Supplementary Information

Yeast fermentation inspired Ca-alginate hydrogel membrane: lower transparency, hierarchical pore structure and higher hydrophobicity

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To investigate the existence of yeast cells, the ESEM micrographs of freeze-dried MIHM15 porous hydrogel membranes under different magnifications were shown in Fig. S1. It is seen that both micro and macro pores present in the MIHM15 hydrogel membrane. Under low magnification, millimeter-sized pores are visible and small micro/nanometer-sized pores can also be observed under high magnification. Furthermore, Fig. S1d shows that massive dead yeast cells ranging from 2 to 4.5 μm adhere to the pore walls and disperse in entire network, which is a clear evidence of low transmittance as shown in Fig. 1e. From a macroscopic view, the homogeneous Ca-alginate network structure becomes more complicated owing to the yeast fermentation. These values are much higher than those of modified Ca-alginate hydrogels previously reported in the literature, e.g., 500 μm for cellulose-alginate hydrogels with 3 wt% SA loading,[1] 250 μm for gelatin-alginate-polyacrylamide hydrogels with 2 wt% SA loading [2] and 105 μm for sericin-SA IPN hydrogel with 2 wt% SA, [3] respectively. Our data indicates that MIHM hydrogel membranes exhibit comparatively large pore, which is considered to be due to a great deal of CO_2 production by yeast fermentation.

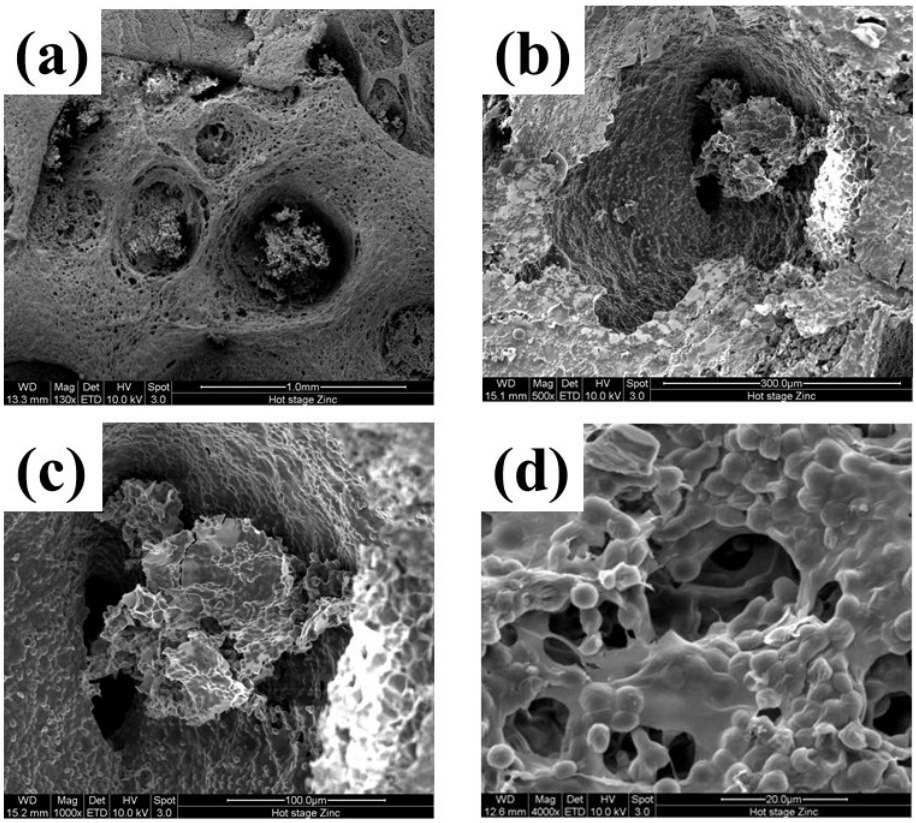

Fig.S1. ESEM images of MIHM15 hydrogel membranes under different magnifications. (a) 130, (b) 500, (c) 1000 and (d) 4000. Massive dead yeast cells ranging from 2 to 4.5 μm adhere to the pore walls and disperse in entire network.

The formation mechanism of porous MIHM samples involved into cross-linking of SA/$CaCl_2$ and fermentation process of yeast/glucose, as shown in Fig.S2. In terms of the cross-linking action between SA and $CaCl_2$, Soazo et al. pointed out that SA were cross-linked when Ca^{2+} interacted with blocks of guluronic residues. [4] According to the "egg-box" model, two contiguous and biaxially linked guluronic residues form a cavity that acts as a binding site for calcium ions. Ca^{2+} binding induces chain-chain associations forming stable junction zones of dimmers and lateral interactions. As a result, Ca-alginate hydrogels are prepared. On the other hand, during the polymerization, CO_2 is produced by yeast fermentation and bubbles dissipate into the air after across the reaction solution. The generated CO_2 gas bubbles rise continuously

and are blocked by the cross-linked network structure of SA/$CaCl_2$ hydrogels, which leads to the formation of porous structures.

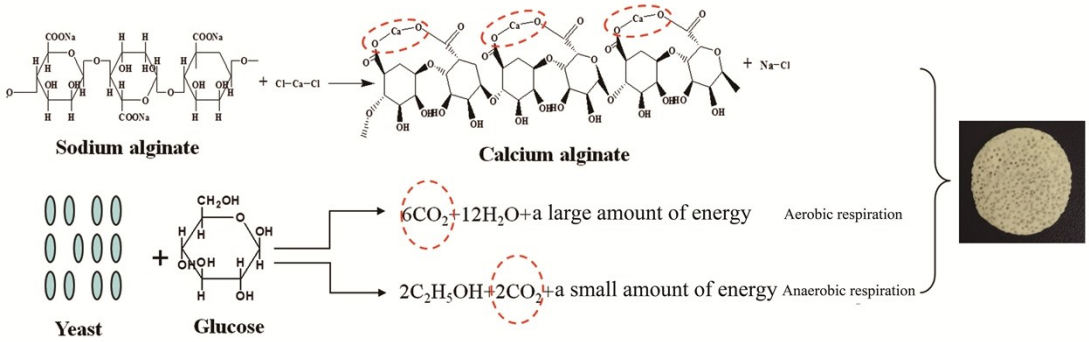

Fig.S2 Pore formation mechanism of MIHM using yeast/glucose as porogen. The formation mechanism of porous MIHM samples involves cross-linking of SA/$CaCl_2$ and fermentation process of yeast/glucose.

References

[1] C.Chang, B.Duan and L.Zhang, *Polymer*, 2009, **50**, 5467-5473.

[2] I.C.Stancu, A.Lungu, D.M.Dragusin, E.Vasile, C.Damian and H.Iovu, *Soft Mater.,* 2013, **11**, 384-393.

[3] Y.S.Zhang, J.Liu, L.Huang, Z.Wang and L.Wang, *Sci. Rep.*, 2015, **5**, 1-13.

[4] M. Soazo, G. Báez, A. Barboza, P.A. Busti, A. Rubiolo, R. Verdini and N.J. Delorenzi, *Food Hydrocolloids,* 2015, **51**, 193-199.