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New Mexico Water and Natural Resources Committee

Orphaned and Abandoned Well Cleanup and Bonding Sufficiency

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TS-Nano is ***an Environmental, Social and Governance (ESG) company*** focused on providing an integrated solution to the problem of ***greenhouse gas (GHG)*** emissions from ***abandoned and orphaned oil and gas wells***.

- ***We offer a unique technology*** that ***allows permanent sealing*** of abandoned and orphaned wells.
- We provide ***a vertically integrated solution*** that encompasses ***monitoring, sealing, quantifying and certifying the provenance*** of the proposed solution.
- TS-Nano is involved in ***national and international efforts*** to address the ***pressing need to stop GHG emissions from abandoned and orphaned oil and gas wells.***

The Problem

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There are a ***very large number of abandoned and orphaned wells*** in the US and the world. ***These wells leak methane*** and other ***greenhouse gases (GHG)*** into the atmosphere as well as ***contaminate groundwater***.

- Estimating the number of & documenting orphan wells across US is a work in progress.
  Currently there is 81,000 documented orphan wells across the US (edf.org).

- EPA estimated that in the US there are ***3.1 million abandoned onshore wells***. ***70% of these wells are unplugged*** and are ***leaking methane and GHG*** into the atmosphere (EPA, 2018).

- ***1,741 orphan wells*** in have been estimated ***in New Mexico*** on private and state lands (Durango Herald, 2022).

The Problem

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The ***traditional approach*** is to ***plug wells with cement***. Today, ***we know this is not an effective long-term solution*** to prevent GHG emissions.

- ***Cement is porous*** and ***allows some gas flow*** even if it is place perfectly in a well.
- ***Cement usually shrinks*** during curing and develops cracks and de-bonds from casing and rock.
- ***Over time, cement will degrade in the harsh subsurface environment*** and develop cracks and flow paths.

If cement alone is used to plug wells***, future generations will have to again face the greenhouse gas emissions problem.***

Cement Integrity Degrades Over Time

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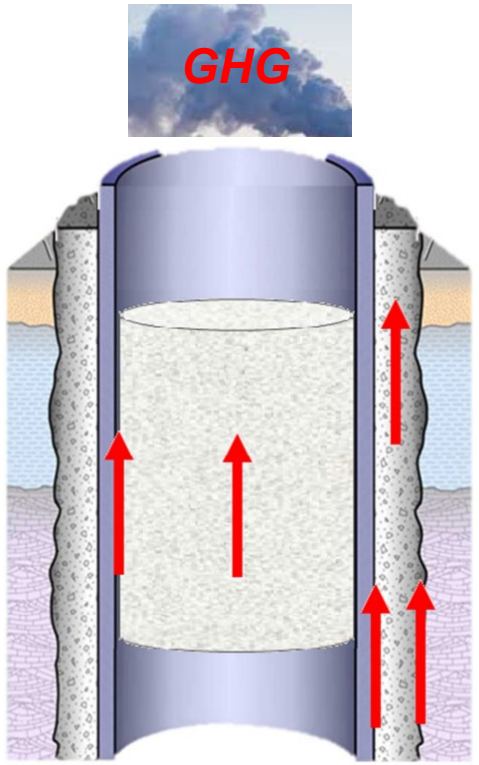
After placement and throughout the well life cycle, cement is normally exposed to gases and fluids from different sources. It is also subject to changes in pressure and temperature. These could negatively affect the cement properties with adverse consequences concerning its effectiveness as a barrier in a long-term perspective. The recognized factors that potentially affect the cement properties include: water penetration, gas migration, chemical attack and variations in pressure and temperature that are able to generate thermo-mechanical failures such as shrinkage, cracking and debonding (Kiran et al., 2017; Andrade et al., 2016; Ferreira et al., 2019). Mapping the consequence of these

(Beltran-Jimenez, 2021)
Journal of Petroleum Science and Engineering



(Vralstad et al, 2018)
Journal of Petroleum Science and Engineering

Placing a cement plug in a cased wellbore is in most cases not sufficient to prevent leakages from the well after abandonment, as leakages may also occur in the annulus outside the casing. Especially for old wells where the annulus cement is likely to be damaged, since

For wellbore plugs to retain their sealing ability over time, the plugging material should be unaffected by the ambient downhole conditions. In other words, the plugging material should not degrade thermally or chemically. Typical potentially detrimental downhole

Cement is commonly used for P&A. The first oilfield cement classification was developed by the American Petroleum Institute (API) in 1952 (Arthur and Hochheiser, 2016). For long-term, traditional P&A jobs, cement may not be ideal, because, during curing, materials can shrink, break, degrade mechanically and/or chemically, and cause leaks into adjacent zones or the atmosphere even a long time after installation (Flopetrol, 2019). Also, the cement may not be

(Achang et al, 2019)
Environmental Engineering Science

- ***Leak pathways in a plugged wells occur*** through cement plug itself or the microannuli created at cement/casing interface.

- ***Cement degrades mechanically and/or chemically over time*** due to downhole conditions creating pathways for GHG emission

US Oil and Gas Production (1900-2021)

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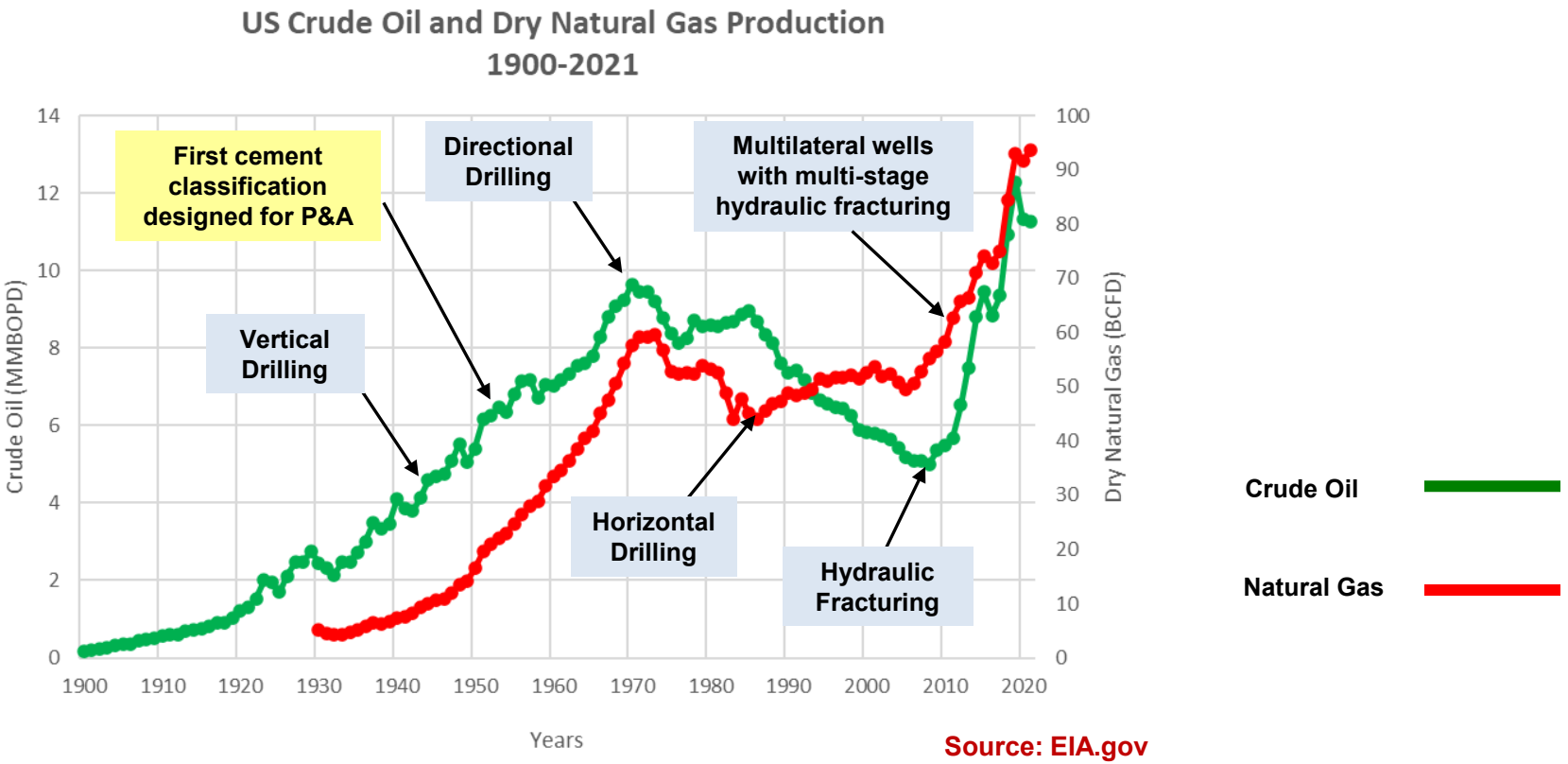

- There have been significant advances in the oil and gas industry ***in drilling & completion practices***, significantly increasing the amount of oil & gas production over time
- ***P&A technology*** has lagged behind advancements in drilling and completion technology and ***needs a technology leap to meet new demands by climate change***

The Solution

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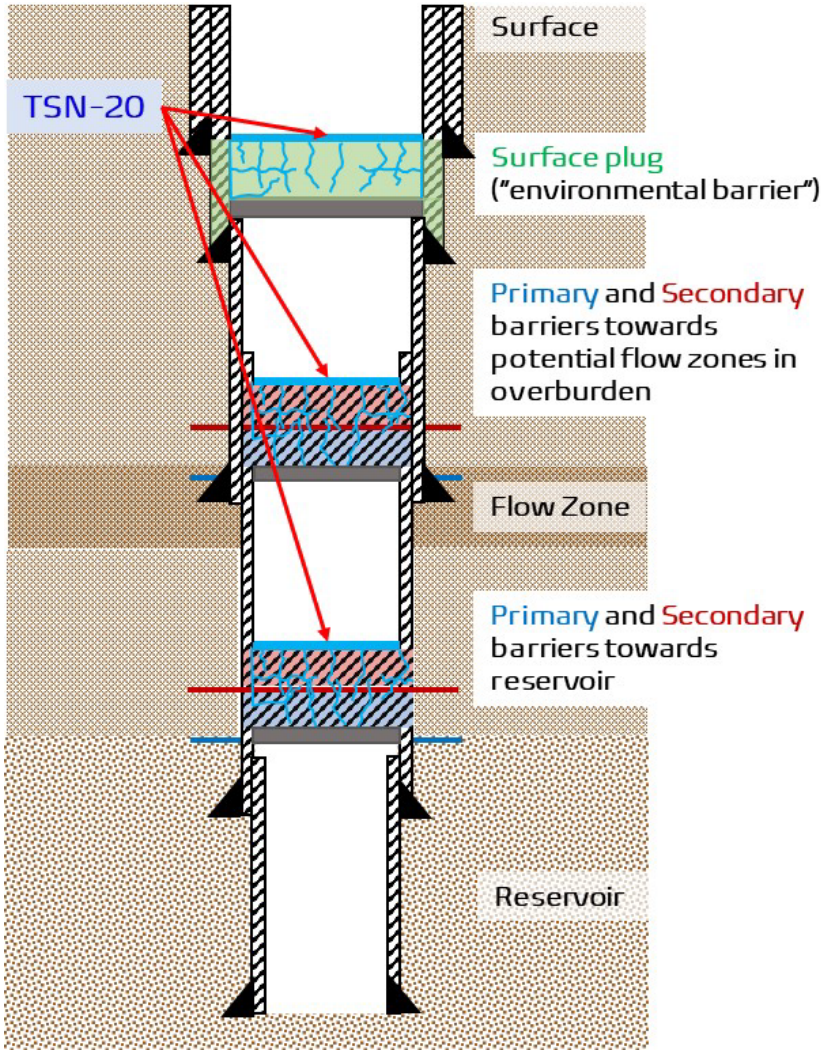
- A high flowability, ***environmentally friendly nano-modified polymer sealant*** developed specifically for improving the quality of cement plugs and ***providing a redundant barrier against GHG emission***.

- Our sealant can be ***applied on the top of hardened cement plug*** to penetrate to flow and seal very thin pores and microcracks in the cement and along the casing interface with cement and the host rock. ***Our sealant creates impermeable cement plugs.***

- Using nanotechnology, ***we developed a low volume-high value nano-modified polymer sealant*** that only needs ~ 5-10% of the cement plug(s) volume to seal a typical well.



The Solution

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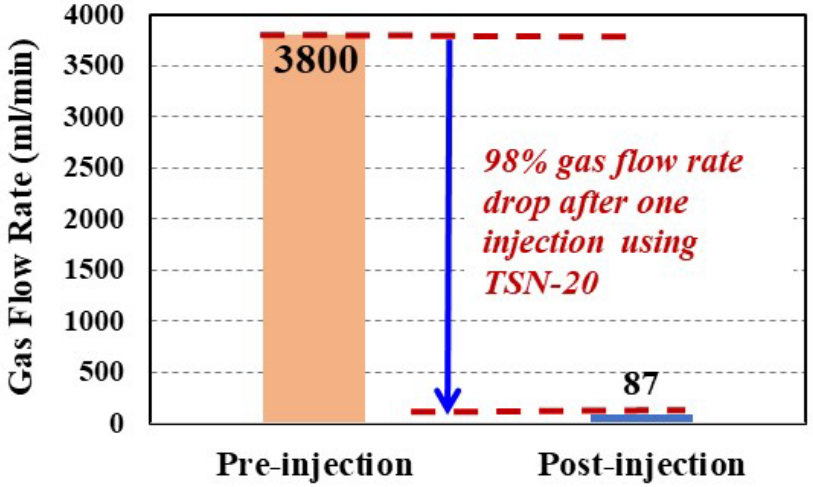
NORCE (Norway) 2022: Successful sealing of cracked cement annulus to prevent gas emission in collaboration with The Norwegian Research Centre.

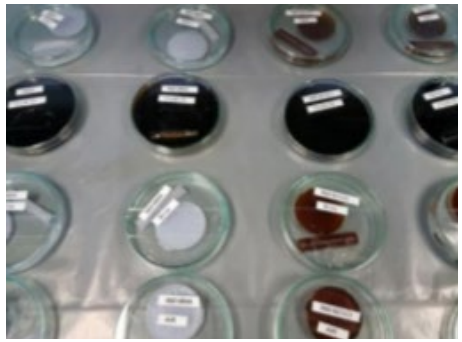
- Our sealant tested against gas leakage and showed the ability to ***drop gas flow rate by 98%*** after one cycle of injection.

- Our sealant shows ***excellent longevity*** as it resists the aggressive chemicals and environmental conditions in the wells and provides ***a better seal against gas leakage on day 1*** and into the future.



Longevity test results showing our sealant to have a much lower mass loss (degradation) in aggressive environments compared with microfine cement

	DI Water	Carbonated Brine	Crude Oil	HTHP*	15% HCL
Microfine cement	2.3%	8.2%	13.3%	18.9%	> 50%
TSN-20	1.0%	1.5%	1.4%	1.5%	0.9%



Our History

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UNM researchers receive multi-year $0.9M grant from the US DOE to develop sealants for CO2 sequestration wells

We synthesized many candidate polymer materials modified with nanomaterials. A comprehensive test program was used to down select to best repair material.

Flowability → Bond strength → Ductility → Push-out tests → Penetrability → Best repair material

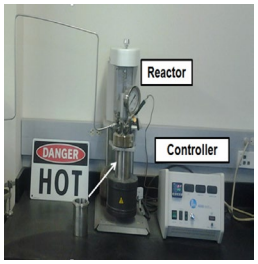
Successful field testing of sealant CO2 sequestration mock well in Switzerland for consortium including Chevron/BP/Total/Petrobras

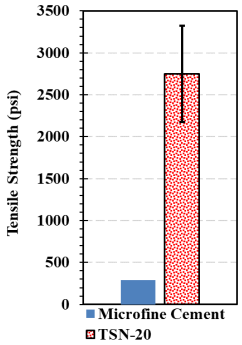
DEVVIO

DevvStream

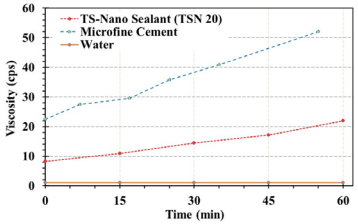
TS-Nano partnered with Devvio & DevvStream to provide an integrated ESG solution for cutting GHG emission

2012 2014 2016 2018 2019 2020 2021 2022





Continued R&D at UNM through $300k grant with Sandia.



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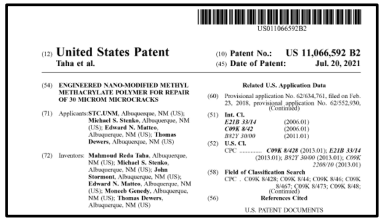
TS-Nano formed to commercialize sealants.

Additional US patents were issued for TS-Nano.



US011066592B2

(12) United States Patent
Taha et al.

(10) Patent No.: US 11,066,592 B2
(45) Date of Patent: Jul. 20, 2021

(54) ENGINEERED NANO-MODIFIED METHYL METHACRYLATE POLYMER FOR REPAIR OF 30 MICRON MICROCRACKS

Related U.S. Application Data

(60) Provisional application No. 62/634,761, filed on Feb. 25, 2018, provisional application No. 62/552,930, (Continued)

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(51) Int. Cl.
B21B 15/14 (2006.01)
C09K 8/42 (2006.01)
B32B 38/00 (2011.01)

(52) U.S. Cl.
CPC *C09K 8/428* (2013.01); *B21B 15/14* (2013.01); *B32B 38/00* (2013.01); *C09K 2208/10* (2013.01)

(58) Field of Classification Search
CPC . C09K 8/428; C09K 8/44; C09K 8/46; C09K 8/467; C09K 8/473; C09K 8/48; (Continued)

(56) References Cited
U.S. PATENT DOCUMENTS

Moving Forward

TS-NANO

- There are ***new technologies and designs*** available to the industry for plugging and abandoning wells that will result in ***improved and longer lasting protection of our environment***.

- ***New Mexico has the opportunity to lead*** the worldwide effort ***to reduce the impacts of abandoned and orphaned wells*** through the use of these technologies and designs.

- TS-Nano can be part of the solution with its ***unique capabilities of monitoring, sealing, quantifying and certifying*** the ESG impact of the technology

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