Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Protein-inorganic hybrid system for efficient his-tagged enzymes immobilization and its application in L-xylulose production

Sanjay K. S. Patel,[a] Sachin V. Otari,[a] Yun Chan Kang,[*b] and Jung-Kul Lee[*a]

[a] Department of Chemical Engineering, Konkuk University, 120 Neungdong-Ro, Gwangjin-Gu, Seoul 05029, South Korea

[b] Department of Materials Science and Engineering, Korea University, Anam-Dong, Seongbuk-Gu, Seoul 02841, South Korea

*Corresponding author. Mailing address:

Department of Chemical Engineering, Konkuk University, Seoul 05029, South Korea. *E-mail: jkrhee@konkuk.ac.kr; Fax: +82-2-458-3504; Tel: +82-2-450-3505*

Department of Materials Science and Engineering, Korea University, Seoul 02841, South Korea. *E-mail: yckang@korea.ac.kr; Fax: +82-2-928-3584; +82-2-3290-3282.*

Table S1. Synthesis of recombinant enzyme nanoflowers as enzyme-$Cu(PO_4)_3 \cdot H_2O$ hybrids.

Method (Reference)	Synthesis conditions	Enzyme			
		HjLAD		SpNox	
		EY[a] (%)	RA[b] (%)	EY (%)	RA (%)
1 (3)	Cu (0.8 mM) and incubation of 3 days at 25 °C	66.8 ± 4.3	14.4 ± 2.1	64.2 ± 4.0	17.1 ± 1.2
2 (28)	Cu (6 mM) and incubation of 24 h at 4 °C	51.2 ± 4.1	90.0 ± 3.3	44.9 ± 3.7	71.6 ± 4.7
3 (**This study**)	Cu (2 mM) and incubation of 24 h at 4 °C	63.4 ± 5.8	246 ± 21	58.9 ± 5.7	144 ± 16

[a] Encapsulation yield; [b] Relative activity.

Relative activity of the free enzyme was considered as 100%.

Table S2. Comparison of his-tagged enzymes immobilization through organic-inorganic hybrid systems.

Enzyme	Organic-inorganic hybrid system		RA[a] (%)	Reference
	Complex	Morphology		
Bs-ADH	$Cu_3(PO_4)_2$-enzyme	Nano-flower	1.74	3
	$Co_3(PO_4)_2$-enzyme	Sponge	44.0	
Ll-ADH	$Cu_3(PO_4)_2$-enzyme	Nano-flower	42.0	3
	$Co_3(PO_4)_2$-enzyme	Sponge	94.0	
Epoxide hydrolase	Fmoc-diphenylalanine-polyethyleneimine-silicate-enzyme	Capsule	60.0	40
ADP-dependent glucokinase	Diatom silica-enzyme	Film	90.0	41
Cellulase	Diatom silica-enzyme	Film	75.0	41
Glucose-6-phosphate dehydrogenase	Diatom silica-enzyme	Film	80.0	41
HjLAD	$Cu_3(PO_4)_2$-enzyme	Nano-flower	246	**This study**
SpNox	$Cu_3(PO_4)_2$-enzyme	Nano-flower	144	

[a] Relative activity.

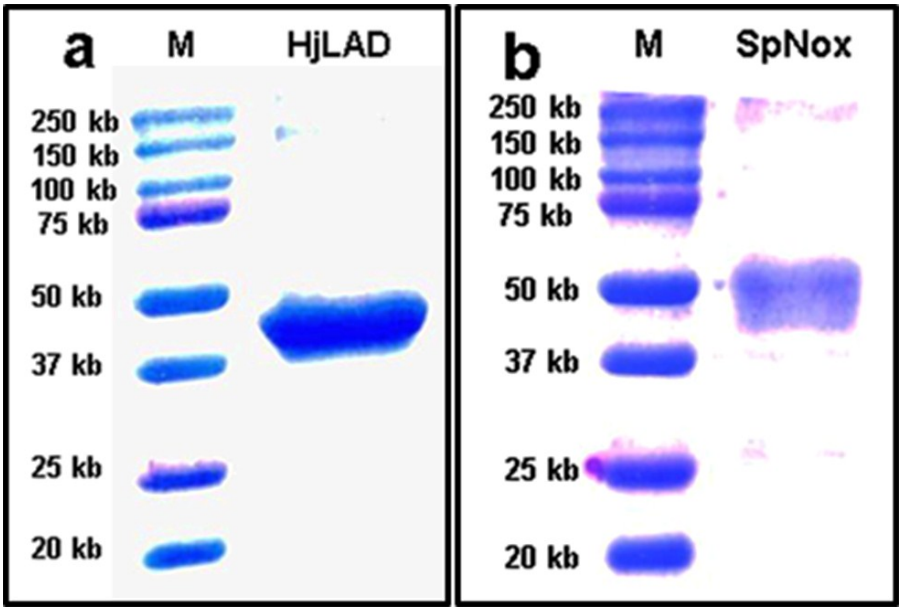

Fig. S1 SDS-PAGE analysis of purified enzymes (Lane M contains the protein markers). a) HjLAD (~41 kDa) and b) SpNox (50 kDa).

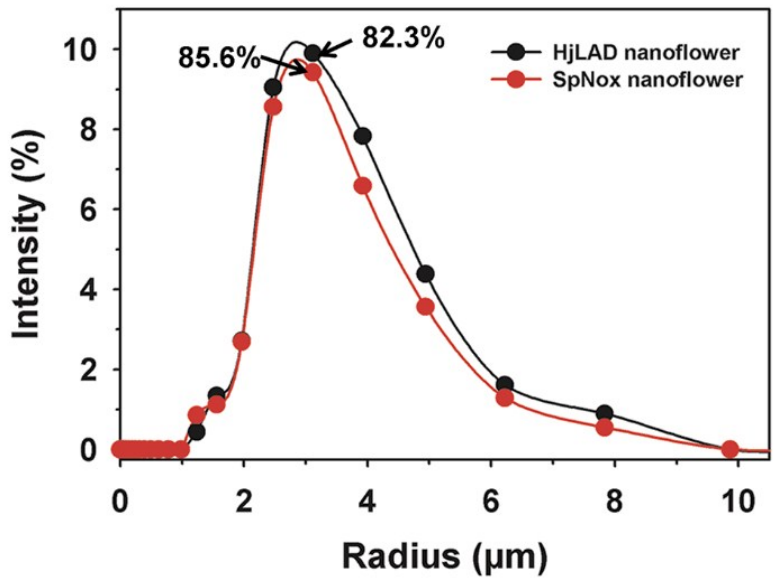

Fig. S2 DLS analysis of the particle distribution of synthesized nanoflowers.

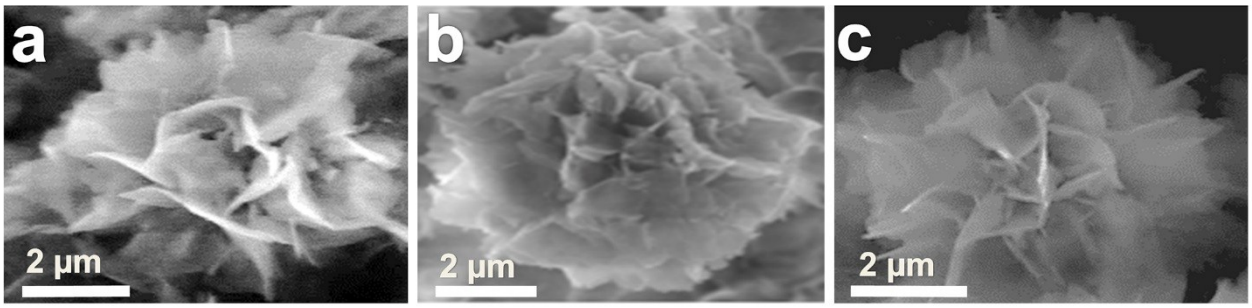

Fig. S3 FE-SEM analysis of the synthesized HjLAD nanoflower at pH 6.5 (a), 7.4 (b), and 8.0 (c) in phosphate buffer (10 mM).

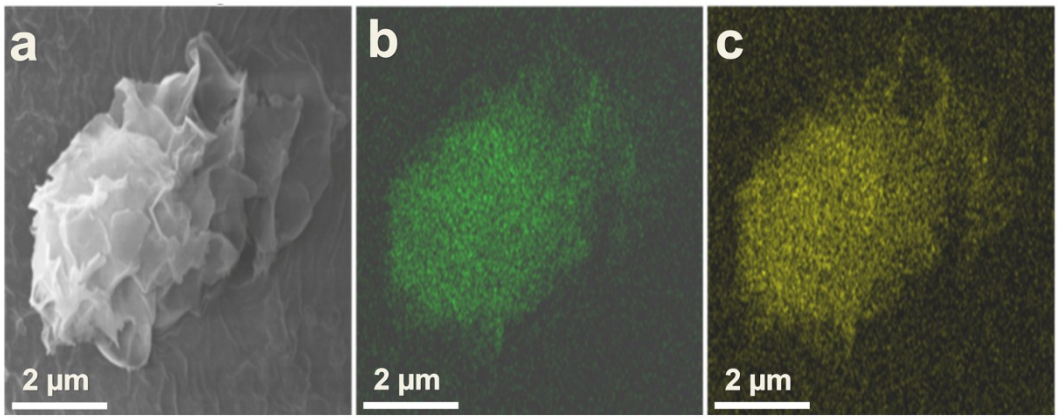

Fig. S4 FE-SEM analysis of the synthesized HjLAD nanoflower (a), and elemental mapping images of copper (b) and phosphorous (c).