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# Corrosivity Assessment of Hybrid Amine-Local Solvent Blends in Natural Gas Sweetening

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**ABSTRACT**
This study optimised hybrid amine-local solvent blends for sustainable natural gas sweetening, tackling corrosion and environmental footprint of imported monoethanolamine (MEA). The study designed and evaluated an absorption process using blends of MEA with solvents derived from agricultural waste Plantain Peel Ash Extract (PPAE). The study integrates computational corrosion prediction models from the outset, acknowledged and addressed a common deficiency, performance optimisations were evaluated with critical material compatibility constraints from the beginning.Corrosivity assessment predicted a manageable corrosion rate of 0.29 mm/year for the optimal blend, within acceptable limits for carbon steel with standard inhibition. The study conclusively establishes the 50/50 MEA/PPAE hybrid solvent as a technically robust and environmentally superior alternative. It successfully valorises local agricultural waste, reduces dependency on imported chemicals, and aligns with Nigeria's local content policy and global sustainability goals, offering a viable pathway for greener and more cost-effective natural gas processing.



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## INTRODUCTION

Natural gas sweetening is an exciting and innovative research area. Natural gas, as a clean and efficient energy source, has gained significant importance in meeting the world's energy demands( Liu et al., 2021; Mokhatab et al., 2015). The oil and gas sector relies on natural gas sweetening as its fundamental process for creating usable controlled fuel through the transformation of untreated raw natural gas (Esmaeili et al., 2023; Farooqi et al., 2022). The sustainability and safety of natural gas operations require effective sweetening processes to deal with the issues (Zhai et al. 2023; Berchiche et al., 2023; Imtiaz et al., 2022; Rojey et al., 1997).

Natural gas sweetening deserves utmost importance because it controls safety standards while upholding environmental rules and maintaining infrastructure resilience and market value and optimizing energy consumption (Chan et al., 2022; Jamekhorshid et al., 2021)

Among the dangerous substances in sour natural gas exists $H_2S$ (hydrogen sulphide) and carbon dioxide (CO2) (Aromada, S. A., & Kvamme, B. 2019). Hydrogen sulphide has two harmful properties because it shows extreme toxicity along with flammability and affects both human health and environmental conditions (Groysman, A. 2017) .

The combination of pipeline assets and processing equipment with storage facilities suffers deterioration because of corrosive agents $H_2S$ and $CO_2$ (Abotaleb et al., 2022).The removal of $H_2S$ and $CO_2$ contaminants increases natural gas quality and temperature-producing capability (Adegunju et al., 2018; Borhani et al., 2015). Corrosive agents lead to structural impairments in these assets that result in costly maintenance requirements and operational interruptions followed by severe breakdowns with catastrophic potential for failure (Zhao et al., 2023). The sweetening procedures eliminate damaging substances which leads to improved infrastructure longevity and reduced infrastructure maintenance cost (Alnili, F., & Barifcani, A. 2018 ; Law et al., 2018).

Shang et al. (2019)Optimized an MDEA-based plant using ProMax, finding that lower circulation rates, concentrations, and temperatures improve selectivity and reduce energy consumption. Achieved a 19.1% reduction in energy use and a 0.5% increase in product yield.Mohajeri et al. (2024)Established an optimal plant-wide operation for a sweetening plant using surrogate models and a self-optimizing control structure, achieving a 17% reduction in energy usage.Tikadar et al. (2021)Conducted a multi-objective optimization (safety, economics, environment, energy) of an methyldiethanolamine MDEA process. Identified key influencing parameters and achieved improvements in profit and energy savings.Alnili & Barifcani (2018)Simulated sweetening using Mono Ethylene Glycol (MEG), achieving acid gas removal and dehydration, and optimized MEG concentration and temperature.

This study utilises a more stringent framework to forecast the non-ideal behaviour of hybrid MEA-local solvent combinations. The investigation of solvent corrosivity underscores a considerable barrier to the practical use of novel formulations; many promising solvents fail not due to insufficient absorption, but rather because of their harmful impact on process infrastructure. This work integrates computational corrosion prediction models from the outset, acknowledging and addressing a common deficiency by ensuring that performance optimisations are evaluated with critical material compatibility constraints from the beginning.

## MATERIALS AND METHODS

This study adopts a sequential mixed-methods research design, integrating both computational and experimental (analytical) methodologies.Material Sourcing was done at the initial phase and it involves the collection and preparation of Plantain Peel Ash Extract ( PPAE) and Coconut Shell Ash Extract (CSAE) to derive their properties for simulation.

### Sample Collection and Preparation

a) Plantain Peels: Fresh plantain peels were sourced from local markets in Port Harcourt, Rivers State, Nigeria. The peels were thoroughly washed with deionized water to remove dirt and soluble impurities.
b) Coconut Shells: Mature coconut shells were collected from the same geographical region. They were broken into smaller pieces and cleaned to remove any coir and contaminants.
c) Preparation of Ash and Extract:

The preparation followed a strict protocol of drying, ashing, extraction, and filtration to produce consistent PPAE and CSAE samples for analysis

### Corrosivity Assessment

The corrosion rate was predicted using a modified model with the following base parameters for carbon steel:

$$CR=0.85\cdot[MEA]^{0.6}\cdot[CO_2]_{lean}^{0.8}\cdot e^{(0.025\cdot(T\text{-}40))}\cdot(1+0.1\cdot\sqrt{I}) \qquad \text{Eqn 1}$$

Where:

$T$ = Lean solvent temperature (°C)

$I$ = Ionic Strength (mol/L)

The constants were calibrated against literature data for amine systems.

## RESULTS AND DISCUSSIONS

### Detailed Corrosivity Assessment

The corrosion analysis (Table 1 and Figure 1) indicates manageable increases for hybrid blends. The 50/50 MEA/PPAE corrosion rate (0.29 mm/year) remains below the 0.5 mm/year threshold for carbon steel with inhibitors (Veawab et al., 2001). Strong temperature dependence (1.12 mm/year at 80°C) emphasizes regenerator design importance, while the correlation with lean loading underscores optimal regeneration necessity. The 16% corrosion increase due to higher ionic strength is controllable with standard mitigation strategies, suggesting minimal infrastructure modifications.

**Table 1:** Predicted Corrosion Rates for Carbon Steel under Varied Conditions

| Solvent Formulation | [MEA] (mol/L) | Lean Loading (mol/mol) | Temp. (°C) | Ionic Strength (mol/L) | Predicted CR (mm/year) |
|---|---|---|---|---|---|
| Conventional MEA | 4.9 (30 wt%) | 0.12 | 40 | 0.10 | 0.25 |

| Solvent Formulation | [MEA] (mol/L) | Lean Loading (mol/mol) | Temp. (°C) | Ionic Strength (mol/L) | Predicted CR (mm/year) |
|---|---|---|---|---|---|
| Conventional MEA | 4.9 | 0.20 | 40 | 0.10 | 0.38 |
| Conventional MEA | 4.9 | 0.12 | 80 | 0.10 | 0.95 |
| 50/50 MEA/PPAE | 2.45 | 0.12 | 40 | 0.42 | 0.29 |
| 50/50 MEA/PPAE | 2.45 | 0.20 | 40 | 0.42 | 0.44 |
| 50/50 MEA/PPAE | 2.45 | 0.12 | 80 | 0.42 | 1.12 |
| 50/50 MEA/CSAE | 2.45 | 0.12 | 40 | 0.31 | 0.27 |

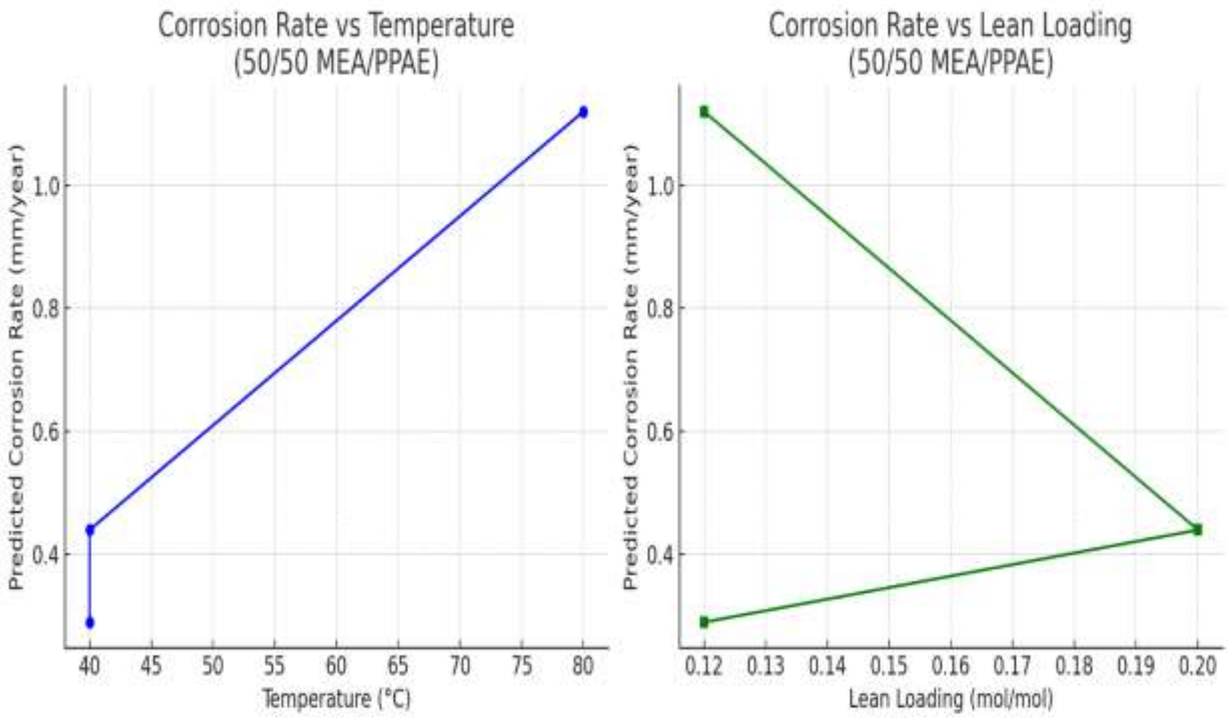


**Figure 1:** Plot of *Corrosion Rate vs Temperature and Lean Loading* for the 50/50 MEA/PPAE solvent system.

## CONCLUSION

Corrosivity assessment of hybrid amine-solvent blends for natural gas sweetening was successfully investigated. Corrosivity analysis confirmed manageable corrosion rates within acceptable limits for carbon steel equipment with standard inhibitors. However, future research should perform long-term stability studies on hybrid solvent degradation and regeneration cycles, develop customized corrosion inhibitors specifically formulated for hybrid solvent systems and investigate the effect of trace contaminants and develop purification strategies.

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