Room-temperature synthesis of air-stable cobalt nanoparticles and their high-efficient adsorption ability for Congo red

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Batch adsorption experiments

A standard CR solution with an initial concentration of 150 mg·L^{-1} was firstly prepared. Then, 5 mg of cobalt powders were added to 50 mL of the above solution under stirring. After a specified time, the solid and liquid were separated by a magnet and UV-vis adsorption spectra were measured by an Agilent Cary 50 UV-vis spectrophotometer to determine the CR concentration in remaining solutions.

The equilibrium adsorbed concentration, q_e, was calculated according to the equation:

$$q_e = \frac{(C_0 - C_e) \times V}{W} \qquad (1)$$

where C_0 is the initial concentration of CR, mg·dm^{-3}; C_e is the equilibrium concentration in solution, mg·dm^{-3}; V is the total volume of the solution, dm^3; and W is the dry mass of the Co nanoparticle, g.

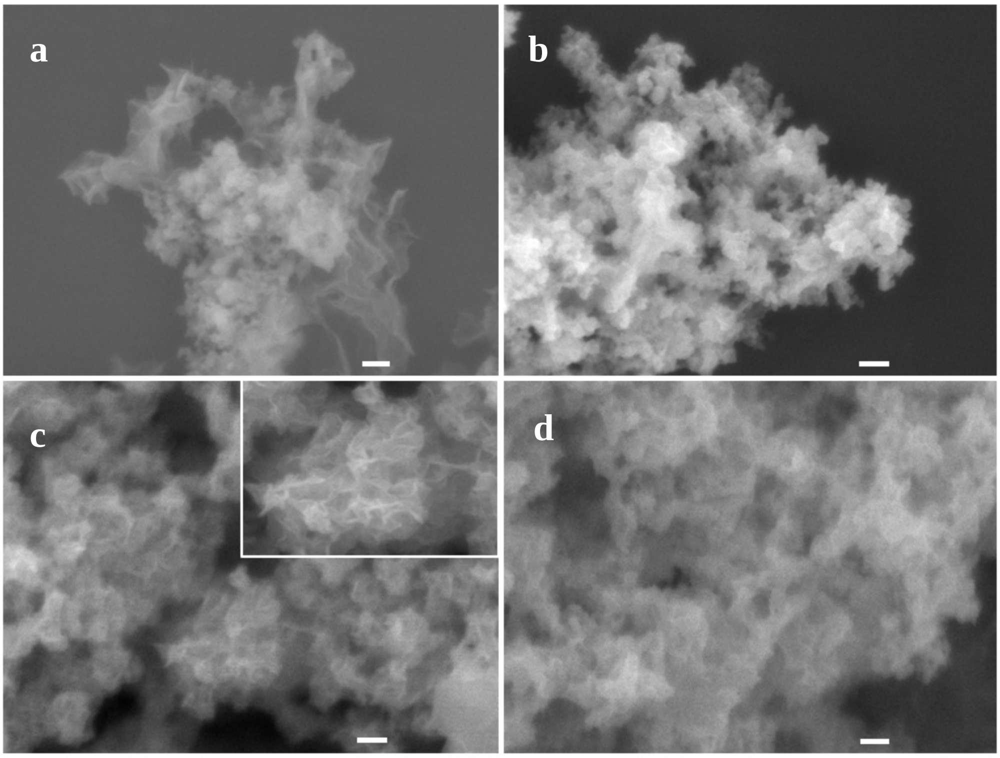

Fig. S1 FESEM images of Co nanoparticles prepared by using different molar ratio of $CoCl_2{\cdot}6H_2O$ and $NaBH_4$: (a) 3.2:1, (b) 0.64:1, (c) 0.16:1 and (d) 0.064:1. Scale bar is 100 nm.

When the molar ratio is 3.2:1, small particles and lamellar structure are observed. Not enough dosage of $NaBH_4$ goes against the formation of single-phase Co. Small aggregated particles with particle sizes about 15 nm can be seen from Fig. S1b, and the molar ratio of $CoCl_2{\cdot}6H_2O$ and $NaBH_4$ is 0.64:1. Further decreasing the molar ratio to 0.16:1 and 0.064:1, the SEM images show that the as-prepared Co nanoparticles possess hierarchical structure and sponge morphology, respectively. Herein, the hierarchical structure is composed lamellaes with a thickness of around 8 nm. Excessive $NaBH_4$ can assure the formation of single-phase Co, but it may not favor the Co nanoparticles with better properties for its future application, because the morphologies of nanoparticles have some influences on the properties.

Table S2 Adsorption capacities of CR dye on various adsorbents

Type of adsorbent	q_{max}(mg·g^{-1})	References
Chitosan hydrogel beads impregnated with carbon nanotubesCS/CNT	450.40	[14]
Maghemite nanoparticles	208.33	[15]
Cattail root	38.79	[16]
Palm kernel seed coat	66.23	[17]
Marine alga	71.46	[18]
CTAB modified chitosan beads	352.50	[19]
CS/CTAB beads	373.29	[20]
Fe_3O_4@mesoC	1656.9	[21]
Co (R. T.)	800	This study
Co (100 °C)	800	This study
Co (160 °C)	1324.5	This study
Co (200 °C)	1165.6	This study
Co (220 °C)	1015.6	This study

Synthesis of Co nanoparticles at different temperature

Twenty mL of aqueous solution containing 0.1 g of $CoCl_2·6H_2O$ was first prepared in Teflon-lined stainless steel autoclaves of 30 mL capacity, and subsequently 0.2 g $NaBH_4$ was added to the autoclaves with stirring. The autoclaves were sealed and heated at different temperatures for 2 h, then cooled naturally to room temperature. The as-formed grayish-black precipitates were collected by a magnet and washed them with deionized water and ethanol for several times. The final powders were dried at room temperature in the air for 24 h.

Compared with other Co samples synthesized at different temperature, although the Co nanoaprticles prepared at room-temperature is not with the highest adsorption ability for CR, it owns the shortest adsorption time (2 min), that is to say, Co nanoparticles synthesized at room temperature show the highest adsorption efficiency. In addition, Cobalt nanoparticles synthesized at room temperature are the best compromise between using an affordable method—from the economical point of view—and getting reasonable good adsorption properties.

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