Long-Term In Vitro Release from Amphiphilic Porous PDMS Membranes in Soft Implantable Drug Delivery Devices

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CRS2026 ANNUAL MEETING & EXPOSITION LISBON PORTUGAL

Abstract ID: 2319975

Poster No. 698

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1 Clinical Need & Motivation

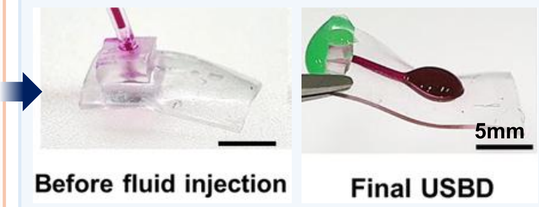
Current Challenges

- Foreign body responses
- Mechanical Mismatch
- Limited drug compatibility
- Poor long-term control

Current implantable systems face major challenges

Previous Platform

Ultrasoft Balloon-type Implant (Device 1)

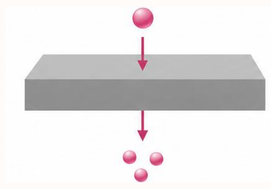


Before fluid injection — Final USBD

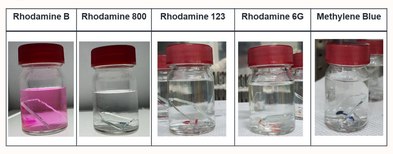
- ✓ Ultrasoft mechanics
- ✓ Significantly reduced foreign body responses
- ✓ Enabled long-term release

Remaining Limitation

Native PDMS membrane



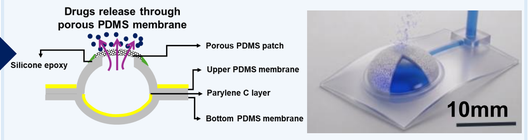
Only Rhodamine B was released



Limited drug compatibility

Our Solution

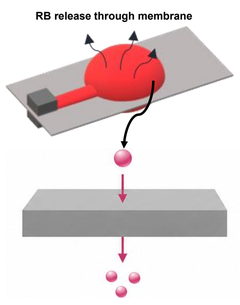
Amphiphilic Porous Membrane-Integrated Ultrasoft Implant (Device 2)



Tunable, long-term release of clinical drugs with various physicochemical properties

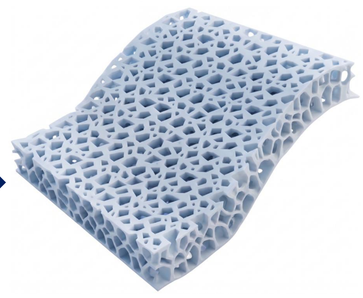
2 Platform Overview

Device with Native PDMS Membranes (Previous work: Device 1)



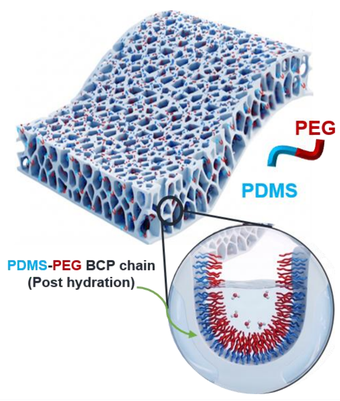
Only Rhodamine B released

Native Porous PDMS Membranes (current work)

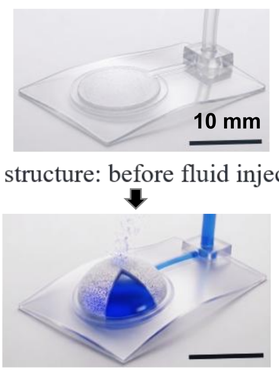


- Hydrophobic interface
- High onset time
- Excessive device failures

Amphiphilic Porous PDMS Membranes (current work)



Integrated in Ultrasoft Implantable Device (current work: Device 2)



2D structure: before fluid injection

3D structure: after fluid injection

Localized, Controlled, & Long-Term Methylene Blue Release

UP TO **224** DAYS

- Controlled release
- Tunbale release
- Diverse therapeutics compatibility

3 Engineering Strategies (What We Control)

1. Amphiphilic Modifications

Block copolymer (BCP)

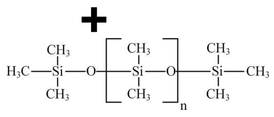
$(CH_3)_3Si\text{-}O\text{-}Si(CH_3)(R)\text{-}O\text{-}Si(CH_3)_3$

R: $CH_2CH_2CH_2\text{-}O\text{-}(OCH_2CH_2)_n\text{-}OCH_3$

Propyl (linker) — EO (PEG segment) — Methoxy end

+

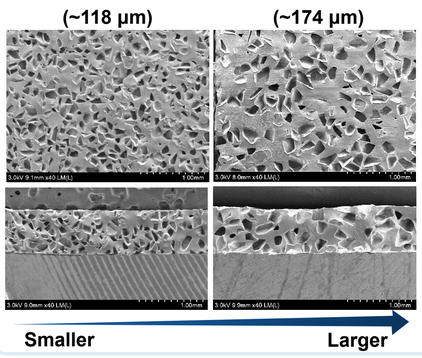
PDMS



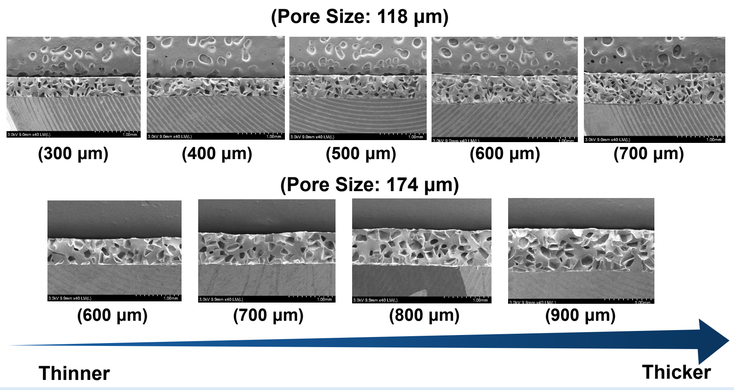
Improves wettability & drug transport

2. Pore Size Control

(Leaching: Porogen size)



3. Membrane Thickness



Engineered Parameters

Amphiphilicity (BCP)
+
Pore Size
+
Membrane Thickness

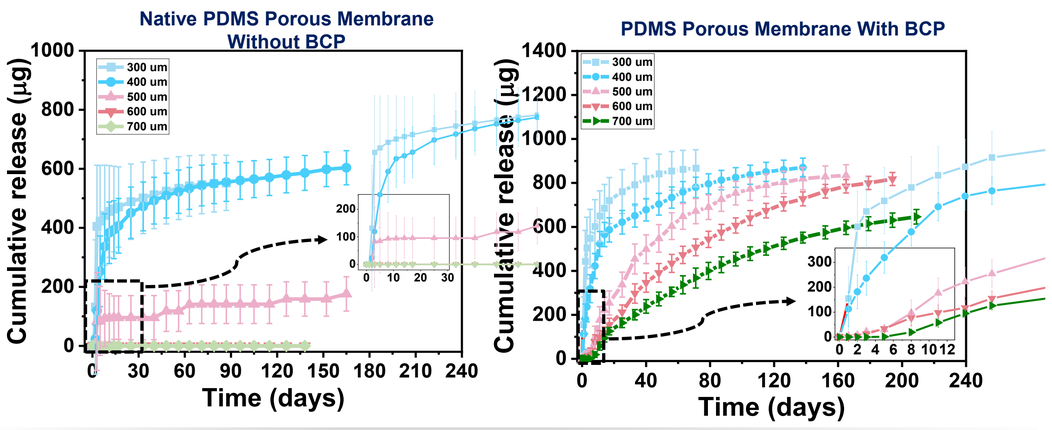
↓

Controlled Release Kinetics

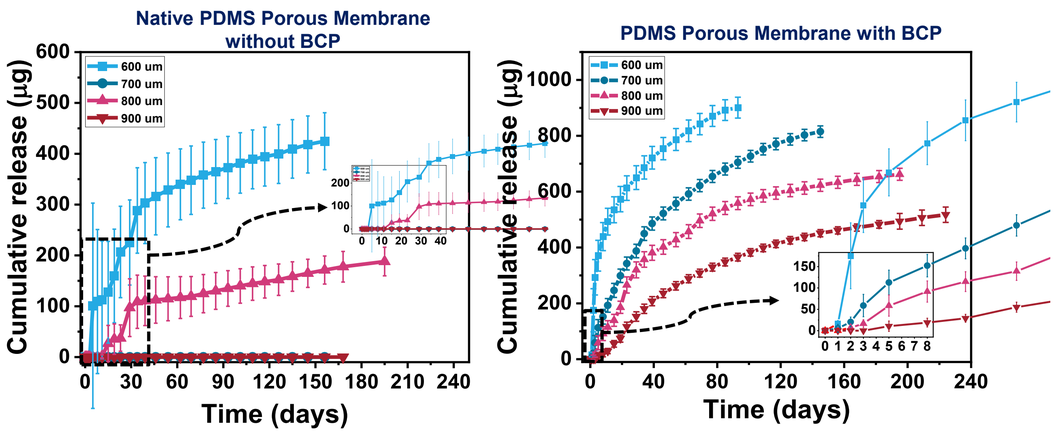
4 In vitro Release Kinetics & Key Results

A. Cumulative Release Profiles of Devices with & without BCP Incorporation

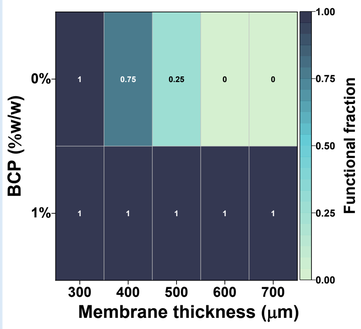
1. Membrane Thickness: 300-700 um I Pore Size: 117.6 ± 34.1 um



2. Membrane Thickness: 600-900 um I Pore Size: 173.6 ± 60.0 um



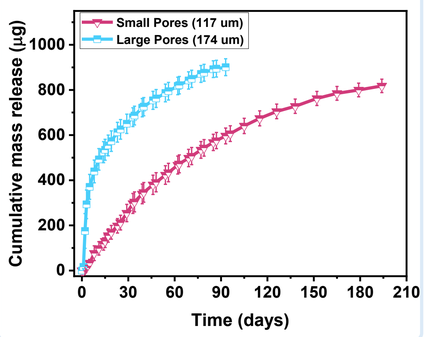
B. Effect of BCP on Device Functionality



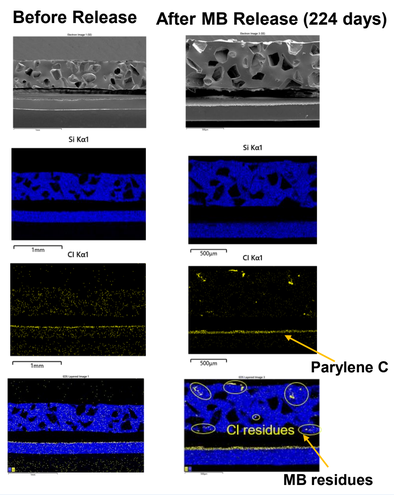
- 1 indicates all devices were functional
- 0 indicates no release

C. Effect of Pore Size

Membrane Thickness: 600 µm

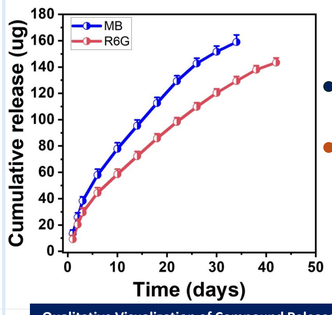


D. Structural Stability after Long-term Release



E. Release of Compounds with Different Physicochemical Properties

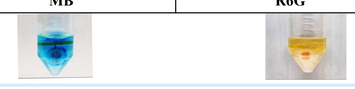
Miniaturized Device, 700 um thickness, 174 um pores)



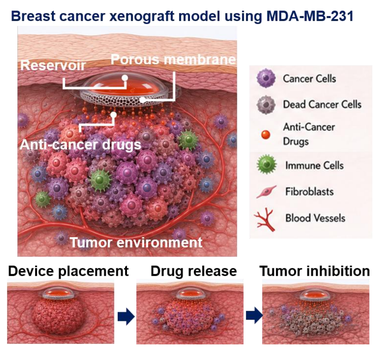
- Methylene Blue (MB) (Hydrophilic)
- Rhodamine 6G (R6G) (Hydrophobic)

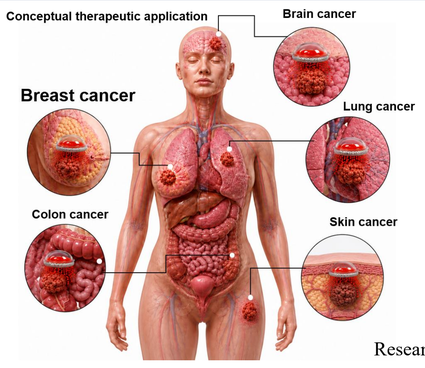
Qualitative Visualization of Compound Release in the Receiving Phase

MB	R6G



5 Translational Impact & Future Work





KEY MESSAGE

Amphiphilic porous membrane integration enables a tunable long-term implantable drug delivery platform.

- Ultrasoft implantable drug delivery platform
- Long-term and tunable release kinetics
- Broad physicochemical compatibility

Research supported by Basic Research Program of the National Research Foundation of Korea (RS-2024-00357432).