

*Nanotechnology for the
Energy Storage Workhorse*

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Acknowledgments



Mr. Meir Arnon, Vulcan Automotive Chairman



Mr. Beni Cahana, Vulcan Automotive R&D Manager



The group of Professor Doron Aurbach
at Bar Ilan University



The CNT team at Arkema



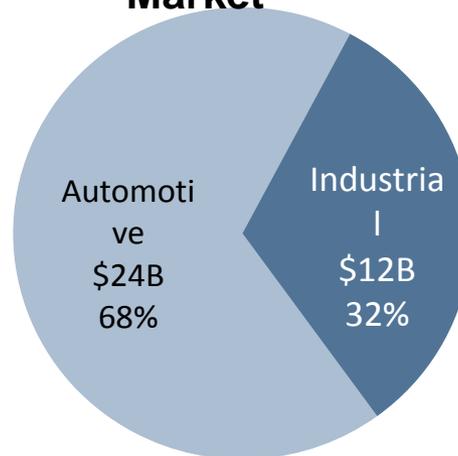
The Office of the Chief Scientist at the Ministry of Economy

The Energy Storage Workhorse

The lead acid battery remains the “workhorse” of energy storage -
Global LAB market is **\$36 billion, >5% CAGR**



Global Lead Acid Battery Market



... But the Industry is Facing Tectonic Shifts



Strong demand for e-storage



Major shift towards micro-hybrid (start-stop)



Booming electric 2-wheeler market



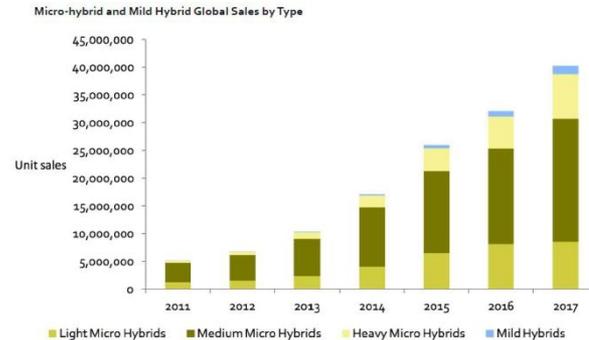
Tightening Emission and environmental Standards



Competition from new chemistries

These challenges create a strong window of opportunity !

Market demand for **longer-life, fast-charging, cost-efficient** batteries is fast growing

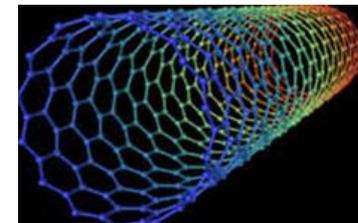


Source: Lux Research, Inc.
www.luxresearchinc.com

Margins are eroding



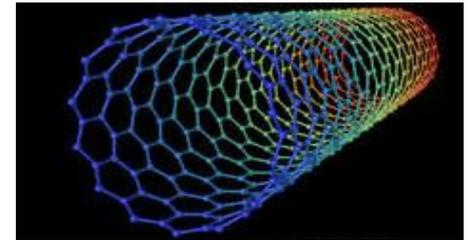
The lead acid industry is **feeling the heat**, and is finally **opening to technology innovation**.



Introducing VoltaNano



Over the last 6 years, VoltaNano has been working on the solution to these vast industry challenges through nanotechnology



Originating at Vulcan – Israel's leading LAB manufacturer – provided deep industry understanding



Lead Acid Battery Key Failure Mechanisms

Irreversible Sulfation – sulfate crystals grow through cycling to the point where they are no longer conductive

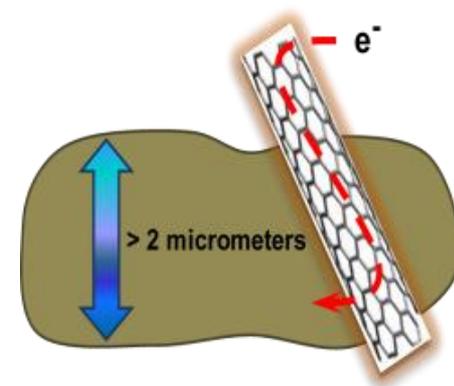
Crumbling of active material – changes in density and structure throughout cycling



CNT's have long held promise for the Lead Acid Battery Industry

It was expected that:

- They can provide a conduction path that would mitigate the sulfation effect
- They would serve as a nucleation agent to reduce sulfate size
- Their mechanical robustness would help mitigate softening and crumbling



A viable CNT technology solution required overcoming major challenges

- Right: Lead slurry in an industrial mixer.
- One ton batches are the industry norm.

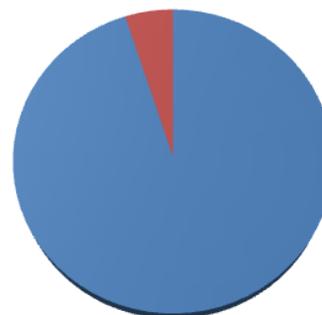


Effective dispersion of \ll kg of CNT in a ton of lead acid paste



Industry pushback to changes in production processes or battery design

Very high cost sensitivity

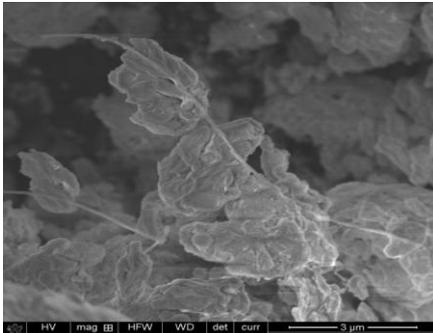


■ Costs
■ Net Margin

How we did it



VoltaNano's enabling technology solution is based on two key pillars



Composite MWCNT-based materials and concentrations highly optimized for dispersion in lead



Proprietary industrial system for introducing our nano-materials, effectively with no change in production or battery design

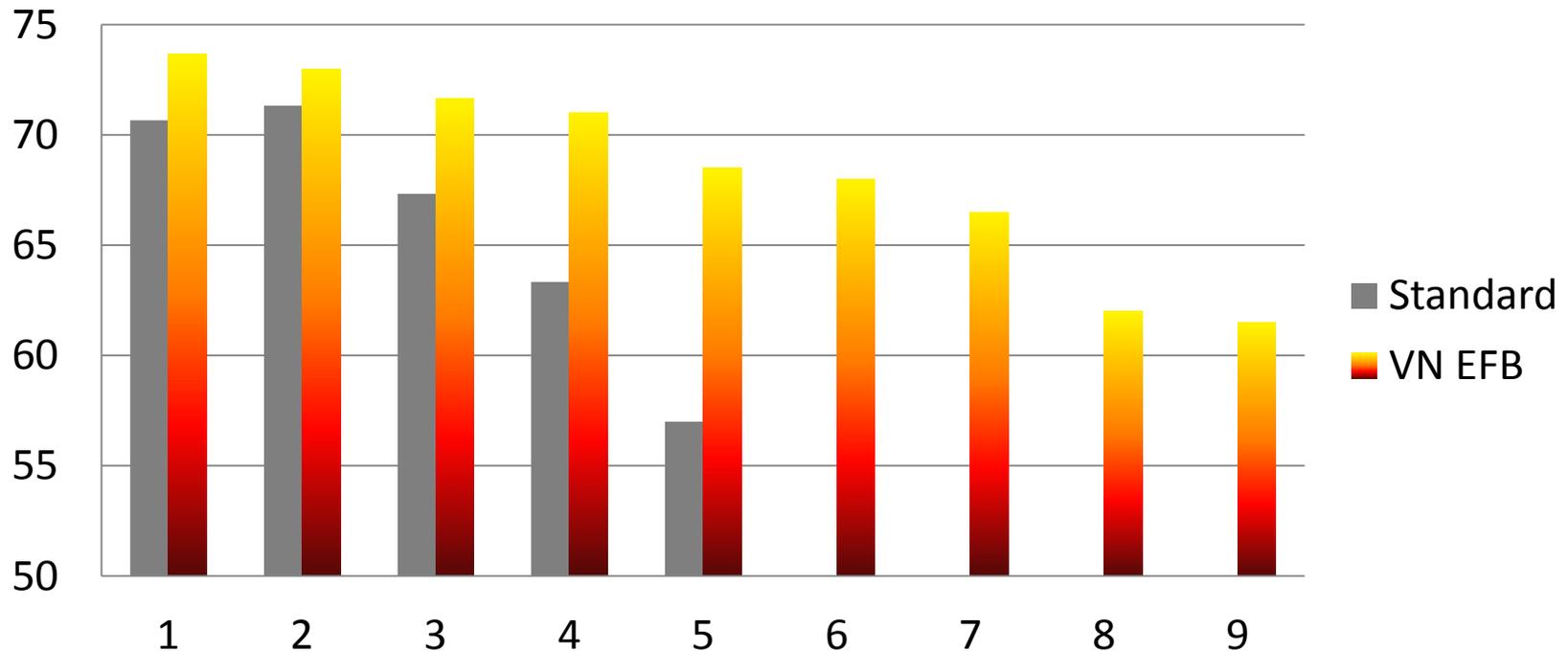
With its combined innovations, VoltaNano can provide a dramatic boost in performance  industry cost targets

VN Performance Enhancement – 17.5% @ 60C



VoltaNano more than doubles 17.5% @60C
cycle lifetime and capacity

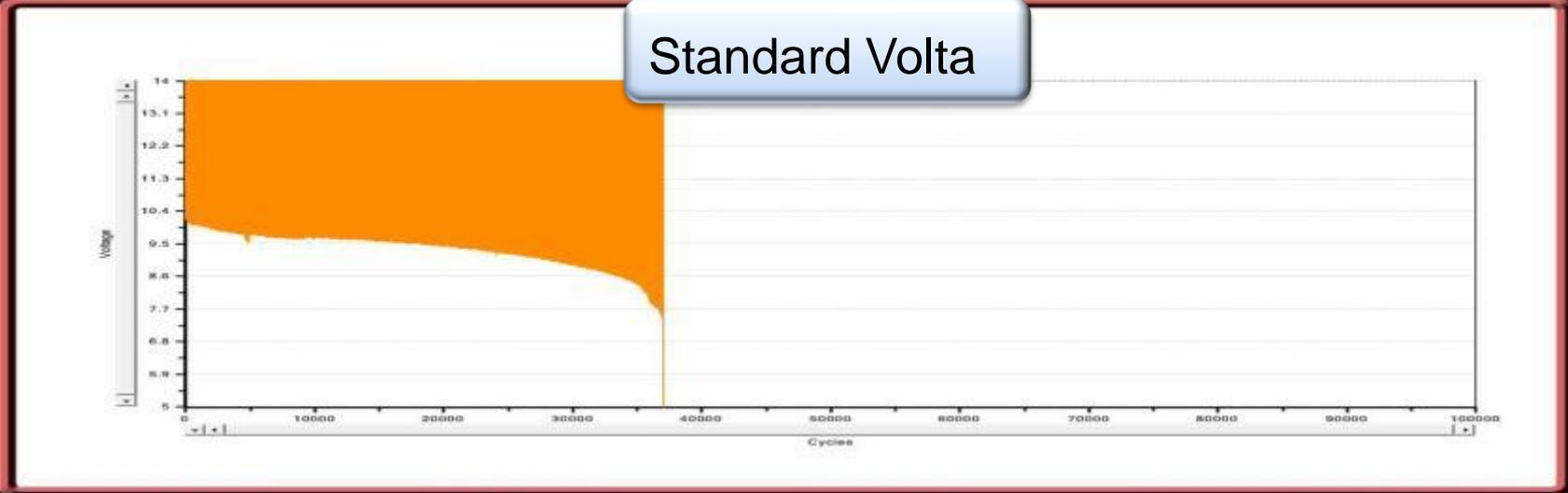
60C 17.5% DoD Capacity [Ah] over week unit



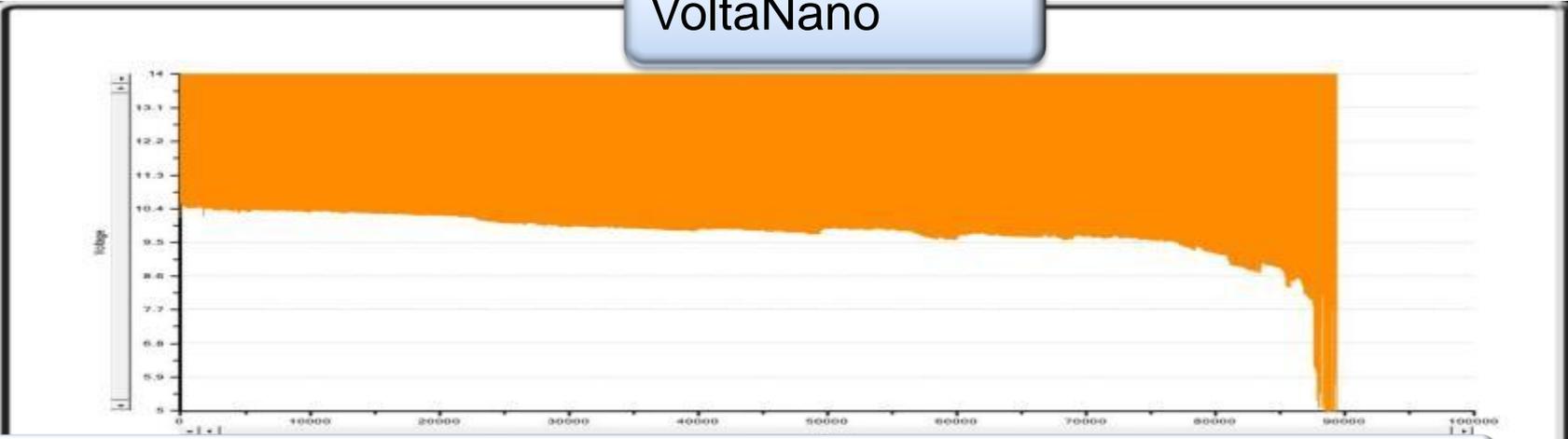
VN Performance Enhancement Shallow Cycling (flooded, Sb positive, SBA)

Cycles until end of life

Standard Volta



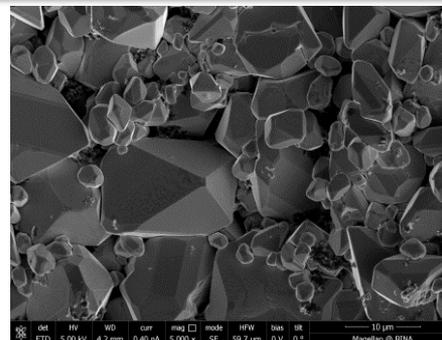
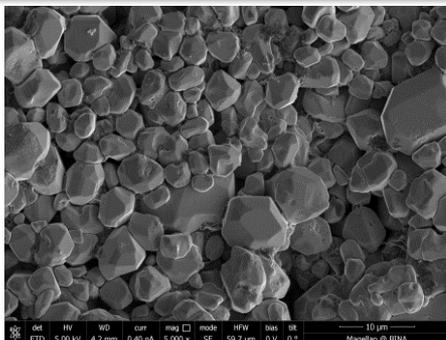
VoltaNano



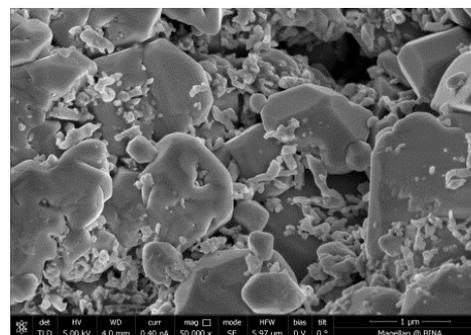
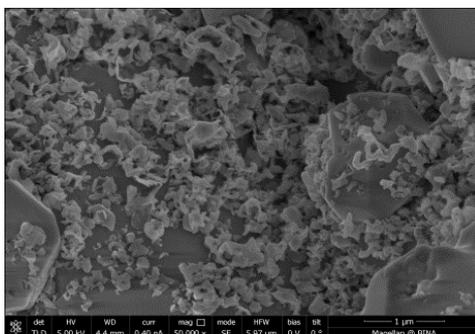
Confidential VoltaNano Information

Oxidation potential > V_{cell}

Strong effect on Sulfation for both NAM and PAM



NAM following cycling with VoltaNano (left) and without (right)



PAM following cycling with VoltaNano (left) and without (right)

Example of VoltaNano effect on positive plate

VoltaNano is the only commercially available carbon additive that works on the positive plate

VN Oxidation Potential > V_{cell} :

Without VoltaNano on positive plate after 50 cycles



After 200 cycles

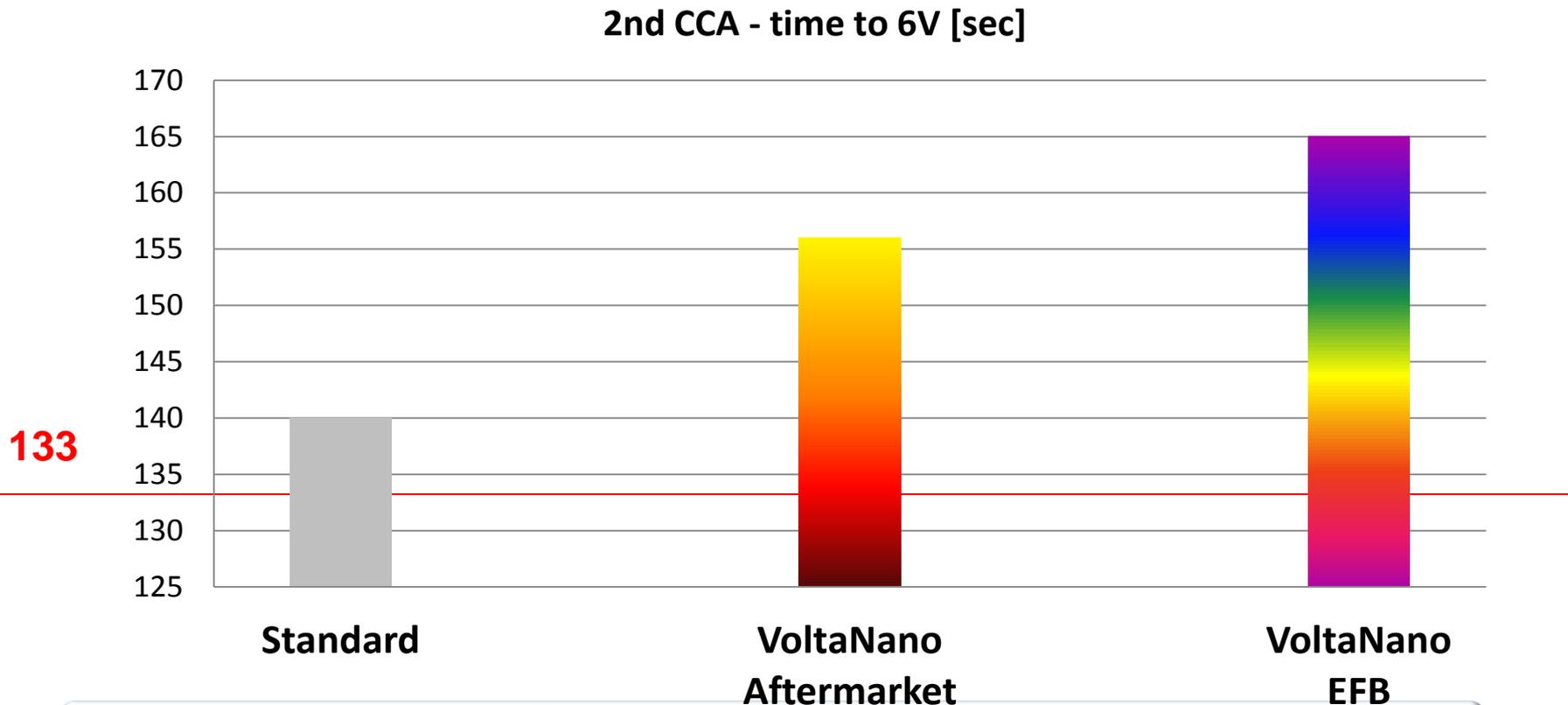
The VoltaNano logo, featuring the word "VoltaNano" in a stylized font with a yellow lightning bolt symbol above the 'V'.



VN Performance Enhancement – Cold Temperature Performance



VoltaNano improves cold cranking ability by **12% to 20%**

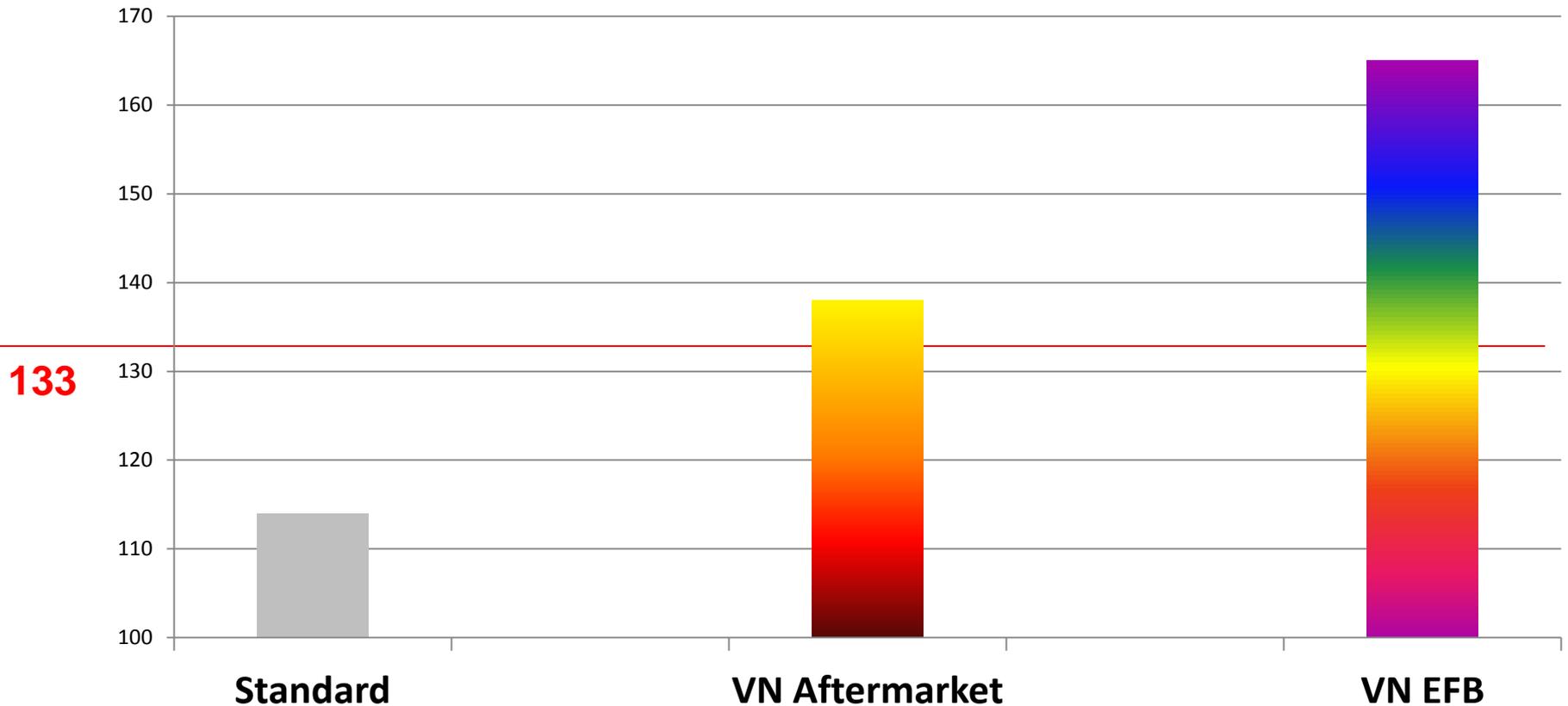


Confidential VoltaNano Information

Performance Enhancement – Exhaustive Discharge



VoltaNano improves exhaustive discharge by **16% to 40%**



VoltaNano System - cartridges



To high speed
solution
mixer

- Starting point LAB-optimized Carbon Nano Material - partnership with



- VN-Ink PAM & NAM cartridges produced by VoltaNano locally

- Delivered over land

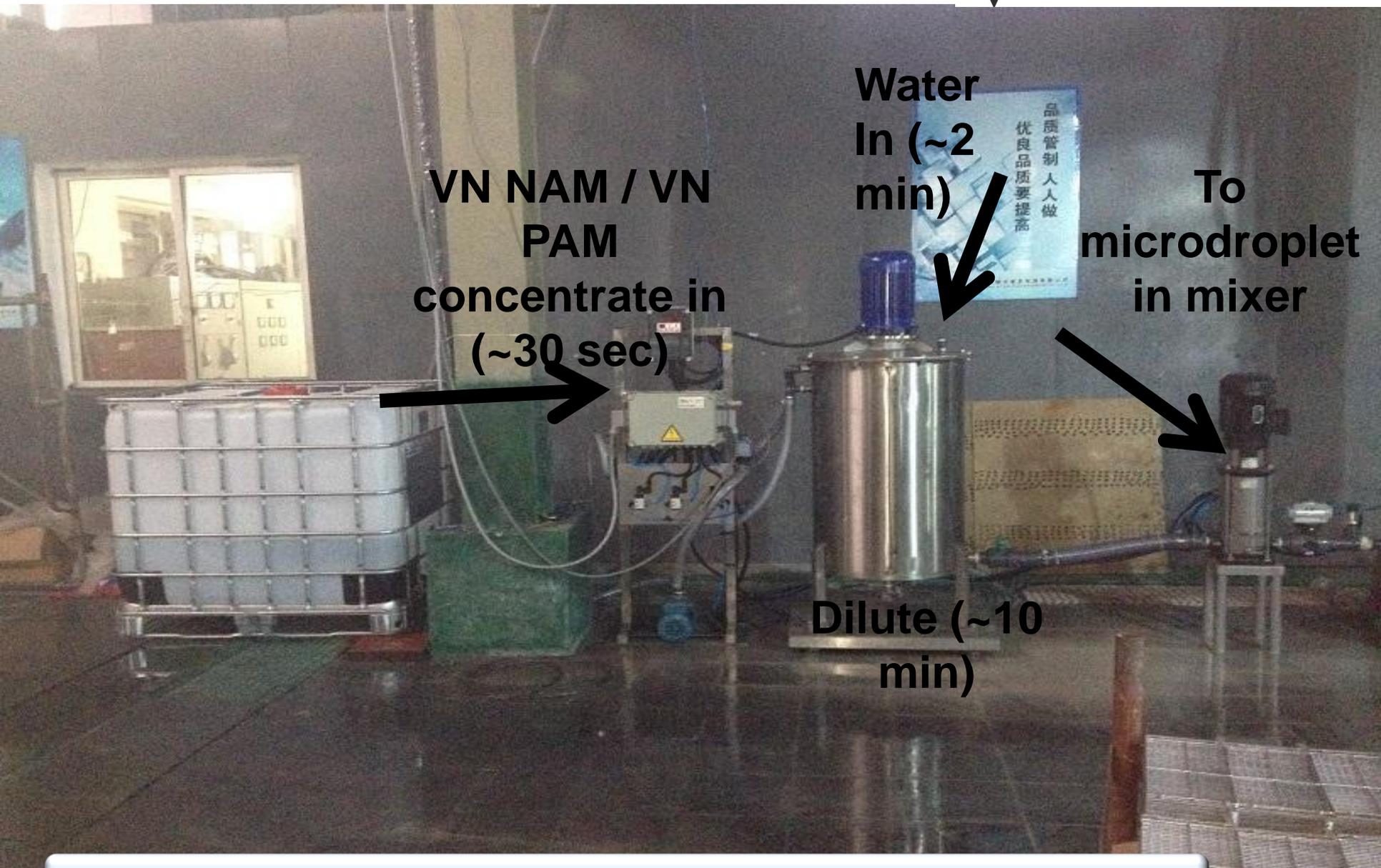
- REACH certified, EPA

- Scalable

- Patents granted and Pending



The VoltaNano Solution



VN NAM / VN
PAM
concentrate in
(~30 sec)

Water
In (~2
min)

To
microdroplet
in mixer

Dilute (~10
min)

- ✓ Vulcan Automotive is introducing VoltaNano-enhanced batteries in the Israeli market
- ✓ Leading manufacturers worldwide have successfully tested VoltaNano in their own plants
- ✓ We expect VoltaNano to become the de-facto standard in lead acid batteries over the course of the coming years

Nano-enhanced Lead Acid Batteries

Soon in your vehicle, and residential energy-storage solution



Thank You !