

Supplementary file

## **Sequential Co-immobilization of Enzymes on Magnetic Nanoparticles for Efficient L-Xylulose Production**

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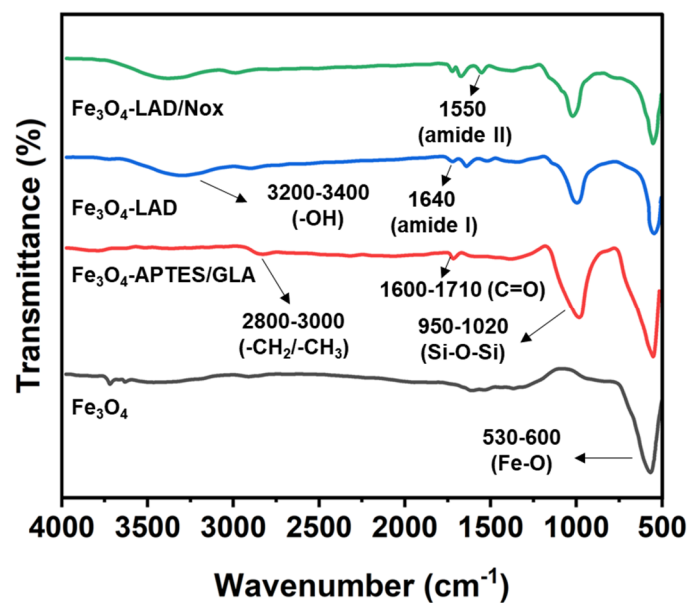
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**Table S1.** Secondary structures analysis of free and immobilized enzymes on Fe<sub>3</sub>O<sub>4</sub>-APTES/GLA nanoparticles.

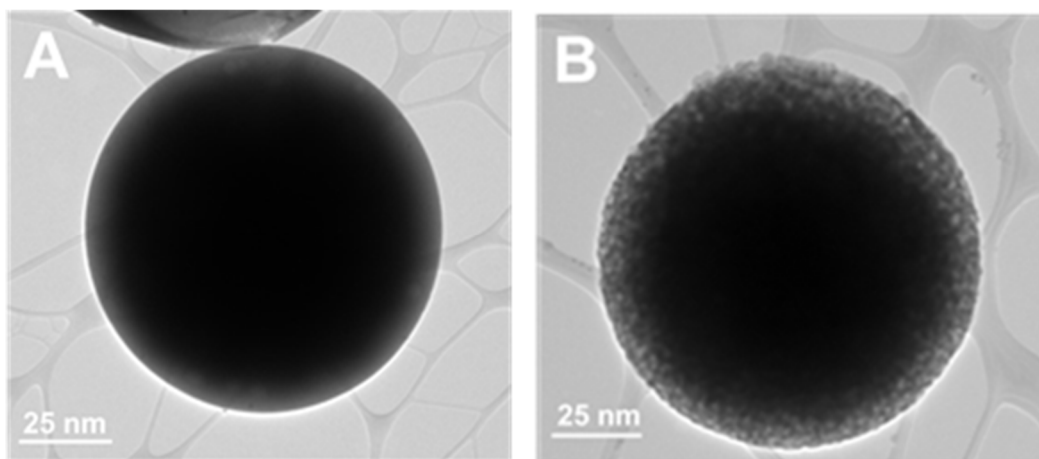
Enzymes	$\alpha$ -helix (%)	$\beta$ -sheet (%)	$\beta$ -turn (%)	Others (%)
Free LAD	39.1	31.6	12.1	17.2
Immobilized LAD	46.9	22.3	20.4	10.4
Free Nox	60.7	10.5	7.9	20.9
Immobilized Nox	71.3	6.2	10.2	12.3

**Table S2.** Influence of enzyme ratio on conversion of L-arabinitol to L-xylulose.

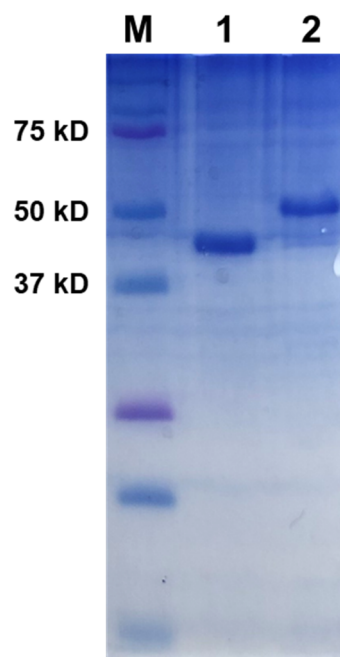
Ratio (LAD:Nox)	Relative conversion (%)
1:2	33.4 ± 2.7
1:3	35.7 ± 2.8
2:1	32.8 ± 3.0



**Figure S1.** Fourier-transform infrared spectra of pure Fe<sub>3</sub>O<sub>4</sub>, functionally activated (Fe<sub>3</sub>O<sub>4</sub>-APTES/GLA), immobilized with LAD (Fe<sub>3</sub>O<sub>4</sub>-LAD), and sequentially co-immobilized LAD and Nox (Fe<sub>3</sub>O<sub>4</sub>-LAD/Nox).



**Figure S2.** High-resolution transmission electron microscopy images of free nanoparticles (A), and with sequentially co-immobilized LAD and Nox ( $\text{Fe}_3\text{O}_4\text{-LAD/Nox}$ ) (B).



**Figure S3.** SDS-PAGE analysis. M - Protein marker, lane 1 - purified LAD, and lane 2 - purified Nox.