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Scientific Publishing

碳钢 A106 Gr B 在含胺-CO2 的溶液中的腐蚀率

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摘 要：二氧化碳（CO2）是石油和天然气工业中的一种腐蚀性元素。为了防止 CO2 对碳钢管道的腐蚀，通常使用胺基溶剂和苛性碱溶液。因此，胺基溶剂和苛性钠溶液在减少腐蚀风险方面的效果成为决定碳钢管道使用寿命的关键参数。在这项研究中，研究了碳钢 A106 Gr B 在含饱和 CO2 气体和苛性碱溶液的胺溶液中的腐蚀率。实验是在静态条件下进行的，使用线性极化电阻（LPR）技术来测量腐蚀率（根据 ASTM G 5-94）。实验发现，胺基溶液中的腐蚀率显著。不知何故，在含有饱和二氧化碳气体的胺基溶剂中，腐蚀率增加到 200%。温度从室温增加到 50℃，也增加了腐蚀率。同时，在胺基溶液中加入苛性碱也降低了碳钢的腐蚀率。

关键词：CO2 腐蚀；碳钢；胺类溶剂；苛性碱溶液；腐蚀率

Corrosion Rate of Carbon Steel A106 Gr B in Amine-CO2 Contained Solutions

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Abstract: Carbon dioxide (CO₂) is one of the corrosive elements which exists in oil and gas industries. To prevent CO₂ corrosion on carbon steel pipelines, amine-base solvent and caustic solutions are commonly applied. Accordingly, effectiveness of amine base solvent and caustic solutions to reduce risk of corrosion becomes key parameters in determining service lifetime of pipelines made of carbon steel. In this research, the corrosion rate of carbon steel A106 Gr B in amine solutions combined with saturated CO₂ gas and caustic solution was studied. The experiments were carried out in static conditions and the Linear Polarization-Resistance (LPR) technique was used to measure the corrosion rate (as per ASTM G 5-94). It was found that the corrosion rate in the amine-based solution had shown remarkable results. Somehow, the corrosion rate in an amine-based solvent containing saturated CO₂ gas has increased to 200%. The temperature increment to 50°C from room temperature has also increased the corrosion rate. Meanwhile, the caustic addition in amine solution has reduced the corrosion rate of carbon steel.

Keywords: CO₂ corrosion; carbon steel; amine solvent; caustic solutions; corrosion rate

一、引言

CO₂

CO₂ Caldona, Wipf, & Smith, 2021

MEA CO₂ Ooi

DEA MDEA 2020 CO₂

DIPA Asma, Asmara, & Mokhtar, 2011 S235 Inconel

Asmara & Ismail, 2012 Asmara & Kurniawan, 2018 Hjelmaas 2017

Rashid & Khadom 2020 CO₂

CO₂

H₂S / CO₂

CO₂

H₂S   Lee 2004

MEA   DEA

MDEA   DEA

MDEA   DEA   MDEA

Sun & Nesic,2007   MEA   DEA   CO₂

R3NCOO-   MDEA

MDEA   Videm &

Dugstad,1989

60℃   CO₂

FeCO₃

Li   2019

Asmara   2015

HSS   HSS

CO₂

SO₂   SO₃

MDEA   HSS   HSS

pH

CO₂

A106 Gr B   CO₂

二、方法

ASTM G 5-94   G5-94   2011

A106 Gr B   12mm

10mm   240   400

600   SiC

G1-90   1999

1   Asmara   (2020)

CO₂   27℃

50℃
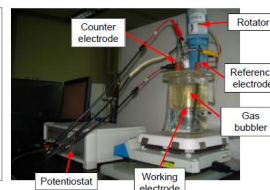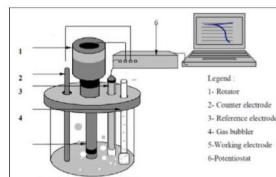
图1.   Asmara   2020

Ag/AgCl

LPR

ASTM G 5-94

CO₂   CO₂

CO₂

pH   1   pH

KS-1

NaOH

表1.   pH

	pH
KS-1	12.7
KS-1+ CO₂	8.0
KS-1+ CO₂+50ppm	8.4
KS-1+ CO₂+250ppm	8.3
/KS-1 50:50 +CO₂	7.9

三、结果和讨论

KS-1

KS-1

-          GC-MS

KS-1   2   KS-1

MDEA   KS-1

```
Pk#     RT   Area%        Library/ID

1    1.727   4.90  C:\Database\NIST05a.L
                    Ammonia
                    Water

2    3.232  88.80  C:\Database\NIST05a.L
                    Ethanol, 2-(ethylamino)-
                    Ethanol, 2-(ethylamino)-
                    N,N-Dimethyl-2-aminoethanol

3    3.822   6.30  C:\Database\NIST05a.L
                    Piperazine
                    Piperazine
                    Piperazine
```
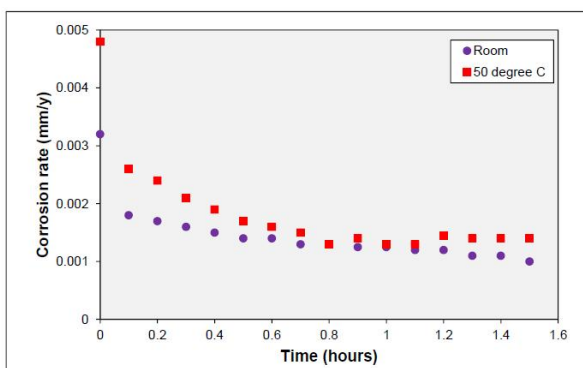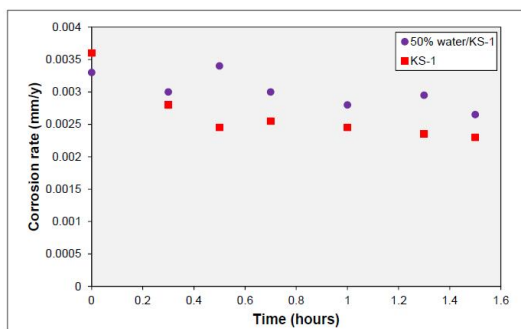
2.KS-1   GCMS

A106 Gr B   KS-1

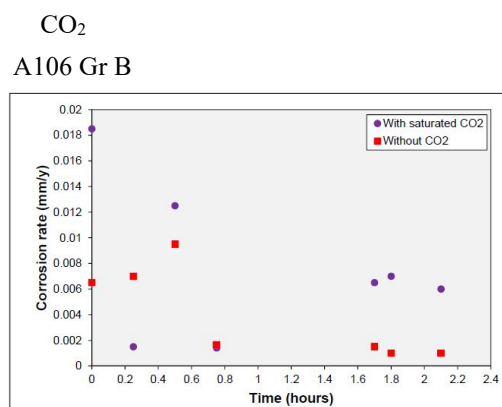   KS-1   A106 Gr B   50℃

3 A106 Gr B   50℃

        0.0015mm/   0.018mm/

                            KS-1

        KS-1   A106 Gr B

3.A106 Gr B   KS-1   50℃

        A106 Gr B   CO$_2$

KS-1

    1. KS-1

        KS-1   A106 Gr B
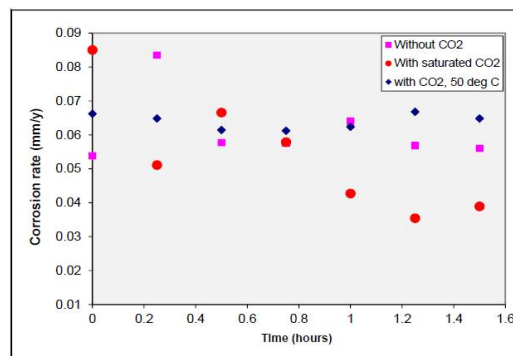
            KS-1

4   0.003mm/

4.   A106 Gr B   CO$_2$ KS-1

2. KS-1   CO$_2$

        5   A106 Gr B

    CO$_2$ KS-1   0.006mm/

    CO$_2$

    A106 Gr B

5.   CO$_2$ A106 Gr B   KS-1

    3. KS-1/   +CO$_2$

        6   CO$_2$ KS-1/

A106 Gr B   0.06mm/   50℃

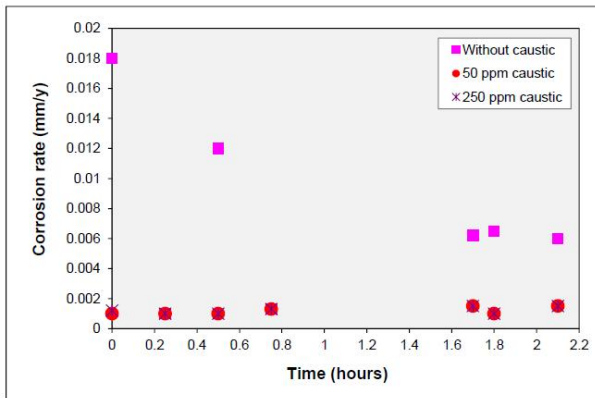   50℃

6.   50℃   CO$_2$ A106 Gr B   KS-1/

        KS-1/   /CO$_2$

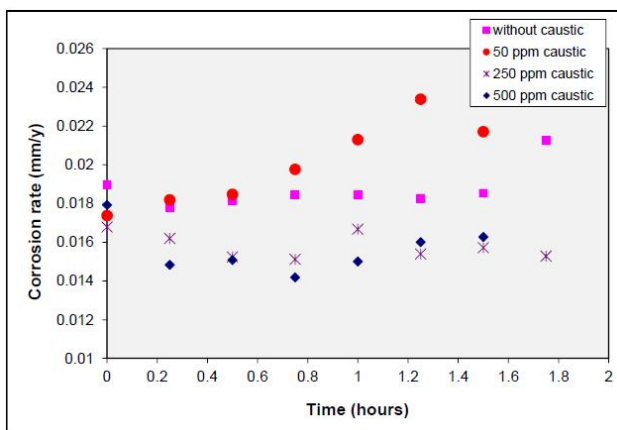   7   8   KS-1

    50-500ppm   A106 Gr B

            CO$_2$/   CO$_2$ KS-1/KS-1/

        50℃

pH   Nešić   2007   7

7.　　　　　　CO₂　　　　KS-1
50ppm　　　　　250ppm

8.　50℃　　　/KS-1　50:50　　　　　　50ppm

　　250ppm　　　　　500ppm　　　　　　CO₂

四、结论

　　　　　　　　A106 Gr B　　　-CO₂
KS-1

　　　　　　　MDEA
　　KS-1　　　　50℃　　　A106 Gr B
　　500ppm　　　　　　　　　A106 Gr B

参考文献

[1]　Asma, B., Asmara, Y., & Mokhtar, C. (2011). Study on the Effect of Surface Finish on Corrosion of Carbon Steel in CO2 Environment. *Journal of Applied Sciences*, *11*. https://doi.org/10.3923/jas.2011.2053.2057

[2]　Asmara, Y P, & Ismail, M. C. (2012). Efficient design of response surface experiment for corrosion prediction in CO₂ environments. *Corrosion Engineering, Science and Technology*, *47*(1), 10–18.

https://doi.org/10.1179/1743278211Y.0000000013

[3]　Asmara, Y P, & Kurniawan, T. (2018). Corrosion Prediction for Corrosion Rate of Carbon Steel in Oil and Gas Environment: A Review. *Indonesian Journal of Science and Technology; Vol 3, No 1 (2018): IJoST: Volume 3, Issue 1, 2018*. https://doi.org/10.17509/ijost.v3i1.10808

[4]　Asmara, Yuli Panca, Ma'arof, M. I. N., & Sutjipto, A. G. E. (2020). Preferential Weld corrosion of carbon steel as Effect of Caustic in amine-CO2 contained solutions. *INTI Journal*, *2020: 055*. Retrieved from http://eprints.intimal.edu.my/1474/

[5]　Asmara, Yuli Panca, Siregar, J. P., Cionita, T., & Alias, J. (2015). Electrochemical Behaviour of High Stress Steel (AISI 4340) in CO₂ Environments with the Presence of H2 Gas. *Applied Mechanics and Materials*, *695*, 98–101. https://doi.org/10.4028/www.scientific.net/AMM.695.98

[6]　Caldona, E. B., Wipf, D. O., & Smith, D. W. (2021). Characterization of a tetrafunctional epoxy-amine coating for corrosion protection of mild steel. *Progress in Organic Coatings*, *151*, 106045. https://doi.org/https://doi.org/10.1016/j.porgcoat.2020.106045

[7]　G1-90, A. (1999). Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens. In *ASTM International*.

[8]　G5-94, A. (2011). Standard Reference Test Method for Making Potentiostatic and Potentiodynamic Anodic Polarization Measurements. In *ASTM International*.

[9]　Hjelmaas, S., Storheim, E., Flø, N. E., Thorjussen, E. S., Morken, A. K., Faramarzi, L., … Hamborg, E. S. (2017). Results from MEA Amine Plant Corrosion Processes at the CO₂ Technology Centre Mongstad. *Energy Procedia*, *114*, 1166–1178. https://doi.org/https://doi.org/10.1016/j.egypro.2017.03.1280

[10]　Lee, K. L. (2004). *A mechanistic modeling of CO₂ corrosion of mild steel in the presence of H₂S*. Ohio University.

[11]　Li, S., Zeng, Z., Harris, M. A., Sánchez, L. J., & Cong, H. (2019). CO2 Corrosion of Low Carbon Steel Under the Joint Effects of Time-Temperature-Salt Concentration. *Frontiers in Materials*, *6*, 10. Retrieved from

https://www.frontiersin.org/article/10.3389/fmats.2019.00

010

[12] Nešić, S. (2007). Key issues related to modelling of internal corrosion of oil and gas pipelines—A review. *Corrosion Science*, *49*(12), 4308–4338. https://doi.org/https://doi.org/10.1016/j.corsci.2007.06.006

[13] Ooi, Z. L., Tan, P. Y., Tan, L. S., & Yeap, S. P. (2020). Amine-based solvent for CO_2 absorption and its impact on carbon steel corrosion: A perspective review. *Chinese Journal of Chemical Engineering*, *28*(5), 1357–1367. https://doi.org/https://doi.org/10.1016/j.cjche.2020.02.029

[14] Rashid, K. H., & Khadom, A. A. (2020). 3-Methoxypropyl-amine as corrosion inhibitor for X80 steel in simulated saline water. *Journal of Molecular Liquids*, *319*, 114326. https://doi.org/https://doi.org/10.1016/j.molliq.2020.114326

[15] Sun, W., & Nesic, S. (2007). A Mechanistic Model of H_2S Corrosion of Mild Steel. *NACE - International Corrosion Conference Series*.

[16] Videm, K., & Dugstad, A. (1989). *Corrosion of carbon steel in an aqueous carbon dioxide environment*. Retrieved from https://www.osti.gov/biblio/5890061