Binder Networking Made Easy: Drop-In Cross-Linker Additives for Silicon Containing Anodes

AnteoTech Ltd.

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AnteoTech Ltd
Overview

AnteoTech is commercializing innovative Australian patented technology – across high impact social sectors:

Energy - Enabling technology that allows for smaller, lighter and cheaper batteries

STRONG IP POSITION

Unique, proprietary nano-polymer technology with proven across Energy & Life Science

HIGHLY SKILLED TEAM AND WELL CREDENTIALED BOARD

World class team: 40 staff - 21 scientist, 22 PhD and Masters across the organization

READY TO DELIVER

Strong pipeline of short to medium term opportunities across Clean Energy Technologies sector

ANTEO X PILOT PLANT

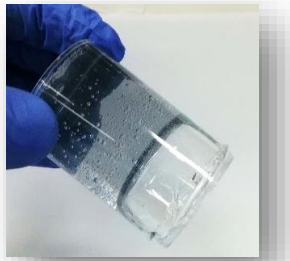
Manufacturing planned to come online in 2023

Technology development roadmap

Combining silicon enabling products + anode design know-how is enabling **pathways to smaller, lighter and cheaper batteries**

High silicon anode system (Wh/L, Wh/kg)
Provide licenses to anode system

AnteoLink – Adv. binder
Manufacture & partnership hybrid model



ANTEO X – Binder additive
Manufacture and supply

ANTEO X

VALUE/RETURN

1st Product

2nd Product

3rd Product

TIME/COMPLEXITY

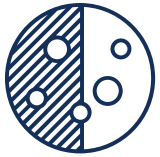
ANTEO X™

Powerful additives for water-based anode binders

The silicon challenge from a binder perspective

Binders form an integral part of electrodes, and act by facilitating

Particle dispersion



Electrode homogeneity

Structural integrity

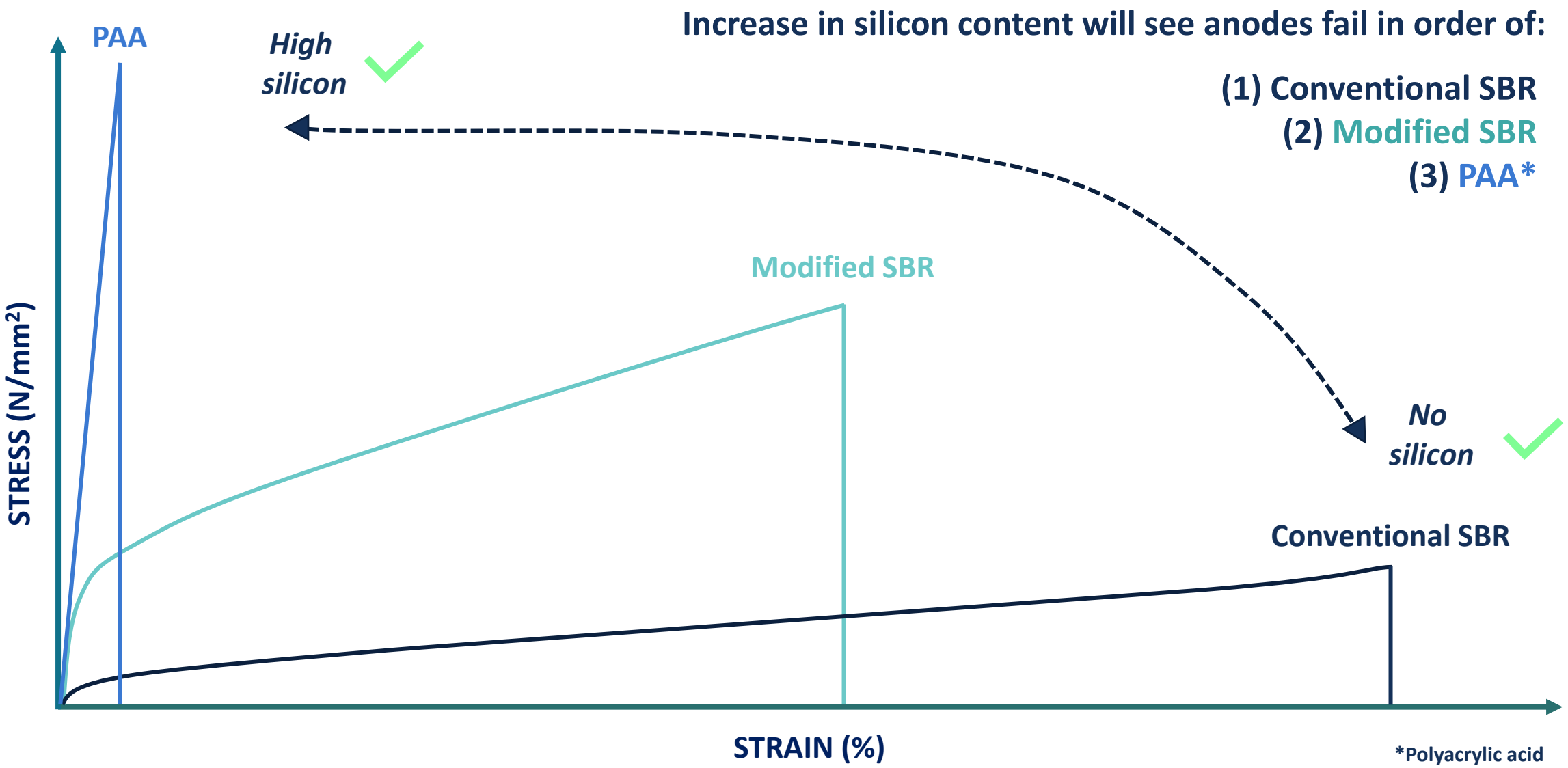
Conductive network

More silicon in the anode generally means more expansion and contraction of electrode structure

This stress largely falls onto to the binder to compensate

➢ To advance silicon anode technology **we also need advanced binders!**

What do we want from a silicon anode binder?

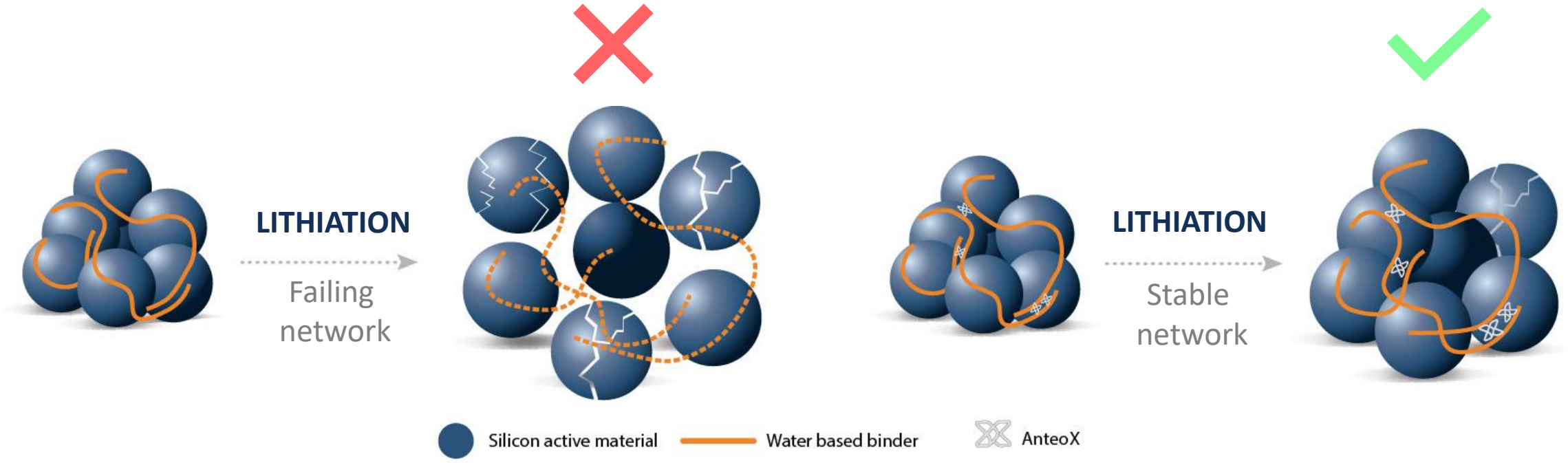


ANTEO X - Advanced silicon anode binder technology

ANTEO X forms a stronger and more resilient binder network

Unique benefits of AnteoTech's CLA compounds

- Water-based and classified as non-dangerous/non-hazardous
- Low-cost alternative to complex binder synthesis
- Forms tightly cohering network structure throughout the anode
- Applied to off-the shelf as well as proprietary binders
- Easily integrates into conventional manufacturing processes
- Stable across a wide pH range



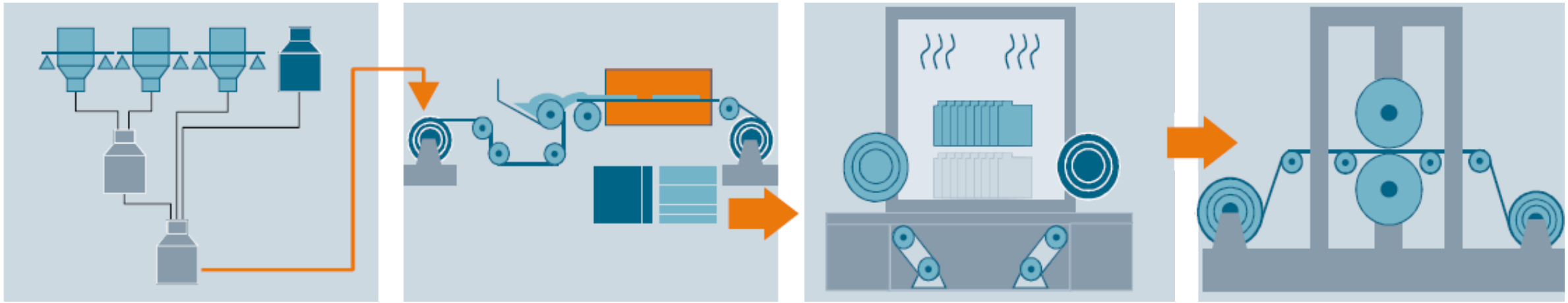
Anode manufacturing – A high speed precision process

ANTEO X designed with the intent to not change any parameters on existing manufacturing processes

Integrates seamlessly with Mixing Step (1) and activates during Drying Step (3)

Added to the process as the final component

ADDITION of



1	MIXING	2	COATING	3	DRYING	4	COMPRESSION

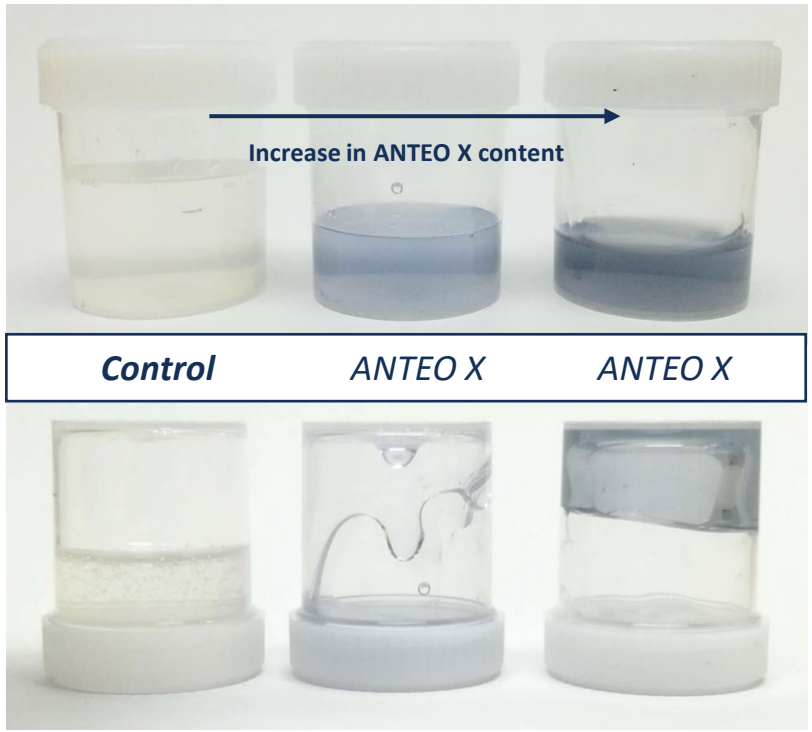
Source: Siemens

ANTEO X cross-links a range of binder chemistries

- ***Demonstrated cross-linking effect with***
  1) *a wide range of conventional binder types (CMC, PAA, Alginate, etc.)*
  2) *proprietary binder chemistries (PAA co-polymers)*
  3) *conventional and modified SBR binder chemistries*

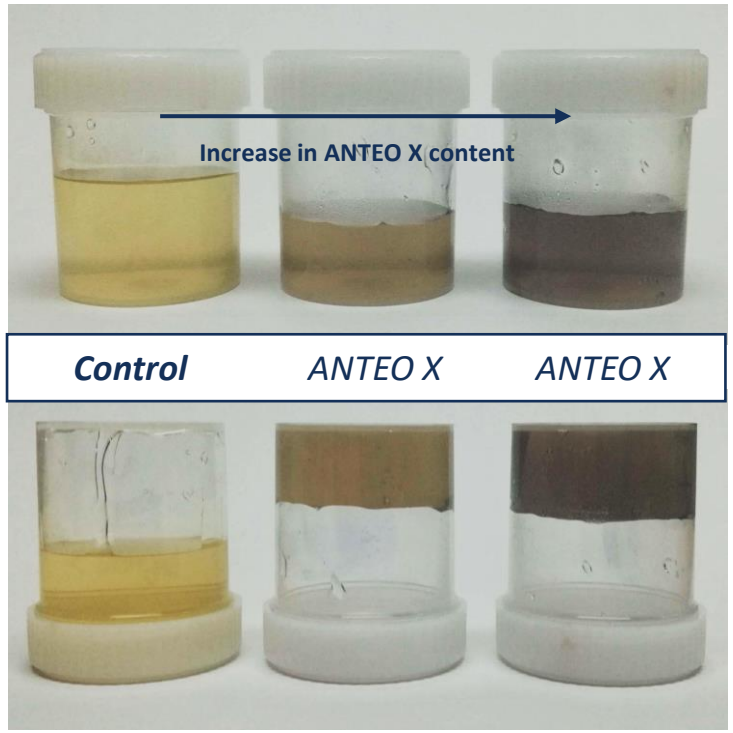
- ***The higher the ANTEO X concentration the stronger the cross-linking effect***

LiPAA (1,250kDa)*



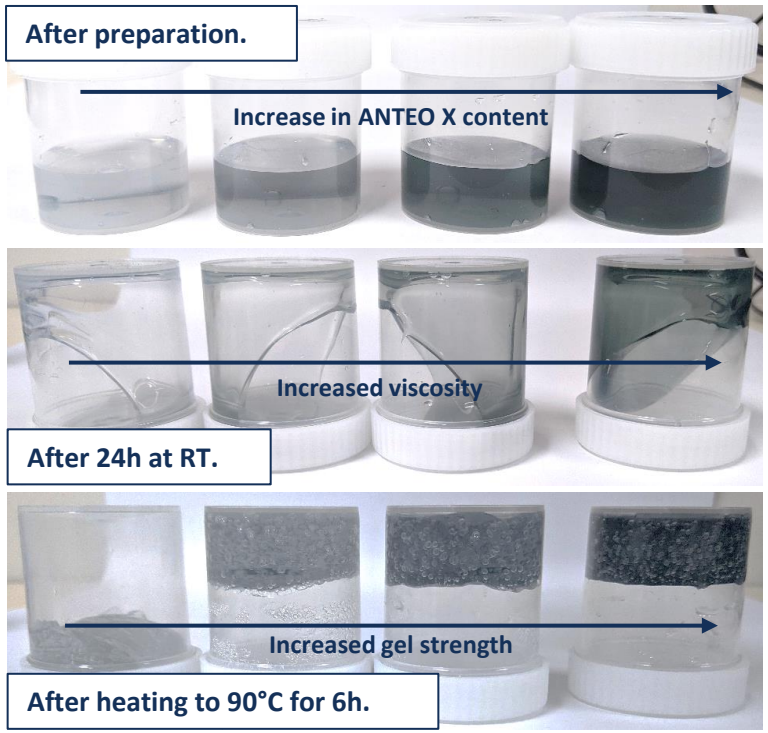
* sourced from Sigma Aldrich – 6wt.% in H_2O, 80% neutr. with LiOH

NaAlginate*



*sourced from Sigma Aldrich – ≥2,000 cP, 2 % (25 °C), 2 wt.% in H_2O

NaCMC*

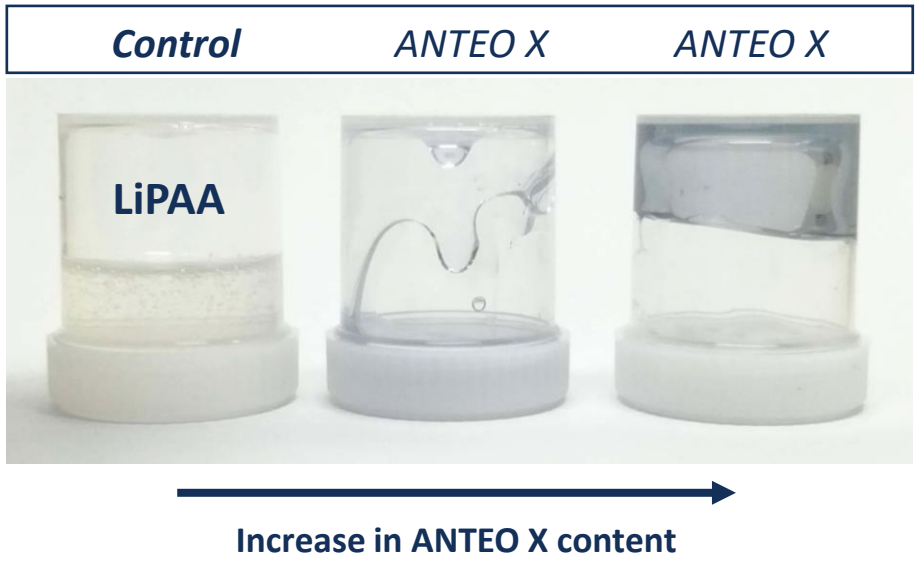


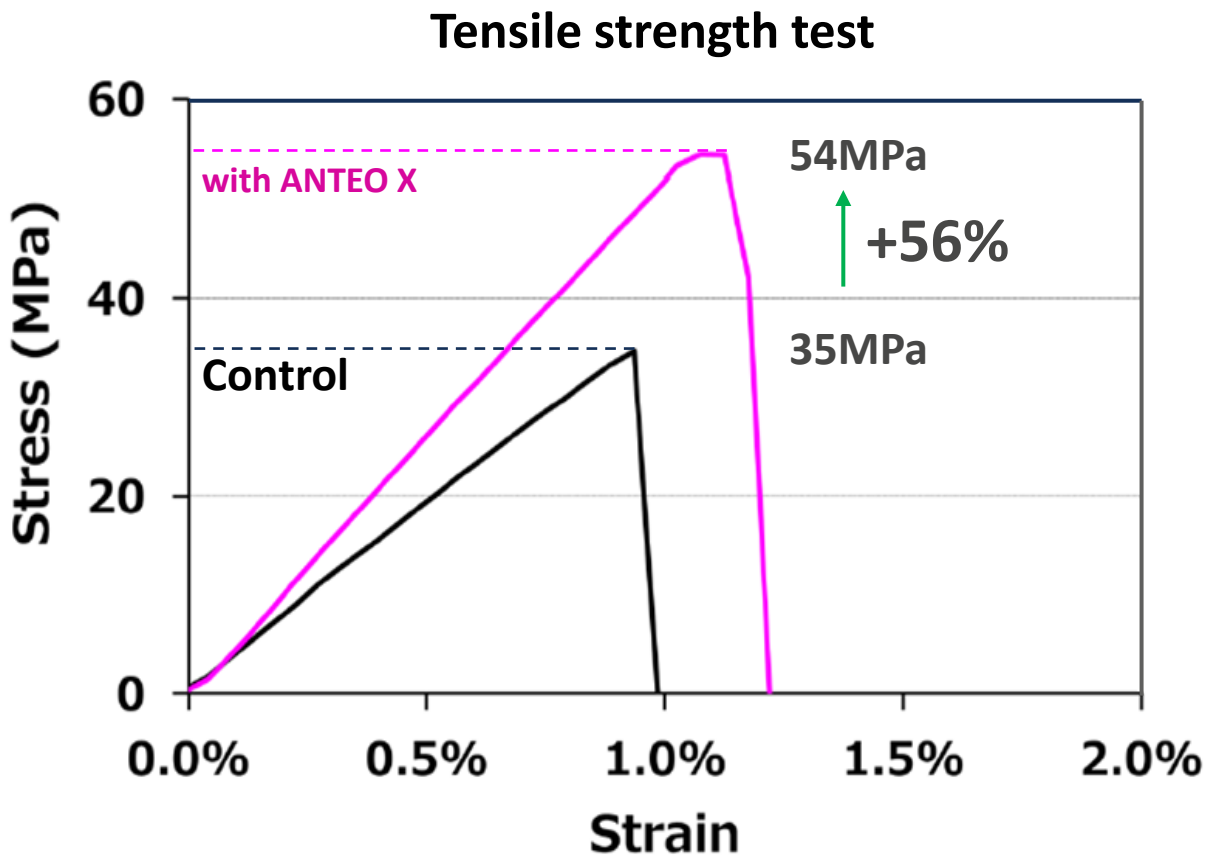
* sourced from MTI – 400,000 g/mol, 1.5 wt.% in H_2O

ANTEO X improves commercial PAA co-polymer binder

ANTEO X effectively cross-links commercial PAA co-polymer binder

(1) Increase in yield and ultimate tensile strength
(2) Increase in Young's modulus
(3) Increase in elongation

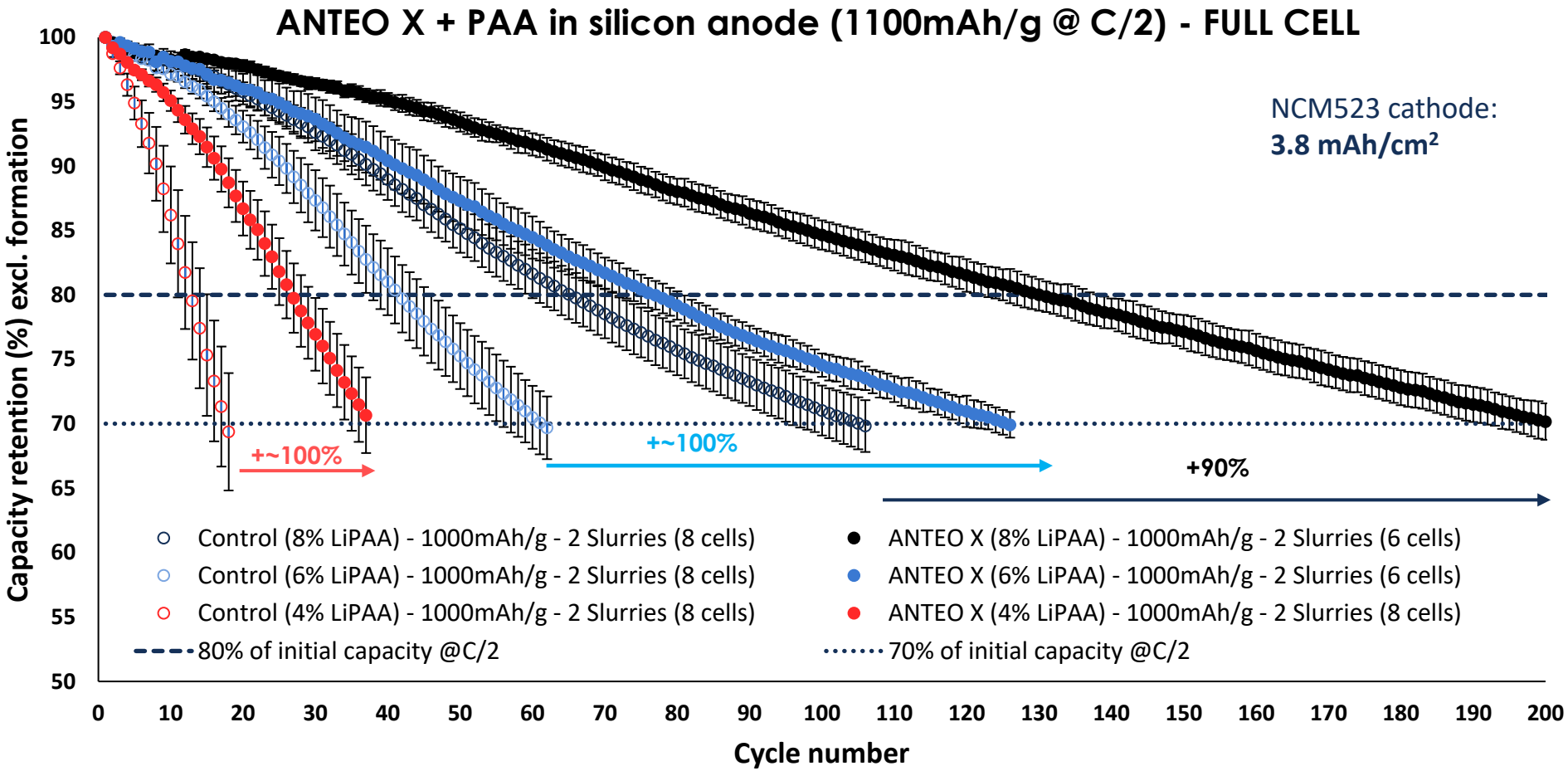




ANTEO X + PAA achieve superior performance

ANTEO X achieves substantial improvements in cycle life for very high-capacity silicon anodes

ANTEO X helps to effectively reduce electrode expansion



EXPANSION STUDY

Capacity @ C/20 ~1600 mAh/g
Capacity @ C/2 ~1300 mAh/g

Reduction in expansion @ cycle 100

8% PAA	-8%
6% PAA	-32%
4% PAA	-43%

ANTEO X compatibility with SBR binder emulsions

Prevalent binder system in the near-term will continue to be CMC/SBR

ANTEO X is compatible with SBR binders by maintaining a stable emulsion

CMC/SBR/ANTEO X mixtures demonstrate effective cross-linking and heat curing effect

CMC/SBR hydrogels with ANTEO X

After preparation.

Increase in ANTEO X content

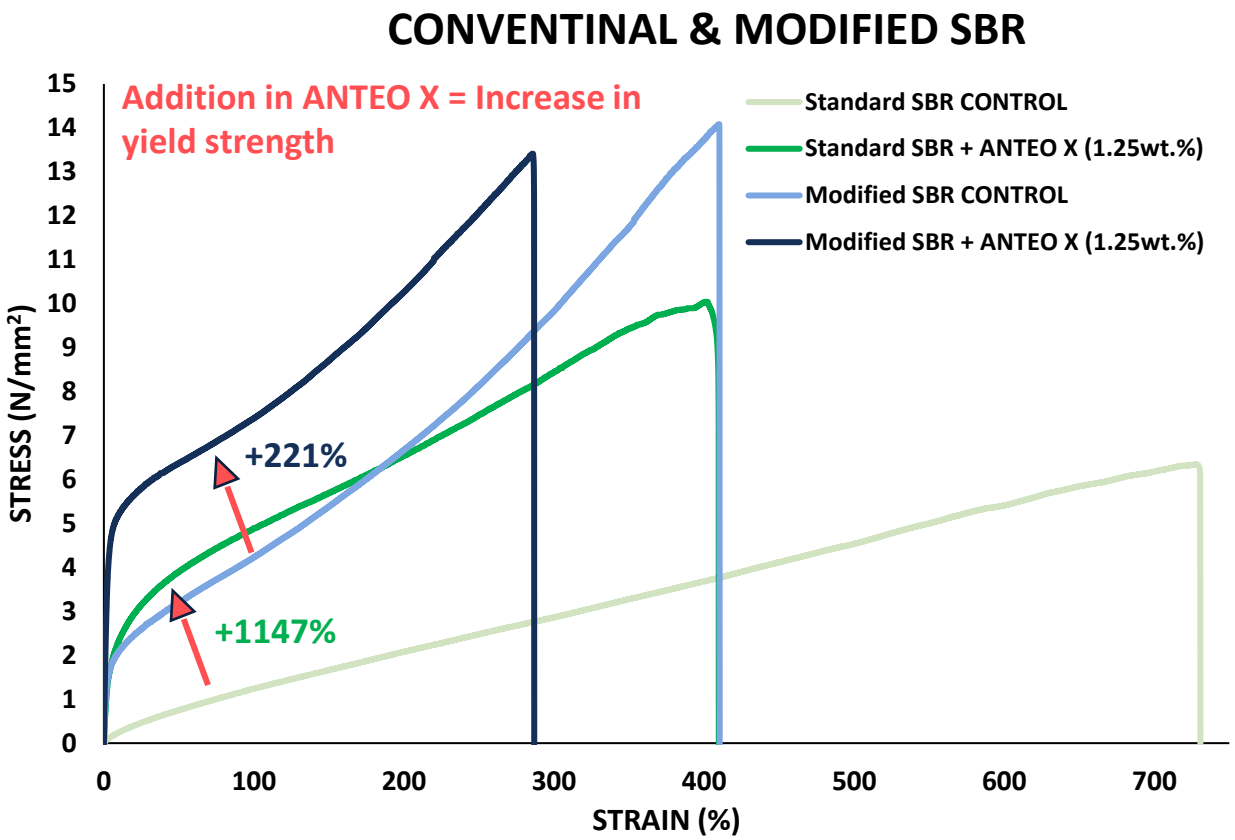
After curing.

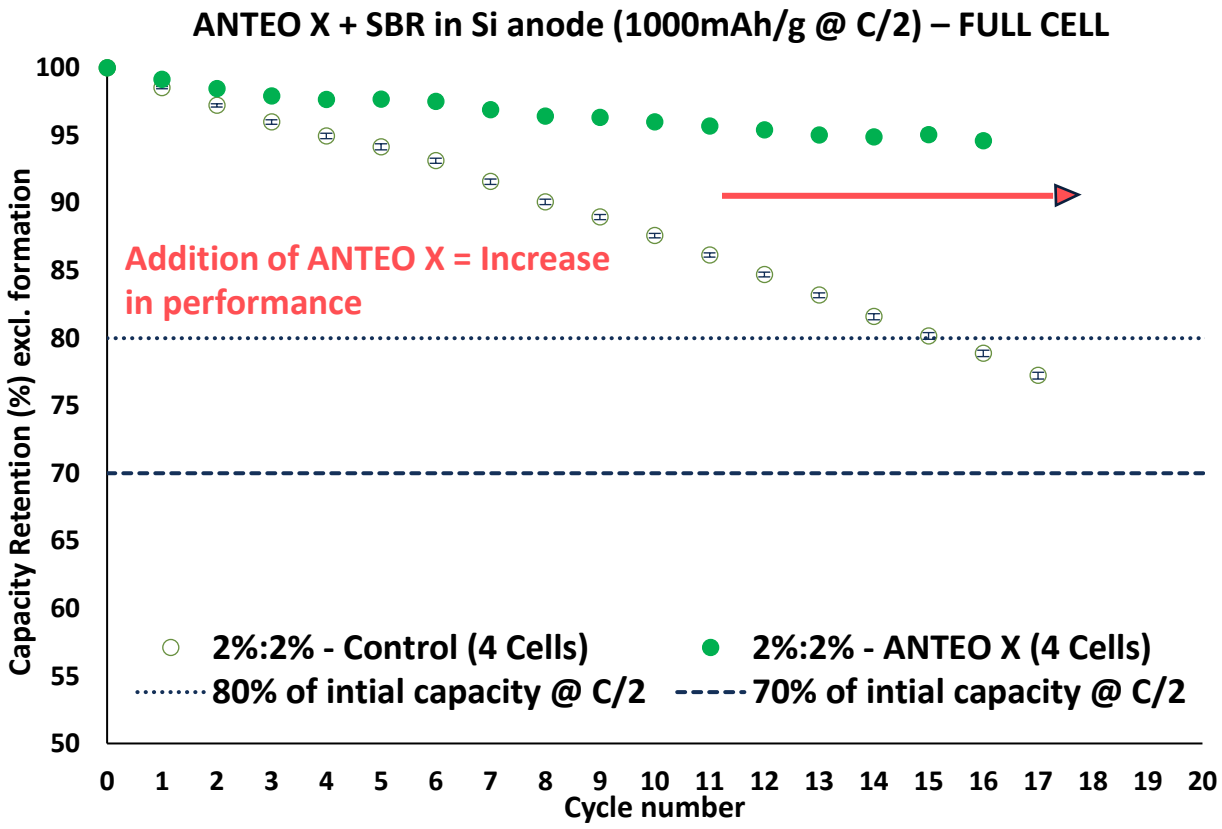
Increase in cross-linking strength

ANTEO X turns conventional SBR into silicon binder

ANTEO X effectively cross-links commercial off-the shelf SBR latex binder for graphite anodes

(1) Substantial improvement in yield strength
(2) ANTEO X turns graphite SBR binder into a silicon anode binder and improves strength of modified SBR further
(3) Ability to heavily tailor stress-strain characteristics of a binders





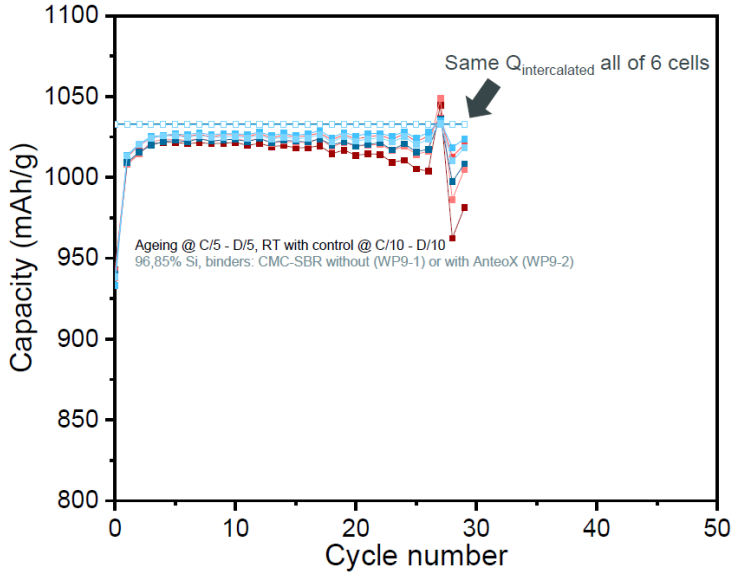
External testing – ANTEO X in silicon anode (low binder %)

"ANTEO X has a clear benefit on CMC/SBR, PAA, or CMC-SBR-PAA based electrodes" Battery Manufacturer

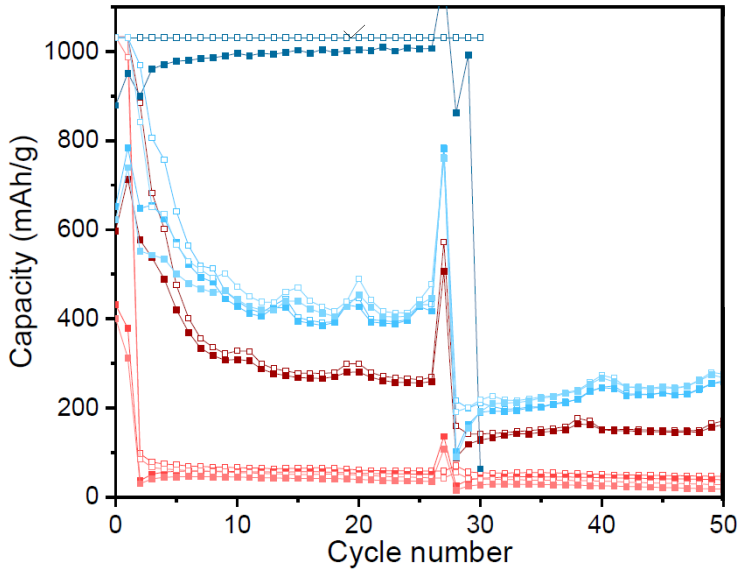
ANODE : High Si % + 3% Binder **Blue curves: ANTEO X** **Red curves:** Control

- ✓ **Improved average coulombic efficiency when ANTEO X is used**
- ✓ **No adverse impact on first cycle efficiency**
- ✓ **Reversibility upon formation is improved by ANTEO X**
- ✓ **Capacity drop is mitigated when ANTEO X is added**
- ✓ **Way better performance with 0.5% ANTEO X**
- ✓ **Clear effect on reversibility and coulombic efficiency when ANTEO X is used**

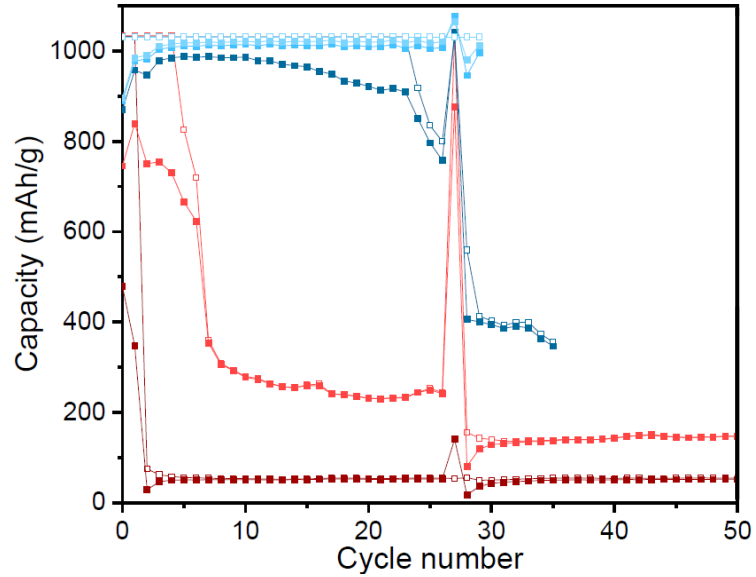
3% CMC/SBR



3% PAA



3% CMC/PAA/SBR



ANTEO X – Target scale-up execution timeline (base case)

PLANNED 2023 MILESTONES:

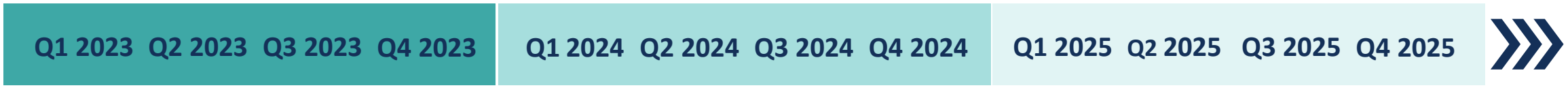
- Gen 1 ANTEO X design freeze
- Pilot facility set-up

- **First 2-3 years of supply to come out of Australia**
- **Beyond year 3, set-up in additional geographies planned**

ANTEO X supply capacity corresponding to up to 36M 5Ah battery cells

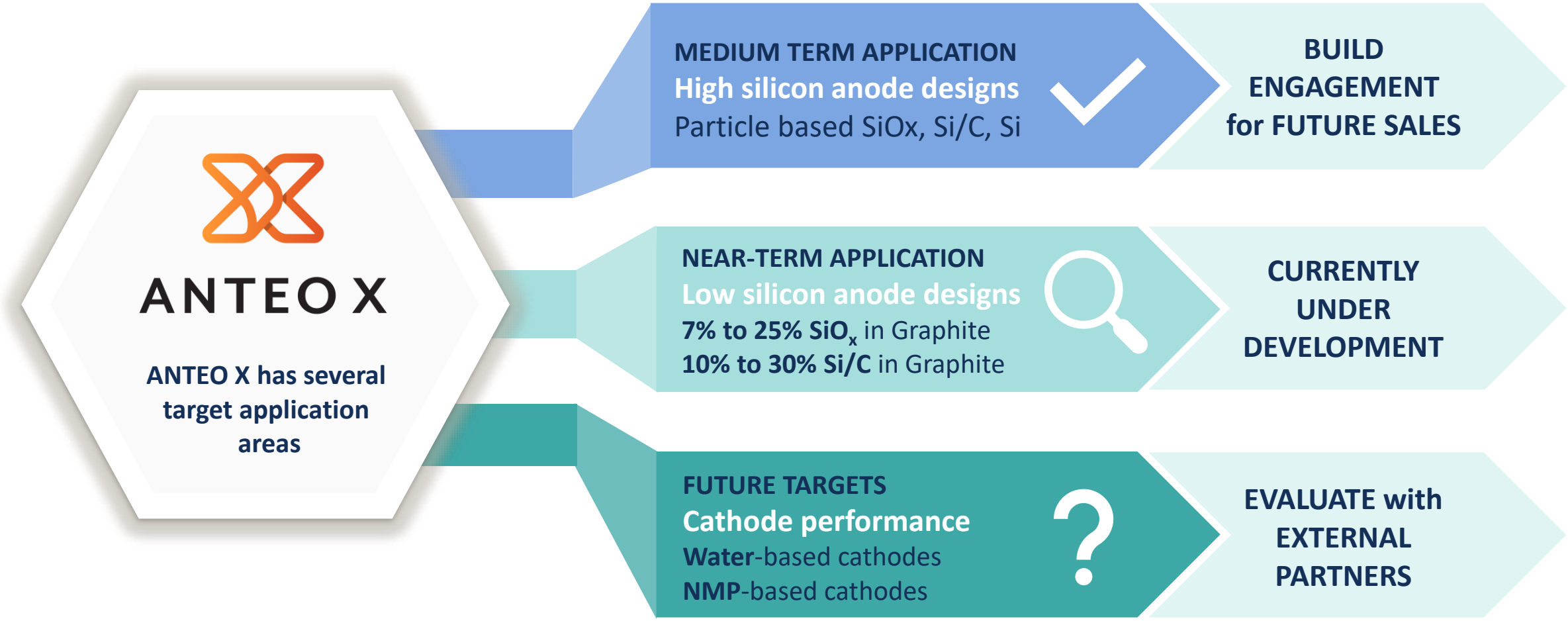
ANTEO X supply capacity corresponding to up to xM 5Ah battery cells

ANTEO X supply capacity corresponding to up to xM 5Ah battery cells



NOTE: Scale-up progression in 2024 and 2025 will be tied to demand profile with faster ramp up to higher volumes possible

Use cases and product-market fit



ANTEO X - Summary

TECHNICAL ACHIEVEMENTS

- Improved cycle life
- Reduction in binder content
- Volume expansion reduction
- Tailored binder properties

DEVELOPMENT PROGRAM MILESTONES

- Successful roll-to-roll-coating trials completed with ANTEO X
- Extended pot-life of ANTEO X to 7+ days for high PAA slurries
- Several successful ANTEO X partner trials completed throughout 2022

SILICON ANODE

Overview

Enabling high energy and cost-effect batteries

Up to 8.5x cheaper AM*	Up to +35% more energy**
Existing Si supply chain	>90% ICE

✓ 300+ cycles in baseline design
✓ 500+ cycles in advanced design

* when compared to other active materials on a $/kWh basis (based on publicly available reports)

** Target prototype design (relative to high energy graphite reference cell)

OBJECTIVE

(1) Develop solutions that achieve extraordinary performance from ordinary materials

(2) Use extremely cost competitive active material with established ton-scale production

HIGH SILICON PARTICLE-BASED ANODE

Progressing development of two iterative anode designs in parallel (BASELINE and ADVANCED)

TARGET METRICS

Baseline design: 500 cycles at 1000mAh/g
Advanced design: >1000 cycles at 1000mAh/g

AnteoTech's Si anode designs are targeting 1000 mAh/g

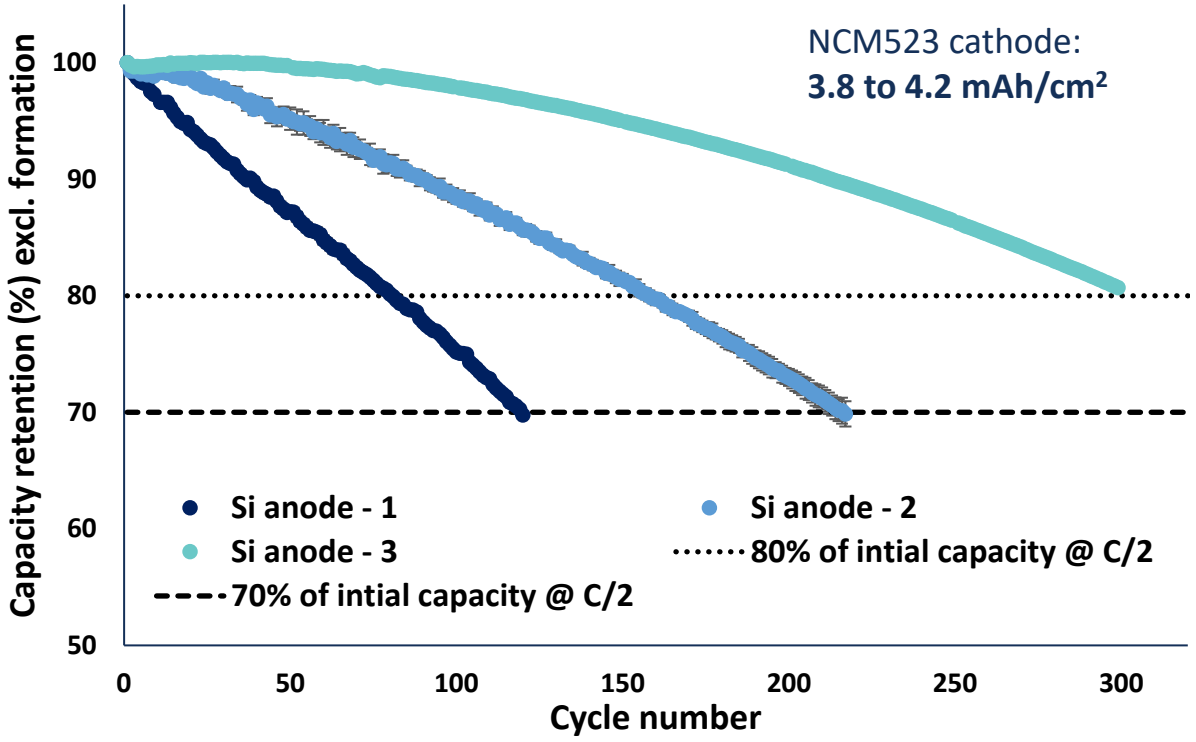
BASELINE DESIGN

Si anode - 3: ~980mAh/g @ C/20
Si anode - 2: ~800mAh/g @ C/20
Si anode - 1: ~727mAh/g @ C/20

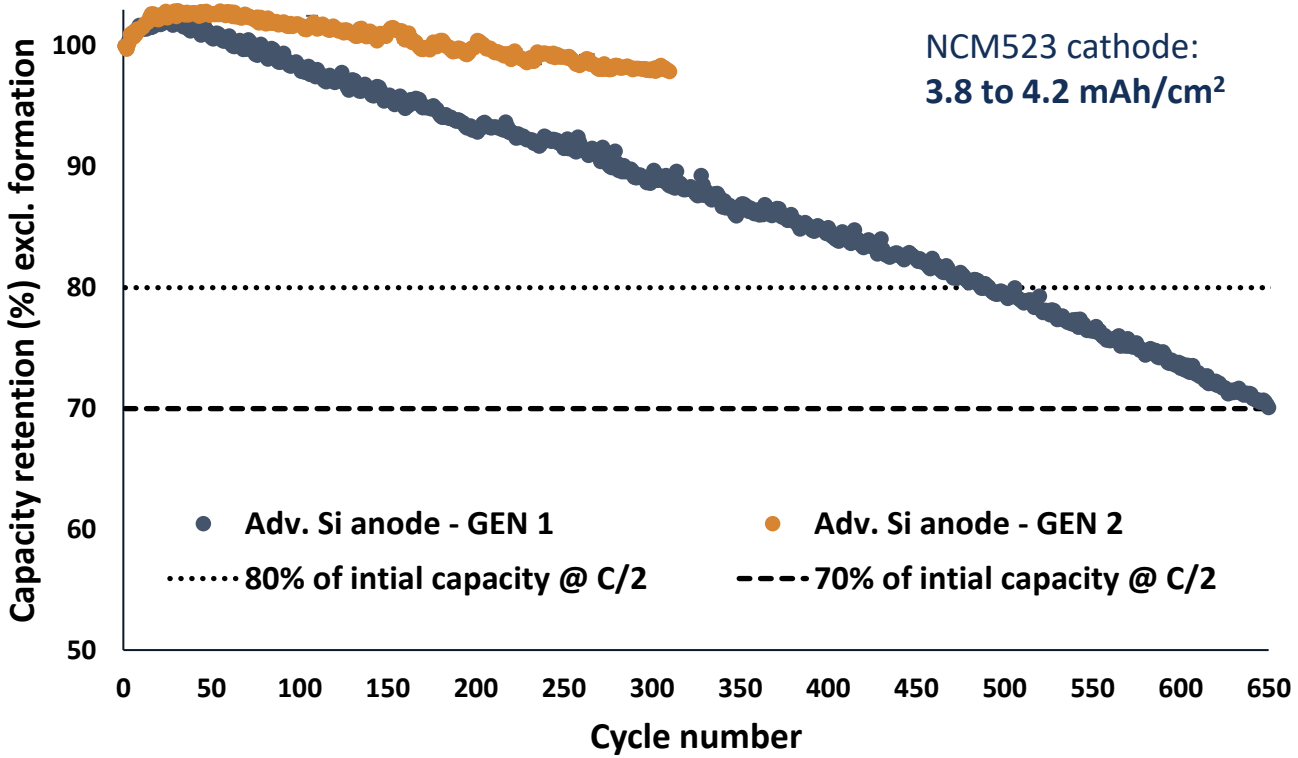
ADVANCED DESIGN **GEN 2:** ~800mAh/g @ C/20

2023 target design: **1000mAh/g @ C/20**

Full cell NCM 523 - Silicon anode (BASELINE DESIGN)



NCM 523 full cell - Silicon anode (ADVANCED DESIGN)



Business direction 2023

Scale-up of ANTEO X supply capacity

Seize opportunities to raise awareness

Establish global strategic partnerships

Establish presence in key geographies

THANK YOU

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