

Medical Device Sterilization: **Broadening the Possibilities** September 24-25, 2024

Title: Supercritical Carbon Dioxide Sterilization

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AGENDA

- The Problems scCO₂ Sterilization Solves
- Technology Overview
- Applications
- Method of Action
- Kill Kinetics
- NovaSterilis Company Overview

The Problems scCO₂ Solves

1. Material Compatibility
 - a. EtO and gamma don't work - generally new products and biologics
2. Improve Functionality
 - a. Traditional method works, but scCO₂ improves performance - existing commercial products
3. Lowering Operational costs
 - a. Total cost and short turnaround times



Regulatory Experience

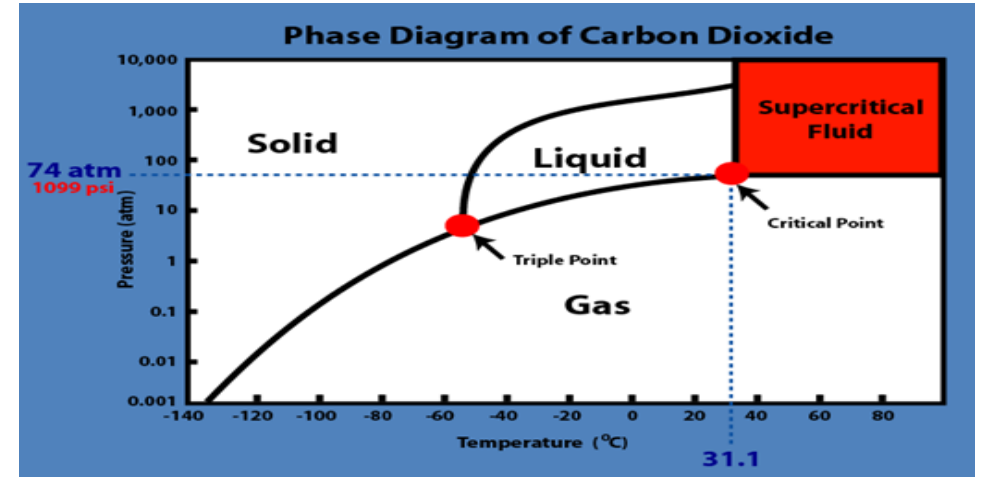
- Regulatory body clearances in Australia (TGA), U.S. (FDA), and Europe
- FDA Innovation Challenge Grant (2019)
 - Standing FDA meeting every 6 weeks
- 4 - 510(k) clearances, 1 - EUA, 1 - therapeutic approved in Europe, multiple European device registrations and TGA approvals



- ISO Standards
 - Sterilization - ISO-14937
 - BI - ISO-11138

scCO₂ Technology Platform

- Supercritical phase
 - Diffusivity of a Gas
 - Density of a Liquid
- Synergistic entrainers drive utility
 - Sterilization, Decellularization, Cleaning, Impregnating bioactives
- Process materials dry, hydrated, liquid

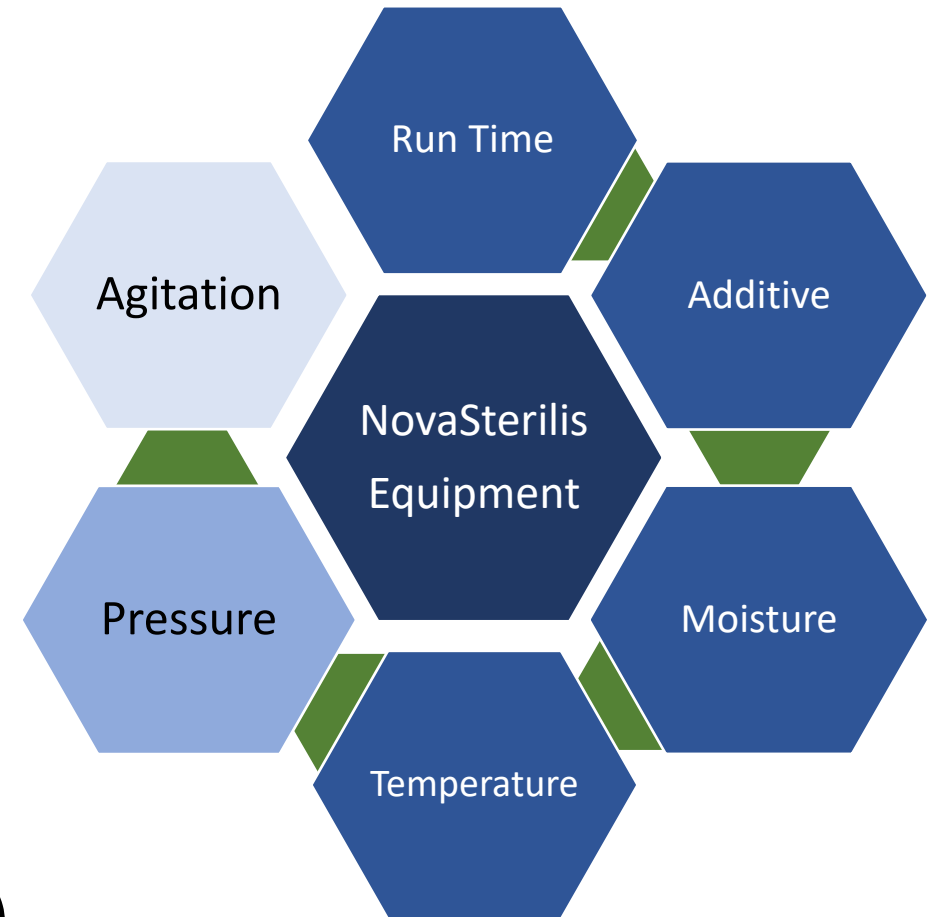


16 hour
Phenol Red Soak

1 hour
Phenol Red + scCO₂

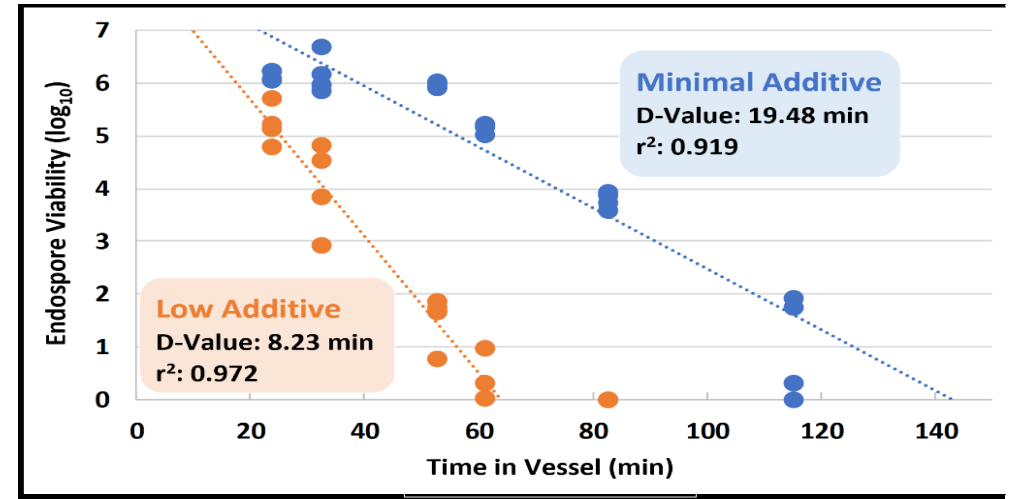
Critical Parameters

- Critical process parameters:
- Parameters optimized to preserve functionality
- Process materials in dry, hydrated, liquid state
- Models: In service: 20L - 100L, 540L; Designed: 2,000L, 10m³
- Touchscreen automation (temperature, pressure, fill/empty rate, stir speed, time)



Kill Kinetics and Linearity

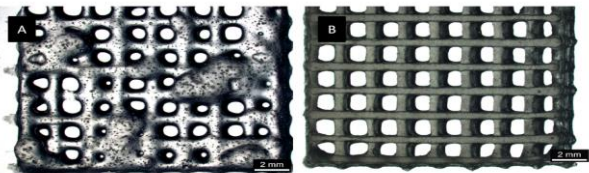
- Nova Process provides predictable linear kill kinetics under standard conditions
- *D* value tuned via critical parameters
 - Additive amount impacts *D* value
 - *D* value varies by material



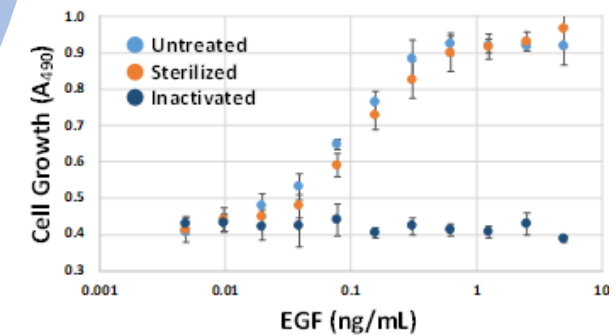
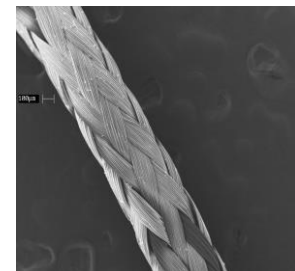
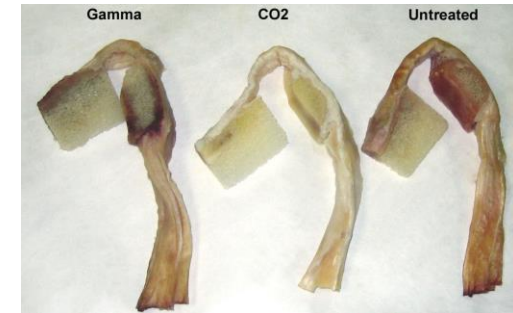
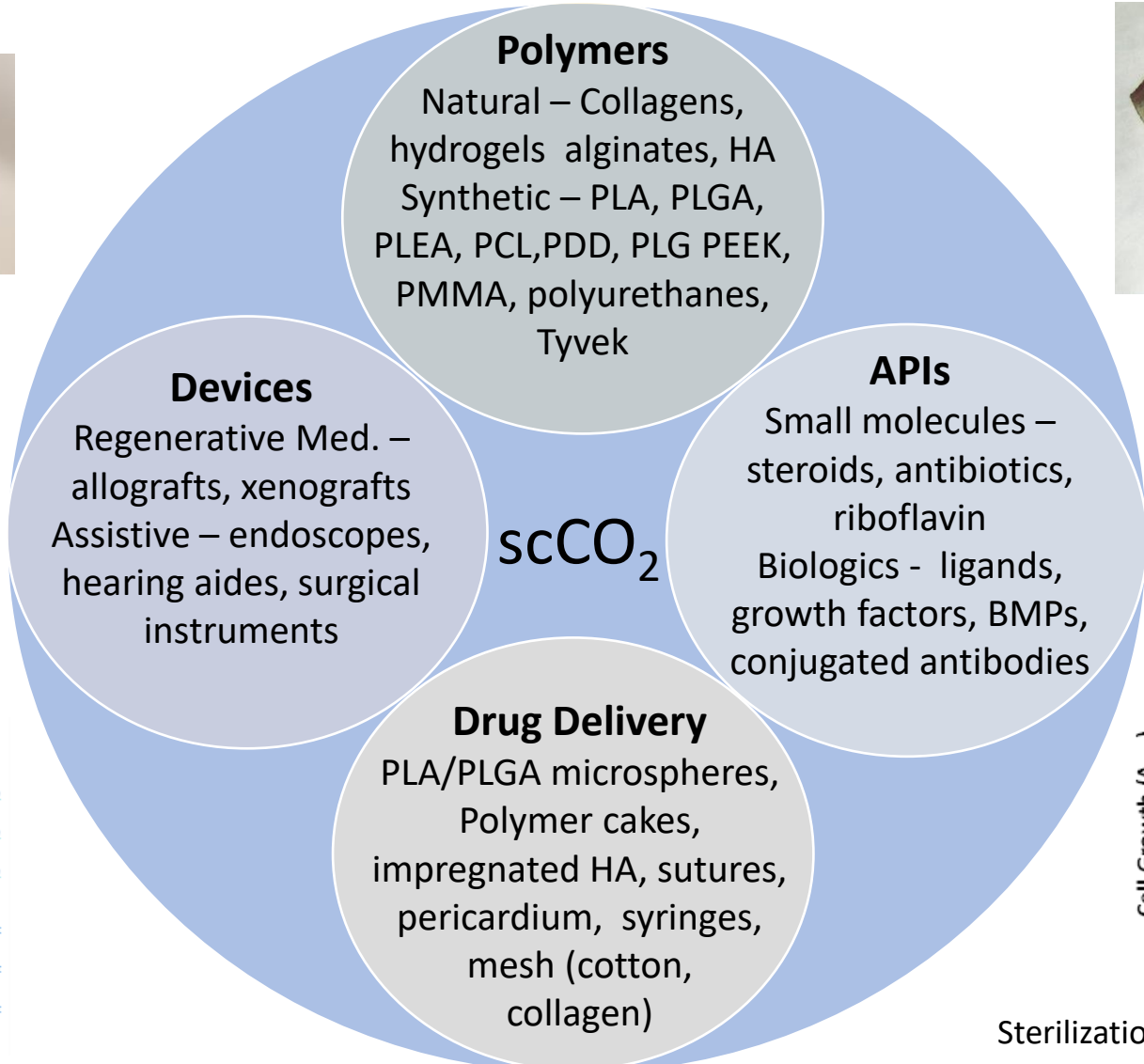
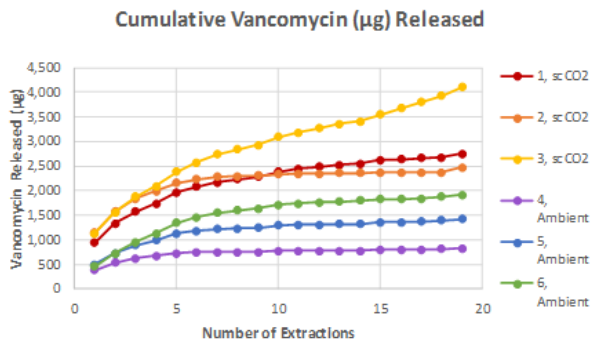
Comparison of *D* values (*B. atrophaeus*) reported for the NovaSterilis process

	Rinsed Tendon	Porcine Dermal Matrix	Ovine Tissue Matrix	Composite Scaffold
Slope (m)	-0.009	-0.17	-0.13	-0.1293
D value (min)	12.4	6.3	7.9	7.63
r²	0.98	0.93	0.84	0.94

scCO₂ Material Compatibility



Gamma – 25kGy scCO₂-additive



Sterilization of EGF


NovaSterilis.com

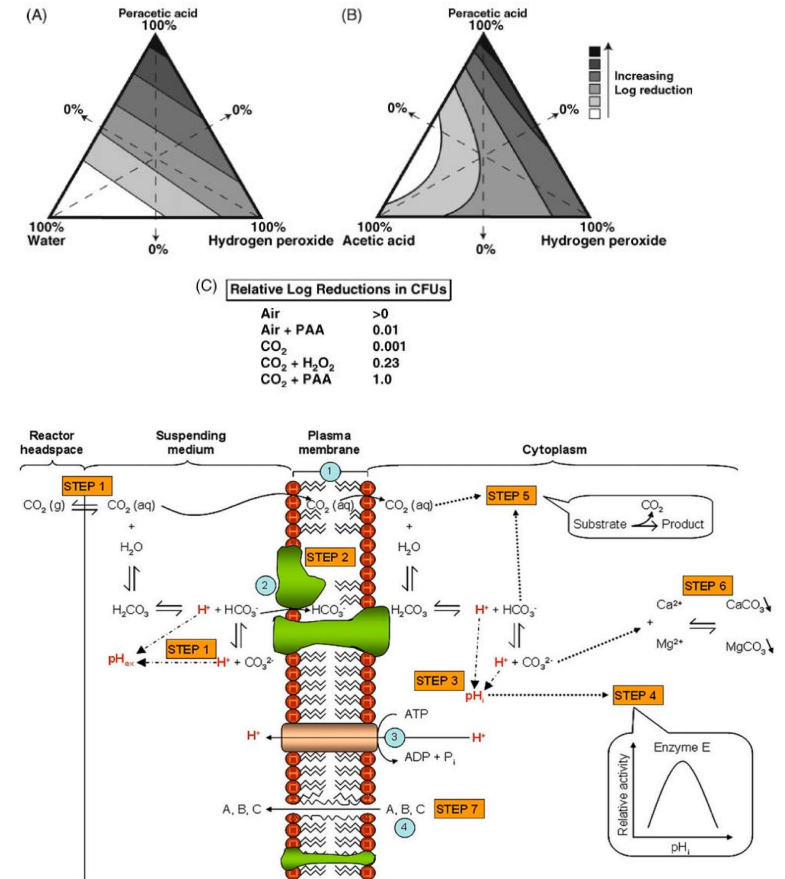
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Keep up with us on LinkedIn

Mechanisms of Action

- NS 2006 paper – PAA, HP, AA required
- Setlow - scCO₂/PAA mechanism Paper
 - Lethality - damage to IM/not barrier rupture
 - Leaky membranes  energy metabolism similar to other oxidizers
- Zhang et al. (2007) - spore permeability impacted following scCO₂ and HP treatment



Soares GC, Learmonth DA, Vallejo MC, Davila SP, González P, Sousa RA, Oliveira AL, Supercritical CO₂ Technology: The Next Standard Sterilization Technique? *Mater Sci Eng C Mater Biol Appl* 99:520-540 (2019)

Academic NovaGenesis Tech Talk Series

- 150 participants representing 60 Universities
- Academic partners share their latest scCO₂ research
- 3 meetings per year - November will be our 11th Tech Talk

**NovaGenesis
Tech Talk**

Jason Spector, M.D., FACS
Weill Cornell Medical College

March 16th



Company Overview



- Global leader in scCO₂ sterilization founded 2001
 - >500K surgeries completed w/ donor tissue sterilized by scCO₂
 - Global client base
 - 2007 EPA Green Chemistry Award
- Founded in 2009
 - Preclinical CRO
 - Virology, cellular biology, microbiology, materials science and chemistry
 - Regulatory Experts on scCO₂ sterilization

Structured Tissue

- Decellularized Pig Aortas – Mayo Clinic
 - Greatly damaged by g-radiation.
 - Direct comparison with low g-radiation (3 kGy), PAA/EtOH perfusion, H₂O₂ perfusion, electrolyzed water.
 - Histological, mechanical and cross-linking analysis



JACC Basic Transl Sci. 2017 Feb;2(1):71-84.
Supercritical Carbon Dioxide-Based Sterilization of Decellularized Heart Valves. Hennessy RS, Jana S, Tefft BJ, Helder MR, Young MD, Hennessy RR, Stoyles NJ, Lerman A.

- ✓ **Sterile Valves**
 - ✓ scCO₂
 - ✓ Et.PA. perfusion
- ✓ **Tensile Strength**
 - ✓ scCO₂
 - ✓ Et.PA perfusion
- ✓ **No Cross-linking**
 - ✓ scCO₂

Reusable Medical Devices



Experimental setup:

- $>10^6$ *Bacillus* spores dried on stainless steel wires
- Treatment completed 3 times (n=30 for each challenge)

Log₁₀
reduction
Bacillus
spores
on stainless
steel wire



Short NovaKill™ cycle

