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Field Evaluation of 1-Methylnaphthalene as a Performance Enhancer for Diethylamine Corrosion Inhibitor in Oil Production Facilities

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Case Report

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Field Evaluation of 1-Methylnaphthalene as a Performance Enhancer for Diethylamine Corrosion Inhibitor in Oil Production Facilities.

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Abstract

This study examines the improvement in the corrosion-inhibitory efficacy of diethylamine (DEA) by incorporating 1-methylnaphthalene (1-MN) at concentrations of 2%-5% in oil production header systems. The assessment was performed in actual operational settings at an oil and gas production plant, utilizing corrosion coupons, online corrosion monitoring systems, fluid analysis, and X-ray diffraction (XRD). Corrosion performance was assessed by comparing the injection of 30 ppm DEA alone with DEA modified by the addition of 1-MN. The results demonstrated a significant reduction in corrosion rates after the addition of 1-MN. At the crude inlet to the HP Wet Separator #01, the corrosion rate decreased from 25 to 14 mpy, while at the crude outlet from LP Wet Separator #03, the corrosion rate decreased from 9 to 2 mpy. Furthermore, the corrosion rate at the crude outlet from LP Dry Separator #04 decreased from 4 mpy to less than 1 mpy. Fluid analysis also confirmed improved corrosion control performance through reductions in total iron concentration and increases in corrosion inhibitor residuals. XRD analysis showed an increase in the magnetite (Fe_3O_4) passivation layer from 50.1% to 53.9% after the addition of 1-MN. In contrast, the troilite (FeS) content decreased from 26.1% to 18.2%, while goethite, previously detected at 1.8%, completely disappeared. The findings demonstrate the synergistic effect of 1-MN in enhancing DEA's adsorption and protective film-forming behaviour under oilfield operating conditions.

Keywords

Corrosion inhibition; Diethylamine; 1-Methylnaphthalene; Oil production headers; Corrosion coupons; Carbon steel; Oilfield chemistry.

1. Introduction

Corrosion is a widespread and costly issue affecting various industries, including construction, transportation, oil & gas, and manufacturing [1]. It causes degradation of metal structures, leading to safety risks, increased maintenance costs, and reduced operational efficiency. [2]. Effective corrosion mitigation strategies are crucial, prompting extensive research into protective coatings, inhibitors, and various control methodologies. Organic chemical compounds employed as corrosion inhibitors have garnered considerable interest among corrosion mitigation techniques. Their environmentally friendly nature, high efficacy, and versatility make them especially valuable. These inhibitors, whether naturally occurring or synthetically derived, adsorb onto metal surfaces to form protective barriers that effectively slow down or prevent corrosive reactions [3, 4]. Studies indicate that amine compounds have a significant capacity to form a robust, effective protective layer on metal surfaces [5, 6, 7]. Recent studies have demonstrated that the corrosion-inhibitory efficacy of amine-based inhibitors can be markedly enhanced by improving their interfacial adsorption properties and their penetration capacity through deposit layers, resulting in superior protection of carbon steel under sour oilfield conditions [8]. Nitrogen, which is easily adsorbed on metal surfaces, is present in amine molecules. Amines bind to metal ions, forming a thick layer of defence on the metal's surface. Amines adsorb onto the metal surface, forming hydrophobic films that reduce the rate of corrosion. It forms a protective coating that limits access of corrosive agents to the metal surface, reducing the rates of the cathodic and anodic processes that cause corrosion [9]. It has enhanced corrosion inhibition through the synergistic augmentation of amine-based corrosion inhibitors with aromatic additives [10]. Diethylamine (DEA) and related chemicals exhibited exceptionally effective corrosion inhibition properties [11, 12]. DEA is used in the production of petroleum products, rubber, corrosion inhibitors, and pharmaceuticals; it has been studied and has exhibited strong corrosion inhibition in sour conditions. In addition to its use as a bactericide to control bacterial growth, DEA helps to reduce corrosion involving adsorption onto metal surfaces and the formation of protective films [13, 14]. DEA is also used in the production of clay-swelling inhibitors [15]. Ethylamine, an organic amine with the chemical formula $(CH_3CH_2)NH$, functions as a corrosion inhibitor primarily through adsorption onto metal surfaces and the formation of protective films. In aqueous environments, DEA molecules can adsorb onto metal surfaces via lone-pair electrons on the nitrogen atom [16, 17]. Naphthalene derivatives have shown considerable effectiveness in inhibiting corrosion of carbon steel in acidic environments across multiple experiments [18, 19]. According to recent research, aromatic ring structures, whose π-electron-rich systems enable strong surface adsorption and lead to increased inhibition efficiencies, are important for corrosion mitigation under H_2S circumstances [20]. This adsorption creates a barrier that prevents corrosive agents such as water, oxygen, or chloride ions from reaching the metal surface. The adsorption process can occur by physisorption, involving weak Van der Waals forces. DEA forms a hydrophobic organic film on the metal surface, which reduces water wetting and ion penetration, key factors in electrochemical corrosion processes. This interaction enhances the

protective effect of DEA. In applications such as oil and gas pipelines, especially in CO_2-rich environments, DEA helps prevent internal corrosion. Enhanced corrosion inhibition performance was observed for mild steel in hydrochloric acid solution when methylnaphthalene was applied as the corrosion inhibitor. [21, 22].

2 Experimental

2.1 Field Description

The study was carried out at an oil gathering and separation facility (hydrocarbon medium upstream of oil and gas production) using three-phase production lines and vessels made of carbon steel at pressures of about 60 psi in headers and 200–250 psi in separator outlets in both low pressure (LP) and high pressure (HP), handling wet and dry crude streams and operating temperatures of about 50–70°C, as shown in fluid analysis data tables 3 and 4. Corrosion inhibitor treatment was applied at several process locations, including wet and dry headers and separator inlet/outlet lines. DEA was injected continuously at concentrations ranging from 20 to 34 ppm. During the trial period, 1-MN was introduced at concentrations between 2% and 5% in combination with DEA under stable operating pressure and temperature conditions.

2.2. Corrosion Monitoring Techniques

Corrosion coupons, namely the flash disc (FL-KS), with a thickness of 1/8 inch (3 mm) and a width of 1¼ inches (32 mm), were used. Electrical resistance probes, model ER7000, were placed to assess the system's corrosivity. The corrosion coupons were implemented to simulate the corrosion rate of the pipelines and to evaluate the effectiveness of the chemical treatment program. The weight loss technique, involving the use of corrosion coupons, is widely recognized as the simplest and most reliable method for monitoring corrosion and characterising the corrosivity of fluids. Several fluid parameters were analysed in conjunction with corrosion monitoring, including pH, hydrogen sulfide (H_2S), calcium, total and dissolved iron, chloride, and residual concentration of corrosion inhibition (CI). CI residual analysis was conducted using the UV-1900i Plus UV-Vis spectrophotometer by individually testing for each location. These parameters provide comprehensive insight into the corrosive environment.

The weight loss method involves introducing coupons into the process stream for a predetermined exposure period. After removal, the coupon is cleaned of all corrosion products and reweighed. The difference in weight before and after exposure is used to calculate the corrosion rate (CR) or metal loss (ML) according to the standard formula:

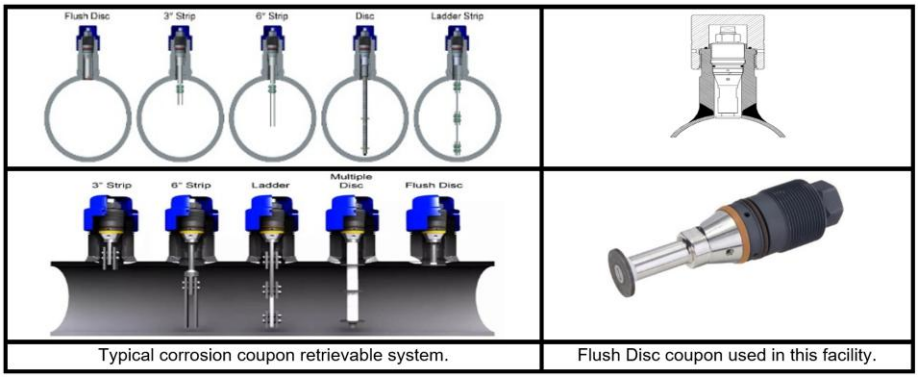
$$\text{Corrosion Rate (CR)} = \frac{\text{Weight loss (g)} * K}{\text{Alloy Density (g/cm}^3\text{)} * \text{Exposed Area (A)} * \text{Exposure Time (hr)}}$$

$$\text{Metal Loss (ML)} = \frac{\text{Weight loss (g)} * K}{\text{Alloy Density (g/cm}^3\text{)} * \text{Exposed Area (A)}}$$

Corrosion coupon testing involves exposing metal coupons to the environment under controlled conditions for a specific period. After retrieval, they are cleaned, weighed, and inspected to calculate the corrosion rate. Perfect Services follows ASTM G1 standards to ensure accuracy. Treatment chemicals are injected into the various process streams for removing oxygen, controlling corrosion, and preventing scale formation and microbial growth. These include individual corrosion inhibitors and scale inhibitors for HP/LP Wet Crude Headers as well as the Test

Crude Headers; corrosion inhibitor, scale inhibitor, and oxygen scavenger to the Desalters Wash Water Inlet Lines. Corrosion and pitting (localized corrosion) rates obtained from coupons are categorized as 'Low, Moderate, High, and Severe' as per Guidelines in NACE SP0775-2018 [12], as summarized in the table below. Coupon processing is done as per NACE [13] ASTM procedure G1-03 (2017). An optical microscope, model VHX-6000, was used to measure the maximum pit depth in microns. For a detailed overview of chemical injection locations, sampling collection (SC)points, and corrosion coupon (CC) monitoring positions throughout the facility, see Figure 5: Schematic Process Flow Diagrams (PFDs) for the Facility.

NACE Classification of Corrosion Rate and Pitting as per SP0775-2018			
Low-General	<1 mpy	Low-Pitting	<5 mpy
Moderate-General	1-4.9 mpy	Moderate-Pitting	5-7.9 mpy
High-General	5-10 mpy	High-Pitting	8-15 mpy
Severe-General	>10 mpy	Severe-Pitting	>15 mpy



Typical corrosion coupon retrievable system. | Flush Disc coupon used in this facility.

2.3. Fluid Analysis

Fluid samples were collected from wet and dry crude streams before and after treatment with 1-MN. The separated water phase was analysed for pH, conductivity, total dissolved solids (TDS), chloride concentration, dissolved oxygen, total iron, dissolved iron, corrosion inhibitor residual, H_2S, and CO_2 content.

2.4 XRD Analysis

Corrosion deposits collected from corrosion coupons were analysed using X-ray diffraction (XRD) on a D8-Discover instrument to identify the corrosion products formed before and after chemical treatment with 1 MN. Deposits collected from coupons of location tag no CC-03-CRW -LP Wet separator #03.

3.Results and Discussion

3.1-Corrosion Coupon Monitoring Data

The preparation, cleaning, and evaluation of the retrieved corrosion coupons were conducted according to NACE SP-0775 and ASTM G1-03 standards. The corrosion coupon monitoring results showed significant improvement in corrosion control after the addition of 1-MN to the DEA treatment program, as detailed in Table 1 and Table 2. At the crude inlet to HP Wet Separator #01, the corrosion rate decreased from 25 mpy to 14 mpy after introducing the DEA/1-MN formulation. Similarly, at the crude outlet from LP Wet Separator #03, the corrosion rate decreased from 9 mpy to 2 mpy. The corrosion rate at the crude outlet from LP Dry Separator #04 also decreased from 4 mpy to less than 1 mpy.For the HP wet header and HP dry header location tags CC-01-CRW and CC-04-CRD, they are upstream of the chemical injection point; as shown in figure 5 schematic process flow diagrams (PFD) for facility, that's why they are not affected by the chemical treatment program, and the corrosion rate is not decreasing.

Corrosion rates before and after adding 1-MN

Location	Before 1-MN (mpy)	After 1-MN (mpy)
HP Wet Separator #01	25	14
LP Wet Separator #03	9	2
LP Dry Separator #04	4	<1

a) Wet Crude: The corrosion rate at the crude outlet from LP Wet Separator No. 3 initially showed high general and pitting corrosion rates before the addition of 1-MN. After adding 1-MN, the corrosion rates decreased to low general and pitting corrosion rates; these results were obtained under the same production line conditions, including pressure, temperature, and exposure time.

b) Dry Crude: The corrosion rate at the crude outlet from LP Dry Separator No. 4 initially showed moderate general and pitting corrosion rates before the addition of 1-MN, as reported in Table 1. After the addition of 1-MN, the corrosion rates decreased to low general and pitting corrosion rates (less than 1 mpy). The corrosion trend charts for the OCM stations located on separator inlets and outlets are provided in Figure 1.

3.2 - Corrosion morphology:

Visual inspection of corrosion coupons revealed considerable differences before and after treatment. Coupons exposed before the addition of 1-MN exhibited dark adherent deposits and visible corrosion attack. After treatment, the coupons showed significantly cleaner surfaces with lower pitting density and reduced corrosion product accumulation on both the front (FS) and back sides (BS) of the coupons before and after cleaning, as shown in Figure 2. The improved surface condition confirms the formation of a more stable and protective inhibitor film. The pitting rates were measured, as presented in Tables 1 and 2.

SN	Location Tag No.	Vessel No./ description	Days Exposed	Corrosion Rate (mpy)	Max Pit Depth (microns)	FS Pitting Rate (mpy)	BS Pitting Rate (mpy)	Visual Inspection)
1	**CC-01-CRW**	HP Wet Header upstream of the chemical injection point	45	**33**	**26**	**22**	**9**	1. Thin, oily brownish black loosely adherent deposits. 3. Uniformly corroded coupon with pits.
2	**CC-02-CRW**	HP Wet separator # 01	45	**25**	**19**	**10**	**7**	1. Thin, oily brownish black loosely adherent deposits. 2. Sulfide present.
3	**CC-03-CRW**	LP Wet separator-No.3	45	**9**	**10**	**6**	**2**	1. Thick, black, strongly adherent deposits. 2. Sulfide present.
4	**CC-04-CRD**	HP dry Header upstream of the chemical injection point	45	**12**	**15**	**12**	**2**	1. Slightly thick, yellowish black loosely adherent deposits. 2. Sulfide present. 3. More or less uniform surface.
5	**CC-05-CRD**	HP Dry separator # 02	45	**9**	**8**	**7**	**NM**	1. Thin, yellowish black loosely adherent deposits. 2. Sulfide present
6	**CC-06-CRD**	From LP Dry separator # 04	45	**4**	**2**	**5**	**NM**	1. Thin, yellowish black loosely adherent deposits.
Remarks: CRW: wet crude stream. CRD: dry crude stream. CC: Corrosion Coupon								

Table 1 -General Corrosion and Pitting Corrosion Rates at Headers / Separators before adding (1-MN)

SN	Location Tag No.	Vessel No./ description.	Days Exposed	Corrosion Rate (mpy)	Max Pit Depth (microns)	FS Pitting Rate (mpy)	BS Pitting Rate (mpy)	Visual Inspection Comments (Laboratory Observation)
1	**CC-01-CRW**	HP Wet Header upstream of the chemical injection point	45	**36**	**31**	**26**	**12**	1. Thin, oily brownish black loosely adherent deposits. 2. Sulfide present
2	**CC-02-CRW**	HP Wet separator # 01	45	**14**	**9**	**7**	**5**	1. Thin, oily brownish black loosely adherent deposits. 3. More or less uniform surface.
3	**CC-03-CRW**	LP Wet separator #03	45	**2**	**3**	**1**	**<1**	1. Thick, black, strongly adherent deposits.
4	**CC-04-CRD**	HP dry Header upstream of the chemical injection point	45	**14**	**7**	**14**	**2**	1. Slightly thick, yellowish black loosely adherent deposits.
5	**CC-05-CRD**	HP Dry separator # 02	45	**4**	**2**	**1**	**<1**	1. Thin, yellowish black loosely adherent deposits. 2. Sulfide present. 3. Uniformly corroded coupon with pits.
6	**CC-06-CRD**	from LP Dry separator # 04	45	**<1**	**1**	**<1**	**<1**	
Remarks: CRW: wet crude stream. CRD: dry crude stream. CC: Corrosion Coupon								

Table 2 - General Corrosion and Pitting Corrosion Rates at Headers / Separators after adding (1-MN).

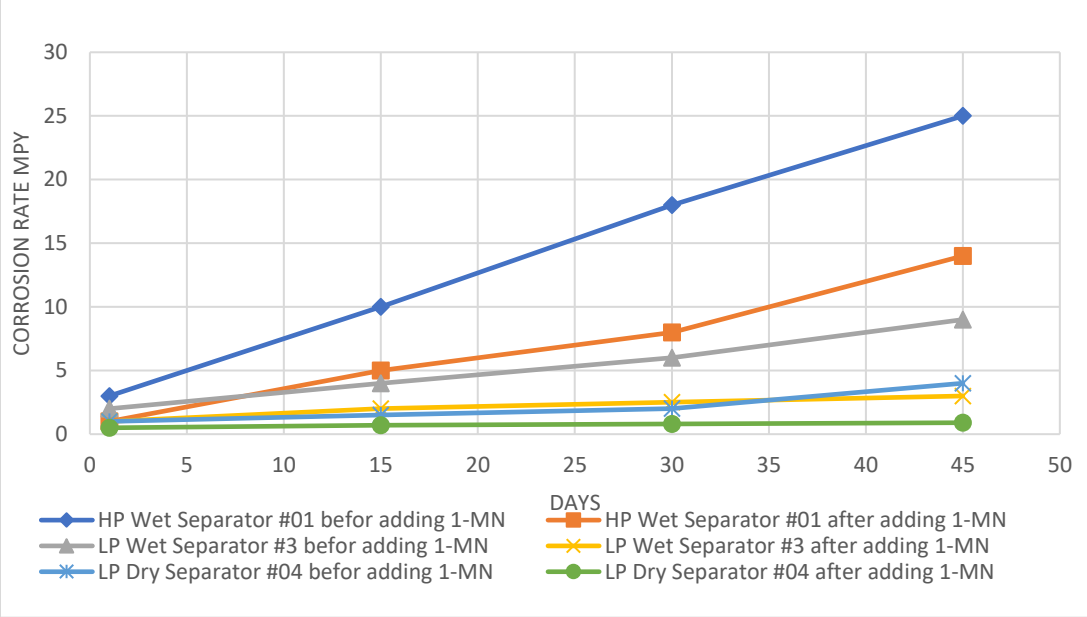


Figure 1a -Trend Chart for Corrosion rates of Separators before/after adding (1-MN).

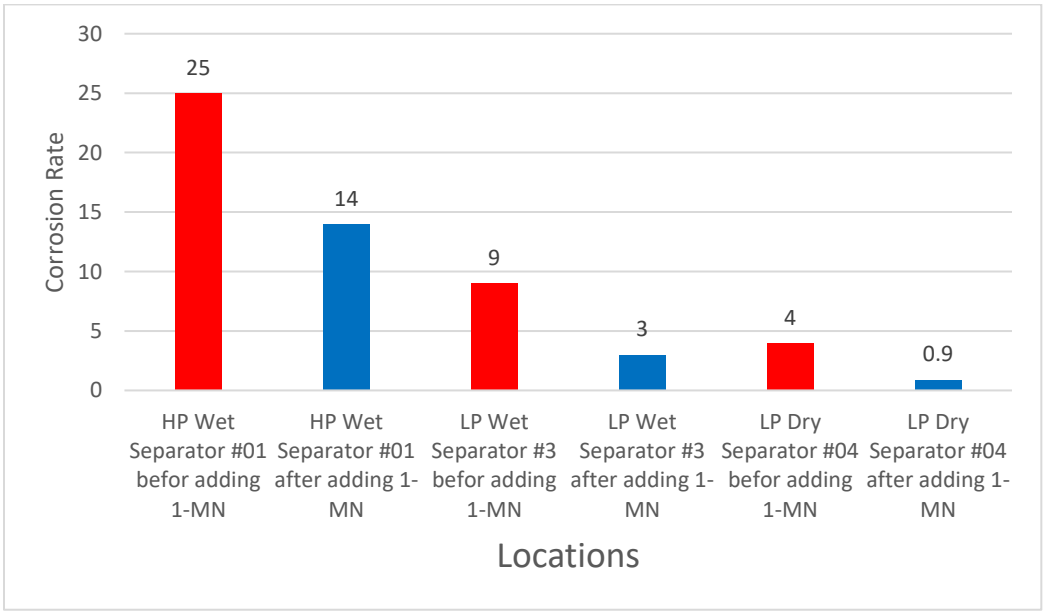


Figure 1b -Trend Chart for Corrosion rates of Separators before/after adding (1-MN).

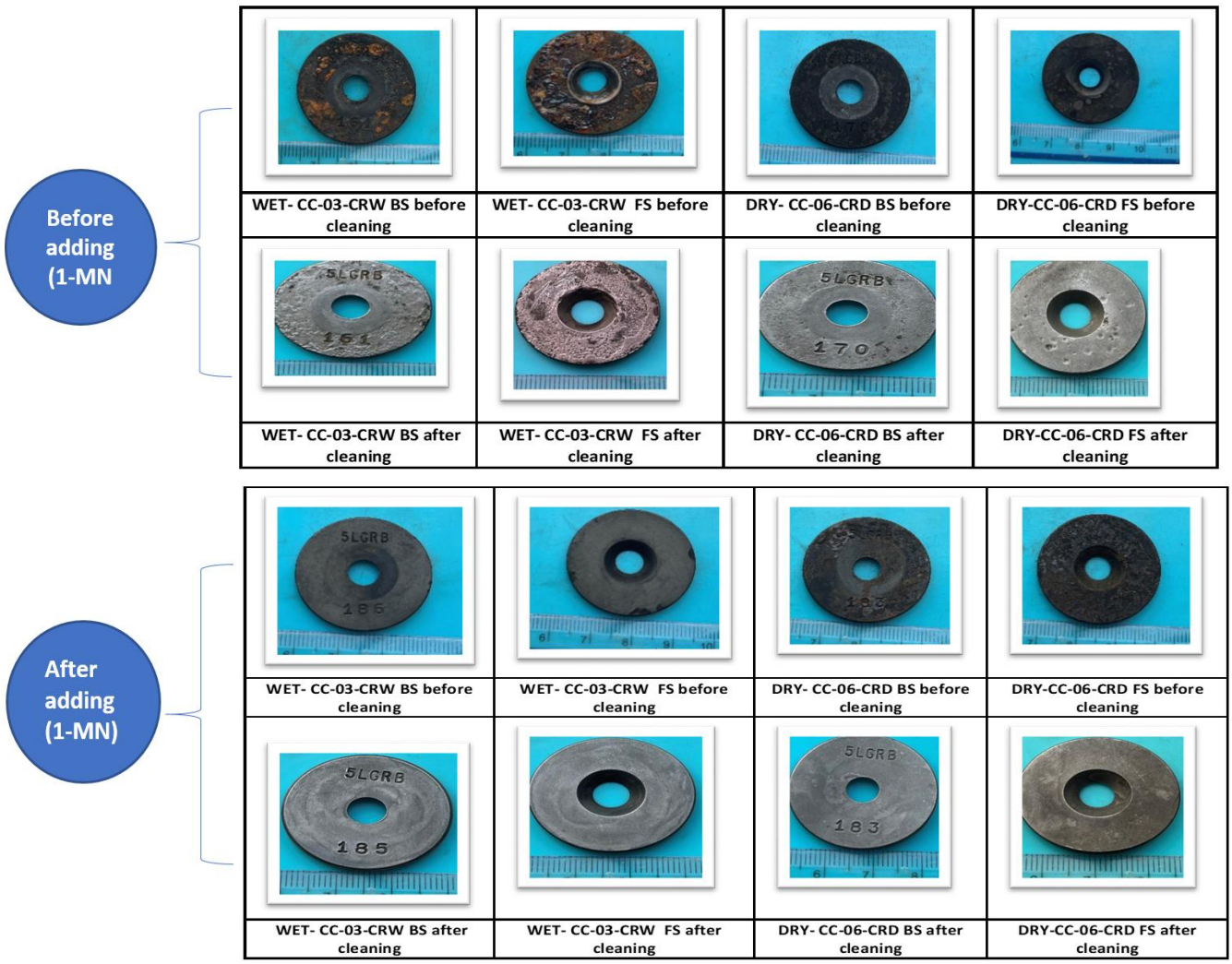


Figure 2 Corrosion morphology of installed coupons in separators before and after adding 1-MN.

3.3- Fluid Analysis Results

Fluid analysis exhibited a reduction in total iron concentration after the addition of 1-MN, confirming lower metal dissolution and reduced corrosion activity. At LP Wet Separator #03, total iron concentration decreased from 28.8 ppm to 16.5 ppm, while corrosion inhibitor residual increased from 5.5 ppm to 12.5 ppm. At LP Dry Separator #04, total iron concentration decreased from 17.5 ppm to 9.7 ppm, while corrosion inhibitor residual

increased from 7 ppm to 14.3 ppm. Fluid analysis observations during this trial are summarised in the following Table 3 and Table 4. Total iron and CI residual trend charts for the Sample Collections (SC) located on the separator's outlet are given in Figure -3.

A direct correlation analysis was conducted to relate coupon corrosion rates (mpy), in conjunction with the total iron concentrations in the produced fluid (ppm). Figure 6 illustrates the simultaneous trends of both independent monitoring parameters in the low pressure (LP) separation vessels prior to and during the implementation of the 1-methylnaphthalene 1-MN performance enhancer.

Total iron and corrosion inhibitor residuals

Location	Total Fe Before 1-MN (ppm)	Total Fe After 1-MN (ppm)	CI Residual Before 1-MN (ppm)	CI Residual After 1-MN (ppm)
LP Wet Separator #03	28.8	16.5	5.5	12.5
LP Dry Separator #04	17.5	9.7	7.0	14.3

3.4 XRD Analysis of Corrosion Deposits:

The XRD results indicated enhancement of the magnetite (Fe_3O_4) passivation layer, increasing from 50.1% to 53.9% following the addition of 1 MN; the troilite (FeS) fraction decreased from 26.1% to 18.2%, and goethite was no longer detected after treatment, as shown in Figure 4. This result confirms the strong inhibition performance of the modified inhibitor system.

Phase	Before 1MN Addition (%	After 1MN Addition (%)
Magnetite(Fe_3O_4)	50.1	53.9
Troilite (FeS)	26.1	18.2
Pyrite (FeS_2)	4.5	3.8
Goethite	1.8	Disappeared

3.5 Corrosion Inhibition Mechanism

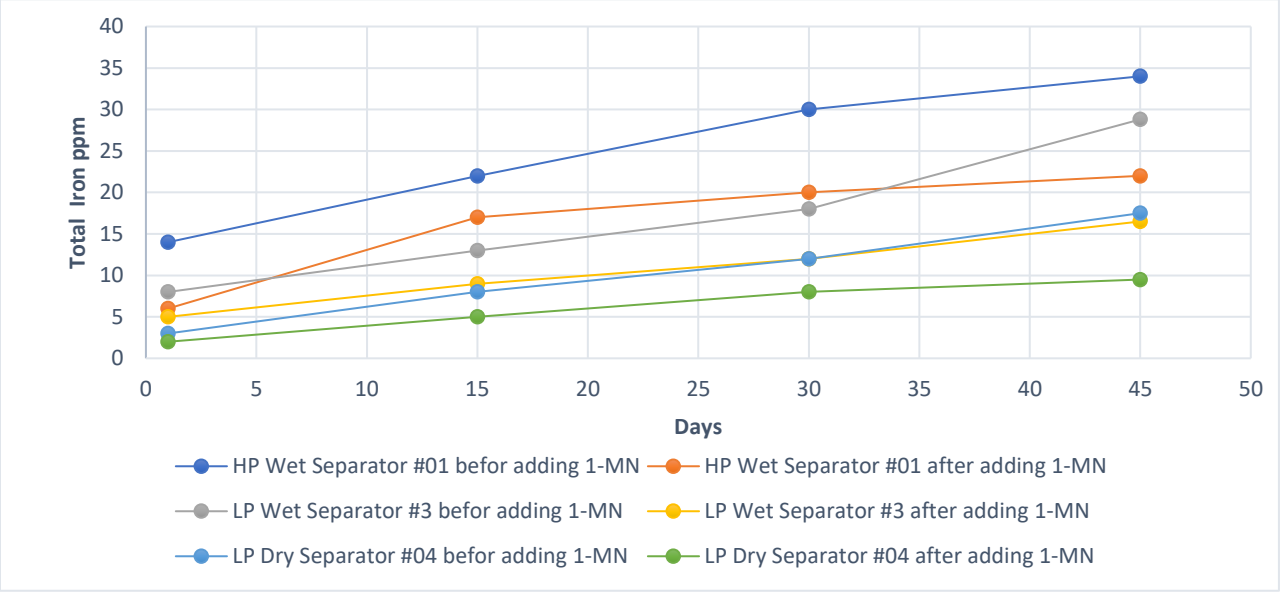
The improved corrosion inhibition performance observed after the addition of 1-MN can be attributed to synergistic adsorption behaviour between DEA and the aromatic structure of 1-MN. DEA molecules adsorb onto the steel surface through the lone pair electrons present on the nitrogen atom, forming a protective barrier against corrosive species. The aromatic rings present in 1-MN increase hydrophobicity and improve surface coverage on the steel surface. The combined effect enhances the stability of the adsorbed inhibitor film. To assess the performance enhancement of adding 1-MN to the baseline DEA program, the inhibition efficiency was calculated from gravimetric weight-loss coupons across three process locations as shown by the linear trend in Figure 7.

S. N	Description	Sampling Location	pH	µs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ppm	mg/l	mg/l	mg/l	psi	°C
				Conductivity	TDS	Chloride Cont. as NaCl	Hardness as $CaCO_3$	Ca^{2+}	Mg^{2+}	Cl Residual	H_2S Content	Total Fe	Dissolved Fe	Mn	Op. Pressure	Op. Temp.
1	HP Wet Header	SC-01-CRW	6.5	404250	210210	189690	39000	10900	3430	0.02	0.2	40.3	33.1	2.7	59	46
2	LP Wet Sep #03	SC-02-CRW	6.6	312500	162500	148450	34000	10400	1940	5.5	0.07	28.8	20.2	1.4	251	62
3	HP dry Header	SC-03-CRD	6.7	386750	201110	190100	37000	10800	2430	0.01	0.0.1	32.9	26.4	1.8	65	49
4	LP Dry Sep #04	SC-04-CRD	6.5	222115	154500	132654	30680	9876	1765	7	0.1	17.5	12.5	1	200	65

Table 3 -Fluid Analysis Data before adding (1-MN)

S. N	Description	Sampling Location	pH	µs/cm	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	ppm	mg/l	mg/l	mg/l	psi	°C
				Conductivity	TDS	Chloride Cont. as NaCl (Water)	Hardness as $CaCO_3$	Ca^{2+}	Mg^{2+}	Cl Residual	H_2S Content	Total Fe	Dissolved Fe	Mn	Op. Pressure	Op. Temp.
1	HP Wet Header	SC-01-CRW	6.2	436220	242438	201376	42000	11352	3876	0.06	0.6	44.5	36.2	3.2	61	50
2	LP Wet Sep #03	SC-02-CRW	7.1	297345	143876	130298	27000	9830	18420	12.5	0.01	16.5	9.4	1.1	243	71
3	HP dry Header	SC-03-CRD	6.5	375329	198365	188740	36300	10400	2365	0.03	0.0.1	36.6	29	1.9	66	52
4	LP Dry Sep #04	SC-04-CRD	6.9	220764	149873	128943	28746	8759	1563	14.3	0.1	9.7	5.4	1	220	70

Table 4 -Fluid Analysis Data after adding (1-MN)



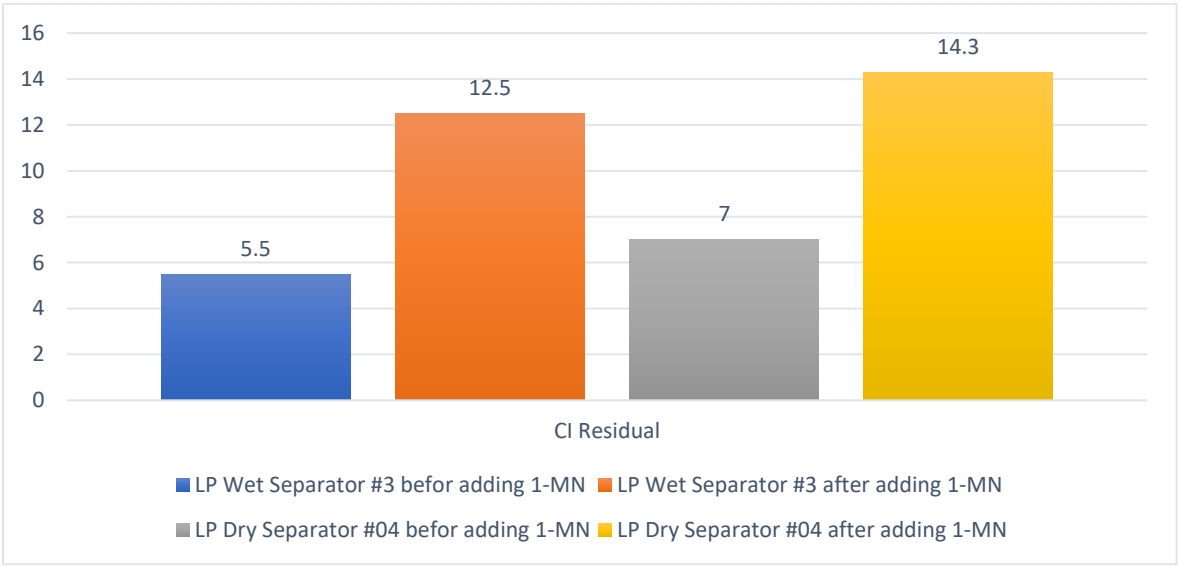
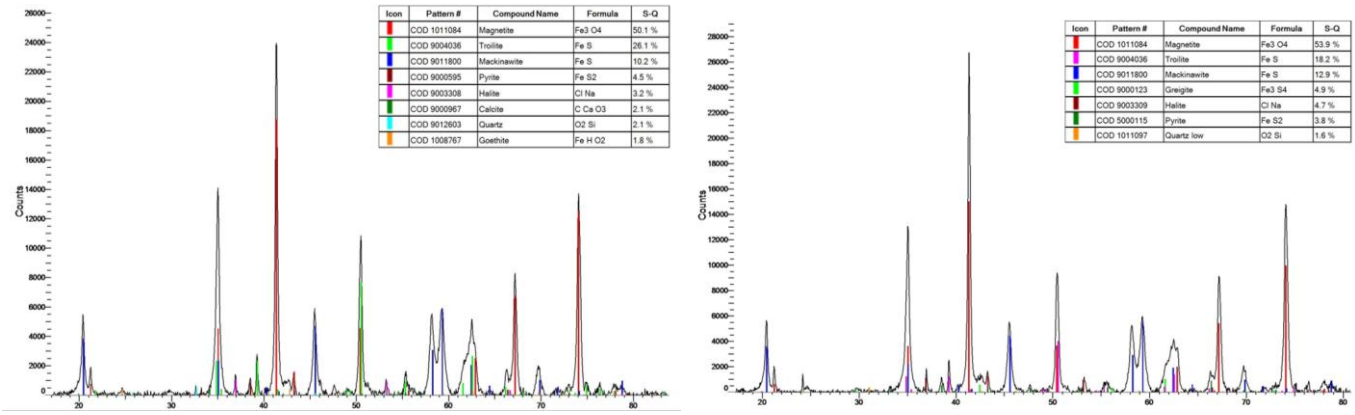


Figure 3 -Trend Chart for Corrosion Residual and Total Iron in Separators before/after adding (1-MN).



XRD result for deposit collected from separator outlet before adding (1-MN).

XRD result for deposit collected from separator outlet after adding (1-MN).

Figure 4 XRD result for deposit collected from separator outlet before/after adding (1-MN)

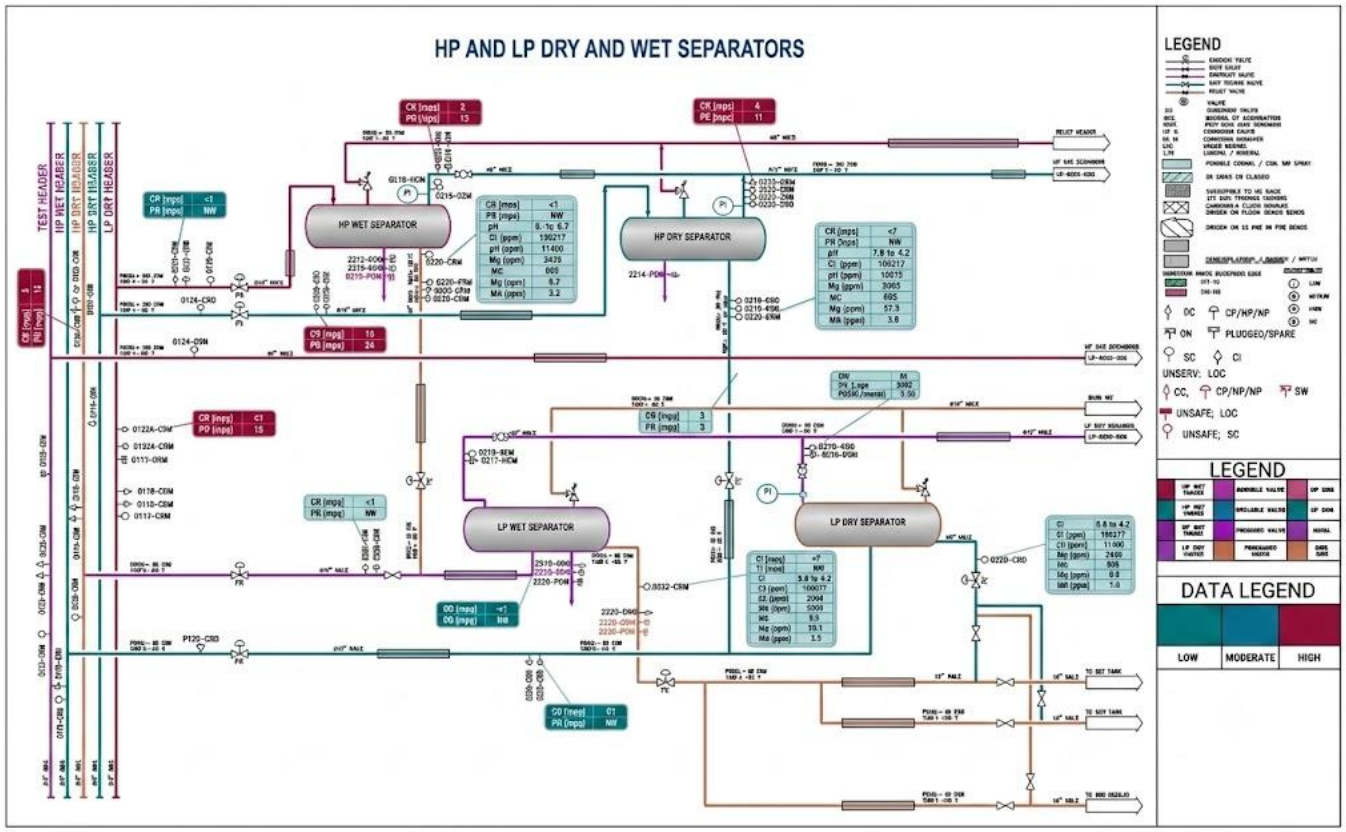


Figure 5 Schematic Process Flow Diagrams (PFD) for Facility

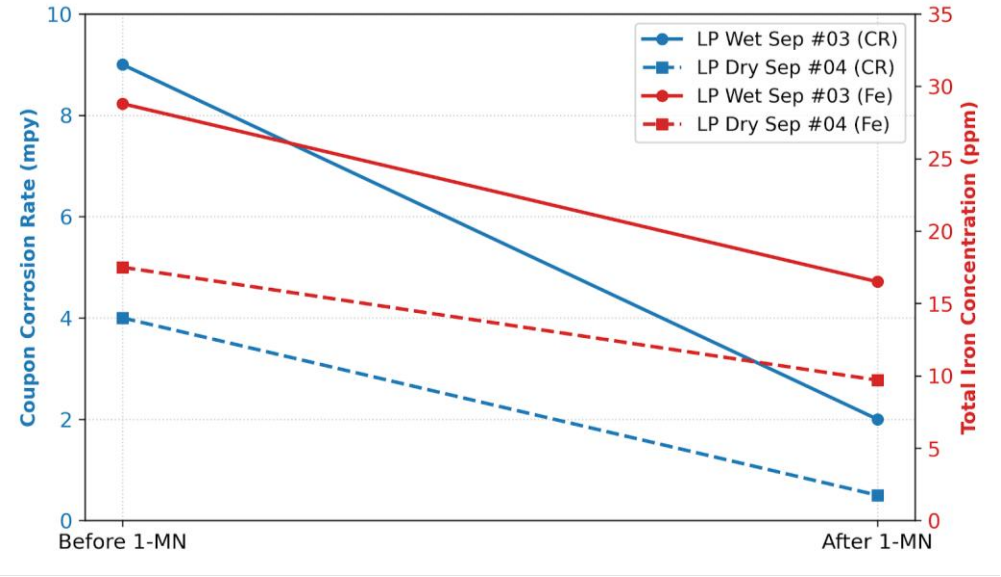


Figure 6 Correlation trend: Gravimetric test(mpy) vs Chemical analysis data (ppm).

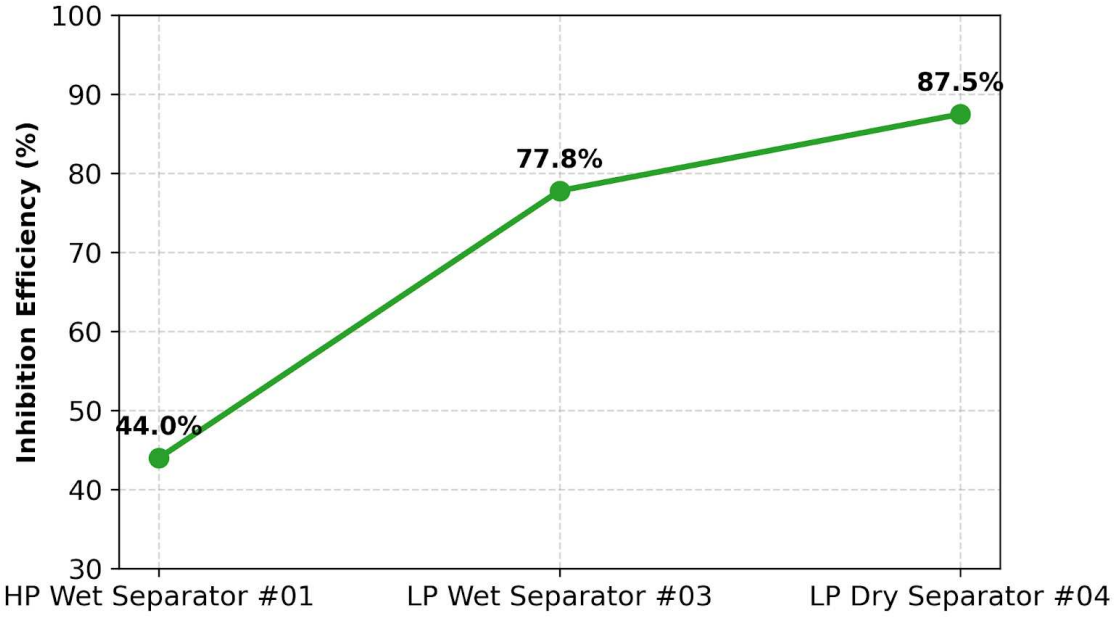


Figure 7 Quantitative assessment of inhibitor protective effect (Inhibition Efficiency % by Location).

4-Conclusions

Based on the corrosion monitoring and fluid analysis results during this trial period, the tendency for corrosion in the crude systems decreased after adding 1-methylnaphthalene (1-MN) at concentrations of 2-5%, under the same conditions of pressure, temperature, and exposure time. Improvements were also observed in the fluid analysis data, evidenced by a reduction in iron (Fe) content and an increase in Corrosion Inhibitor Residual (CI) levels following chemical treatment.

Moreover, corrosion morphology, as shown in the coupon images before and after cleaning for both wet and dry crude, indicates enhanced effectiveness of the protective layer formed on the metal surfaces.

5. Tables and figure captions

Table 1: General Corrosion and Pitting Corrosion Rates at Headers/Separators before Adding (1-MN)

Table 2: General Corrosion and Pitting Corrosion Rates at Headers/Separators after Adding (1-MN).

Table 3: Table 3 -Fluid Analysis Data before adding (1-MN). Table 4: Fluid Analysis Data after adding (1-MN).Figure 1 -Trend Chart for Corrosion Rates of Separators before/after adding (1-MN).

Figure 2: Figure 2 corrosion morphology of installed coupons in separators before and after adding 1-MN.

Figure 3: Figure 3 -Trend Chart for Corrosion Residual and Total Iron in Separators before/after adding (1-MN).

Figure 4: Figure 4 XRD result for deposit collected from wet separator outlet before adding (1-MN), showing 73% of Fe3O4.

Figure 5: Figure 5 Schematic Process Flow Diagram (PFD) for Facility.

Figure 6: Correlation trend: Gravimetric test (mpy) vs Chemical analysis data (ppm)

Figure 7 Quantitative assessment of inhibitor protective effect (Inhibition Efficiency % by Location).

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Not applicable

Author contributions

YAHIA Z ABDELNASER: Writing original draft, Data curation; Formal analysis; Visualization

Rabeea D. Abdel-Rahim: Writing, review, and editing

Adham M. Nagiub: Supervision, administration; project, data curation; formal analysis

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

Ethical approval and consent to participate were not required for this study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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6- References

[1] Assad, H., Lone, I. A., Sharma, P. K., & Kumar, A. (2025). Corrosion in the Oil and Gas Industry. Industrial Corrosion, 39–63. Portico. https://doi.org/10.1002/9781394301560.ch3

[2] Manu, K. C., Madhushree, C., Chandini, M. S., Shree, N., Hemanth, S., & Jeevan, T. P. (2025). Corrosion in Steel Structures: A Review. Journal of Mines, Metals and Fuels, 189–198. https://doi.org/10.18311/jmmf/2025/46985

[3] Aydinsoy, E. A., Aghamaliyev, Z. Z., Aghamaliyeva, D. B., & Abbasov, V. B. (2024). A systematic review of corrosion inhibitors in marine environments: insights from the last 5 years. Processes of Petrochemistry and Oil Refining, (03), 793.https://doi.org/10.62972/1726 4685.2024.3.793

[4] Quraishi, M. A., Chauhan, D. S., & Ansari, F. A. (2021). Development of environmentally benign corrosion inhibitors for organic acid environments for oil-gas industry. Journal of Molecular Liquids, 329, 115514. https://doi.org/10.1016/j.molliq.2021.115514

[5] Jero, D., Caussé, N., & Pébère, N. (2024). Film-forming amines as corrosion inhibitors: a state-of-the-art review. Npj Materials Degradation, 8(1). https://doi.org/10.1038/s41529-024-00523-0

[6] Jero, D., Caussé, N., Marsan, O., Buffeteau, T., Chaussec, F., Buvignier, A., Roy, M., & Pébère, N. (2023). Film-forming amines adsorption and corrosion kinetics on carbon steel surface in neutral solution investigated by EIS and PM-IRRAS analysis. Electrochimica Acta, 443, 141925. https://doi.org/10.1016/j.electacta.2023.141925

[7] Ali, H. A., Shaban, M. M., Abousalem, A. S., Ghaith, E. A., Fouda, A. S., & Ismail, M. A. (2023). Novel biphenylidene-thiopyrimidine derivatives as corrosion inhibitors for carbon steel in oilfield produced water. Scientific Reports, 13(1). https://doi.org/10.1038/s41598-023-43312-6

[8] Fayyad, E. M., Ipadeola, A. K., Sliem, M. H., Abdeen, D., Al-Qahtani, N., RajKumar, A., Jeffrey, J., Yalavarthy, P. K., & Abdullah, A. M. (2025). Interfacial robustness of commercial amine-based inhibitors mitigates under-deposit corrosion of carbon steel in simulated sour conditions: a merged electrochemical and machine learning study. Emergent Materials, 8(8), 7667–7693. https://doi.org/10.1007/s42247-025-01196-4

[9] Puzikova, D., Khussurova, G., Leontyeva, X. et al. Review of organic corrosion inhibitors: application with respect to the main functional group. J. Saudi Chem. Soc. 29, 20 (2025). https://doi.org/10.1007/s44442-025-00021-1

[10]LOTO, R. T. (2017). ANTI-CORROSION PERFORMANCE OF 1,3-BENZOTHIAZOLE ON 410 MARTENSITIC STAINLESS STEEL IN H₂SO₄. Surface Review and Letters, 24(07), 1750121. https://doi.org/10.1142/s0218625x17501219

[11] Efficacy of diethylamine as a corrosion inhibitor compared to other organic amines

[12] (Ed.). (2023). Diethylamine as corrosion inhibitor for zinc in hydrochloric acid solutions. International Research Journal of Modernisation in

Engineering Technology and Science. https://doi.org/10.56726/irjmets44292

[13] Ahmed, A., Elkatatny, S., & Onaizi, S. (2025). Evaluating Diethylamine and Triethylamine as Alternative Amine-Based H₂S Scavengers for Safe and Efficient Drilling in Sour Conditions. ACS Omega, 10(29), 31492–31500

[14] Ulhaq, I., Wang, Q., Alanazi, N., & Aleisa, R. (2024). Dual-Functional Corrosion and Scale Inhibitors for Oil and Gas Industry. Industrial Scale Inhibition, 399–457. Portico. https://doi.org/10.1002/9781394191208.ch20

[15] Wang, Y.-L.; Yan, Q.-B.; Guo, Z.; Guo, G.; Deng, Q.; Zhang, J.; Chen, G. Investigation of Oleate-Diethylamine-Epichlorohydrin Copolymer as a Clay Swelling Inhibitor for Shale Oil/Gas Exploration. Pet. Chem. 2018, 58 (3), 245– 249, DOI: 10.1134/S0965544118030167

[16] Vashi, R T.; Desai, Sagar A.; Desai, Piyush S. Ethylamines as Corrosion Inhibitors for Zinc in Nitric Acid (September 30, 2022). Asian Journal of Chemistry, Vol. 20, No. 6 (2008), 4553-4560. Available at SSRN: https://ssrn.com/abstract=4234356.

[17] Mohamed, H.A., Badran, B.M. and Aglan, H.A. (2001), Waterborne methylamine adduct as corrosion inhibitor for surface coatings. J. Appl. Polym. Sci., 80: 286-296.

[18] Kumar, D., K, V. M., Jain, V., & Rai, B. (2024). Accelerating corrosion inhibitor discovery through computational routes: a case of naphthalene 1-thiocarboxamide. Npj Materials Degradation, 8(1). https://doi.org/10.1038/s41529-023-00421-x

[19] Fouda, A. E.-A. S., Etaiw, S.-E. H., Ismail, M. A., Abd El-Aziz, D. M., & Eladl, M. M. (2023). Experimental and computational approaches of methoxy naphthylbithiophene derivatives and their use as corrosion protection for carbon steel in acidic medium. Scientific Reports, 13(1). https://doi.org/10.1038/s41598-023-35498-6

[20] Iravani, D., Esmaeili, N., Guo, L., & Akbarinezhad, E. (2023). Experimental and computational study of aromatic ring effects on corrosion inhibition in the H2S media. Materials Today Communications, 35, 105559. https://doi.org/10.1016/j.mtcomm.2023.105559

[21] Haruna, A., Rumah, M.M., Sani, U., & Ibrahim, A.K. (2021). Synthesis, Characterisation and corrosion Inhibition Studies on Mn (II) and Co (II) Complexes Derived from 1-{(Z)-[(2-hydroxyphenyl) imino]methyl}naphthalen-2-ol in 1M HCl Solution. International Journal of Biological, Physical and Chemical Studies, 3(1), 09–18. https://doi.org/10.32996/ijbpcs.2021.3.1.2

[22] Mariyam, M., & Oktapianti, S. (2018). Synthesis, Characterization and Antimicrobial Evaluation of Novel 1-[(1-Phenyl-1h-Tetrazol-5-yl-imino)-Methyl]-Naphthalen-2-ol and Its Cu(II), Co(II) Complexes. Oriental Journal of Chemistry, 34(3), 1541–1550. https://doi.org/10.13005/ojc/340346

[23] (2023). Preparation, Installation, Analysis, and Interpretation of Corrosion Coupons in Hydrocarbon Operations. AMPP. https://doi.org/10.5006/nace_sp0775-2023

[24] 2017). ASTM and ISO unveil plans to create global AM standards. Metal Powder Report, 72(1), 63–64. https://doi.org/10.1016/j.mprp.2016.12.028