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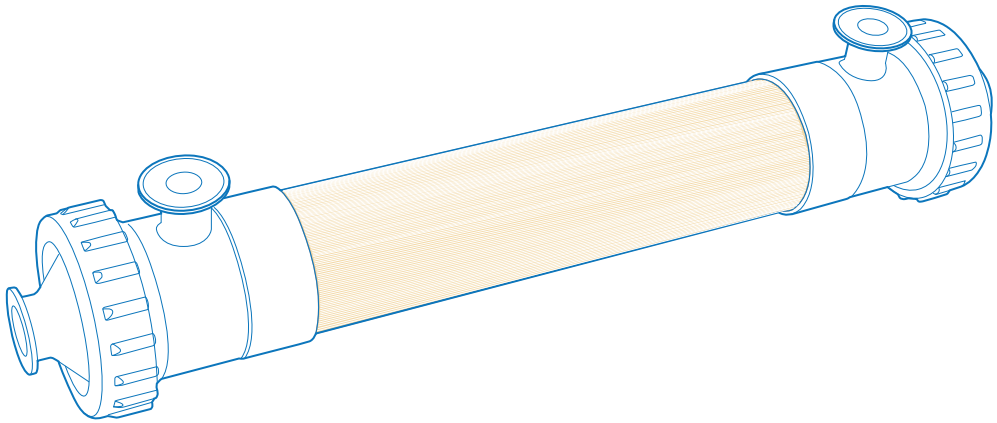
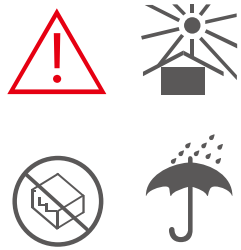
中空纤维组件使用指南
Hollow Fiber Cartridges User Manual



使用前请仔细阅读
Please read the user manual carfully.



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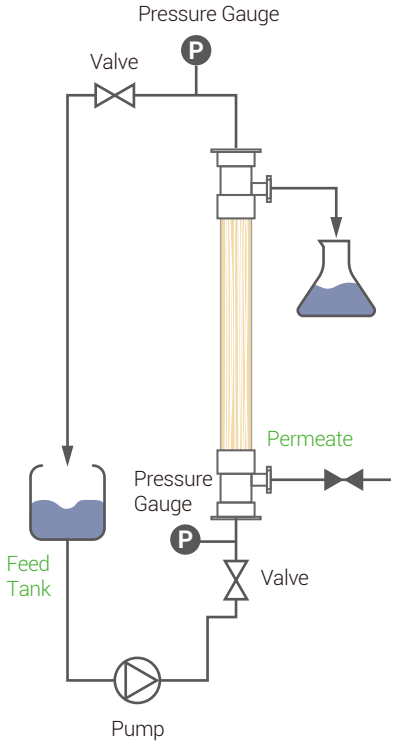
1. Preparation of Hollow Fiber

For laboratory or pilot scale application, the basic manual control system includes a pump, a feed tank, a permeate collection tank, pressure gauges and valves, and the system is connected with hoses and connectors of appropriate specifications.

The pressure gauges shall be filled with glycerin or mechanically wetted out.

Usually, a hose clamp is installed at one permeate port to control the outflow of the permeate, and the other permeate port is set closed. A pressure gauge may be connected to the permeate end if necessary.

Cobetter's hollow fiber module initially contains glycerin to protect the membrane structure, which needs to be rinsed before use. First, add sufficient deionized(DI) water to the feed tank, close the permeate valve, open the retentate valve, discharge waste via the retentate line, and maintain an inlet pressure of 2-5psi. The volume of flushing liquid should be greater than 20L/m^2. Then, move the retentate line back to the feed tank, discharge the waste through the permeate end, open the permeate valve, adjust TMP to 2-5psi, and the permeate volume should also be greater than 20L/m^2.



一、组件准备

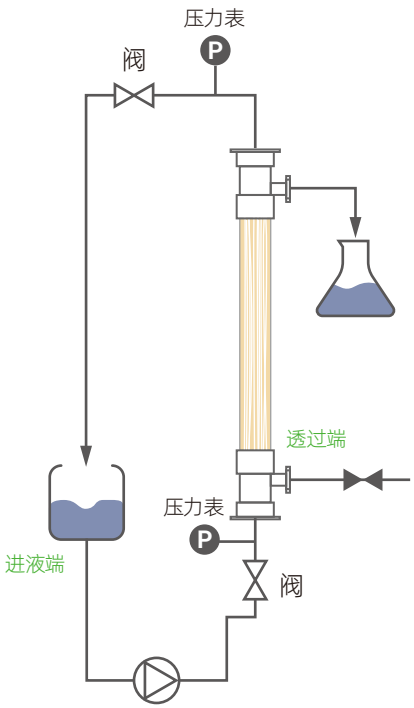
对于实验室或中试应用，基本的手动控制系统包括一台泵、进料罐、透过液收集罐、压力表和阀门，使用合适规格的软管和接头连接系统。

压力表应填充甘油或机械润湿。

通常在一个透过液端口安装软管夹控制透过液流出，另一个透过液端口封闭。如有必要，可在透过液端连接一个压力表。

科百特中空纤维组件含有用于保护膜结构的甘油，使用前需要冲洗干净。

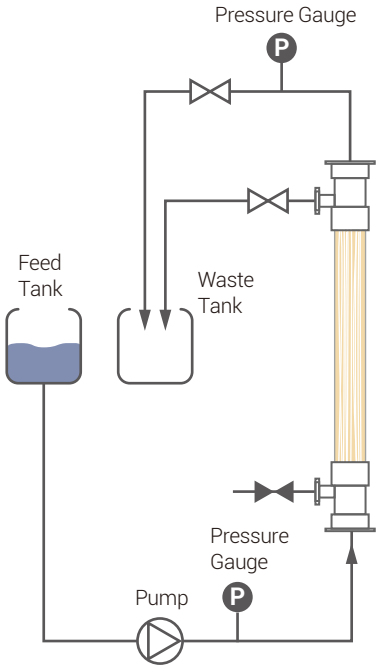
首先在进料罐中加入足量去离子水，关闭透过阀，打开回流阀，回流端排废，进口压力维持在2-5psi，冲洗液体体积>20L/m^2，然后将回流端移入进料罐，将透过端排废，打开透过阀，调节TMP维持在2-5psi，冲洗透过液体积>20L/m^2。



2. Sterilization

If necessary, sanitize after the system has been thoroughly cleaned. The recommended disinfectant is 0.1M NaOH solution.

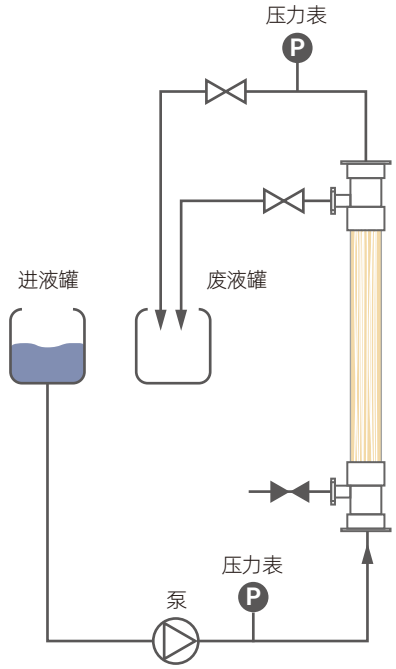
1. Add 10-20L/m² disinfectant to the feed tank. Open the retentate valve and the permeate valve, and place the retentate end and the permeate end into the feed tank.
2. Adjust the pump speed and retentate valve to maintain a TMP of 2-5psi and circulate for 30min.
3. Drain the disinfectant in the system after circulation.
4. Add sufficient DI water to the cleaned feed tank, close the permeate valve, open the retentate valve, direct the retentate line to drain, adjust the pump speed to maintain the inlet pressure at 2-5psi, and flush until the outflow liquid is neutral.
5. Move the retentate line into the feed tank, open the permeate valve and direct the permeate line to drain, adjust the pump speed and the retentate valve to maintain TMP at 2-5psi, and process until conductivity or pH of the flushing liquid meets customer's requirements.



二、消毒

在对中空纤维组件进行清洗之后，如有必要，可以进行消毒步骤，常用消毒剂为0.1M的NaOH溶液。

1. 在进料罐中加入10-20L/m²的消毒剂。打开回流阀和透过阀，回流端和透过端均置于进料罐中。
2. 调节泵速和回流阀使TMP维持在2-5psi，循环30min。
3. 循环结束后排净中空纤维组件内的消毒剂。
4. 在冲洗干净的进料罐中加入足量去离子水，关闭透过阀，打开回流阀，回流端排废，调节泵速使进口压力维持在2-5psi，冲洗至流出液体呈中性。
5. 将回流端移入进料罐，打开透过阀，透过端排废，调节泵速和回流阀使TMP维持在2-5psi，冲洗至流出液体的电导率或者pH满足客户需求。

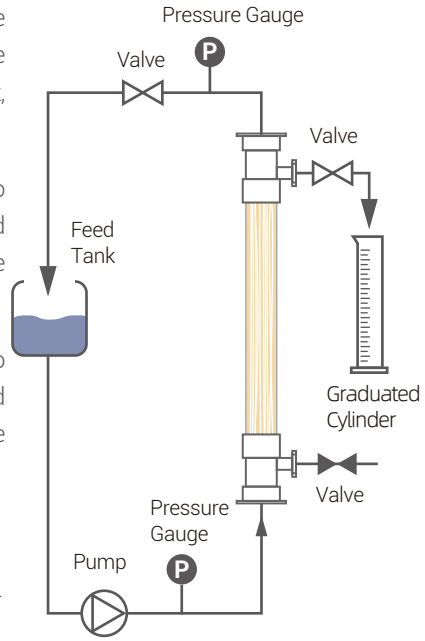


3. Measuring Water Flux

1. Add enough DI water to the feed tank, open the permeate valve and retentate valve, place both the permeate end and retentate end into the feed tank, and drain the gas in the system.
2. Adjust the pump speed and retentate valve to maintain the TMP at 3 psi, then measure and record the permeate flow rate and water temperature in the inlet tank.
3. Adjust the pump speed and retentate valve to maintain the TMP at 7psi, again measure and record the permeate flow rate and water temperature in the inlet tank.
4. Use the following equation to calculate water flux.

$$\text{Flux in LMH } (l/m^2/hr) = \frac{\text{Permeate flow } (mL/min)*0.06}{\text{Cassette surface}(m^2)}$$

5. Multiply the calculated flux by temperature correction factor for corresponding temperature from Table 1 to obtain standard water flux, and then divide by corresponding pressure value to obtain the unit pressure water flux (per psi).
6. If there is no large deviation between the two values, the average of the two may be taken as the standard water flux of the module.
7. If there is a large deviation between the two values, repeat steps 2-6.



三、水通量测试

1. 在进料罐中加入足量去离子水，打开透过阀和回流阀，透过端和回流端均置于进料罐中，排净系统内气体。
2. 调节泵速和回流阀使TMP维持在3psi，测量并记录透过液流速以及进液罐中水温。
3. 调节泵速和回流阀使TMP维持在7psi，测量并记录透过液流速以及进液罐中水温。
4. 计算水通量。

$$\text{水通量(LMH)} = \frac{\text{透过液流速 } (mL/min)*0.06}{\text{有效膜面积}(m^2)}$$

5. 将计算所得水通量乘以Table 1中相应温度下粘度(温度)校正系数，得到标准温度下的水通量，再除以相应的压力数值，得到单位压力(1psi)下水通量数值。
6. 若两数值没有较大偏差，可以取两值的平均值作为组件的标准水通量值。
7. 若两数值存在较大偏差，重复步骤2-6。

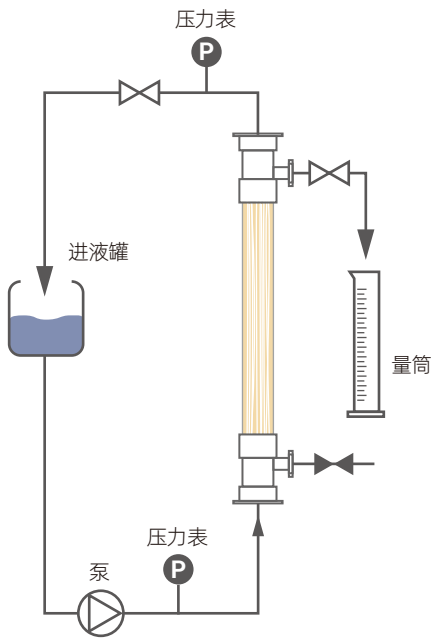


Table 1. Viscosity conrection factor

Temperature in °C when permeate flow was measured T (°C)	Viscosity Correction factor F	Temperature in °C when permeate flow was measured T (°C)	Viscosity Correction factor F
4	1.567	25	0.89
5	1.519	26	0.871
6	1.472	27	0.851
7	1.428	28	0.833
8	1.386	29	0.815
9	1.346	30	0.798
10	1.307	31	0.781
11	1.271	32	0.765
12	1.235	33	0.749
13	1.202	34	0.734
14	1.169	35	0.719
15	1.139	36	0.705
16	1.109	37	0.692
17	1.081	38	0.678
18	1.053	39	0.665
19	1.027	40	0.653
20	1	41	0.641
21	0.978	42	0.629
22	0.955	43	0.618
23	0.933	44	0.607
24	0.911	45	0.596

Table 1. 粘度(温度)校正系数

温度 T (°C)	温度校正系数 F	温度 T (°C)	温度校正系数 F
4	1.567	25	0.89
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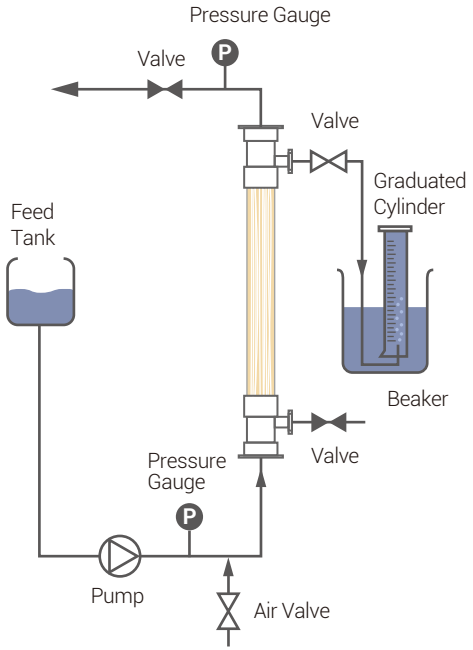
4. Integrity Test

Ensure that the system is thoroughly cleaned and the membrane is thoroughly wetted out. Drain the system as thoroughly as possible for integrity test. This document provides two test methods, one of which may be applied according to actual operating conditions.

1. Diffusion Flow Method

1. Close the permeate valve and retentate valve, and immerse both lines under water.
2. Pressurize the retentate end with compressed air to increase the inlet pressure of the system to 15psi, then close the vent valve to maintain a positive pressure in the hollow fiber membrane.
3. Monitor the change of pressure with time. If the pressure drop is greater than 1psi/min, the system pipeline may have leakage. Check and tighten the pipeline, re-pressurize to 15psi, and monitor the pressure drop again.
4. After confirming that the integrity of the system is good, open the permeate valve, discharge the excess water, re-pressurize to 15psi, and measure the gas flow rate at the permeate end with a graduated cylinder full of water.
5. If the diffusion flow rate is less than 20ml/min/m^2, it is considered that the integrity of the module is good. Release the pressure.
6. If the diffusion flow rate is greater than 20ml/min/m^2, release the pressure, thoroughly wet the module again, and repeat step 1-5.



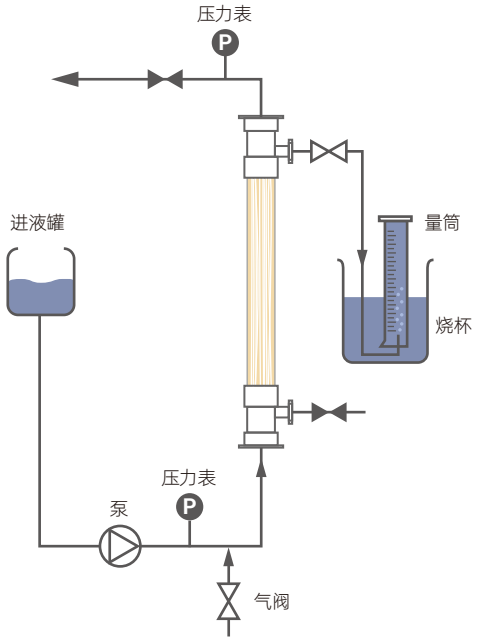
7. If the diffusion flow rate is still greater than 20ml/min/m^2, it is considered that the membrane may have integrity defects. Do not use it.

四、组件完整性测试

经过上述步骤，组件处于润湿状态，排干组件循环流路中的液体，进行完整性测试。本文件提供两种测试方法，可根据实际操作条件选择其中一种方法测试。

一．扩散流法

1. 关闭透过阀和进液阀并将端口浸没在水中。
2. 在回流端使用压缩空气加压，使系统进口压力上升至对应测试压力(其中微滤膜为10psi，超滤膜为15psi)，然后关闭通气阀门，使中空纤维膜内保持正压状态。
3. 观测压力随时间的变化情况。如果压力降大于1psi/min，说明系统管路可能存在泄漏，检查并紧固管路，重新加压至测试压力，再次观测压力降。
4. 确定系统完整性良好后，打开透过阀，将过量的水排出，重新加压至测试压力，使用量筒测量透过液端气体流速。
5. 如果扩散流小于20ml/min/m^2，认为组件完整性良好，释放压力。
6. 如果扩散流大于20ml/min/m^2，释放压力，重新充分润湿组件，重复步骤1-5。
7. 如果扩散流依然大于20ml/min/m^2，认为膜可能存在完整性缺陷，请勿使用。



2. Pressure Retaining Method

1. Close the permeate valve and retentate valve.

2. Slowly pump air by a peristaltic pump at the inlet end to increase the inlet pressure of the system to 15psi, then close the inlet valve to maintain the positive pressure in the hollow fiber membrane.

3. Monitor the change of pressure with time. If the pressure drop is greater than 1psi / min, the system pipeline may have leakage. Check and tighten the pipeline, re-pressurize to 15psi, and monitor the pressure drop again.

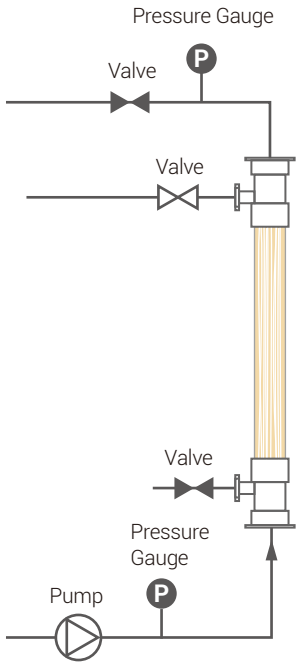
4. After confirming that the integrity of the system is good, open the retentate valve and permeate valve to drain the air and water in the system.

5. Close the retentate valve and keep the permeate valve open. Slowly pump air by the peristaltic pump at the inlet end to increase the inlet pressure of the system to 15psi, then close the liquid inlet valve and monitor the inlet pressure drop rate.

6. If the pressure drop is less than 2psi / min, it is considered that the integrity of the module is good for use. Release the pressure.

7. If the pressure drop is less than 2psi / min, release the pressure, fully wet ou the components again, and repeat steps 1-5.

8. If the pressure drop is less than 2psi / min, it is considered that the membrane may have integrity defects. Do not use it.



二．保压法

1. 关闭透过阀和回流阀

2. 在进液端通过蠕动泵缓慢泵入空气，使系统进口压力上升至对应测试压力(其中微滤膜为10psi，超滤膜为15psi)，然后关闭进液阀门，使中空纤维膜内保持正压状态。

3. 观测压力随时间的变化情况。如果压力降大于1psi/min，说明系统管路可能存在泄漏，检查并紧固管路，重新加压至测试压力，再次观测压力降。

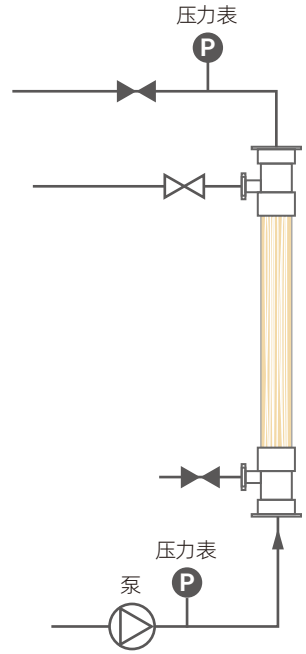
4. 确定系统完整性良好后，打开回流阀和透过阀，将系统内的空气和水排出。

5. 关闭回流阀，保持透过阀打开状态。在进液端通过蠕动泵缓慢泵入空气，使系统进口压力重新加压至测试压力，然后关闭进液阀门，观察进口压力下降速率。

6. 如果压力降小于2psi/min，认为组件完整性良好，释放压力。

7. 如果压力降大于2psi/min，释放压力，重新充分润湿组件，重复步骤1-5。

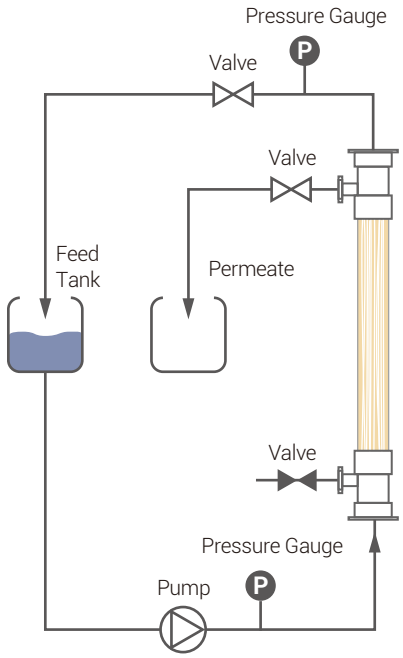
8. 如果压力降大于2psi/min，认为膜可能存在完整性缺陷，请勿使用。



5. Preprocessing Buffer Equilibrium (Optional)

The purpose of flushing hollow fiber membrane modules with buffer is to ensure that the pH and salt ion conditions of the system are as similar as possible to the initial state of the sample to be treated, so as to reduce membrane pollution and product loss.

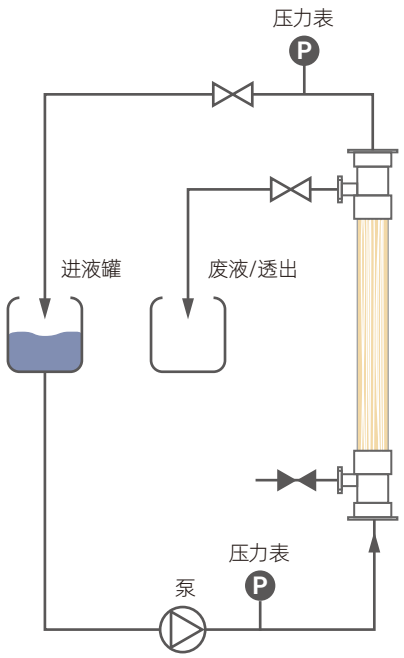
1. Open both the retentate valve and the permeate valve; place both the retentate line and permeate line back to the feed tank.
2. Add sufficient buffer to the feed tank and circulate for 5-10min. Check pH or conductivity of the filtrate to ensure a similar condition to the buffer.



五、工艺前缓冲液平衡（可选）

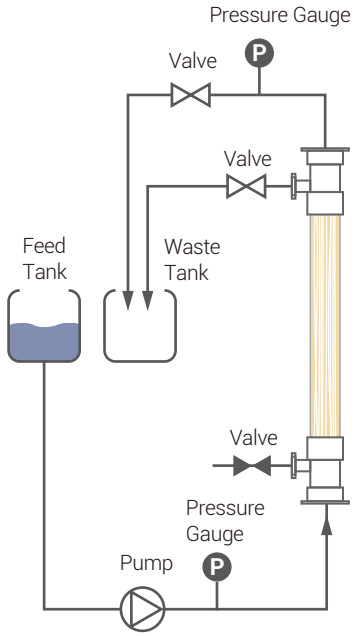
缓冲液润洗中空纤维膜组件是为了保证膜的pH值和盐离子状态与待处理样品的起始状态尽量接近，以减少膜污染和产品损失。

1. 回流阀和透过阀均打开，回流端与透过端均置于进料罐。
2. 向进料罐中加入足量缓冲液，循环 5-10min。检查滤液pH值或电导，以确保与缓冲液性质相近。



6. Cleaning After Use

The modules must be cleaned before storage and reuse. They should be flushed with buffer and/or DI water, and then washed with appropriate sanitizing agent. Under normal conditions, 0.5N NaOH may be used to circulate for 30min at 20-40°C. 300ppm NaCl may also be added to 0.5N NaOH solution if the cleaning effect is poor.

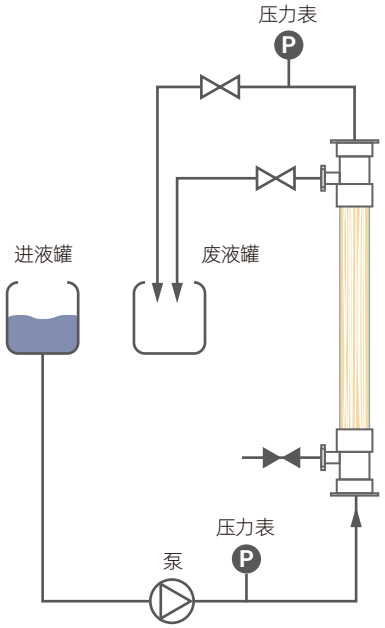


1. Add sufficient buffer to the feed tank.
2. Close the permeate valve, open the retentate valve, and place the retentate and permeate line into the waste tank.
3. Start the pump slowly until the washing liquid fills the module, increase the pump speed and adjust the flow rate to 50% of the process flow rate.
4. A flushing volume of greater than 20L/m^2 is recommended.
5. Open the permeate valve, move the retentate line into the feed tank, adjust the retentate valve to let liquid flow out of the permeate end. The recommended permeate volume is greater than 20 L/m^2. Drain the liquid in the system.
6. Add sufficient DI water to the cleaned feed tank and repeat step 2-5.
7. Add 20L/m^2 sanitizing agent into the cleaned feed tank.
8. Open the permeate valve and the retentate valve, and place the retentate and the permeate line into the waste tank.
9. Slowly start the pump until the sanitizing agent fills the system, increase the pump speed and adjust the flow rate to 100-150% of the process flow, so that 10% volume of sanitizing agent passes through the retentate and the permeate line, respectively.

Note: Single use of Cobetter's hollow fiber cartridges is highly recommended. The cleaning method does not guarantee a full recovery of membrane performance. There might be compatibility issues if a specific solution/ reagent is applied, or a special cleaning agent is needed for cleaning. Please consult Cobetter technical engineers for information before use.

六、使用后清洗

在组件重复使用和保存之前，应当进行清洗，应先使用缓冲液和/或去离子水进行冲洗，然后使用适当的清洗剂进行清洗。通常条件下可使用0.5N NaOH在20-40°C下循环30min，如清洗效果不佳也可向0.5N NaOH溶液中加入300ppm NaClO。



1. 进料罐中加入足量缓冲液。
2. 关闭透过液阀，打开回流阀，回流端和透过端置于废液罐。
3. 缓慢开泵，待冲洗液充满组件，提高泵速调节流量到工艺流量的50%。
4. 推荐冲洗液量大于20L/m^2。
5. 打开透过阀，可将回流端移入进料罐，调节回流阀使透过端有液体流出，推荐透出液量大于20L/m^2，排净组件内液体。
6. 冲洗干净的进料罐中加入足量去离子水，重复步骤2-5。
7. 冲洗干净的进料罐中加入20L/m^2的清洗剂。
8. 打开透过液阀和回流阀，回流端和透过端置于废液罐。
9. 缓慢开泵，待清洗剂充满组件，提高泵速调节流量到工艺流量的100-150%，使回流端和透过端分别透过10%体积的清洗剂。

注意：科百特推荐中空纤维组件一次性使用，本清洗方法不保证清洗后膜性能完全恢复。如操作中存在特殊溶液/试剂，或需使用特殊清洗剂清洗，可能存在兼容性问题，使用前请咨询科百特技术工程师。

10. Move the retentate and permeate line into the feed tank, adjust the retentate valve so that there is liquid flowing out of the permeate end. Clean for 30min.
11. Empty the system and stop the pump.
12. Add sufficient DI water to the cleaned feed tank, rinse the retentate and permeate line until the pH of the effluent is neutral or the conductivity is low enough.

7. Hollow Fiber Storage

The hollow fiber module may be stored in 0.1N NaOH solution. For long-term storage (1-12 months), it is recommended to be stored in a refrigerated state (4°C).

Note: the appropriate storage of the modules ensures a wet membrane state and a effective prevention of biological pollution. Change of the storage solution once a month is highly recommended.

10. 将回流端和透过端移入进料罐，调节回流阀使透过端有液体流出，循环清洗30min。
11. 排空系统，停泵。
12. 冲洗干净的进料罐中加入足量去离子水，冲洗回流和透过管路，直至流出液pH呈中性或电导率最低。

七、组件储存

当中空纤维组件不使用时，需保存至 0.1N NaOH 溶液中。长期存放时（1-12个月），建议将组件保存在冷藏状态（4°C）。

注意：中空纤维膜组件的正确存储需保证膜在湿润状态，并防止生物污染。建议每月更换一次保存溶液。