Can a dialyzer expedite extracorporeal gas exchange?

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Oxygenator: a luxury single use product

Status Quo

- Standard hollow fibers for gas exchange
  - Polypropylene (PP): CPB oriented
  - Polymethylpentene (PMP): gold standard for ECMO
    - Fiber mats often develop **microcracks** near the thread knots
- Alternative materials
  - Silicone flat sheets (e.g. Kolobow): still occasionally used in pediatrics
  - Whole silicone fibers: ~35-55 µm wall thickness – reduced gas diffusion rate

Silicone-coated Fibers

- Microporous hollow fiber membrane as scaffold

› Ann Thorac Surg. 1997 Jun;63(6):1730-6. doi: 10.1016/s0003-4975(97)00119-7.

Silicone-coated polypropylene hollow-fiber oxygenator: experimental evaluation and preliminary clinical use

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Affiliations + expand

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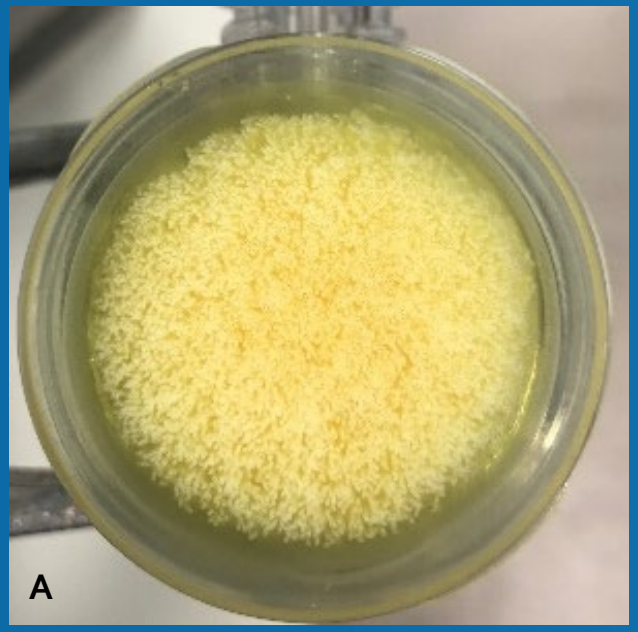
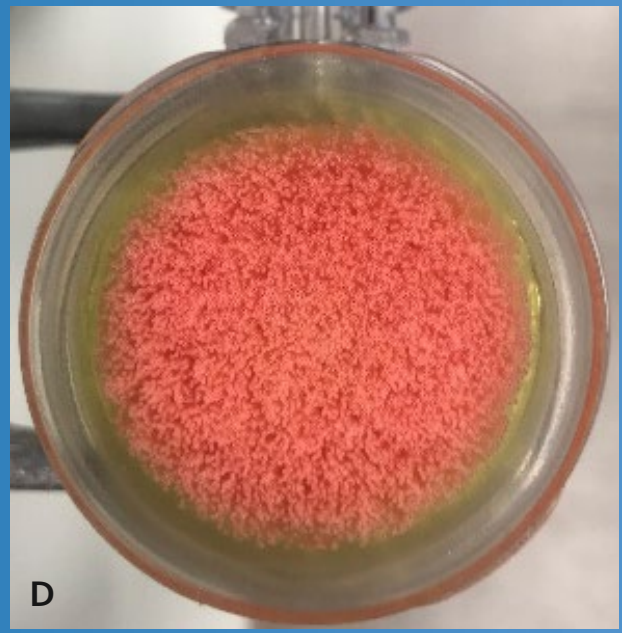
Silicone-coated Fibers

- Highly porous scaffold materials
- Defined silicone coating thickness
  - Penetration depth vs. Silicone film
- Intra-/extracapillary coating
  - Affordable dialysis membranes (PSU/PES)
  - Conventional dialyzers
    - Suitable for plug & play applications, e.g. CO_2 elimination (ECCO2R) - Hypercapnia

The manufacturing process



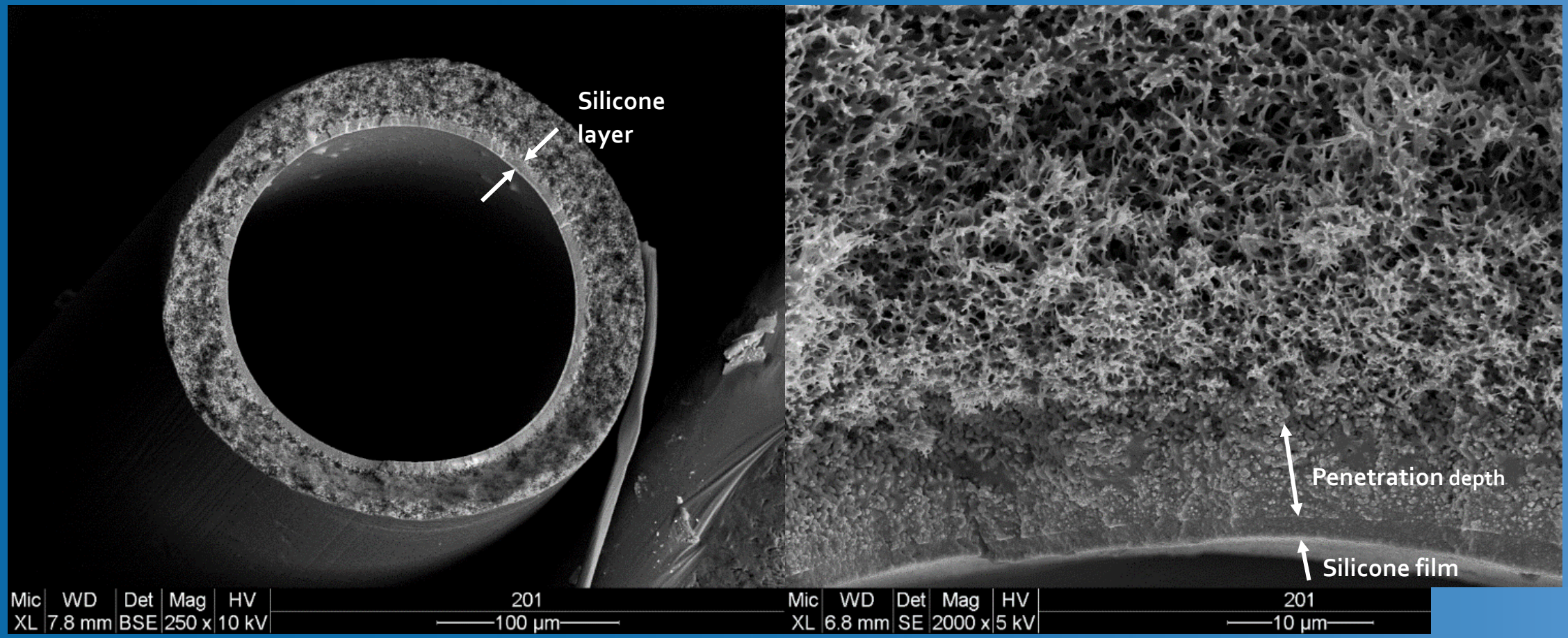


Coating with red-dyed silicone for enhanced visibility

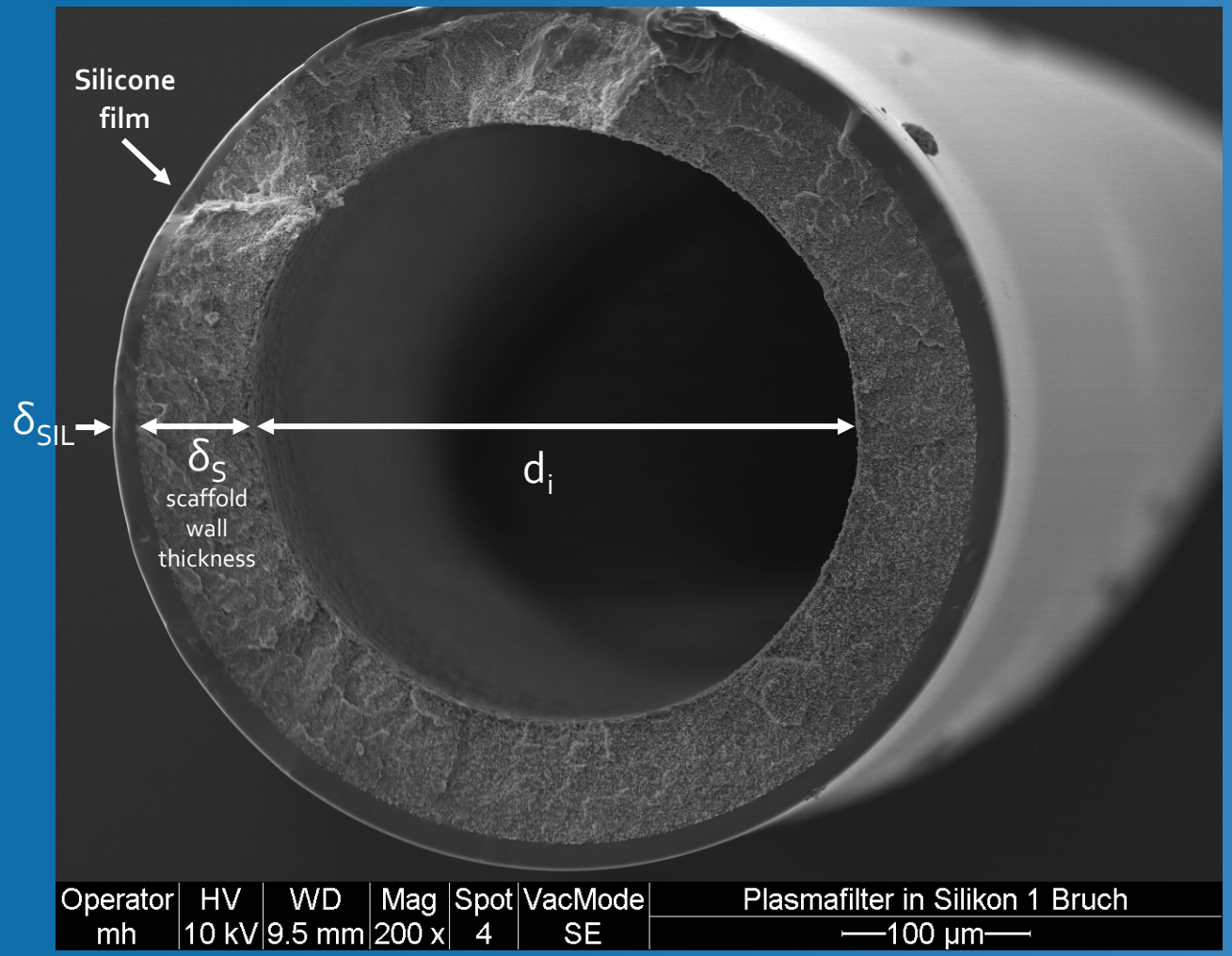
Validation techniques

- Leakage control
  - Gas pressure build-up
- Pressure drop monitoring
  - Gas
  - Liquid
- Scanning electron microscopy (SEM)

SEM Images

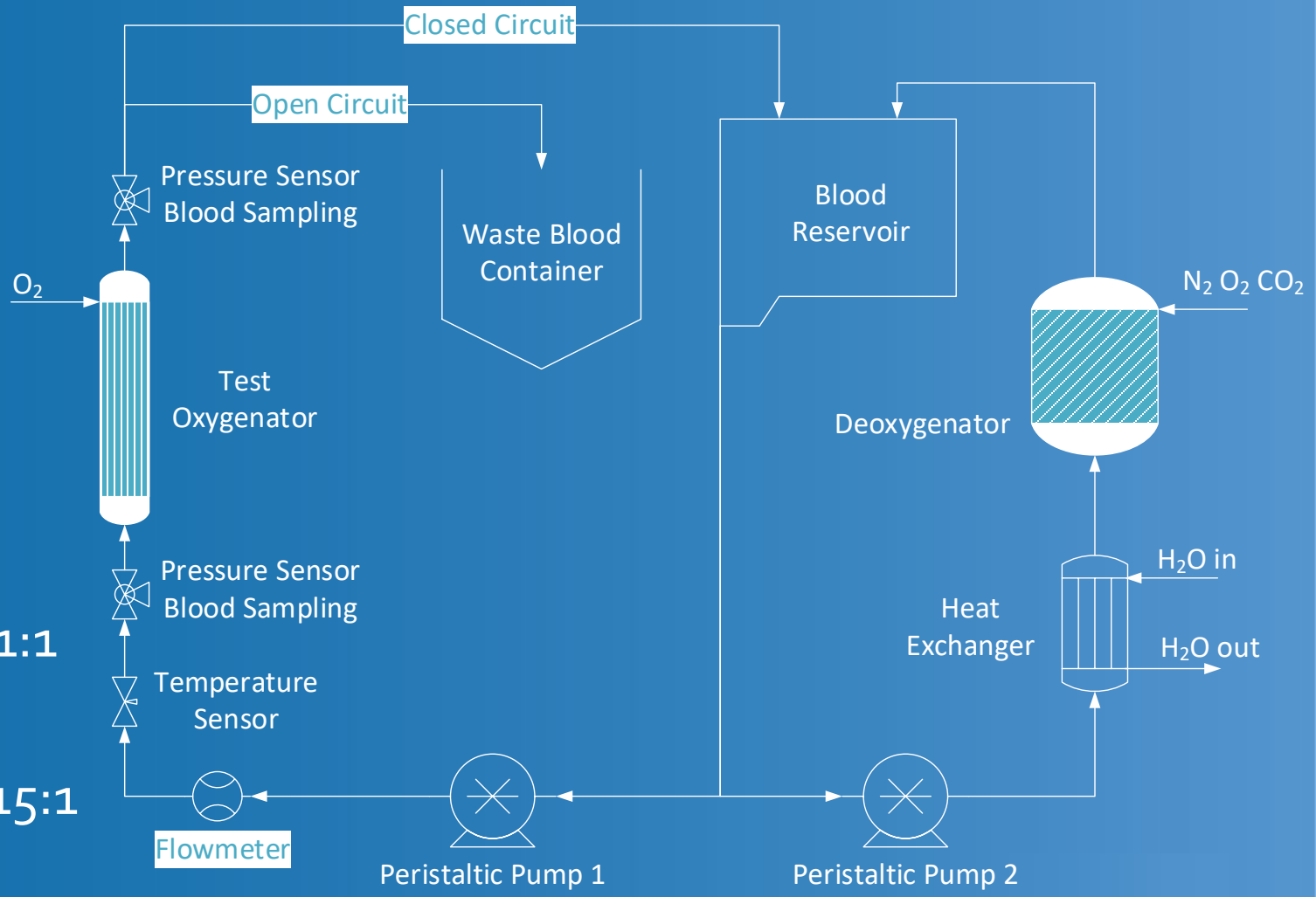

Silicone layer
Penetration depth
Silicone film
Mic XL | WD 7.8 mm | Det BSE | Mag 250 x | HV 10 kV | 201 | 100 µm
Mic XL | WD 6.8 mm | Det SE | Mag 2000 x | HV 5 kV | 201 | 10 µm

SEM Images


Silicone film
δ_{SIL}
δ_S
scaffold wall thickness
d_i
Operator mh
HV 10 kV
WD 9.5 mm
Mag 200 x
Spot 4
VacMode SE
Plasmafilter in Silikon 1 Bruch
100 µm

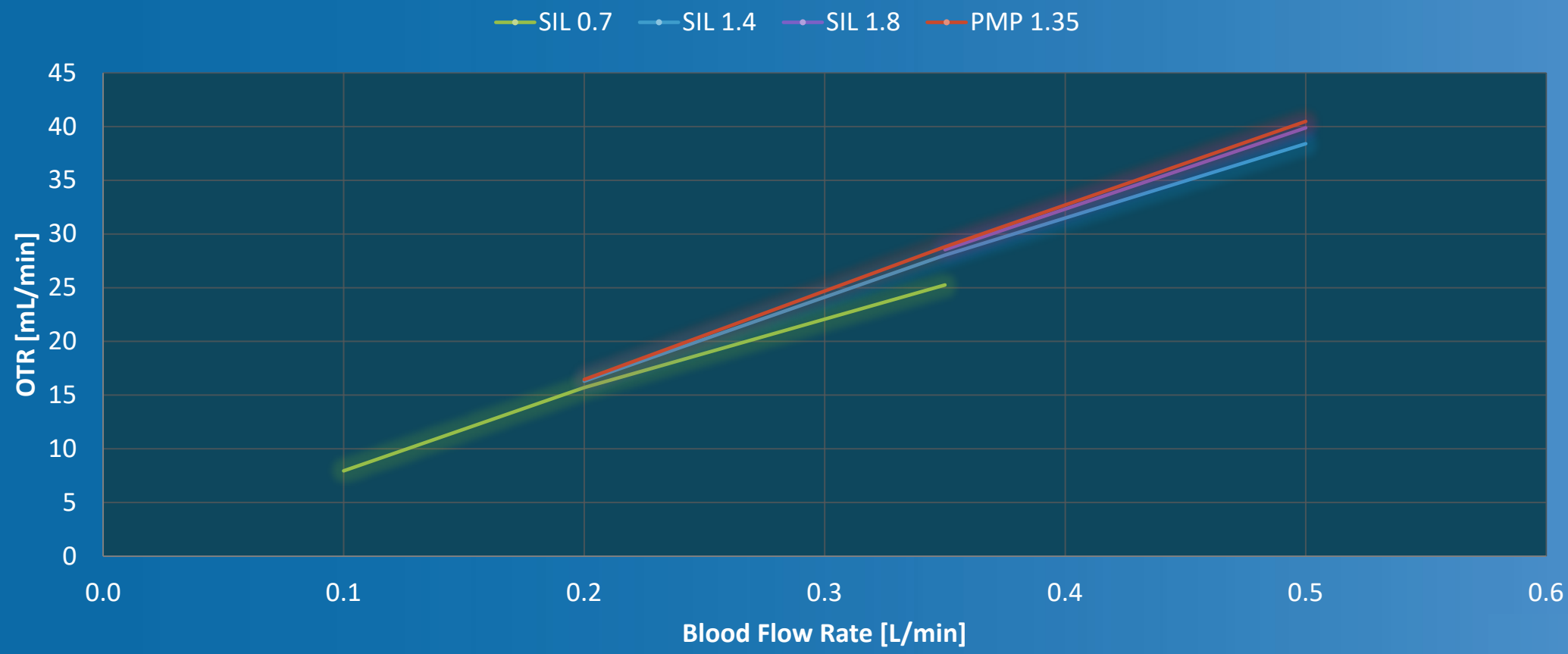
Gas exchange performance

- Silicone Coated Dialyzer
  - A_{eff}: 0.7 / 1.4 / 1.8 m²
- PMP oxygenator
  - A_{eff}: 1.35 m²
- Test conditions
  - ISO 7199:2016 - Gas:Blood 1:1
  - COPD: $pCO_2 \geq 80$ mmHg, $sO_2 \leq 50\%$, Gas:Blood 1:1 - 15:1



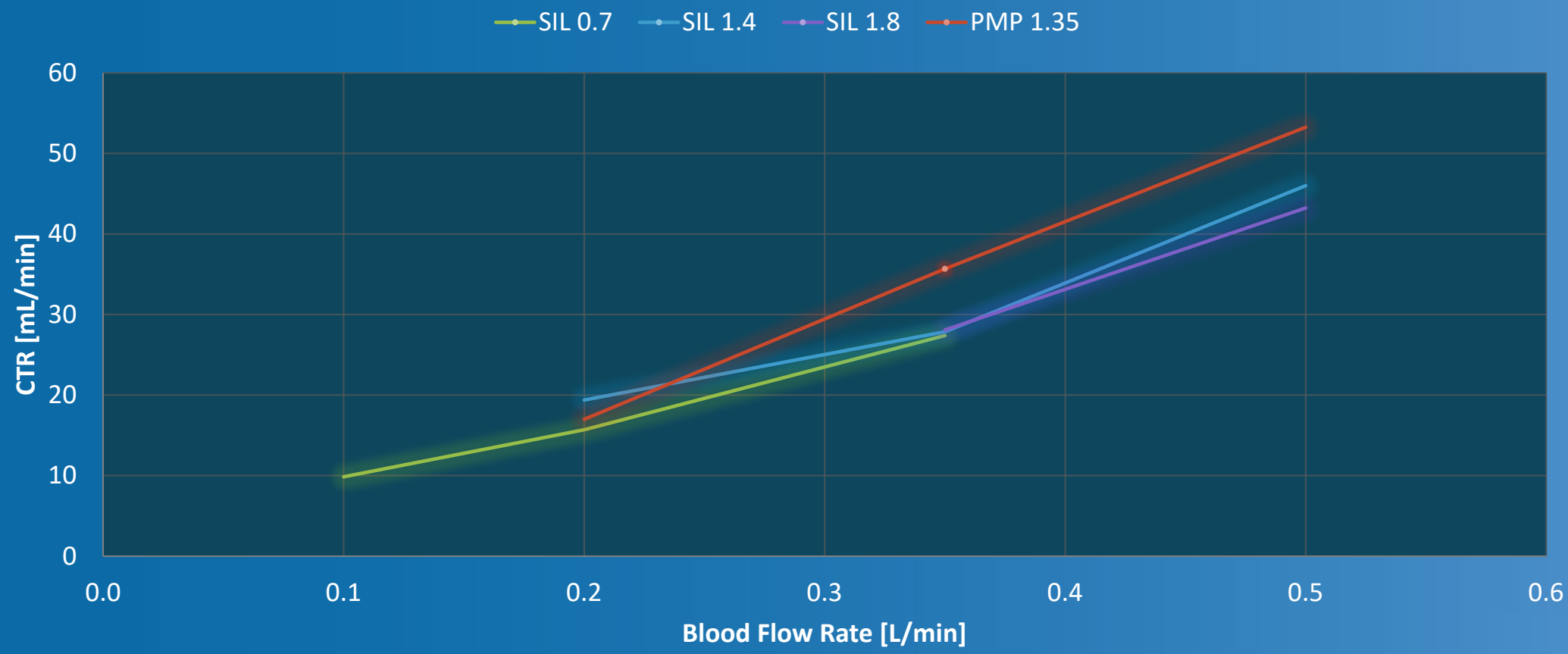
O_2 Transfer Rate

ISO7199 Gas:Blood 1:1



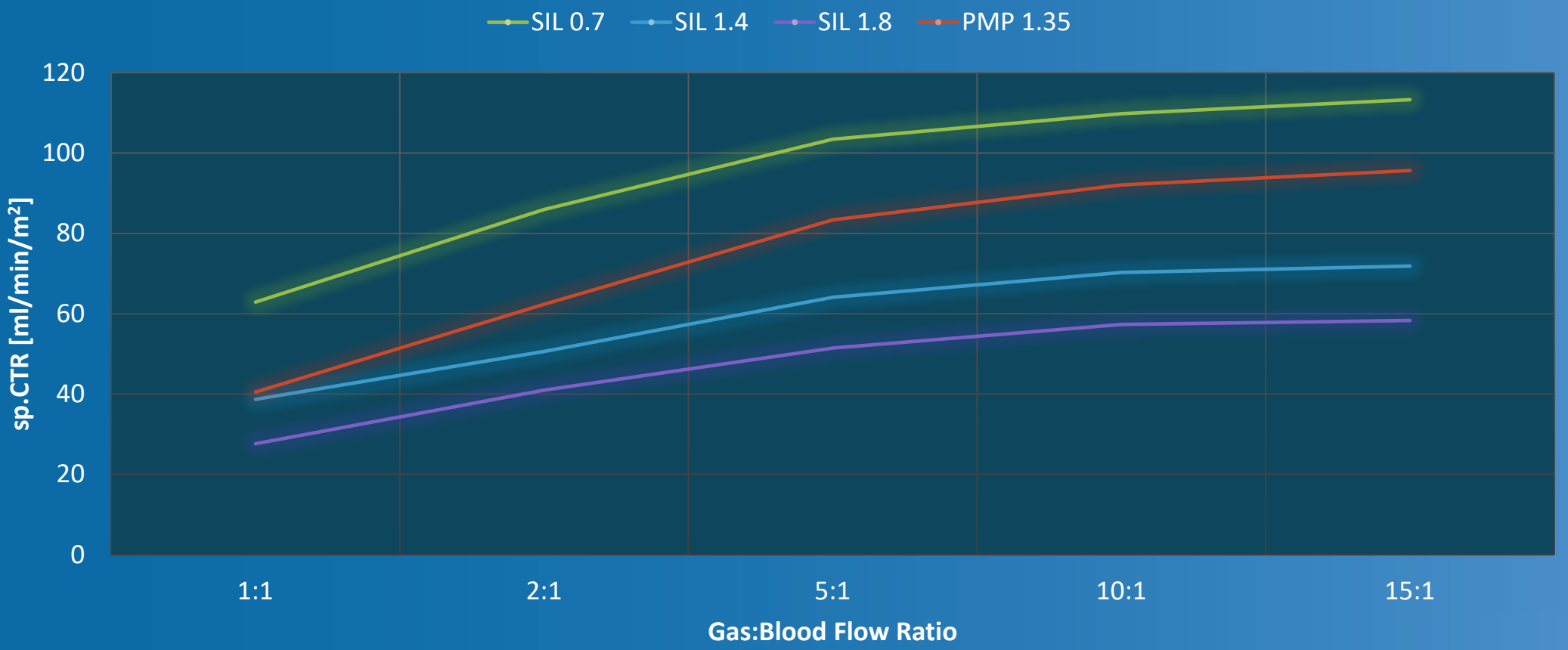
CO_2 Transfer Rate

ISO7199 Gas:Blood 1:1



Specific CTR

Hypercapnia/COPD Q_B: 0.35 l/min



Epilogue

- Silicone-coated fibers/dialyzers
  - efficient & durable coating
  - bio-/hemocompatible surface
  - high gas permeability (comparable-superior to PP/PMP)
  - cost-effective & expeditious production
  - operated by dialysis machines for Low-Flow applications (e.g. ECCO2R)
- Prospective implementation
  - Applicability in High-Flow therapies (CPB, ECMO etc.)
  - In vivo animal experiments


thank you
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рахмат
謝謝
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tesekkür ederim
barpnanaa
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спасибо
faafetai lava
vinaka
спасибi
biagodaram
dank je
misaotra
matondo
paldies
grazzi
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gracias
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তোমাকে ধন্যবাদ
감사합니다
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