Electronic Supplementary Material (ESI) for Journal of Materials Chemistry B.

Supporting Information

Microwave-assisted synthesis of Gd(III)-loaded nanozeolite SOD as MRI contrast agent with remarkable stability *in vivo*

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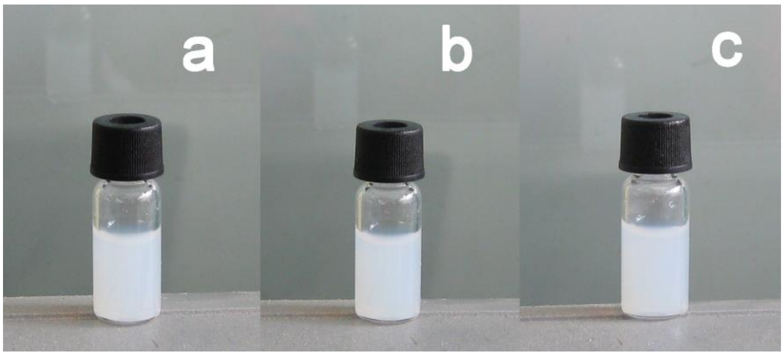

Figure S1. Optical photographs of colloidal nanozeolites Gd^{3+}-SOD suspensions after settling 0 h (a), 2 h (b) and 12 h (c).

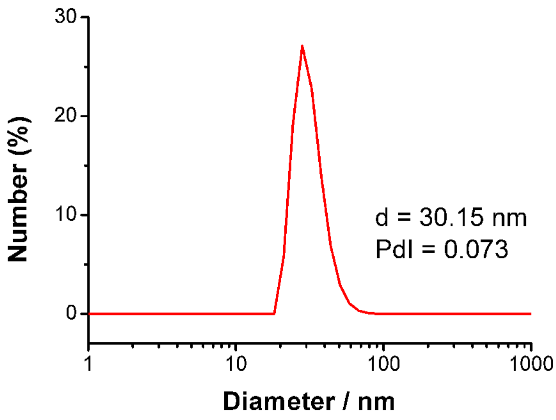

Figure S2. Particle size distribution of nanozeolites SOD determined by dynamic light scattering.

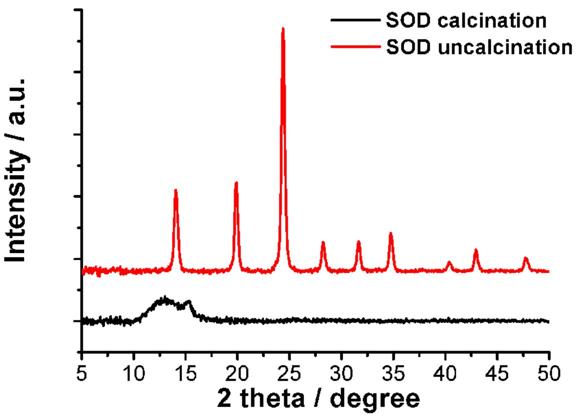

Figure S3. XRD patterns of nanozeolites SOD before and after calcination.

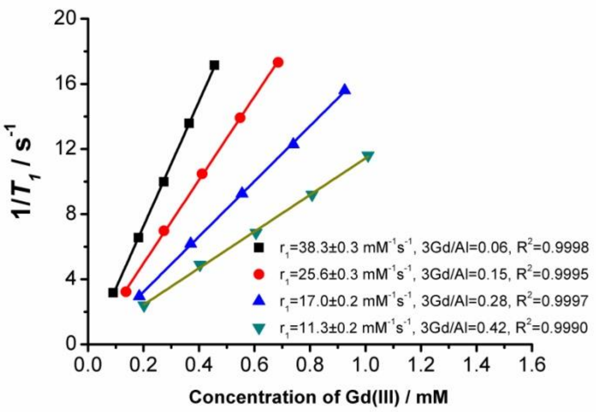

Figure S4. The plots of $1/T_1$ versus Gd^{3+} concentration in the suspension of nanozeolites Gd^{3+}-SOD with different 3Gd/Al ratios (standard error).

The calculation procedure of Gd^{3+} theoretical exchange degree (3Gd/Al) in β cage layer I, layer II, layer III, and layer IV:

According to the unit cell structure of zeolite SOD, it is known that one β cage of SOD framework contains 6 T atoms and all the T atoms are constituted by Si and Al atoms. Since Al/(Si+Al) ratio of as-prepared Gd^{3+}-SOD is 1/9 according to the EDS result, the average Al atom number per β cage is 6/9. According to the charge balance theory, one Gd^{3+} ion could balance three negative charges given by three AlO_4, so the average Gd atom number per β cage is 2/9. It has been known that SOD cell parameter *a* is 8.87 Å, and T atom density ρ is 17.2T/1000Å^3.[1] Since one β cage contains 6 T atoms, the space volume of β cage is calculated by equation (1).

$$V_{\beta\ \mathrm{cage}} = \frac{6T_{atom}}{\rho} \quad (1)$$

It is assumed that nanozeolite SOD is a spherical nanoparticle consisted of layer-by-layer β cages from surface to inner (scheme 1a). The r_0 represents the particle radius and d_0 represents the height of β cage, i.e. the thickness of one β cage layer. Thus, the value of r_0 and d_0 for the used nanozeolite SOD are 15±1 nm and 8.87 Å, respectively. The *x* represents the layer number of β cage shell from surface to inner. Thus, the space volume of β cage shell V_x is calculated by equation (2) and (3).

$$r_x = r_0 - xd_0 \quad (2)$$

$$V_x = \frac{4}{3}\pi r_0^3 - \frac{4}{3}\pi r_x^3 \quad (3)$$

And the number of β cages (N_x) in *x* layers can be obtained through equation (4).

$$N_x = \frac{V_x}{V_{\beta\ cage}} \quad (4)$$

It is reminded that the average Gd atom number in one β cage is 2/9, therefore, the total Gd atom number (N_{Gdx}) in β cages (N_x) could be expressed by equation (5).

$$N_{Gd\,x} = \frac{2}{9} \cdot N_x \quad (5)$$

In addition, the number of total Al atoms in one SOD nanoparticle can be calculated by Al/(Si+Al) = 1/9, T atom density and particle volume through equation (6).

$$N_{Al} = \frac{1}{9} \cdot \rho \cdot \frac{4}{3}\pi r_0^3 \cdot \frac{1}{T_{atom}} \quad (6)$$

If the balance ions in the micropores of SOD are exchanged strictly by Gd^{3+} from surface to inner with the increase of exchange degree, the Gd^{3+} content will rise up with the increase of *x*. Therefore, the theoretical exchange degree of Gd^{3+} with the variation of *x*, which is easily expressed by $3Gd_x/Al$ ratio, can be finally obtained by equation (7).

$$3Gd_x / Al = \frac{3N_{Gd\,x}}{N_{Al}} \quad (7)$$

Finally, the calculated number of β cages (N_x), number of Gd atom (N_{Gdx}), and Gd^{3+} exchange degree ($3Gd_x/Al$) in layer I, layer (I+II), layer (I+II+III), and layer (I+II+III+IV) are summarized in Table S1. Moreover, the theoretical Gd^{3+} exchange capacity in layer I, II, III, IV can also be calculated from the data of $3Gd_x/Al$ in Table S1. In detailed, the theoretical Gd^{3+} contents in layer I, II, III, IV are 0.17 ±0.01, 0.15 ±0.01, 0.13 ±0.01, 0.11 ±0.01, respectively, which is corresponding to the partition and the width (described as 3Gd/Al ratio) of column I, II, III, IV in Figure 3.

Table S1. The theoretical number of β cage (N_x), number of Gd atom (N_{Gdx}), and $3Gd_x/Al$ in the different β cage shell layers of one nanozeolite SOD particle.

x (Layer)	**N_x (×10^4)**	**N_{Gdx} (×10^3)**	**$3Gd_x/Al$**
1 (layer I)	0.7±0.04	1.5±0.1	0.17±0.01
2 (layer I+II)	1.3±0.2	2.8±0.1	0.32±0.02
3 (layer I+II+III)	1.8±0.3	4.0±0.2	0.45±0.02
4 (layer I+II+III+IV)	2.2±0.3	4.9±0.2	0.56±0.04

[1] Ch. Baerlocher, W. M. Meier and D. H. Olson, in *Atlas of Zeolite Framework Types*, Elsevier, Amsterdam, 2001, pp. 254-255.

Table S2. The recovery rate of Gd^{3+} in the tissue through the microwave digestion method.

Volume of nanozeolites Gd^{3+}-SOD solution / μL	50	20	20	20	10	5
Recovery rate (%)	57.5	59.4	59.9	58.0	55.7	55.3
Average recovery rate (%)	57.6 ± 1.9					

Table S3. The pharmacokinetic parameters of nanozeolites Gd^{3+}-SOD in mice.

C_0 / μg mL^{-1}	V_d / mL	V_{ss} / mL	$T_{1/2\alpha}$ / min	$T_{1/2\beta}$ / min	K_{21} / min^{-1}	K_{10} / min^{-1}	K_{12} / min^{-1}	AUC / min ·μg mL^{-1}	CL / mL min^{-1}
5.02	2.36	5.70	9.23	90.4	0.024	0.024	0.034	212	0.056

D_0: The injected dose

C_0: The concentration at zero time (C_0 = A+B)

V_d: The apparent volume of distribution ($V_d = D_0/C_0$)

V_{ss}: The steady-state volume of distribution ($V_{ss} = V_d * (K_{21}+K_{12})/K_{21}$)

$T_{1/2\alpha}$: The distributional half-life time ($T_{1/2\alpha} = 0.693/\alpha$)

$T_{1/2\beta}$: The eliminative half-life time ($T_{1/2\beta} = 0.693/\beta$)

K_{21}: The rate of transfer from peripheral to central compartment

K_{10}: The rate of elimination from central compartment

K_{12}: The rate of transfer from central to peripheral compartment

AUC: The area under the blood concentration versus time curve (AUC = $A/\alpha+B/\beta$)

CL: The total clearance (CL = D_0/AUC)

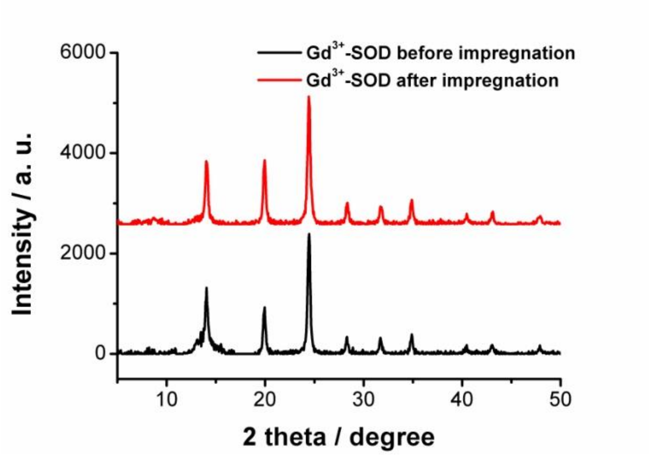

Figure S5. XRD patterns of nanozeolites Gd^{3+}-SOD before and after impregnated in phosphate buffer solution with pH = 5 for 6 days.

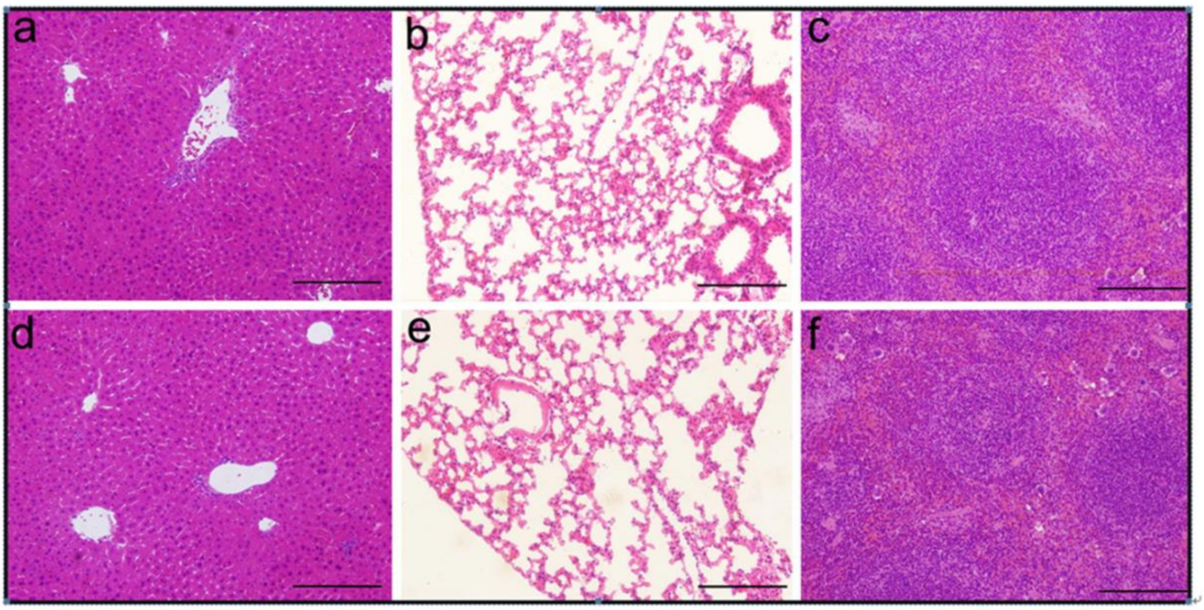

Figure S6. The histological morphology images of liver (a and d), lungs (b and e) and spleen (c and f) from mice exposed to nanozeolites Gd^{3+}-SOD at the dose of 80 mg kg^{-1} (a-c) and PBS (d-f) for 7 days. (Scale bars show 200 μm).