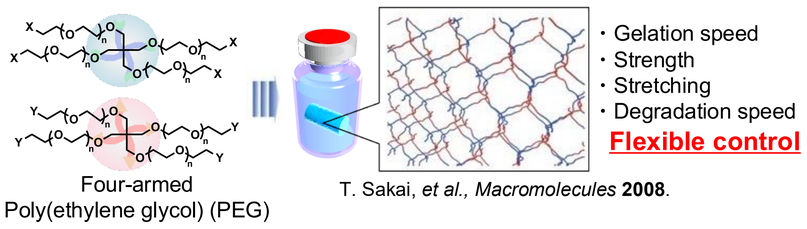
Design of poly (ethylene glycol) sponge hydrogels with a three-dimensionally interconnected structure for bone tissue regeneration

Shohei Ishikawa[1], Jinyan Si[1], Hironori Hojo[2], Takamasa Sakai[1]

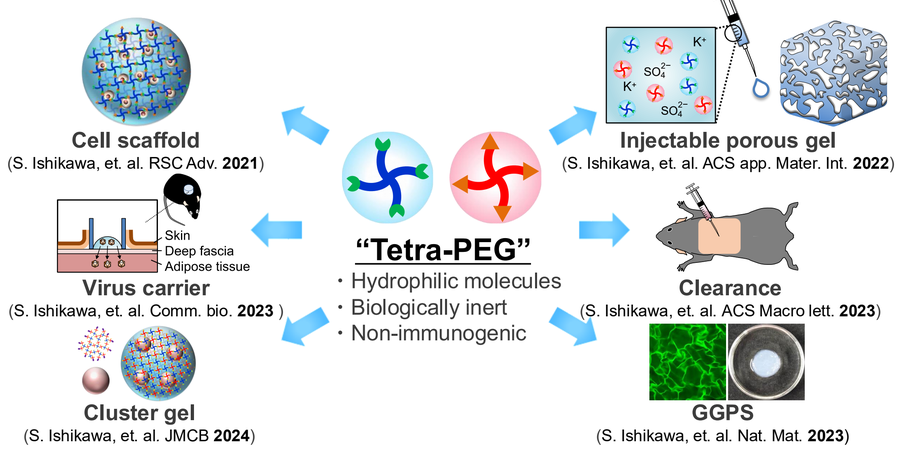
([1]Grad. Sch. of Eng., The Univ. of Tokyo, Tokyo, Japan, [2]Grad. Sch. of Med. The Univ. of Tokyo, Tokyo, Japan)

1. Tetra-PEG hydrogel



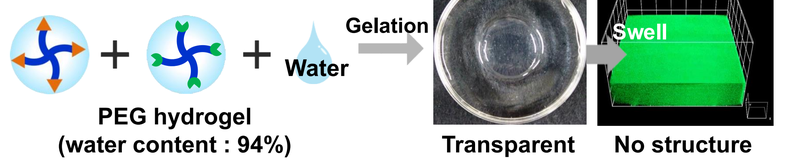
Hydrogel with uniform network structure

✧Tetra-PEG Hydrogel for tissue engineering

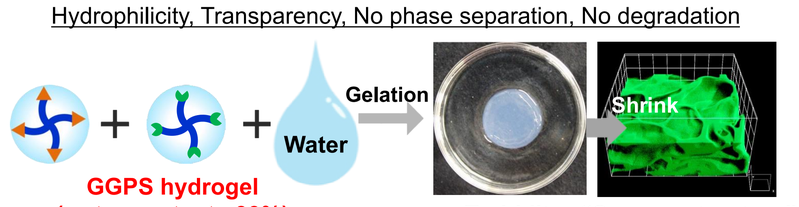


Essential material for tissue engineering

2. Gel-gel phase separation (GGPS)



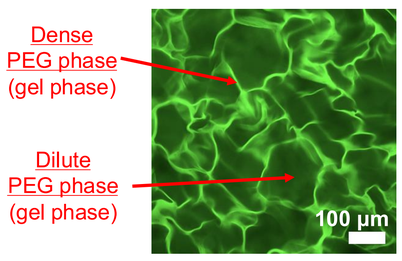
Hydrophilicity, Transparency, No phase separation, No degradation



Hydrophobicity, Turbidity, Phase separation, Degradation

S. Ishikawa, *et al. Nature Materials* **2023**

✧Phase-separated structure of GGPS hydrogel



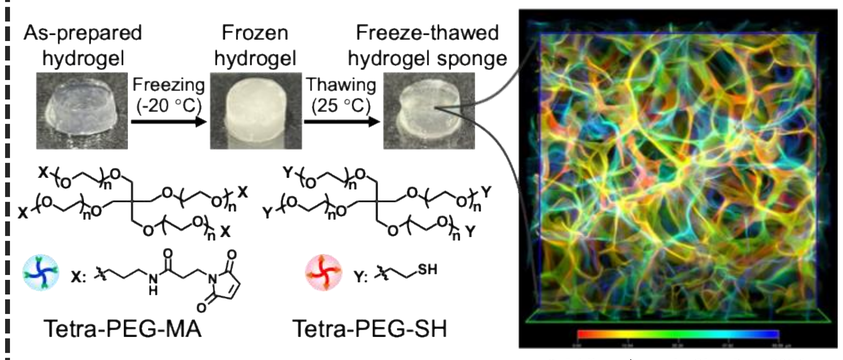
Two gel phases
(Dense phase & Dilute phase)

・No interconnected pore
→ Poor permeability of materials (cells) with μm size

Condensation into dense phase

3. This study

GGPS templated PEG hydrogel sponge : tailorable 3D interconnected structure



S. Ishikawa*, *et. al.*, *ChemRxiv.* **2026**

Porous hydrogel with μm size of pore (void)

→ High materials permeability (~μm)

→Bone tissue formation (cell migratory)

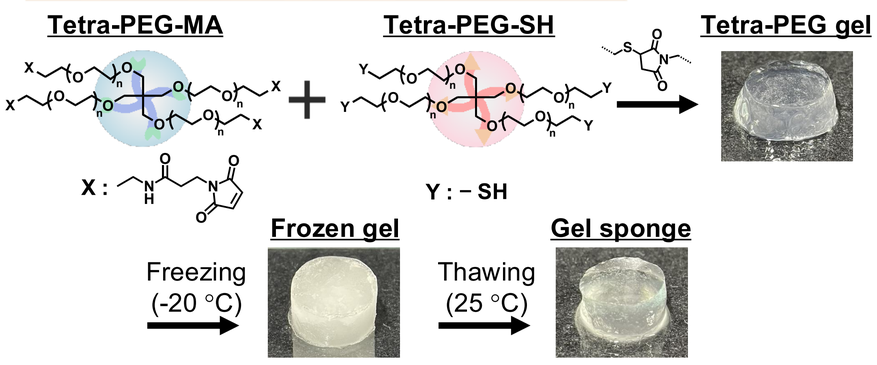
✧Experimental details

- Evaluation of phase-separated structure
- Differentiation of mesenchymal stem cells (hMSCs)
- Implantation in calvaria defect of mice

4. Results and Discussion

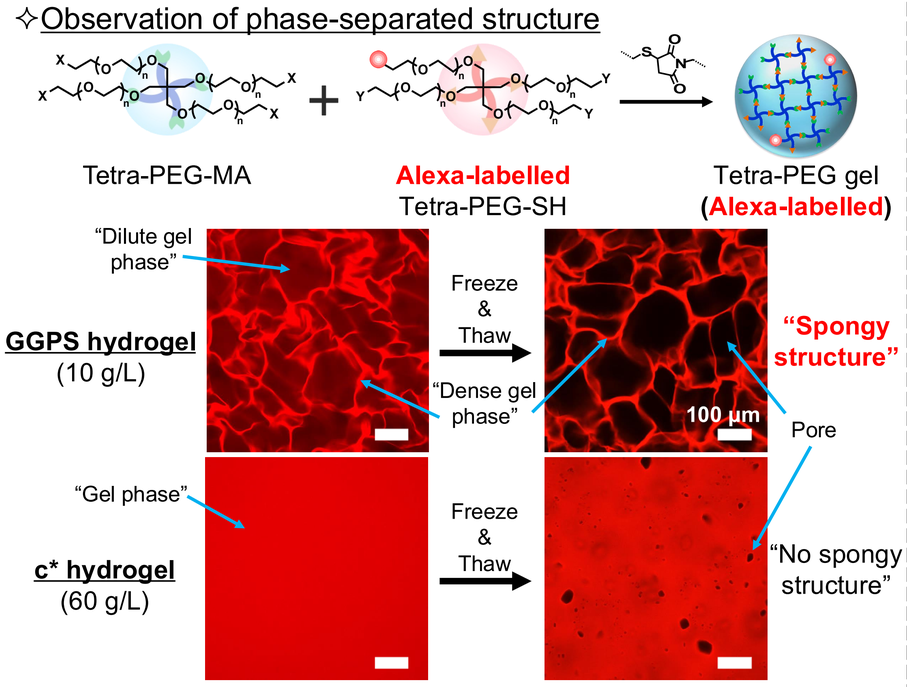
✧Preparation of PEG hydrogel sponge

Gel composition :	Buffer: Citrate phosphate buffer (CPB, 50 mM)
Concentration: 10-80 g/L	Molecular weight : 10,000 and 20,000 g/mol



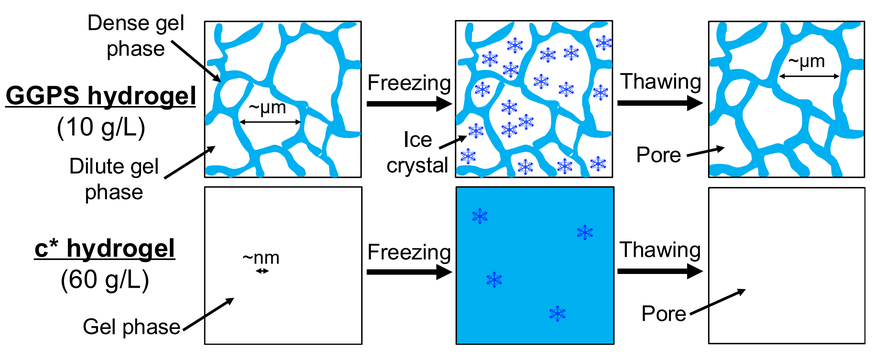
Simple method of fabricating PEG hydrogel sponge

✧Observation of phase-separated structure



Sponge structure formation of GGPS hydrogel

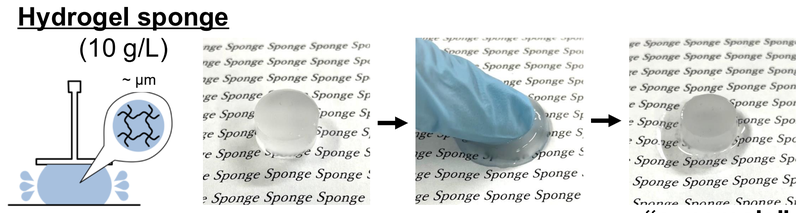
✧Mechanism of sponge structure formation



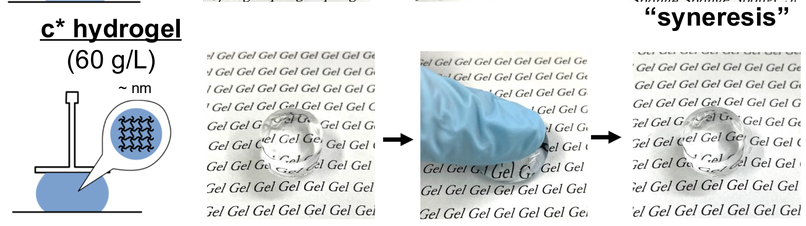
GGPS as template for sponge structure formation

✧Syneresis test

Hydrogel sponge
(10 g/L)

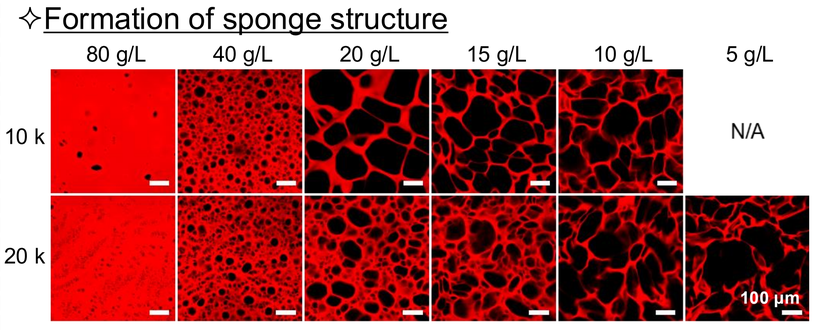


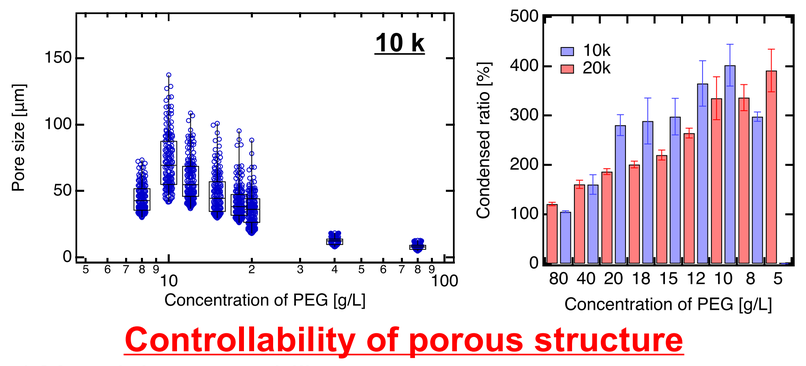
c* hydrogel
(60 g/L)



Syneresis property of hydrogel sponge

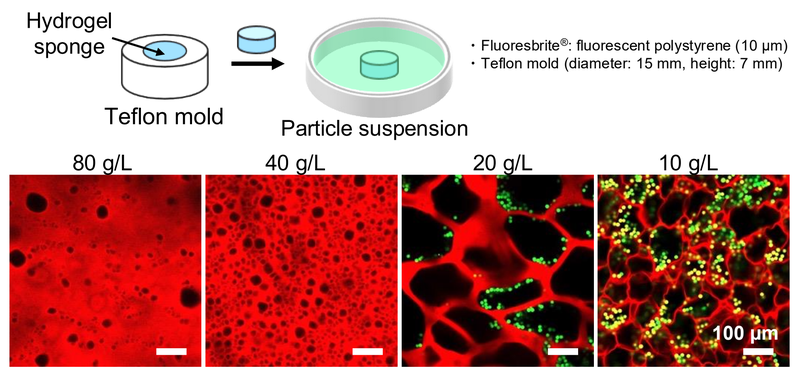
✧Formation of sponge structure





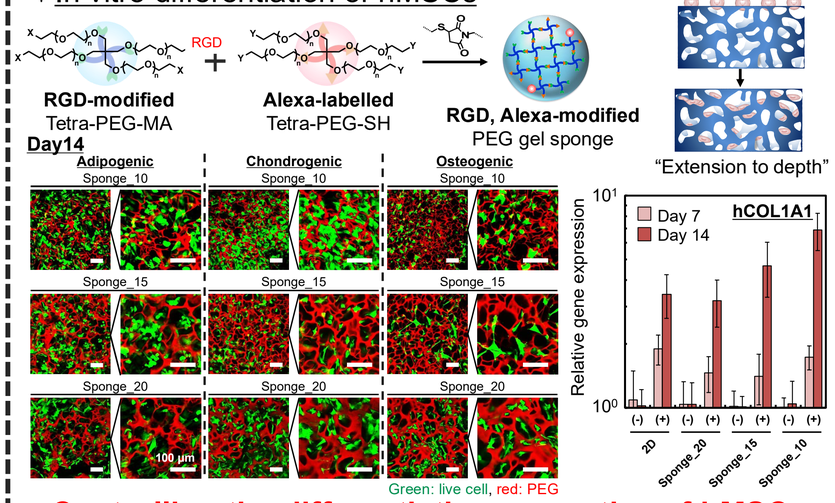
Controllability of porous structure

✧Materials permeability



High materials permeability

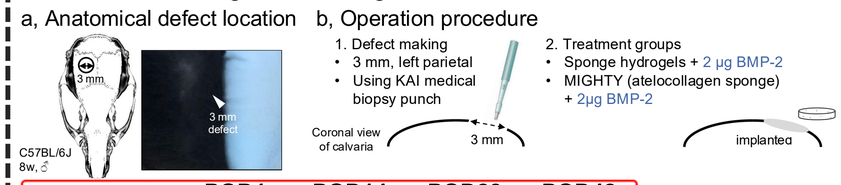
✧In vitro differentiation of hMSCs

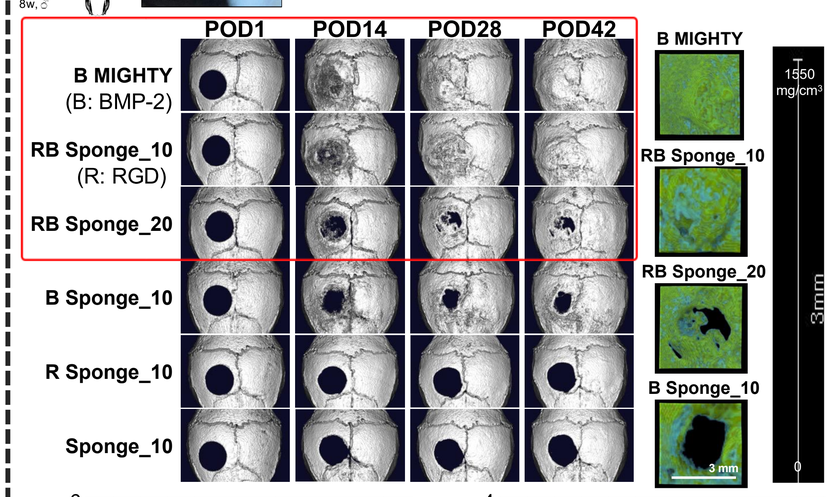


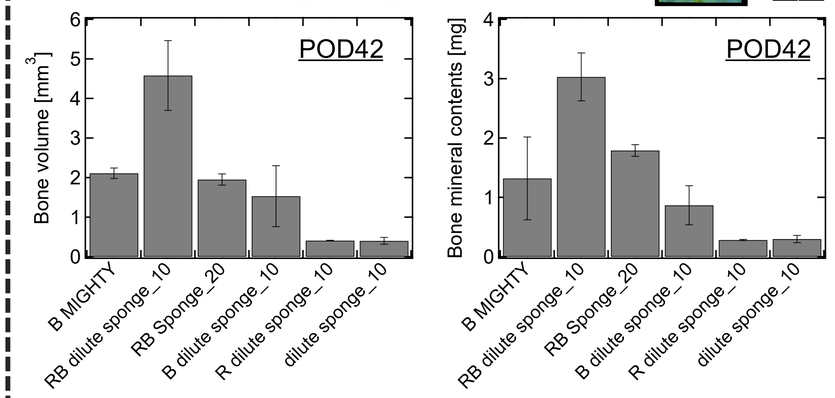
Controlling the differentiation properties of hMSCs

✧Cranial bone regeneration against calvaria critical defect model

a, Anatomical defect location b, Operation procedure







Tissue-forming materials superior to collagen sponge

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