
Article

Research and Performance Evaluation on Selective Absorption of H₂S from Gas Mixtures by Using Secondary Alkanolamines

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1. Absorption evaluation experimental device and operating parameters

Table S1. Comparison of absorption effect between atmospheric pressure test device and industrial device.

| Name of device | | | atmospheric pressure test device | industrial device |
|------------------------------------|------------------|-------------------|----------------------------------|-------------------|
| gas-liquid ratio | v/v | | 93 | 93 |
| Packing height or number of plates | | | 1.0 m | 10 plates |
| Lean liquid inlet temperature | °C | | 39.6 | 39.0 |
| Raw gas | H ₂ S | % | 2.01 | 1.96 |
| | CO ₂ | % | 35.63 | 35.38 |
| Purified gas | H ₂ S | mg/m ³ | 46.72 | 47.71 |
| | CO ₂ | % | 29.16 | 29.67 |

Table S2. Operating parameters for desulfurization performance evaluation.

| Items | Operating parameters | Items | Operating parameters |
|------------------------------------|----------------------|------------------------------------------------------------------------|----------------------|
| H ₂ S in raw gas, % (V) | 2.0~2.1 | Packing height, m | 1.0 |
| CO ₂ in raw gas, % (V) | 30~31 | amine concentration, % (wt) | 40 |
| Lean liquid inlet temperature, °C | 38~40 | The temperature of the rich liquid entering the regeneration tower, °C | 85~95 |
| Solution circulation volume, L/h | 2.0 | Regenerator operating pressure, MPa | 0.04~0.08 |
| Gas flow, L/h | 400 | Regeneration tower top temperature, °C | 104~108 |

2. Experiment results of absorption of H₂S and CO₂ by MDEA, TBEE and their mixture

Table S3. Experiment results of MDEA aqueous solution to absorb H₂S and CO₂.

| 40%MDEA+60%H ₂ O | | | | | | | | | | | |
|-----------------------------|----------------|-------------------------|---------------|-----------------------------|------------------|------------------|-----------------|-------------------|-----------------|-------------------------------|------------------------------------|
| Entry | Packing height | Lean liquid temperature | Feed gas flow | Solution circulation volume | gas-liquid ratio | Raw gas | | Purified gas | | H ₂ S removal rate | CO ₂ co-absorption rate |
| | | °C | | | | H ₂ S | CO ₂ | H ₂ S | CO ₂ | | |
| | m | | L/h | L/h | | % | % | mg/m ³ | % | % | % |
| 1 | 1.0 | 39.2 | 400 | 2.0 | 200 | 2.01 | 30.45 | 366.86 | 25.66 | 98.37 | 23.41 |
| 2 | 1.0 | 39.5 | 400 | 2.0 | 200 | 1.97 | 30.43 | 359.74 | 25.19 | 98.34 | 25.17 |
| 3 | 1.0 | 39.6 | 400 | 2.0 | 200 | 2.00 | 30.50 | 374.23 | 25.60 | 98.33 | 23.82 |
| 4 | 1.0 | 39.3 | 400 | 2.0 | 200 | 2.05 | 30.46 | 398.27 | 25.96 | 98.29 | 22.28 |
| 5 | 1.0 | 39.7 | 400 | 2.0 | 200 | 2.04 | 30.50 | 378.24 | 25.85 | 98.36 | 22.87 |
| | | average | | | | 2.01 | 30.47 | 375.47 | 25.65 | 98.33 | 23.52 |

Table S4. Experiment results of TBEE aqueous solution to absorb H₂S and CO₂.

| 40%TBEE+60%H ₂ O | | | | | | | | | | | |
|-----------------------------|------------------------|-----------------------|------|----------------------------|--------------|------------------|-----------------|-------------------|-----------------|---------------------------------------|-----------------------------------------------|
| Entry | Pack- ing height | Lean | Feed | Solu- | gas- | Raw gas | | Purified gas | | H ₂ S re- moval rate | CO ₂ co-ab- sorption rate |
| | | liquid | gas | tion | liq- | H ₂ S | CO ₂ | H ₂ S | CO ₂ | | |
| | | tem- pera- ture | flow | circula- tion volume | uid ratio | | | | | | |
| | m | °C | L/h | L/h | | % | % | mg/m ³ | % | % | % |
| 1 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.08 | 30.29 | 27.04 | 25.17 | 99.88 | 24.90 |
| 2 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.01 | 29.21 | 32.49 | 25.23 | 99.86 | 20.54 |
| 3 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.03 | 29.55 | 37.06 | 26.00 | 99.84 | 18.65 |
| 4 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.11 | 30.17 | 25.72 | 26.70 | 99.90 | 18.24 |
| 5 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.10 | 30.41 | 28.71 | 26.67 | 99.88 | 19.28 |
| | average | | | | | 2.07 | 29.93 | 30.20 | 25.95 | 99.87 | 20.38 |

Table S5. Experiment results of absorption of H₂S and CO₂ by mixed solution of TBEE and MDEA.

| 5%TBEE+35%MDEA+60%H ₂ O | | | | | | | | | | | |
|------------------------------------|----------------|-----------------------------------|------------------|------------------------------------------|------------------------------|------------------|-----------------|-------------------|-----------------|---------------------------------------|-----------------------------------------------|
| Entry | Packing height | Lean liquid tem- pera- ture | Feed gas flow | Solu- tion cir- culation volume | gas- liq- uid ratio | Raw gas | | Purified gas | | H ₂ S re- moval rate | CO ₂ co-ab- sorption rate |
| | | | | | | H ₂ S | CO ₂ | H ₂ S | CO ₂ | | |
| | | m | °C | L/h | L/h | % | % | mg/m ³ | % | | |
| 1 | 1.0 | 38.8 | 400 | 2.0 | 200 | 1.96 | 30.98 | 47.18 | 26.35 | 99.79 | 22.55 |
| 2 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.02 | 30.5 | 44.19 | 25.71 | 99.80 | 23.43 |
| 3 | 1.0 | 38.8 | 400 | 2.0 | 200 | 1.92 | 30.42 | 47.53 | 25.86 | 99.78 | 22.42 |
| 4 | 1.0 | 38.8 | 400 | 2.0 | 200 | 2.02 | 30.6 | 46.79 | 26.01 | 99.80 | 22.59 |
| 5 | 1.0 | 38.5 | 400 | 2.0 | 200 | 2.02 | 30.59 | 45.3 | 26.05 | 99.80 | 22.39 |
| | | average | | | | 1.99 | 30.62 | 46.20 | 26.00 | 99.79 | 22.68 |

3. Comparison of absorption ability of fresh solution and regeneration solution

Table S6. Comparison of absorption ability of fresh solution and regeneration solution.

| Solution | Fresh solution H ₂ S (g·L ⁻¹) | Solution after regeneration H ₂ S (g·L ⁻¹) | Fresh solution CO ₂ (g·L ⁻¹) | Solution after regeneration CO ₂ (g·L ⁻¹) |
|--------------------|---------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------|------------------------------------------------------------------------|
| 40%MDEA | 5.868 | 5.600 | 20.303 | 19.920 |
| 40%TBEE | 10.547 | 10.223 | 20.270 | 20.292 |
| 35%MDEA+5%TBE E | 7.220 | 6.988 | 21.795 | 21.055 |

4. Corrosion rate data of TBEE solvent system and MDEA aqueous solution

Table S7. Static corrosion rate data of TBEE solvent system and MDEA aqueous solution.

| Entry | H ₂ S and CO ₂ content in solution | | Test piece length | Test piece width | Thick-ness of test piece | Round hole diame-ter | weightweight before test after test | | temp | time | Corro-sion rate |
|-----------------------|----------------------------------------------------------|---------------------|----------------------------------------|------------------|--------------------------|----------------------|-------------------------------------|--------|------|------|-----------------|
| | H ₂ S g/L | CO ₂ g/L | mm | mm | mm | mm | g | g | °C | h | mm/a |
| TBEE aqueous solution | 5.39 | 25.69 | 40.00 | 13.22 | 2.16 | 4.22 | 8.4051 | 8.4032 | 90 | 72 | 0.0229 |
| | | | 39.92 | 13.20 | 2.14 | 4.22 | 8.3601 | 8.3582 | 90 | 72 | 0.0230 |
| | | | 40.00 | 13.22 | 2.16 | 4.24 | 8.3614 | 8.3597 | 90 | 72 | 0.0205 |
| | | | Average corrosion rate in liquid phase | | | | | | | | 0.0221 |
| MDEA aqueous solution | 4.95 | 26.27 | 39.94 | 13.14 | 2.12 | 4.24 | 8.3405 | 8.3381 | 90 | 72 | 0.0293 |
| | | | 39.48 | 13.16 | 2.12 | 4.24 | 8.1947 | 8.1924 | 90 | 72 | 0.0283 |
| | | | 40.02 | 13.20 | 2.16 | 4.16 | 8.3406 | 8.3384 | 90 | 72 | 0.0266 |
| | | | Average corrosion rate in liquid phase | | | | | | | | 0.0281 |

5. ¹H NMR spectrum of synthesized TBEE

Figure S1. ¹H NMR (400 MHz, D₂O) δ 3.63–3.56 (m, 2H), 3.54–3.46 (m, 4H), 2.63 (s, 2H), 0.97 (s, 9H).

