北京有色金属研究总院
GENERAL RESEARCH INSTITUTE For NONFERROUS METALS

BIOMETEK
生物冶金国家工程实验室
National Engineering Lab.of Biohydrometallurgy

Treatment of Heavy-metal Wastewater by UF and Membrane distillation

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REPORT OUTLINE

1. Heavy-metal wastewater
2. Membrane distillation
3. Fe(III) Removal by UF
4. Concentration of wastewater by MD
5. Conclusions

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- **EDUCATION**

- Ph.D., Environmental Engineering, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (2013)
- B.E., Environmental Engineering, Dalian University of Technology (2007)

- **RESEARCH INTERESTS**

- Mining and metallurgy waste water treatment;
- Organic waste water treatment and desalination;
- Membrane distillation and related membrane technology

1 Heavy-metal wastewater

Heavy-metal wastewater ⟶ origin and harm

➢ ORIGIN

- smelting wastewater
- electroplating wastewater
- waste acid (exhaust gas washing in smelting plant)

➢ HARM

- soil pollution
- river pollution
- grain pollution

Heavy-metal wastewater ⟹ treatment

- Conventional treatment methods
  - chemical precipitation
  - adsorption

  ⟹ producing much solid waste

- Recovery of valuable metals
  - ion exchange
  - solvent extraction

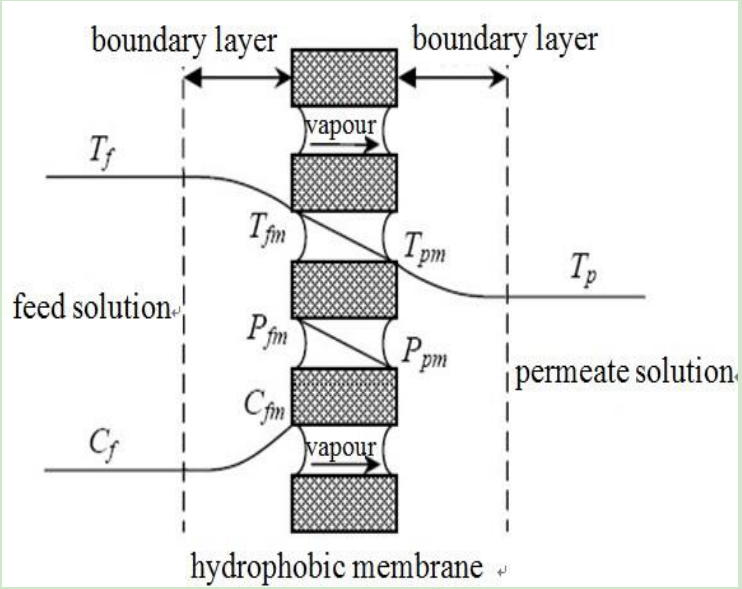
- Difficulties of recovery
  - many impurities ⟹ pretreatment by UF
  - low content of metal ions ⟹ concentration by RO and **membrane distillation**

2 Membrane distillation (MD)

Membrane distillation ⟶ theory

➢ Principle

- a special membrane separation
- hydrophobic membrane materials
- driven force: vapor pressure difference
- only gas cross membrane pore
- pore size: about 0.2 μm



➢ Characteristic (contrasting with RO)

- operation at ordinary pressure
- higher separation coefficient
- better acid resistance (concentrating H_2SO_4)
- operation at low temperature (waste heat)

Membrane distillation ⟶ material and module

➢ Membrane materials

PTFE： best performance but hard to prepare

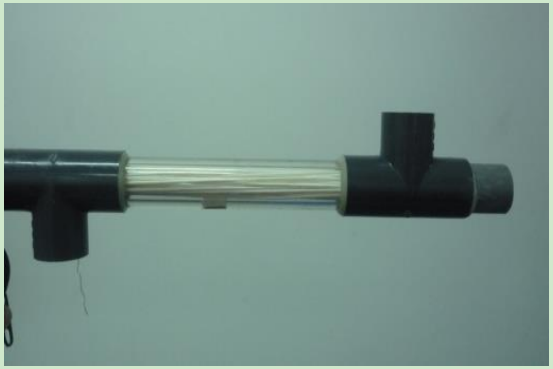
PVDF： good performance and easy to prepare

PP： poor performance, low cost

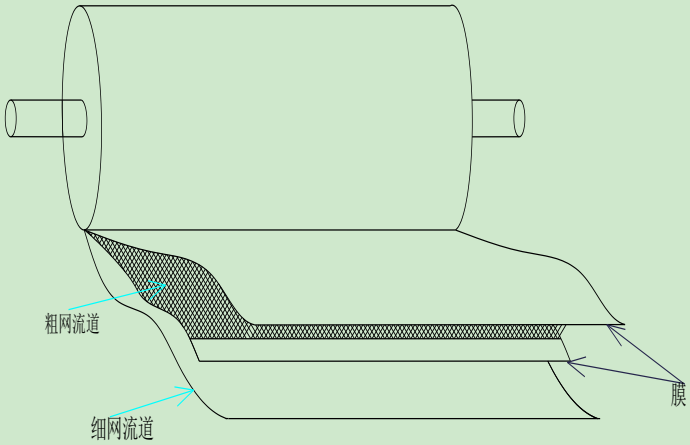
PTFE hollow fiber membrane

➢ Membrane modules

Flat



Hollow fiber



Spiral module

Membrane distillation ⟶ application

- **Desalinaton**
  - seawater
  - brine water
- **Removal or recovery of volatile gas**
  - ammonia
  - hydrochloric acid
- **Treatment of organic wastewater**
  - garbage leachate
  - pharmaceutical wastewater
- **Concentration of fruit juice and medicine**

3 Fe(III) removal by UF

pretreatment of membrane distillation

Fe(III) removal by UF

➢ Electroplating wastewater

- pH=1.65
- containing Cu, Zn, Ni, Fe, Cr, Ca, Mg

The quality characteristics of the electroplating wastewater (mg/L)

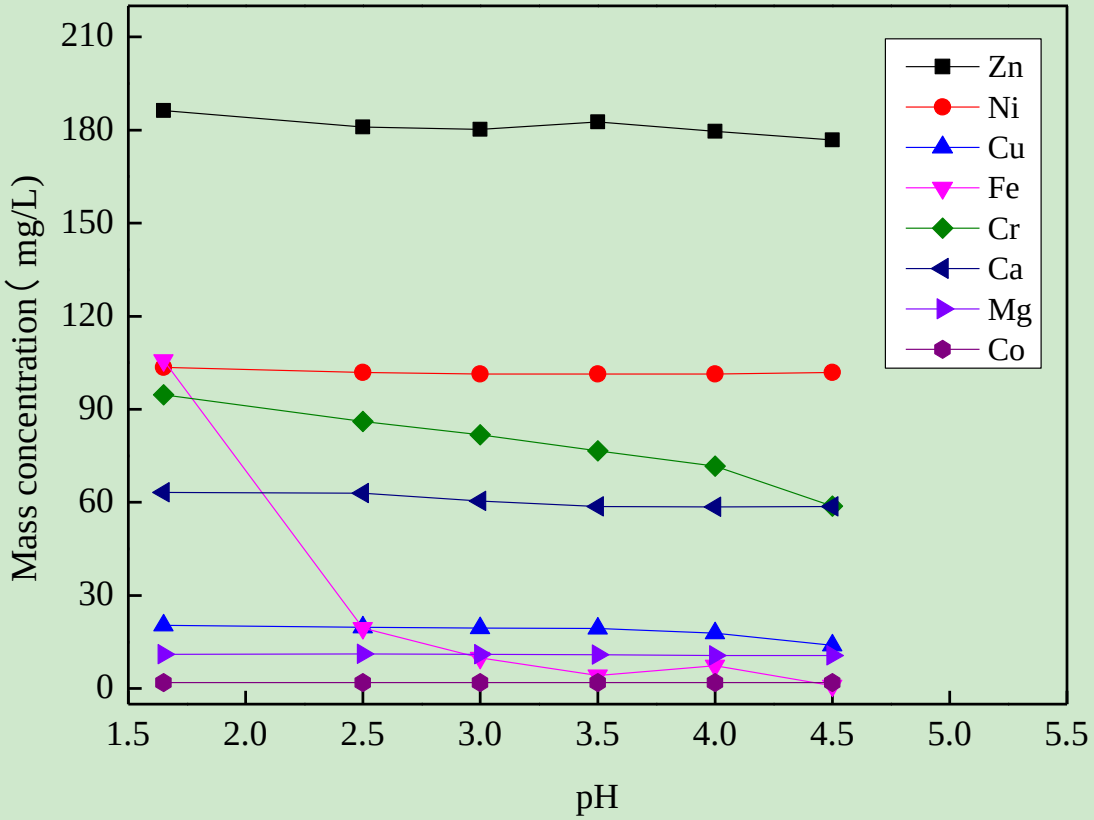
Zn	Ni	Cu	Fe	Cr	Ca	Mg	Co	PH
193.2	110.35	21.48	113.37	100.97	66.72	11.82	2.02	1.65

Fe(III) removal by UF

➢ Effect of pH on UF

pH of wastewater was adjusted to 2.5, 3.0, 3.5, 4.0 and 4.5

aeration: 2 L/min pressure: 20 Kpa



- **with the increase of pH,** Fe(III) Removal was improved
- valuable metas, such as Cu, Zn, Ni was still remained

Fe(III) removal by UF

➢ Effect of Fe content

Fe content was set to 600mg/L, 1000mg/L, 2000mg/L and 4000mg/L

pH=3.5 aeration: 2 L/min pressure: 20 Kpa

	Zn	Ni	Cu	Fe	Cr	Ca	Mg	Co
Fe113	**182.57**	**101.34**	**19.44**	**--**	**76.6**	**58.61**	**10.87**	**1.93**
Fe600	**183.93**	**102.47**	**19.73**	**19.34**	**54.21**	**60.48**	**11.03**	**1.96**
Fe1000	**184.32**	**102.29**	**19.58**	**22**	**40.41**	**60.42**	**10.71**	**1.97**
Fe2000	**180.86**	**99.34**	**19.14**	**20.08**	**26.7**	**60.9**	**11.02**	**1.95**
Fe4000	**170.53**	**90.68**	**16.94**	**16.32**	**16.11**	**57.83**	**10.75**	**1.9**

- The increase of Fe content did not cause entrainment evidently of valuable metals
- UF was proved to be a excellent pretreatment method

4 Concentration of wastewater by MD

Concentration of wastewater by MD

➢ Simulated heavy-metal solution

- simulated solution was prepared for the preliminary study of the concentration of heavy-metal solution by MD
- containing Cu, Zn, Ni

The quality characteristics of the simulated solution (mg/L)

Elements	Cu	Zn	Ni
Solution 1	2000	3000	1000
Solution 2	400	600	200

Concentration of wastewater by MD

➢ Vacuum membrane distillation (VMD)

feed temperature of 56.0 ℃, feed velocity of 0.70 m/s
vacuum degree of -94 Kpa.

The flux and the conductivity of the permeate in the MD process

Operation time (h)	Flux（kg/(m²·h)）		Conductivity（μs/cm）	
	Solution 1	Solution 2	Solution 1	Solution 2
1	19.53	18.85	21.1	18.9
2	17.93	17.84	5.3	21.5
3	17.34	17.68	4.54	108
4	18.18	16.58	3.38	261
5	17.51	17.59	12.43	580

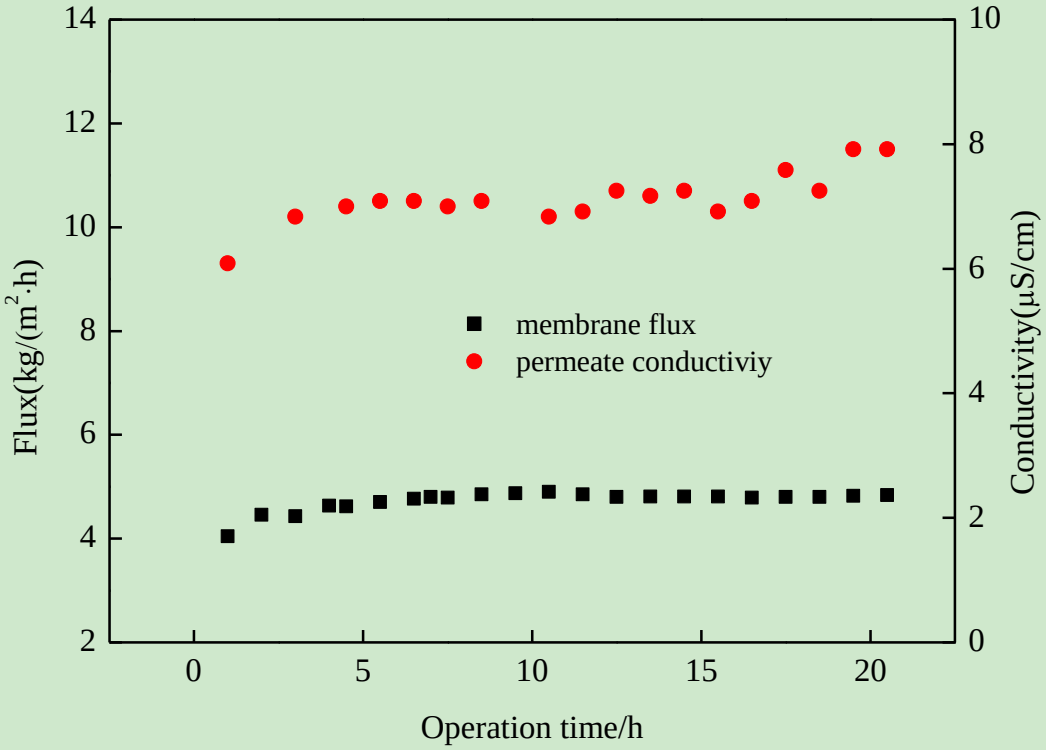
- Crystallization was discovered on the outside surface of the membrane,which was considered as the reason of the rise of the permeate conductiviy
- Vacuum membrane distillation easily cause leakage of metals?

Direct contact membrane distillation (DCMD)

Concentration of wastewater by MD

➢ Direct contact membrane distillation

Temperature of feed solution and the condensation were set at 65.3℃ and 21.5 ℃. Feed velocity was set at 1.00 m/s.



The variation of membrane flux and permeate conductivity with the operation time

- The membrane flux keeps constant in 4.8 kg/(m2·h) until the end of the process
- The interception performance can be improved DCMD for this kind of membrane materials

Conclusions

- **Effective separation of Fe from the solutions can be realized by UF**
- **Membrane distillation can be applied to treat heavy-metal wastewater**
- **Interception performance of DCMD was better than VMD for this kind of membrane**

THE END

THANKS!