

# **IT'S SCIENCE, NOT VODOO: PREVENTING ASPHALTENES AND PARAFFIN WITH PHYSICS INSTEAD OF CHEMICALS**

Courtney Richardson and Anthony Allison, OXY

Dr. Douglas Hamilton, JW Enterprises

## Abstract

Leveraging advancements in material science, a comprehensive pilot study of the effectiveness of vibrational-energy tools to inhibit asphaltene and paraffin was conducted involving over 40 wells throughout the Permian Basin, encompassing both conventional and unconventional reservoirs. This technical paper provides an in-depth analysis of the tool, which operates on the interaction of specially formulated solid materials that passively emit vibrational energy at targeted frequencies. This energy alters the physical behavior of hydrocarbon molecules, producing lasting changes in fluid properties.

Raman spectrometry provides solid, quantitative proof for how these modifications work, backing up the scientific foundation of the tool. The vibrational energy it creates interferes with the Van der Waals forces that normally cause paraffin to clump together, which helps keep hydrocarbons stable right at the source. In addition, this resonant energy not only helps prevent further aggregation but also lowers viscosity and density. It also makes it easier to separate oil and water by reducing their interfacial tension. Altogether, these effects lead to more efficient production.

For the pilot, comprehensive candidate well selection criteria were established. The chosen wells were systematically excluded from all existing chemical treatment regimens targeting paraffin and asphaltenes. This case study presents empirical evidence of the tool's performance, utilizing production metrics and operational monitoring data to demonstrate its effectiveness. The findings illustrate the tool's ability to significantly reduce chemical spend, extend operational runtime in wells historically susceptible to solids-related issues, and achieve substantial production uplift.

## Background

Asphaltenes, paraffin, and scale (APS) are common byproducts of oil and gas production. Each substance can interfere with the operation of artificial lift equipment, leading to premature failure and lost production. Paraffin buildup in the tubing increases drag on the rods and may lead to the rods becoming stuck in the tubing. Asphaltenes

can cause a plunger to get stuck in the barrel of a rod pump; they can also accumulate and plug the small flow paths in rod pump valves and ESP stages. Scale buildup can also plug ESP stages, lead to stuck plungers in rod pumps, or plug sand screens.

Each of these substances is normally managed with chemical treatments. Chemical inhibitors prevent APS molecules from aggregating together and forming deposits on downhole equipment. Dispersants are sometimes used to keep these aggregates in suspension with the wellbore fluids and produce them to surface. Preventing 100% of APS molecules from forming is generally less cost effective than a combination of preventative and remedial treatments. A variety of remedial treatments are available, depending on the specific APS substance that needs to be removed. These treatments include hot oil/water, diesel, xylene, and condensate. Though acid can be used in some circumstances to remove scale deposits, this is often detrimental to the artificial lift equipment. Such treatments are normally focused on formation damage and not treating scale deposits in the artificial lift equipment.

Maintaining an effective, cost-efficient chemical program is a challenging task. Treating with too low a concentration or frequency of treatment will not be effective in preventing the formation of APS deposits in the well. Treating with too much chemical leads to excessive costs and can sometimes be detrimental. Overtreatment with certain chemicals can occasionally cause the depositions that those chemicals intend to prevent, may lead to emulsions, or create general problems with oil and water separation at downstream production facilities. Maintaining effective chemical treatment on a per-well basis requires significant efforts in surveillance and testing. This is made more challenging with changes in a well's production, water cut, and gas-liquid ratio over time. Wells in areas undergoing enhanced oil recovery, especially areas that alternate between water and CO<sub>2</sub> injection, are especially challenging to monitor given their constantly changing conditions.

Another challenge with chemical treatment is that many wells require multiple chemicals to protect the downhole equipment. This is most often a corrosion inhibitor that is used alongside an APS inhibitor. There are a limited number of combination products that are capable of treating scale and corrosion or paraffin and corrosion, but effective treatment of both often requires the use of multiple chemicals. These chemicals are not always compatible with one another prior to mixing with wellbore fluids and may require separate tanks, pumps, and treatment lines. Wells using capillary tubing to deliver the chemical directly to the pump may require multiple strings to deliver multiple chemical products.

The logistics of delivering chemical treatments can also impact how effectively a well is treated. For continuous treatment applications, potential points of failure include the

chemical pumps, solar power systems, and plugging of the chemical lines between the tanks and the wellhead. If the tanks themselves are not effectively monitored, wells may go untreated if they are allowed to run dry. Batch treatments are sometimes interrupted due to weather or other issues impacting road conditions. All of these scenarios lead to a lack of chemical treatment and increase the likelihood of downhole equipment failure.

The cost of chemically treating asphaltenes, paraffin, and scale is approximately USD 10,000 per well per year. Failure costs related to APS substances are significant. Oxy experienced over 300 failures on rod pumps and ESPs in 2024 and 2025 (Figure 1), with an associated repair cost of almost USD 36 million each year (Figure 2).

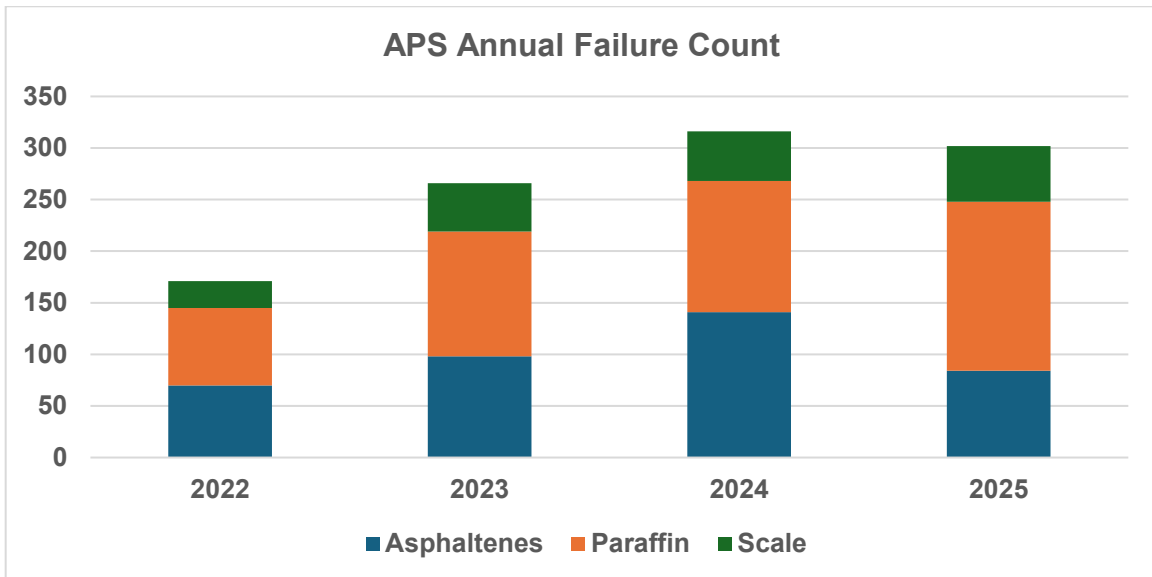


Figure 1—Number of annual failures caused by APS substances.

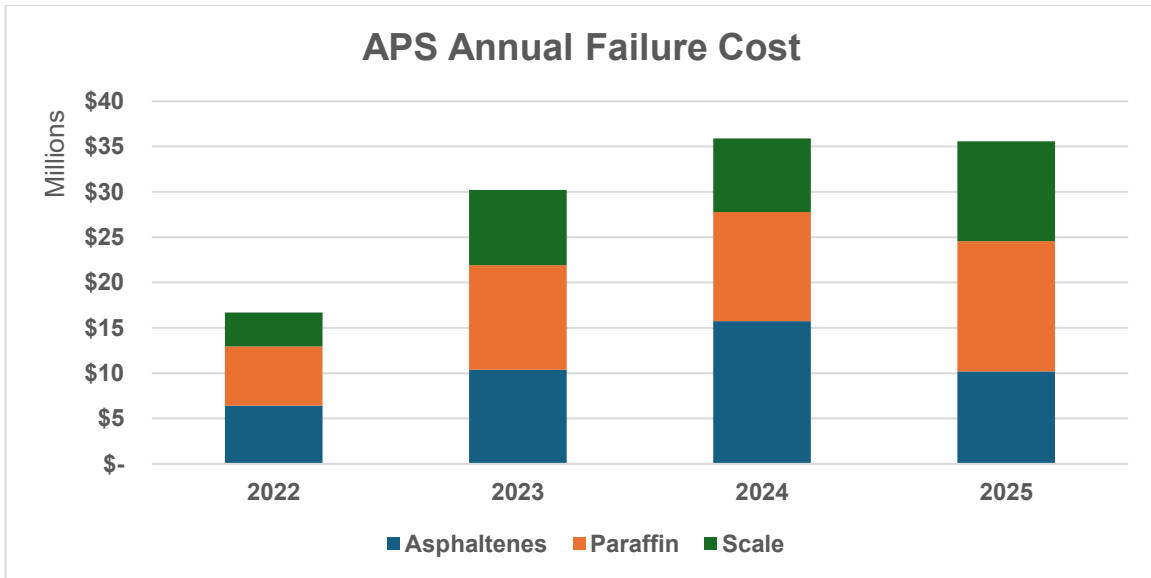


Figure 2—Annual cost of failures caused by APS substances.

Recognizing the challenges with effectively treating asphaltenes, paraffin, and scale chemically, Oxy began field trials of a tool that uses vibrational energy to inhibit APS substances at the molecular level. If successful, the trial would eliminate the cost to treat these wells for APS substances chemically (corrosion inhibitor would still be necessary) and extend the life of the artificial lift equipment, decreasing failure costs.

#### Vibrational-Energy Tool Technology

Crude oil is a colloidal solution of hydrocarbon molecules composed primarily of saturates (paraffins), aromatics, asphaltenes and resins. The hydrocarbon molecules assemble as micelles and remain in the colloidal solution when in equilibrium with each other. Changes in temperature and pressure during crude oil production, storage and transport can destabilize the micelle structures however, leading to deposition of paraffin from paraffinic crudes, asphaltene from asphaltenic crudes and sharp transitions in crude oil physical properties such as increased density, surface tension and viscosity in heavy crudes. The fundamental principle of the vibrational-energy tool is that it stabilizes the micelle structures of the crude oils as they exist in the reservoir, mitigating the detrimental depositions of paraffin and asphaltenes and increases in viscosity and density during oilfield operations, among many other benefits.

Crude oil samples from Kansas, Oklahoma, California, Colorado, Texas, Trinidad, and Argentina were tested at Colorado State University (CSU) over a multi-year, multimillion dollar research program. Parameters tested before and after treatment with the vibrational-energy technology were API gravity, viscosity, pour point temperature and

Wax Appearance Temperature (WAT). The effects of the vibrational-energy technology after treatment are shown in Table 1 and Table 2.

- Crude oil gravity increased on average 7.5°API; lighter oils (above 34°API) showed a slightly smaller increase of 4°API.
- Viscosity was reduced 94% on average due to arresting asphaltene aggregation, resolving interfacial tension related emulsions, or both.
- Oil-water interfacial tension was reduced, leading to breaking of emulsions.
- Wax appearance and pour point temperatures in paraffinic crude oils decreased.
- Calcium carbonate (CaCO<sub>3</sub>) scale was eliminated.

Crude Oil Region	Well	API <sup>o</sup> Gravity			Viscosity (cP or cSt)			
		Pre-tool	Post-tool	Uplift	Pre-tool	Post-tool	% Reduction	Temp Measured
Kansas	Daylight Coleman 3	12	18.6	6.6				
Easton Field, KS	Eberhart 1	13.9	24	10.1				
Oklahoma	Ardmore	14	22	8				
Hardtner, KS	Lotus Terwort 3	15	23	8	42,000	380	99%	20°C
LA Basin, CA	Stewart 26	17	19	2	14,500	411	97%	87°F
LA Basin, CA	Confidential	20	34	14				
Oklahoma	Mach Resources	22	28	6				
Fyzabad, Trinidad	CO-229	22.54	28.79	6.25	439	23	95%	15°C
SW Colorado	Confidential	25.6	39.4	13.8	298.7	6.3	98%	
Permian Basin, TX	Sparks TE-9	27	34	7	18,500	10	99.9%	
Oklahoma	Ardmore	28	35	7				
Anaco Field, Venezuela	JMN 169	34	38.1	4.1				
Permian Basin, TX	Confidential	40.4	45	4.6				
PC Field, Argentina	PC 2081				7,730	1,807	77%	30°C
Averages				7.5			94%	

Table 1— Results of CSU laboratory testing of crude oil API gravity and viscosity before and after treatment with the vibrational-energy technology.

Crude Oil Region	Well	API <sup>o</sup> Gravity			Pour Point (°C or °F)			Wax Appearance Temp (°C or °F)		
		Pre-tool	Post-tool	Uplift	Pre-tool	Post-tool	Reduction	Pre-tool	Post-tool	Reduction
Kansas	Daylight Coleman 3	12	18.6	6.6						
Easton Field, KS	Eberhart 1	13.9	24	10.1						
Oklahoma	Ardmore	14	22	8						
Hardtner, KS	Lotus Terwort 3	15	23	8	18	-21	39			
LA Basin, CA	Stewart 26	17	19	2	-1	-26	25	45	20	25
LA Basin, CA	Confidential	20	34	14	-1	-20	19	24	23	1
Oklahoma	Mach Resources	22	28	6						
Fyzabad, Trinidad	CO-229	22.54	28.79	6.25	13	-40	53			
SW Colorado	Confidential	25.6	39.4	13.8	13.4	-3.2	16.6	53.1	12.2	40.9
Permian Basin, TX	Sparks TE-9	27	34	7	-18	-24	6	71.7	19.6	52.1
Oklahoma	Ardmore	28	35	7						
Anaco Field, Venezuela	JMN 169	34	38.1	4.1	42.8	35.5	7.3			
Permian Basin, TX	Confidential	40.4	45	4.6						
PC Field, Argentina	PC 2081									
Browning Field, Saskatchewan	15-9-6-5 W2M				6	-12	18			
Averages				7.5			23.0			29.8

Table 2— Results of CSU laboratory testing showing the effects of the vibrational-energy technology on crude oil API gravity, pour point, and wax appearance temperature.

### Vibrational-Energy Tool Fundamentals

The efficacy of the vibrational-energy technology in stabilizing hydrocarbon micelle structures is a function of the unique lattice vibrations of the alumina-silica alloy matrix coupled with and reinforced by the proprietary charging process. The vibrational-energy technology capitalizes on the fundamentals of material science wherein all solid-state materials (metals) transmit energy through lattice vibrations, and normal mode oscillations depend on the material composition. These concepts can be visualized by the following illustrations. Figure 3 shows one-dimensional lattice dynamics where the black dots represent electrons that move back and forth until repelled by a neighboring electron. The electron movement is instantaneous and constant within the rigid structure of the metal framework and occurs in three dimensions. Figure 4 endeavors to illustrate the lattice vibrations in three dimensions.

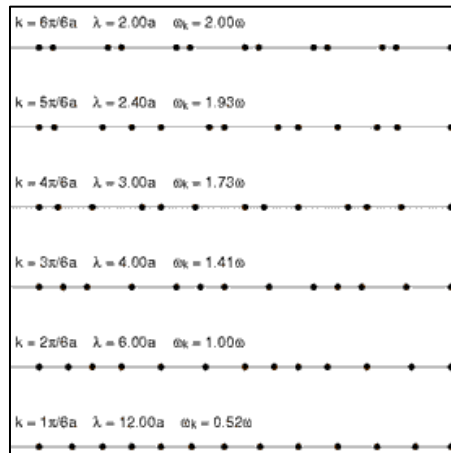


Figure 3—One-dimensional lattice dynamics.

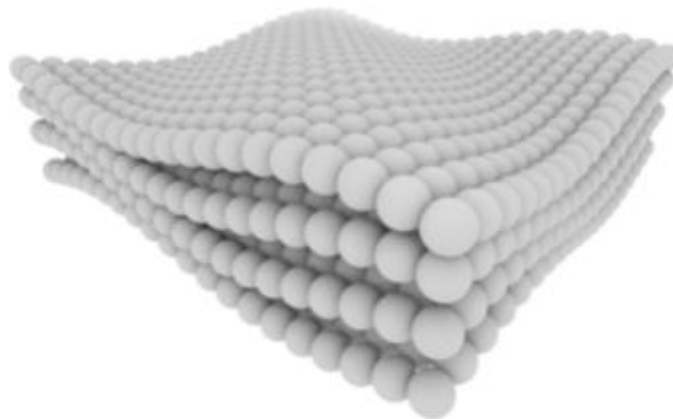


Figure 4—Lattice dynamics in three dimensions.

Hydrocarbon micelles also vibrate at very low frequencies that interact with the lattice vibrations of the vibrational-energy tool material. Models of paraffin and asphaltene-like molecules are shown in Figure 5 and Figure 6.

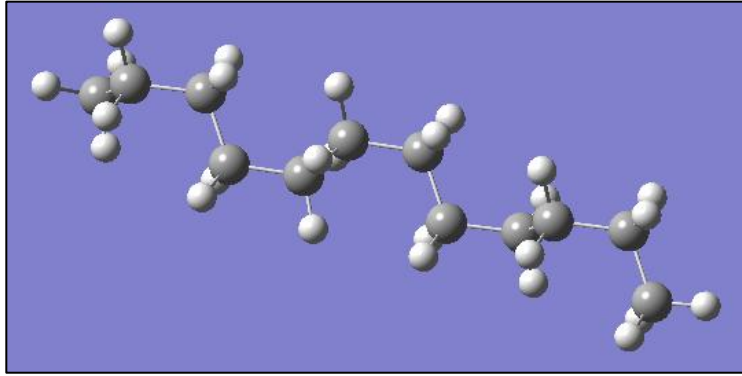


Figure 5— Model of a paraffin molecule.

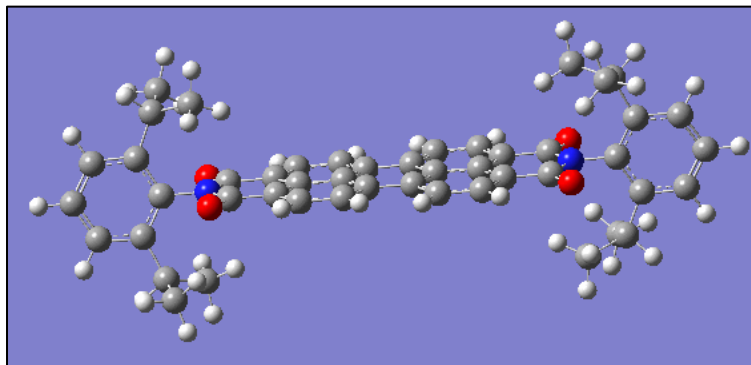


Figure 6— Complex asphaltene-like molecule.

The cast alumina alloy and silica matrix of the vibrational-energy technology, coupled with the proprietary charging process, is specifically designed to emit lattice vibrations that are in resonance with the hydrocarbon molecules to promote micelle stability.

#### Arresting Asphaltene and Paraffin Aggregation

Asphaltene micelles grow by clumping together or aggregating. Figure 7 illustrates the stepwise aggregation of asphaltene micelles from a single asphaltene molecule to an asphaltene micelle 3–4 nm in size and then an asphaltene aggregate 12–15 nm in size. The asphaltene aggregation causes sharp transitions in the crude's physical properties, especially increased density and viscosity.

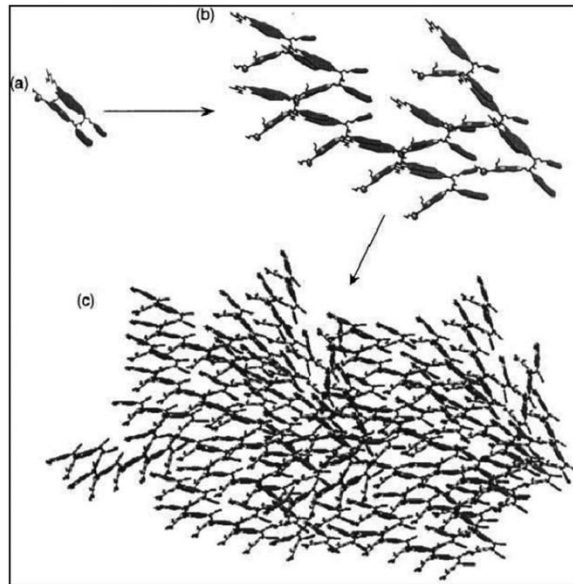


Figure 7— A model of asphaltene aggregation: (a) an asphaltene molecule, (b) an asphaltene micelle with size ca. 3-4 nm and (c) an asphaltene aggregate with size ca. 12-15 nm (from Lesueur, D., 2008).

The same process is pertinent to paraffins. As paraffin-rich crudes cool during upward flow to the wellhead, Van der Waals dispersion forces increase, and long-chain alkanes can clump together to form agglomerations that behave as longer chain alkanes (i.e., two C20 molecules can clump to behave like one C40; Figure 8) thus increasing density, raising wax appearance and pour point temperatures, and potentially depositing paraffin in production tubulars, pumps and flowlines.

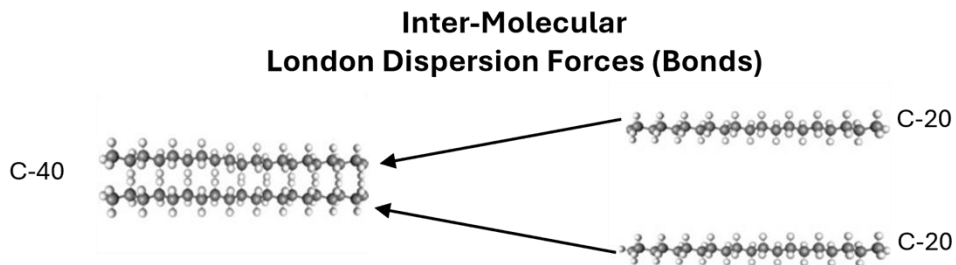


Figure 8— Clumping of long-chain alkanes.

The lattice vibrational energy of the vibrational-energy technology overcomes the Van der Waals dispersion forces, stabilizing the micelles and mitigating the agglomeration, thus reducing density and viscosity.

## Crude Oil Density Reduction (or API Gravity Uplift)

Gas chromatography–mass spectrometry (GC–MS) investigations of a paraffinic Permian Basin crude demonstrates that the vibrational-energy technology can reduce crude oil density or conversely uplift API gravity. The carbon number by weight % of the untreated crude prior to exposure to the vibrational-energy technology is illustrated by the black bars in Figure 9. There is an obvious peak in weight % of hydrocarbons with carbon number from C38 to C50. The post-treatment crude is illustrated by the green bars. It is evident that the peak in hydrocarbons with carbon number from C38 to C50 has disappeared, and that there is a substantial increase in shorter chain hydrocarbons with carbon numbers ranging from C6 to C18. Moreover, there is significant reduction in hydrocarbons with carbon numbers from C52 through C60. The large shift from heavier to lighter hydrocarbons (i.e., substantial reduction in weight % of hydrocarbons with high carbon number) following treatment of the crude with the vibrational-energy technology shows that aggregation or clumping of long chain alkanes is a characteristic of the paraffinic Permian Basin crude. Treatment with the vibrational-energy technology resolved the aggregation problem, enhancing crude oil quality and increasing API gravity.

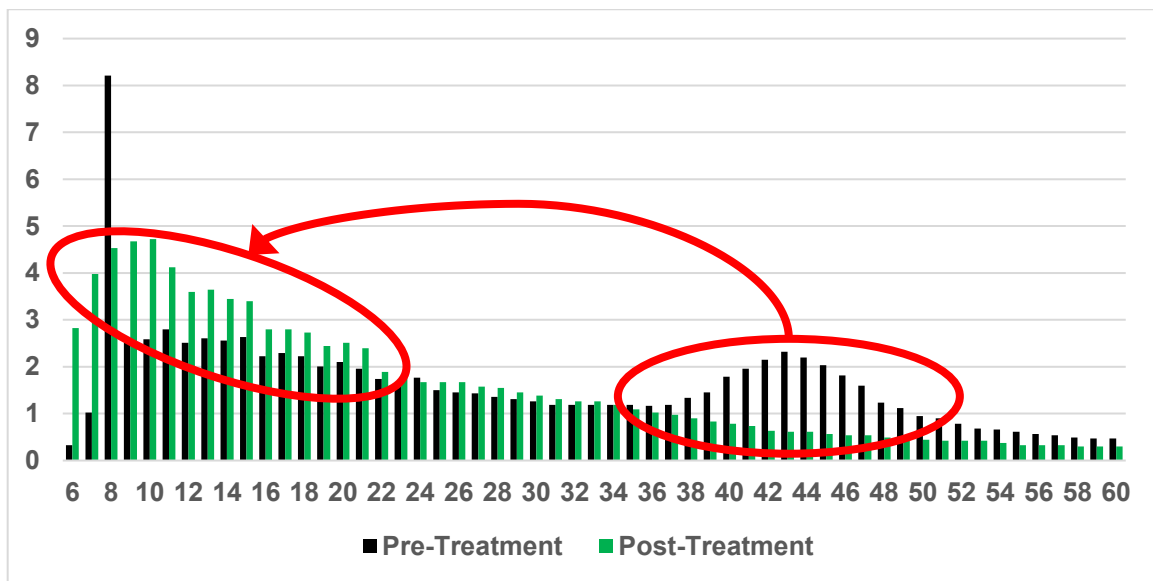


Figure 9—GC-MS analysis of pre-and post-vibrational-energy technology treated paraffinic crude from the Permian Basin.

The effect of carbon number on crude oil density and API gravity is illustrated in Figure 10. For example, if a crude oil is composed entirely of n-alkanes with carbon number 40, the density is 0.817 g/ml and API gravity is 41.7. In contrast, if the crude is composed entirely of n-alkanes with carbon number 12, the density is 0.75 g/ml and API gravity is 57.2.

Class of hydrocarbon	IUPAC name	Common name	#C	#H	Molweight g/mol	Melting point °C	Boiling point °C	Density@20°C g/ml	Flash point °C	Autoignition temp °C
N-alkane	Methane		1	4	16.04	-183	-162	-	-135	595
N-alkane	Ethane		2	6	30.07	-183	-89	-	-135	515
N-alkane	Propane		3	8	44.09	-188	-42	0.498	-104	470
N-alkane	N-butane	Butane	4	10	58.12	-138	-1	0.577	-60	365
N-alkane	N-pentane	Pentane	5	12	72.15	-130	36	0.630	-49	260
N-alkane	N-hexane	Hexane	6	14	86.17	-95	69	0.664	<-20	230
N-alkane	N-heptane	Heptane	7	16	100.20	-91	98	0.683	-7	220
N-alkane	N-octane	Octane	8	18	114.22	-57	126	0.702	12	205
N-alkane	N-nonane	Nonane	9	20	128.25	-53	151	0.719	31	205
N-alkane	N-decane	Decane	10	22	142.28	-30	174	0.730	46	200
N-alkane	N-undecane		11	24	156.30	-26	196	0.740	61	195
N-alkane	N-dodecane		12	26	170.33	-10	216	0.750	80	200
N-alkane	N-tridecane		13	28	184.35	-5	235	0.756		
N-alkane	N-tetradecane		14	30	198.38	6	254	0.760		
N-alkane	N-pentadecane		15	32	212.41	15	270	0.769		
N-alkane	N-hexadecane		16	34	226.43	18	287	0.773		
N-alkane	N-heptadecane		17	36	240.46	22	303	0.778		
N-alkane	N-octadecane		18	38	254.48	28	316	0.777 <sup>28</sup>		
N-alkane	N-nonadecane		19	40	268.51	32	330	0.785		
N-alkane	N-eicosane		20	42	282.54	37	344	0.789	187	
N-alkane	N-heneicosane		21	44	296.56	40	359	0.792		
N-alkane	N-docosane		22	46	310.59	44	369	0.794	211	
N-alkane	N-tricosane		23	48	324.61	47	381	0.779 <sup>48</sup>		
N-alkane	N-tetracosane		24	50	338.64	50	391	0.799		
N-alkane	N-pentacosane		25	52	352.67	53	402	0.801		
N-alkane	N-hexacosane		26	54	366.69	56	415	0.778 <sup>60</sup>		
N-alkane	N-heptacosane		27	56	380.72	59	422	0.780 <sup>60</sup>	269	
N-alkane	N-octacosane		28	58	394.74	61	435	0.806		
N-alkane	N-nonacosane		29	60	408.77	64	443	0.808		
N-alkane	N-triacontane		30	62	422.80	66	451	0.810		
N-alkane	N-hentriacontane	Untriacontane	31	64	436.82	68	458	0.781 <sup>68</sup>		
N-alkane	N-dotriacontane		32	66	450.85	70	470	0.812		
N-alkane	N-tritriacontane		33	68	464.87	71				
N-alkane	N-pentatriacontane		35	72	492.93	74	489	0.816		
N-alkane	N-tetracontane		40	82	563.06	81	522	0.817 <sup>25</sup>		

Figure 10— Relationship between crude oil carbon number, density, and API gravity.

The manufacturer of the vibrational-energy tool has not yet undertaken GC-MS investigations on heavy crudes, but they have carried out rheological analyses that render fluid property data comparable to GC-MS analysis. This analysis revealed the occurrence of agglomeration processes responsible for density and viscosity increases. Heavy crude oil from the Lotus Terwort 3 well in the Hardtner Field, Kansas was sampled before and after installation of the vibrational-energy technology. Viscosity versus shear rate, API gravity, and percentage of asphaltenes were measured both before and after treatment (Figure 11 and Table 3).

Crude oil gravity before installation of the vibrational-energy tool was 15°API and the viscosity was 42,000 cP. After installation, crude oil gravity uplifted to 23°API and viscosity dropped to 380 cP. The testing also showed a significant decrease in crude oil viscosity with increasing shear rate prior to treatment with the vibrational-energy

technology (black line in Figure 11). This is indicative of non-Newtonian fluid flow caused by very high crude oil surface tension emblematic of heavy oil molecules sticking together or agglomerating. After vibrational-energy treatment, crude oil viscosity (green line in Figure 11) drops to 380 cP and remains constant regardless of shear rate. The crude is now behaving as a Newtonian fluid (like water) because the heavy oil molecules are not sticking together, and agglomeration did not occur.

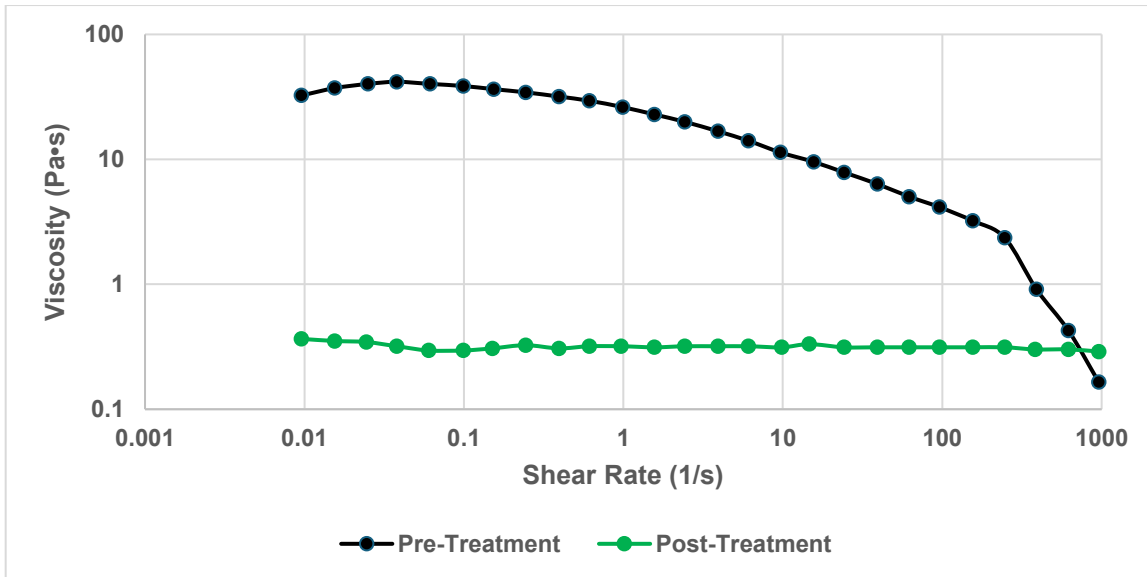


Figure 11—Viscosity versus shear rate for the heavy crude oil in Lotus Terwort 3 well, Hardtner, Kansas.

	Oil Gravity (°API)	Pour Point (°C)	Paraffins (%)	Asphaltenes (%)	Filterable Solids (%)
Pre-treatment	15	18	0.02	0.38	0.3
Post-treatment	23	-21	0.17	6.71	2.56
Change	+8	-39	+0.15	+6.33	+2.26

Table 3—Changes in oil properties of Lotus Terwort 3 well post-treatment.

### Interfacial Tension

Lattice vibrations of the vibrational-energy technology also resonate with hydrogen-oxygen bonds that govern surface tension of both water and oil molecules, substantially reducing surface tension between the water and oil molecular interfaces and thus, resolving water-in-oil and oil-in-water emulsions (Figure 12). A significant, potential benefit of reducing heavy oil viscosity is reducing hydrocarbon carryover in separation of produced water. Figure 13 shows that viscosity of a mid-range crude (22.3°API) can

vary from 173 cP to 1,200 cP depending on water content in the dispersed phase (i.e., emulsion).

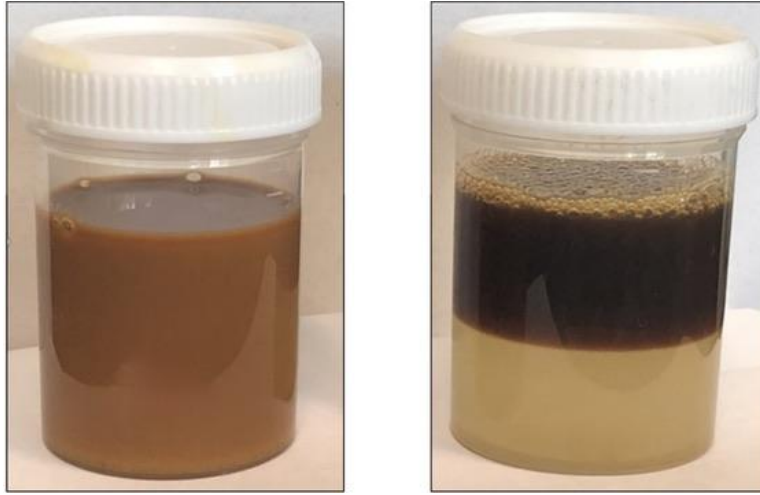


Figure 12—Before (left) and after (right) treatment with the vibrational-energy technology.

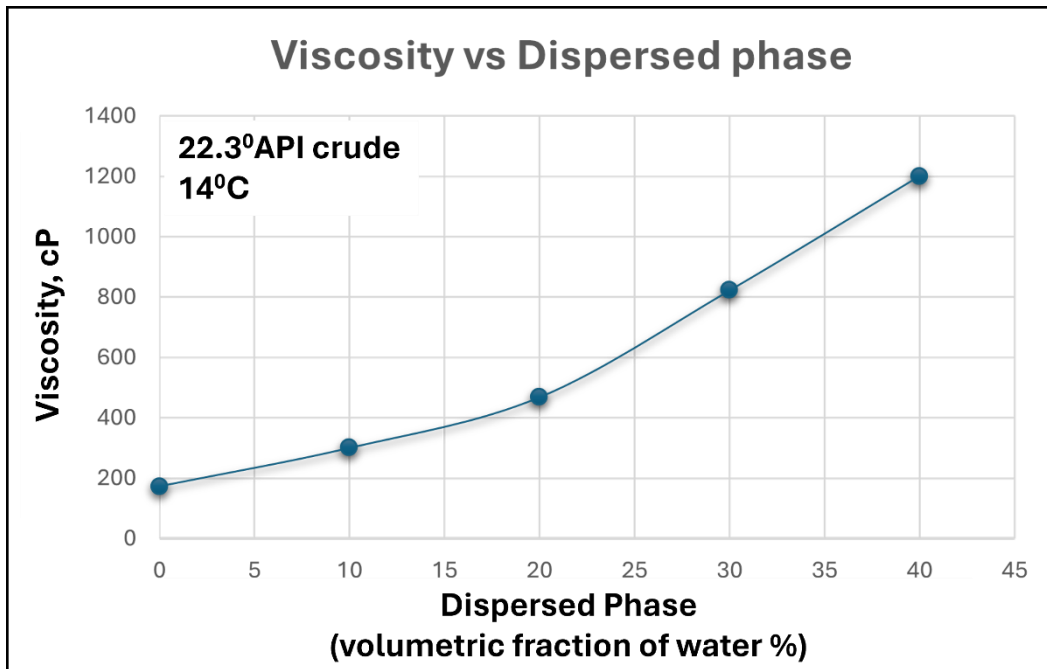


Figure 13— The impact of emulsions on crude oil viscosity (Data from Farah and others, 2005)

The principal causes of increased viscosity in heavy oils are agglomeration of micelles, water-in-oil emulsions, or a combination of the two. Viscosity in paraffinic crudes increases when the temperature drops below the wax appearance temperature (and the

pour point when the oil becomes solid). Lattice vibrations of the vibrational-energy technology address both causes, and laboratory investigations with Colorado State University mentioned above have demonstrated the technology's success at reducing heavy crude oil viscosity, lowering pour point and wax appearance temperatures, and increasing crude oil API gravity (Table 1 and Table 2).

### Field Trial Results

Oxy developed a thorough New Technology Implementation Protocol (NTIP) that clearly outlined how wells were chosen for vibrational-energy tool installation. The protocol also defined what success would look like ahead of time, making it easier to accurately assess the results once the tests ended.

The well selection criteria included:

- Wells exhibiting subsurface challenges related to paraffin, asphaltene, or scale deposition on rods, production tubulars, and pumping equipment.
- Wells with high annual expenditures on asphaltene and paraffin chemical treatments.
- Wells with a history of requiring reactive interventions for paraffin during workover operations, resulting in increased repair costs due to rig time and chemical usage.
- Wells maintaining a minimum water cut of 20%, as stipulated by the vendor's specifications.

Additionally, wells selected as candidates were required to comply with the following requirements outlined in the protocol:

- Immediate removal from all chemical treatment programs, with the exception of corrosion inhibition applications.
- Proper sizing based on the oil production threshold specified by the vendor (one tool per 35 BOPD produced).
- Ongoing tracking and performance monitoring through Oxy's NTIP tracking process to ensure comprehensive evaluation of results.

Oxy implemented the vibrational-energy tools across a total of 42 wells. Of these, 38 wells continue to accumulate operational days since their installation, and 16 of the 38 currently active wells have exceeded their previous runtime benchmarks. Figure 14 below illustrates the runtime performance for the 38 wells still in operation, with green bars indicating wells that have surpassed their prior runtime records.

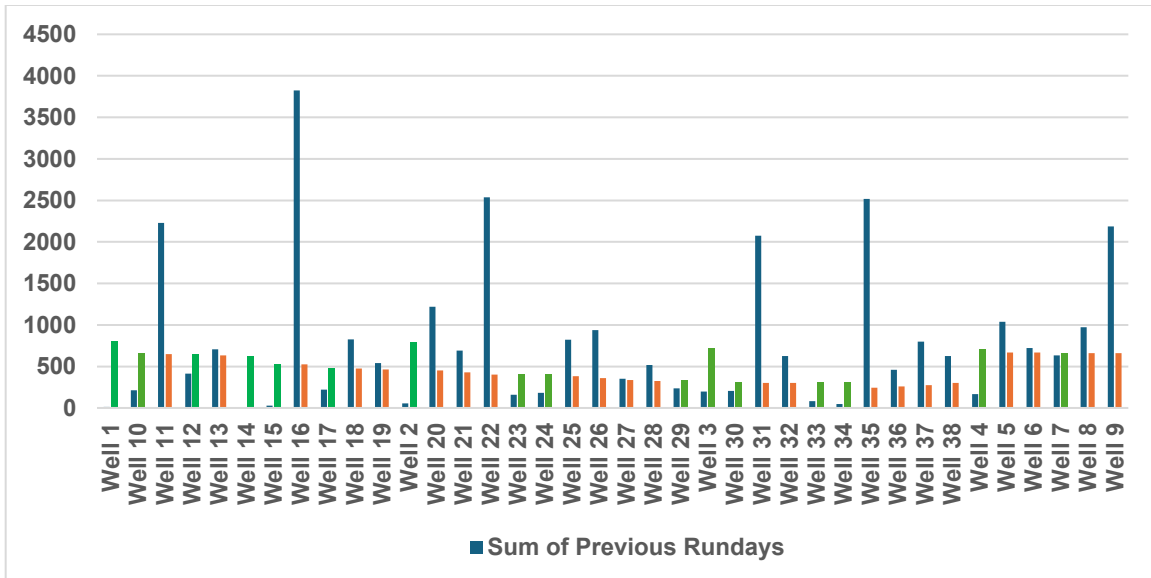


Figure 14— Operating runtime comparison for wells equipped with vibrational-energy tools.

Oxy encountered four failures in wells equipped with the vibrational-energy tools. The root causes of these failures were found to be varied and well-specific.

- In Well 39, the failure was attributed to improper placement of the vibrational-energy tool, as it was installed below a perforated sub in the bottom hole assembly (BHA) rather than above it. This configuration allowed fluid to bypass the tool rather than flow through it as intended. After the well was pulled and the vibrational-energy tool was repositioned correctly, the well has continued to accumulate runtime, surpassing its previous record by a factor of four.
- Well 40 experienced a failure due to downtime from gas curtailment, during which a corrosion hole developed in the tubing string. Upon surfacing equipment, minimal paraffin was observed on both the OD and ID of the equipment. During this runtime period the well achieved a runtime of 225 days, double its historical runtime performance. Upon the failure intervention, the vibrational-energy tool was removed and the well reverted to traditional chemical treatment methods. Since the return to traditional chemical methods, the well has had two additional failures, with runtimes of 139 and 5 days, respectively.
- Well 41 was not classified as a failure; rather it was proactively pulled for deepening and converted from sucker rod pump (SRP) to electric submersible pump (ESP) at 225 days of runtime. Significant asphaltene and paraffin deposits were encountered during the pull. The decision was made not to reinstall the vibrational-energy tool, and the well was returned to traditional chemical

treatment methods. Since this intervention, the well has failed again, with a runtime of 16 days.

- In Well 42, failure was attributed to solids accumulation in the pump. The well operated for 244 days, an improvement over its previous 145-day run. Upon retrieval, heavy asphaltene buildup was observed on the pump and the lower section of the BHA. Notably, a downtime event occurred 10 days prior to failure, after which the well was returned to production and operated for an additional 10 days before the failure. There were no indications of sticking, friction, solids, or gas interference during this post downtime 10-day period. The well is characterized by a high gas-liquid ratio (GLR), producing approximately 1.5 million cubic feet of gas, which may have influenced performance in conjunction with the downtime. It is theorized that solids accumulated in the backside fluid column several hundred feet above the vibrational-energy tool during the downtime and were subsequently drawn into the pump when production resumed, ultimately leading to the failure.

One notable observation from the trials was the consistent trend of increased oil production (uplift) in a significant portion of the evaluated wells. Of the 38 wells currently in operation, 24 demonstrated measurable uplift. In several cases, the increase was substantial enough to exceed the threshold of 35 BOPD per tool, indicating that an additional vibrational-energy tool would be required should the production be maintained. Figure 15 below illustrates these uplift trends, with wells exhibiting uplift highlighted in green. The red line represents the 35-barrel threshold per tool; wells where the post-installation oil production bar surpasses this line would necessitate the deployment of an additional tool to maintain optimal performance.

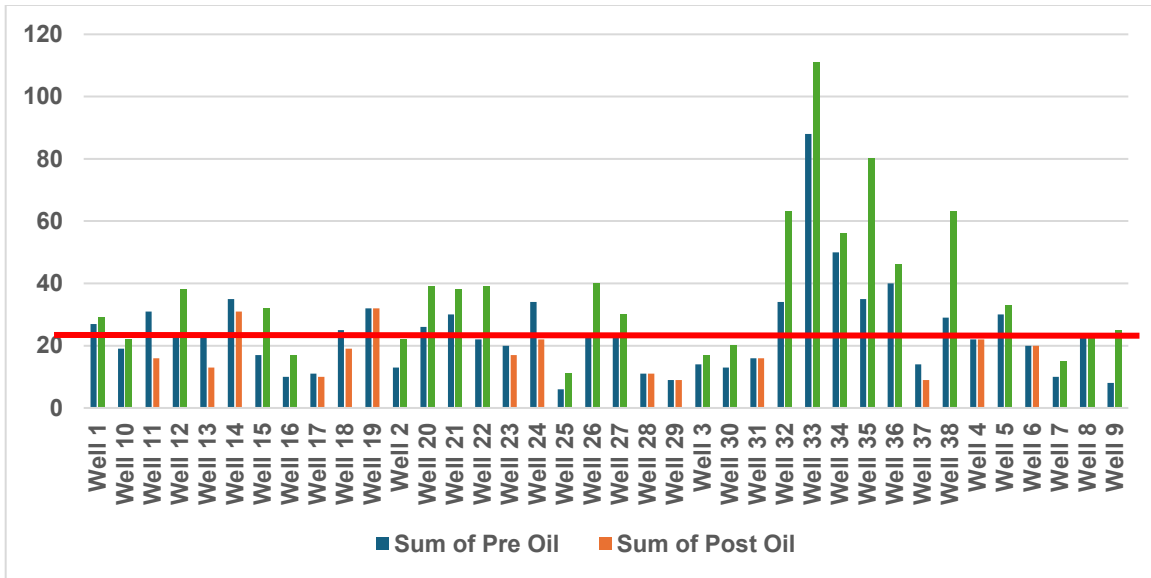


Figure 15— Uplift trends in wells equipped with vibrational-energy tools.

Economic analysis was conducted on wells equipped with vibrational-energy tools to assess cost savings and operational efficiency. Notably, wells requiring asphaltene chemical treatment exhibited significantly greater cost savings, given the higher expenses associated with their treatment programs. Annual costs for both proactive and reactive chemical treatments were compared to the cost of the vibrational-energy tool to establish breakeven runtime thresholds. Cost savings are realized for each day the well operates beyond this breakeven point. Oxy determined that wells utilizing asphaltene treatment programs achieved payout in well under one year, whereas wells on standard, lower-cost paraffin treatment programs required more than one year to reach payout.

Subsequent installations of vibrational-energy tools outside the established protocol, following Oxy's qualification of the tools for broader application, have resulted in a few additional failures. A comprehensive review is currently underway to develop more detailed criteria for tool deployment, as preliminary findings suggest performance correlations in wells with elevated CO<sub>2</sub> concentrations and gas-liquid ratios (GLR) greater than 3. Overall, the majority of installations have demonstrated robust tool performance and substantial cost savings.

### Conclusion

The vibrational-energy technology capitalizes on the long-established fundamentals of material science wherein solid-state materials emit energy through lattice vibrations. The vibrational-energy tool utilizes lattice vibrations that are unique to its charged alumina-silica alloy matrix. The tool is specifically designed to emit energy that is in resonance with hydrocarbon and hydrogen-oxygen molecular motions that promote

hydrocarbon micelle stability and reduce hydrocarbon-water interfacial tensions during hydrocarbon production, storage, and transportation. Industry applications and laboratory analyses confirm that the technology: increases crude oil API gravity, reduces heavy crude oil viscosity, breaks oil-in-water and water-in-oil emulsions, lowers wax appearance and pour point temperatures in paraffinic crude oils, and eliminates CaCO<sub>3</sub> scale.

Field trials of the vibrational-energy tools demonstrated significant benefits in wells that produce asphaltenes, paraffin, and scale. Over half of the wells exceeded their previous runtime using the vibrational-energy tool compared to using chemical inhibitors and remedial treatments to maintain production. A small number of failures were attributed primarily to improper installation or operating with extremely high gas rates that potentially interfered with conduction of the vibrational energy to the liquid phase of the production fluids. All wells that continued operation with the vibrational-energy tool did so without chemical treatment for asphaltenes, paraffin, or scale.

The vibrational-energy tools enable operation of artificial lift equipment in the presence of asphaltenes, paraffin, and scale without the cost and logistics required to implement a chemical inhibition program that targets these substances. These trials proved that the tool allows for cost-effective treatment of these wells without chemical and will have a direct impact on the cost of these failures going forward. Given Oxy spent almost \$36 million on asphaltene, paraffin, and scale failures in 2025, these tools have the potential to provide significant cost savings by reducing equipment failures related to these substances.

## References

Carnegie Endowment. <http://oci.carnegieendowment.org/#analysis>).

Farah and others, 2005. Viscosity of Water-in-Oil Emulsions: Variation with Temperature and Water Volume Fraction. *Journal of Petroleum*, 2005, 06.014. Volume Thermodynamics. <https://doi.org/10.1016/j.petrol.2005.06.014>.

Hitchon, B. 1993. *Geochemical Studies – 4, Physical and Chemical Properties of Sediments and Bitumen from some Alberta Oil Sand Deposits*. Alberta Research Council Open File Report 1993-25.

Kostina and others, 2023. Use of Raman Spectroscopy in Analysis of Crude Oils, Petroleum Products, Oil-Bearing Rocks, and Petrochemical Catalysts (A Review), *Petroleum Chemistry*, Volume 63, March 21<sup>st</sup>, 2023.

Lesueur, D., 2008. The colloidal structure of bitumen: Consequences on the rheology and on the mechanisms of bitumen modification, *Advances in Colloid and Interface Science* 145 (1-2):42-82.

Shimanouchi and others, 2009. "Tables of Molecular Vibrational Frequencies" in the *Journal of Physical and Chemical Reference Data* 7, 1323 (1978);  
<https://doi.org/10.1063/1.555587>.