Electronic Supplementary Information

Separation of Enantiomers with Magnetic Silica Nanoparticles Modified by a Chiral Selector: Enantioselective Fishing

Hee Jung Choi and Myung Ho Hyun*

Department of Chemistry and Chemistry Institute for Functional Materials, Pusan National university, Busan 609-735, Korea

Preparation of magnetic silica nanoparticles (MSNPs)

Oleic acid stabilized iron oxide (Fe_3O_4) nanoparticles prepared using the procedures reported previously[1] were dispersed in chloroform to form magnetic fluid. Magnetic fluid (1 mL, 2.0 wt.%) was diluted with ethanol (200 mL), water (1.0 mL), cetyltrimethylammonium bromide (CTAB, 0.3 g, 0.823 mmol) and ammonium hydroxide solution (1.0 mL, 28 wt. % in water). The resulting solution was homogenized by ultrasonic vibration in water bath for 30 min. To the solution was added tetraethylorthosilicate (TEOS, 0.4 g, 1.90 mmol) slowly with mechanical stirring and then the whole mixture was stirred for 12 hr. The precipitate was collected with a magnet and washed with water, methanol, ethanol, acetone and dichloromethane. The resulting MSNPs were redispersed in acetone (20 mL), sonicated for 30 min to remove CTAB and then collected by a magnet and this process was repeated for five times. MSNPs were sonicated again for 30 min in acidic ethanol solution to remove oleic acid and then collected by a magnet. This process was repeated for three times. Finally, MSNPs were washed with water and then acetone.

Preparation of MSNPs tagged to chiral selector [MSNPs/(*S*)-CS]

A 250 mL three neck flask equipped with a Dean-Stark trap, a condenser and a mechanical stirrer was charged with MSNPs (1.0 g) and toluene (150 mL). The mixture was heated to reflux until the complete azotropic removal of water. To the heterogeneous solution was added (*S*)-*N*-[5-(ethoxydimethylsilyl)-2,2dimethyl-pentanoyl]-proline-3,5-dimethylanilide (0.7 g, 1.6 mmol), which was prepared from (*S*)-proline via the reported procedure,[2] dissolved in 10 mL of toluene. The whole mixture was refluxed for 72 hr and then the resulting surface modified MSNPS, MSNPs/(*S*)-CS, were filtered and washed successively with methanol, acetone, ethyl acetate,

dichloromethane, hexane and diethyl ether. Finally MSNPs/(*S*)-CS were dried under high vacuum.

Preparation of non-magnetic silica particles (NMSPs) tagged to chiral selector [NMSPs/(*R*)-CS]

NMSPs/(*R*)-CS were prepared by bonding (*R*)-*N*-[5-(ethoxydimethylsilyl)-2,2-dimethylpentanoyl)-proline-3,5-dimethylanilide (0.7 g, 1.6 mmol) to NMSPs (Kromasil silica gel, 5 μm, 1.0 g) by the method described for the preparation of MSNPs/(*S*)-CS.

Determination of the enantiomeric excess of the enantiomers separated by MSNPs/(*S*)-CS and NMSPs/(*R*)-CS

MSNPs/(*S*)-CS/Enantiomer or NMSPs/(*R*)-CS/Enantiomer separated were washed with ethanol (300 μL) and then the ethanol solution (3 μL) was injected into the high performance liquid chromatography system equipped with (*R*,*R*)-Whelk-O1 chiral column (at this step we tried to use minimum amount of ethanol in washing off the enantiomer from the MSNPs/(*S*)-CS/Enantiomer or NMSPs/(*R*)-CS/Enantiomer complex to use the ethanol solution in HPLC analysis directly and from several tries we found that 300 μL ethanol was sufficient). From the size of the peaks corresponding to the two enantiomers, the enantiomeric excess was calculated. Chromatography was performed with an HPLC system consisting of a Waters model 515 pump (Milford, MA, USA), a Rheodyne model 7725i injector (Rohnert Park, CA, USA) with a 20 μL sample loop, a Waters 2487 Dual absorbance detector and a Younglin Autochro data module (Software: YoungLin Autochro 2000).

Reference

1. H. Xu, L. Cui, N. Tong, H. Gu, *J. Am. Chem. Soc.*, 2006, **128**, 15582.
2. W. H. Pirkle, P. G. Murray, *J. Chromatogr*. 1993, **641**, 11.

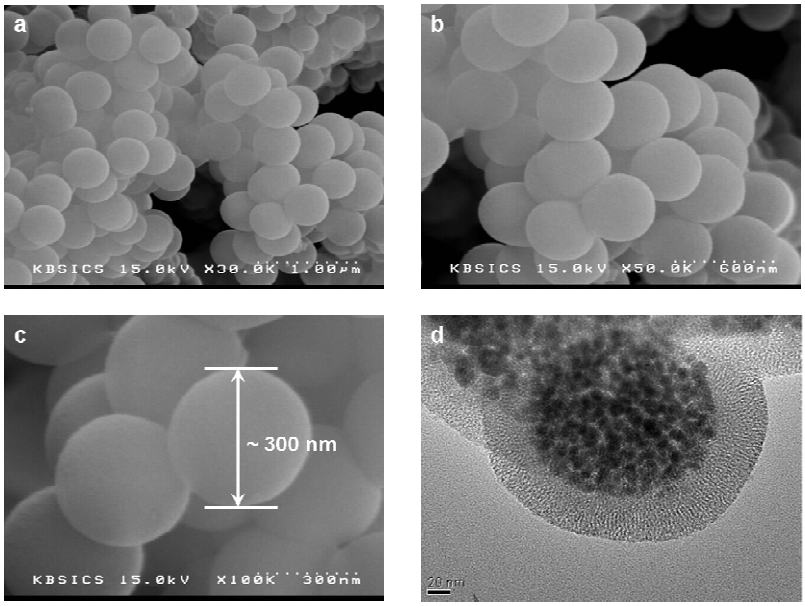

Fig. S1 SEM (a, b and c) and TEM (d) images of MSNPs prepared in this study.

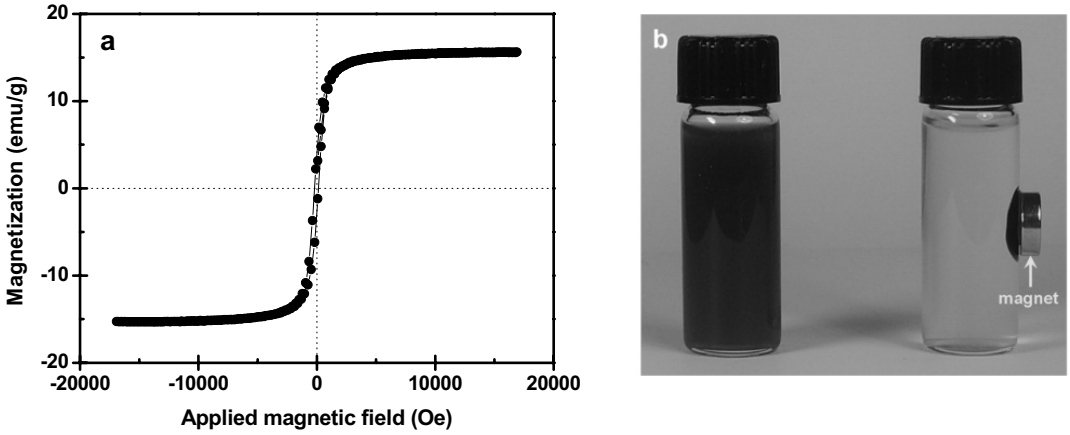

Fig. S2 (a) The hysteresis loop of the synthesized MSNPs. (b) MSNPs dispersed homogeneously in ethanol (left) and MSNPs captured by a magnet (right)

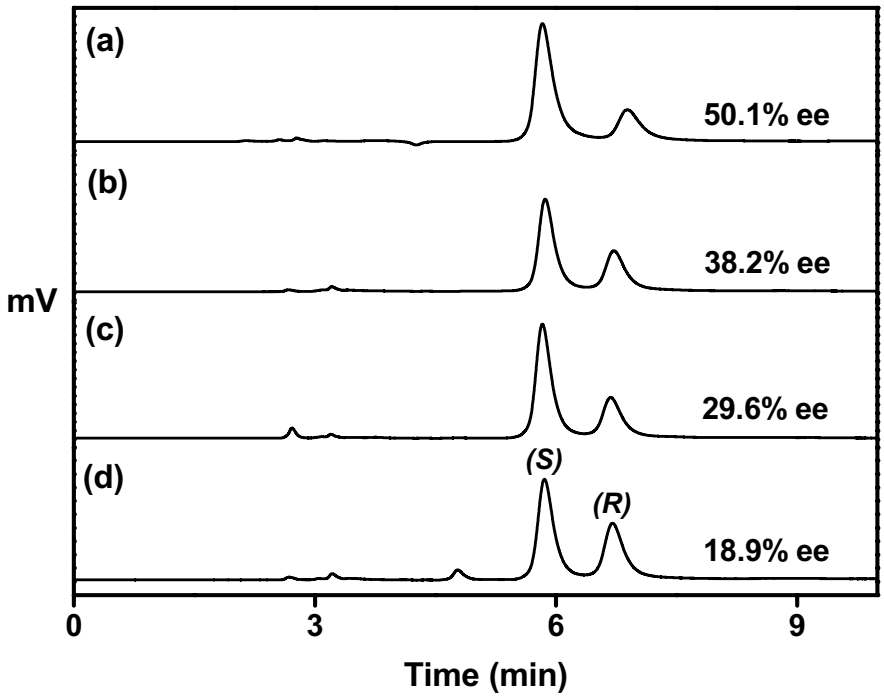

Fig. S3 Chromatograms for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide separated by MSNPs/(S)-CS in 10 % 2-propanol in hexane (a), 30 % 2-propanol in hexane (b), 50 % 2-propanol in hexane (c) and 80 % 2-propanol in hexane (d). Concentration of racemic *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide: 0.5 mg/mL. Chiral column: (*R*,*R*)-Whelk-O1 (250 x 4.6 mm ID). Mobile phase: 30 % 2-propanol in hexane. Flow rate: 1.0 mL/min. Temperature: 20 ^{o}C. Detector: 254 nm UV.

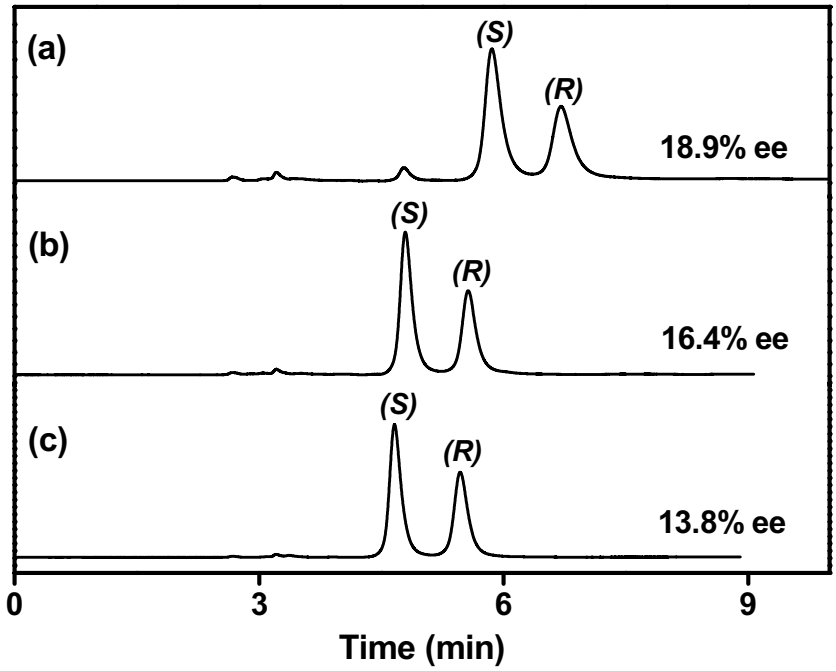

Fig. S4 Chromatograms for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide (a), *N*-(3,5-dinitrobenzoyl)valine *N*-propylamide (b) and *N*-(3,5-dinitrobenzoyl)leucine *N*-propylamide (c) separated by MSNPs/(S)-CS in 80 % 2-propanol in hexane. Concentration of racemic *N*-(3,5-dinitrobenzoyl)alanine, valine and leucine *N*-propylamide: 0.5 mg/mL. Chiral column: (*R*,*R*)-Whelk-O1 (250 x 4.6 mm ID). Mobile phase: 30 % 2-propanol in hexane. Flow rate: 1.0 mL/min. Temperature: 20 ^{o}C. Detector: 254 nm UV.

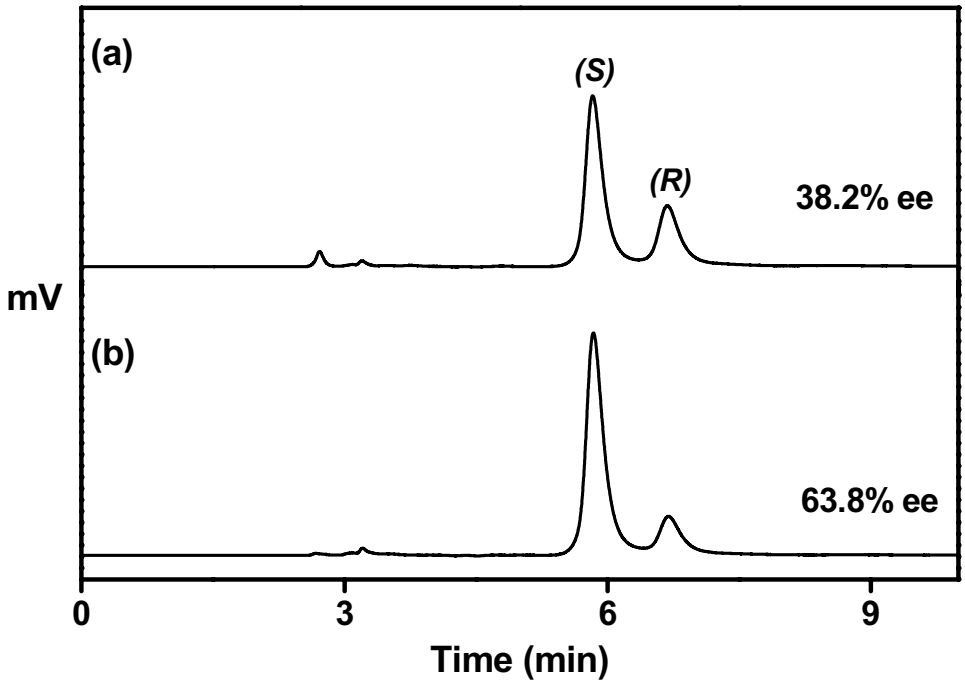

Fig. S5 Comparison of the chromatograms for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide of different concentration separated by MSNPs/(*S*)-CS in 30 % 2-propanol in hexane. (a) Concentration of racemic *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide: 0.5 mg/mL. (b) Concentration of racemic *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide: 2.0 mg/mL. Chiral column: (*R*,*R*)-Whelk-O1 (250 x 4.6 mm ID). Mobile phase: 30 % 2-propanol in hexane. Flow rate: 1.0 mL/min. Temperature: 20 ^{o}C. Detector: 254 nm UV.

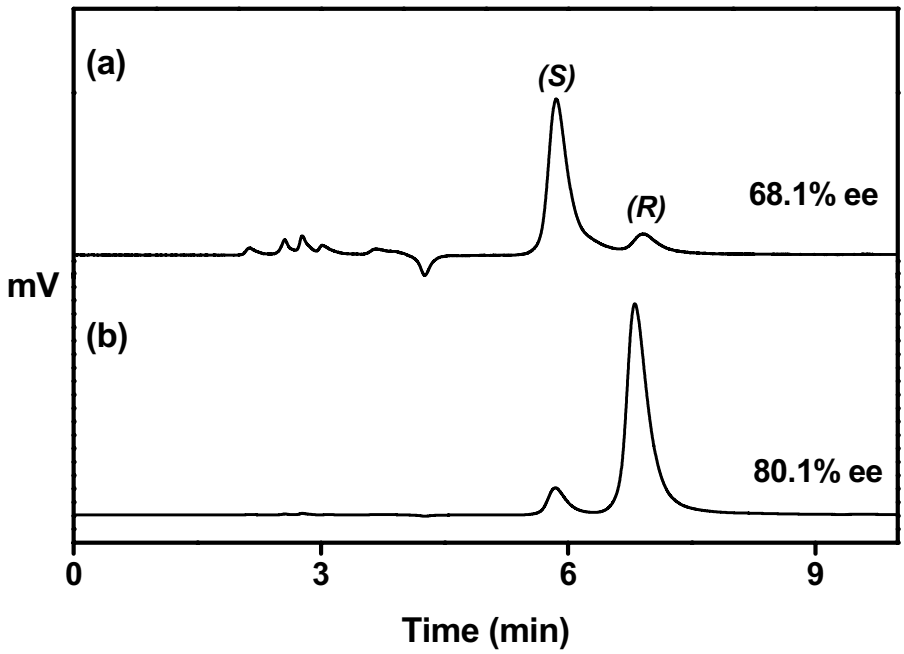

Fig. S6 Chromatograms for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide separated by the use of both MSNPs/(*S*)-CS and NMSPs/(*R*)-CS in 30 % 2-propanol in hexane. (a) Chromatogram for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide separated with MSNPs/(*S*)-CS. (b) Chromatogram for the resolution of the enantiomers of *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide separated with NMSPs/(*R*)-CS. Concentration of racemic *N*-(3,5-dinitrobenzoyl)alanine *N*-propylamide: 2.0 mg/mL. Chiral column: (*R*,*R*)-Whelk-O1 (250 x 4.6 mm ID). Mobile phase: 30 % 2-propanol in hexane. Flow rate: 1.0 mL/min. Temperature: 20 ^{o}C. Detector: 254 nm UV.