Supporting Information

The Purely Inorganic Highly Efficient Ice Nucleating Particle

Mainak Ganguly[a] Simon Dib[b] and Parisa A. Ariya*[a,b]

[a]Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Quebec H3A 0B9, Canada

[b]Department of Chemistry, McGill University, Montreal, Quebec H3A 0B8, Canada

A

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	15.65	23.48	58.42	11.30	0.0512	1.1064	0.2958	1.0000
O K	49.02	55.20	541.92	6.75	0.2961	1.0460	0.5775	1.0000
AlK	16.80	11.22	216.22	4.36	0.1379	0.9117	0.8983	1.0020
SiK	15.27	9.79	179.04	5.06	0.1248	0.9287	0.8795	1.0010
PtM	3.26	0.30	11.01	22.87	0.0197	0.5487	1.1082	0.9964

B

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	13.02	32.23	49.82	10.72	0.0688	1.2866	0.4103	1.0000
O K	18.03	33.50	154.20	7.10	0.1325	1.2218	0.6011	1.0000
FeL	62.56	33.30	185.13	5.34	0.4326	0.9120	0.7581	1.0000
PtM	6.38	0.97	16.55	13.49	0.0467	0.6483	1.0986	1.0263

C

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	15.51	28.84	43.39	11.50	0.0652	1.1884	0.3539	1.0000
O K	32.32	45.12	227.30	7.15	0.2127	1.1264	0.5844	1.0000
FeL	32.17	12.87	70.45	7.38	0.1794	0.8401	0.6637	1.0000
AlK	8.71	7.21	62.70	6.84	0.0685	0.9860	0.7959	1.0013
SiK	6.86	5.45	48.44	7.86	0.0578	1.0051	0.8380	1.0015
PtM	4.43	0.51	9.64	20.71	0.0296	0.5945	1.1052	1.0175

D

Element	Weight %	Atomic %	Net Int.	Error %	Kratio	Z	A	F
C K	20.53	38.76	76.52	10.73	0.0876	1.2441	0.3432	1.0000
O K	30.33	42.99	225.71	8.67	0.1611	1.1812	0.4497	1.0000
FeL	3.42	1.39	9.35	27.37	0.0181	0.8817	0.6008	1.0000
AlK	7.04	5.92	74.32	6.47	0.0619	1.0376	0.8477	1.0004
SiK	6.26	5.05	63.78	7.13	0.0581	1.0584	0.8764	1.0007
PtM	4.39	0.51	13.21	16.97	0.0309	0.6267	1.1180	1.0052
HgM	23.84	2.70	67.89	7.94	0.1638	0.6207	1.1020	1.0047
ClK	4.20	2.69	23.06	14.50	0.0369	0.9811	0.8977	0.9972

Figure S1. Elemental analysis of (A) kaolin, (B) BHFe, (C) KaFe and (D) HgKaFe

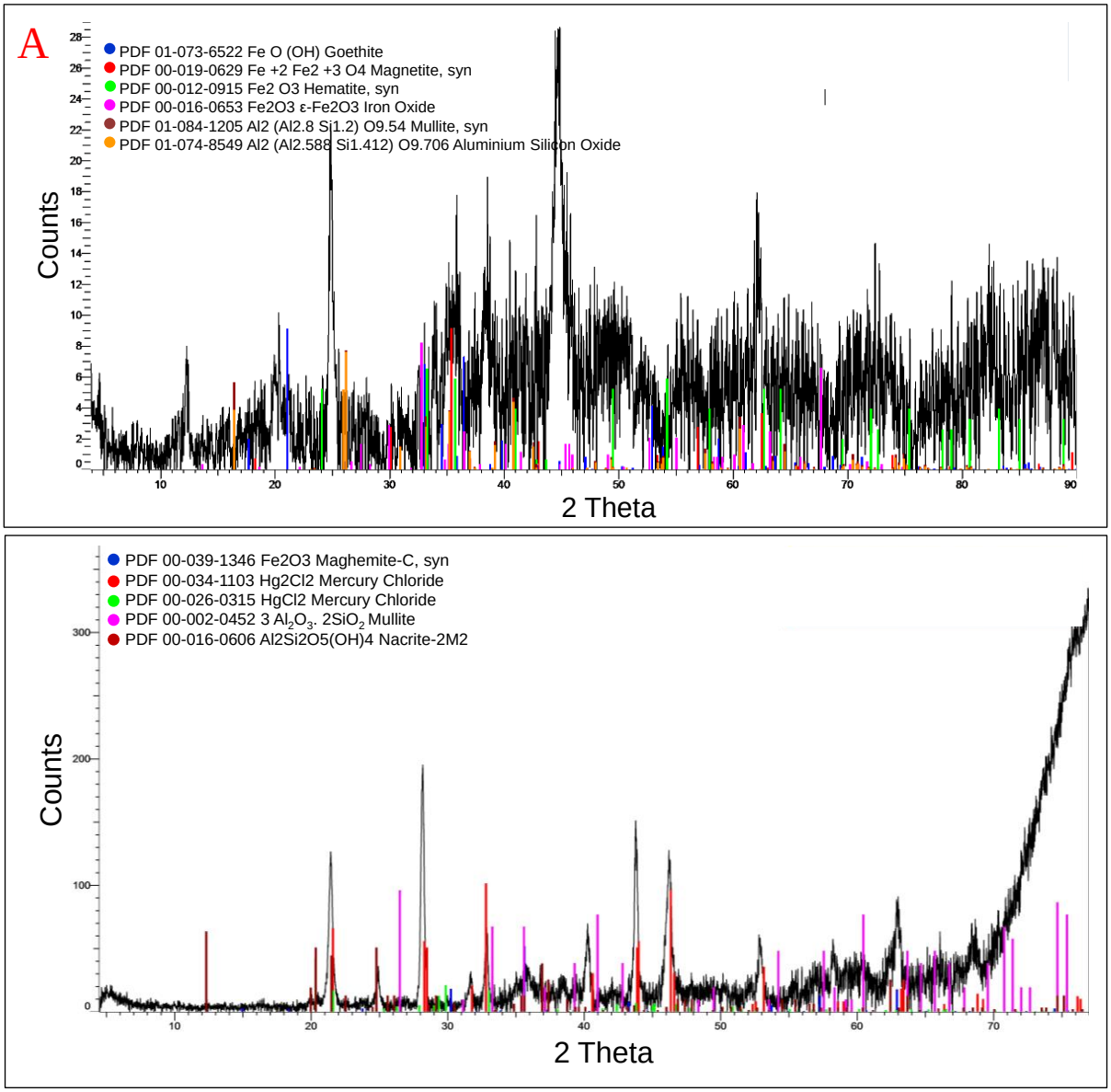

Figure S2. (A) and (B) represent powder XRD spectra of KaFe and HgKaFe with probable match.

Pattern List #1

Show	Icon	Color	Index	Name	Parent
Yes			1	PDF 01-073-6522	Pattern List #1
Yes			2	PDF 00-019-0629	Pattern List #1
Yes			3	PDF 00-002-0915	Pattern List #1
Yes			4	PDF 00-016-0653	Pattern List #1
Yes			5	PDF 01-084-1205	Pattern List #1
Yes			6	PDF 01-074-8549	Pattern List #1

Scan	Pattern #	Compound Name
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 01-073-6522	Goethite
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 00-019-0629	Magnetite, syn
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 00-002-0915	Hematite, syn
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 00-016-0653	ε-Fe2 O3 | Iron Oxide
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 01-084-1205	Mullite, syn
KaFeblack0_01_exported_3.91_90.00.raw #1	PDF 01-074-8549	Aluminum Silicon Oxide

Formula	Quality	Y-Scale	I/Ic DB	I/Ic User	S-Q	Concentration Level
Fe O (O H)	Indexed	32.99 %	2.210	0.000	10.2 %	Major
Fe +2 Fe2 +3 O4	Star (*)	33.09 %	4.900	0.000	4.6 %	Minor
Fe2 O3	Blank	23.64 %	(1)	0.000	16.1 %	Major
Fe2 O3	Indexed	29.70 %	(1)	0.000	20.3 %	Major
Al2 (Al2.8 Si1.2) O9.54	Blank	28.03 %	0.760	0.000	25.2 %	Major
Al2 (Al2.588 Si1.412) O9.706	Blank	27.60 %	0.800	0.000	23.6 %	Major

Added Reference	d x by	Scan WL	Wavelength	System	Space Group	a	b
	1.0000	Yes	1.54060 Å	Orthorhombic	Pbnm (62)	4.64000 Å	10.00000 Å
	1.0000	Yes	1.54060 Å	Cubic	Fd-3m (227)	8.39600 Å	
	1.0000	Yes	1.54060 Å	Rhombo.H.axes	R-3c (167)	5.02800 Å	
	1.0000	Yes	1.54060 Å	Monoclinic	P (0)	12.97000 Å	10.21000 Å
	1.0000	Yes	1.54060 Å	Orthorhombic	Pbam (55)	7.57850 Å	7.68170 Å
	1.0000	Yes	1.54060 Å	Orthorhombic	Pbam (55)	7.57410 Å	7.68560 Å

c	alpha	beta	gamma	Z	Volume	Density	Cell Tuned	F (N)
3.03000 Å				4	140.59 Å³	4.198 g/cm³	No	F30= 209.4(0.0042, 34)
				8	591.86 Å³	5.176 g/cm³	No	F26= 59.2(0.0129, 34)
13.72800 Å				6	300.56 Å³	5.260 g/cm³	No	F27= 8.6(0.0680, 46)
8.44000 Å		95.330 °		20	1112.82 Å³	4.780 g/cm³	No	F30= 1.6(0.0500, 383)
2.88640 Å				1	168.03 Å³	3.121 g/cm³	No	F30= 999.9(0.0000, 34)
2.88582 Å				1	167.99 Å³	3.151 g/cm³	No	F30= 999.9(0.0000, 32)

Figure S3. Pattern list of KaFe, representing composition, obtained from XRD analysis.

Pattern List #1

Show	Icon	Color	Index	Name	Parent	Scan	Pattern #	Compound Name
Yes			3	PDF 00-026-0315	Pattern List #1	HgKaFe_full_exported_background substracted.raw #1	PDF 00-026-0315	Mercury Chloride
Yes			1	PDF 00-039-1346	Pattern List #1	HgKaFe_full_exported_background substracted.raw #1	PDF 00-039-1346	Maghemite-C, syn
Yes			5	PDF 00-016-0606	Pattern List #1	HgKaFe_full_exported_background substracted.raw #1	PDF 00-016-0606	Nacrite-2M2
Yes			4	PDF 00-002-0452	Pattern List #1	HgKaFe_full_exported_background substracted.raw #1	PDF 00-002-0452	Mullite
Yes			2	PDF 00-034-1103	Pattern List #1	HgKaFe_full_exported_background substracted.raw #1	PDF 00-034-1103	Mercury Chloride

Formula	Quality	Y-Scale	I/Ic DB	I/Ic User	S-Q	Concentration Level	Added Reference	d x by	Scan WL	Wavelength	System
Hg Cl2	Star (*)	12.58 %	3.200	0.000	4.2 %	Minor		1.0000	Yes	1.54060 Å	Orthorhombic
Fe2 O3	Star (*)	15.46 %	1.400	0.000	11.9 %	Major		1.0000	Yes	1.54060 Å	Cubic
Al2 Si2 O5 (O H)4	Indexed	18.95 %	(1)	0.000	20.4 %	Major		1.0000	Yes	1.54060 Å	Monoclinic
3 Al2 O3 ·2 Si O2	Indexed	28.67 %	(1)	0.000	30.9 %	Major		1.0000	Yes	1.54060 Å	Orthorhombic
Hg2 Cl2	Indexed	30.30 %	(1)	0.000	32.6 %	Major		1.0000	Yes	1.54060 Å	Monoclinic

Space Group	a	b	c	alpha	beta	gamma	Z	Volume	Density	Cell Tuned	F (N)
Pmnb (62)	5.97560 Å	12.76800 Å	4.33470 Å				4	330.72 Å³	5.490 g/cm³	No	F30= 55.9(0.0117, 46)
P4132 (213)	8.35150 Å						11	582.50 Å³	4.900 g/cm³	No	F30= 94.9(0.0090, 35)
Cc (9)	8.90900 Å	5.14600 Å	15.69700 Å		113.700 °		4	658.95 Å³	2.650 g/cm³	No	F30= 19.8(0.0320, 47)
	7.52000 Å	7.65000 Å	2.89000 Å					166.26 Å³	3.156 g/cm³	No	F29= 6.6(0.0600, 74)
P21/m (11)	4.43700 Å	10.90200 Å	4.43900 Å		90.400 °			214.72 Å³		No	F28= 8.2(0.0220, 158)

Figure S4. Pattern list of HgKaFe, representing composition, obtained from XRD analysis.

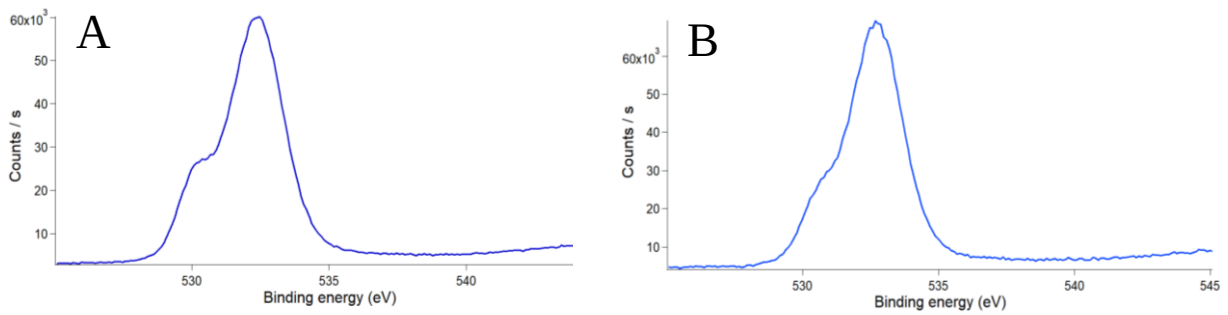

Figure S5. A represents XPS spectra for the element O in KaFe; B represents XPS spectra for the element O, respectively in HgKaFe.

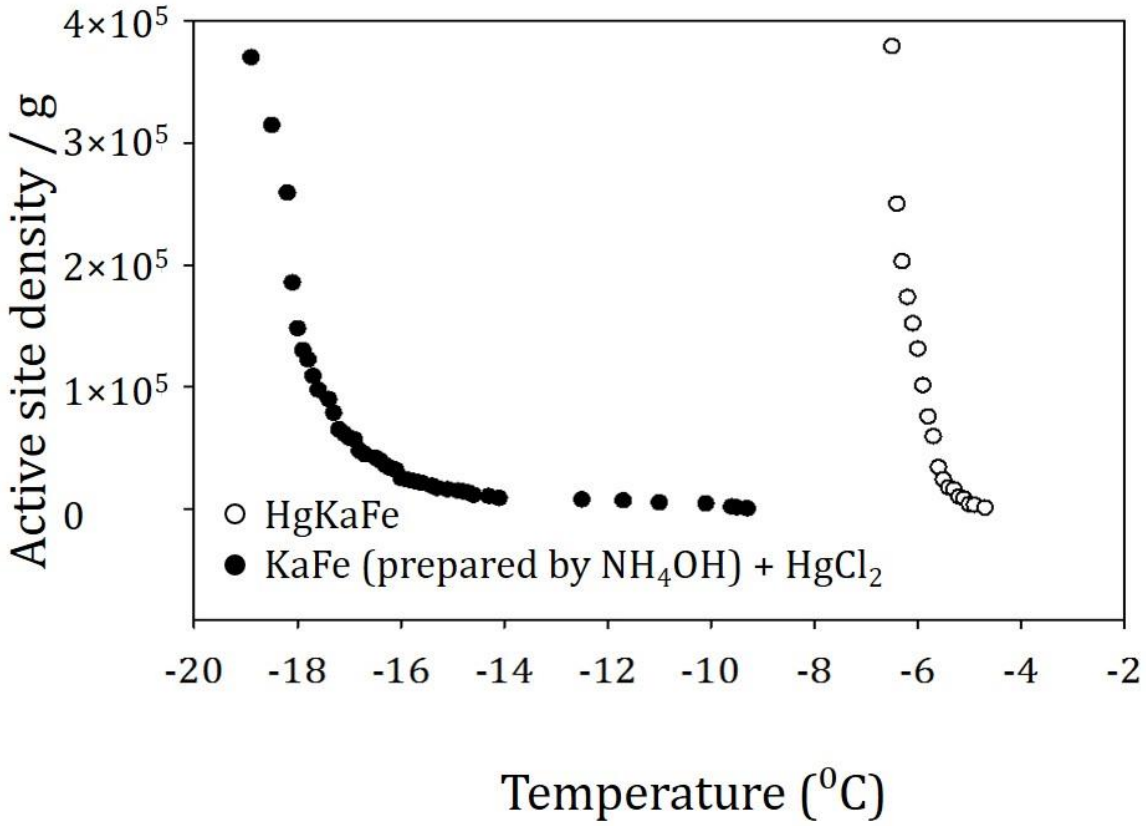

Figure S6. Comparison of the active site density per gram against temperature of $HgCl_2$ (3.69×10^{-3} M) with 0.0025g KaFe (made by using $NaBH_4$ and ammonium hydroxide) in 10 mL milli-Q water.

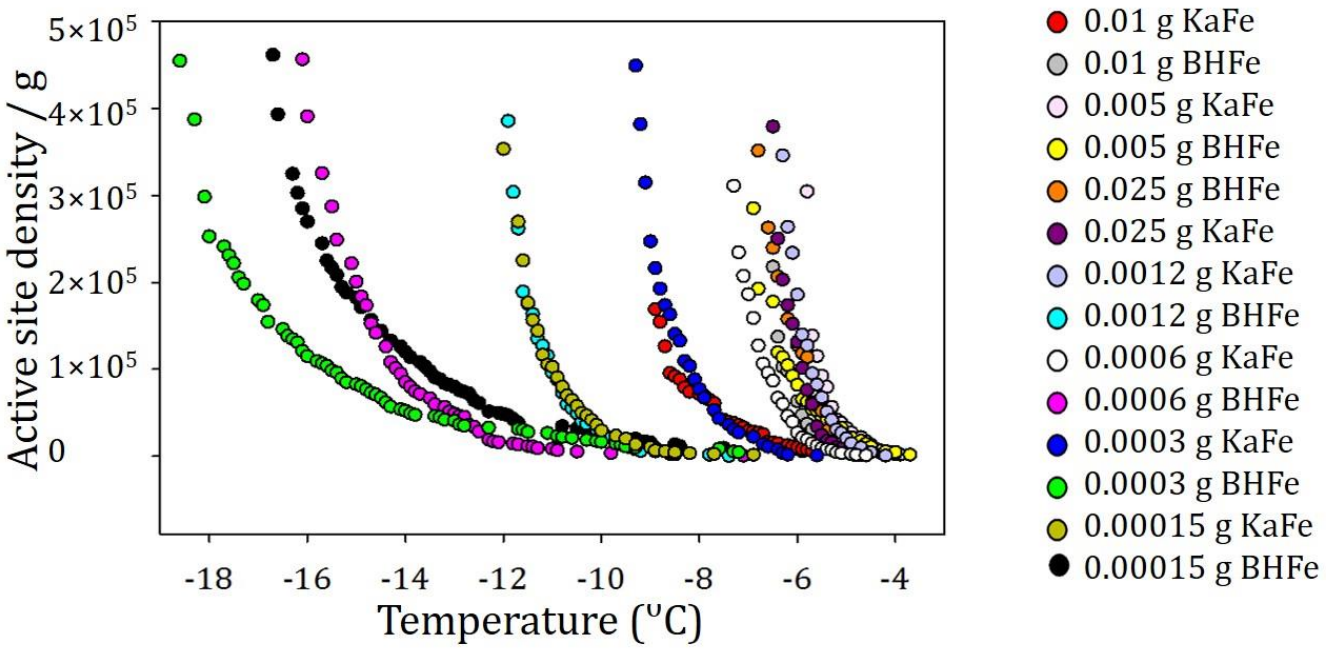

Figure S7. Comparison of the active site density per gram against temperature of 3.69×10^{-3} M $HgCl_2$ with different amount of BHFe and KaFe in 10 mL milli-Q water.

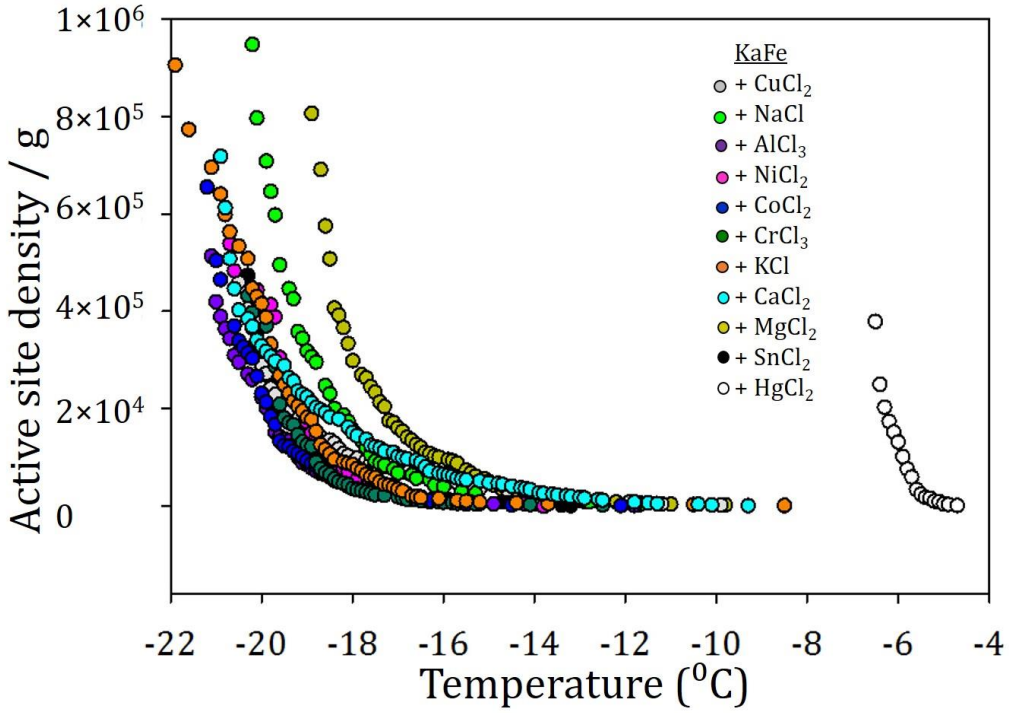

Figure S8. Comparison of the active site density per gram against temperature of 3.69 × 10^{-3} M different metal chloride with 0.0025g KaFe in 10 mL milli-Q water.

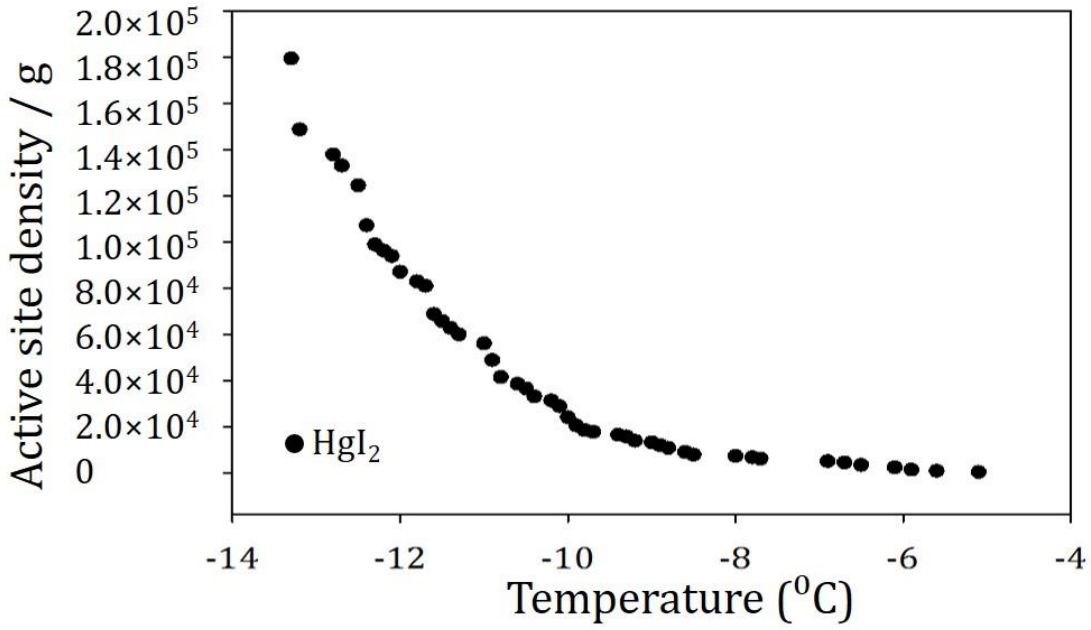

Figure S9. The active site density per gram against temperature of 0.01 g HgI_2, dispersed in 10 mL milli-Q water.

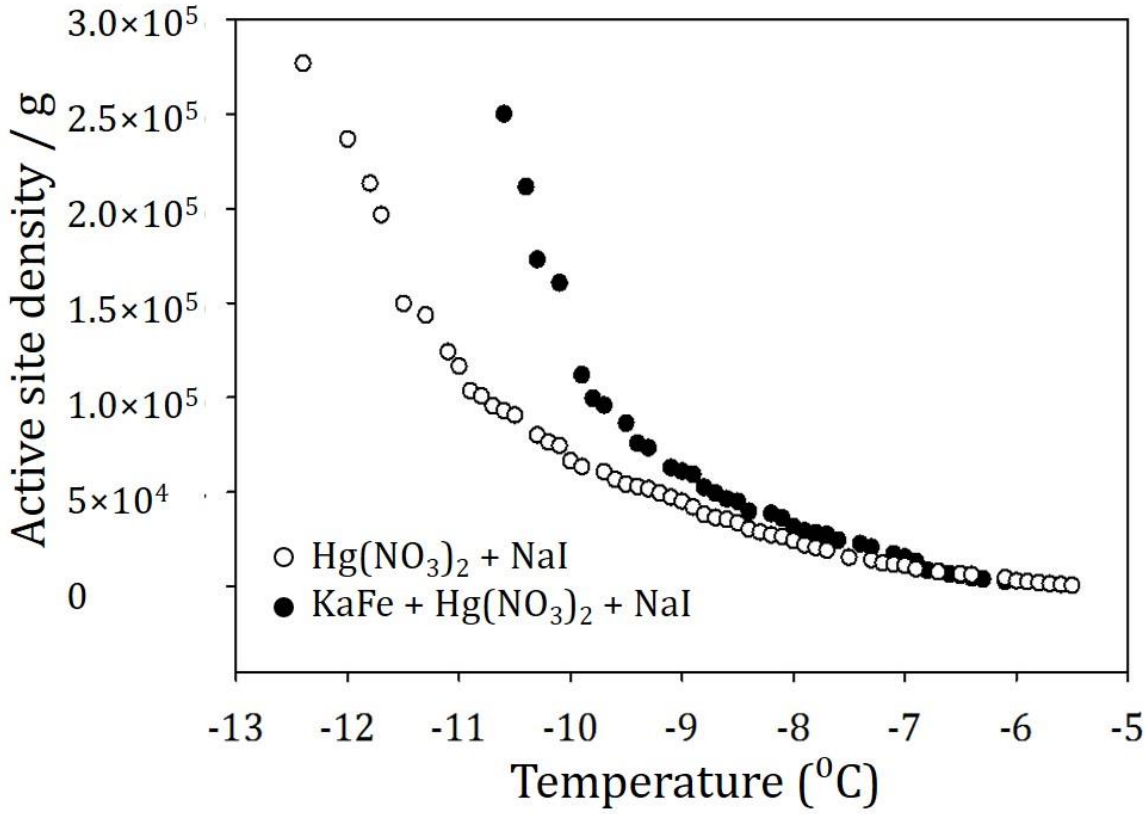

Figure S10. Comparison of the active site density per gram against temperature of 3.69×10^{-3} M $Hg(NO_3)_2$ and 1.7×10^{-2} M NaI in 10 mL milli-Q water with and without KaFe.

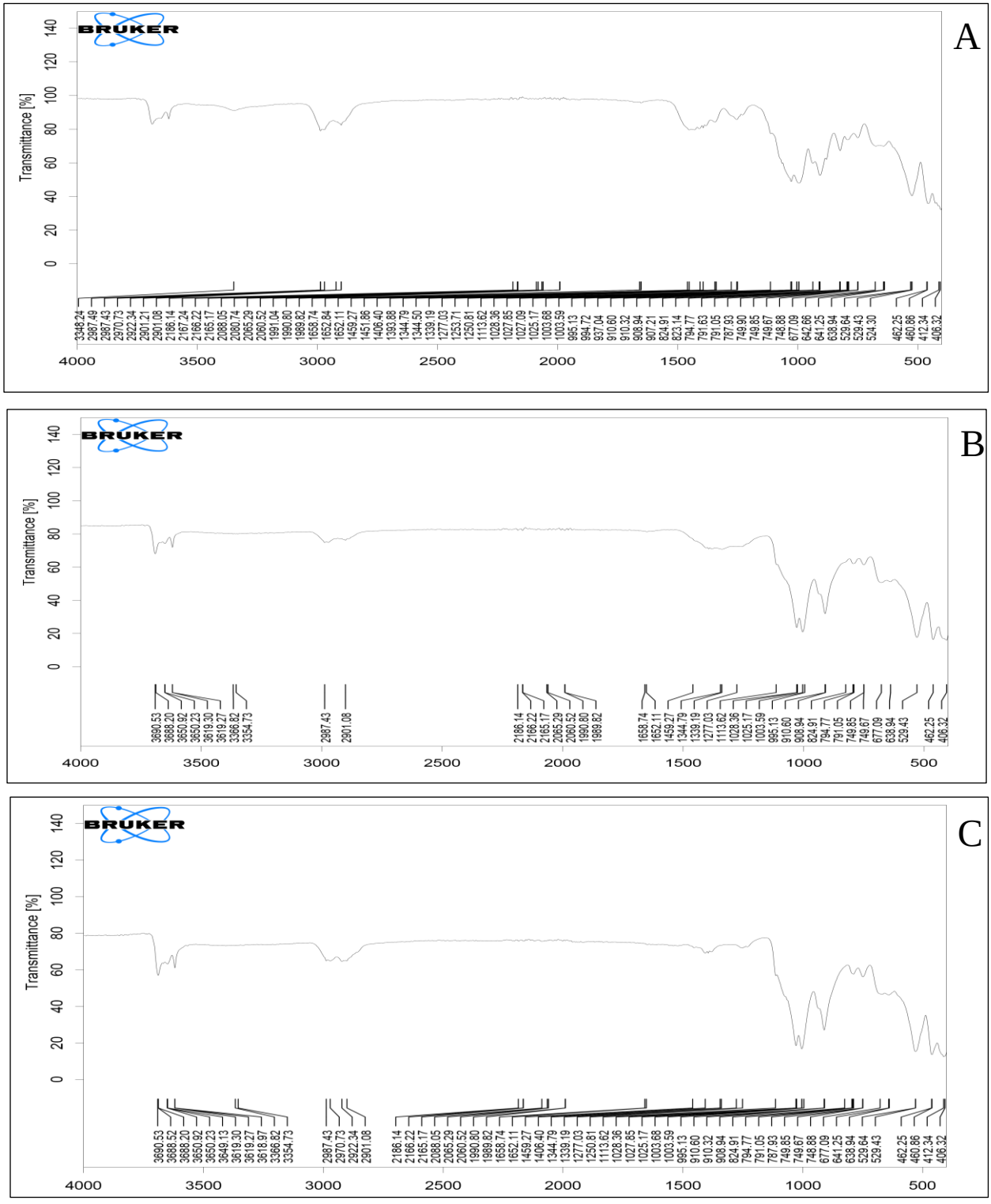

Figure S11. Infra-red spectra of (A) kaolin, (B) KaFe and (C) WHgKaFe

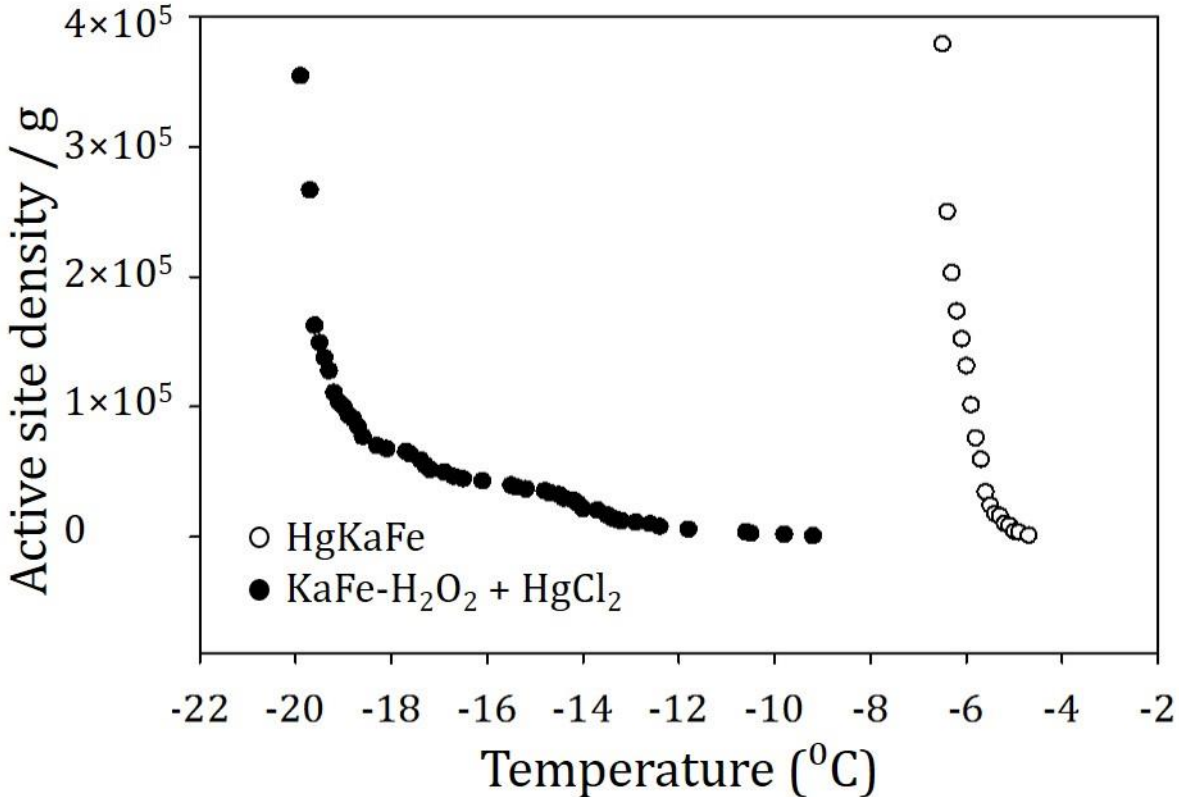

Figure S12. Comparison of the active site density per gram against temperature of 0.0025 g KaFe and OKaFe with 10 mL 3.69×10^{-3} M $HgCl_2$.

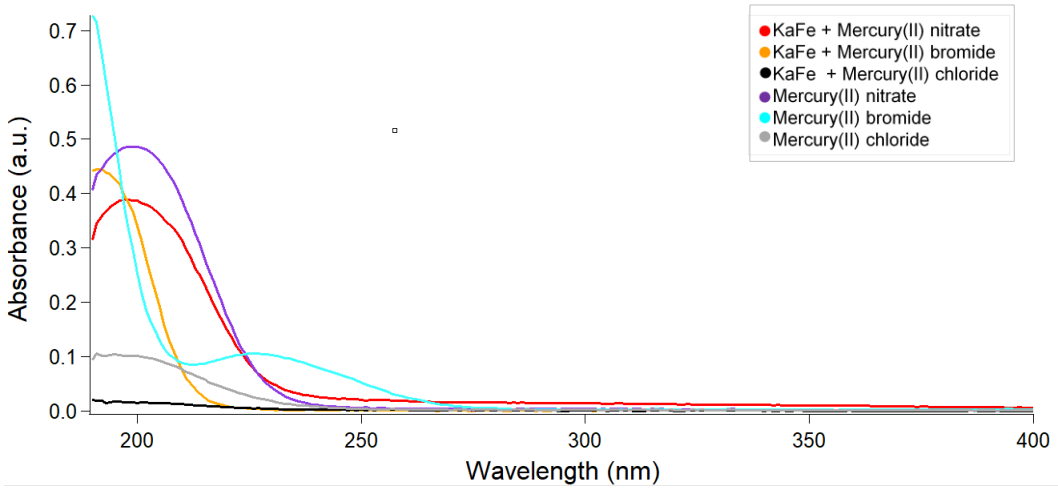

Figure S13. UV-Vis spectra after sonication of 3.69×10^{-3} M different Hg(II) salts with and without KaFe (0.01 g). The spectra have been recorded after diluting the supernatant by 130 times.

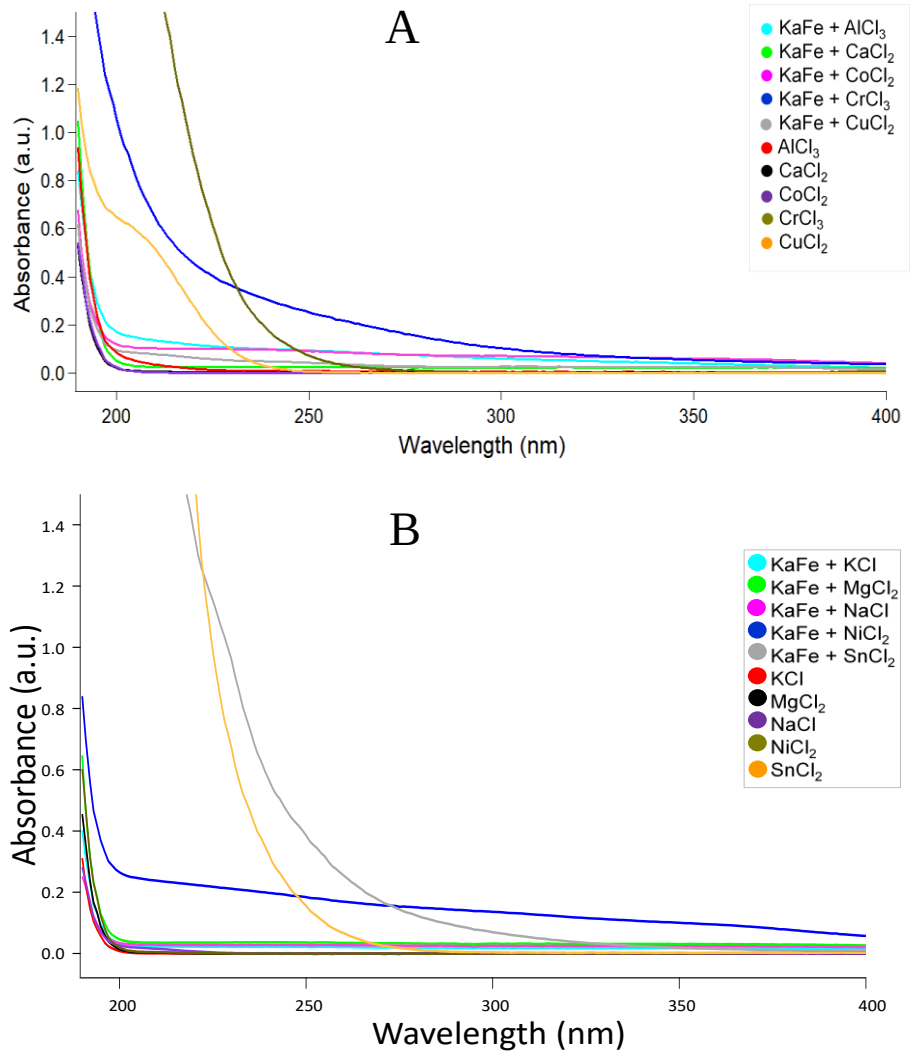

Figure S14. (A) UV-Vis spectra of 3.69×10^{-3} M different metal (K, Mg, Na, Ni, Sn) chloride with and without KaFe (0.01 g), spectra were recorded after 13 times dilution of the supernatant with milli-Q water; (B) UV-Vis spectra of 3.69×10^{-3} M different metal (Al, Ca, Co, Cr, Cu) chloride with and without KaFe (0.01 g), spectra were recorded after 13 times dilution of the supernatant with milli-Q water.

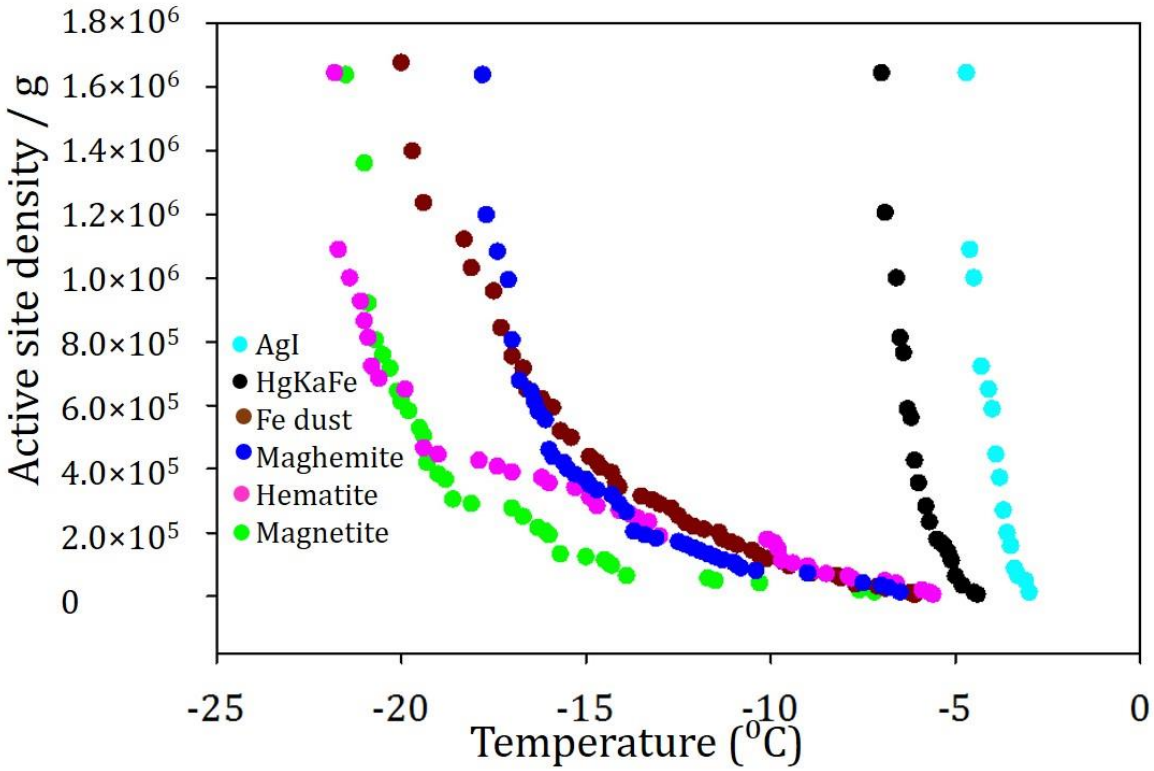

Figure S15: Comparison of active site density against temperature of different samples of 0.0025 g in 10 mL milli-Q water. HgKaFe was diluted 5 times to obtain total mass of 0.0025 g in 10 mL milli-Q water.