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June 19-21, 2018 Park City UT, USA

Study on Membrane Absorption Performance of Bromine and Water Mixture Solution

Dr. Jun Xiang

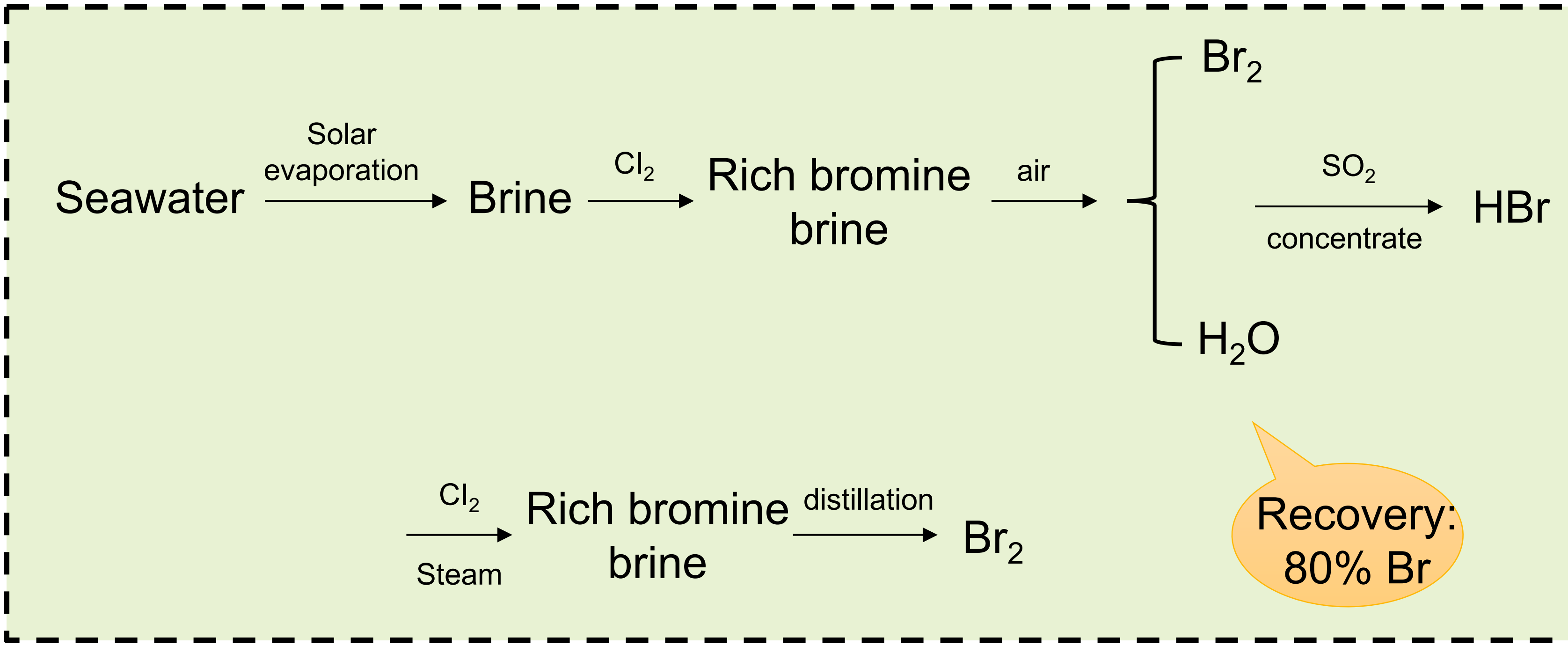
College of Chemical Engineering and Materials Science,

Tianjin University of Science & Technology,

People's Republic of China

Authors: Jun Xiang, Penggao Cheng, Wei Du, Songbo Wang, Qinxin Tang, Xuekui Wang, Na Tang

Background



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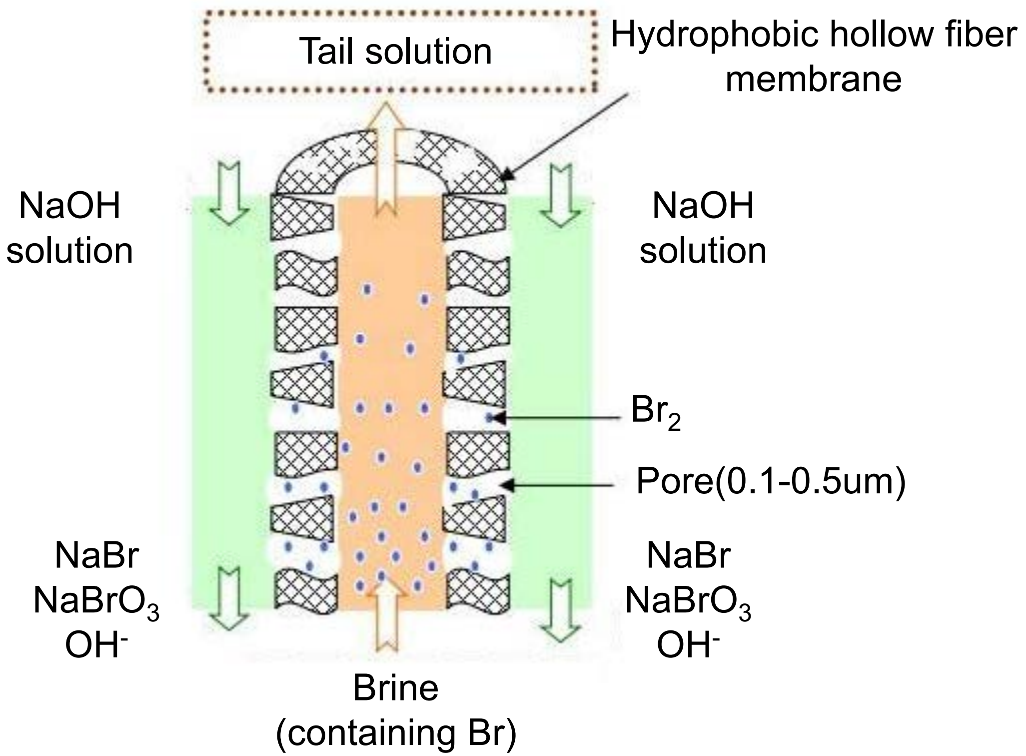
Purpose & Significance



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Purpose & Significance

- Process feasibility;
- Br^- recovery rate.;
- Material;
- **Efficient;**

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Experiment approach

$$3Br_2 + 6NaOH = 5NaBr + NaBrO_3 + 3H_2O$$

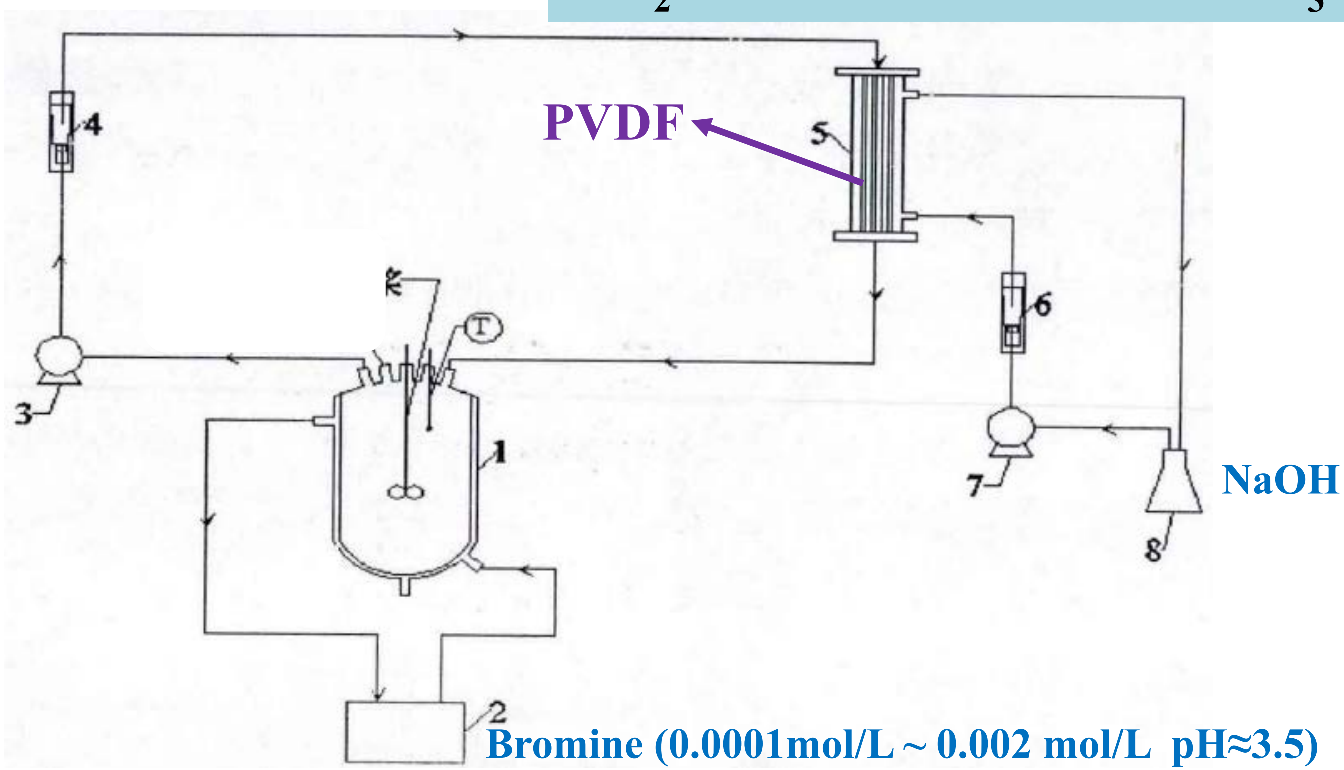

Fig.1 Schematic diagram of aqueous bromine solution membrane absorption experimental setup

1. Circulating bottle of raw material liquid, **2.** Constant temperature sink, **3.** Peristaltic pump, **4.** Flow meter, **5.** PVDF hollow fiber membrane, **6.** Flow meter, **7.** Peristaltic pump, **8.** Absorbent circulation bottle.

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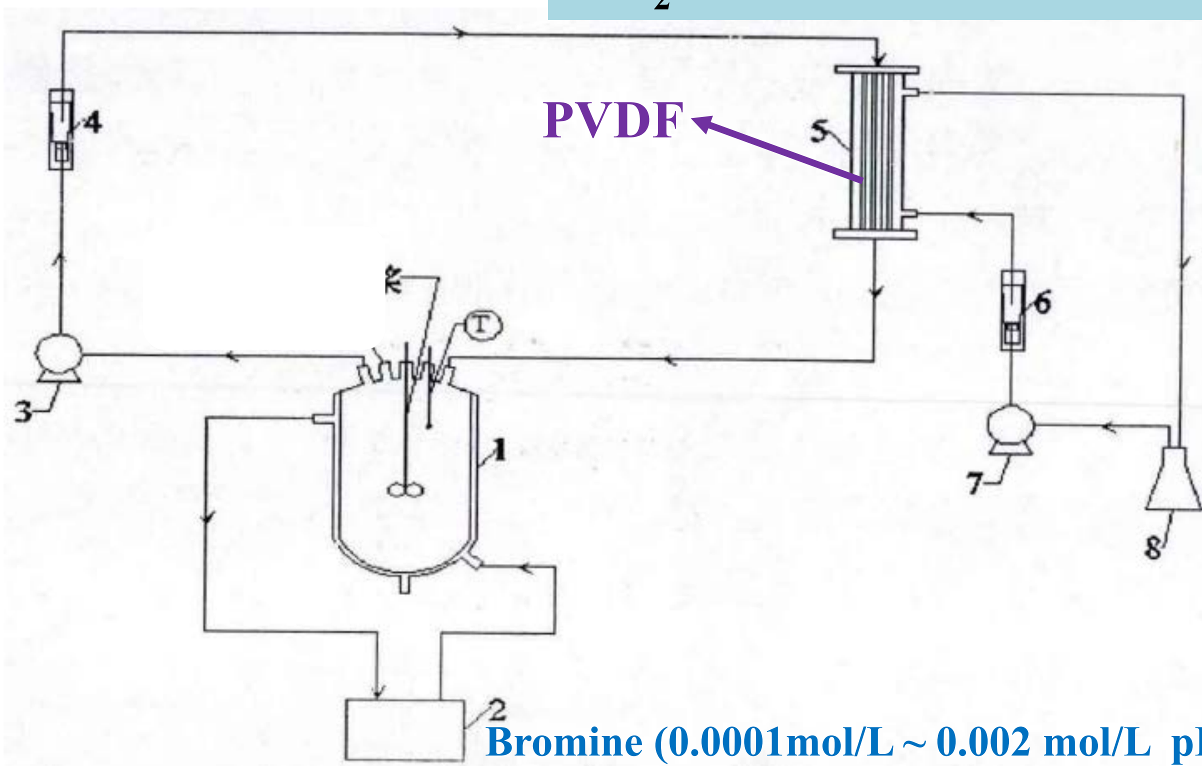

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Experiment approach

Table 1 The physical properties of PVDF hollow fiber membranes

Performance index	Performance parameter
Effective membrane area, m^2	0.05
Average pore size, μm	0.05
Membrane inner diameter, mm	0.8
Membrane thickness, mm	0.16
Porosity, %	85
Tortuosity factor	2

Experiment approach

Flux

$$J = \frac{W}{S \cdot t}$$

Yield

$$\eta = \frac{C^0_{Br_2} - C^1_{Br_2}}{C^0_{Br_2}} \times 100\%$$

Mass transfer coefficients

$$K = -\frac{du}{4L} \ln\left[1 - \frac{4V}{\pi Nutd^2} \ln\frac{V_0}{V_1}\right]$$

The absorption time

The bromine solution temperature

The absorption solution concentration

The absorption solution flow rate

Condition optimization

Results and discussion

- Effect of **absorption time** on membrane absorption performance

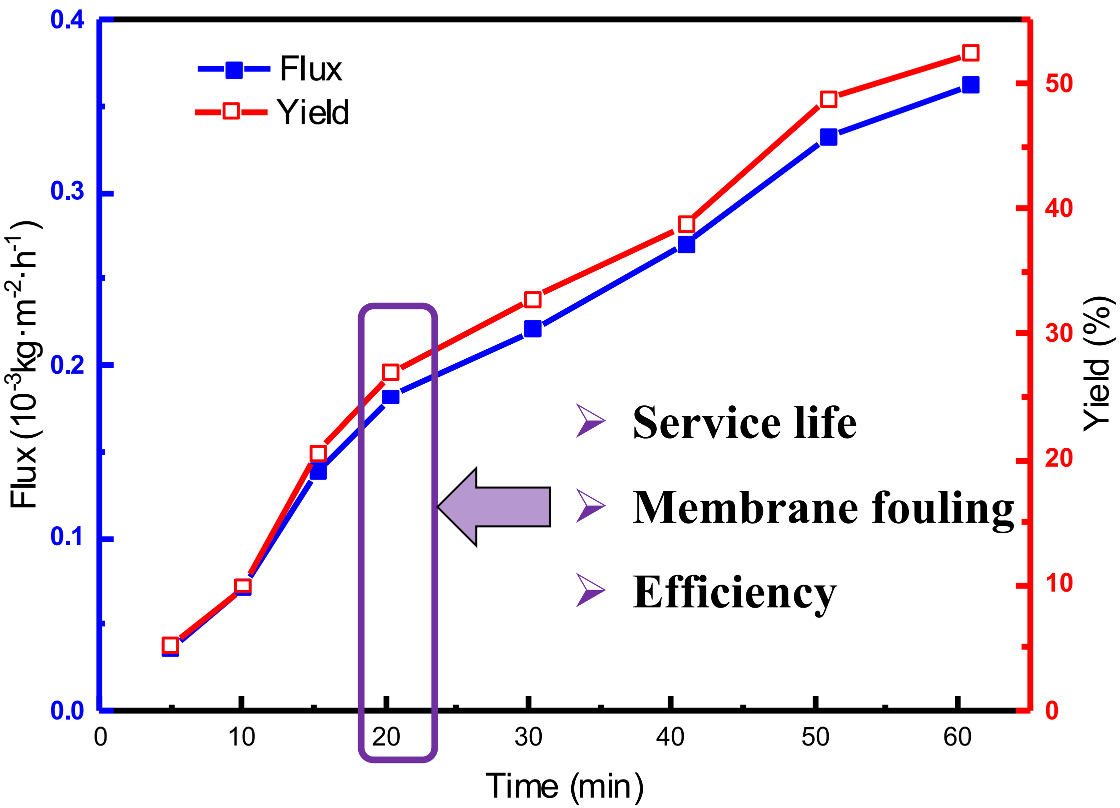

Fig. 2 The effect of membrane absorption time on flux and mass transfer coefficient of aqueous bromine solution for membrane absorption

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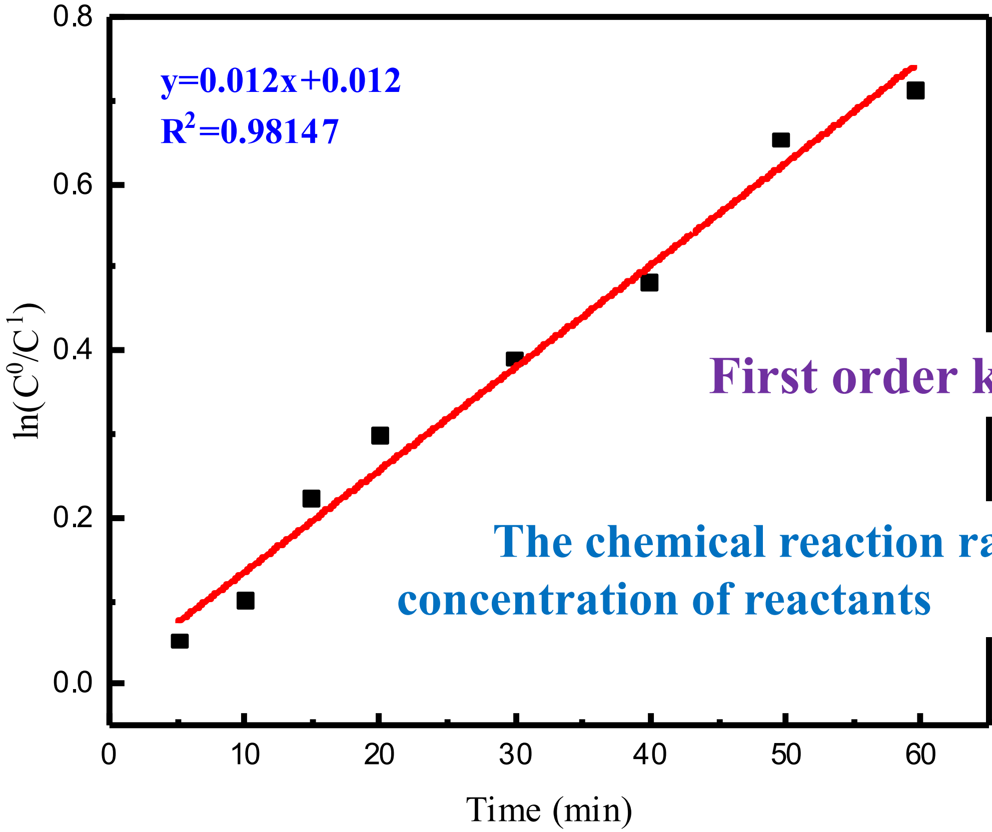
Results and discussion



First order kinetics process

The chemical reaction rate is proportional to initial concentration of reactants

Fig. 3 Membrane absorption time vs. In (C^0/C^t)

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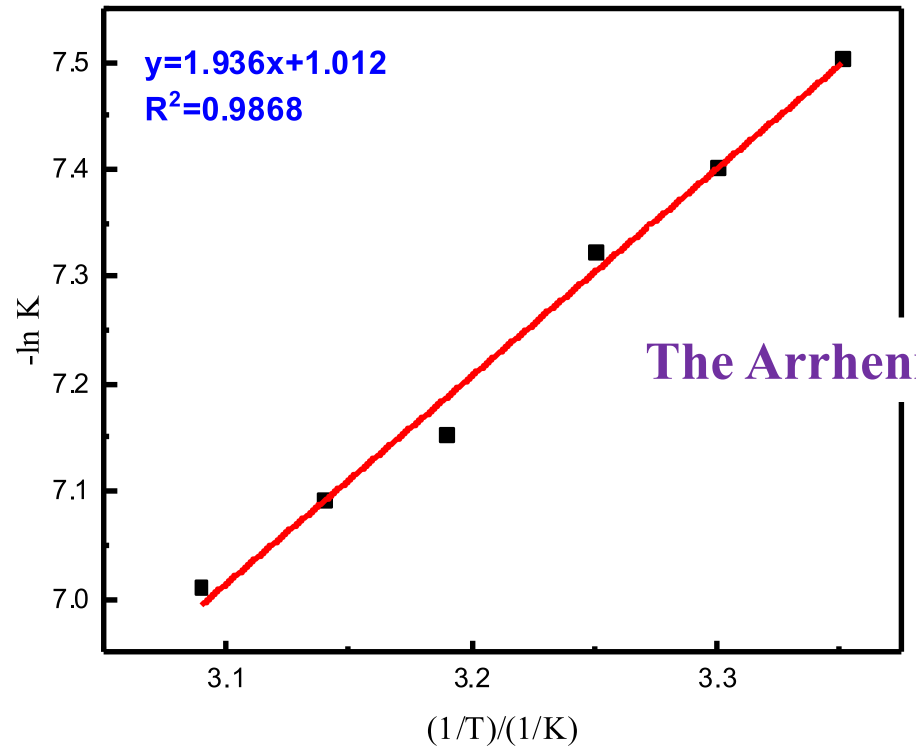
Results and discussion

- Effect of **bromine solution temperature** on membrane absorption performance



The Arrhenius relationship

Fig. 4 Relationship between –InK vs. 1/T

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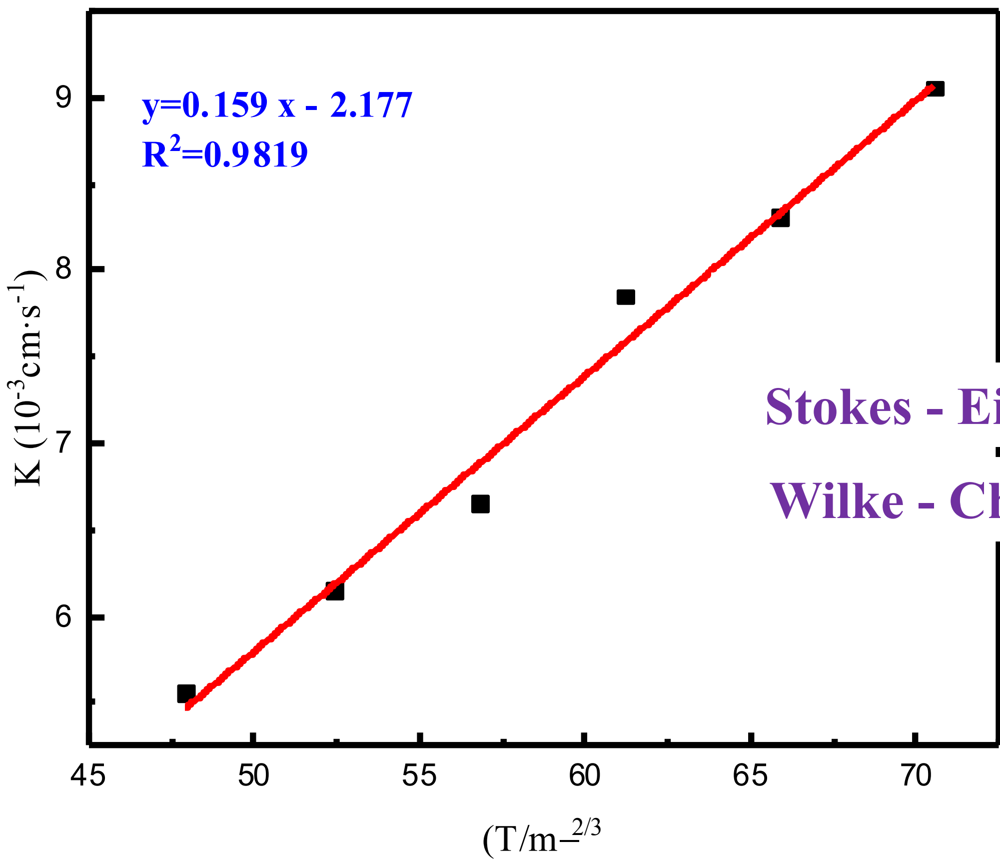
Results and discussion



Stokes - Einstein equation

Wilke - Change equation

Fig. 5 Relationship between K vs. $(T/\mu)^{2/3}$

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Results and discussion

- Effect of **absorption solution concentration** on membrane absorption performance

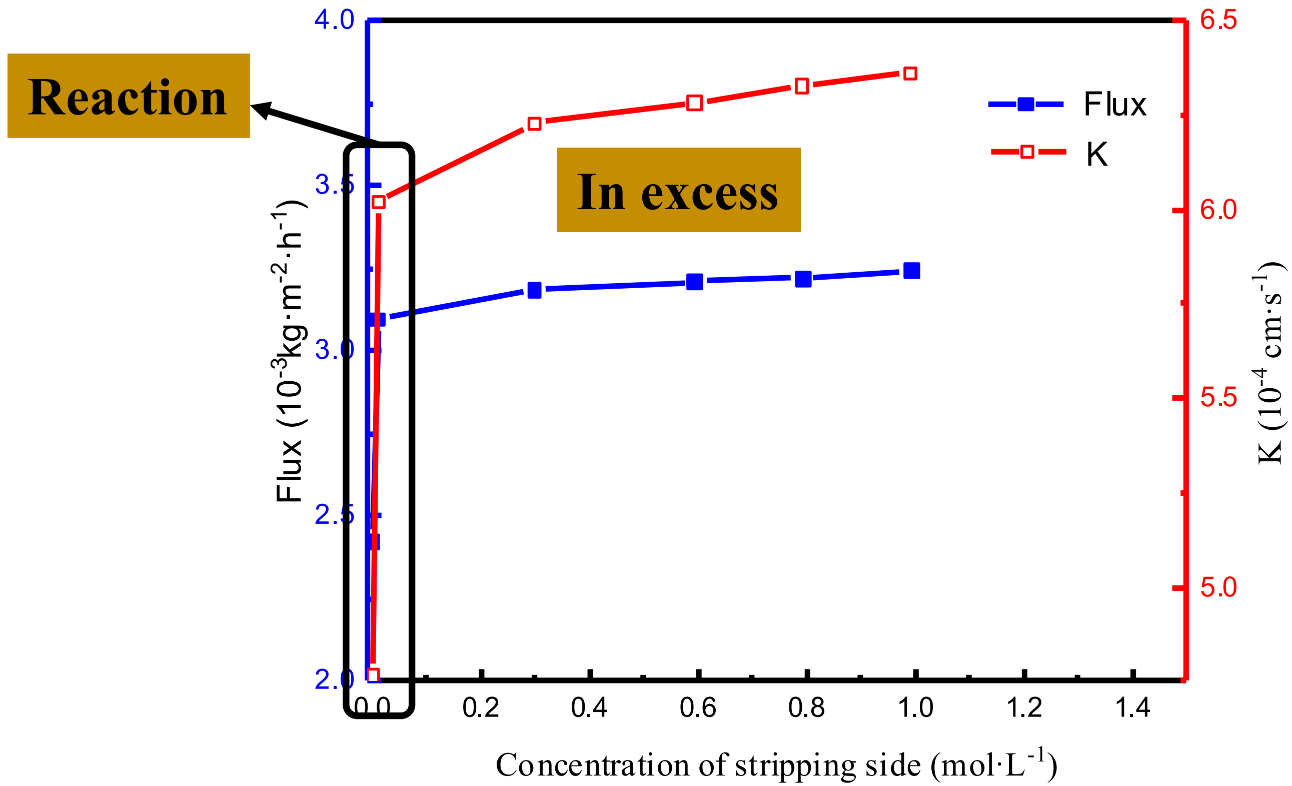

Fig. 6 The effect of concentration of stripping side (NaOH) on mass transfer coefficient and flux of aqueous bromine solution for membrane absorption

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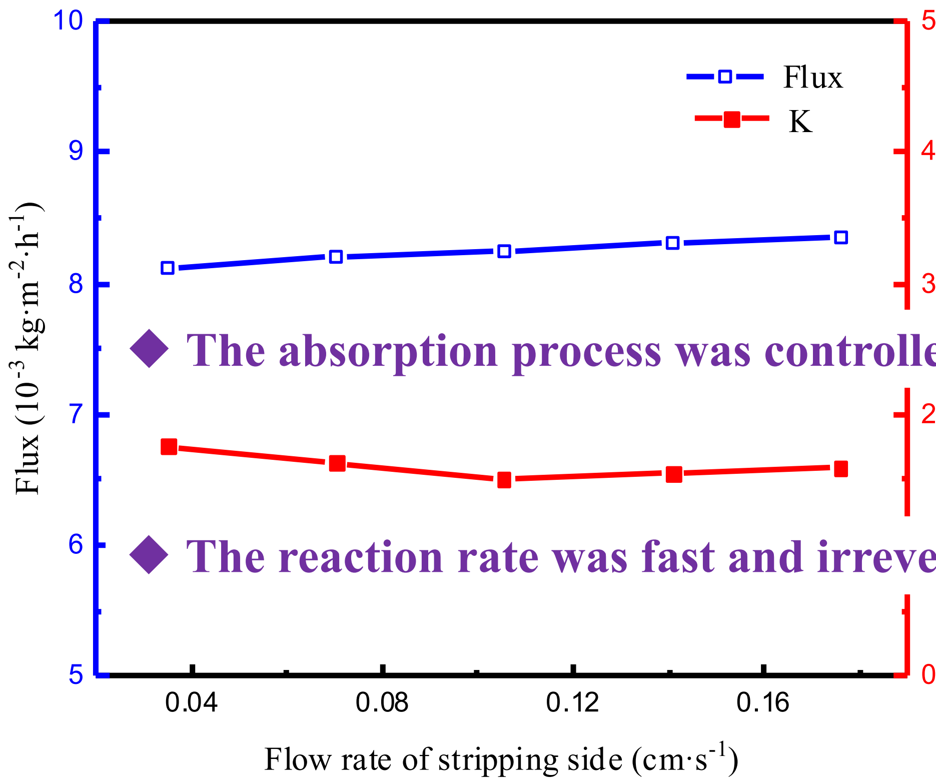
Results and discussion

- Effect of **absorption solution flow** rate on membrane absorption performance



◆ **The absorption process was controlled by main gas liquid.**

◆ **The reaction rate was fast and irreversible**

Fig. 7 The effect of flow rate of stripping side (NaOH) on mass transfer coefficient and flux of aqueous bromine solution for membrane absorption

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Results and discussion

The regression orthogonal test

- **Optimization** of aqueous bromine solution membrane absorption process

Table 2. Factors and levels of coding table in the process of membrane absorption extracting

Canonical variate z_j	Natural variable		
	Flow rate(cm/s)	Concentration of feed/(mg/L)	Temperature of feed/℃
Lower level (-1)	2.78	40	25
Uper level (1)	22.24	220	50
Zero level (0)	12.51	130	37.5
Changes interval $\triangle_j$	9.73	90	

Table 3 Simplified regression equations

Factor	Simplified regression equation
Absorption rate	$y=1.07*10^{-1}x_1+0.328$
Mass transfer coefficient	$y=7.94*10^{-4}x_3-5.8*10^{-4}$
Membrane flux	$y=1.142*10^{-5}x_1+2.407*10^{-5}x_2+1.71*10^{-5}x_3+2.078*10^{-7}x_1x_2-1.25*10^{-3}$

- **In the absorption solution side,** the flux of NaOH solution was **2L/h** and the concentration was **0.01mol/L.**
- **In the feed solution side**, the temperature of the feed solution was **50℃**, the flow was **22. 24 cm/s** and feed solution concentration was **220 mg/L**.

The membrane flux reaching to **6.17 × 10^{-3} kg / (m^2·h).**

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Conclusions

The membrane absorption method is one of the methods that cost low energy and have high extraction efficiency to purify bromine in bromide solution.

- The relationship between the feed solution temperature and mass transfer coefficient of the aqueous bromine solution membrane absorption process is **in line with the Arrhenius relationship**
- When the concentration of NaOH solution **increased from** 0.003 mol/L **to** 0.01 mol/L, the mass transfer coefficient **increased from** 4.75×10^{-4} cm/s **to** 6.02×10^{-4} cm/s, and the corresponding membrane flux **increased from** 2.4×10^{-3} kg/(m^2·h) **to** 3×10^{-3} kg/(m^2·h).
- The fluid dynamics conditions of the absorption solution **had no significant influence on** aqueous bromine solution membrane absorption.
- **The optimum process** of aqueous bromine solution membrane absorption was obtained by **the regression orthogonal test.**

Thank you for your attention