Materials List for:

Detection and Recovery of Palladium, Gold and Cobalt Metals from the Urban Mine Using Novel Sensors/Adsorbents Designated with Nanoscale Wagon-wheel-shaped Pores

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Materials

Name	Company	Catalog Number	Comments
Tetramethylorthosilicate (TMOS)	Sigma–Aldrich Company Ltd. (USA)	CAS Number 681-84-5	Molecular Weight 152.22; Linear Formula $Si(OCH_3)_4$; 218472-500G
Poly(ethylene glycol)-block-poly(propylene glycol)-block-poly(ethylene glycol), PEG-PPG-PEG, Pluronic® P-123	Sigma–Aldrich Company Ltd. (USA)	CAS Number 9003-11-6	average Mn ~5,800
Sodium citrate tribasic dehydrate	Sigma–Aldrich Company Ltd. (USA)	CAS Number 6132-04-3	Linear Formula $HOC(COONa)(CH_2COONa)_2 \cdot 2H_2O$; Molecular Weight 294.10; S4641-500G
Pentadecane, C15	Sigma–Aldrich Company Ltd. (USA)	CAS Number 629-62-9	Linear Formula $CH_3(CH_2)_{13}CH_3$; Molecular Weight 212.41
N-cyclohexyl-3-aminopropane sulfonic acid (CAPS)	Dojindo Chemicals (Japan)	343-00484, Lot.DE132	Linear Formula $C_9H_{19}NO_3S$, M1254-250G, Molecular Weight 221.32
2-Nitroso-1-naphthol (NN)	Tokyo Chemical Industry Con, LTD (TCI)	Product Number N0267	Linear Formula $ONC_{10}H_6OH$, M1254-250G, Molecular Weight 173.17
Sunset Yellow FCF	Sigma–Aldrich Company Ltd. (USA)	CAS Number 2783-94-0	Empirical Formula (Hill Notation) $C_{16}H_{10}N_2Na_2O_7S_2$, Molecular Weight 452.37, 465224-25G
Diphenylthiocarbazone	Sigma–Aldrich Company Ltd. (USA)	CAS Number 60-10-6	Linear Formula $C_6H_5NHNHCSN=NC_6H_5$, Molecular Weight 256.33, 194832-10G
4-hydrazinobenzoic acid	Sigma–Aldrich Company Ltd. (USA)	CAS Number 619-67-0	Linear Formula $H_2NNHC_6H_4CO_2H$, Molecular Weight 152.15, 246395-25G
Carbon disulfide	Sigma–Aldrich Company Ltd. (USA)	CAS Number 75-15-0	Empirical Formula (Hill Notation) CS_2, Molecular Molecular Weight 76.14, 335266-100ML
Ethanol absolute	Sigma–Aldrich Company Ltd. (USA)	CAS Number 64-17-5	Linear Formula CH_3CH_2OH, Molecular Weight 46.07, 24102-1L-R
Small angle powder X-ray diffraction (XRD)	Bruker D8 Advance		Small angle powder X-ray diffraction (XRD) patterns were measured by using a 18 kW diffractometer (Bruker D8 Advance) with monochromated CuKα radiation and with scattering reflections recorded for 2θ angles between 0.1° and 6.5° corresponding to d-spacing

			between 88.2 and 1.35 nm. First, the powder samples were ground and spread on a sample holder. The samples were scanned in the range from 2θ = 0.1°–6.5° with step size of 0.02°. To confirm the resolution of the diffraction peaks with standard reproducibility in 2θ (±0.005), the sample measurement was recorded by using both graphite monochromator and Göbel mirror detectors. Both detectors were used to generate focusing beam geometry and parallel primary beam. The sample measurement was repeated three times under rotating at various degrees (15°, 30° and 45°).
N_2 adsorption–desorption isotherms	BELSORP MIN-II analyzer (JP. BEL Co. Ltd)		N_2 adsorption–desorption isotherms were measured using a BELSORP MIN-II analyzer (JP. BEL Co. Ltd) at 77 K. The pore size distribution was determined from the adsorption isotherms by using nonlocal density functional theory (NLDFT). Specific surface area (SBET) was calculated using multi-point adsorption data from a linear segment of the N_2 adsorption isotherms using Brunauer–Emmett–Teller (BET) theory. Before the N_2 isothermal analysis, all prepared samples were pre-treated at 100 °C for 8 hr under vacuum until the pressure was equilibrated to 10^{-3} Torr.
High-resolution transmission electron microscopy (HRTEM)	JEOL JEM model 2100F microscope		High-resolution transmission electron microscopy (HRTEM) was performed using a JEOL JEM model 2100F microscope. HRTEM was conducted at an acceleration voltage of 200 kV to obtain a lattice resolution of 0.1 nm. The HRTEM images were recorded using a CCD camera. In the HRTEM characterization, the sample was dispersed in ethanol solution using an ultrasonic cleaner, and then dropped on a copper grid. Prior to inserting the samples in the HRTEM column, the grid was vacuum dried for 20 min. Energy Dispersive X-ray micro-analyzers (EDX) were recorded by employing Horiba EDS-130S, which directly connected with Hitachi FE-SEM S-4300. Elemental mapping of all samples was carried out with the energy dispersive X-ray micro-analyzers with an acceleration voltage of 30 kV. Ten distinct spots were analyzed per sample, which resulted in 99% confidence bounds of ±0.01 in the molar fraction of each cation (with their sum normalized to unity).

UV-Vis-NIR spectrophotometer	Shimadzu 3700		The absorbance spectrum of the nano-collectors material was measured by UV-Vis-NIR spectrophotometer (Shimadzu 3700).
Inductively coupled plasma mass spectrometry (ICP-MS)	Perkin Elmer Elan-6000 ICP-MS		In selective removal, metal ion concentrations were determined by ICP-AES. The instrument was calibrated using four standard solutions containing 0, 0.5, 1.0 and 2.0 mg/L (for each element) and the correlation coefficient of calibration curve was higher than 0.9999.
inductively coupled plasma atomic emission spectrometry (ICP-AES)	PerkinElmer Elan-6000		