

極微量溶媒を利用した高機能ナノ粒子合成プロセスの発展

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主要な発表論文
[1] Low-temperature solvent-free synthesis of polycrystalline hematite nanoparticles via mechanochemical activation and their adsorption properties for Congo red, Solid State Sci., 129 (2022) 106917.
[2] Mechanochemically assisted synthesis of composite nanoparticles consisting of hematite, magnetite, akaganeite, and siderite using iron redox reactions, Ceram. Int., 51 (2025) 36593-36598.
[3] Mechanochemically assisted quasi solvent-free homogeneous precipitation of magnetite nanoparticles by urea hydrolysis using stainless steel grinding media and their heterogeneous Fenton catalytic properties, J. Alloys. Compd., 1037 (2025) 182508.

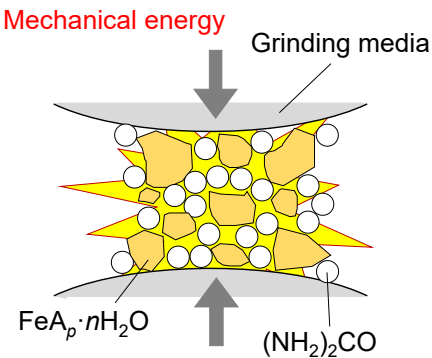
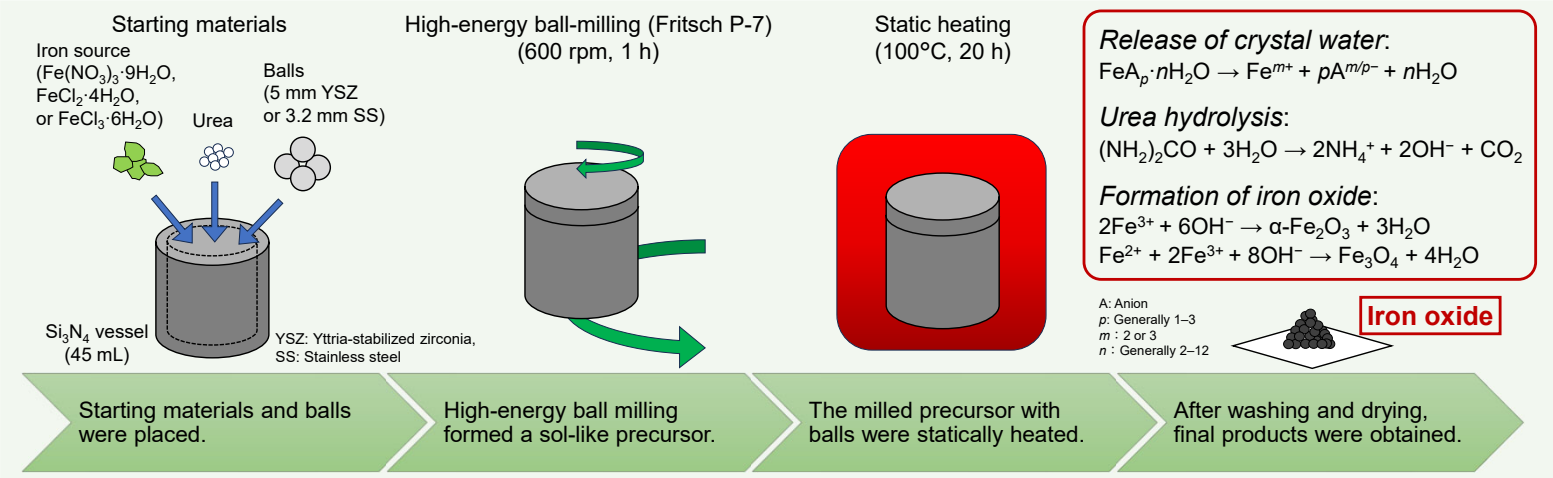
Introduction

Functional iron oxide (α -Fe₂O₃, Fe₃O₄) nanoparticles

- *Environmental purification*: Heterogeneous Fenton catalyst for degradation of organic compounds ¹⁾
- *Green energy*: Anode material for lithium-ion battery ²⁾
- *Biomedicine*: Heating mediator for magnetic hyperthermia treatments ³⁾

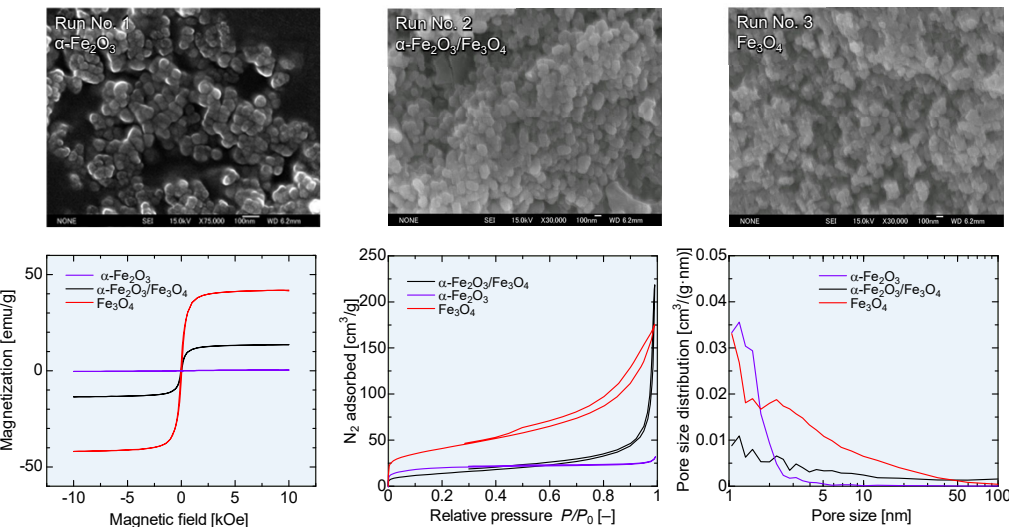
- Liquid-phase process ▶ Relatively high environmental impacts
- Gas- or solid-phase process ▶ Increase in the aggregate size; Low performance
- **Mechanochemically assisted quasi-solvent-free synthesis of slightly agglomerated iron oxide nanoparticles**

Synthesis process



Mechanochemical activation

Results and discussion



➤ Polycrystalline iron oxide nanoparticles with high specific surface areas were obtained.

Run No.	Starting materials	Ball material (size, number)	Product	Crystallite size [nm]	Particle size [nm]	Specific surface area [m ² /g]	Pore volume [cm ³ /g]	Saturation magnetization [emu/g]	Residual magnetization [emu/g]	Coercivity [Oe]
1	$\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ (2 mmol) urea (6 mmol)	YSZ (5 mm, 180)	$\alpha\text{-Fe}_2\text{O}_3$	$\alpha\text{-Fe}_2\text{O}_3$: 16	61	122	0.11	0.6	0.003	20
2	$\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ (3 mmol) urea (4 mmol)	YSZ (5 mm, 180)	$\alpha\text{-Fe}_2\text{O}_3/\text{Fe}_3\text{O}_4$	$\alpha\text{-Fe}_2\text{O}_3$: 19 Fe_3O_4 : 24	60	50	0.31	13.5	1.6	43
2	$\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ (3 mmol) urea (4 mmol)	SS (3.2 mm, 529)	Fe_3O_4	Fe_3O_4 : 29	57	145	0.27	41.8	4.5	43

Conclusion

- Polycrystalline iron oxide nanoparticles with high specific surface areas were synthesized.

References

1) F. Chen et al., J. Hazard. Mater. 322 (2017) 152–162.
2) A. González-Banciella et al., J. Energy Storage 90 (2024) 111904.
3) C.J. Perecin et al., Colloid Surf. A 627 (2021) 127169.