seevix spidersilk innovations

A spidersilk revolution

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March 2019


BBC
earth
UNPLUGGED

THE OUTSTANDING PROPERTIES OF SPIDERSILK

STRENGTH

6 times stronger than high tensile steel

of the same diameter

ELASTICITY

Stretches up to 35% without tearing

WEIGHT

1/5 the weight of high tensile steel

of the same diameter

DURABILITY

Chemically resilient & durable up to +230^{0} C

Spidersilk is applicable to

NUMEROUS INDUSTRIES

Medical & tissue engineering

Sports

Automotive/ Aerospace

Electronic Screens

3D printing

Defense

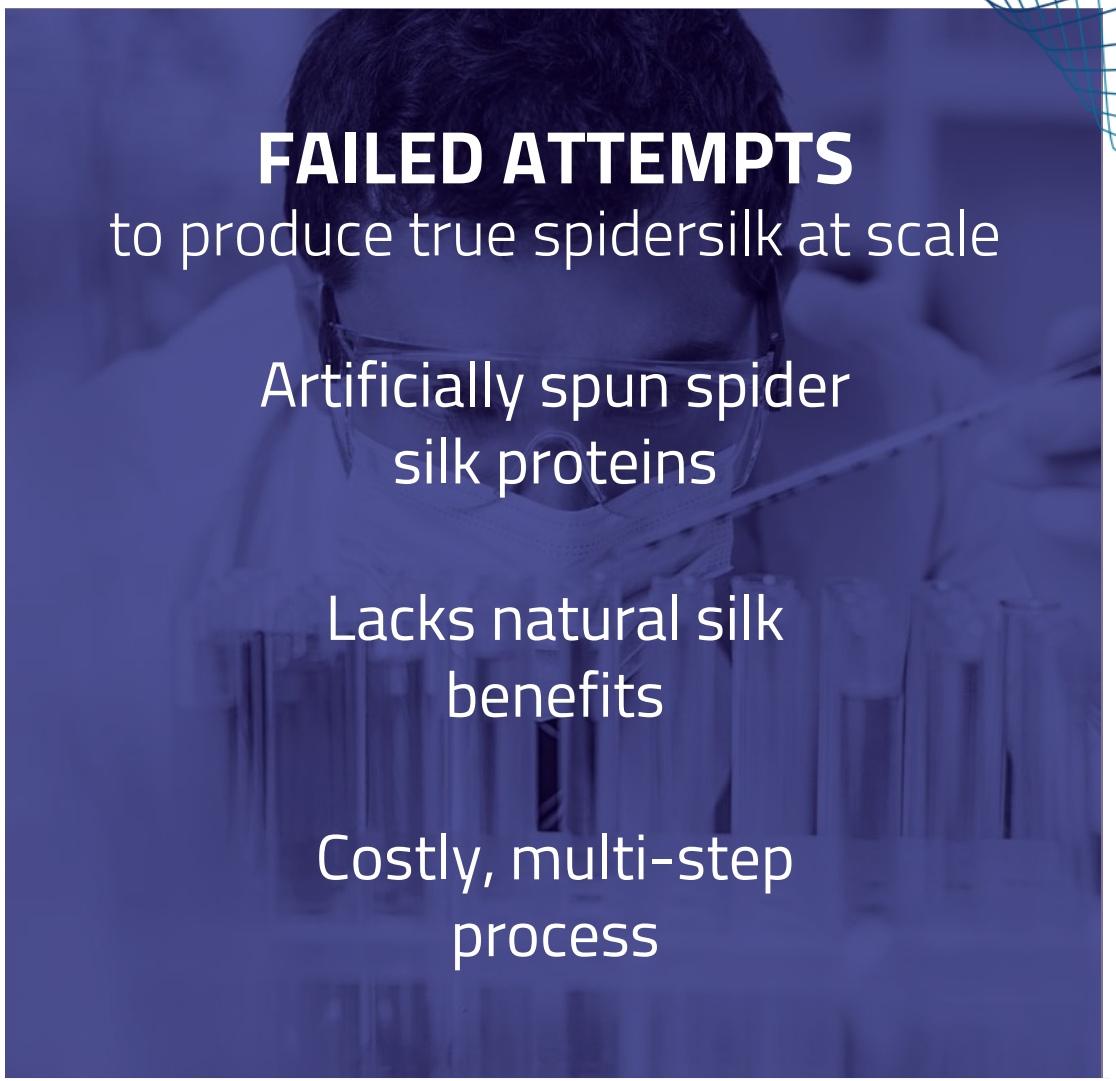
THE BARRIERS TO PRODUCING SPIDERSILK

SPIDERS ARE NOT
a cooperative workforce

Territorial

Cannibalistic

Limited supply of silk



FAILED ATTEMPTS
to produce true spidersilk at scale

Artificially spun spider silk proteins

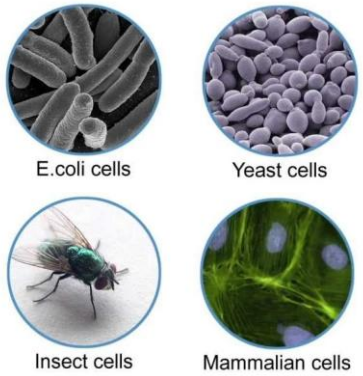
Lacks natural silk benefits

Costly, multi-step process

We take a different approach

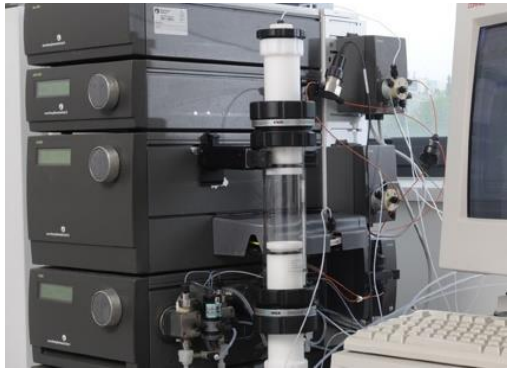
LETTING BIOLOGY DO THE WORK

Protein production



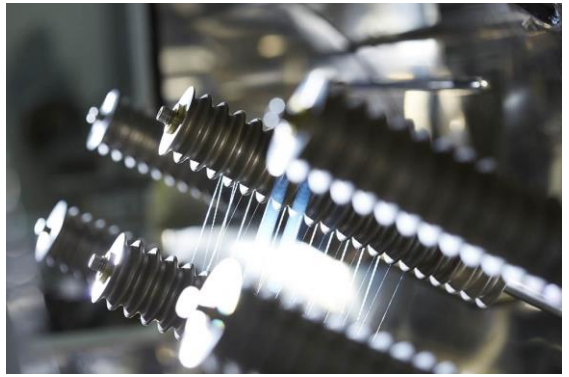
Step 1

Protein purification



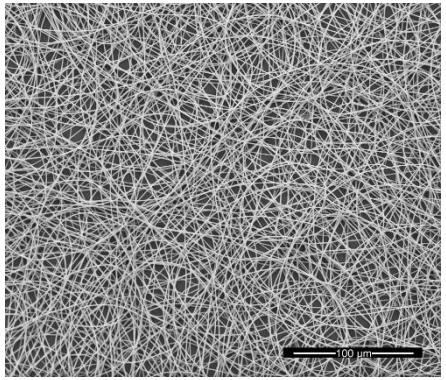
Step 2

Artificial spinning



Step 3

Fiber production



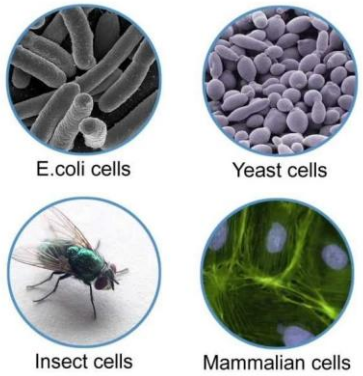
Step 4

We take a different approach

LETTING BIOLOGY DO THE WORK

Spontaneous self assembly

Protein production



Step 1

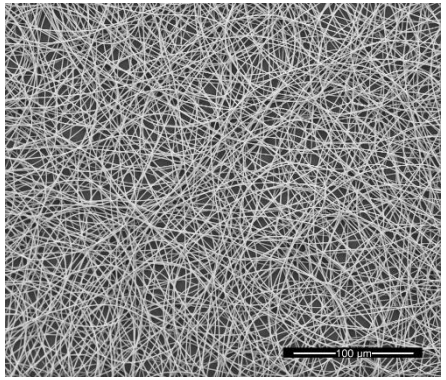
Protein purification

Step 2

Artificial spinning

Step 3

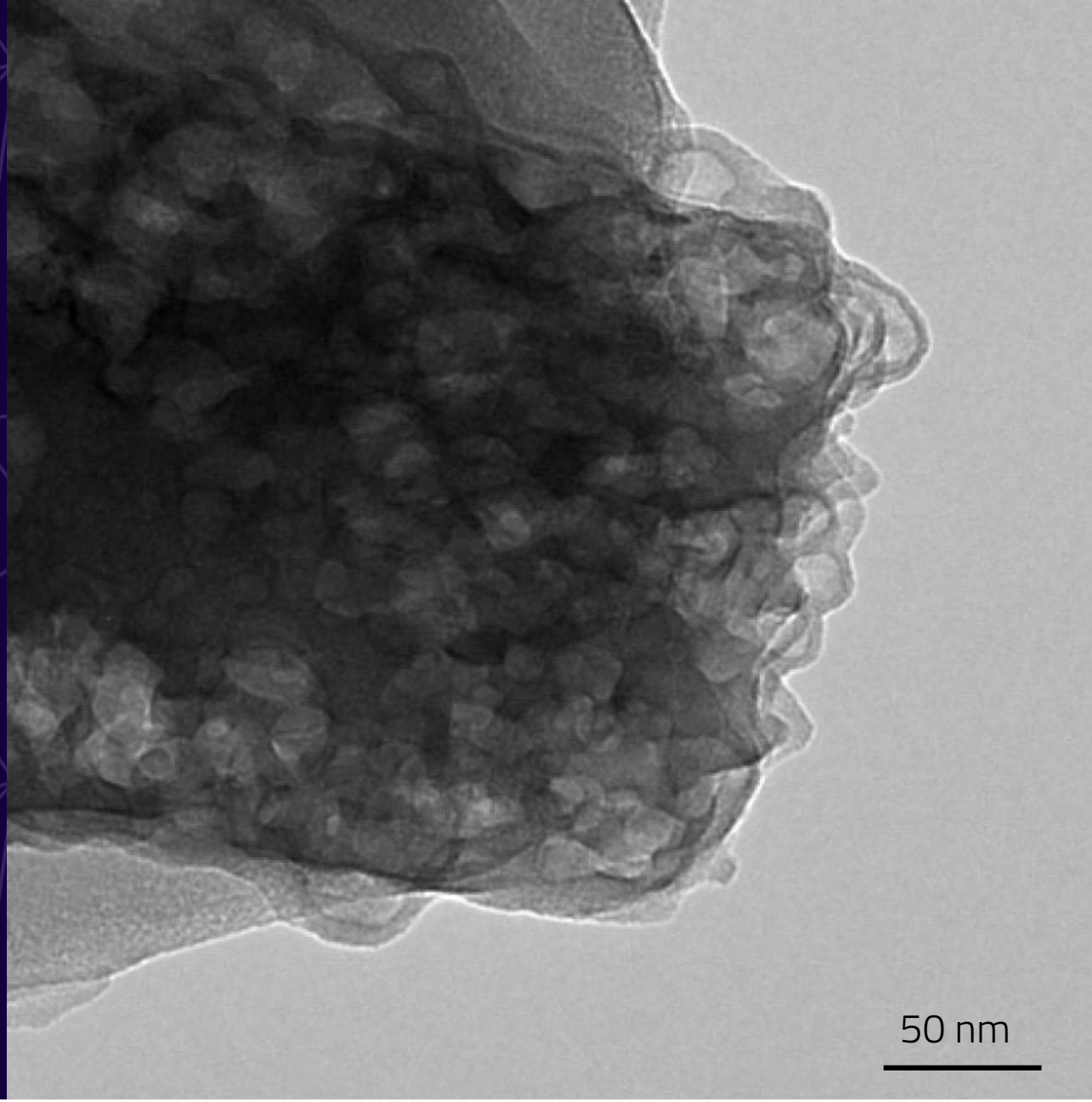
Fiber production

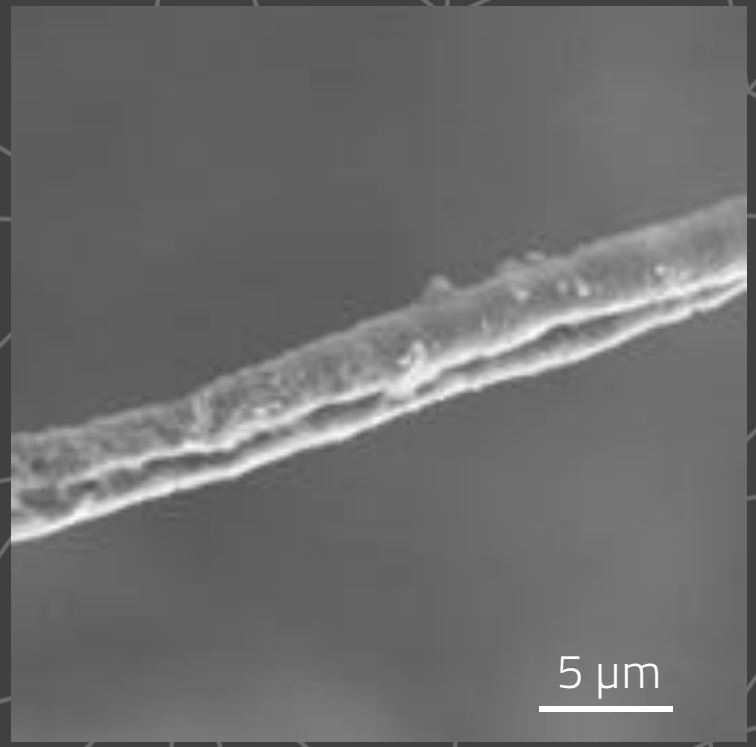


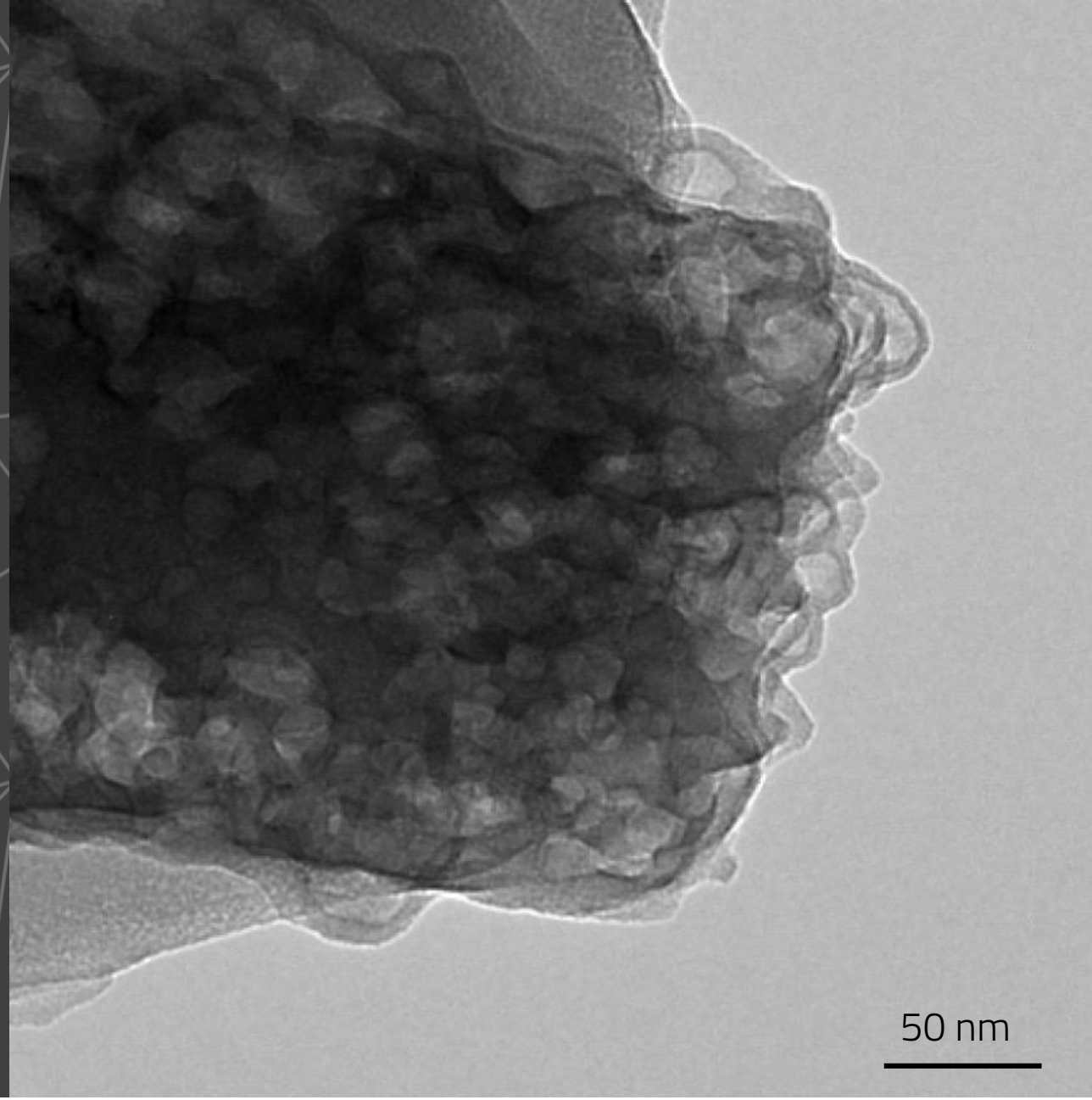
Step 4

Only one production step

SVX™

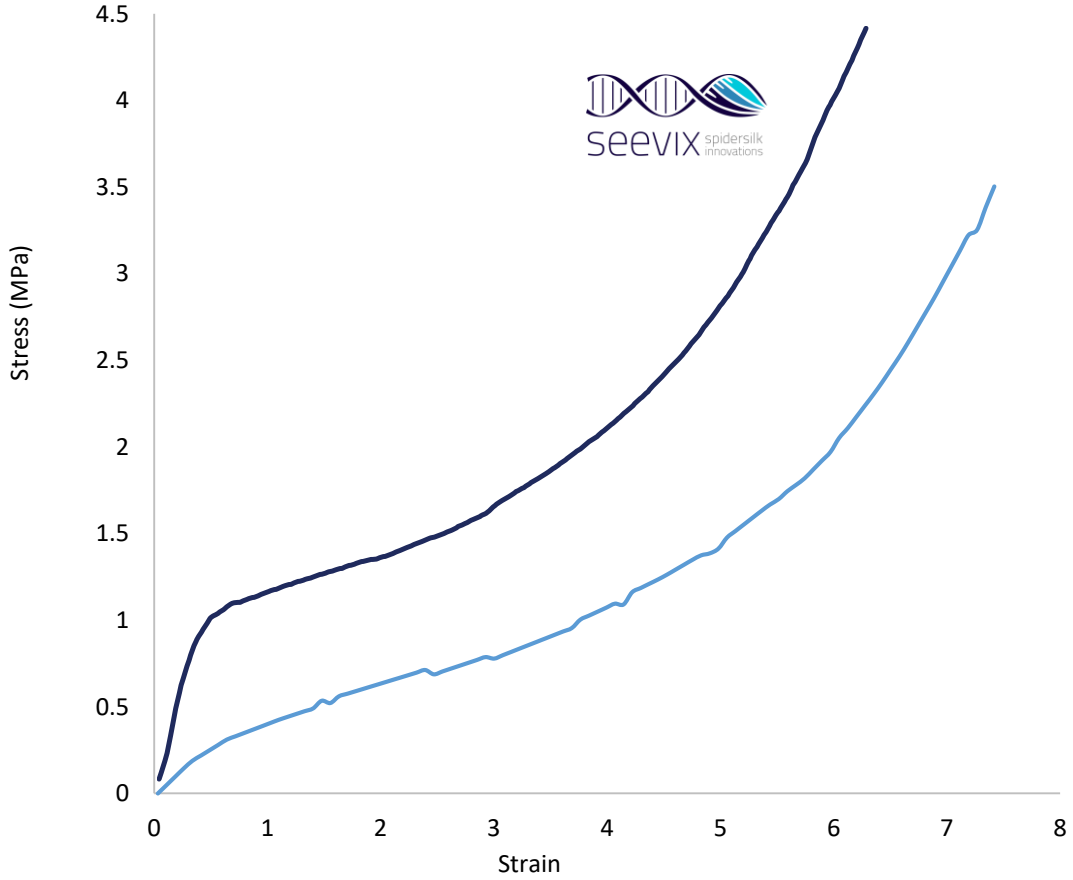



5 µm


50 nm

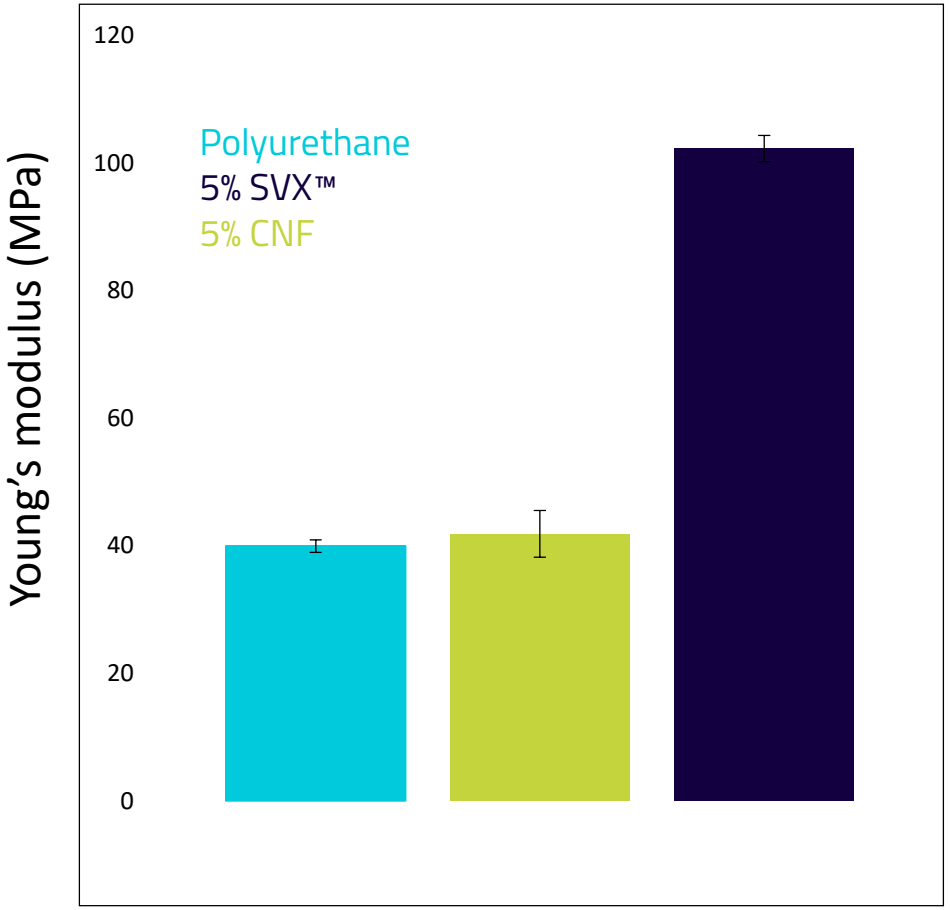
HIGH QUALITY COMPOSITE MATERIALS

Reinforced polymers with SVX

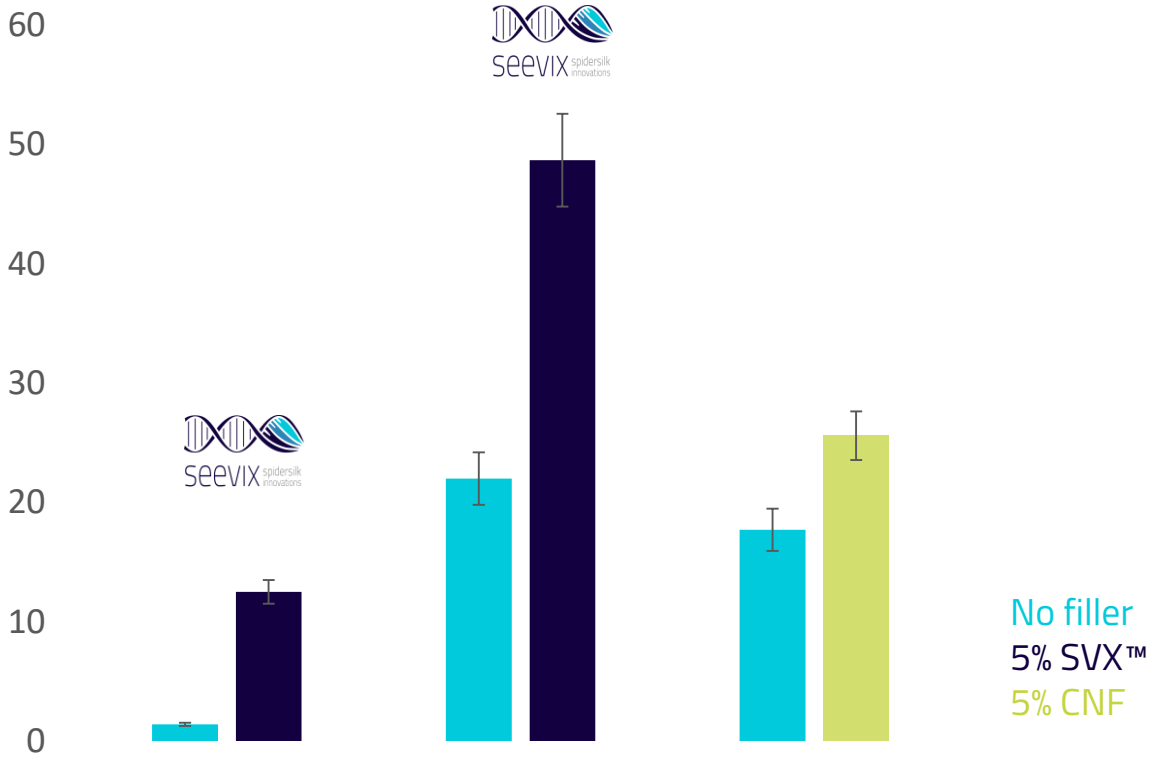


SVX™ IMPROVED MECHANICAL PROPERTIES

Outperforms cellulose fibers



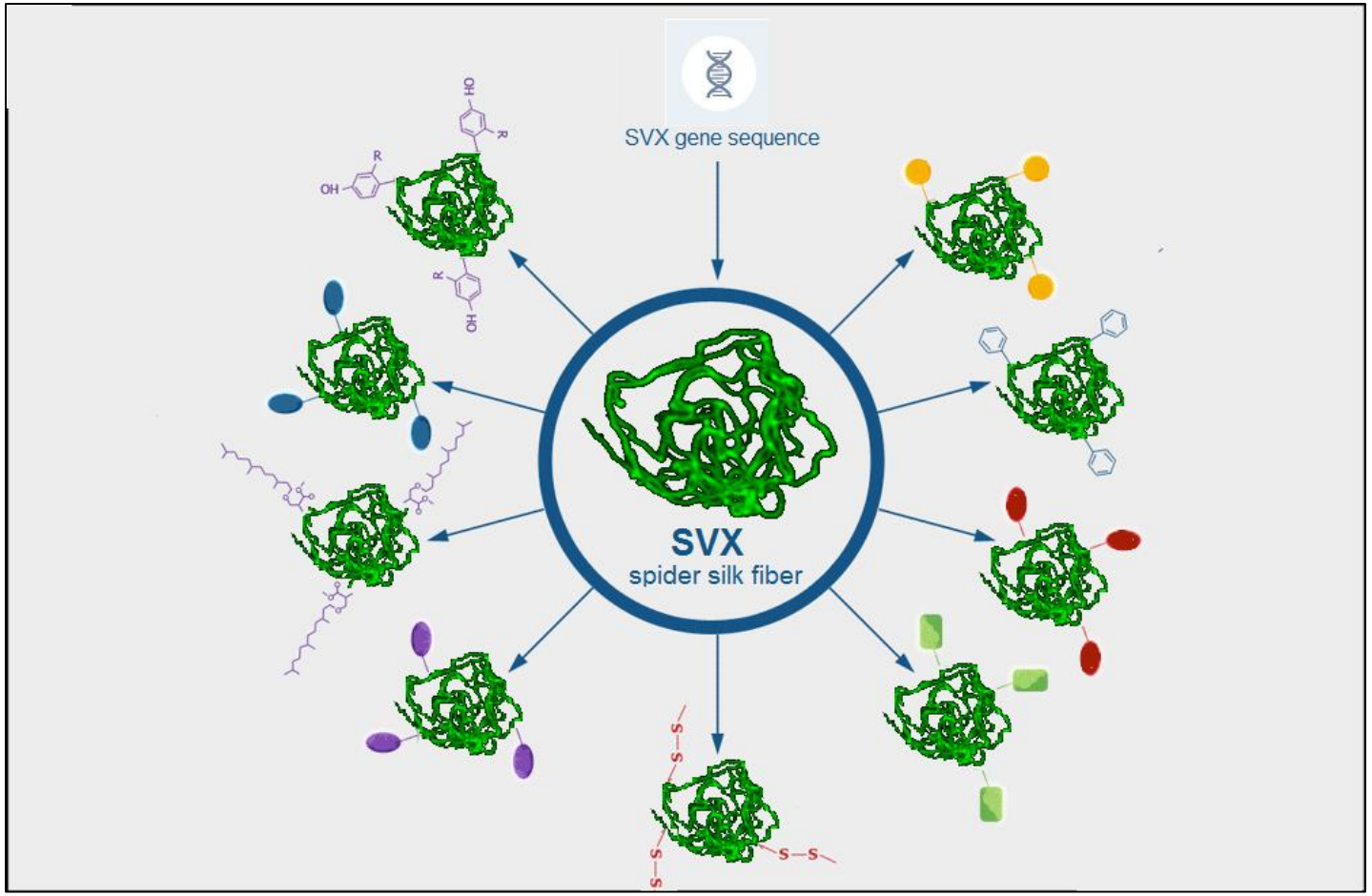
Tested at Seevix



Tested at collaborator

PIPELINE OF SVX™ FIBERS

SVX™ backbone can be treated to form tailor-made properties for enhanced interaction with specific polymers



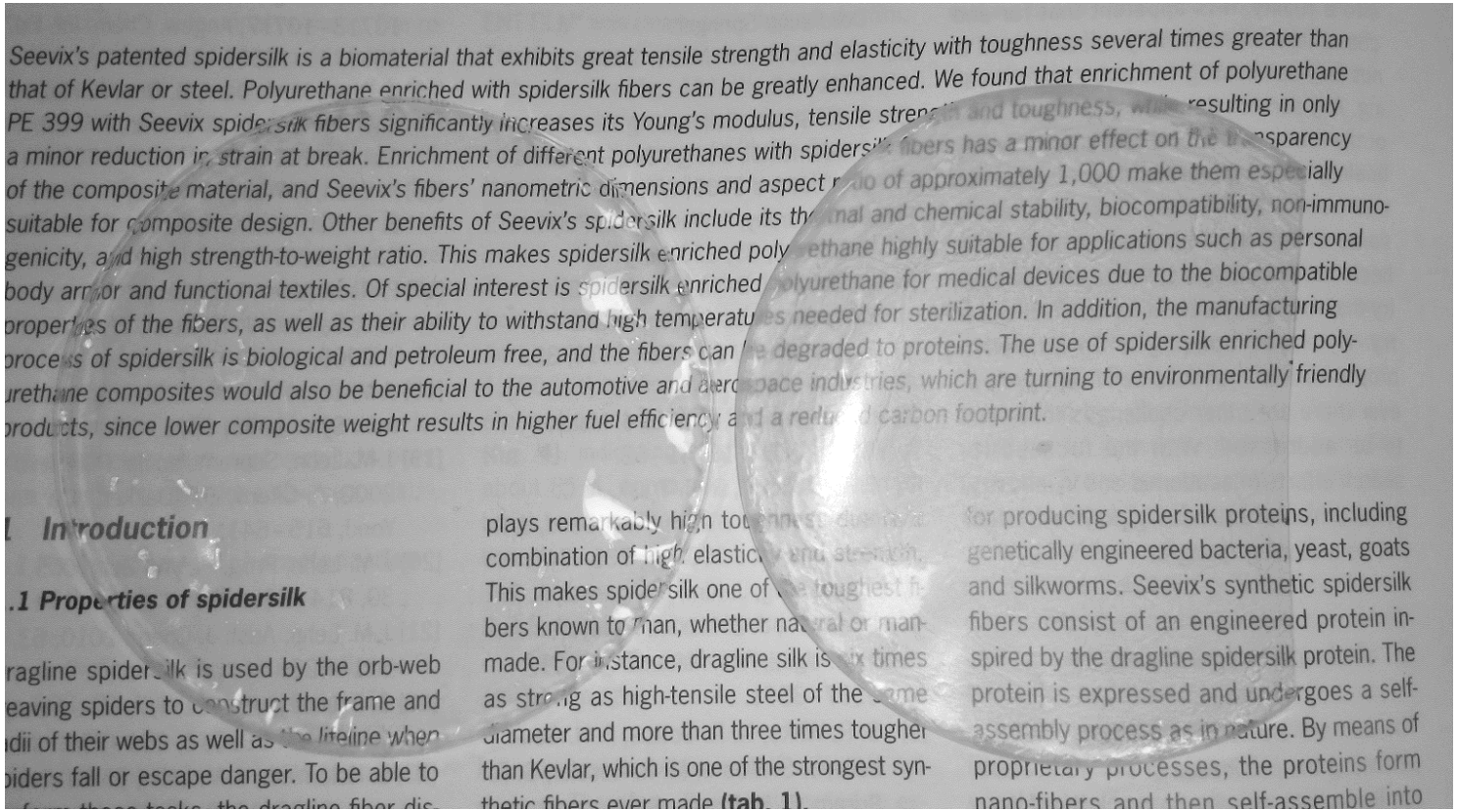
There are endless possibilities of manipulations to the fibers' backbone to expand a pipeline of patented SVX fibers targeted towards specific polymers

SVX™ OPTICAL BENEFITS

Minor transparency change of SVX™-enriched films

Polyurethane film without SVX™

Polyurethane film enriched with 20% SVX™



Seevix's patented spidersilk is a biomaterial that exhibits great tensile strength and elasticity with toughness several times greater than that of Kevlar or steel. Polyurethane enriched with spidersilk fibers can be greatly enhanced. We found that enrichment of polyurethane PE 399 with Seevix spidersilk fibers significantly increases its Young's modulus, tensile strength and toughness, while resulting in only a minor reduction in strain at break. Enrichment of different polyurethanes with spidersilk fibers has a minor effect on the transparency of the composite material, and Seevix's fibers' nanometric dimensions and aspect ratio of approximately 1,000 make them especially suitable for composite design. Other benefits of Seevix's spidersilk include its thermal and chemical stability, biocompatibility, non-immunogenicity, and high strength-to-weight ratio. This makes spidersilk enriched polyurethane highly suitable for applications such as personal body armor and functional textiles. Of special interest is spidersilk enriched polyurethane for medical devices due to the biocompatible properties of the fibers, as well as their ability to withstand high temperatures needed for sterilization. In addition, the manufacturing process of spidersilk is biological and petroleum free, and the fibers can be degraded to proteins. The use of spidersilk enriched polyurethane composites would also be beneficial to the automotive and aerospace industries, which are turning to environmentally friendly products, since lower composite weight results in higher fuel efficiency and a reduced carbon footprint.

1 Introduction

1.1 Properties of spidersilk

Dragline spidersilk is used by the orb-web weaving spiders to construct the frame and radii of their webs as well as the lifeline when spiders fall or escape danger. To be able to

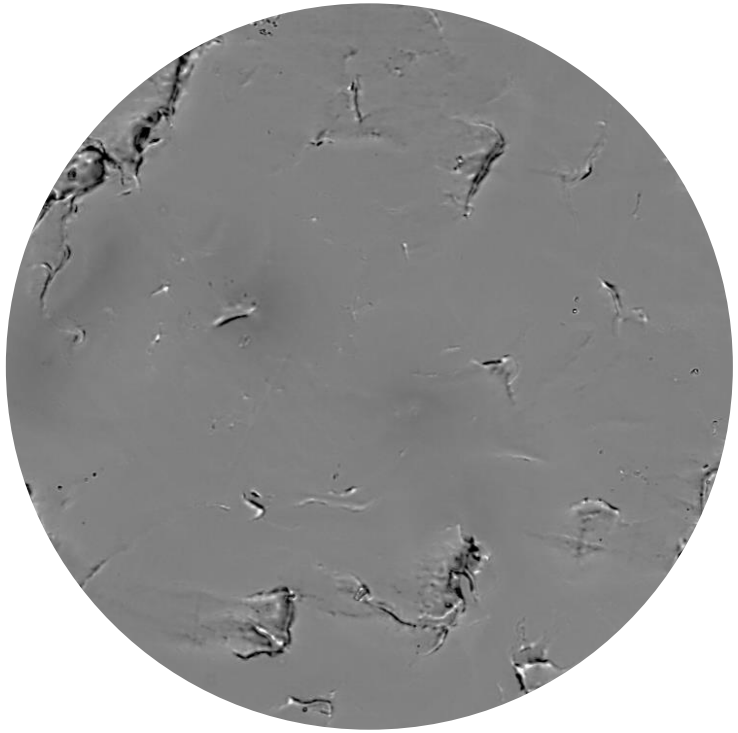
plays remarkably high toughness due to a combination of high elasticity and strength. This makes spidersilk one of the toughest fibers known to man, whether natural or man-made. For instance, dragline silk is six times as strong as high-tensile steel of the same diameter and more than three times tougher than Kevlar, which is one of the strongest synthetic fibers ever made (tab. 1).

for producing spidersilk proteins, including genetically engineered bacteria, yeast, goats and silkworms. Seevix's synthetic spidersilk fibers consist of an engineered protein inspired by the dragline spidersilk protein. The protein is expressed and undergoes a self-assembly process as in nature. By means of proprietary processes, the proteins form nano-fibers and then self-assemble into

SVX™ COATING OF POLYURETHANE

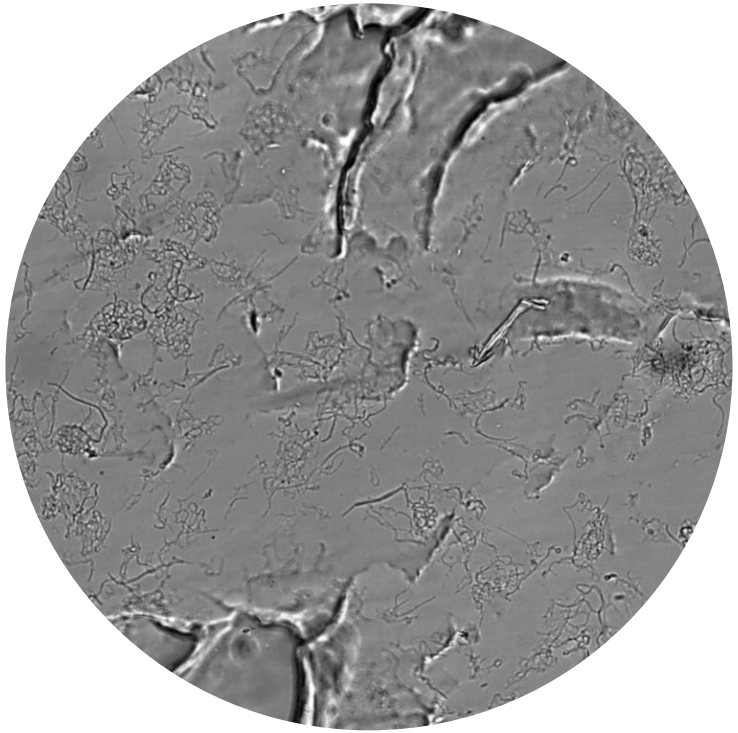
Different concentrations controlled thickness

Polyurethane without SVX™



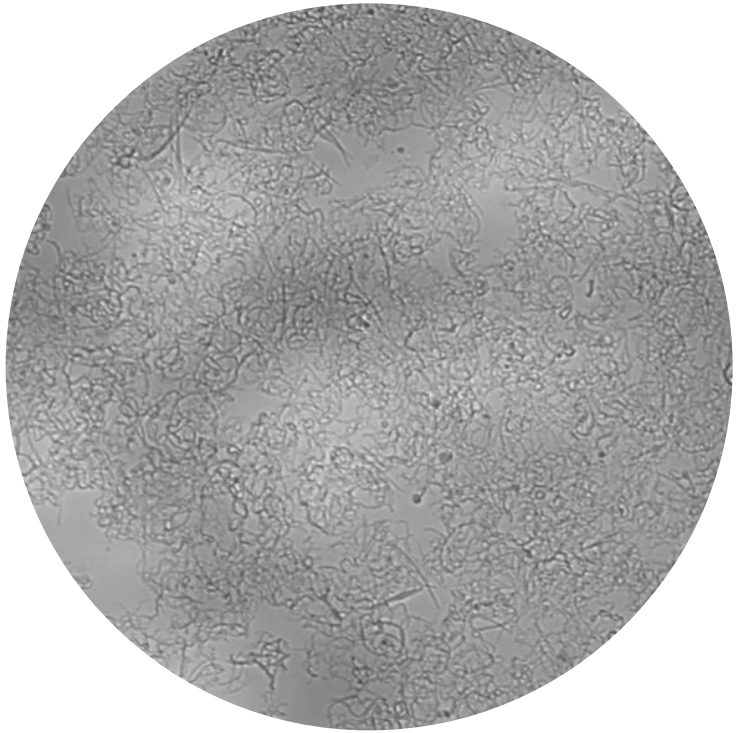
100 µm

Polyurethane treated with SVX™ (low concentration)



100 µm

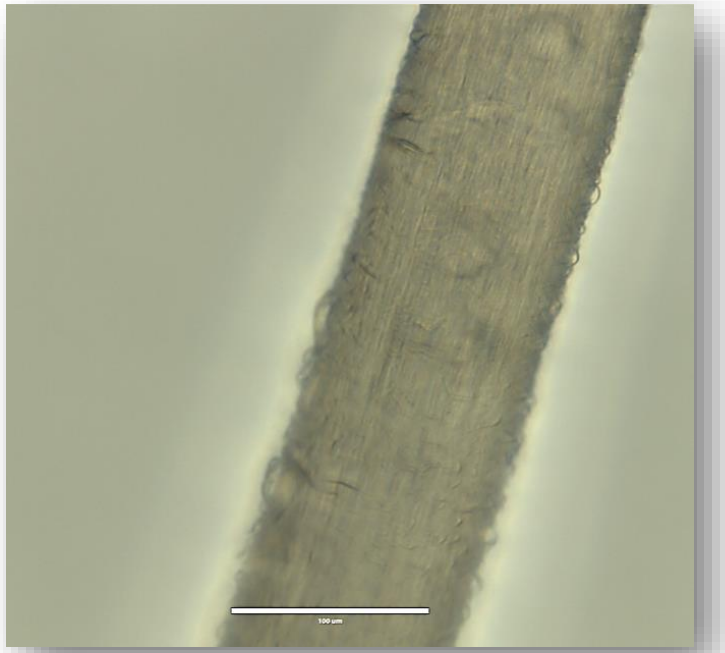
Polyurethane treated with SVX™ (high concentration)

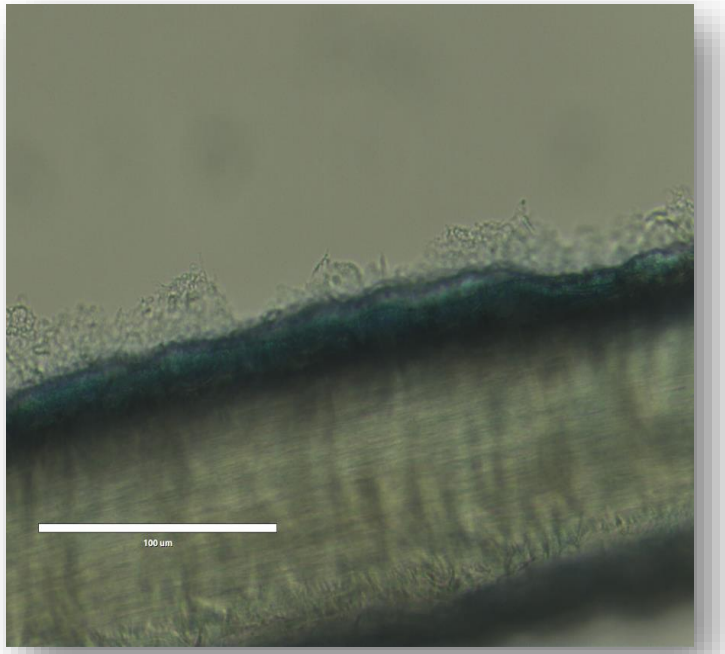


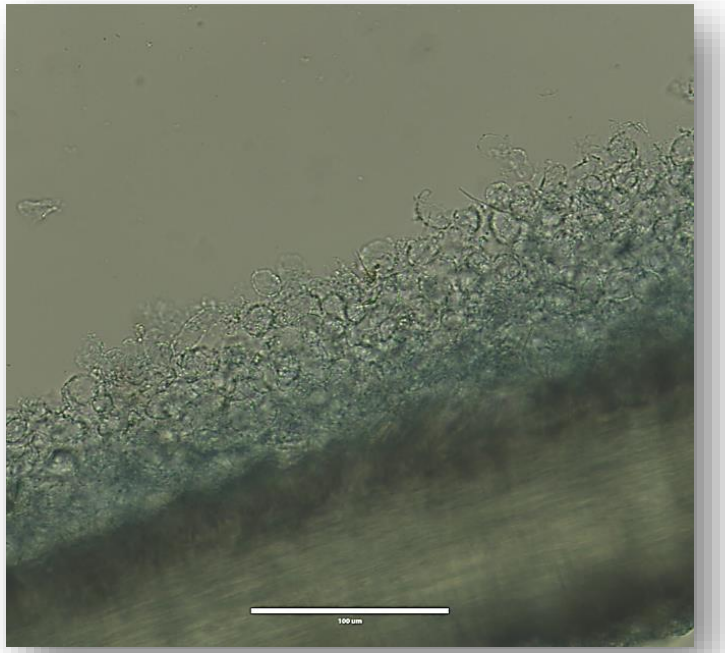
100 µm

SVX™ ADHESION AND COATING

Number of residues on SVX™ surface can be optimized to achieve thickness of coating

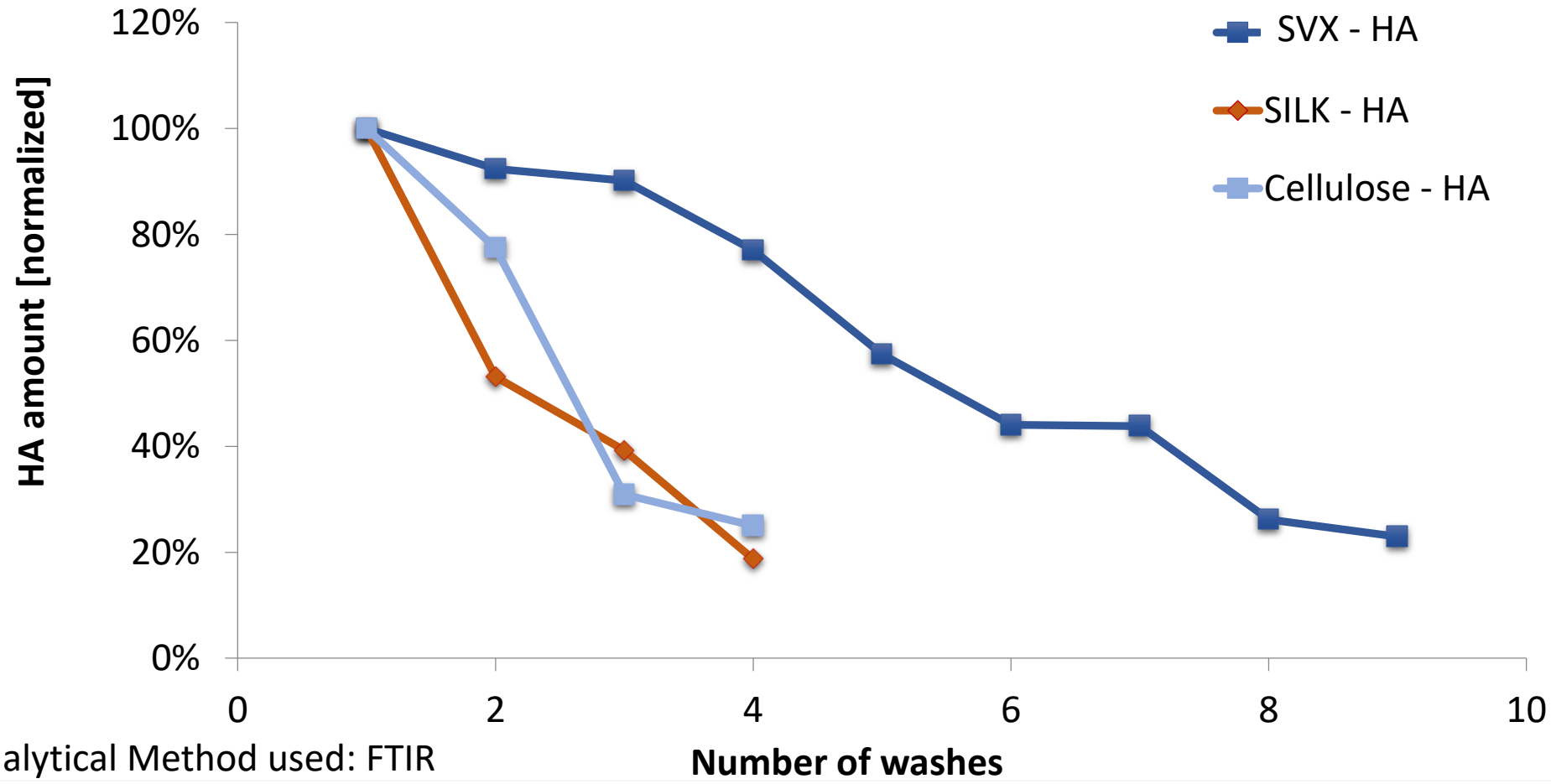






SVX RELEASE KINETICS BENEFITS

BETTER RELEASE OF HYALURONIC ACID OVER TIME COMPARED TO SILK AND CELLULOSE



*Analytical Method used: FTIR

A PERFECT FIT FOR MEDICAL PRODUCTS

BIOCOMPATIBLE

Accelerates cell proliferation and tissue growth, faster healing process, no corrosion in the body

NON-IMMUNOGENIC

Expected to be safe

3D "SPONGE-LIKE" STRUCTURE

Possible loading for controlled drug release

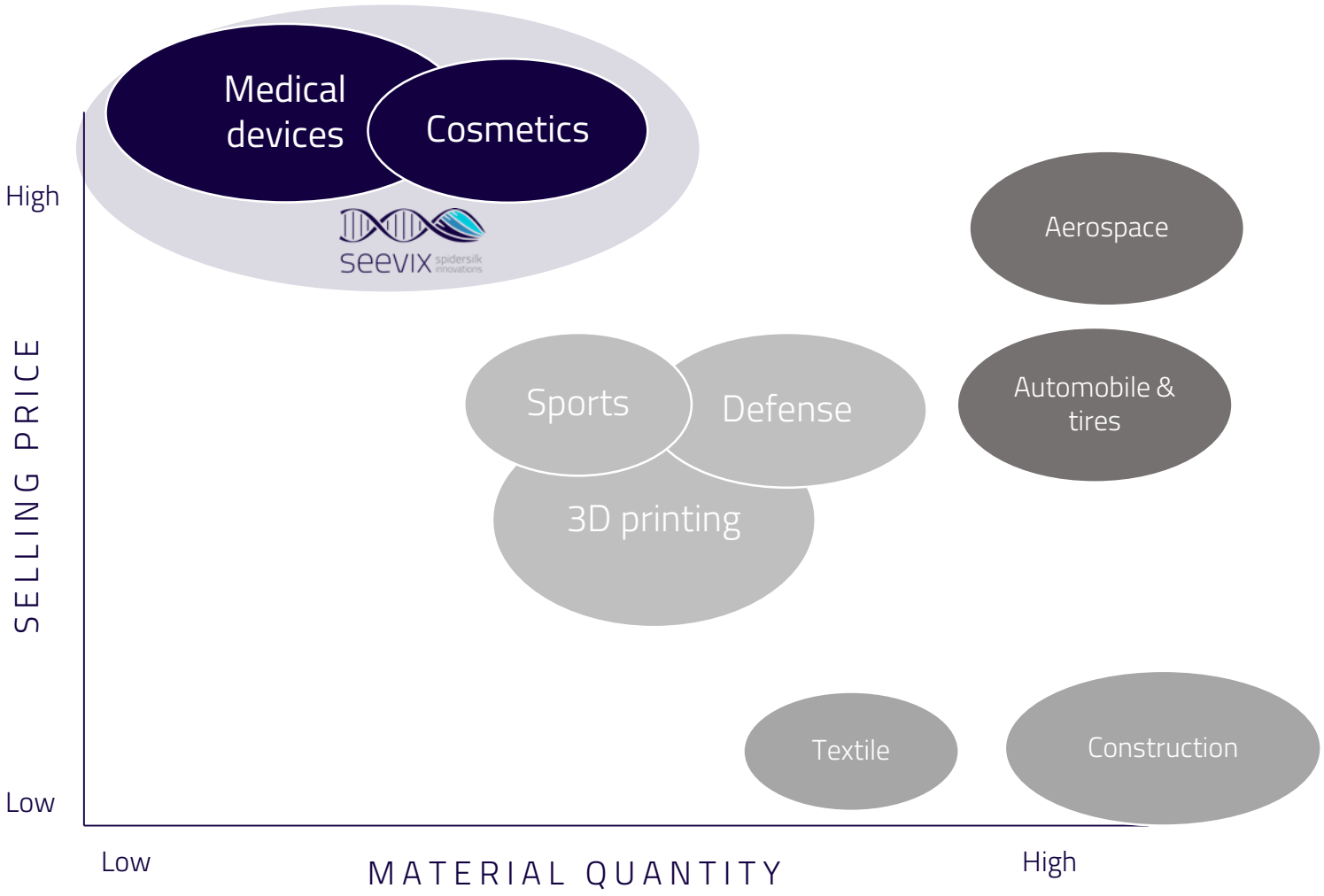
DURABLE

Withstands sterilization process

STRONG & ELASTIC

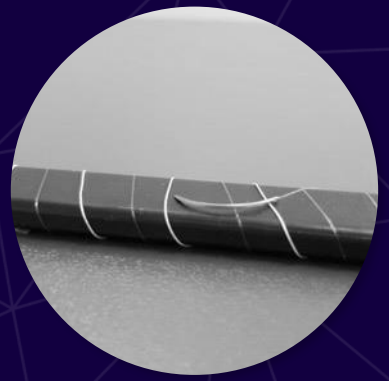
Withstands pressure, tension and movement

HEALTHCARE – HIGH VALUE, SMALL QUANTITY



SVX™ ENRICHED MEDICAL PRODUCTS

1 GRAM OF SVX™



30 balloons
Intra-aortic balloon*

1,000 sutures
Surgical sutures*

STRONGER
less likely to rupture or fail

ELASTIC AND DURABLE
withstanding the wear and tear of natural movement

THINNER
less invasive, speeding procedures

BIO-COMPATIBLE
conducting nutrients and speeding up healing process

Already on the market

3D CELL CULTURE APPLICATIONS

SVXgro™

Combines scaffold-free and scaffold-based advantages for 3D tissue-culture

Launched in Japan in 2018

3D cell cultures

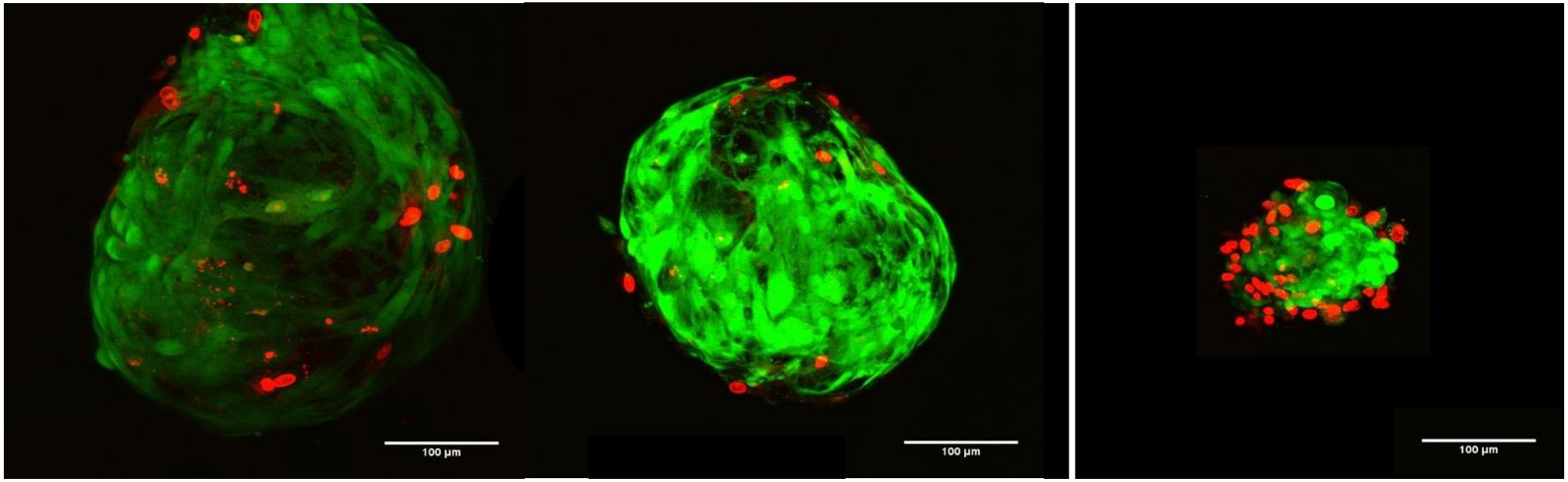
provide the requisite microenvironment for the study of cell morphology, proliferation, viability and overall cell behavior

Beyond compatibility

IMPROVED STEM CELL VITALITY

With 4 ng SVXgro

Without SVXgro



Live cells Dead cells

SURGICAL SUTURES | R&D

Reaching the hands of every surgeon

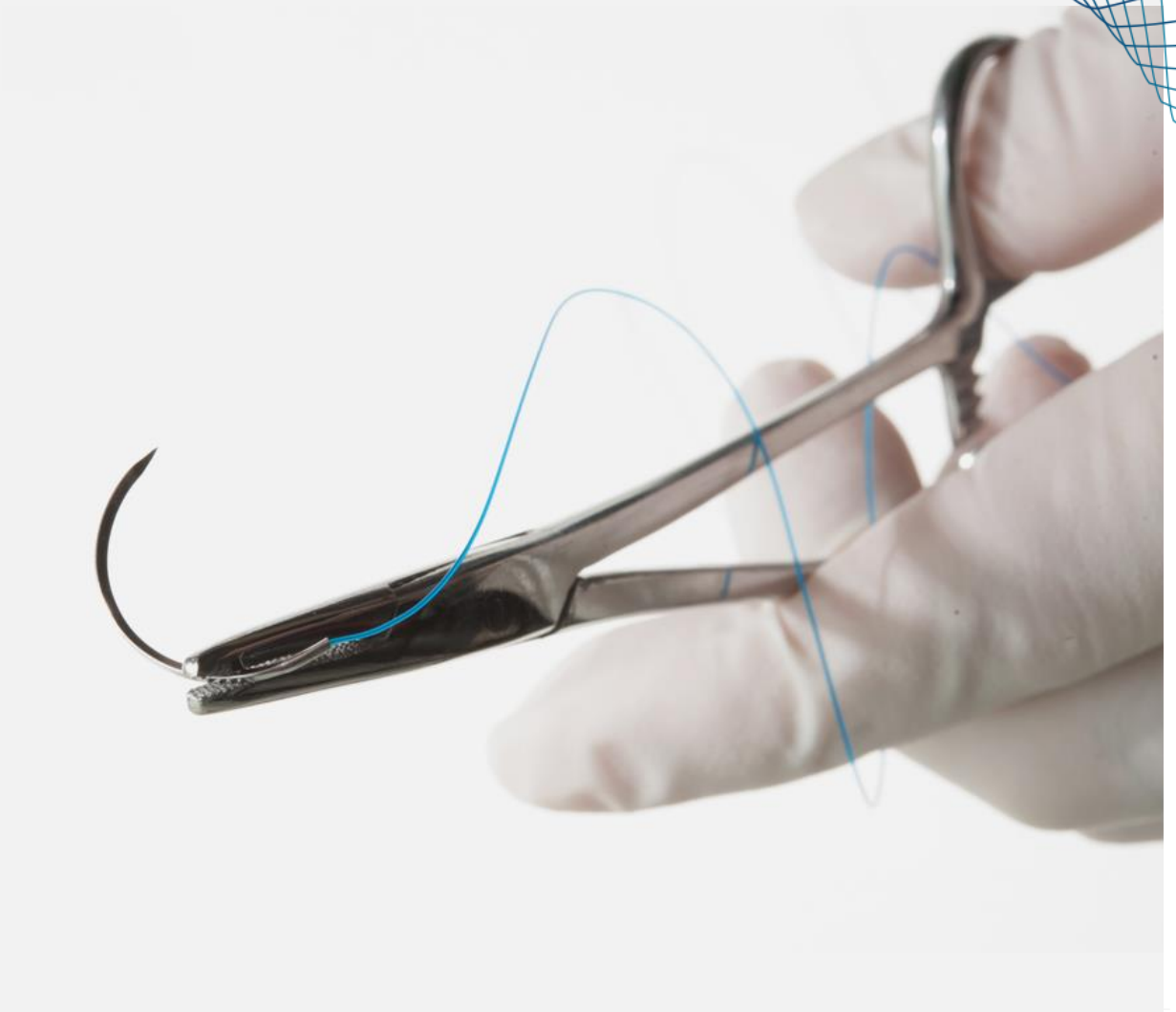
Sutures Market

$4.6B

By 2022

Suited for cosmetic, neuro, ophthalmic, vascular and microsurgery

- Thinner (5-0) and 40% stronger (4-0) suture
- No adverse effects according to *in vivo* pathology/toxicology testing in mice
- Positive handling feedback from surgeons
- A 12-month 510K path for our sutures
- Market launch expected in 2020



TISSUE ENGINEERING | PIPELINE

Trailblazing cutting-edge products

Tissue Engineering Market

$12B

By 2022

Tissue engineering combines cells and materials to replace natural tissues

Bio-scaffolding involves the use of a tissue scaffold for the generation of new viable tissue for medical purposes.

The ability to build patient specific implants has made 3D printing technology revolutionary in the medical field.

Bio-scaffolding

3D bioprinting

DEVELOPMENT ROAD MAP

SCALABLE BIOTECH PRODUCTION SYSTEM

Enabled by our unique manufacturing process

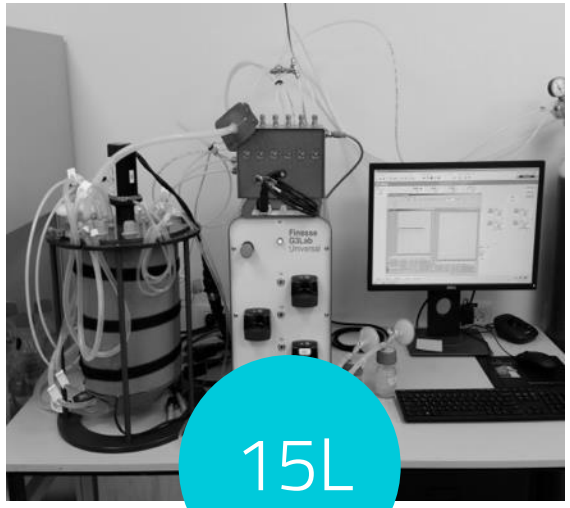
From grams to kilograms per year:

- High yields
- Easy set-up and maintenance

Flasks

2.5L

Prototype bioreactor



15L

Commercial bioreactor

200L

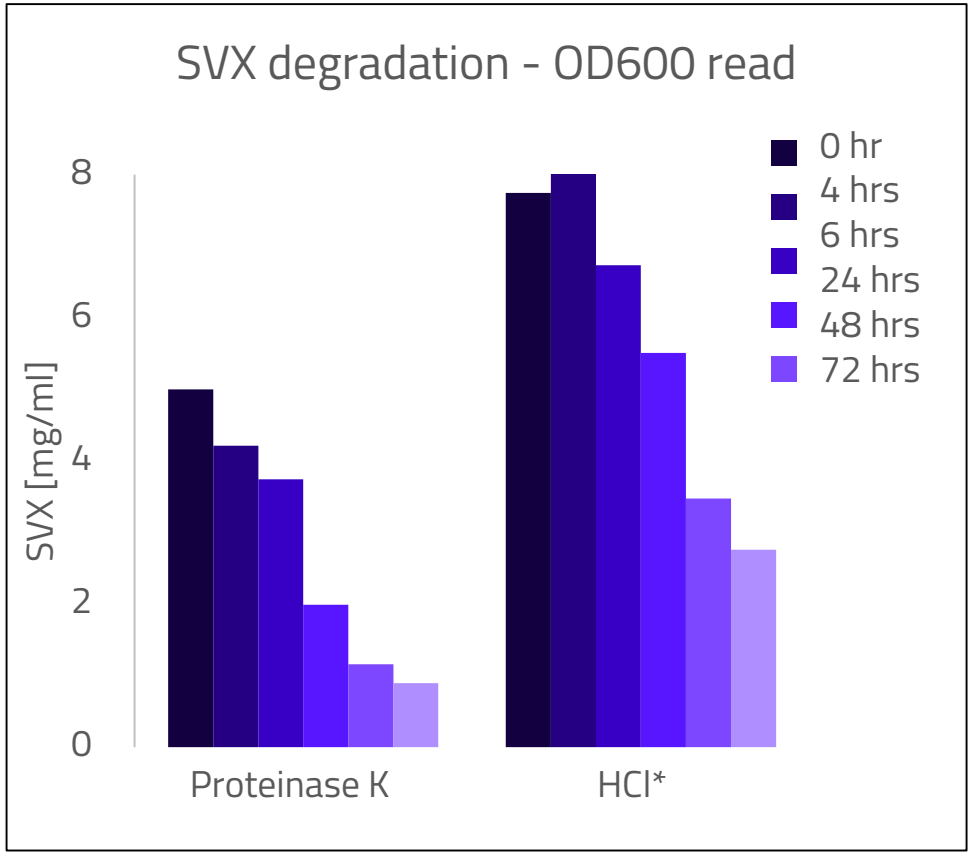
SVX™ IS ECO-FRIENDLY

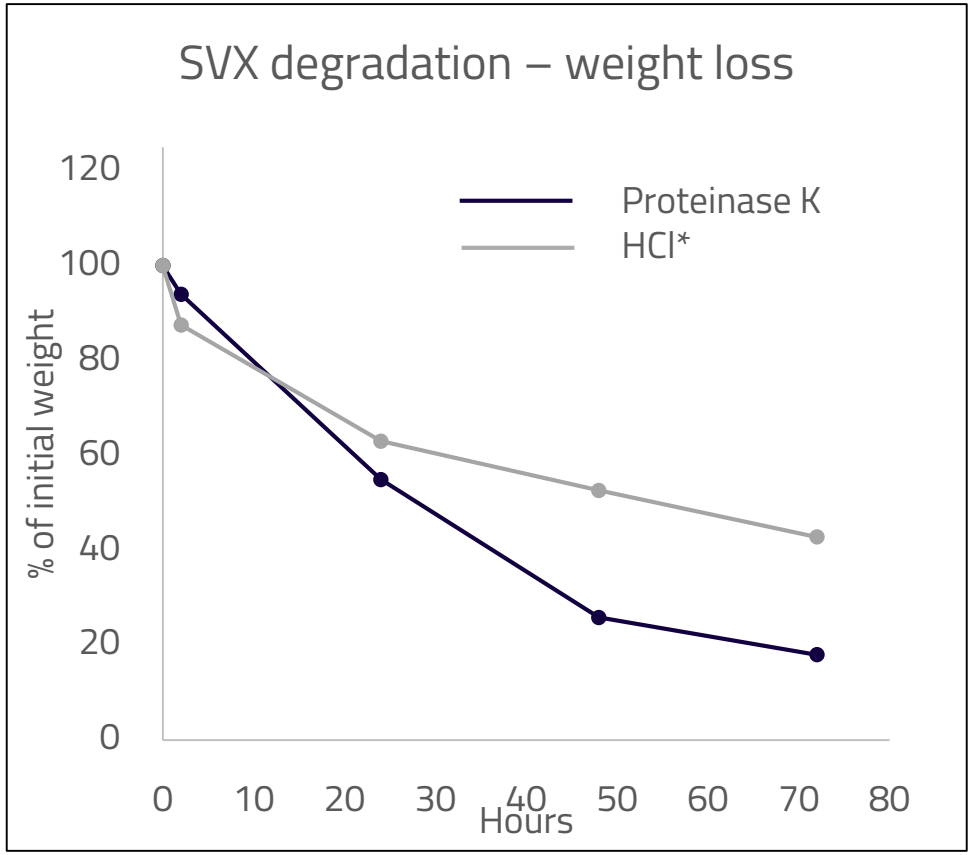
Sustainable, degradable, petroleum-free

	Seevix contribution	Outcome
Product	Strong and lightweight fiber	Stronger lighter parts entail less energy consumption
Product Life cycle	Fiber is a bio-polymer, not synthetic	Fibers can be degraded to proteins and even used as fertilizers
Production process	• Manufacturing process - genetically engineered biological method • No use of synthetic chemistry Purification - Simple, one-step using nonpolluting material • No need for complex analytical and preparative methods using various chemicals	Environmentally friendly (green) process

SVX™ IS EASY TO RECYCLE

Strong, elastic, chemically resilient, thermally stable biopolymer yet bio-degradable





*HCl treatment: 3M

A BRIEF HISTORY

THE HEBREW UNIVERSITY OF JERUSALEM

2002 to 2013

- Research
- Know-how
- Patent granted

seevix spidersilk innovations

Founded 2014

- Proprietary intellectual property portfolio
  - Licensed Hebrew University patent
  - Additional patent applications in national phase
- Multidisciplinary R&D team: biologists, chemists, engineers
- Advisors: key opinion leaders across the board
- Funding by private investors and Israel's Innovation Authority

MANAGEMENT TEAM

Shlomzion Shen
Ph.D, MBA
CEO

Noa Hadar
Ph.D
COO

Total headcount:
15 employees

Alon Meir
Ph.D
VP R&D

Ella Sklan
Ph.D
VP Biology applications

R&D headcount:
12 employees
8 Ph.D