量以及分析样品的性质有关,操作不当将导致色谱柱寿命的降低,合理科学的使用是延长其寿命的最佳办法。

1. 载气:当色谱柱处于高温且没有载气通过时,色谱柱的固定液热分解较迅速,所以在柱箱升温前应该先通上载气,柱箱冷却后才能把载气关上。
2. 温度:色谱柱的寿命与它的使用温度有关。一般实际使用的最高温度比固定相使用温度上限低20-30°C有助于延长色谱柱寿命。
3. 水分:载气中的水分能透过固定液膜吸在柱管表面上,会取代或破坏固定液膜,采用干燥的载气同样有助于延长色谱柱寿命。
4. 氧气:对于易氧化的固定液(INOWAX,PEG-20M,FFAP等),对载气除氧很重要,建议使用脱氧管进行除氧。

5. 老化：新毛细管柱使用前一般需要进行老化处理，以去除溶剂残留和杂质干扰。一般是先在50°C柱温下保持1h，赶走多余的溶剂，然后以2~3°C/min的速度程序升温，当达到固定液允许的最高使用温度以下30°C老化1-2h即可（例如铭牌上温度为Max Temp 330/340，就是330减30，升温到300°C），如有必要可以重复2-3次。如果在高温保存10min背景不下降，立即将柱子降温，并检查柱子是否有泄漏。如果是强极性柱（聚乙二醇类固定相）一定要先在常温下（进样口、柱箱、检测器都不升温）至少通气十几分钟，再设置程序进行升温老化。放置较长时间的柱子，在使用之前，也可以按上述程序进行老化，而不可突然将柱温升至很高，防止柱液膜被破坏。

常见问题分析

我们针对毛细管色谱柱分析中常见的一些问题进行了分析，并提出了相应的解决方法，整理如下:

	常见问题	原因分析及解决方法
1	峰丢失	1.进样针有问题，重新更换做验证； 2.进样温度或柱温温度过低:检查温度，并根据需要调整; 3.载气流量过低:检查压力调节阀，并检查泄露，验证载气流速； 4.检测器没连好或参数设置不当：检查连接，重新调整设定值； 5.柱断裂：若柱断裂发生在两端口，切去断裂部分，重新安装即可;若发生在柱中段部分，则需更换新柱。
2	峰前沿	1.色谱柱超载：减少进样量; 2.两个化合物共洗脱：提高灵敏度和减少进样量，使温度降低10-20°C，以使峰分开; 3.样品冷凝:检查进样口和柱温，如有必要可以升温; 4.样品分解:采用失活化进样器衬管或调低进样器温度。
3	峰拖尾	1.柱或进样器温度太低:升温，但不要超过柱最高使用温度，进样器温度应比样品最高沸点高20°C; 2.两个化合物共洗脱:提高灵敏度和减少进样量，使温度降低10-20°C，以使峰分开; 3.柱污染：将柱进样端截去1-2cm，再重新安装; 4.柱已损坏：需更换新柱。
4	宽溶剂峰	1.进样口存有死体积：重新安装柱; 2.进样技术差：采用快速平稳进样技术; 3.进样器温度太低：提高进样器温度; 4.柱内残留样品溶剂：调整或清洗; 5.隔垫清洗不当：调整或清洗; 6.分流比不正确（分流排气流速不足）：调整流速。
5	基线不规则成不稳定	1.检测器或进样器污染：清洗检测器和进样器; 2.载气控制不协调:检查载气等气源压力是否充足，如压力≤500psi，请更换气瓶 3.载气有杂质或气路污染:更换气瓶，使用载气净化装置清洁金属管; 4.进样器隔垫流失:更换隔垫; 5.柱流失或污染:将柱进样端截去1~2cm，重新安装、老化。
6	同一根柱保留时间长短不一	1.柱温波动变化:检查并调节柱温; 2.载气流速波动变化:检查并调节流速; 3.进样器隔垫或柱泄露：检查并修复; 4.柱污染或损坏:重新老化或换柱; 5.色谱柱超载：减少进样量。

色谱柱的选择

1.固定液的选择

WEL经济型	WM高性能型	固定相类型	相似固定液	极性	温度限（℃）	应用范围
WEL-30 WEL-1	WM-1	100% 聚二甲基硅氧烷	DB-1, HP-1,OV-1, BP-1, Rtx-1,OV-101, SBP-1, CP-Sil 5CB	非极性	-60 to 325/350	胺类、烃类、农药、多氯联苯、酚类、硫化物、香料香精
	WM-1MS		ZB-1MS , DB-1MS, HP-1MS, OV-1MS			
WEL-52 WEL-54	WM-5	5% 苯基，95% 聚二甲基硅氧烷	BP-5, ZB-5, CP-Sil 8CB, DB-5, HP-5, SPB-5, Rtx-5, OV-5	弱极性	-60 to 325/350	半挥发性物质、生物碱、药物、生物柴油(FAME)、卤代物、杀虫剂、除草剂
	WM-5MS		ZB-5MS, DB-5MS, HP-5MS, OV-5MS			
WEL-1301	WM-1301	6% 氰丙基-苯基，94% 聚二甲基硅氧烷	DB-1301, HP-1301, PE-1301,Rtx-1301	中极性	-20 to 280/300	醇类、杀虫剂，VOC's、溶剂，磷、农药残留
WEL-35	WM-35	35% 苯基，65% 聚二甲基硅氧烷	DB-35, HP-35, SPB-35, Rtx-35, PE-35, AT-35	中极性	40 to 320/340	杀虫剂、醇类、药物滥用、分子药物
WEL-1701	WM-1701	14% 氰丙基-苯基，86% 聚二甲基硅氧烷	BP-10,CB-1701,CP-Sil 19CB, DB-1701, Rtx-1701	中极性	-20 to 280/300	芳氯物、杀虫剂、除草剂
WEL-17	WM-17	50% 苯基，50% 聚二甲基硅氧烷	DB-17,HP-17,HP-50,Rtx-50,AT-50, ZB-50,SPB-50,CP-Sil 24,SP-2250	中极性	0 to 300/320	类固醇、药物、农药、乙二醇、肌醇
WEL-624	WM-624	6% 氰丙基-苯基，94% 聚二甲基硅氧烷	007-624, AT-624, CP-624, DB-624, HP-624, Rtx-502.2, VOCOL	中极性	-20 to 260	环境中挥发性化合物、溶剂
WEL-PEG20M	WM-InoWax	交联聚乙二醇	CP-Wax, DB-Wax, HP-Innowax,PE-Wax,Rtx-Wax	强极性	40 to 260/280	醇类、溶剂、香精油、香料
WEL-FFAP	WM-FFAP	交联聚乙二醇（酸修饰）	BP-21,HP-FFAP,PE-FFAP,CP-FFAP,DB-FFAP,Nukol	强极性	40 to 260	醇类、有机酸、醛、酮、丙烯酸酯

2.柱内径与理论分离效率、最佳流速的关系

内径ID（mm）	最小理论塔板高（mm）	最大每米塔板数（/m）	线速（cm/s）	容积流量（ml/min）
0.10	0.109	11000	40~50	0.12~0.3
0.25	0.22	4400	25~35	0.7~1.0
0.32	0.29	3500	20~35	1.0~1.7
0.53	0.45	2200	18~27	2.4~3.5

（流速以氮气为准，氢气的约为1.18倍，氮气约为0.15倍）

3.不同内径下样品容量与液膜厚度关系

内径ID（mm）	不同膜厚时的对应样品容量（ng）			
	0.1μm	0.25μm	0.5μm	1.0μm
0.10	10	30~40	50~70	100~200
0.18	20~30	60~80	100~150	250~350
0.25	30~40	125~175	175~250	400~500
0.32	50~70	200~250	250~350	600~800
0.45	80~100	300~400	400~500	800~1000
0.53	100~120	400~500	500~700	1000~1500

4.不同内径时柱长与分离效能的关系

内径ID（mm）	不同分离效能所对应的柱长（m）		
	高	中	低
0.25	50~60	25~30	10~15
0.32	50~60	25~30	10~15
0.53	25~30	15	10

Description of this Manual

This manual is the instruction guide for the GC chromatographic column, covering the following content:

1. **Identity confirmation of GC column**
2. **GC column installation**
3. **Column storage**
4. **Correct usage of GC column**
5. **GC troubleshooting**
6. **Selection of GC column**

Identity confirmation of GC column

To ensure the quality of each chromatographic column, every column sold by Welch Materials comes with a unique identification code. With this code, our company can trace quality issues back to individuals. To safeguard your benefits, please follow these procedures upon receiving a chromatographic column:

1. Carefully inspect the packaging box to ensure it is intact and matches the chromatographic column you ordered.

2. Check if there is a quality inspection report inside the box, along with the signature of the inspector.

3. Examine the surface of the chromatographic column for any scratches, avoiding the use of hard objects that may damage the column.

4. Confirm the presence of Welch's chromatographic column identification label on the column body. Carefully compare the model and serial numbers on the packaging box and the column label to ensure consistency.

GC column installation

Improper installation of a good gas chromatographic column can lead to reduced theoretical plate numbers, peak broadening, tailing, and decreased sensitivity. Capillary columns, due to their small volume and low carrier gas flow rates, can be significantly affected by tiny dead volumes. When connecting a capillary column to the injector and detector, instruments from different companies have strict requirements. Special attention should be paid during the installation process.

Pre-Installation Checks:

1. Check gas cylinder pressure to ensure an adequate supply of carrier gas, make-up gas, and fuel gas. The purity of the carrier gas should not be less than 99.999%.

2. Clean the injector port, and if necessary, replace the injector port's sealing gasket, liner, and septa.

3. Inspect the detector's sealing gasket, and replace if necessary. Clean or replace the detector nozzle if required.
4. Thoroughly inspect the column for any damage or breakage.

Installation of Capillary Column

Step 1: Attach the nut and ferrule to the column and carefully cut the capillary column at both ends.

From both ends, gently unwind the capillary column from the column bracket, and attach the corresponding nut and ferrule at the two ends of the capillary column.
Suspend the capillary column on the column bracket in the column oven. The support part of the capillary column holder should always face the column oven door.
After attaching the nut and ferrule, cut off 3-5cm from both ends of the capillary column. Use a magnifying glass to inspect and ensure that the cut ends are perpendicular to the tube wall, without any residual debris, burrs, or uneven cutting surfaces.
Recommended Cutting Tools: Diamond or synthetic diamond cutting knife, sapphire cutting tool, ceramic blade.
Do Not Use: Scissors, Files.

Step 2: Connect the capillary column to the injector

In normal circumstances, the top of the capillary column should be kept in the middle or lower part of the injector liner. When the injection needle is fully inserted into the injector after passing through the septa, an ideal situation is achieved if the needle tip is 1-2cm away from the top of the capillary column inside the liner.
Retrieve a sufficient length of the column from the column bracket and cut it according to step 2, then connect it to the injector. Avoid forcefully bending or squeezing the capillary column, and be careful not to let sharp-edged items like tags contact with or rub against the capillary column to prevent column breakage or damage. Once the capillary column is correctly inserted into the injector, hand-tighten the connecting nut, then use a wrench to

tighten it an additional 1/4-1/2 turn. This ensures that the capillary column will not detach from the joint under pressure.

Step 3: Connect the carrier gas

The carrier gas must be high-purity nitrogen (or helium, hydrogen) with a purity of 99.999%. When using polar columns (such as INOWAX, PEG-20M, FFAP, etc.), it is advisable to further deoxygenate the carrier gas, which can extend the column's lifespan.

Once the capillary column is connected to the injector, connect the carrier gas. Adjust the column inlet pressure to achieve the appropriate carrier gas flow rate. Insert the other end (open end) of the capillary column into a sample bottle containing hexane. Under normal circumstances, you should observe a stable and continuous stream of bubbles in the bottle. If there are no bubbles, recheck the carrier gas delivery system and flow controller to ensure they are properly installed and set correctly. Also, check for any leaks in the entire gas path. Once all issues are resolved, remove the column port from the bottle, wipe it clean to ensure no solvent residue, and proceed with the next installation step.

Approximate Head Pressure of Capillary Column (psi)
Column Temperature: 20°C; Carrier Gas: Helium; Linear Velocity: 30 cm/s; Liquid Film Thickness: 0.25 μm

Column length/ml	Column inner diameter I.D.(mm)						
	0.05	0.10	0.18	0.25	0.32	0.45	0.53
10	110	27	7.3	3.8	2.3	1.2	0.8
15	--	54	--	5.7	3.4	1.7	1.3
20	--	--	15	--	--	--	--
25	--	--	--	10	5.8	2.9	2.1
30	--	--	--	12	6.9	3.5	2.5
40	--	--	32	--	--	--	--
50	--	--	--	21	12	5.8	4.2
60	--	--	--	25	15	7.0	5.0
100	--	--	--	42	25	12	8.6

Note: psi is pounds per square inch gauge pressure, and the approximate conversion to the standard unit is 1 psi = 6894.76 Pa.

Step 4: Connect the capillary column to the Detector

The installation process and precautions for connecting the capillary column to the detector are generally similar to the above section on connecting the column to the injector (Step 3). In general, the capillary column's end should be positioned higher than the makeup gas point.

Step 5: Perform gas leak detection

Before heating the capillary column, it is necessary to perform a leak check on the GC system.

Note: Refer to the chromatograph manual for the recommended installation distance between the injector and the detector.

Column storage

Long-Term Storage (Removing the capillary column from the Column Oven): Store the capillary column in its original packaging box. Seal both ends of the capillary column with suitable sealing pads to prevent contamination from moisture and volatile chemicals.

Correct usage of GC column

The lifespan of a capillary column is influenced by the purity of the carrier gas, the moisture content, and the nature of the analyzed samples. Improper handling can lead to a reduction in the lifespan of the capillary column. Rational and scientific use is the best way to extend its lifespan.

1. Carrier Gas: When the capillary column is at a high temperature and there is no carrier gas passing through, the stationary liquid in the column can decompose rapidly. Therefore, before raising the column oven temperature, the carrier gas should be turned on, and it can be turned off only after the column oven cools down.

2. Temperature: The lifespan of the capillary column is related to its operating temperature. Generally, setting the actual maximum temperature to be 20-30°C lower than the upper temperature limit of the stationary phase contributes to extending the column's lifespan.

3. Moisture: Moisture in the carrier gas can permeate through the stationary liquid film and be absorbed on the column surface, replacing or disrupting the stationary liquid film. Using a dry carrier gas also helps prolong the lifespan of the capillary column.

4. Oxygen: For easily oxidizable stationary phases (e.g., INOWAX, PEG-20M, FFAP), removing oxygen from the carrier gas is crucial. It is recommended to use a deoxygenation tube.

5. Aging: New capillary columns generally need aging treatment before use to remove solvent residues and impurities. Generally, start by holding at 50°C column temperature for 1 hour to remove excess solvents. Then, program the temperature to increase at a rate of 2-3°C/min. When reaching a temperature 30°C below the maximum allowed usage temperature of the stationary phase, age the column for 1-2 hours (e.g., if the temperature on the tag is Max Temp 330/340, subtract 30, and age at 300°C). Repeat 2-3 times if necessary. If the baseline does not stabilize within 10 minutes at a high temperature, immediately cool the column and check for leaks. For strong polar columns (e.g., polyethylene glycol phases), it is essential to ventilate at room temperature (no heating in the injector, column oven, or detector) for at least ten minutes before setting the program for temperature aging. If the column has been stored for an extended period, it is advisable to perform aging according to the above procedure before use. Avoid suddenly raising the column temperature to very high levels to prevent damage to the column's liquid film.

GC troubleshooting

We have analyzed some common issues encountered in gas chromatography and provided corresponding solutions. Here is a summary:

	Common issue	Cause Analysis and Solutions
1	Peak Loss	1. Issue with the injector needle, replace it for verification. 2. Low injection or column temperature: Check the temperatures and adjust as needed. 3. Low carrier gas flow: Check the pressure regulator and inspect for leaks; verify the carrier gas flow.

	Common issue	Cause Analysis and Solutions
1	Peak Loss	4. Detector not properly connected or incorrect parameter settings: Check the connections and readjust the settings. Column breakage: If the column breaks at both ends, cut off the broken portion. 5. Column breakage: If the column breaks at both ends, cut off the broken portion and reinstall; if it breaks in the middle section, replace with a new column.
2	Peak Fronting	1. Chromatographic column overload: Reduce the injection volume. 2. Co-elution of two compounds: Increase sensitivity and reduce injection volume; lower the temperature by 10-20°C to separate the peaks. 3. Sample condensation: Check the injection port and column temperature; if necessary, increase the temperature. 4. Sample decomposition: Use a deactivation-treated injection liner or lower the injection port temperature.
3	Peak Tailing	1. Column or injector temperature too low: Increase the temperature, but do not exceed the maximum allowable column temperature. The injector temperature should be 20°C higher than the highest boiling point of the sample. 2. Co-elution of two compounds: Increase sensitivity and reduce injection volume; lower the temperature by 10-20°C to separate the peaks. 3. Column contamination: Cut 1-2 cm from the column's injection end and reinstall. 4. Column damage: Replace with a new column.
4	Wide Solvent Peak	1. Dead volume in the injection port: Reinstall the column. 2. Poor injection technique: Use a rapid and smooth injection technique. 3. Injector temperature too low: Increase the injector temperature. 4. Residual sample solvent in the column: Adjust or clean. 5. Improper liner cleaning: Adjust or clean. Incorrect split ratio (insufficient split flow): Adjust the flow rate.

	Common issue	Cause Analysis and Solutions
5	Irregular Baseline or Unstable Baseline	1. Detector or injector contamination: Clean the detector and injector. 2. Inconsistent carrier gas control: Check if the carrier gas and other gas source pressures are sufficient. If the pressure is ≤500 psi, replace the gas cylinder. 3. Impurities in the carrier gas or gas path contamination: Replace the gas cylinder and use a gas purification device to clean the metal tubing. 4. Loss of liner in the injector: Replace the liner. 5. Column loss or contamination: Cut 1-2 cm from the column's injection end, reinstall, and age.
6	Uneven Retention Times on the Same Column	1. Fluctuations in column temperature: Check and adjust the column temperature. 2. Fluctuations in carrier gas flow rate: Check and adjust the flow rate. 3. Leakage in the injector liner or column: Check and repair. 4. Column contamination or damage: Re-age or replace the column. 5. Column overload: Reduce the injection volume.

Selection of GC column

1.Selection of the Stationary Phase

WEL Economy Series	WM High Performance Series	Type of Stationary Phase	Similar Stationary Phase	Polarity	Temperature (℃)	Applications
WEL-30	WM-1	100% Dimethyl Polysiloxane	DB-1, HP-1,OV-1, BP-1, Rtx-1,OV-101, SBP-1, CP-Sil 5CB	Non-polar	-60 to 325/350	Hydrocarbon, Aromatic Compound, Pesticide, Phenols, Herbicide, Amine, Fatty Acid Methyl Ester etc.
WEL-1	WM-1MS		ZB-1MS , DB-1MS, HP-1MS, OV-1MS			
WEL-52	WM-5	5% Phenyl 95% Dimethyl Polysiloxane	BP-5, ZB-5, CP-Sil 8CB, DB-5, HP-5, SPB-5, Rtx-5, OV-5	Non-polar	-60 to 325/350	Hydrocarbon, Aromatic Compound, FAMEs, Pesticide, Herbicide, Drugs etc.
WEL-54	WM-5MS		ZB-5MS, DB-5MS, HP-5MS, OV-5MS			
WEL-1301	WM-1301	6% Cyanopropylphenyl 94% Methylpolysiloxane	DB-1301, HP-1301, PE-1301,Rtx-1301	Mid-polar	-20 to 280/300	Aromatic Compound, Alcohol, Pesticide, VOC's, Iodine etc.
WEL-35	WM-35	35% Diphenyl 65% Dimethyl Polysiloxane	DB-35, HP-35, SPB-35, Rtx-35, PE-35, AT-35	Mid-polar	40 to 320/340	Alcohol, Pesticide, Drugs etc.

WEL Economy Series	WM High Performance Series	Type of Stationary Phase	Stationary Phase	Polarity	(℃)	Applications
WEL-1701	WM-1701	14% Cyanopropylphenyl 86% Methylpolysiloxane	BP-10,CB-1701,CP-Sil 19CB, DB-1701, Rtx-1701	Mid-polar	-20 to 280/300	Pesticide, Herbicide, Drugs, Environmental Sample etc.
WEL-17	WM-17	50% Phenyl 50% Dimethyl Polysiloxane	DB-17,HP-17,HP-50,Rtx-50,AT-50, ZB-50,SPB-50,CP-Sil 24,SP-2250	Mid-polar	0 to 300/320	Pesticide, Herbicide, Drugs, Environmental Sample etc.
WEL-624	WM-624	6% Cyanopropyl Phenyl 94% Dimethyl Polysiloxane	007-624, AT-624, CP-624, DB-624, HP-624, Rtx-502.2, VOCOL	Mid-polar	-20 to 260	VOCs, Solvent Impurities etc.
WEL-PEG20M	WM-InoWax	PEG -20M	CP-Wax, DB-Wax, HP-Innowax,PE-Wax,Rtx-Wax	Polar	40 to 260/280	Alcohol, Free Acid, Fatty Acid Methyl Ester, Polynuclear Aromatic Compound, Solvent, Essential Oil etc.
WEL-FFAP	WM-FFAP	Reaction products of PEG -20M and TPA	BP-21,HP-FFAP,PE-FFAP, CP-FFAP,DB-FFAP,Nukol	Polar	40 to 260	Alcohols, Free Acid, Fatty Acid Methyl Ester, Aldehyde, Acrylic Ester, Ketone etc.

2. The relationship between column diameter and the separation efficiency and the optimized flow rate

ID (mm)	Minimum Theoretical Tower Plate Height (mm)	Maximum Plate per meter(/m) (/m)	Velocity (cm/s)	Volume flow Rate (ml/min)
0.10	0.109	11000	40~50	0.12~0.3
0.25	0.22	4400	25~35	0.7~1.0
0.32	0.29	3500	20~35	1.0~1.7
0.53	0.45	2200	18~27	2.4~3.5

(The flow rate is based on helium, approximately 1.18 times that of hydrogen, and approximately 0.15 times that of nitrogen)

3. The relationship between sample capacity and liquid film thickness under different inner diameters

ID (mm)	Corresponding sample capacity at different film thicknesses(ng)			
	0.1μm	0.25μm	0.5μm	1.0μm
0.10	10	30~40	50~70	100~200
0.18	20~30	60~80	100~150	250~350
0.25	30~40	125~175	175~250	400~500
0.32	50~70	200~250	250~350	600~800
0.45	80~100	300~400	400~500	800~1000
0.53	100~120	400~500	500~700	1000~1500

4.The relationship between column length and separation efficiency at different inner diameters.

ID (mm)	The column length corresponding to different separation efficiencies(m)		
	High	Middle	Low
0.25	50~60	25~30	10~15
0.32	50~60	25~30	10~15
0.53	25~30	15	10


welch