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# *Supporting information*

Catalytic reduction of nitrate in water over alumina-supported nickel catalyst toward purification of polluted groundwater

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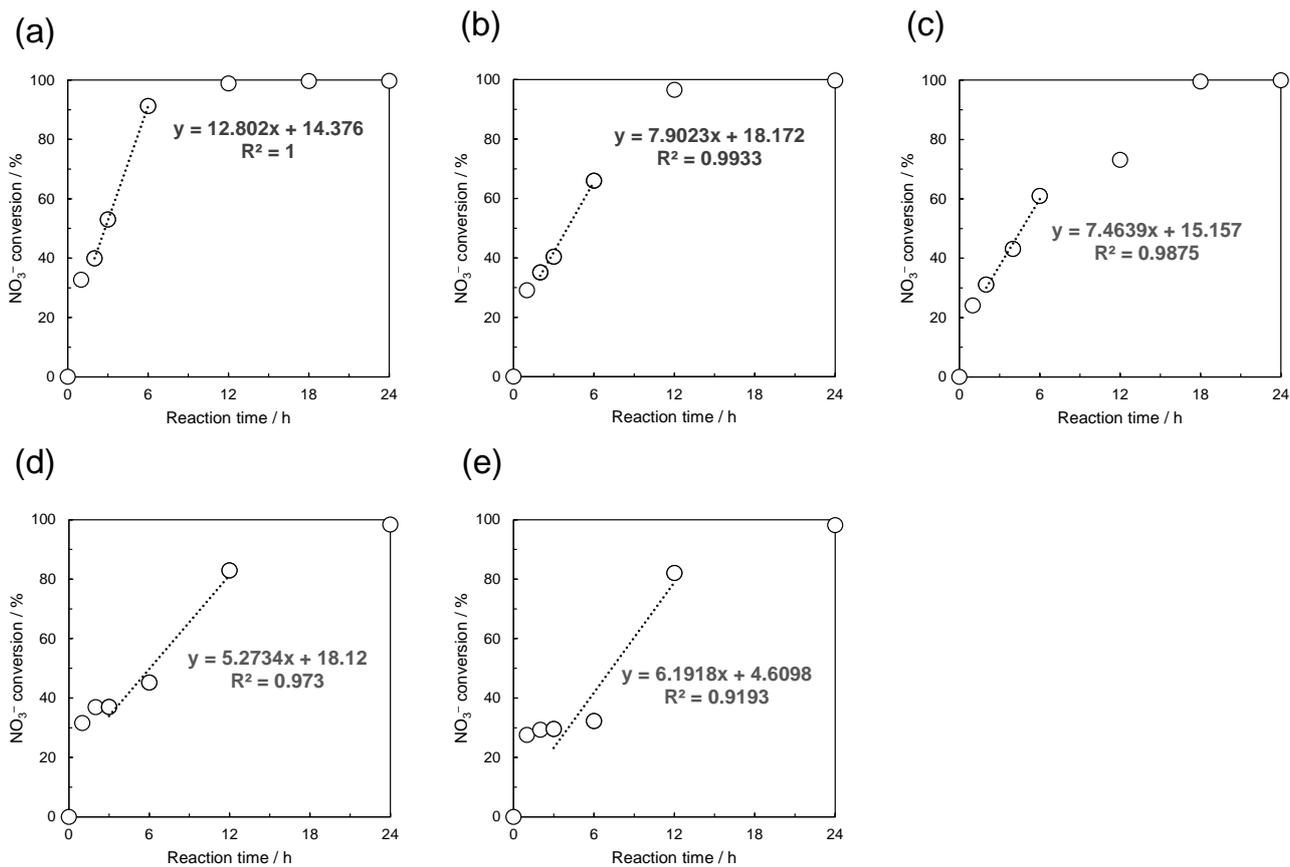
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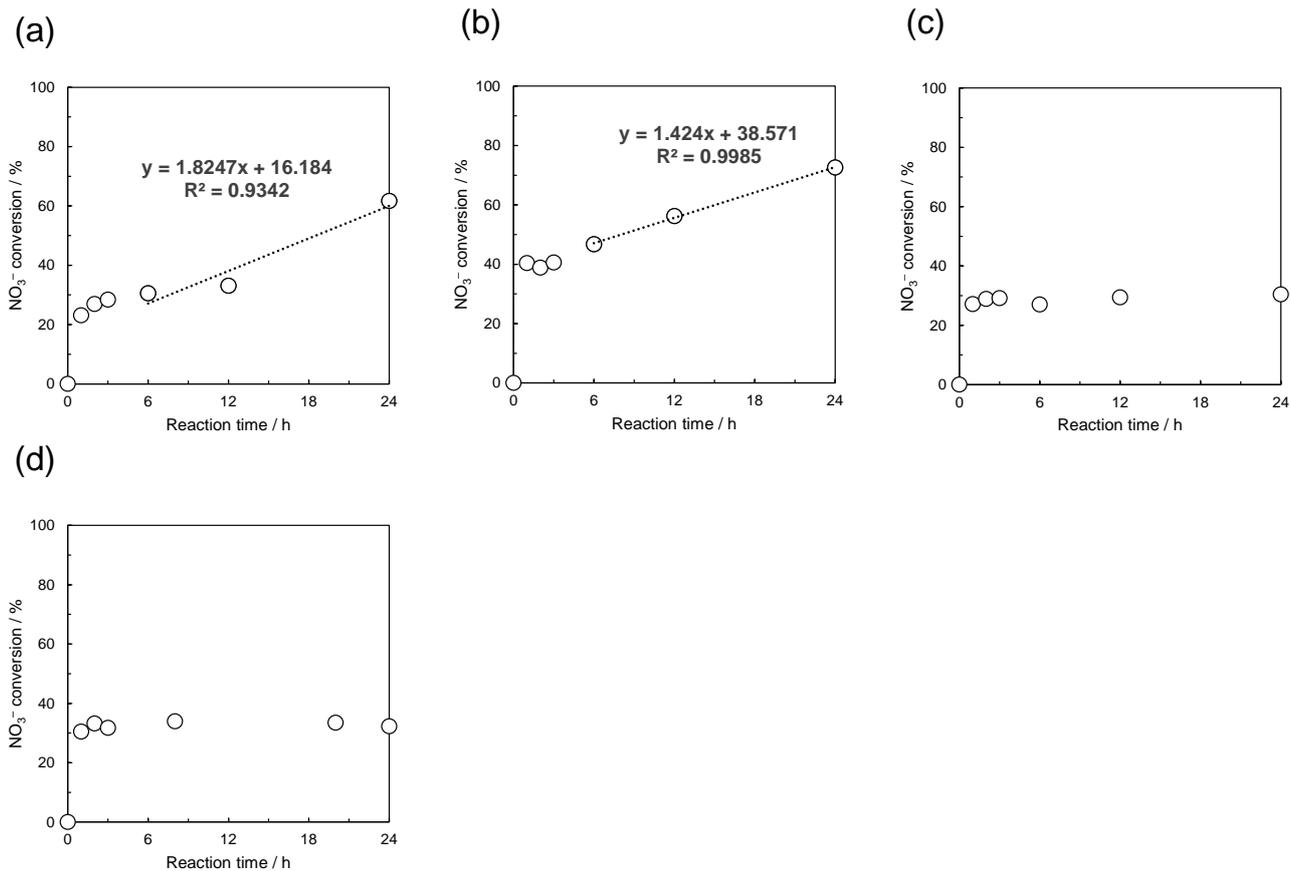
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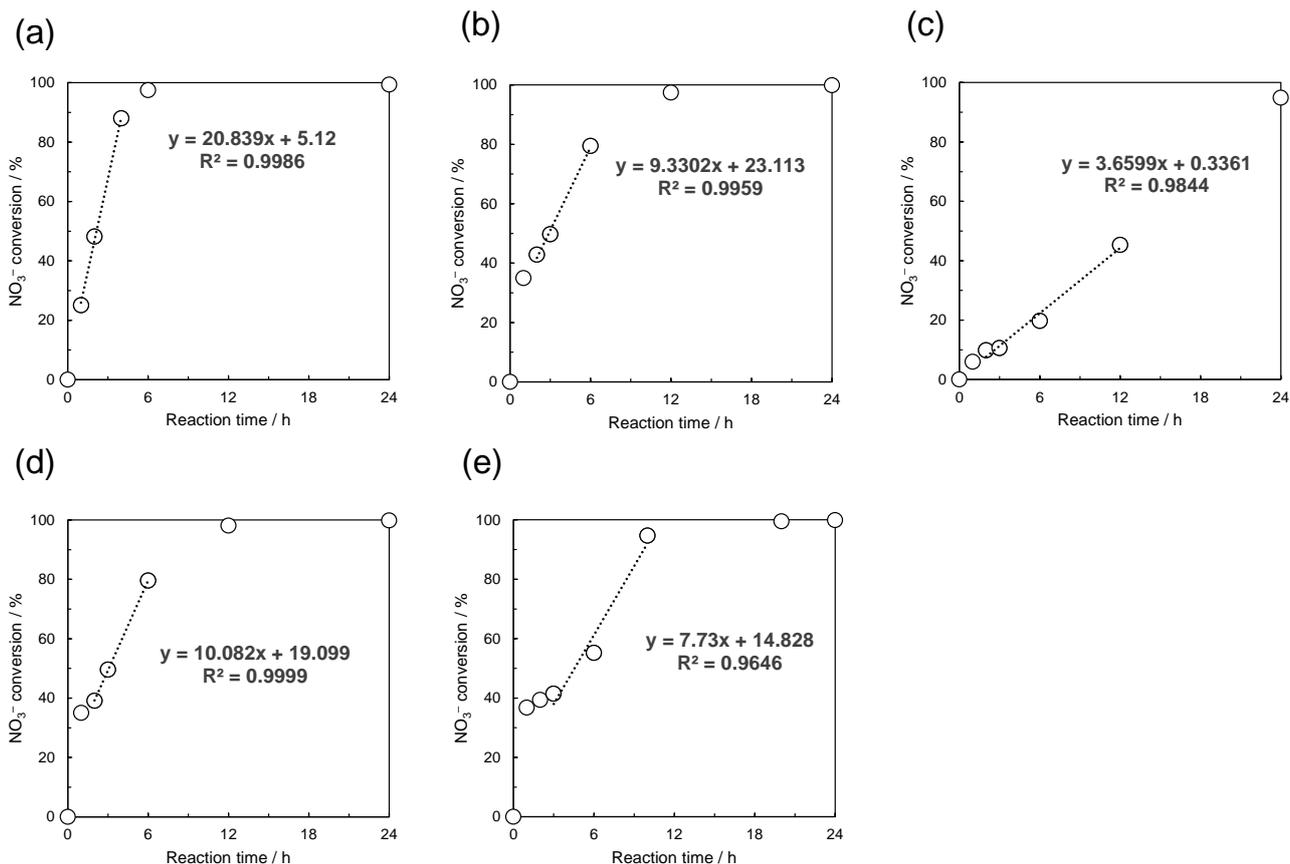
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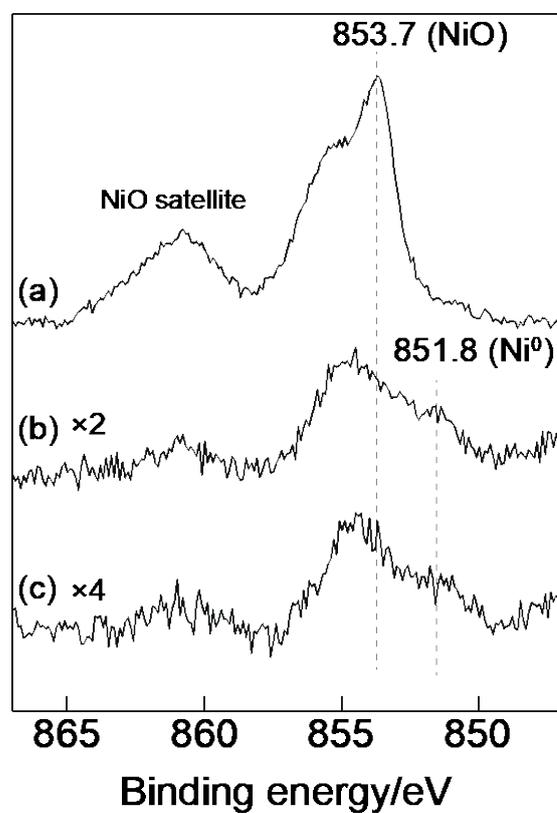
**Fig. S1** Time courses of  $\text{NO}_3^-$  conversion in catalytic reduction of  $\text{NO}_3^-$  over 5 wt.%  $\text{Ni}/\text{Al}_2\text{O}_3$  with different initial concentrations of  $\text{NO}_3^-$  ( $[\text{NO}_3^-]_0$ ) and partial pressures of  $\text{H}_2$  ( $P(\text{H}_2)$ ). Reaction conditions: catalyst weight, 0.2 g; (a)  $[\text{NO}_3^-]_0 = 200 \text{ ppm}$ ,  $P(\text{H}_2) = 1.0 \text{ atm}$ , (b)  $[\text{NO}_3^-]_0 = 400 \text{ ppm}$ ,  $P(\text{H}_2) = 1.0 \text{ atm}$ , (c)  $[\text{NO}_3^-]_0 = 800 \text{ ppm}$ ,  $P(\text{H}_2) = 1.0 \text{ atm}$ , (d)  $[\text{NO}_3^-]_0 = 400 \text{ ppm}$ ,  $P(\text{H}_2) = 0.5 \text{ atm}$  and (e)  $[\text{NO}_3^-]_0 = 400 \text{ ppm}$ ,  $P(\text{H}_2) = 0.75 \text{ atm}$ ; volume of reaction solution, 120 mL; gas flow rate,  $30 \text{ mL min}^{-1}$ ; and reaction temperature,  $40 \text{ }^\circ\text{C}$ .  $P(\text{H}_2)$  was adjusted by mixing  $\text{N}_2$  with  $\text{H}_2$ .



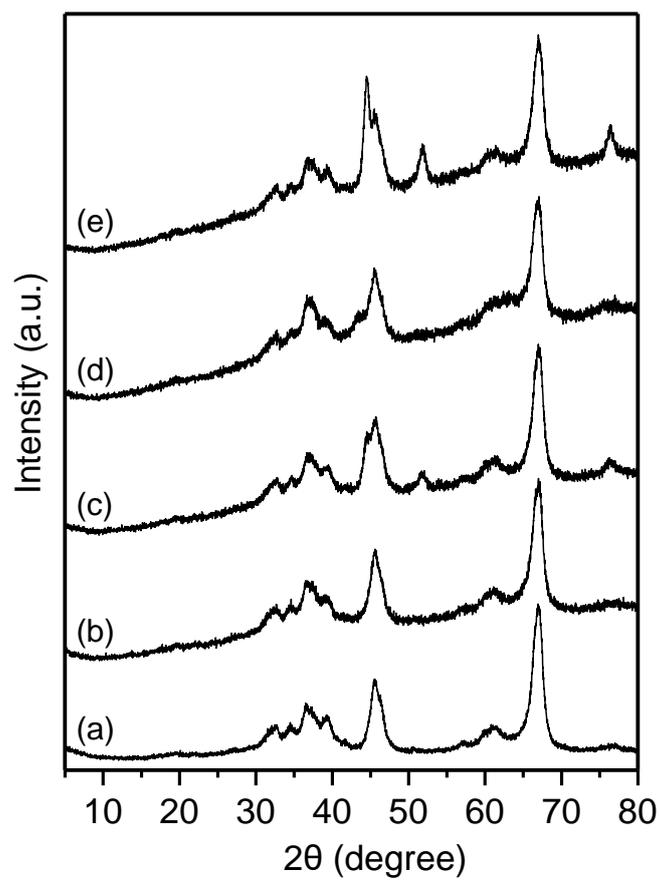
**Fig. S2** Time courses of  $\text{NO}_3^-$  conversion in catalytic reduction of  $\text{NO}_3^-$  over unsupported Ni with different initial concentrations of  $\text{NO}_3^-$  ( $[\text{NO}_3^-]_0$ ) and partial pressures of  $\text{H}_2$  ( $P(\text{H}_2)$ ). Reaction conditions: catalyst weight, 0.2 g; (a)  $[\text{NO}_3^-]_0 = 200$  ppm,  $P(\text{H}_2) = 1.0$  atm, (b)  $[\text{NO}_3^-]_0 = 400$  ppm,  $P(\text{H}_2) = 1.0$  atm, (c)  $[\text{NO}_3^-]_0 = 800$  ppm,  $P(\text{H}_2) = 1.0$  atm and (d)  $[\text{NO}_3^-]_0 = 400$  ppm,  $P(\text{H}_2) = 0.75$  atm; volume of reaction solution, 120 mL; gas total flow rate, 30  $\text{mL min}^{-1}$ ; and reaction temperature, 40 °C.  $P(\text{H}_2)$  was adjusted by mixing  $\text{N}_2$  with  $\text{H}_2$ .



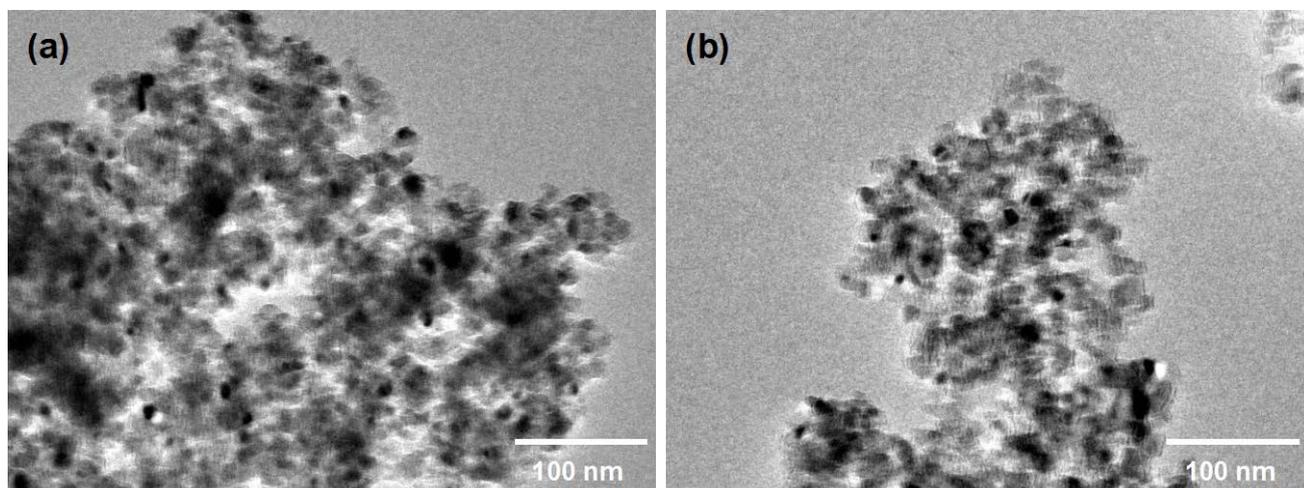
**Fig. S3** Time courses of  $\text{NO}_3^-$  conversion in catalytic reduction of  $\text{NO}_3^-$  over 10 wt.% Ni/ $\text{Al}_2\text{O}_3$  with different initial concentrations of  $\text{NO}_3^-$  ( $[\text{NO}_3^-]_0$ ) and partial pressures of  $\text{H}_2$  ( $P(\text{H}_2)$ ). Reaction conditions: catalyst weight, 0.2 g; (a)  $[\text{NO}_3^-]_0 = 200$  ppm,  $P(\text{H}_2) = 1.0$  atm, (b)  $[\text{NO}_3^-]_0 = 400$  ppm,  $P(\text{H}_2) = 1.0$  atm, (c)  $[\text{NO}_3^-]_0 = 800$  ppm,  $P(\text{H}_2) = 1.0$  atm, (d)  $[\text{NO}_3^-]_0 = 400$  ppm,  $P(\text{H}_2) = 0.5$  atm and (e)  $[\text{NO}_3^-]_0 = 400$  ppm,  $P(\text{H}_2) = 0.75$  atm; volume of reaction solution, 120 mL; gas flow rate,  $30 \text{ mL min}^{-1}$ ; and reaction temperature,  $40^\circ\text{C}$ .  $P(\text{H}_2)$  was adjusted by mixing  $\text{N}_2$  with  $\text{H}_2$ .



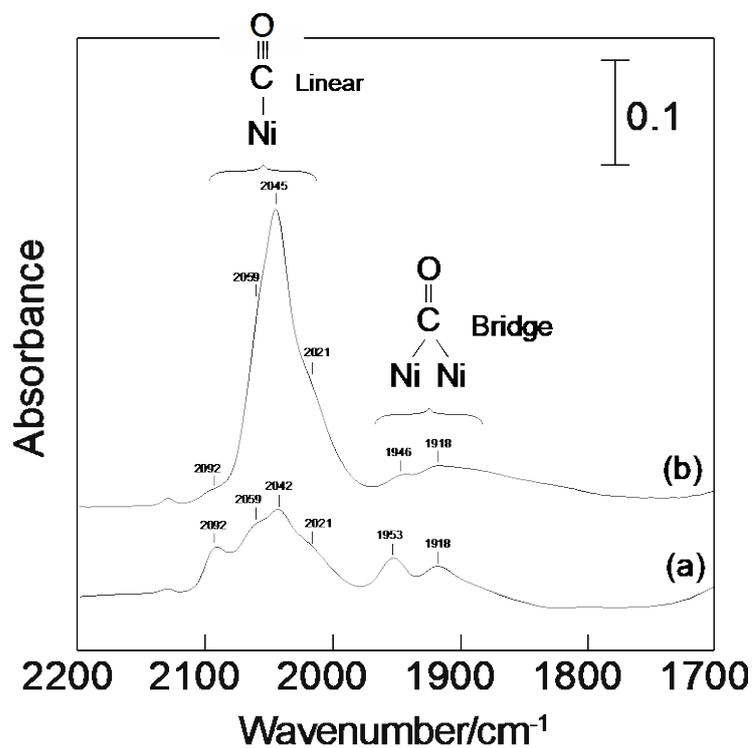
**Fig. S4** Ni 2p<sub>3/2</sub> XPS spectra for (a) unsupported NiO, (b) 10 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> exposed to air and (c) 5 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> exposed to air. Both Ni/Al<sub>2</sub>O<sub>3</sub> exposed to air gave peaks due to Ni<sup>2+</sup> at 853.7 eV in addition to those due to Ni metal (Ni<sup>0</sup>) at 851.8 eV, indicating the formation of the oxidized Ni species on the surface.



**Fig. S5** XRD patterns of (a) bare Al<sub>2</sub>O<sub>3</sub>, (b) 5 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> after calcination in air at 500 °C for 3 h, (c) 5 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> after reduction in H<sub>2</sub> at 600 °C for 1 h, (d) 10 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> after calcination in air at 500 °C for 3 h, and (e) 10 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> after reduction in H<sub>2</sub> at 600 °C for 1 h.



**Fig. S6** TEM images for (a) 5 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> and (b) 10 wt.% Ni/Al<sub>2</sub>O<sub>3</sub>.



**Fig. S7** IR spectra of CO adsorbed at  $-80\text{ }^{\circ}\text{C}$  on (a) 5 wt.% Ni/Al<sub>2</sub>O<sub>3</sub> and (b) 10 wt.% Ni/Al<sub>2</sub>O<sub>3</sub>. The samples were pretreated in H<sub>2</sub> at 500  $^{\circ}\text{C}$  for 15 min. After the adsorption of CO at  $-80\text{ }^{\circ}\text{C}$  was saturated, the IR cell was evacuated at the same temperature and the spectrum was taken.