Biomaterials developed through chemical engineering principles constitute key enabling technologies in tissue engineering and regenerative medicine. In this talk, recent progress in our laboratory on injectable hydrogels, particulate systems, and membrane engineering will be presented. The first topic concerns artificial oxygen carriers (AOCs). As cells continuously consume oxygen, efficient oxygen delivery is essential for maintaining tissue viability. To address oxygen transport limitations, we have developed deformable and homogeneous core–shell microparticles that mimic the size and morphology of human erythrocytes [1-2]. These particles are fabricated by Shirasu porous glass (SPG) membrane emulsification followed by evaporation-induced phase separation. The cores consist of perfluorocarbons (PFCs), such as perfluorooctyl bromide and perfluorodecalin, while the shells are composed of oxygen-permeable thermoplastic elastomers, including polydimethylsiloxane (PDMS)-based elastomers and fluorinated polyimides. Owing to the high oxygen solubility of PFCs and the gas permeability of the shell polymers, these particles demonstrate efficient oxygen and carbon dioxide transport. Their physicochemical properties are being investigated for applications in spheroid culture and organ machine perfusion. The second topic focuses on injectable hydrogels. We recently synthesized N,N-dimethylaminopropylamine–conjugated hyaluronic acid (HA-DMAPA) [3], a polyampholyte hydrogel exhibiting strong shear-thinning behavior and rapid self-healing. The material shows minimal cytotoxicity, low cell adhesion, enzymatic degradability, and favorable hemocompatibility despite amine modification. In vivo studies demonstrated effective reduction of severe postoperative peritoneal adhesions in rat cecum abrasion and partial hepatectomy models. Furthermore, benzaldehyde-modified chitosan (CH-CBA) [4]and alginate derivatives were developed to form dynamic covalent networks via reversible Schiff-base bonding between amine and aldehyde groups. These hydrogels exhibit injectability, self-healing properties, and tissue adhesiveness in vivo. Collectively, these engineered particles and hydrogels provide versatile platforms for oxygen delivery and minimally invasive biomaterial applications in tissue engineering and regenerative medicine.

References

[1] Da Xiao, Natsuko F. Inagaki, Taichi Ito et al. "Combined Regulation of Macrophage Phagocytosis by the Size, Shape, and Mechanical Stiffness of Concave Core−Shell Artificial Oxygen Carriers" ***ACS Applied Materials & Interfaces*** , 2026, 18, 7910−7922. [2] Xiaoting Fu, Seiichi Ohta, Taichi Ito et al. "Bioinspired perfluorocarbon-based oxygen carriers with concave shape and deformable shell." ***Advanced Materials Technologies,*** 2021, 2100573. DOI:10.1002/admt.202100573. [3] Yizhou Dai, Natsuko F. Inagaki, Taichi Ito et al. " Injectable Shear-Thinning Polyampholyte Hydrogel Derived From Functionalized Hyaluronan for pH-Responsive Prevention of Postoperative Peritoneal Adhesions." ***Advanced Healthcare Materials,*** 2026 (in press) [4] Ching-Cheng and Taichi Ito et al. ""Injectable, Shear-Thinning, Self-Healing, and Self-Cross-Linkable Benzaldehyde-Conjugated Chitosan Hydrogels as a Tissue Adhesive" ***Biomacromolecules***, 2024, 25, 2, 1084–1095