Electronic Supplementary Information

Confined encapsulation of living cells in self-assembly fiber macrospheres with micro/nanoporous polymer shell for transformation of contaminants to green energy

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Experimental

Materials and chemicals

Glass fiber was purchased from Hangzhou hi tech composite material Co., Ltd. (China). PVDF (average Mw 95000Da of 1010) and PSf pellets (Mw 120000Da of P-3500) were obtained from Solvay (USA). N, N-Dimethylformamide, sodium alginate, calcium chloride, sodium chloride and sodium hydroxide were bought from Sinopharm chemical Reagent Co. Ltd. (China). All chemicals were of analytical grade without further purification. The experiment solutions were prepared from deionized water prepared by a self-made RO−EDI system, in which ion concentration was analyzed by IRIS Intrepid ICP and Metrohm 861Compact IC and controlled to meet $\sigma \leq 0.5\ \mu S\ cm^{-1}$.

Analytical methods

Standard analytical methods were used to determine COD and ammonia-nitrogen (NH_3-N). Total organic carbon (TOC) was measured by a TOC-V analyzer (Shimadzu, Japan). The light intensity was examined by using the digital lux meter (AS831). Hydrogen production was analyzed by gas chromatography (GC-2010, China), equipped with the thermal conductivity detector.

Table S1. Synthetic high-salinity organic wastewater characterization.

Composition	Values
COD (mg/L)	3056-3945
NaCl (g/L)	40.0-80.0
pH	5.0-9.0
SS (mg/L)	100-150
NH_3-N (mg/L)	42.5-48.7
$NaHCO_3$ (g/L)	0.1
$CaCl_2$ (g/L)	0.1
$MgSO_4 \cdot 7H_2O$ (g/L)	0.1

Table S2. Comparison of encapsulated cell within different host matrix for various applications.

Microorganism	Immobilizing matrix	Application	Performance	Ref.
Pseudomonas putida	structural membrane constructed particle	phenol degradation	similar biodegradation rates were observed in encapsulated and free cell (C_{phenol}= 800 g/L)	S1
heterotrophic acteria	structural membrane constructed particle	olive mill wastewater treatment	biodegradation rate between encapsulated and free cells was 1:2	S2
Klebsiella oxytoca	Alginate	KCN (cyanide) degradation	removal efficiency of free cell (90 %) and encapsulated cell (91 %)	S3
Ammonia-oxidizing bacteria	calcium alginate	ammonia degradation	around 1.8 times reduction of activity after encapsulation in the initial stage (6 days)	S4
Rhodococcus erythropolis LSSE8-1	Fe_3O_4 nanoparticles (NPs)	dibenzothiophene (DBT) degradation	encapsulated and free cells exhibited similar desulfurizing activities	S5
Strain XA05 and FG03	polyvinyl alcohol (PVA)	phenol degradation	encapsulated cells showed lower degradation rate than free cells (C_{phenol} below 500 mg/l)	S6
Chlorophyta *Dunaliella tertiolecta*	alginate–SiO_2–polycation@ alginate–SiO_2	CO_2 remediation	activity of cells inside a hybrid matrix is consistently higher than for those encapsulated within alginate beads	25
NIH-3T3 cells and human mesenchymal stem cells	CNT-gelatin methacrylate (GelMA) hybrid	tissue engineering	enhancer for mechanical properties while maintaining beneficial bioactive properties of GelMA material	S7

Botryococcus braunii and *Chlorella vulgaris*	low-sodium silica gels	CO_2 remediation	decrease in activity with time due to stresses exerted on cells isolated from natural environment or from oxygen saturation within gel	17
THP-1 cells	different types of alginate microsphere	cell culture	type of alginate affected cell proliferation, but there was no significant effect on viability of encapsulated cells	S8
Photosynthetic bacteria cells	self-assembly fiber macrospheres with porous polymer shell	high-salinity wastewater treatment	encapsulated cells exhibited 1.3 times higher than free cells	This work

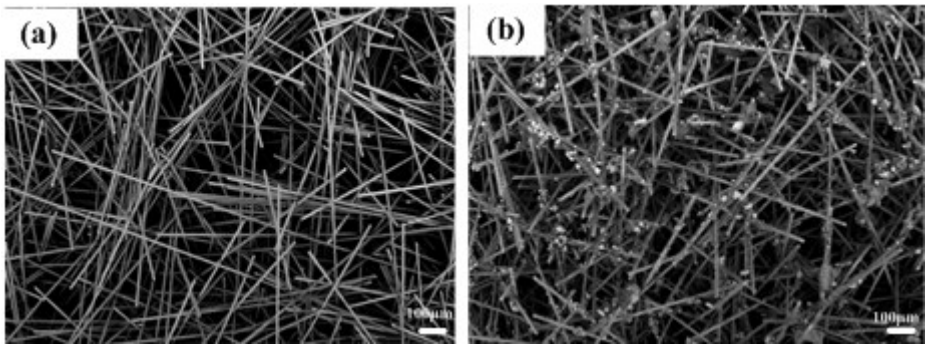

Figure S1. SEM images of interior morphology for sample MGFS@Polymer and PSB/MGFS@Polymer.

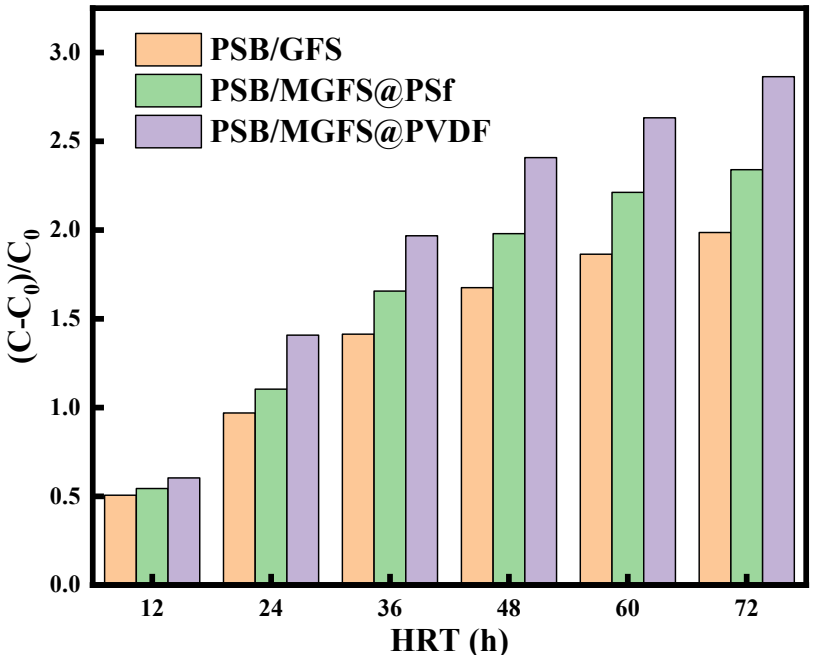

Figure S2 Encapsulation yields of PSB cells into GFS, MGFS@PSf, and MGFS@PVDF based on the initial concentration with different HRT.

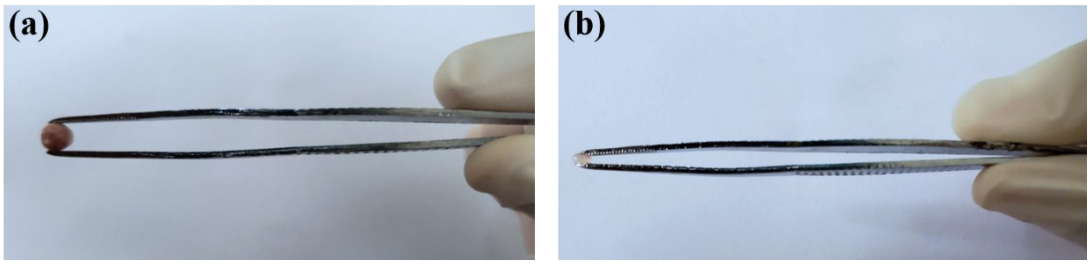

Figure S3. Comparison of mechanical strength between the polymeric coated GFS macrospheres (a) and alginate beads (b). Compared with the traditional sodium alginate entrapped beads, the compression tests showed that the prepared MGFS@Polyme macrocapusles maintained the original structure even if under the strong squeezing.

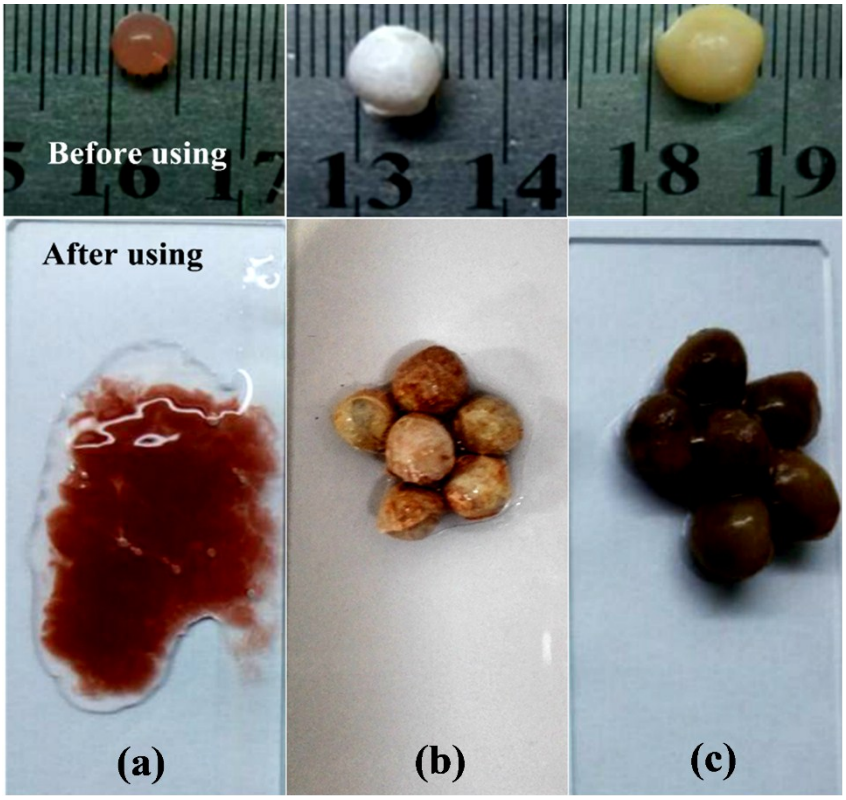

Figure S4. Photograph of the sodium alginate entrapped beads (a), PSB/MGFS@PSf (b) and PSB/MGFS@PVDF (c) before and after operation._After the high-salinity wastewater treatment, it was found that the sodium alginate (SA) entrapped beads was broken and became colloidal liquid, while all the core-shell structured macrospheres contained a large number of PSB and still kept their spherical forms.

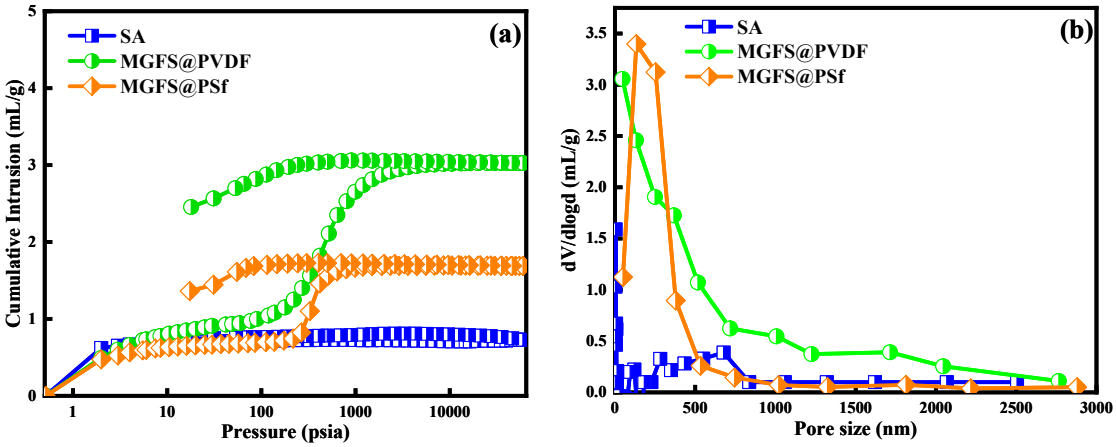

Figure S5. Cumulative intrusion/extrusion vs pressure curve (a) and pore size distribution (b) for different samples.

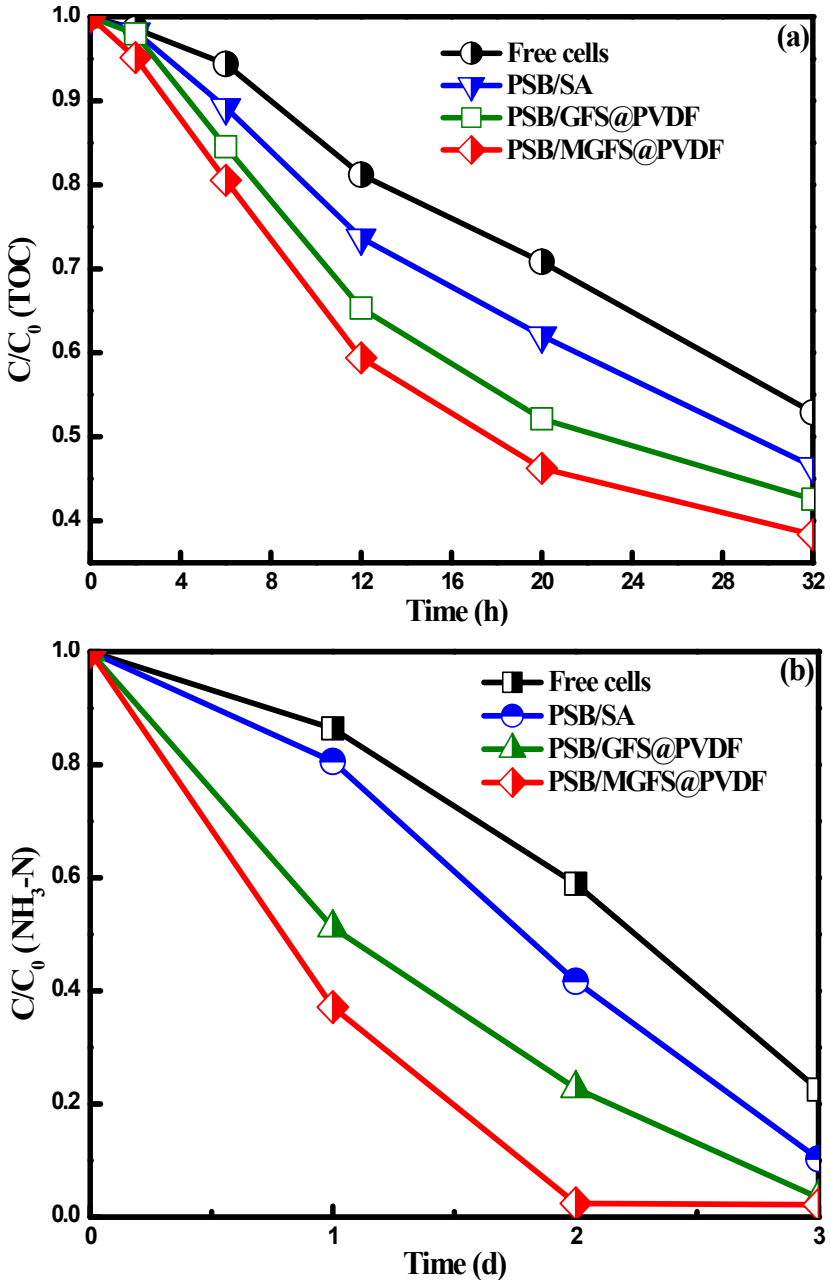

Figure S6. TOC (a) and NH_3-N (b) removal efficiency of the different operation systems.

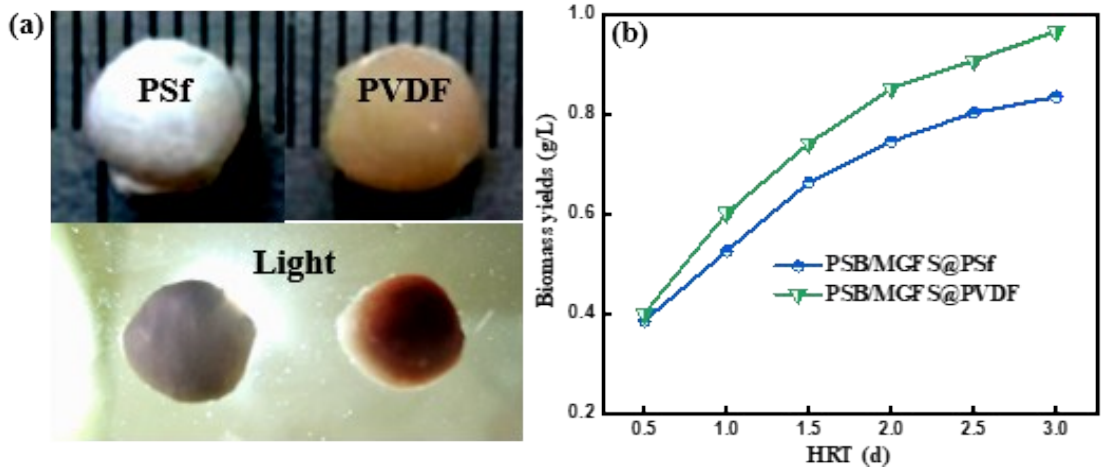

Figure S7. (a) Photograph of PSB/MGFS@PSf and PSB/MGFS@PVDF; (b) Comparison of biomass harvesting between MGFS@PSf and MGFS@PVDF with different HRT.

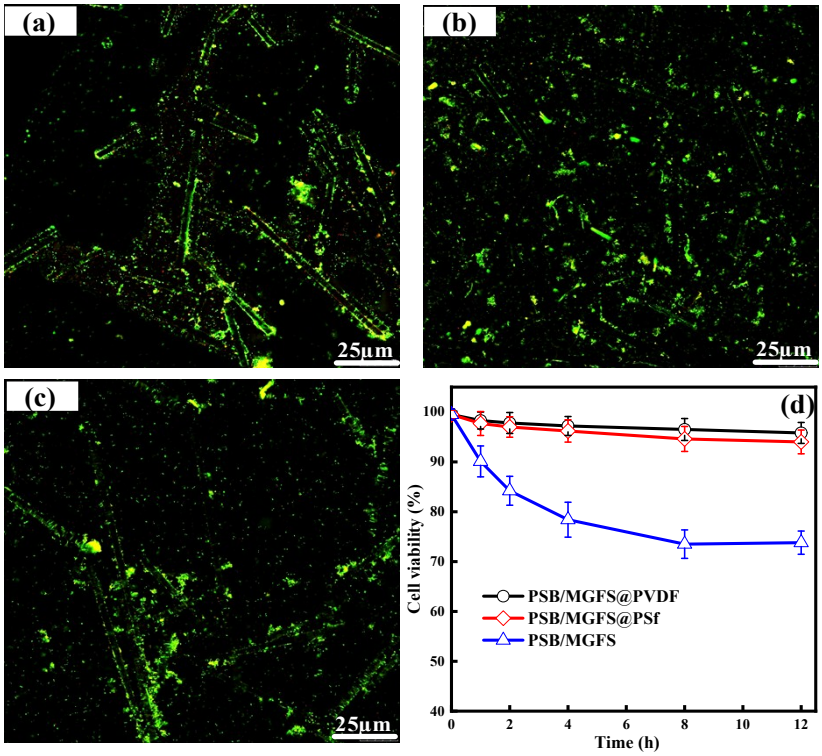

Figure S8. (a-c) Live/dead staining of encapsulated PSB cells in MGFS, MGFS@PSf, and MGFS@PVDF and (d) Viability of encapsualted cells after incubation for di□erent time.

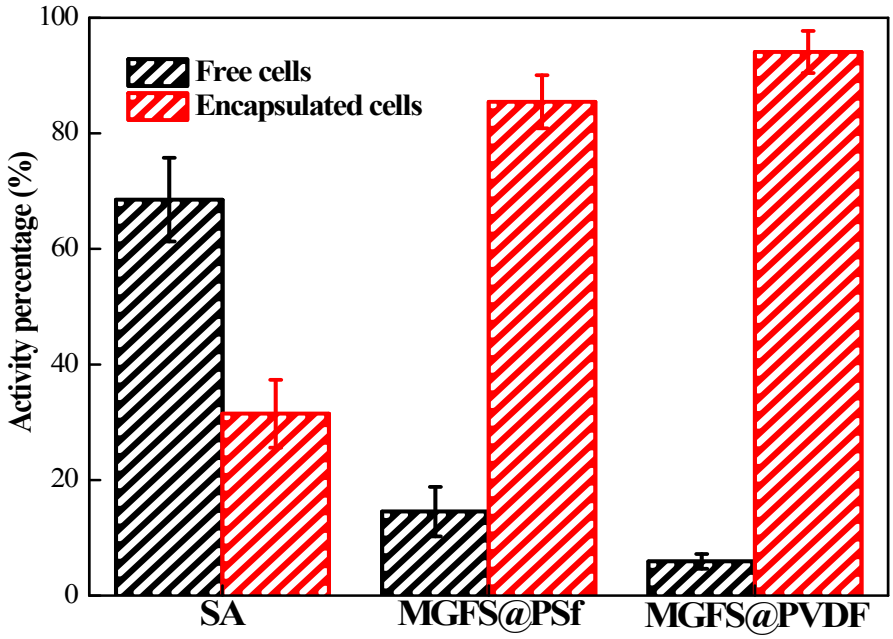

Figure S9. Activity percentage of leached and encapsulated cells into different colloids.

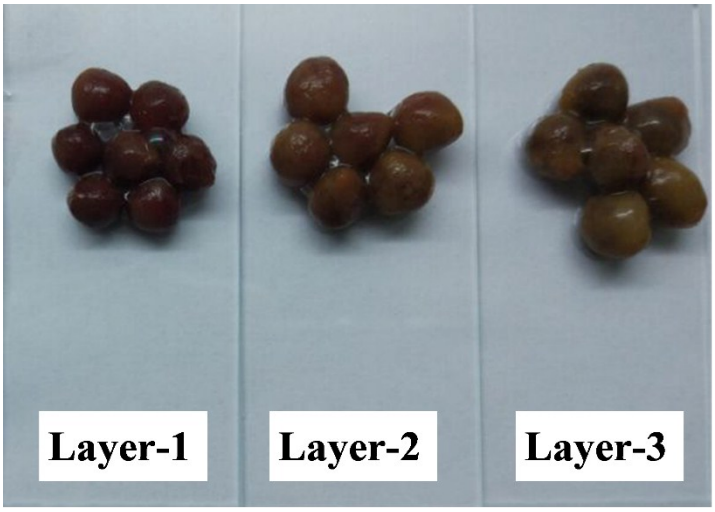

Figure S10. Photograph of the PSB/MGFS@PVDF macrospheres coated with different layers after the long-term operation.

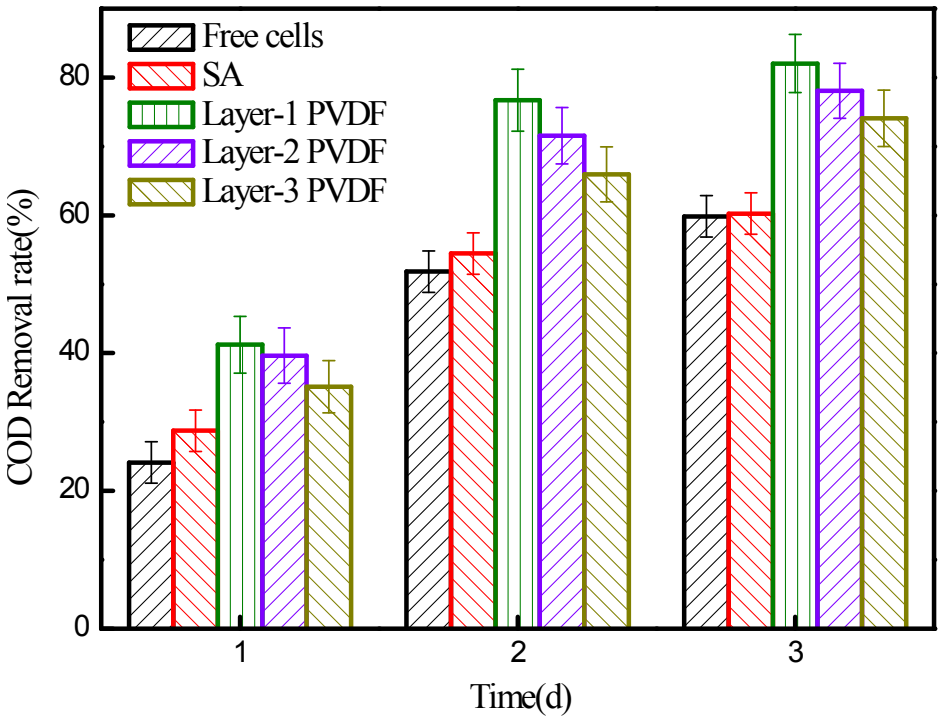

Figure S11. Performance of the prepared PSB/MGFS@PVDF macrospheres coated with different layers on the COD removal.

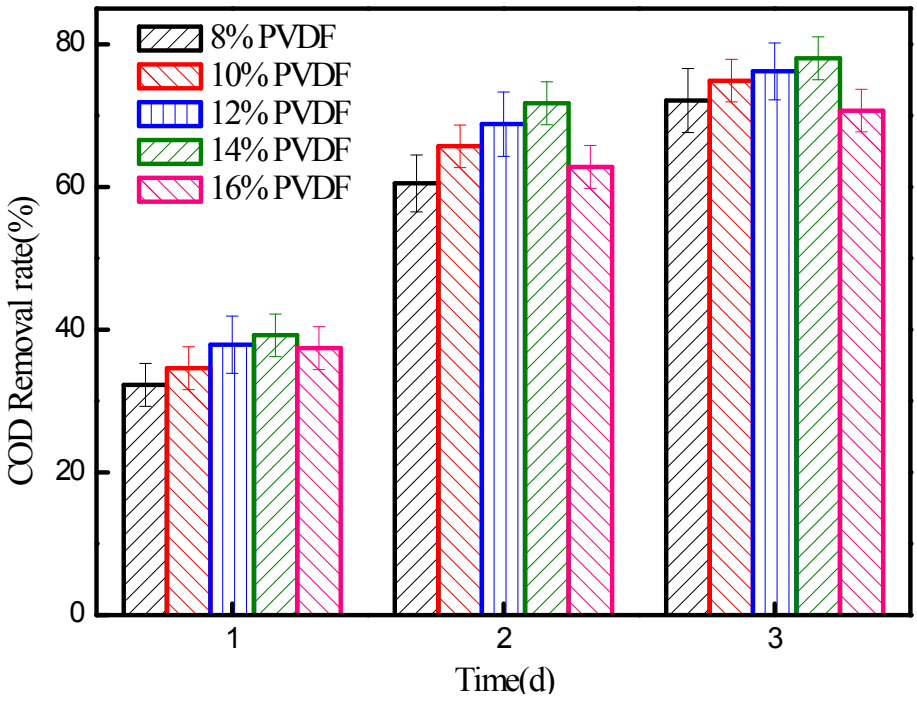

Figure S12. Performance of the prepared PSB/MGFS@PVDF macrospheres coated with different polymer concentration on the COD removal.

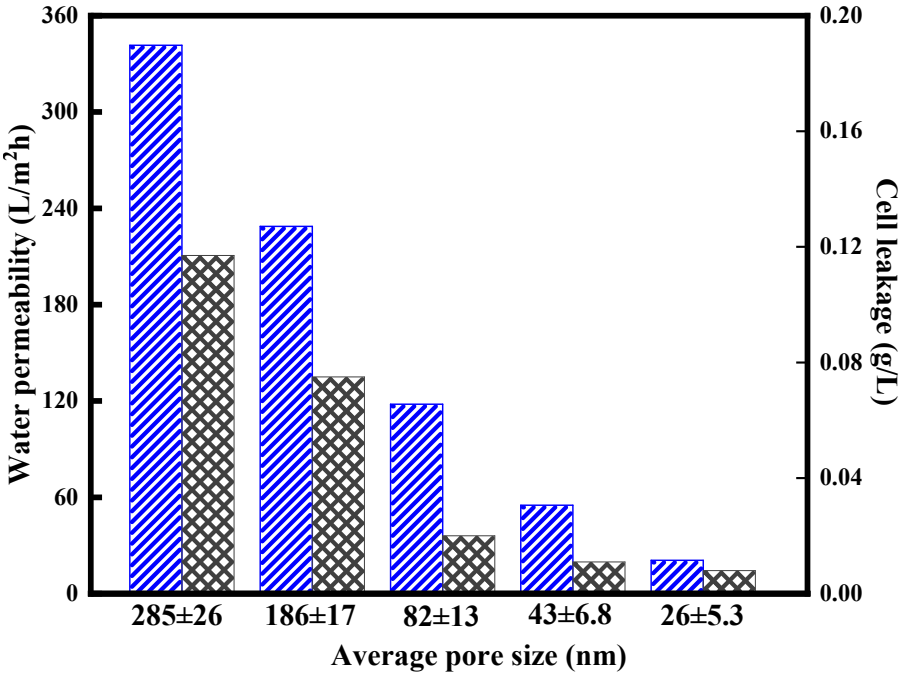

Figure S13. Variation on water permeability and living cells leakage of porous polymeric shells with different sizes.

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