Supplementary data

Table S1 Common solid-state kinetic models and expressions of $f(X)$ and $g(X)$

	No.	symbol	kinetic model		differential form $f(x)= 1/k \cdot dx/dt$	integral form $g(x)= kt$
nucleation models	1	P2	power law	$n = 2$	$2X^{1/2}$	$X^{1/2}$
	2	P3		$n = 3$	$3X^{2/3}$	$X^{1/3}$
	3	P4		$n = 4$	$4X^{3/4}$	$X^{1/4}$
	4	A2	Avrami–Erofeyev	$n = 2$	$2(1 - X)(-\ln(1 - X))^{1/2}$	$(-\ln(1 - X))^{1/2}$
	5	A3		$n = 3$	$3(1 - X)(-\ln(1 - X))^{2/3}$	$(-\ln(1 - X))^{1/3}$
	6	A4		$n = 4$	$4(1 - X)(-\ln(1 - X))^{3/4}$	$(-\ln(1 - X))^{1/4}$
geometrical contraction models	7	R2	2-D (contracting area)		$2(1 - X)^{1/2}$	$1 - (1 - X)^{1/2}$
	8	R3	3-D (contracting volume)		$3(1 - X)^{2/3}$	$1 - (1 - X)^{1/3}$
diffusion models	9	D1	1-D		$1/(2X)$	X^2
	10	D2	2-D		$1/(-\ln(1 - X))$	$(1 - X)\ln(1 - X) + X$
	11	D3	3-D (Jander)		$(3/2)(1 - X)^{2/3}(1 - (1 - X)^{1/3})$	$(1 - (1 - X)^{1/3})^2$
	12	D4	3-D (Ginstling–Brounshtein)		$(3/2)((1 - X)^{-1/3} - 1)$	$1 - (2/3)X - (1 - X)^{2/3}$
reaction-order models	13	F0(R1)[a)]	zero-order		1	X
	14	F1(A1)[a)]	first-order		$(1 - X)$	$-\ln(1 - X)$
	15	F2	second-order		$(1 - X)^2$	$(1 - X)^{-1} - 1$
	16	F3	third-order		$(1 - X)^3$	$(1/2)((1 - X)^{-2} - 1)$

Note: a) Same form

Table S2 Linear fitting results of pure Fe_2O_3 at all temperature ranges. R^2 is the linear regression coefficient obtained with MS Excel®

No.	model	R^2				
		973 K	1023 K	1073 K	1123 K	1173 K
1	P2	0.811	0.844	0.865	0.875	0.877
2	P3	0.714	0.755	0.778	0.787	0.788
3	P4	0.643	0.684	0.705	0.708	0.706
4	A2	0.957	0.969	0.971	0.978	0.988
5	A3	0.922	0.941	0.951	0.957	0.958
6	A4	0.869	0.892	0.904	0.908	0.903
7	R2	0.994	0.996	0.996	0.996	0.997

8	R3	0.978	0.978	0.975	0.978	0.985
9	D1	0.997	0.992	0.987	0.985	0.984
10	D2	0.971	0.962	0.956	0.956	0.958
11	D3	0.811	0.806	0.794	0.807	0.839
12	D4	0.936	0.927	0.920	0.922	0.930
13	F0	0.949	0.962	0.969	0.971	0.970
14	F1	0.845	0.851	0.838	0.857	0.903
15	F2	0.140	0.178	0.172	0.217	0.358
16	F3	0.059	0.079	0.088	0.104	0.155

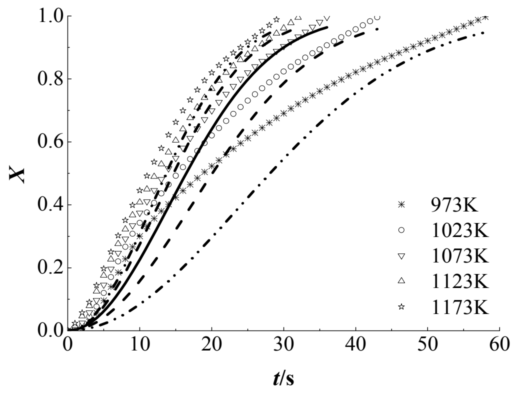
Table S3 Linear fitting results of Fe_5Al_5 at all temperature ranges. $R^2$is the linear regression coefficient obtained with MS Excel®

No.	model	R^2				
		973 K	1023 K	1073 K	1123 K	1173 K
1	P2	0.772	0.766	0.784	0.784	0.793
2	P3	0.647	0.639	0.658	0.658	0.667
3	P4	0.545	0.539	0.559	0.559	0.569
4	A2	0.927	0.919	0.906	0.954	0.964
5	A3	0.890	0.883	0.887	0.896	0.898
6	A4	0.822	0.813	0.822	0.814	0.812
7	R2	0.981	0.981	0.985	0.989	0.993
8	R3	0.963	0.961	0.957	0.980	0.987
9	D1	0.997	0.997	0.996	0.995	0.995
10	D2	0.979	0.980	0.979	0.981	0.980
11	D3	0.803	0.788	0.759	0.838	0.857
12	D4	0.942	0.941	0.937	0.950	0.953
13	F0	0.925	0.922	0.931	0.932	0.939
14	F1	0.812	0.780	0.717	0.878	0.909
15	F2	0.131	0.120	0.111	0.286	0.386
16	F3	0.064	0.078	0.094	0.140	0.188

Table S4 F-test on the best approximate models

oxygen carrier	model	973 K		1023 K		1073 K		1123 K		1173 K	
		F	F_c [a)]	F	F_c	F	F_c	F	F_c	F	F_c
pure Fe_2O_3	R2	0.00[b)]	3.92	0.22	3.95	0.44	3.97	0.41	3.99	0.33	4.01
Fe_5Al_5	D1	0.00[c)]	3.94	0.02	3.97	0.19	4.00	0.21	4.03	0.29	4.07

Notes: a) F_c is the critical value at 95% CL, i.e., the significant level α = 0.05; b) F = 0.0003; c) F = 0.0004


X
t/s
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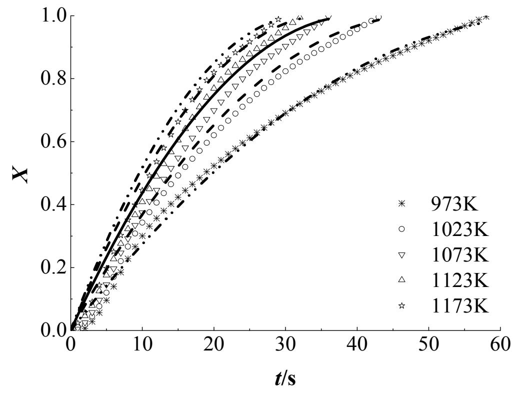
1023K
1073K
1123K
1173K

(a)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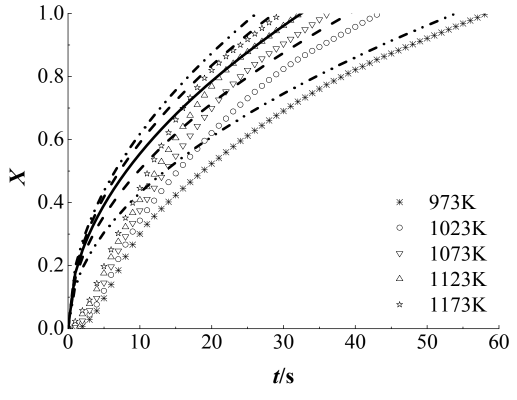
(b)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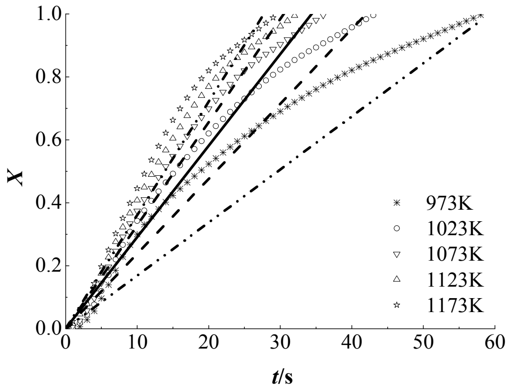
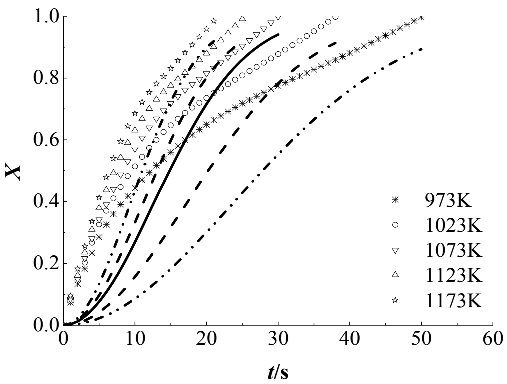
1073K
1123K
1173K

(c)



(d)

Fig. S1 Comparison of the calculated conversion curves with the experimental data for pure Fe_2O_3: (a) A2, (b) R2, (c) D1, and (d) F0. Symbols denote the experimental data. Lines represent the calculated conversion curves



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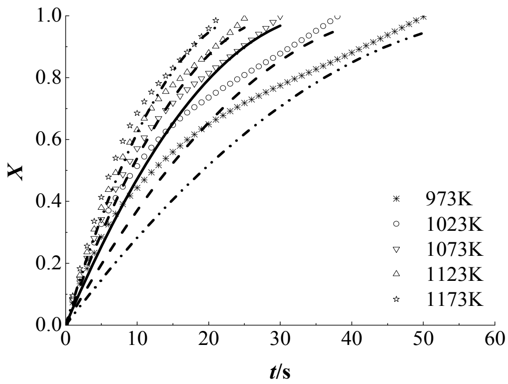

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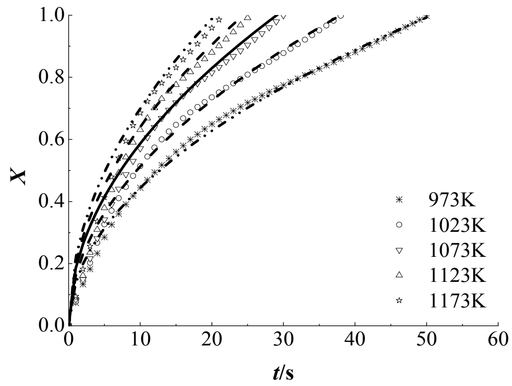

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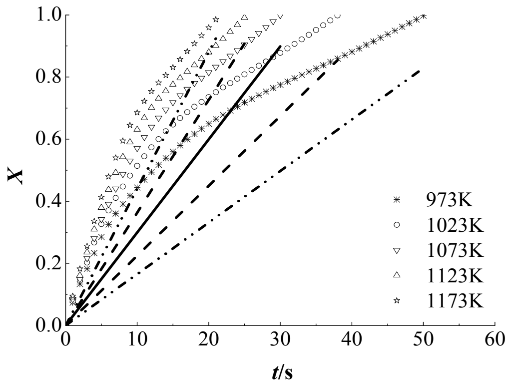

(d)

Fig. S2 Comparison of the calculated conversion curves with the experimental data for Fe_5Al_5: (a) A2, (b) R2, (c) D1, and (d) F0. Symbols denote the experimental data. Lines represent the calculated conversion curves