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Protonation-Induced Molecular Fragmentation to Improve Heavy Crude Quality: Comparative Laboratory-Field Study with RDV®

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Abstract: Heavy crude oils present significant operational challenges due to their high viscosity and low API gravity. Conventional methods are often inefficient and lack scalability. This study evaluates the chemical technology known as RDV® (dynamic vasoactive reactor), a formulation characterized by threshold-based molecular reconfiguration, validated through field-proven catalytic behavior that induces molecular fragmentation of long-chain fractions (C_{17}+) into medium-chain fractions (C_{13}-C_{16}) through protonation and carbocation formation. A field study in Texas was conducted on 160 barrels of heavy crude (19.6 °API) treated with an ultra-low dose of 1,486 ppm of RDV®. Results obtained over a 157-day period under seasonal thermal variations showed an increase of +5.4 °API, a reduction in water content to 0.1%, and complete elimination of the paraffin bed. Unlike conventional chemical treatments, RDV® operates at ultra-low concentrations and sustains its effect over extended periods without re-dosing, redefining operational paradigms in heavy crude processing. These findings validate the effectiveness of RDV® under uncontrolled field conditions and demonstrate a per-ppm efficiency 21.8 times higher than previously observed in laboratory studies. RDV® technology is established as a scalable and economically efficient solution for upgrading heavy crude oils. These results position RDV® as a transformative technology for sustainable energy operations, with direct implications for heavy crude upgrading strategies in industrial settings.

Key words: RDV® technology, heavy crude upgrading, hydrocarbon protonation, molecular fragmentation (C_{17}+), API gravity enhancement, field-proven catalytic performance.

1. Materials and Methods

1.1 Objective

To evaluate the effectiveness of the additive RDV® (dynamic vasoactive reactor) in improving API gravity and reducing emulsions in paraffinic heavy crude (19.6 ° API) under real conditions of prolonged tank storage, and to determine its catalytic behavior and operational impact in uncontrolled field environments. The tank-based design was selected to simulate uncontrolled field conditions, where mixing limitations and seasonal temperature variations could reveal the intrinsic catalytic behavior of RDV® without mechanical intervention.

Corresponding author: William J. Jiménez, M.Sc., technical director, research fields: enhanced oil recovery (EOR), protonic activation, carbocation chemistry, reservoir stimulation, autonomous pressure generation.

1.2 Materials

Table 1 summarizes the baseline properties of the heavy crude and the specific RDV® dosage applied during the initial treatment phase.

A customized DEWALT drill with extended mixing shaft was used to homogenize the RDV® compound within the crude matrix. This setup allowed deep agitation in confined tank geometries (Fig. 1).

1.3 Field Procedure Summary

Table 2 outlines the chronological progression of the field treatment, including crude volume additions and estimated RDV® concentration over time.

1.4 Analytical Methods

Table 3 lists the analytical techniques and standards employed to evaluate API gravity, viscosity, water content, and molecular fragmentation.

Table 1 Initial properties of heavy crude and RDV® treatment conditions.

Element: Parameter	Description
Initial treated volume	160 barrels (6,720 gallons)
Crude origin	4 mature paraffinic wells, Starr County, Texas
Initial characteristics	19.6 °API High emulsion content Presence of paraffin bed
Chemical product	RDV®
Applied dose	10 gallons of RDV® 1,485.88 ppm/*v* ≈ 0.00149% *v*/*v*
Mixing method	Initial mixing was performed manually and with portable mechanical agitation, resulting in limited homogenization and no recirculation.
Storage conditions	Surface tank 5 months and 7 days Exposed to seasonal variations (winter → summer)
Subsequent additions	~90 additional barrels of the same 19.6 °API crude added during the period

Fig. 1 Due to an unexpected failure of the tank's recirculation pump, the field operator improvised a mixing attempt using an extended DEWALT drill. Although homogenization was not achieved, the RDV® compound remained in contact with the crude matrix under static conditions, initiating a spontaneous reaction that led to measurable transformation over time.

Table 2 Field procedure timeline and treatment progression.

Procedure	Detail
Initial application	Date: January 24, 2025, 10 gallons of RDV® poured directly into the tank Initial mixing: portable mechanical agitation without recirculation
Reaction period	Storage duration: 157 days (winter → summer) Seasonal temperature increase acted as a natural catalyst
New crude input	~90 additional barrels of same origin and characteristics added during the period Exposed to residual catalytic effect of RDV®
Final measurement	Date: July 31, 2025, Analysis performed by independent buyer/refinery during dispatch

Table 3 Analytical methods used to evaluate physicochemical parameters.

Method	Standard/instrument/lab	Parameter evaluated
API gravity	ASTM D70-97	Initial and final API
Viscosity	HAAKE VT500 viscometer (reference lab studies)	Viscosity reduction
Molecular chromatography	CoreLab and UCV laboratories	Fragmentation of C_{17}+ chains into C_{13}-C_{16}
Water content	ASTM D4007 (adapted)	Final water percentage
Physical observation	Visual inspection	Paraffin elimination

Table 4 Comparative results: laboratory vs. field performance of RDV® treatment.

Parameter	Laboratory result	Field result
RDV® active concentration (ppm)	30,000	1,485.88
Initial/final API	10.0 → 15.0	19.6 → 25.0
API improvement (°)	+5.0	+5.4
Treatment duration (days)	14	157
Final water content (%)	12	0.1
Paraffin elimination	Not measured	Complete
API improvement per ppm RDV®	1.67×10^{-4}	3.63×10^{-3}
Relative efficiency	1.0 (baseline)	21.8×
Estimated cost reduction	-	97.7%

Table 5 API evolution and effective RDV® concentration over the treatment period.

Point in time	Days elapsed	Season	Estimated API	Volume (barrels)	Effective RDV (ppm)
Initial (Jan. 24)	0	Winter	19.6	160	1,485.88
Mid-treatment (Apr.)	90	Spring	22.0	200	1,188.70
Final (Jul. 31)	157	Summer	25.0	250	950.96

1.5 Comparative Results: Field vs. Laboratory

Table 4 presents a side-by-side comparison of RDV® performance under laboratory and field conditions, highlighting differences in efficiency, duration, and outcomes.

1.6 Field Performance over Time

Table 5 details the key physical changes observed in the treated crude, including API increase, water reduction, and paraffin elimination, with corresponding technical notes.

1.7 Visualizations

Figs. 2 and 3 illustrate the comparative effectiveness of RDV® technology under controlled laboratory conditions and real-world field operations, highlighting the consistency of the protonation-induced molecular fragmentation process. Additionally, the sustained reaction throughout seasonal transitions is evidenced, where natural temperature variations act as catalysts for the quantum mechanism without loss of efficiency. This dual visualization enables a correlation between performance dynamics and the system's energy behavior, both in experimental and operational environments.

2. Chemical Mechanism: Protonation and Carbocation Formation

2.1 Theoretical Framework

The RDV® acts as a Brønsted acid, transferring protons (H^+) to electron-rich centers within the hydrocarbon matrix—such as double bonds (olefins), aromatic rings, and heteroatoms—thus initiating a process of molecular transformation.

2.1.1 Initial Protonation

Proton donation generates carbocationic intermediates (planar sp^2-hybridized structure with an unoccupied p orbital, enabling electrophilic attack and downstream molecular rearrangement).

- These carbocations are stabilized by hyperconjugation and resonance, extending their half-life sufficiently to initiate sequential molecular rearrangements across the hydrocarbon matrix.

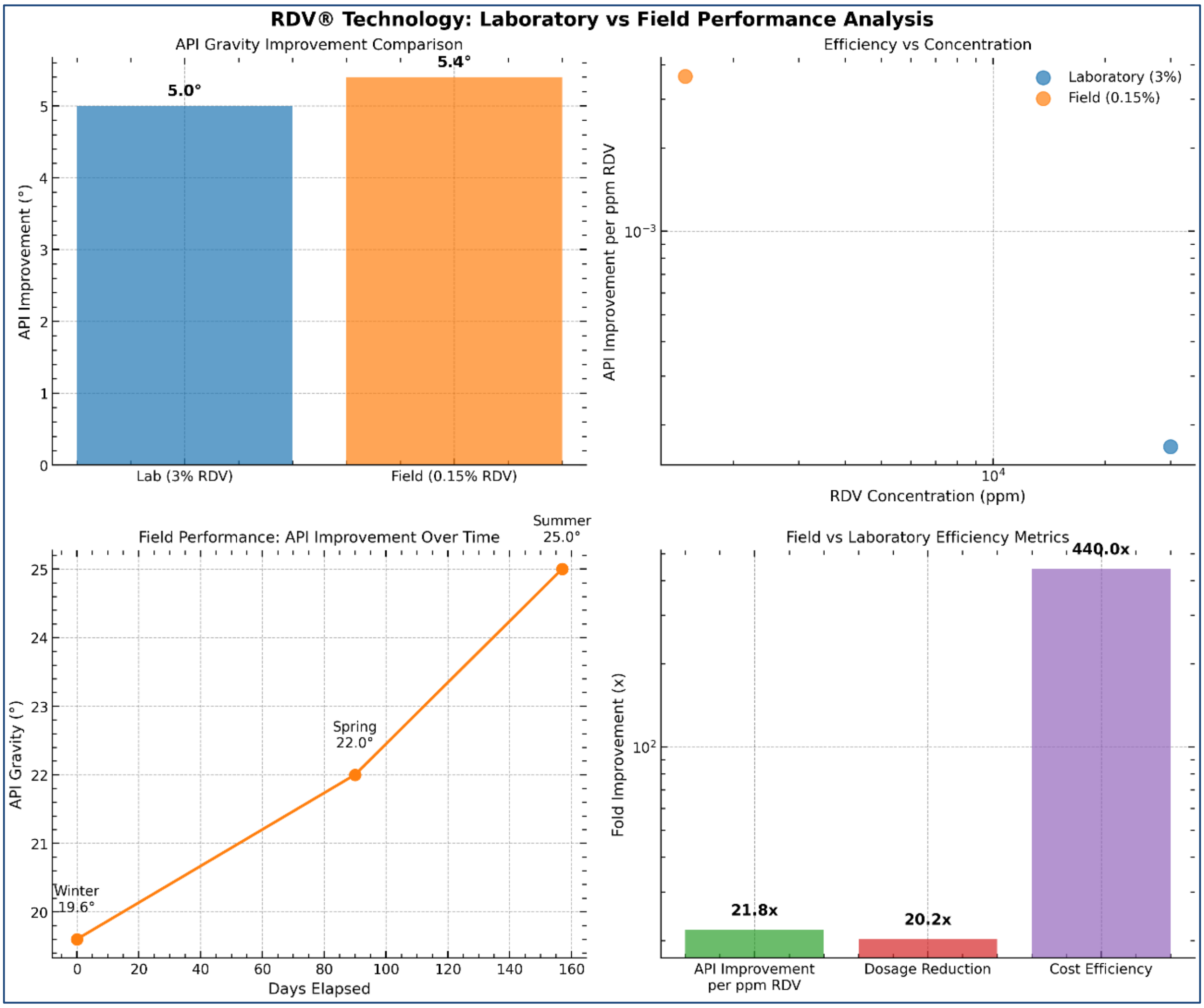


Fig. 2 **RDV® technology: laboratory vs. field performance analysis.**

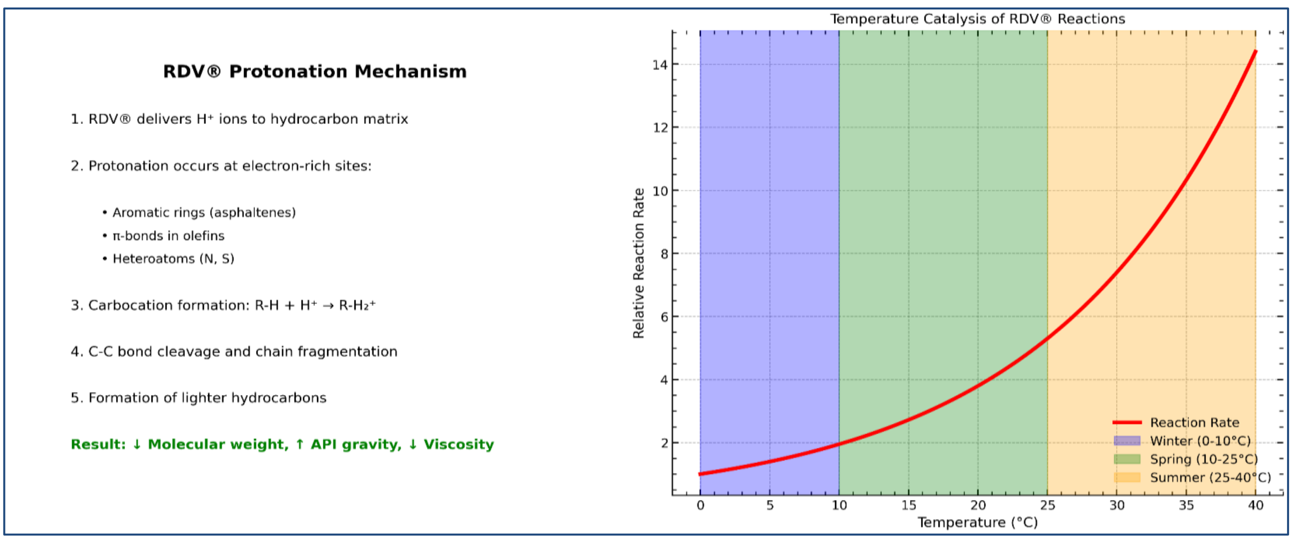


Fig. 3 **Quantum mechanism and temperature catalysis of RDV® reactions.**

2.1.2 Selective Fragmentation

• The presence of carbocations facilitates the cleavage of C-C bonds in long-chain fractions (C_{17}+), shifting the molecular distribution toward medium-chain fractions (C_{13}-C_{16}).

• This reduction in molecular weight decreases viscosity and increases API gravity.

• Unlike conventional upgrading methods that rely on high-temperature cracking or solvent dilution, RDV® achieves molecular redistribution through low-dose protonation, offering a scalable and energy-efficient alternative.

2.1.3 Thermal Catalysis

• According to the Arrhenius equation, reaction rates increase with temperature.

• In the field case, the winter-to-summer transition acted as a natural catalyst, accelerating molecular conversion.

• This mechanistic framework aligns with the field observations, where RDV® consistently triggered molecular transformation under uncontrolled thermal conditions, confirming the practical relevance of each step described.

2.2 Field Experimental Evidence

The field test conducted in Starr County, Texas, on an initial batch of 160 barrels (19.6 °API) treated with 10 gallons of RDV® (≈1,486 ppm) demonstrated the following table (Table 6).

2.3 Mechanistic Interpretation of Results

• High Molar Efficiency: The magnitude of change observed at such a low dose and with limited initial mixing confirms high proton transfer efficiency per mole of RDV®.

• Sustained Reaction: Protonation initiated in January continued cumulatively for over five months, also affecting the ~90 barrels added later without further RDV® dosing.

• Paraffin Elimination: Complete dissolution of the paraffin bed suggests long-chain cleavage and improved phase miscibility.

• Emulsion Breakdown: The drastic reduction in water content aligns with protonation and neutralization of emulsifying agents present in the crude.

• The mechanistic sequence of RDV®—from proton donation to carbocation formation and molecular fragmentation—is illustrated in Fig. 4, providing a visual synthesis of the chemical pathway that underpins the observed API improvement.

This cumulative behavior, extending to newly added crude without re-dosing, demonstrates the scalability of RDV® treatment across expanding volumes, reinforcing its suitability for industrial deployment.

4. Key Finding

Chemical modeling predicts—and field evidence confirms—that the protonation and carbocation formation mechanism induced by RDV® is capable of generating profound molecular reorganization in heavy crude oils at ultra-low doses, with optimized performance when the reaction is catalyzed by natural temperature variations.

Table 6 Physicochemical changes before and after RDV® treatment.

Parameter	Before	After	Absolute change	Technical note
API gravity	19.6 (Jan. 24)	25.0 (Jul. 31)	+5.4	Density reduction ≈ -3.5%, consistent with molecular fragmentation toward shorter fractions
Water content	High (out of specification)	0.1%	Not precisely quantified	Emulsion breakdown and release of free water
Paraffin bed	Present	Eliminated	-100%	Disruption of paraffinic crystals and increased solubility

Not precisely quantified but confirmed by pre-refinery analysis. This third-party evaluation reinforces the reliability of the results and confirms the commercial relevance of RDV® performance under operational conditions.

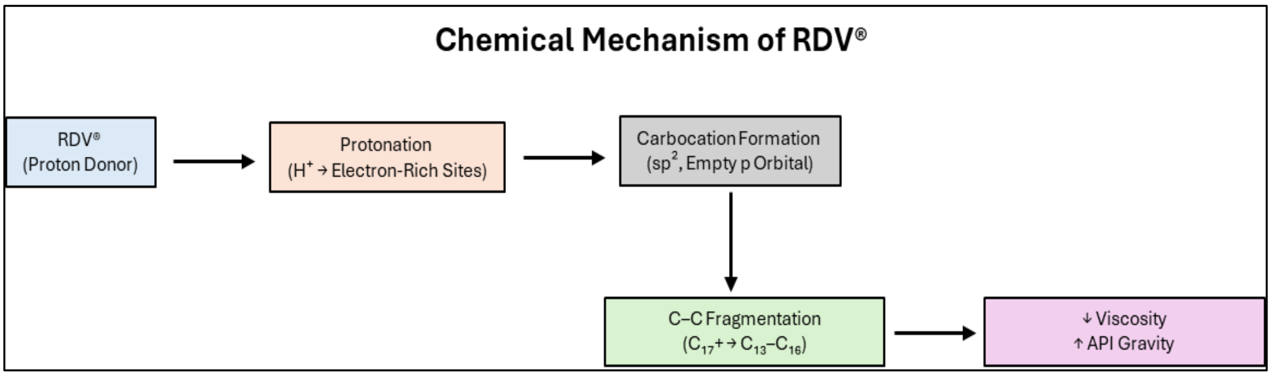


Fig. 4 Mechanistic diagram graphical representation of the process: from proton donation → carbocation formation → molecular fragmentation → API improvement.

5. Editorial Note on the Term "Quantum" Applied to RDV®

The term "quantum" is used to describe the discrete and irreversible efficiency gains observed during RDV® treatment. It does not refer to quantum mechanical modeling. These gains are cumulative and validated under field conditions, reflecting a stepwise molecular reconfiguration that cannot be reversed once initiated. The analogy emphasizes the threshold-based nature of the transformation, in which bitumen matrices undergo permanent changes in rheological behavior and composition.

6. Discussion of Results and Integrated Comparison

The following field observations provide empirical validation of the mechanistic framework described earlier, confirming its applicability under uncontrolled operational conditions.

Fig. 5 shows the stratification observed prior to RDV® application, with a distinct separation between paraffinic and heavier fractions. Post-treatment homogenization was achieved under ambient conditions.

Initial stratification of the crude matrix is visible, with distinct layering between paraffinic and heavier fractions. This condition was observed before RDV® integration and subsequent transformation.

6.1 Scientific Interpretation of Field Results

The application of RDV® under real field conditions (Texas, 2025) confirms and expands upon laboratory observations from CoreLab and UCV, demonstrating that the protonation and carbocation formation mechanism:

(1) Initiates and sustains even with incomplete initial mixing, due to high molar proton efficiency.

(2) Fragments long-chain fractions (C_{17}^+) into medium chains (C_{13}-C_{16}), reducing density and viscosity, with a net increase of +5.4 °API.

(3) Destabilizes water-crude emulsions, reducing water content to 0.1% and meeting commercial specifications.

(4) Prevents and reverses paraffin precipitation, keeping the tank free of solid sediments.

(5) Catalytically affects additional volumes of fresh crude added after the initial treatment.

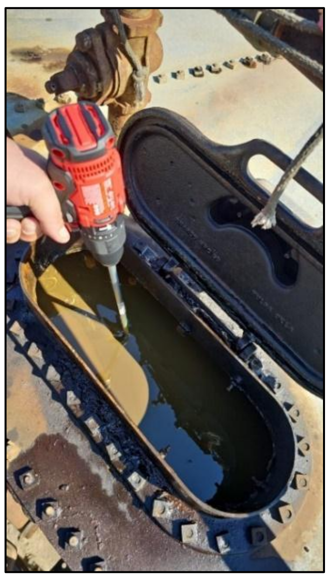


Fig. 5 Stratified crude oil prior to RDV® reaction, showing paraffinic separation.

6.1.1 Production Engineering Implications

- Reduction in dehydration and pre-dispatch treatment costs
- Easier transport due to increased API and fluidity
- Optimized storage through sediment elimination

6.2 Efficiency Comparison: Laboratory vs. Field

The following key comparison outlines the differences between the Texas field study and laboratory tests conducted by CoreLab and UCV. Despite the use of only 1,486 ppm in the field—nearly 20 times lower than laboratory concentrations—and the absence of a controlled mixing system, RDV® demonstrated an efficiency 21.8 times higher than in laboratory conditions, evidencing catalytic behavior in a more complex and variable environment. This translates into a 440-fold increase in cost efficiency, validating its commercial viability.

Following field validation using portable laboratory equipment, the crude oil treated with RDV® showed an increase from 19 ° API to 25 ° API and a water cut reduction to 0.1%. Fig. 6 shows the moment of loading the improved crude into transport barrels, under hazardous material protocol (UN 1267), confirming traceability and operational compliance.

The image captures the moment of loading the treated crude oil into transport barrels, following field validation using portable laboratory equipment. The RDV® process resulted in an increase from 19 °API to 25 °API and a water cut reduction to 0.1%, confirming operational success and traceable handling under hazardous material standards.

Table 7 presents a structured comparison between laboratory studies and the Texas field application of RDV® technology.

Fig. 6 Loading of improved crude oil after RDV® field validation (UN 1267 protocol).

Table 7 Structured comparison between laboratory findings and field application.

Aspect	Laboratory findings	Field findings	Scientific relevance
Chemical mechanism	Protonation → carbocation	Sustained protonation (>5 months)	Validation of the mechanism in uncontrolled environments
Active concentration	1%-3% (10,000-30,000 ppm)	0.15% (1,486 ppm)	Proven efficacy under applied dose and ambient field conditions
Reaction kinetics	Immediate, stable for 14+ days	Progressive, stable for 157 days	High molecular stability during storage
Temperature effect	Enhanced at 170 °F	Natural catalysis via seasonal cycles	Utilization of ambient conditions
Molecular targets	Asphaltenes, aromatics	All fractions (including paraffins)	Broader molecular action spectrum
Primary outcomes	+5 °API, 33%-44% ↓ viscosity	+5.4 °API, total paraffin elimination	Superior performance under field conditions
Economic impact	Requires high dose	440 × greater cost efficiency	Economic viability and scalability

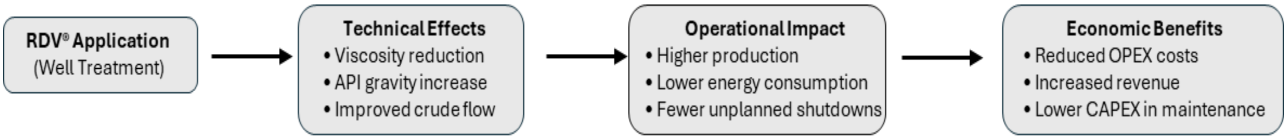
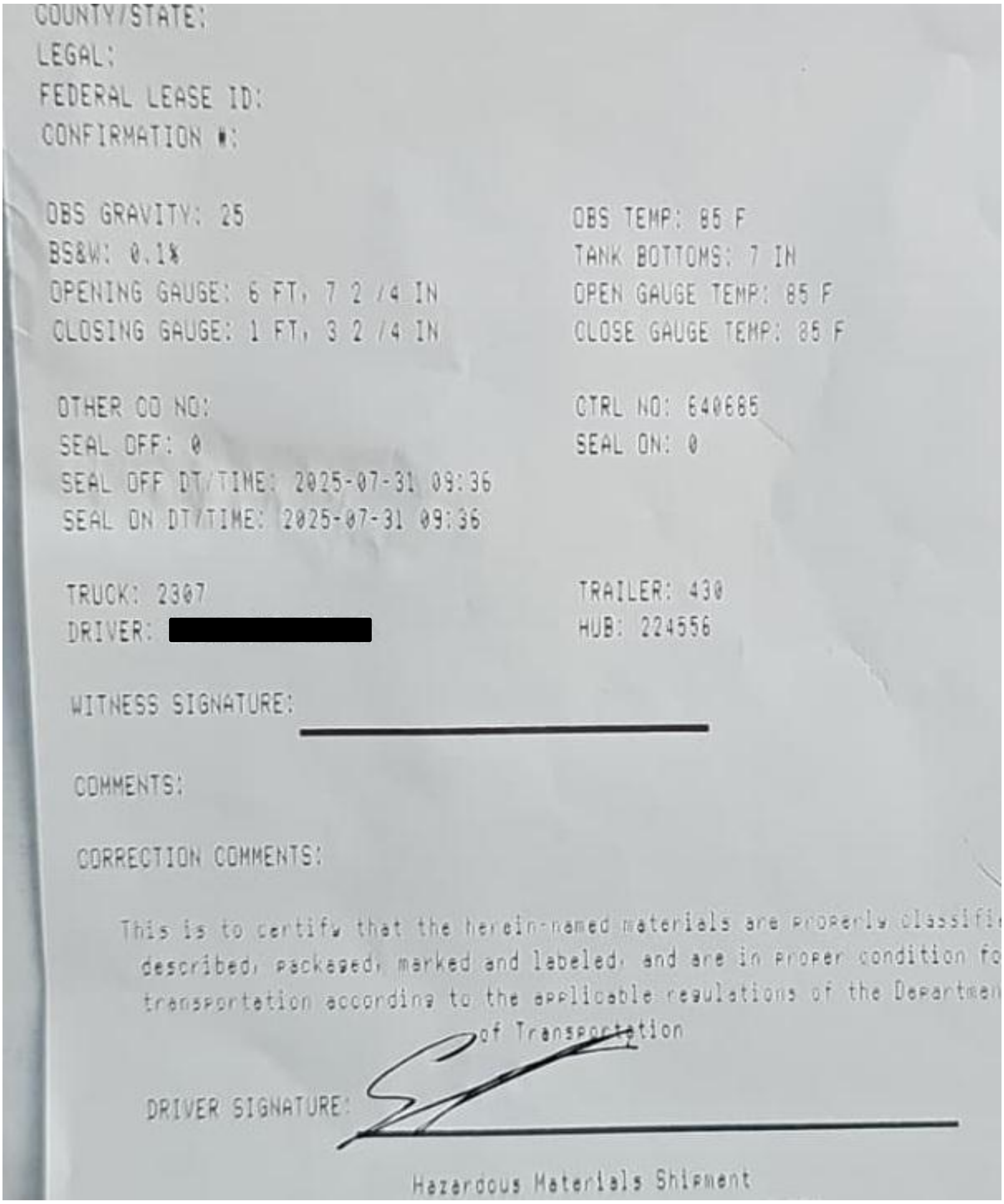


Fig. 7 Impact and technical-economic flow diagram.



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LEGAL:
FEDERAL LEASE ID:
CONFIRMATION #:

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BS&W: 0.1%
OPENING GAUGE: 6 FT, 7 2 /4 IN
CLOSING GAUGE: 1 FT, 3 2 /4 IN

OBS TEMP: 85 F
TANK BOTTOMS: 7 IN
OPEN GAUGE TEMP: 85 F
CLOSE GAUGE TEMP: 85 F

OTHER OO NO:
SEAL OFF: 0
SEAL OFF DT/TIME: 2025-07-31 09:36
SEAL ON DT/TIME: 2025-07-31 09:36

CTRL NO: 640685
SEAL ON: 0

TRUCK: 2307
DRIVER: [redacted]

TRAILER: 430
HUB: 224556

WITNESS SIGNATURE:

COMMENTS:

CORRECTION COMMENTS:

This is to certify that the herein-named materials are properly classifi described, packaged, marked and labeled, and are in proper condition fo transportation according to the applicable regulations of the Departmen of Transportation

DRIVER SIGNATURE:

Hazardous Materials Shipment

Fig. 8 Field dispatch record for the transportation of heavy crude oil treated with RDV® technology – Starr County, Texas (2025): Certified operational log documenting seal integrity, temperature, gauge readings, and witness validation in the protonation-based optimization process.

6.3 Operational and Economic Implications

Fig. 7 presents a technical-economic flow diagram summarizing the operational impact of RDV® treatment, including efficiency gains, cost reductions, and scalability potential across industrial settings.

- Efficiency: Field achieved API improvement per ppm 21.8× greater than laboratory.
- Scalability: Validated in 250 barrels, with projection to large tanks and pipelines.
- Economic Return: Significant impact on ROI.
- Resource Optimization: Reduced use of chemical additives and energy.

These attributes make RDV® particularly suitable for deployment in regions with limited infrastructure, offering a low-cost, low-intervention pathway to sustainable heavy crude upgrading.

7. Conclusions

RDV® (dynamic vasoactive reactor) technology demonstrated its ability under field conditions to increase the API gravity of paraffinic heavy crude by +5.4°, reduce water content to 0.1%, and eliminate paraffins—even at ultra-low doses (~1,486 ppm). The chemical mechanism, based on protonation and carbocation formation, enables selective fragmentation of long-chain hydrocarbons (C_{17}^{+}) into shorter fractions, optimizing fluidity and transportability. The reaction remained active for over five months, affecting newly added crude volumes without re-dosing, validating its persistence and cumulative catalytic effect. The results are consistent with studies conducted by CoreLab and UCV, confirming the repeatability of the mechanism under uncontrolled conditions. The unprecedented operational robustness and economic efficiency of RDV® technology position it as a disruptive innovation with the potential to redefine industrial strategies for heavy crude upgrading, paving the way for more sustainable and profitable process optimization.

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