Supporting Information

Experimental

Materials and chemicals

Purchased from Sigma-Aldrich: bovine serum albumin (BSA), chicken egg ovalbumin (OVA), 2, 5-dihydroxy-benzoic acid (DHB), 2-methylimidazole (MIM, purity 99%). Purchased from Sinopharm Chemical Reagent Co., Ltd.: $CoCl_2 \cdot 6H_2O$ (purity 97%), $Zn(NO)_3 \cdot 6H_2O$. Purchased from Genetimes Technology: PNGase F. Ultrafiltration membrane with MWCO of 10 KDa was purchased from Millipore (Bedford, MA). Human serum was provided by Shanghai Second Military Medical University. All applied deionized water during the process of experiment were prepared by Milli-Q system (Millipore, Bedford, MA). Acetonitrile (ACN) was purchased from Merck (Darmstadt, Germany). All of other chemicals are of analytical grade.

Preparation of Mag-NHCs

Firstly, ZIF-8 crystals were synthesized according to the reported procedures. [1] Briefly, 2.72 mmol $Zn(NO)_3 \cdot 6H_2O$, 0.156 mmol MIM and 40 mL methyl alcohol were mixed and stirred, then transferred into autoclave. Finally, the autoclave was placed in 100 degrees oven for 12 h.

Secondly, ZIF-67 crystals were coated on the outside of core ZIF-8 crystals. Briefly, 80 mg ZIF-8 crystals were dispersed in solution of 10 mL methyl alcohol, following ultrasonicated about half an hour, then stirred for another 20 minutes. Then methanolic solution of $CoCl_2 \cdot 6H_2O$ (3 mL, 0.74 mmol) and methanolic solution of MIM (3 mL, 10.9mmol) were added in above mixture solution. After stirring for 5 minutes, the mixture was transferred into autoclave. Finally, the autoclave was placed in 100 degrees oven for 12 h.

Core-shell ZIF-8@ZIF-67 crystals were washed and collected for further thermal treatment in nitrogen atmosphere (800 degrees, 3 hours). The final products were acquired.

Protocol of enrichment process

Mag-NHCs (10 mg/mL, 50uL) were added in the solution containing a certain concentration of sample, such as OVA digestion and human serum (total volume kept at 150 μL). After incubated for 30 min, solid-liquid mixture was separated by additional magnetic field. Then the obtained solids were washed with water for three times. In the end, 10 μL eluent (50% ACN) was used for MS analysis.

A certain concentration of OVA digestion solution (1μg/μL, 10μL) was added in the mixed solution consisting of different proportions of BSA and OVA protein (total volume kept at 150 μL). After incubated for 30 min, solid-liquid mixture was separated by additional magnetic field. Then the obtained solids were washed with water for three times. In the end, 10 μL eluent (50% ACN) was used for MS analysis.

The recycle of Mag-NHCs was conducted as follow:

During the process of recycle, the detailed steps of enrichment and elution are the same as the above. After the usage of Mag-NHCs, the Mag-NHCs were washed with eluent for three times, for which thoroughly clear away the N-glycans adsorbed on the Mag-NHCs. Then the regenerated Mag-NHCs were washed with deionized water three times to recycle.

MALDI-TOF MS analysis

Respectively, sample solutions (1μL) and DHB matrix solution (10 mg/mL, 0.1% TFA in 20% ACN/H_2O solution, 1μL) were spotted onto the MALDI plate in order, and then dried naturally.

Positive ion mode on a 5800 Proteomics Analyzer (Applied Biosystems, USA) in the reflector TOF detection modes was applied to detect the sample which was motivated by a Nd:YAG laser (383 nm) that was run at a frequency of 200 Hz and accelerated voltage of 20 kV.

Reference

[1] M. M. Liu, W. M. Lü, X. F. Shi, B. B. Fan, Chinese J. Inorg. Chem. **2014**, 30.

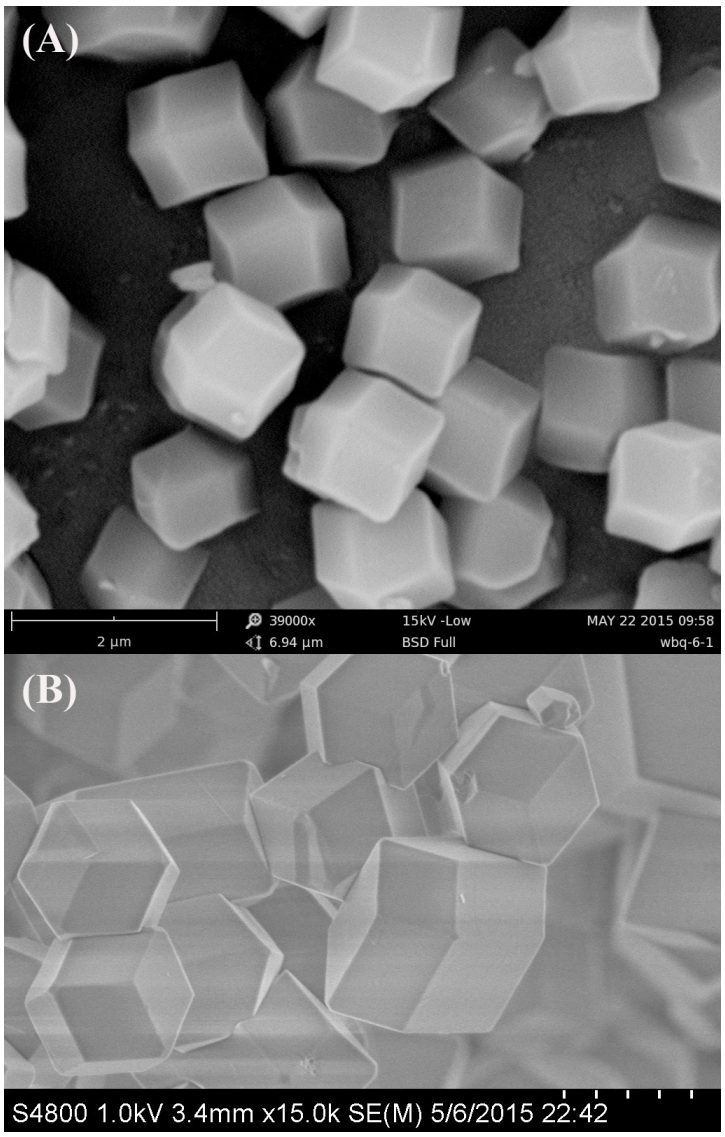


Fig. S1. SEM images of (A) ZIF-8 crystals; (B) ZIF-8@ZIF-67 crystals.

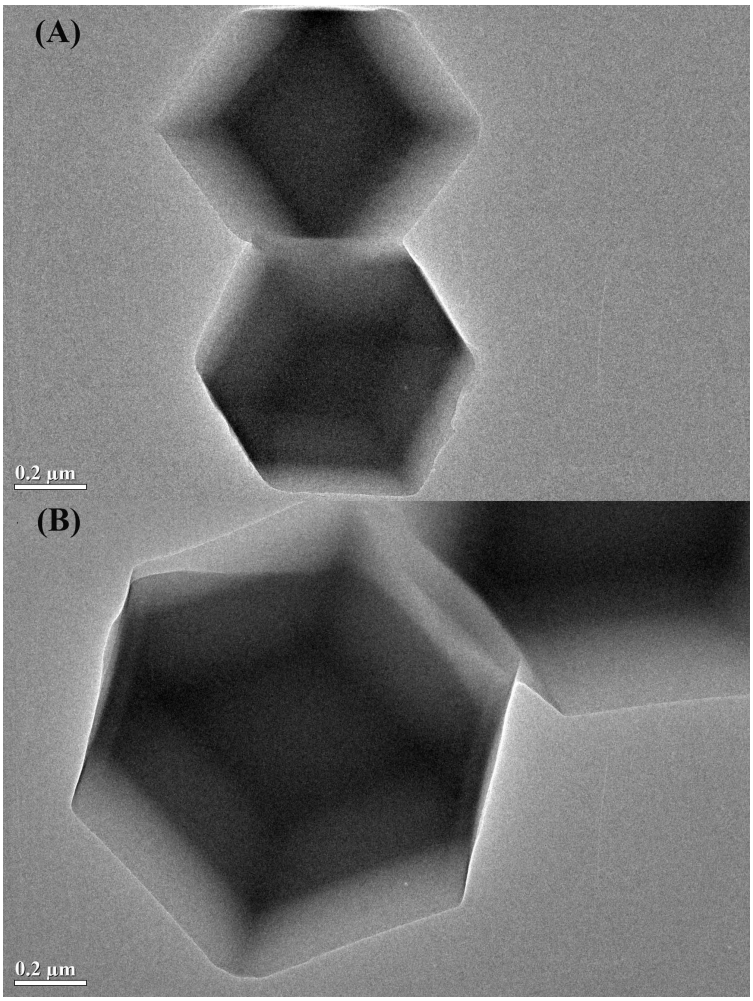


Fig. S2. TEM images of (A) ZIF-8 crystals; (B) ZIF-8@ZIF-67 crystals.

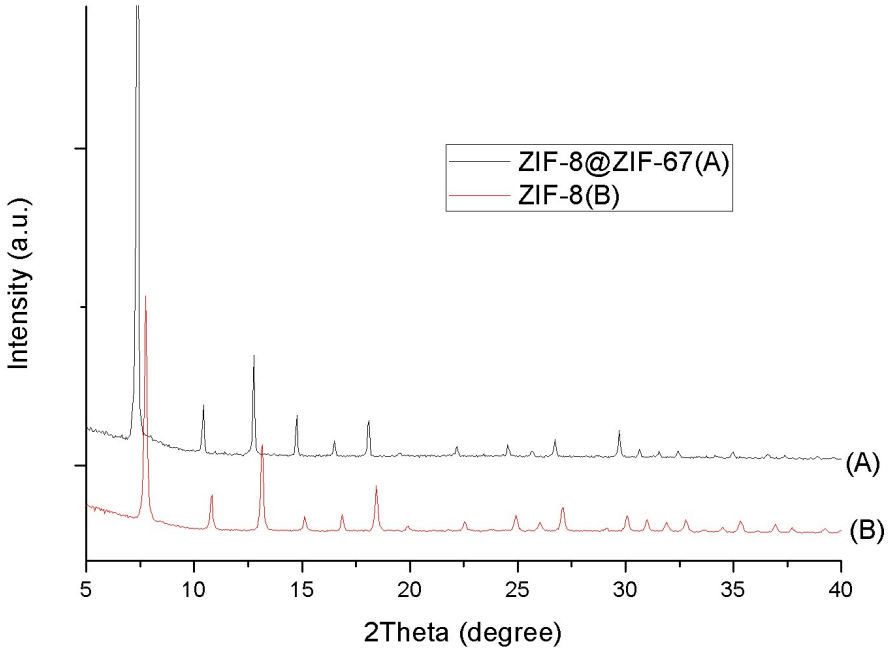


Fig. S3. Wide-angle XRD pattern of (A) ZIF-8@ZIF-67 crystals; (B) ZIF-8 crystals.

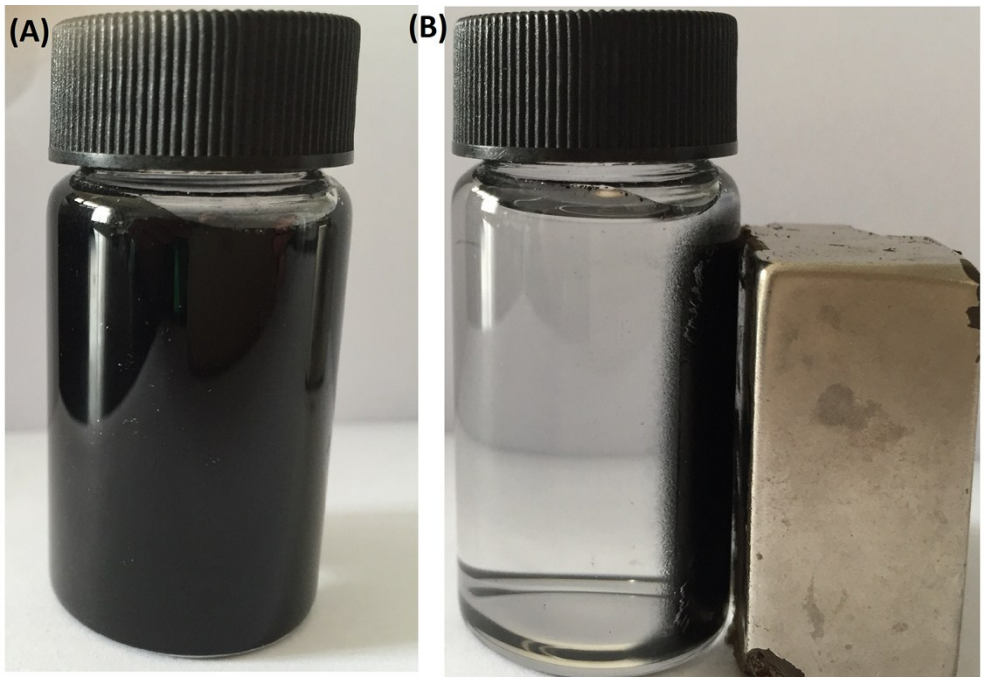


Fig. S4. Mag-NHCs dispersed in water (A) and magnetically separated (B).

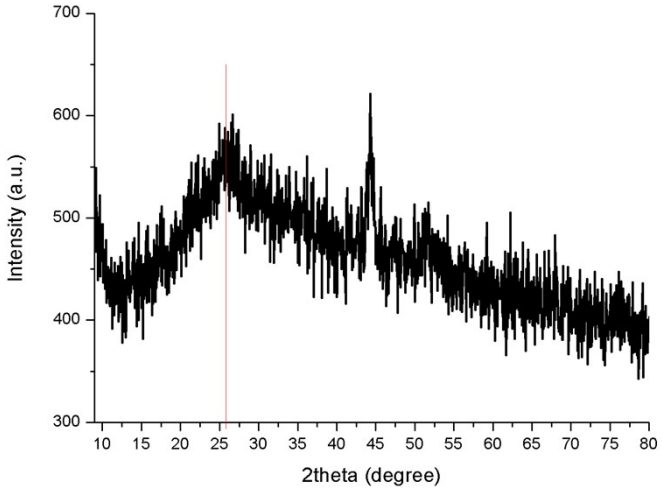


Fig. S5. Wide angle XRD pattern of Mag-NHCs.

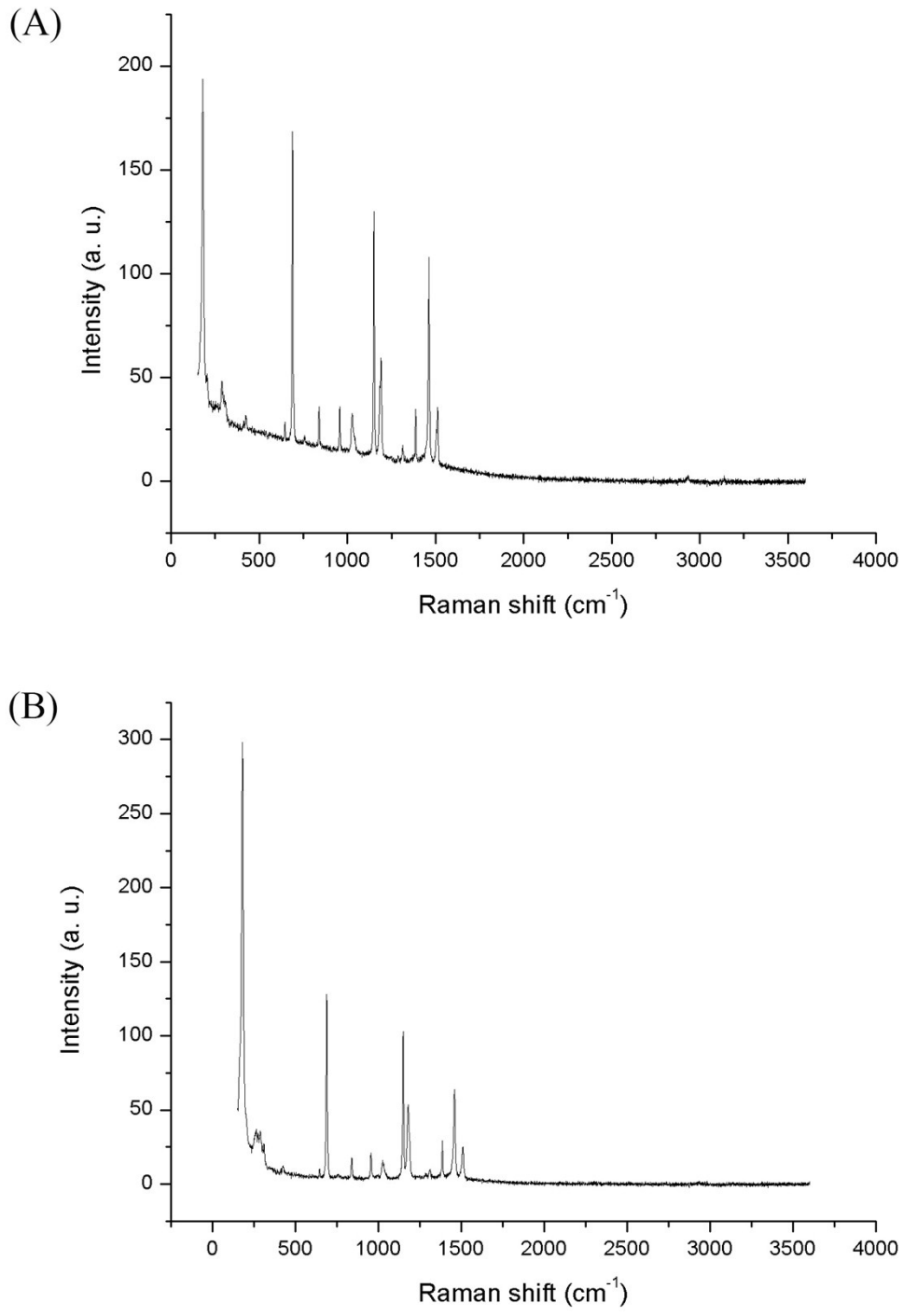
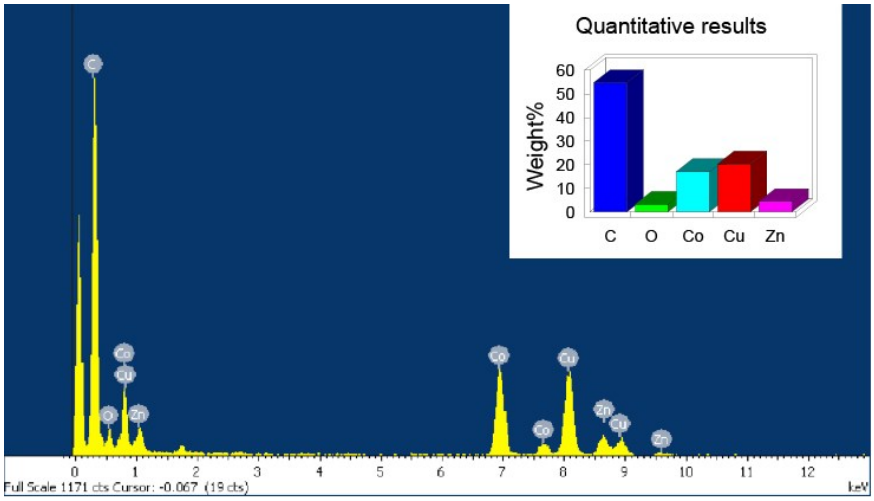


Fig. S6. Raman spectrum of (A) ZIF-8 crystals; and (B) ZIF-8@ZIF-67 crystals.



Element	Weight%	Atomic%
C K	54.89	83.83
O K	3.26	3.74
Co K	17.10	5.32
Cu K	20.33	5.87
Zn K	4.41	1.24
Totals	100.00	

Fig. S7. Elemental analysis of Mag-NHCs.

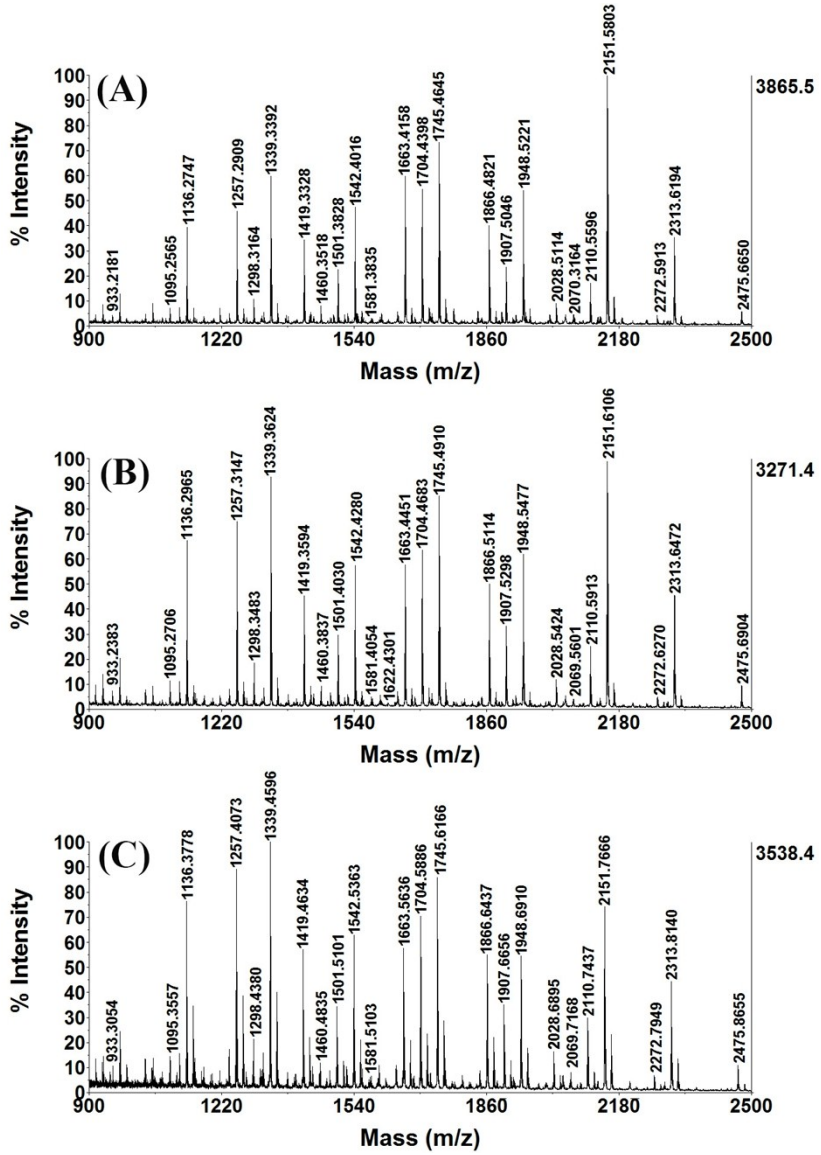


Fig. S8. MALDI mass spectra of N-glycans enriched from ovalbumin digests(10μg) by Mag-NHCs (50μL, 10mg/mL, in water). (A) first application of the materials; (B) second application of the materials; (C) third application of the materials.

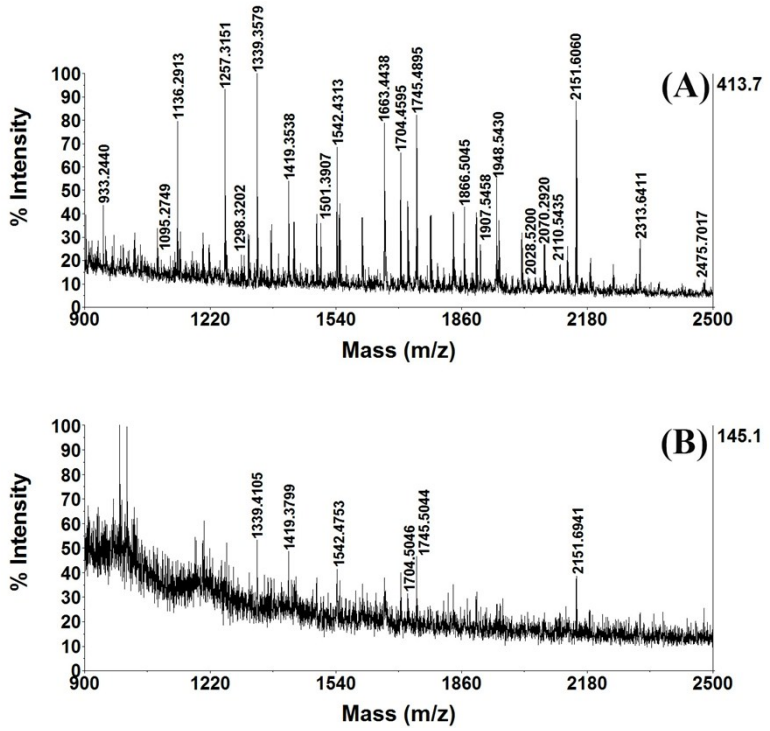


Fig. S9. MALDI mass spectra of N-glycans enriched from ovalbumin digests with different concentrations (A) 5 ng/μL; (B) 2 ng/μL, using Mag-NHCs.

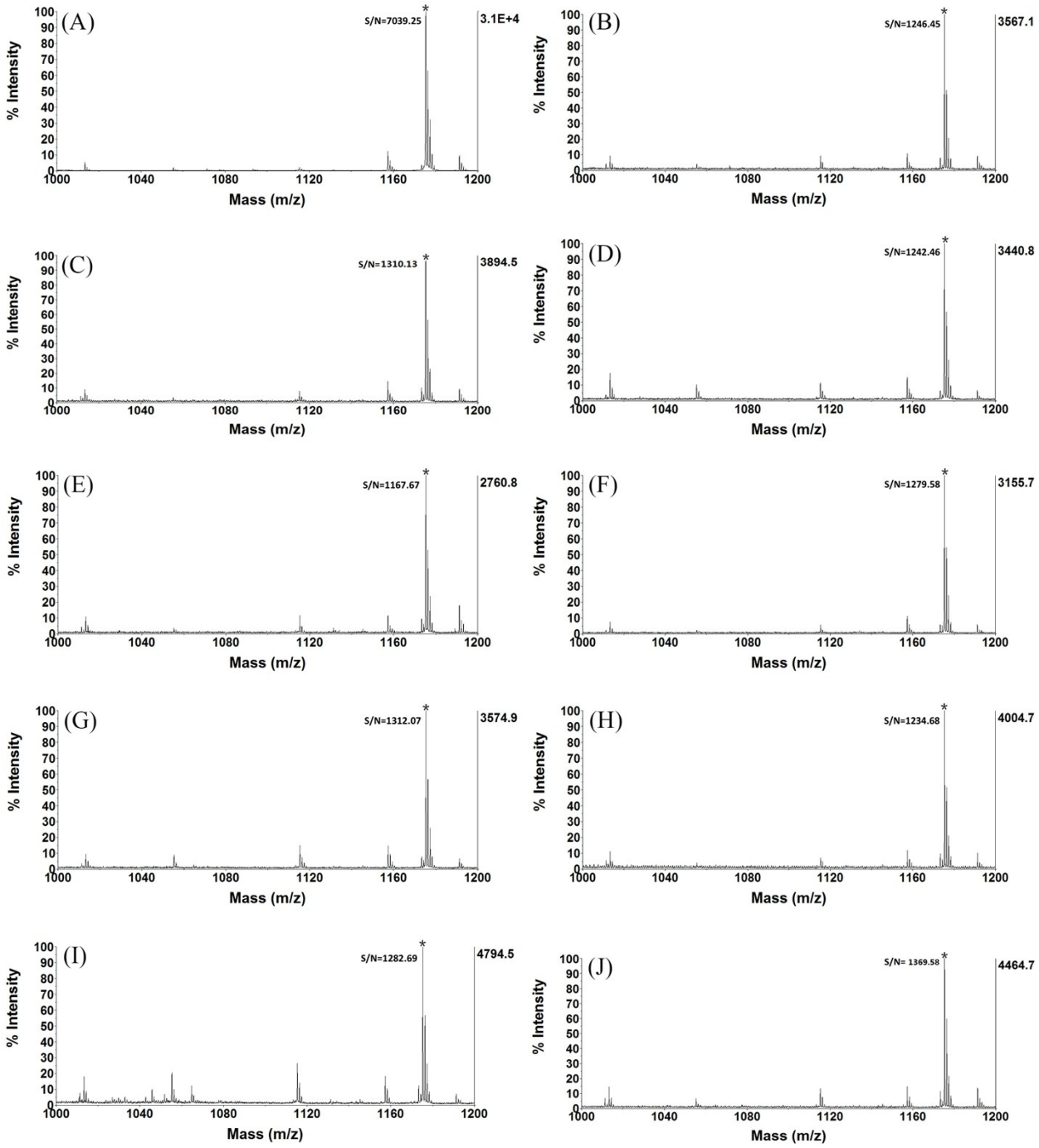


Fig. S10. MALDI mass spectra of (A) 500 ng of maltoheptaose and (B-J) the elution (5μL, 1μL was spotted on the MALDI plate) after enrichment with Mag-NHCs.

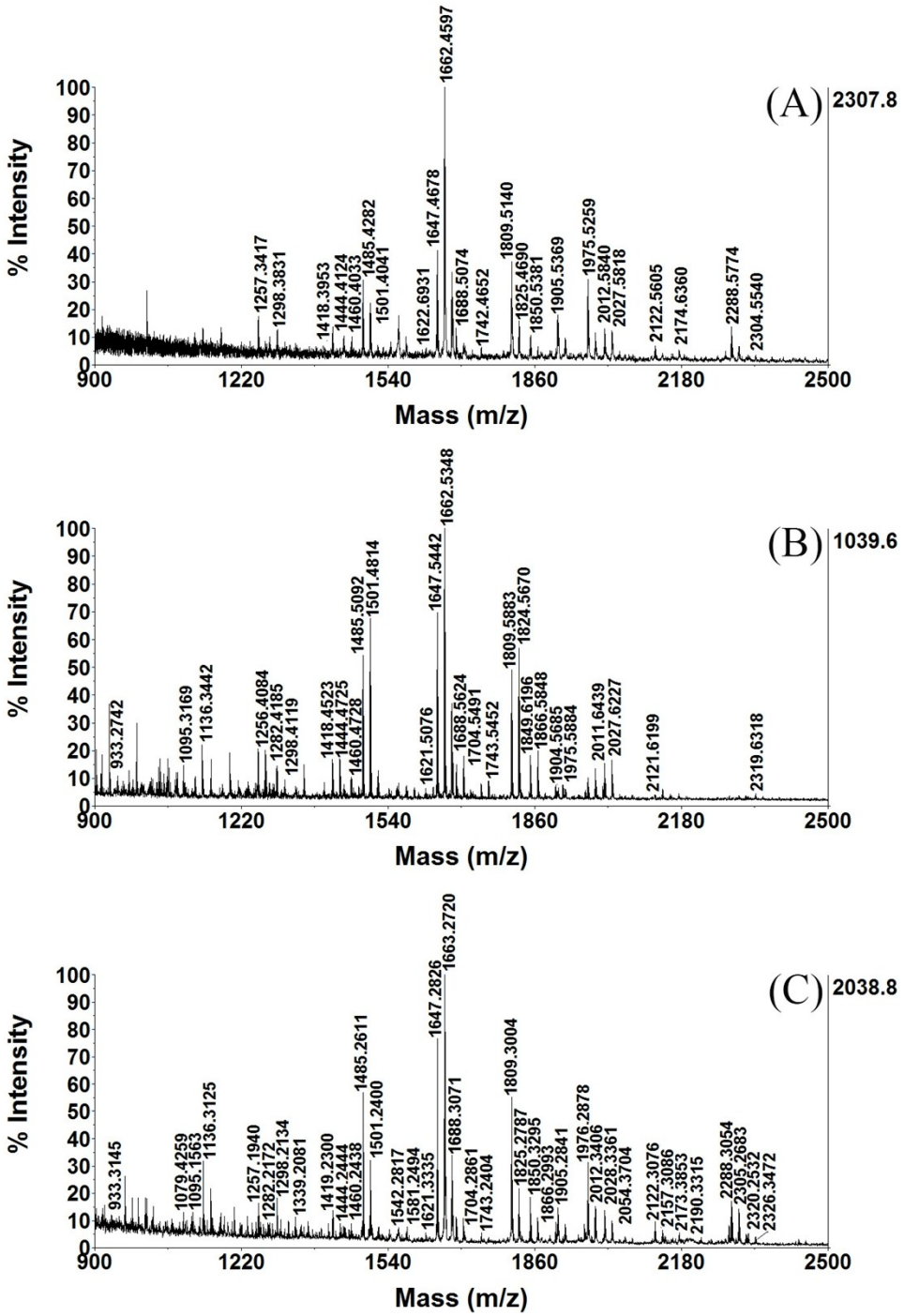
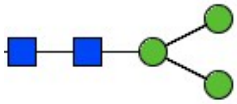
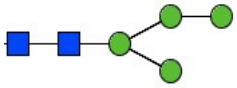
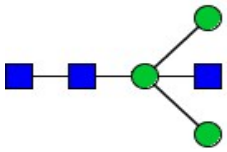
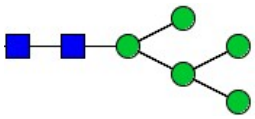
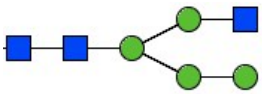
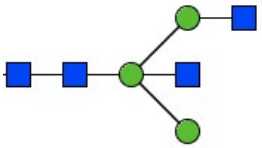
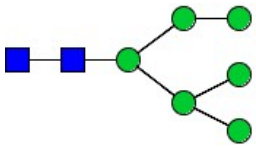
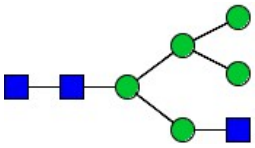
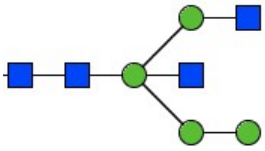
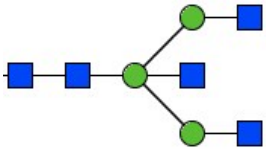
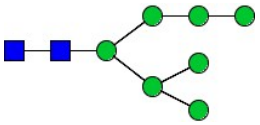
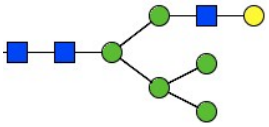
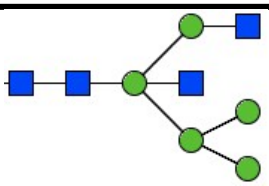
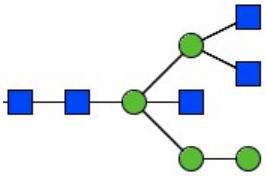
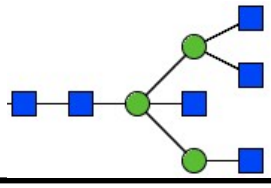
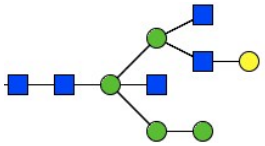
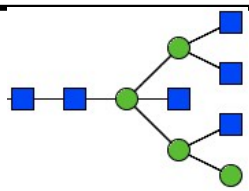
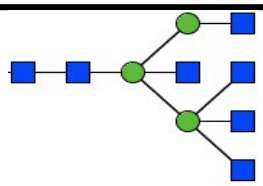
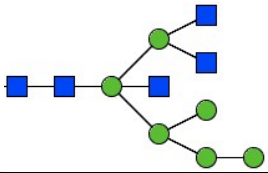
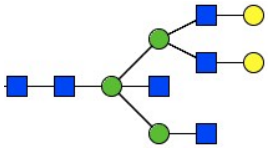
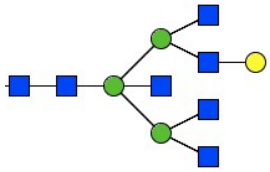
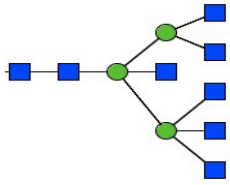
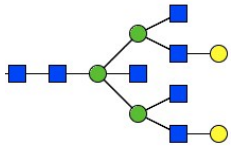


Fig. S11. MALDI mass spectra of N-glycans released from human serum after enrichment with active carbon (A), NPC from ZIF-67 and Mag-NHCs (C).

Table S1. List of identified N-glycans released from OVA. Symbols in composition: H=Hexose; N=N-Acetyl hexosamine; ●,Mannose; ○,Galactose; ■,GlcNAc.

No	M/Z ([M+nNa]$^{+}$)	Structure (M)	Composition
1	933.2		H3N2
2	1095.3		H4N2
3	1136.3		H3N3
4	1257.3		H5N2
5	1298.3		H4N3
6	1339.3		H3N4

7	1419.3		H6N2
8	1460.3		H5N3
9	1501.4		H4N4
10	1542.4		H3N5
11	1581.4		H7N2
12	1622.4		H6N3
13	1663.4		H5N4
14	1704.4		H4N5

15	1745.5		H3N6
16	1866.5		H5N5
17	1907.5		H4N6
18	1948.5		H3N7
19	2028.5		H6N5
20	2069.5		H5N6
21	2110.6		H4N7
22	2151.6		H3N8
23	2272		H5N7

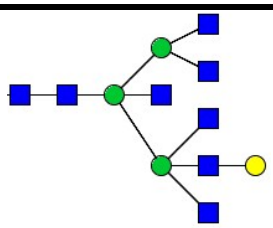
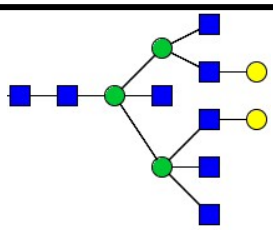
24	2313.6		H4N8
25	2475.7		H5N8

Table S2. The S/N ratios of 500 ng maltoheptaose and the elution (5 μL, 1 μL was spotted on the the MALDI plate) after enrichment with Mag-NHCs and calculated recovery of the maltoheptaose on Mag-NHCs.

No.	S/N	Recovery (%)
1	1246.45	88.54
2	1310.13	93.06
3	1242.46	88.25
4	1167.67	82.94
5	1279.58	90.89
6	1312.22	93.21
7	1234.68	87.70
8	1282.69	91.11
9	1369.58	97.28
500ng maltoheptaose (S/N=7039.25)		