Electronic Supplementary Material (ESI) for Energy Advances.

LSNR: GO template for BSA interaction, photo and sonocatalytic reductions of fluorescent dyes in aqueous solutions

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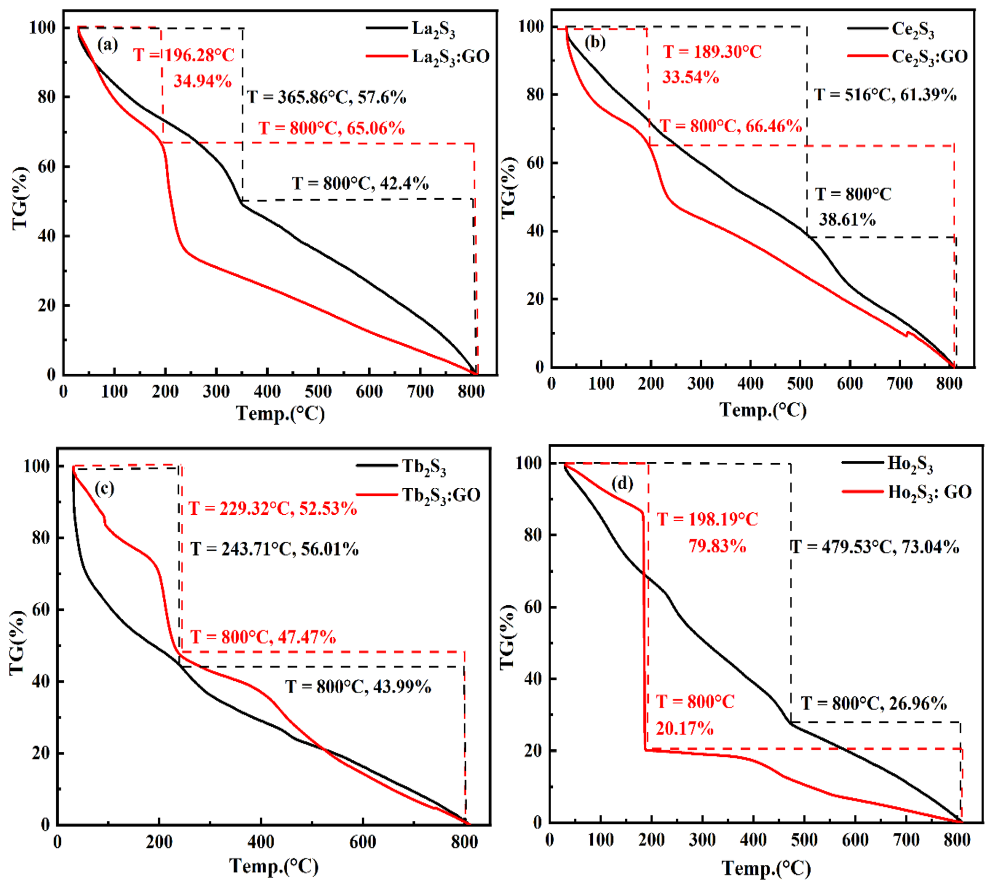
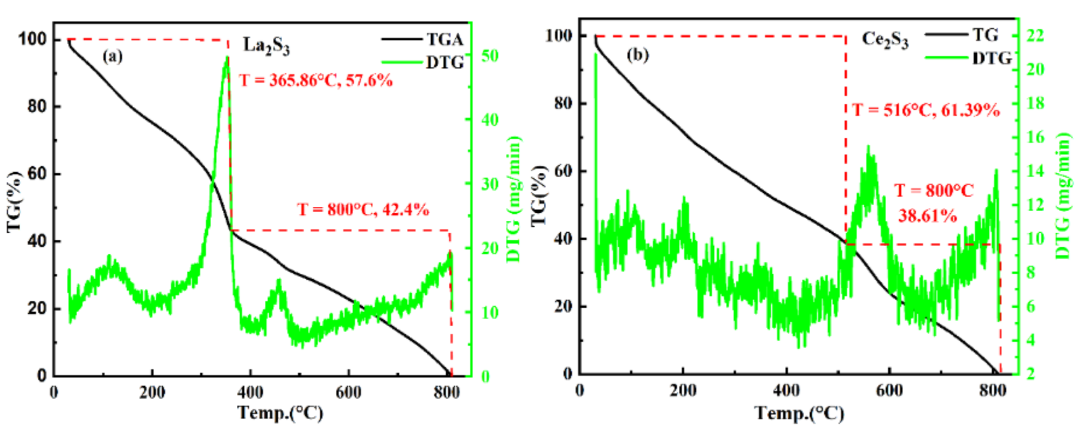
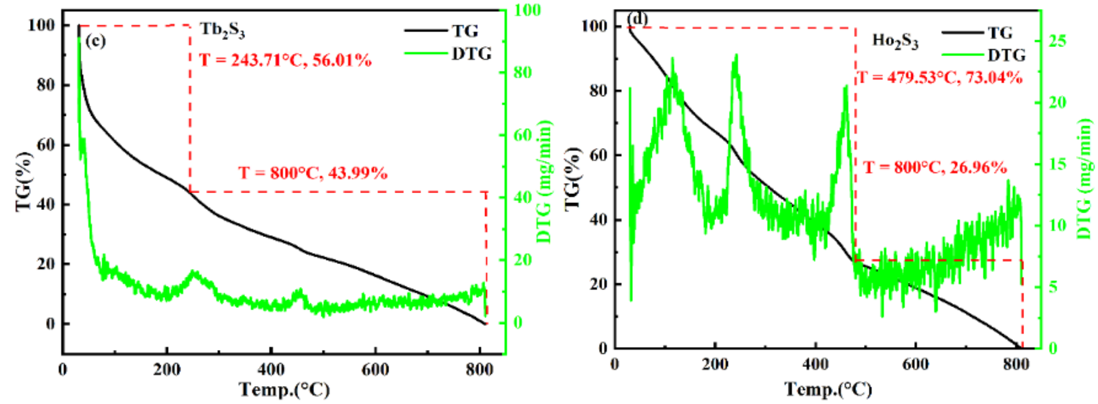
1. Figures-

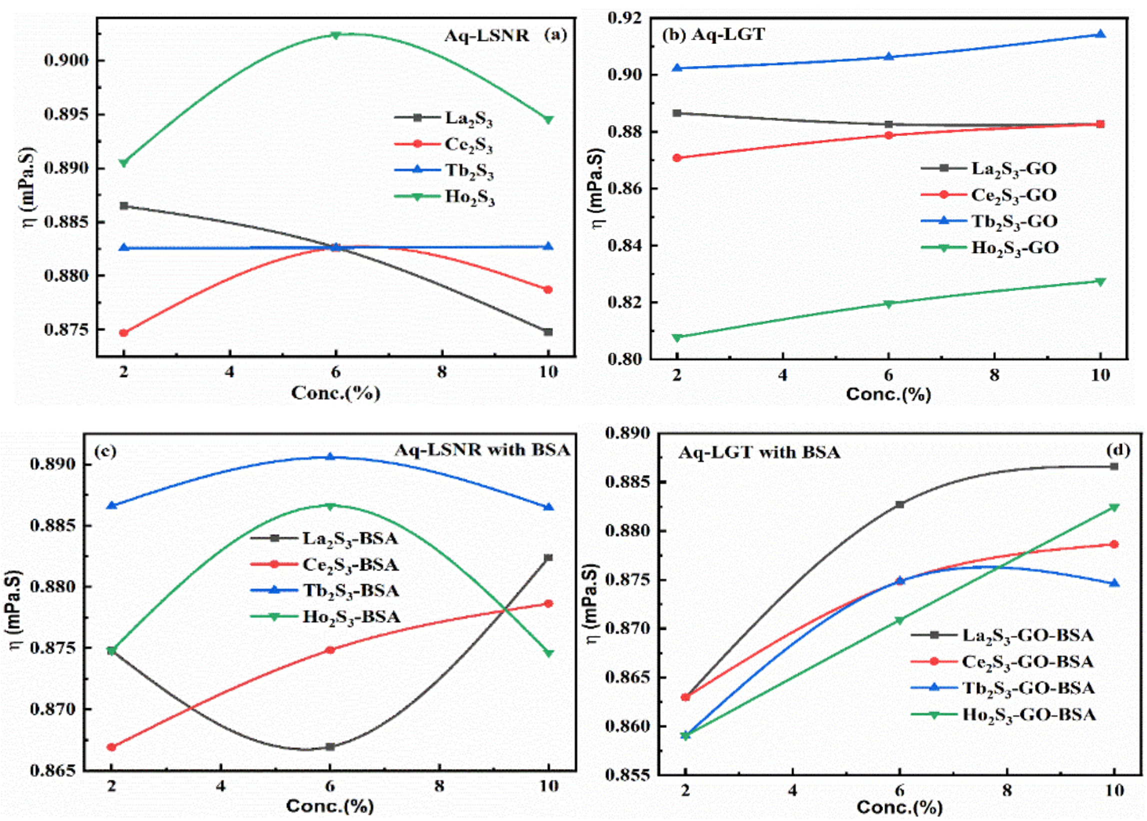


Figs. (SI-1.0). The difference in weight loss of LSNR and LGT.

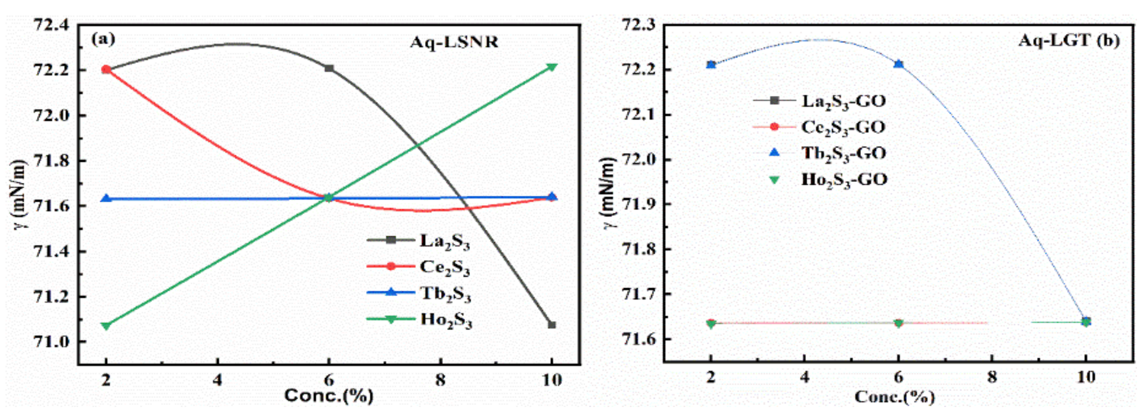


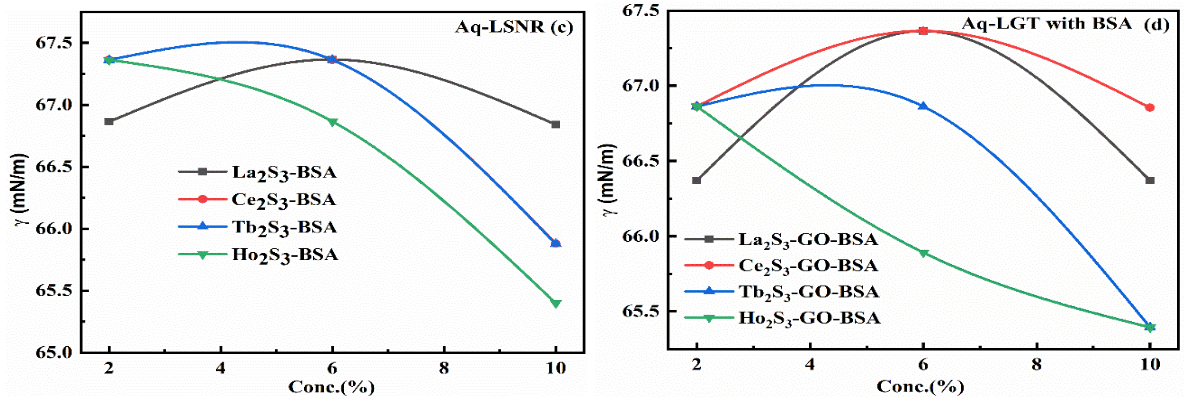


Figs. (SI-1.1). TGA and DTG of LSNR.

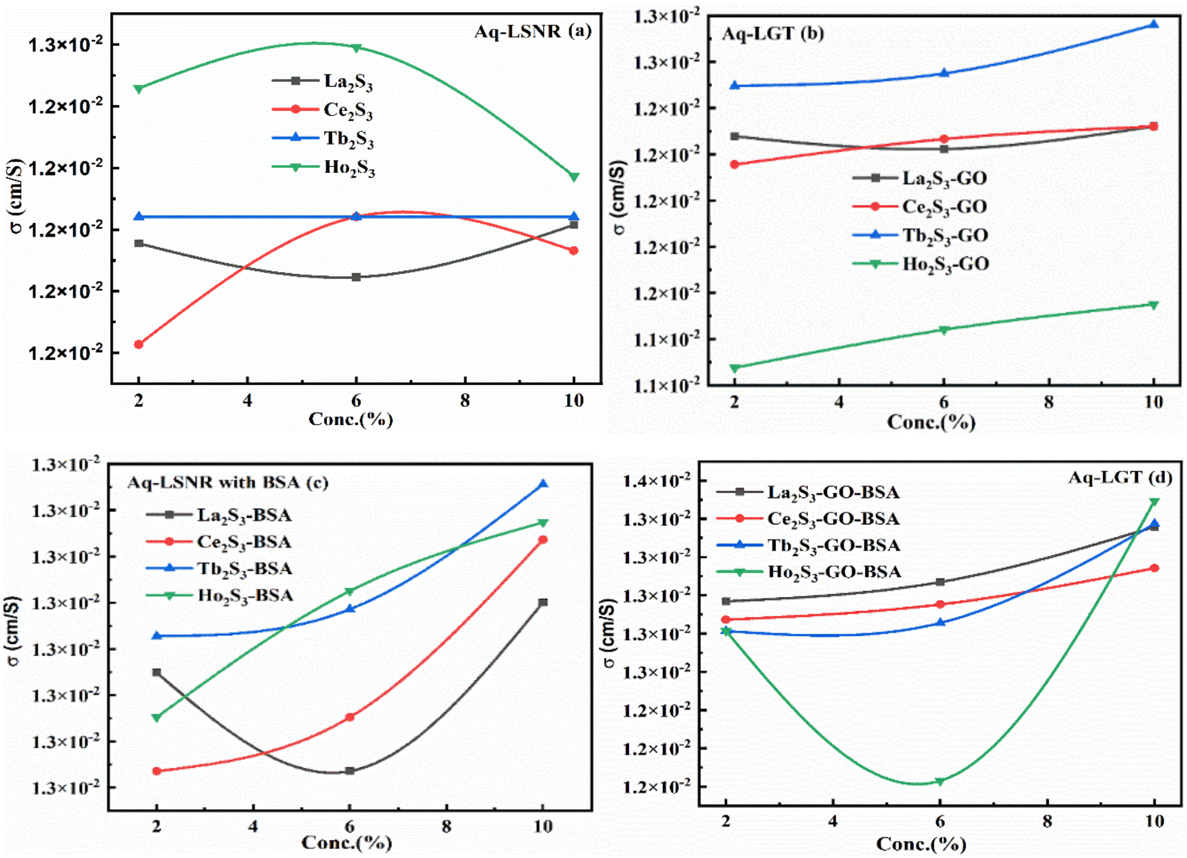


Figs. (SI-1.2). The viscosity vs conc. of LSNR, LGT and with BSA.

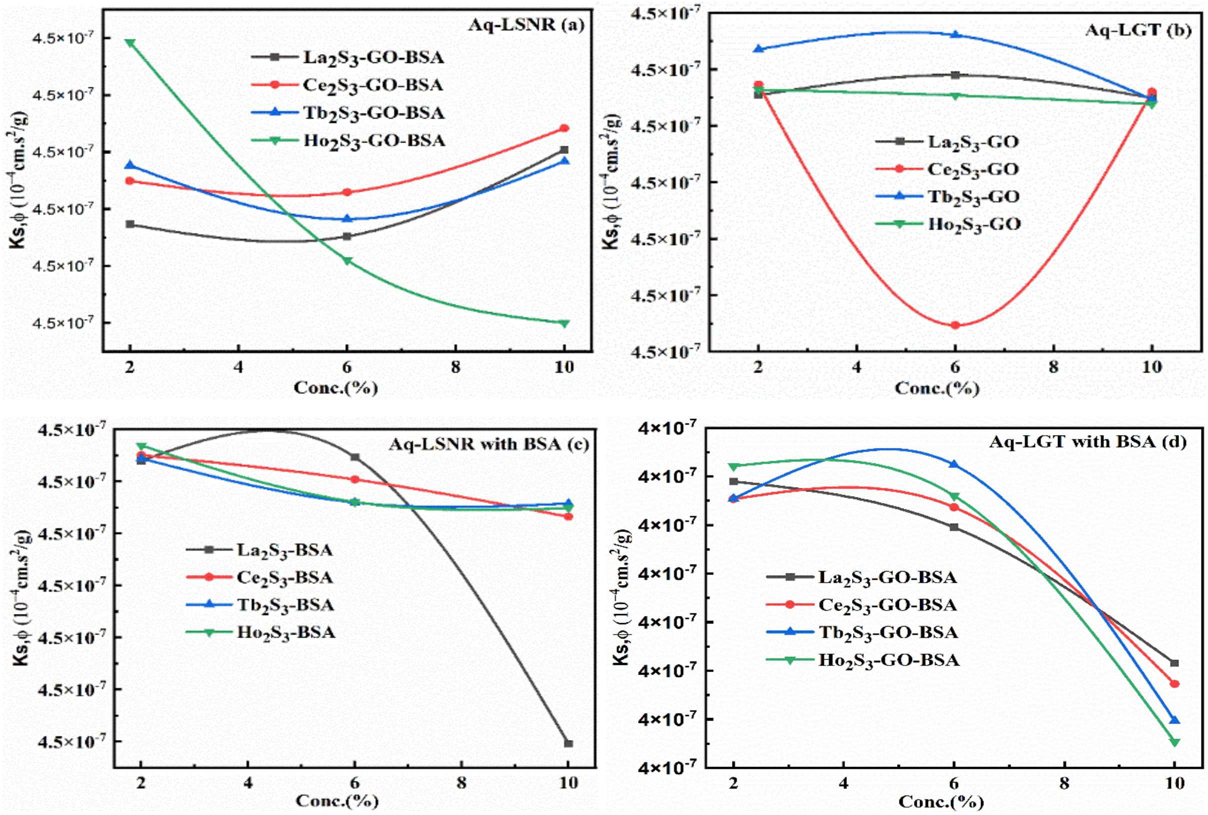




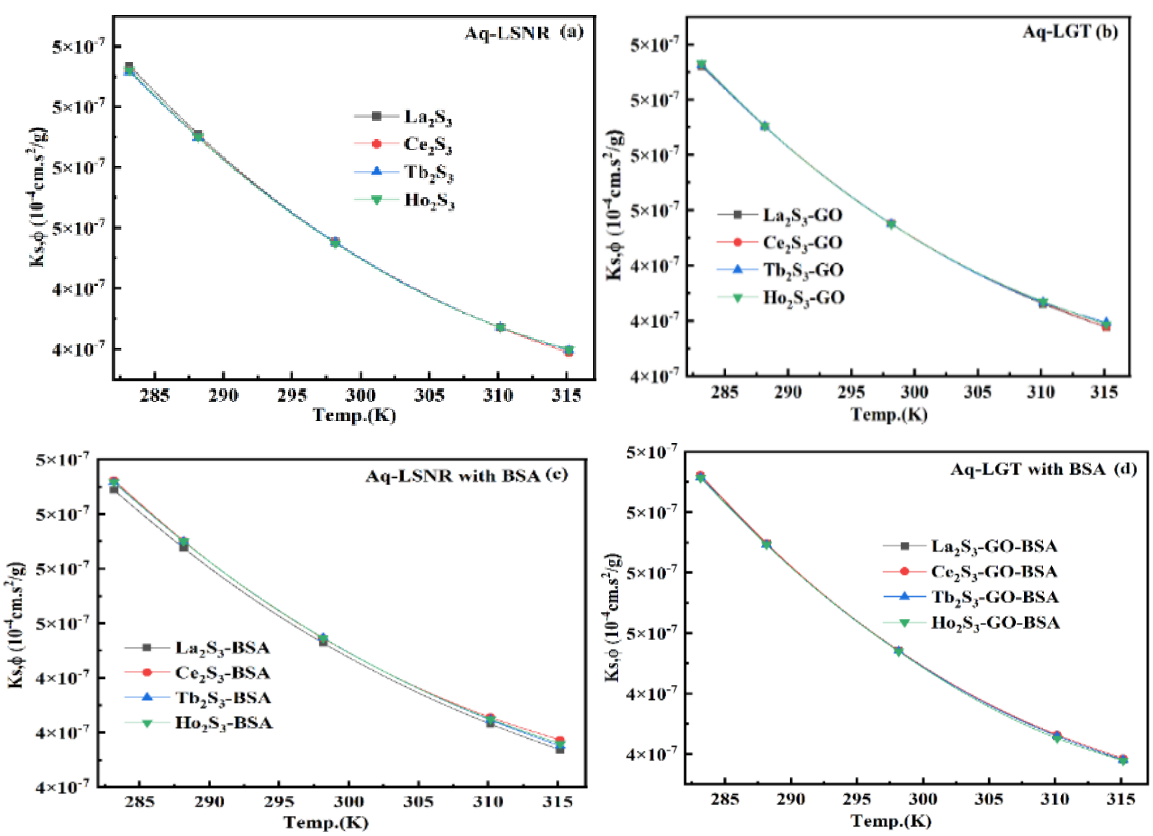
Figs. (SI-1.3). The surface tension vs conc. of LSNR, LGT and with BSA.



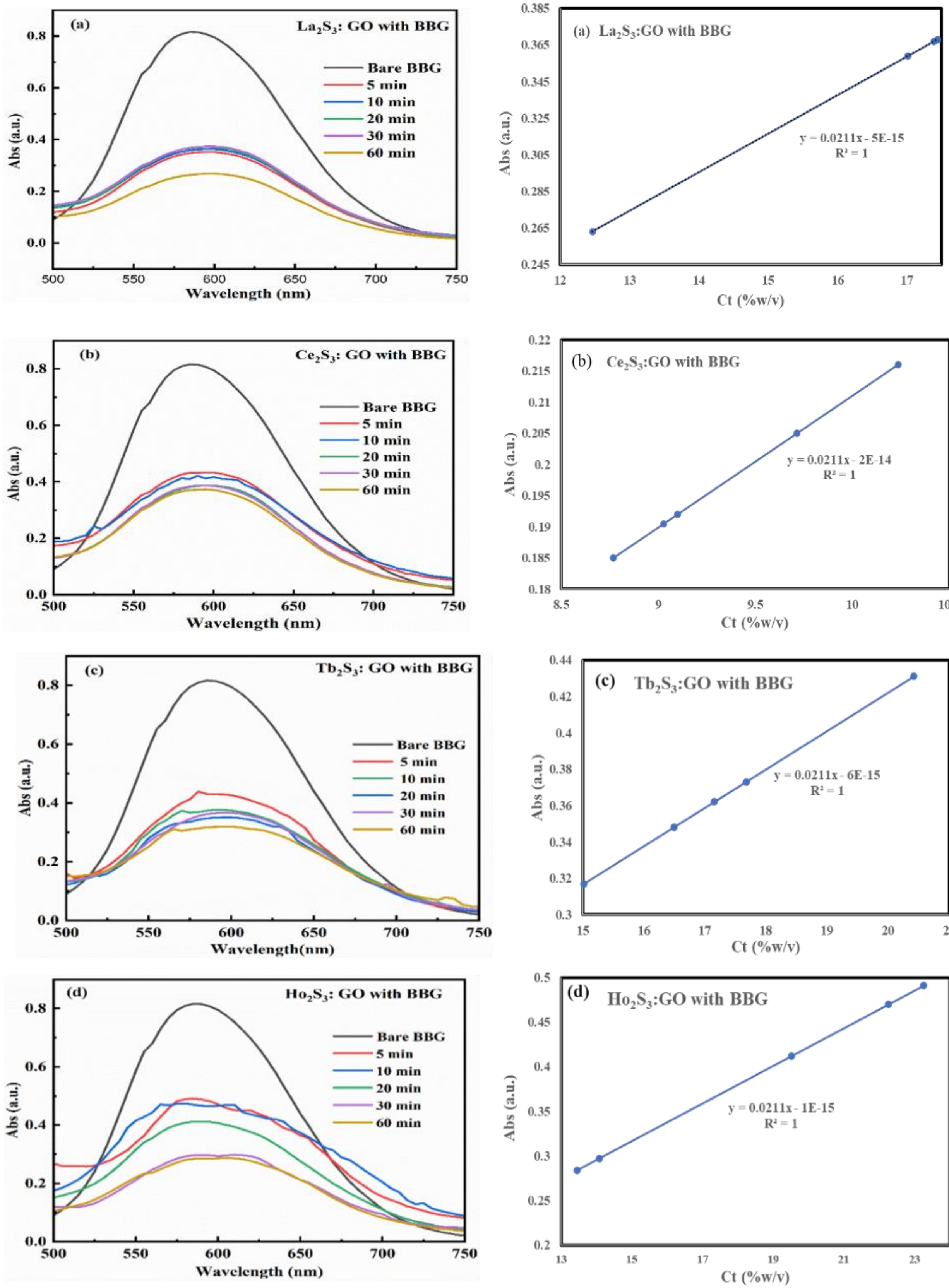
Figs. (SI-1.4). The friccohesity vs conc. of LSNR, LGT and with BSA.

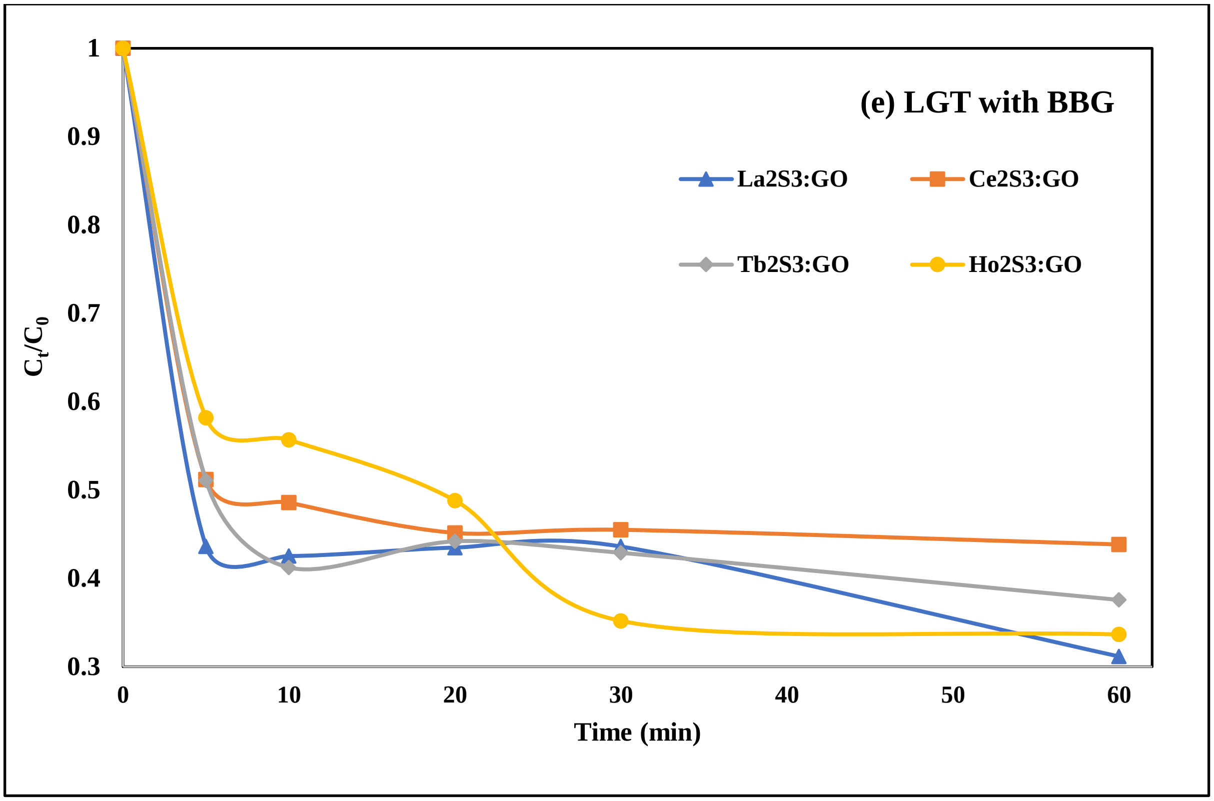


Figs. (SI-1.5). The isentropic compressibility vs conc of LSNR, LGT and with BSA.

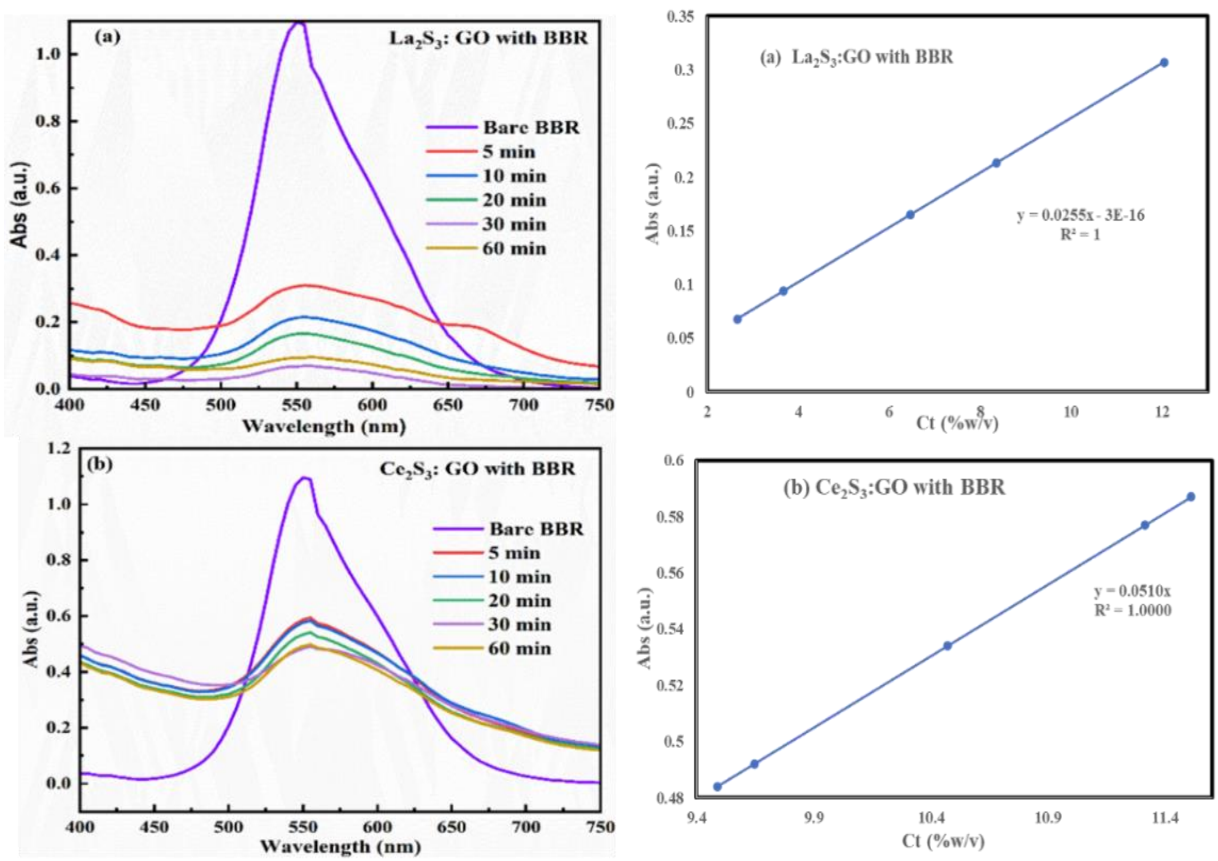


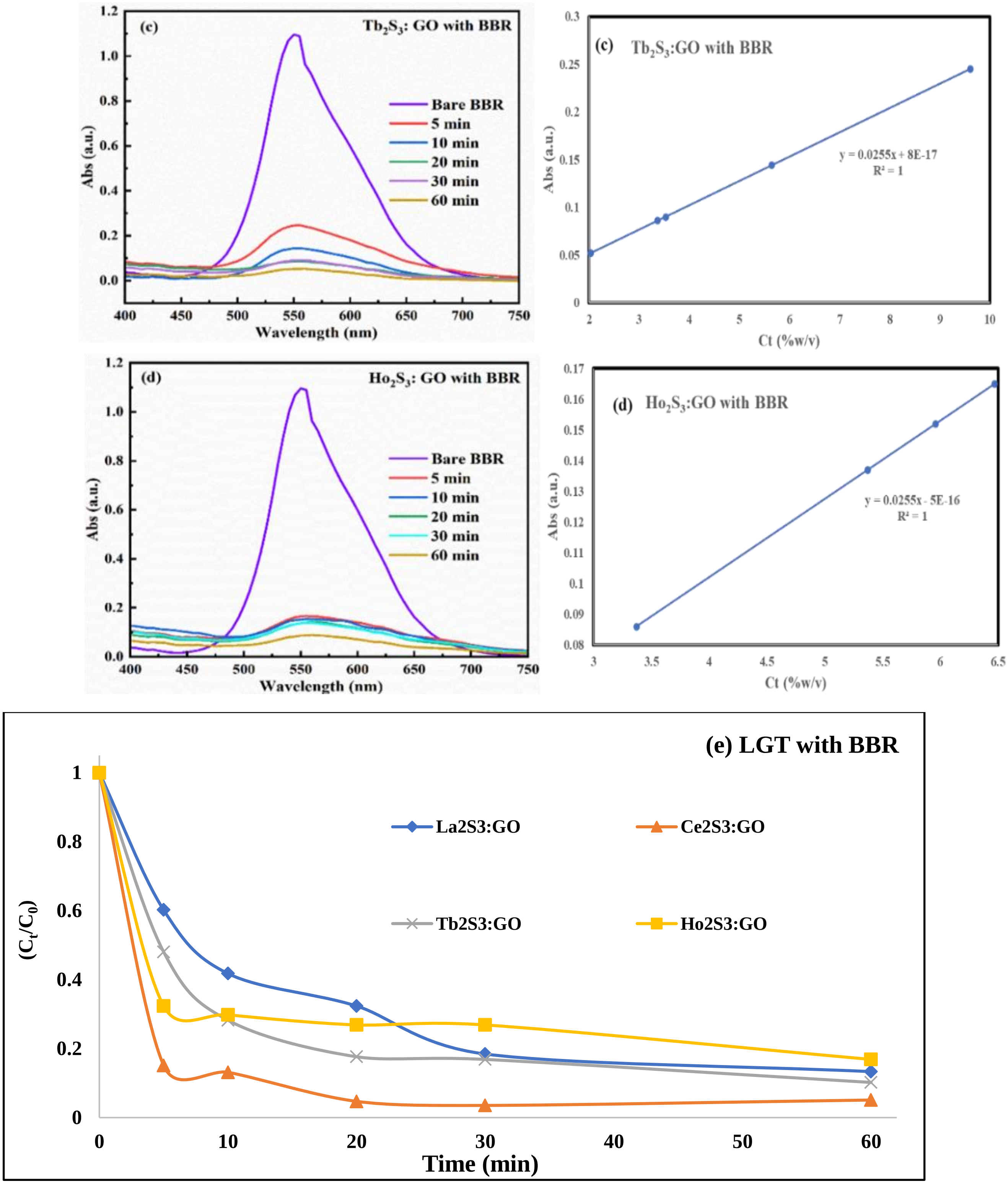
Figs. (SI-1.6). The isentropic compressibility vs temperature of LSNR, LGT with BSA at 5T.


(a)
La2S3: GO with BBG
Bare BBG
5 min
10 min
20 min
30 min
60 min
Abs (a.u.)
Wavelength (nm)
(a) La2S3:GO with BBG
y = 0.0211x - 5E-15
R² = 1
Abs (a.u.)
Ct (%w/v)
(b)
Ce2S3: GO with BBG
Bare BBG
5 min
10 min
20 min
30 min
60 min
Abs (a.u.)
Wavelength (nm)
(b) Ce2S3:GO with BBG
y = 0.0211x - 2E-14
R² = 1
Abs (a.u.)
Ct (%w/v)
(c)
Tb2S3: GO with BBG
Bare BBG
5 min
10 min
20 min
30 min
60 min
Abs (a.u.)
Wavelength(nm)
(c) Tb2S3:GO with BBG
y = 0.0211x - 6E-15
R² = 1
Abs (a.u.)
Ct (%w/v)
(d)
Ho2S3: GO with BBG
Bare BBG
5 min
10 min
20 min
30 min
60 min
Abs (a.u.)
Wavelength (nm)
(d) Ho2S3:GO with BBG
y = 0.0211x - 1E-15
R² = 1
Abs (a.u.)
Ct (%w/v)

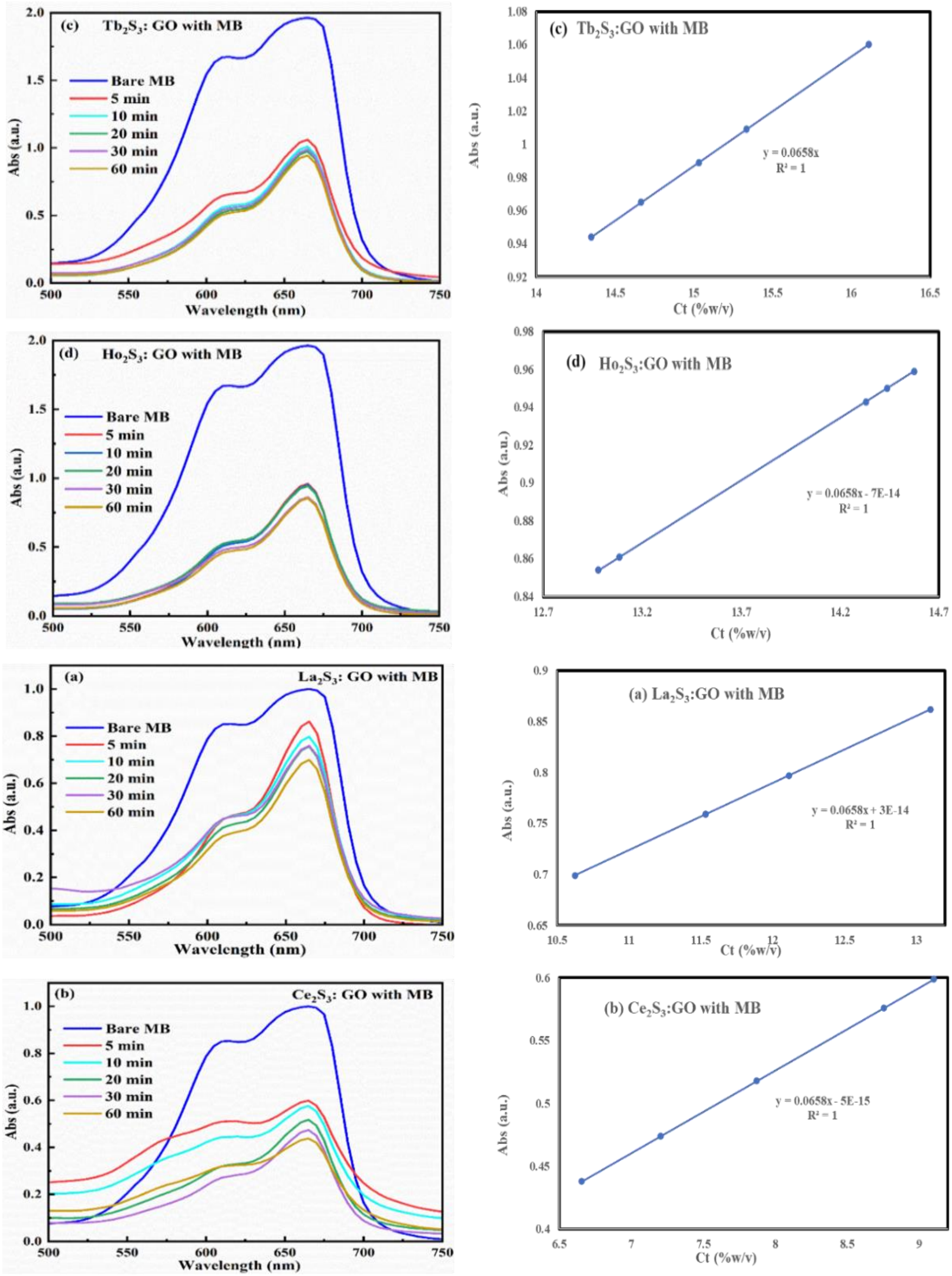


Figs. (SI-1.7). Sonocatalytic reduction activities and as a function of time with BBG.





Figs. (SI-1.8). Reduction of BBR dye by LGT under SCR and with function of time.



Figs. (SI-1.9). Reduction of MB dye by LGT under SCR and with 1st order kinetics.

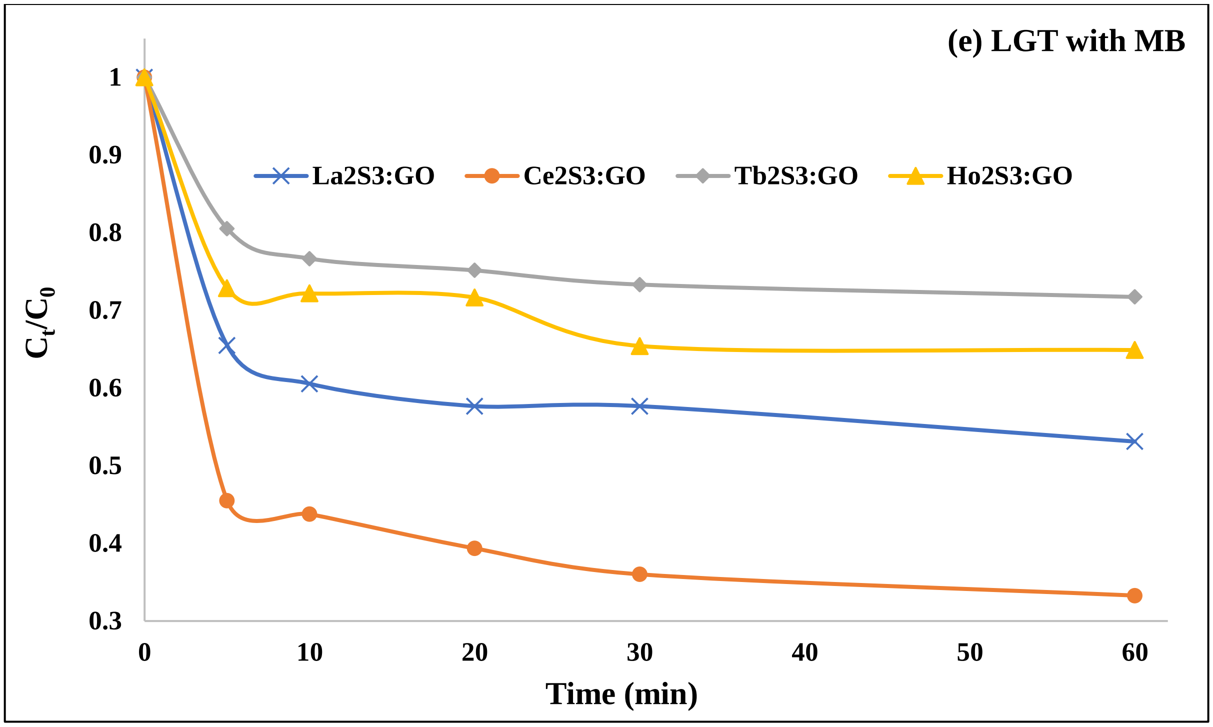
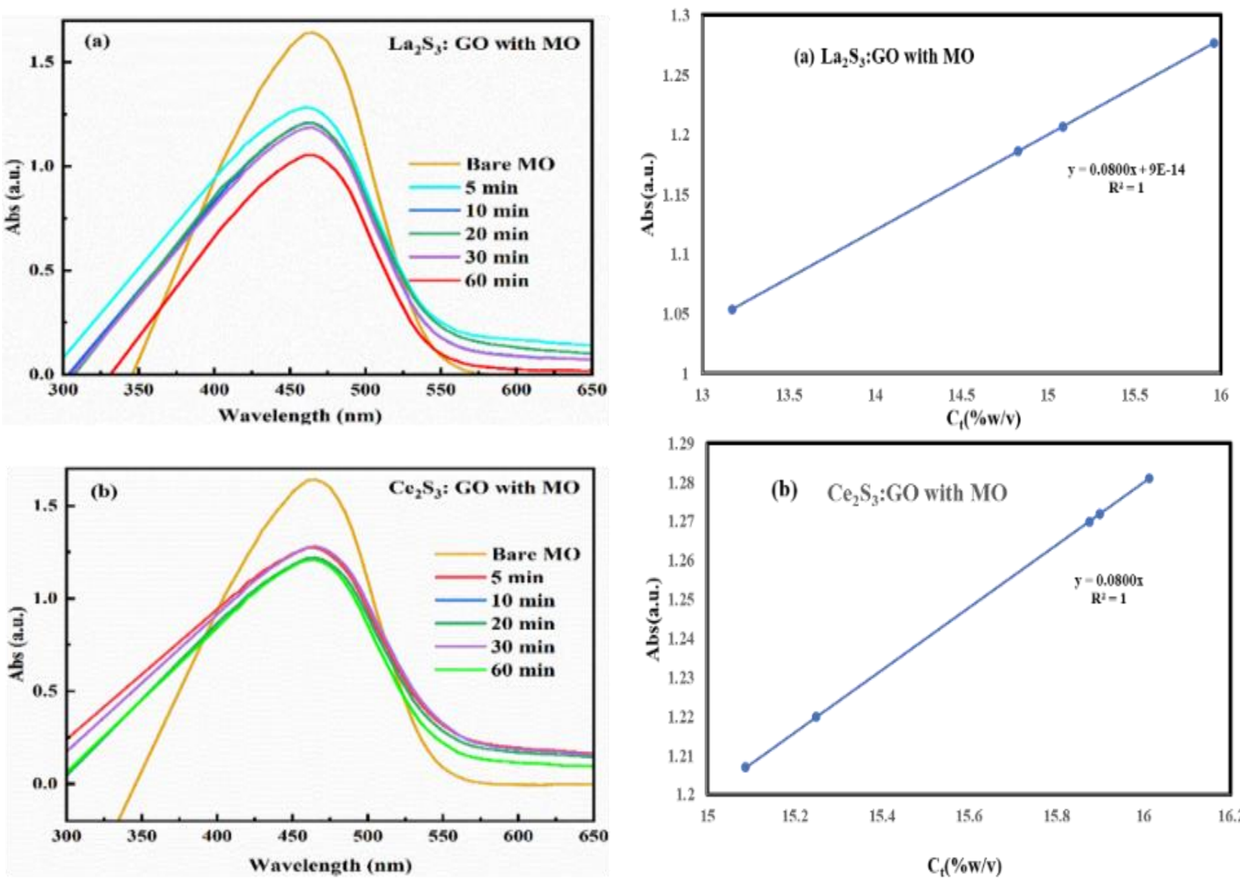
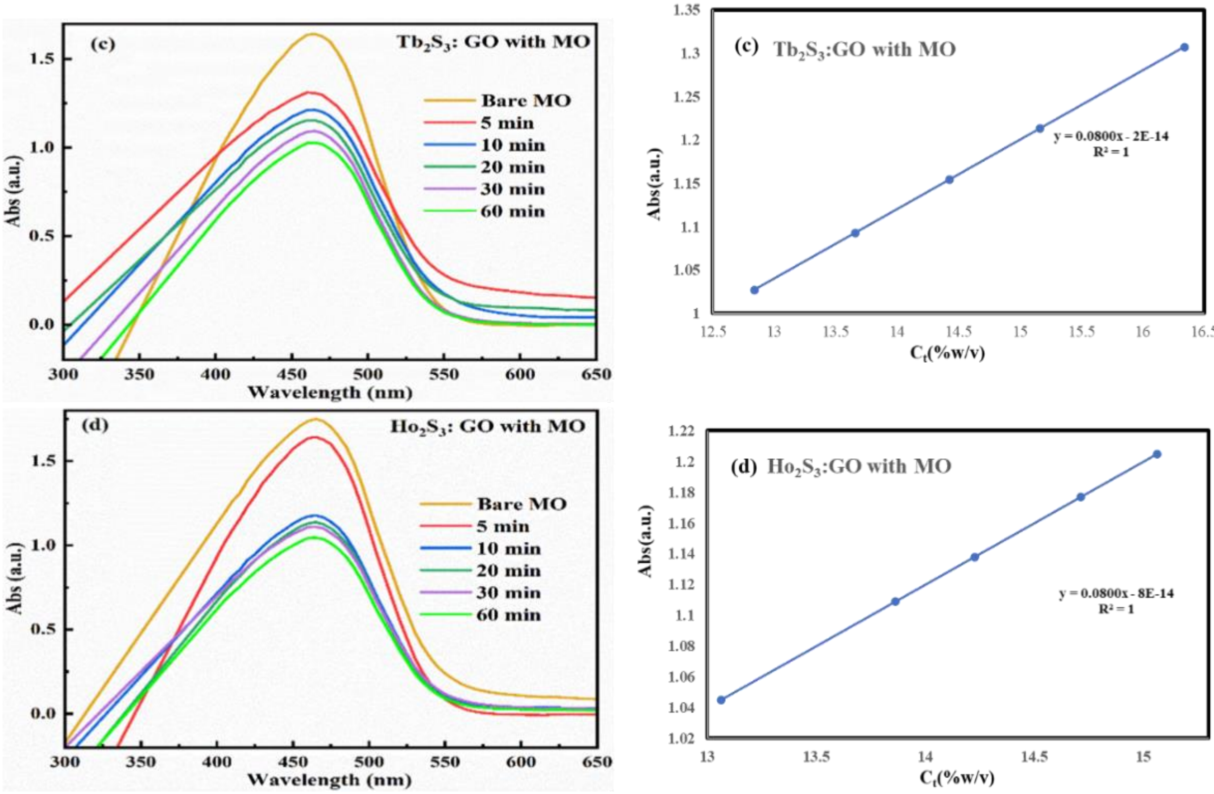


Fig. (SI-2.0). Sonocatalytic reduction activities with MB as a function of time.





Figs. (SI-2.1). Degradation of MO dye LGT under SCR and with 1st order kinetics.

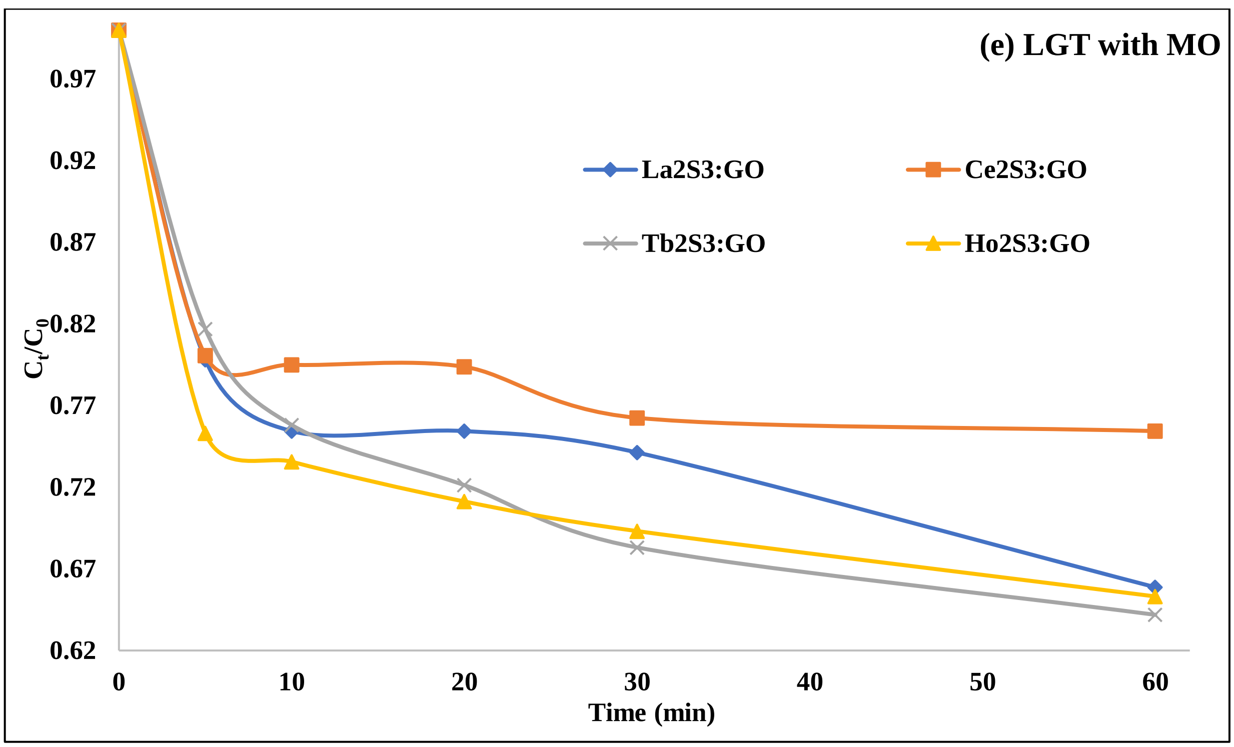
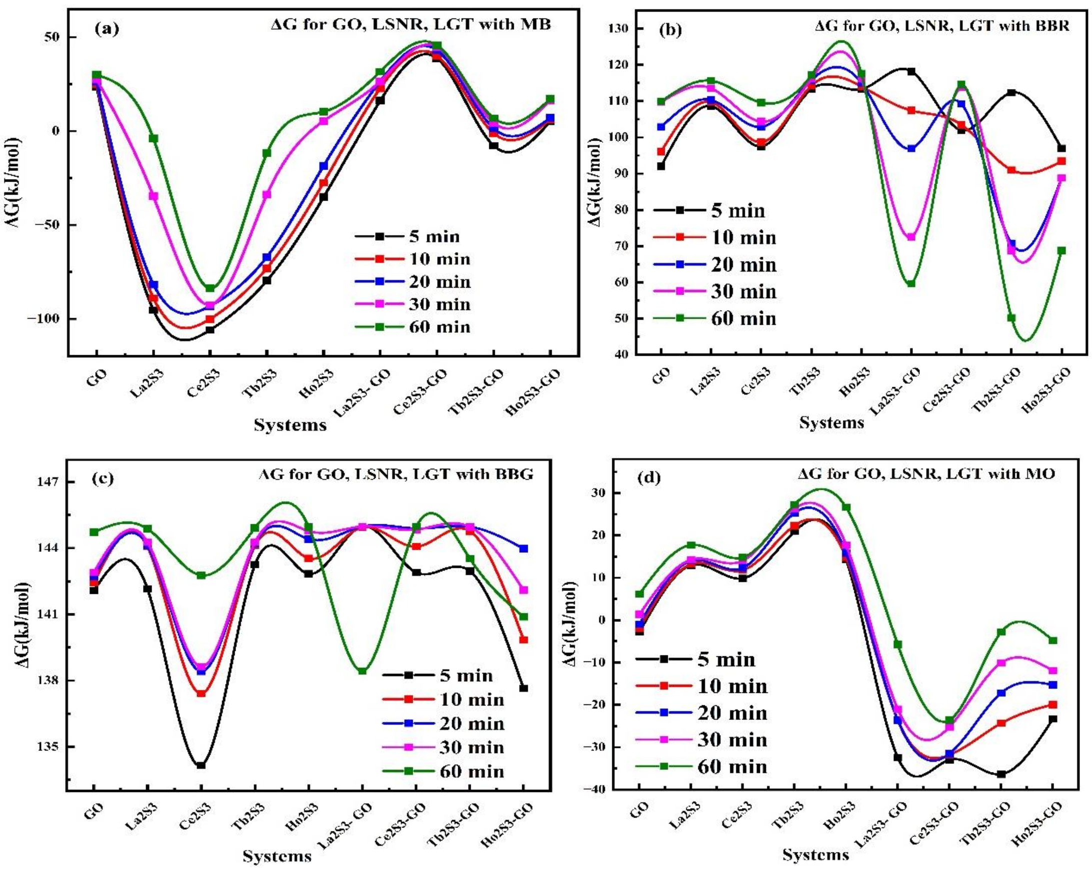
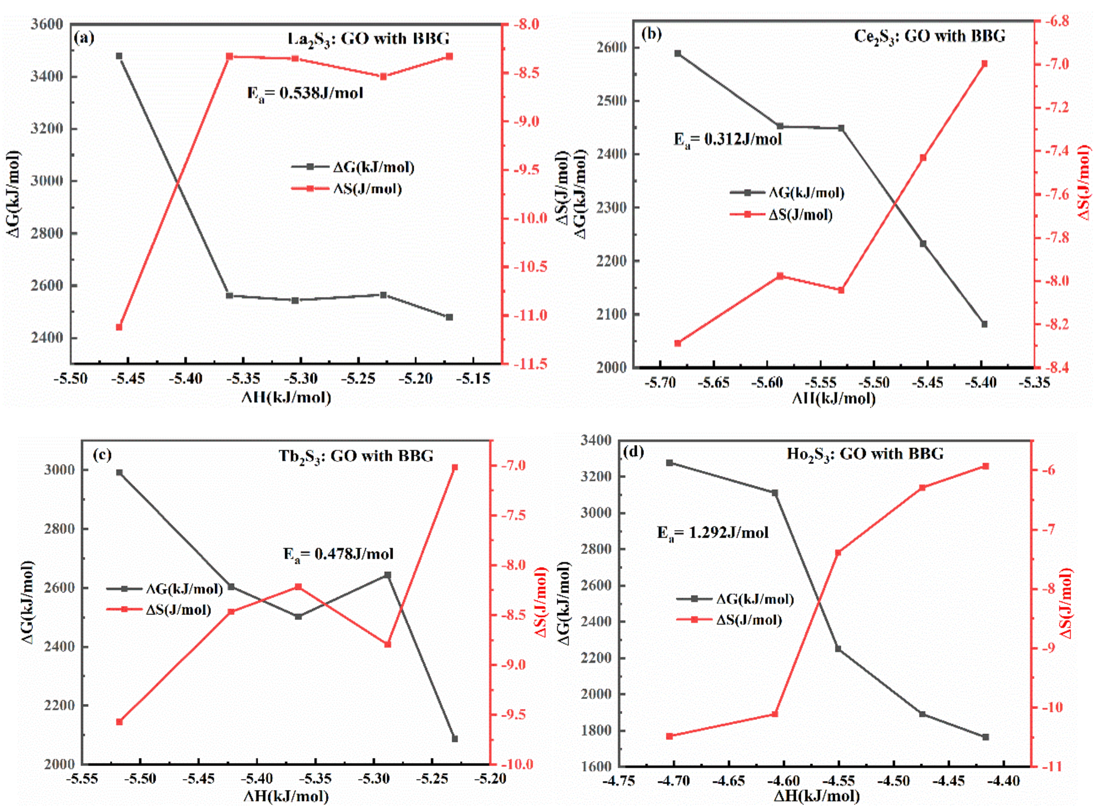


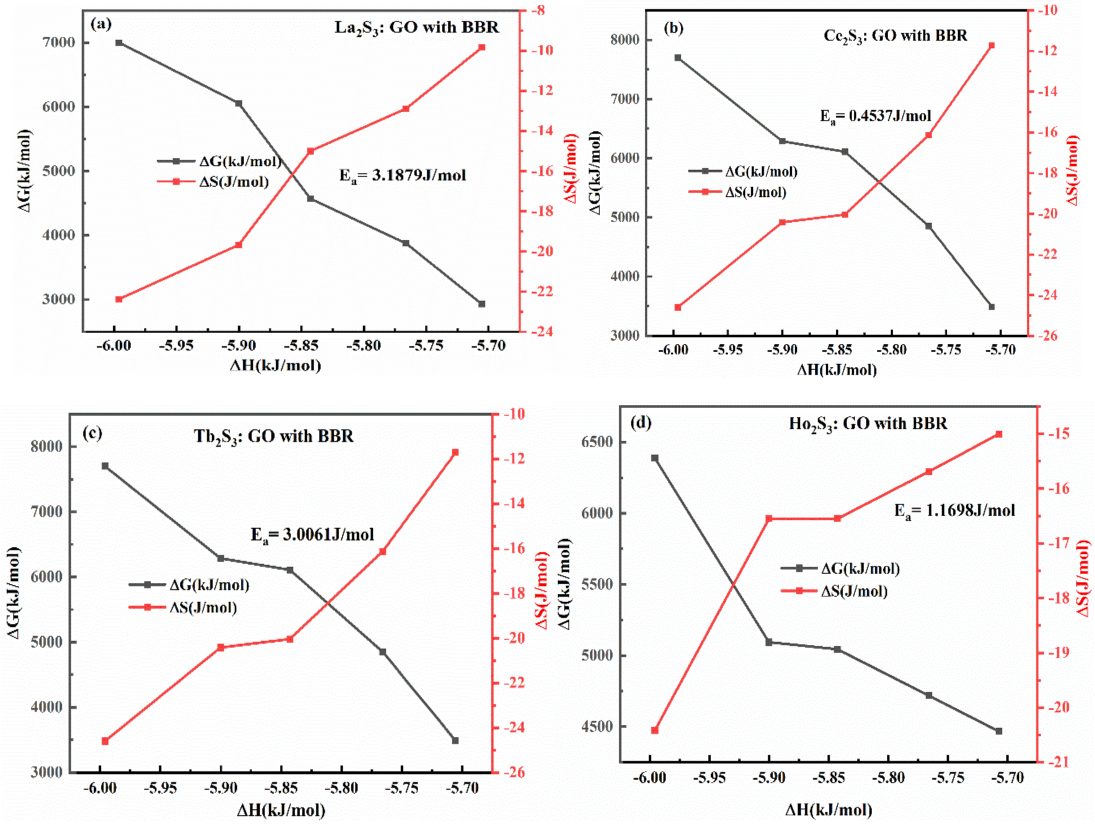
Fig. 2.2. Sonocatalytic reduction activities with MO as a function of time.



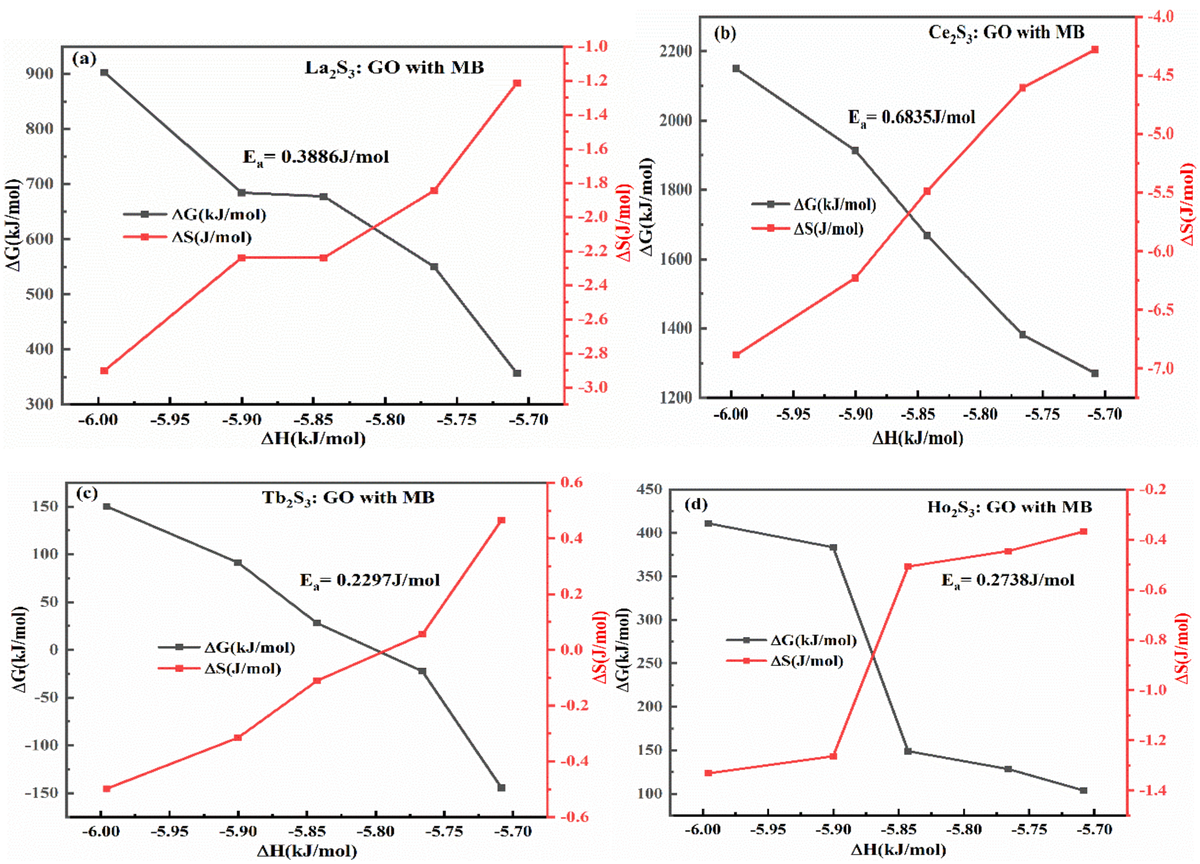
Figs. (SI-2.3). The time dependent, ΔG for GO, LSNR and LGT with (a) BBR (b) BBG (c) MO.



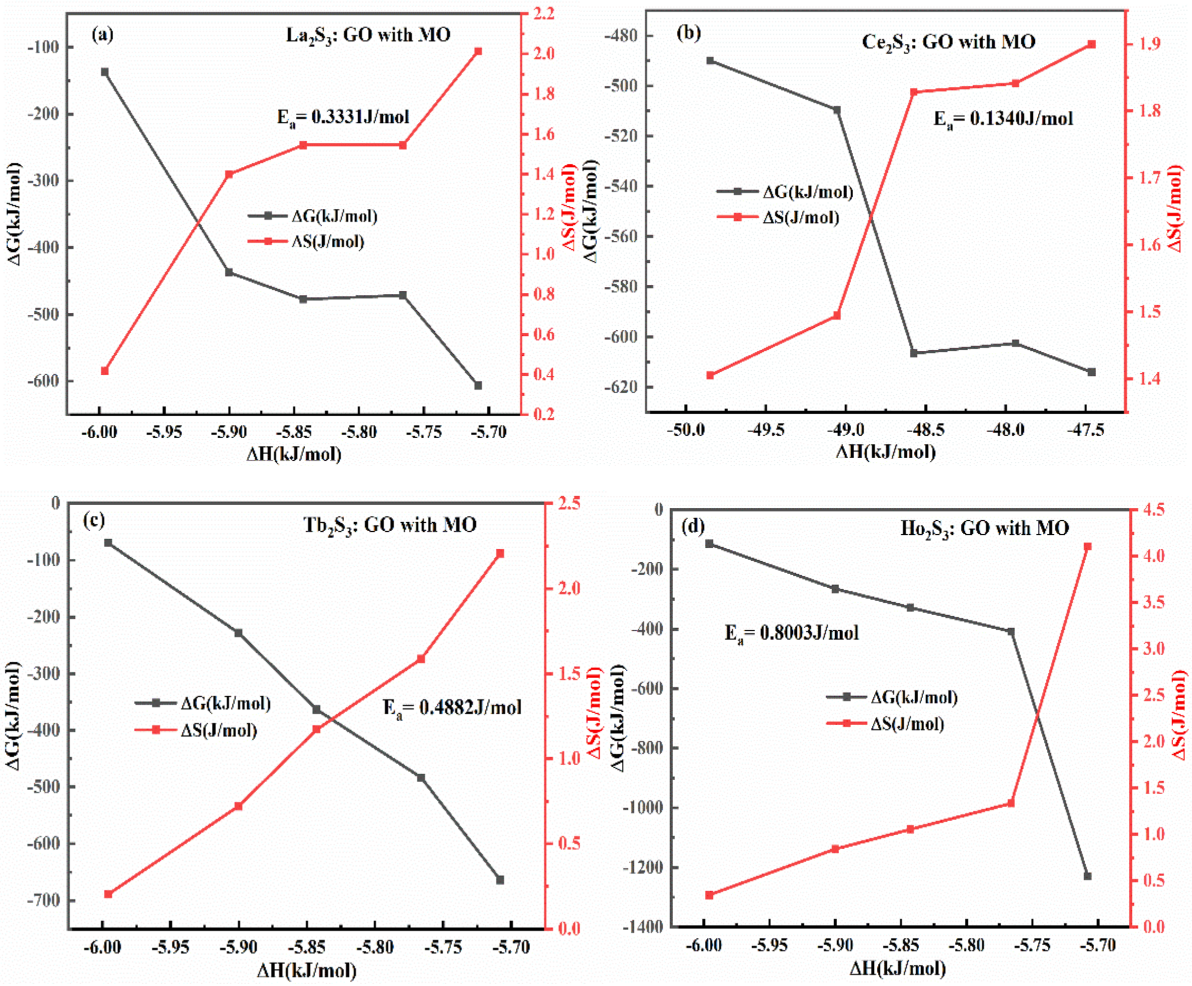
Figs. **(SI-2.4).** The relation between Gibbs free energy, enthalpy, and entropy of BBG with LSNR.



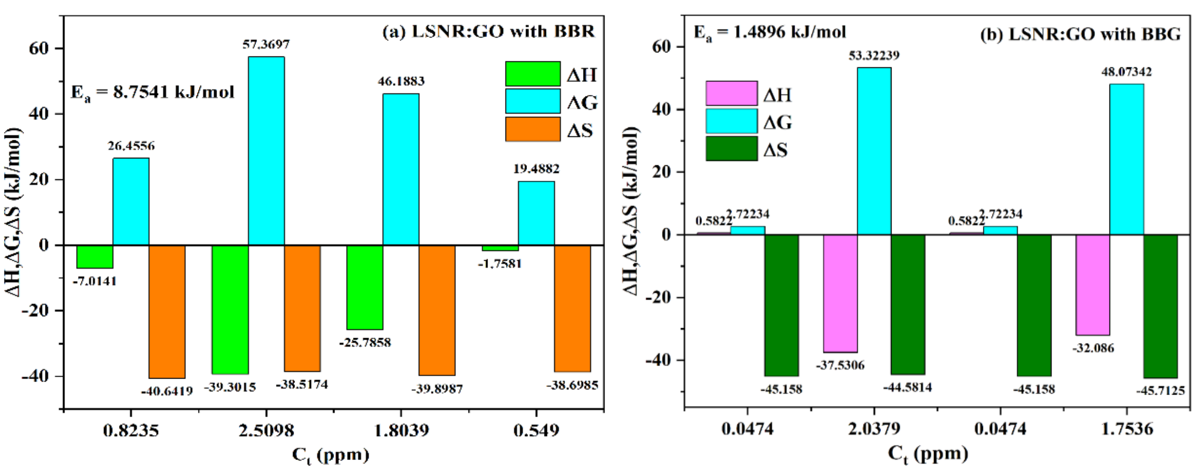
Figs. **(SI-2.5).** The relation between Gibbs free energy, enthalpy, and entropy of BBR with LSNR.

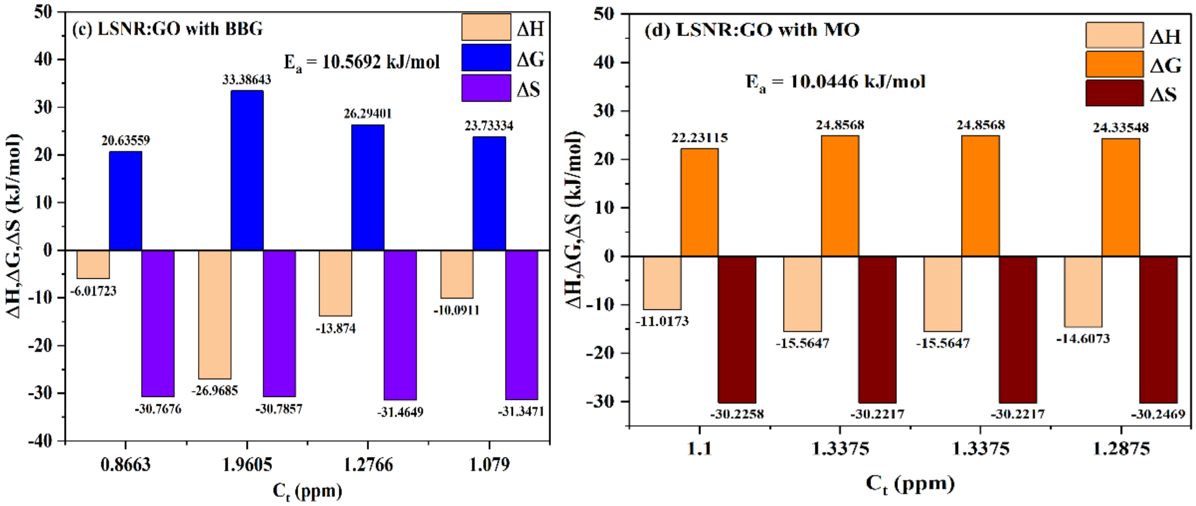


Figs. **(SI-2.6).** The relation between Gibbs free energy, enthalpy, and entropy of MB with LSNR.

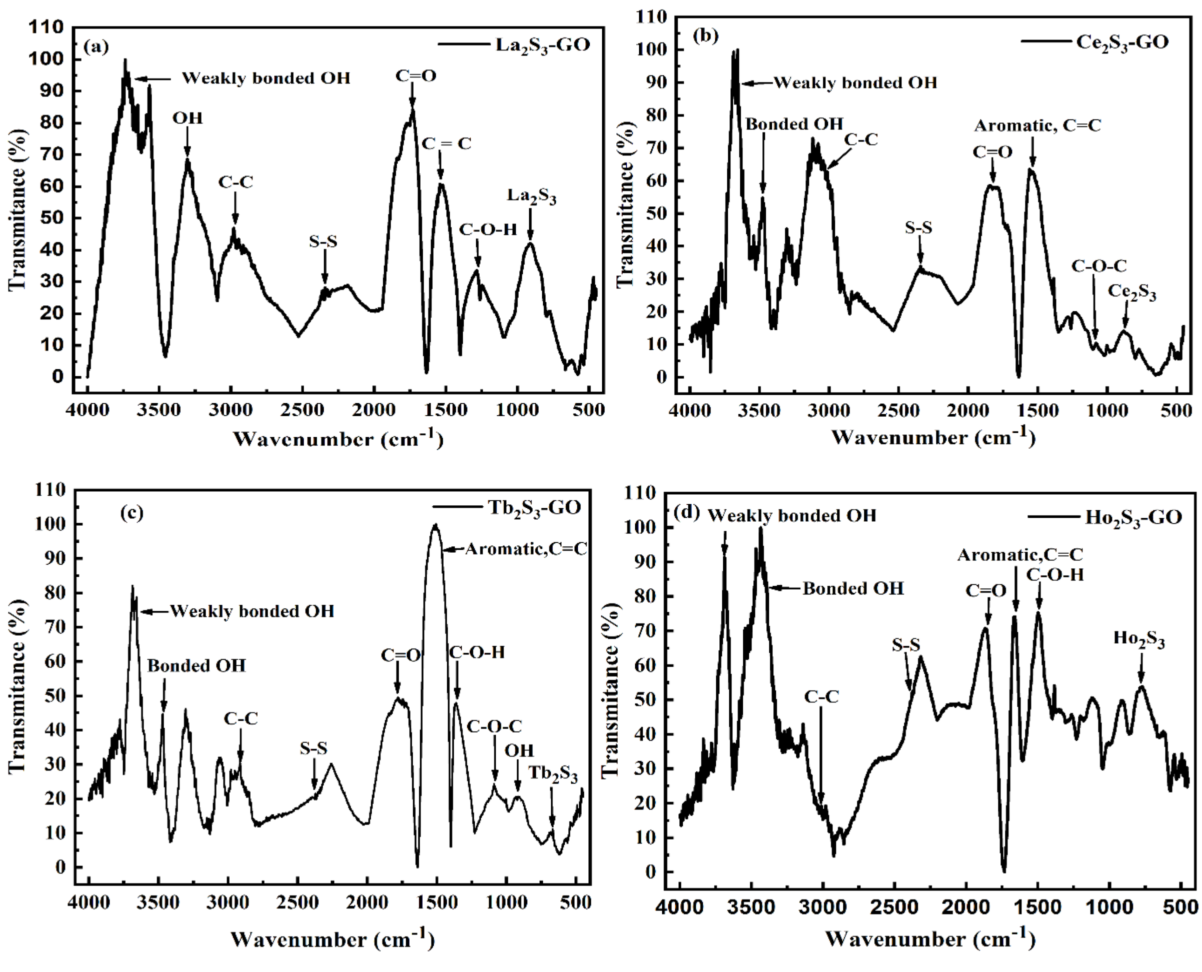


Figs. **(SI-2.7).** The relation between Gibbs free energy, enthalpy, and entropy of MO with LSNR.

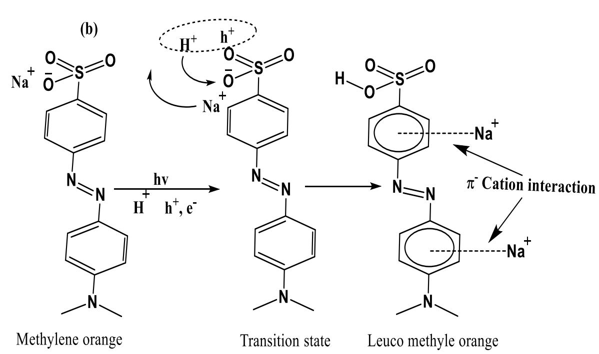


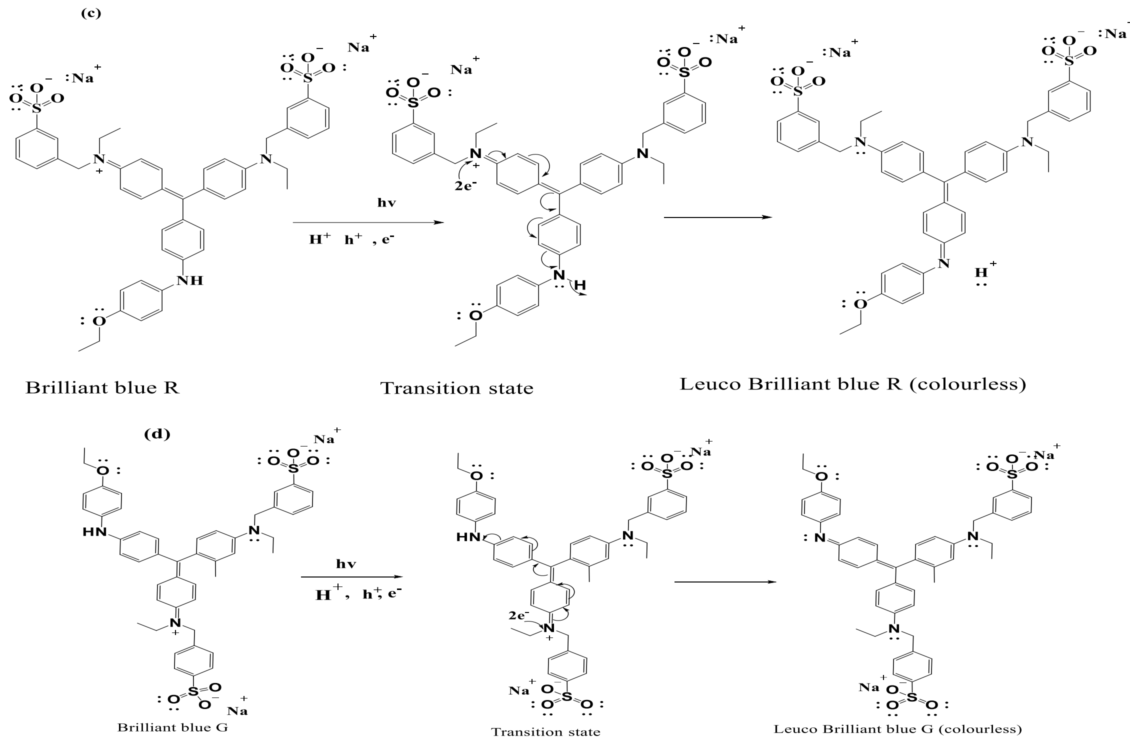


Figs. (SI-2.8). The thermodynamic parameters (ΔH, ΔG and ΔS) of aq-LGT with (a) BBR (b) BBG (c) MB (d) MO under PCR process.

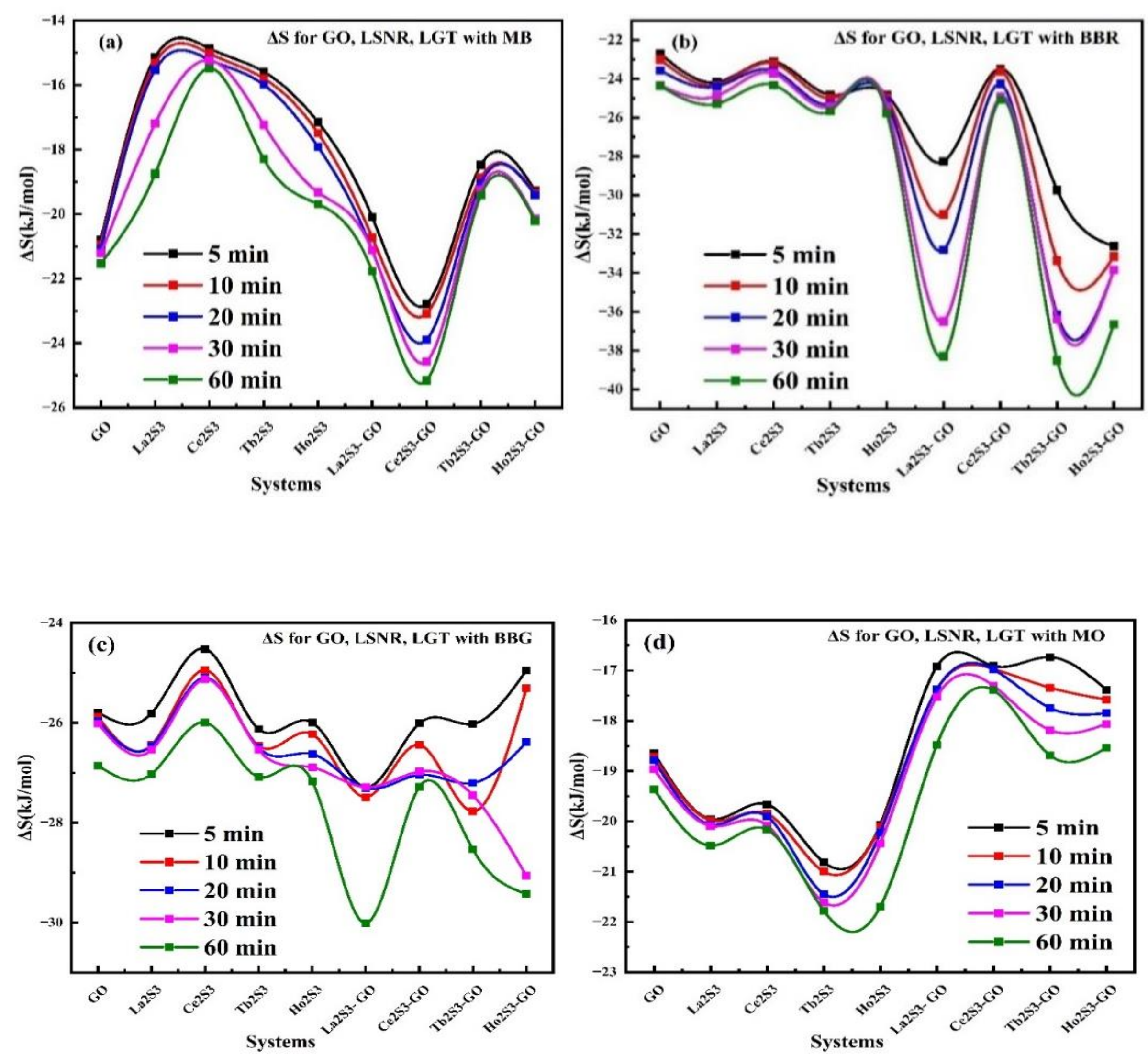


Figs. (SI-2.9). FT-IR analysis of $\boldsymbol{LSNR}$: $\boldsymbol{GO}$.

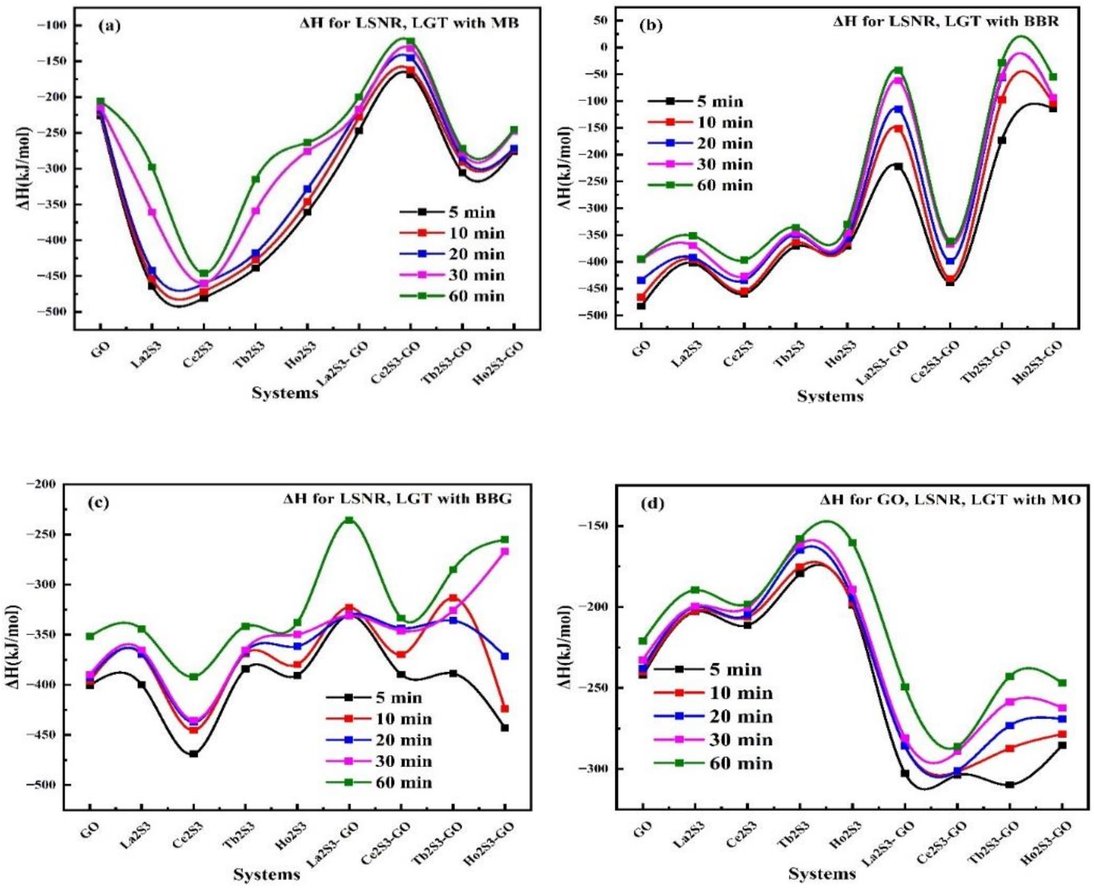




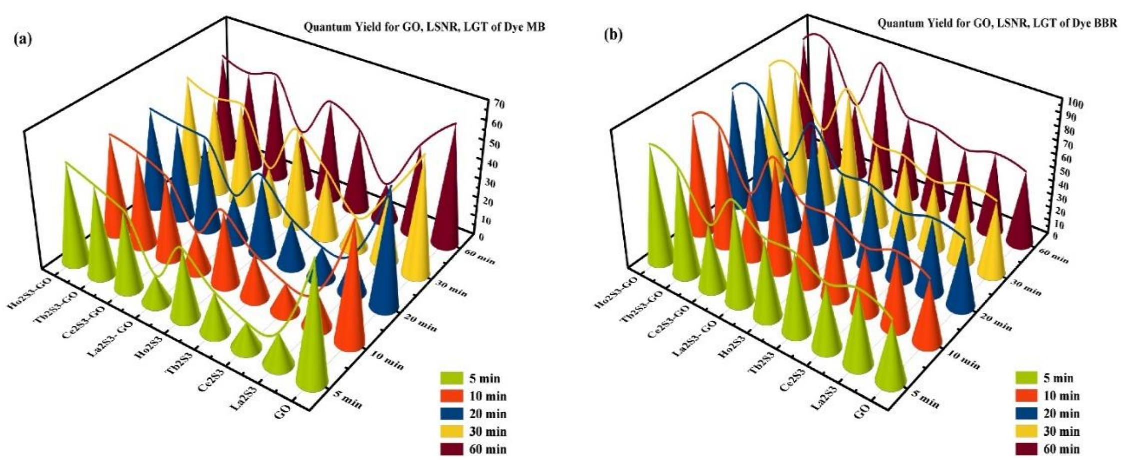
Figs. (SI-3.0). PCR and SCR mechanism of (b) MO (c) BBR (d) BBG by LGT.

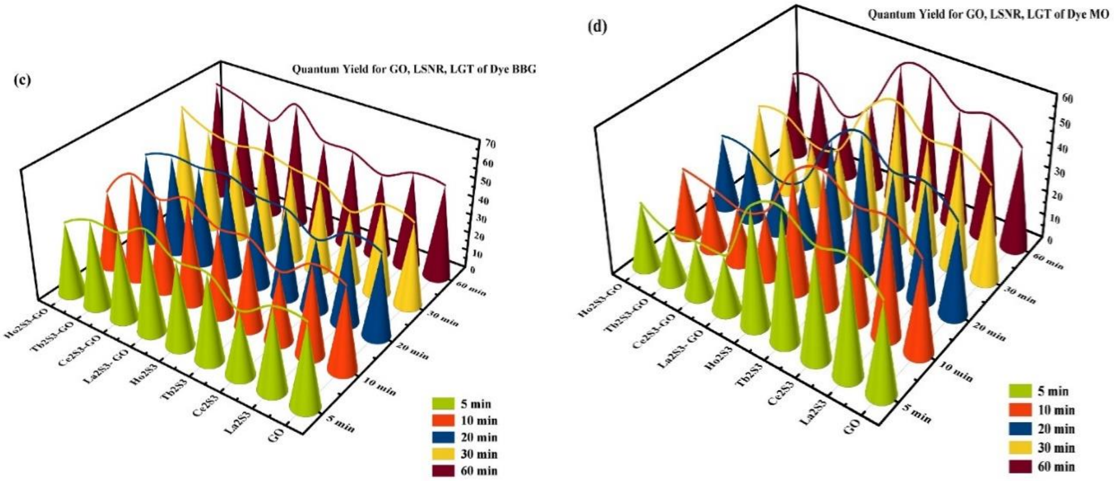


Figs. (SI-3.1). Time dependent, ΔS for GO, LSNR and LGT with (a) BBR (b) BBG (c) MO.

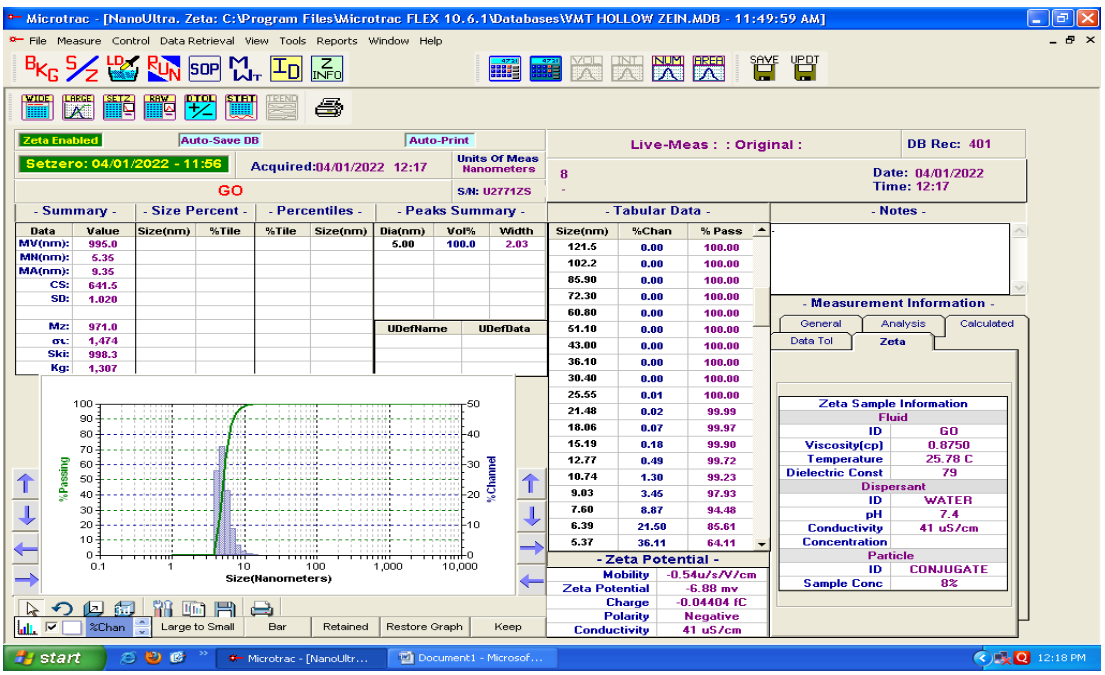


Figs. (SI-3.2). Time dependent ΔH for GO, $LSNR$ and LGT under SCR.





Figs. (SI-3.3). The Φ (%) of MB, BBR, BBG and MO under SCR with the @time.



10.6.1
Zetatrac

La2S3

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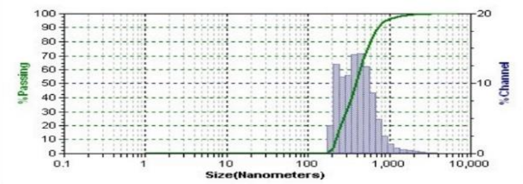
Data Acquired: 04/01/2022 - 13:09
Calculated: 04/01/2022 - 13:09



Summary

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MN(nm):	464.0
MA(nm):	1,386
CS:	4.33
SD:	190.6
PDI:	0.425
Mz:	2,724
σi:	1,920
Ski:	248.4
Kg:	705.2

Percentiles

%Tile	Size(nm)

Size Percent

Size(nm)	%Tile

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.02	100.00	18.06	0.00	0.00
5500	0.03	99.98	15.19	0.00	0.00
4620	0.05	99.95	12.77	0.00	0.00
3890	0.08	99.90	10.74	0.00	0.00
3270	0.13	99.82	9.03	0.00	0.00
2750	0.20	99.69	7.60	0.00	0.00
2312	0.32	99.49	6.39	0.00	0.00
1944	0.45	99.17	5.37	0.00	0.00
1635	0.58	98.72	4.52	0.00	0.00
1375	0.80	98.14	3.80	0.00	0.00
1156	1.32	97.34	3.19	0.00	0.00
972.0	2.55	96.02	2.690	0.00	0.00
818.0	4.91	93.47	2.260	0.00	0.00
687.0	8.63	88.56	1.900	0.00	0.00
578.0	12.43	79.93	1.600	0.00	0.00
486.0	14.30	67.50	1.340	0.00	0.00
409.0	14.14	53.20	1.130	0.00	0.00
344.0	11.22	39.06	0.950	0.00	0.00
289.0	10.97	27.84			
243.0	12.82	16.87			
204.4	4.05	4.05			
171.9	0.00	0.00			
144.5	0.00	0.00			
121.5	0.00	0.00			
102.2	0.00	0.00			
85.90	0.00	0.00			
72.30	0.00	0.00			
60.80	0.00	0.00			
51.10	0.00	0.00			
43.00	0.00	0.00			
36.10	0.00	0.00			
30.40	0.00	0.00			
25.55	0.00	0.00			
21.48	0.00	0.00			

Peaks

Dia(nm)	Vol%	Width
457.0	74.8	344.00
230.3	25.2	54.90

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SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	221
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.0265
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00061
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.8230
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	103.425%	Cell Temp(C):	28.54
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	415	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

La2S3 GO

10
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10.6.1

04/01/2022 14:48
DB Rec: 431

Zetatrac
U2771ZS

Summary

Data	Value
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MN(nm):	334.0
MA(nm):	719.0
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SD:	79.40
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Mz:	1,955
σi:	1,748
Ski:	655.6
Kg:	551.3

Size %

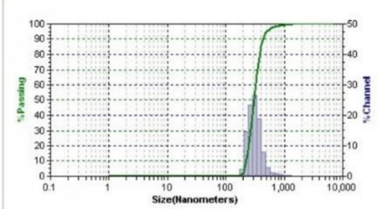
Size(nm)	%Tile

%Tile

%Tile	Size(nm)

Peak Summary

Dia(nm)	Vol%	Width
307.0	100.0	158.70



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Warnings: NONE

SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	206
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.102
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Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7740
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	83.443%	Cell Temp(C):	31.43
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	431	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	0.00	0.00
5500	0.01	100.00	15.19	0.00	0.00
4620	0.02	99.99	12.77	0.00	0.00
3890	0.01	99.97	10.74	0.00	0.00
3270	0.01	99.96	9.03	0.00	0.00
2750	0.02	99.95	7.60	0.00	0.00
2312	0.03	99.93	6.39	0.00	0.00
1944	0.03	99.90	5.37	0.00	0.00
1635	0.05	99.87	4.52	0.00	0.00
1375	0.15	99.82	3.80	0.00	0.00
1156	0.32	99.67	3.19	0.00	0.00
972.0	0.51	99.35	2.690	0.00	0.00
818.0	0.74	98.84	2.260	0.00	0.00
687.0	1.23	98.10	1.900	0.00	0.00
578.0	2.81	96.87	1.600	0.00	0.00
486.0	8.09	94.06	1.340	0.00	0.00
409.0	18.99	85.97	1.130	0.00	0.00
344.0	26.56	66.98	0.950	0.00	0.00
289.0	23.38	40.42			
243.0	14.71	17.04			
204.4	2.33	2.33			
171.9	0.00	0.00			
144.5	0.00	0.00			
121.5	0.00	0.00			
102.2	0.00	0.00			
85.90	0.00	0.00			
72.30	0.00	0.00			
60.80	0.00	0.00			
51.10	0.00	0.00			
43.00	0.00	0.00			
36.10	0.00	0.00			
30.40	0.00	0.00			
25.55	0.00	0.00			
21.48	0.00	0.00			

10.6.1

Zetatrac

Ce2S3

10

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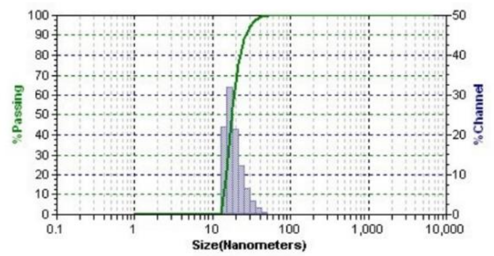
Data Acquired: 04/01/2022 - 13:38

Calculated: 04/01/2022 - 13:38



Summary

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PDI:	1.002
Mz:	1,985
σi:	1,141
Ski:	313.9
Kg:	1,249

Percentiles

%Tile	Size(nm)

Size Percent

Size(nm)	%Tile

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
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5500	0.00	100.00	15.19	21.92	21.92
4620	0.00	100.00	12.77	0.00	0.00
3890	0.00	100.00	10.74	0.00	0.00
3270	0.00	100.00	9.03	0.00	0.00
2750	0.00	100.00	7.60	0.00	0.00
2312	0.00	100.00	6.39	0.00	0.00
1944	0.00	100.00	5.37	0.00	0.00
1635	0.00	100.00	4.52	0.00	0.00
1375	0.00	100.00	3.80	0.00	0.00
1156	0.00	100.00	3.19	0.00	0.00
972.0	0.00	100.00	2.690	0.00	0.00
818.0	0.00	100.00	2.260	0.00	0.00
687.0	0.00	100.00	1.900	0.00	0.00
578.0	0.01	100.00	1.600	0.00	0.00
486.0	0.01	99.99	1.340	0.00	0.00
409.0	0.01	99.98	1.130	0.00	0.00
344.0	0.01	99.97	0.950	0.00	0.00
289.0	0.01	99.96			
243.0	0.00	99.95			
204.4	0.00	99.95			
171.9	0.00	99.95			
144.5	0.00	99.95			
121.5	0.00	99.95			
102.2	0.00	99.95			
85.90	0.00	99.95			
72.30	0.00	99.95			
60.80	0.00	99.95			
51.10	0.53	99.95			
43.00	1.64	99.42			
36.10	3.39	97.78			
30.40	6.53	94.39			
25.55	12.40	87.86			
21.48	21.46	75.46			

Peaks

Dia(nm)	Vol%	Width
17.66	100.0	9.28

-

SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	214
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.255
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00119
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.8070
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	98.943%	Cell Temp(C):	29.45
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	419	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Ce2S3 GO

10.6.1

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04/01/2022 15:17

DB Rec: 435

Zetatrac

U2771ZS

Summary

Data	Value
MV(nm):	819.0
MN(nm):	192.1
MA(nm):	344.0
CS:	17.43
SD:	101.4
PDI:	0.1754
Mz:	488.2
σi:	737.5
Ski:	760.8
Kg:	8,456

Size %

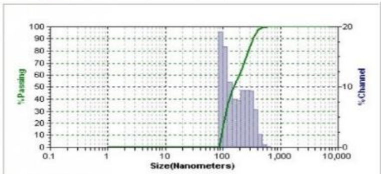
Size(nm)	%Tile

%Tile

%Tile	Size(nm)

Peak Summary

Dia(nm)	Vol%	Width
263.7	47.2	161.10
109.3	52.8	44.40



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Warnings: NONE

SOP Name: **BSA(*)**

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	184
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.201
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00686
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7660
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	18.091%	Cell Temp(C):	31.93
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	435	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	0.00	0.00
5500	0.00	100.00	15.19	0.00	0.00
4620	0.00	100.00	12.77	0.00	0.00
3890	0.00	100.00	10.74	0.00	0.00
3270	0.00	100.00	9.03	0.00	0.00
2750	0.00	100.00	7.60	0.00	0.00
2312	0.00	100.00	6.39	0.00	0.00
1944	0.00	100.00	5.37	0.00	0.00
1635	0.00	100.00	4.52	0.00	0.00
1375	0.01	100.00	3.80	0.00	0.00
1156	0.02	99.99	3.19	0.00	0.00
972.0	0.04	99.97	2.690	0.00	0.00
818.0	0.05	99.93	2.260	0.00	0.00
687.0	0.10	99.88	1.900	0.00	0.00
578.0	0.47	99.78	1.600	0.00	0.00
486.0	2.20	99.31	1.340	0.00	0.00
409.0	6.30	97.11	1.130	0.00	0.00
344.0	9.34	90.81	0.950	0.00	0.00
289.0	9.54	81.47			
243.0	9.46	71.93			
204.4	7.76	62.47			
171.9	7.96	54.71			
144.5	10.87	46.75			
121.5	16.64	35.88			
102.2	19.24	19.24			
85.90	0.00	0.00			
72.30	0.00	0.00			
60.80	0.00	0.00			
51.10	0.00	0.00			
43.00	0.00	0.00			
36.10	0.00	0.00			
30.40	0.00	0.00			
25.55	0.00	0.00			
21.48	0.00	0.00			

10.6.1
Zetatrac

Tb2S3

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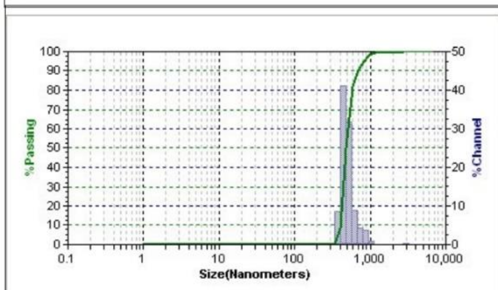
Data Acquired: 04/01/2022 - 14:02
Calculated: 04/01/2022 - 14:02



Summary

Data	Value
MV(nm):	1,879
MN(nm):	532.0
MA(nm):	927.0
CS:	6.47
SD:	84.70
PDI:	0.619
Mz:	1,677
σi:	1,384
Ski:	731.9
Kg:	639.0

Percentiles

%Tile	Size(nm)

Size Percent

Size(nm)	%Tile

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	0.00	0.00
5500	0.01	100.00	15.19	0.00	0.00
4620	0.03	99.99	12.77	0.00	0.00
3890	0.06	99.96	10.74	0.00	0.00
3270	0.18	99.90	9.03	0.00	0.00
2750	0.11	99.72	7.60	0.00	0.00
2312	0.01	99.61	6.39	0.00	0.00
1944	0.00	99.60	5.37	0.00	0.00
1635	0.00	99.60	4.52	0.00	0.00
1375	0.11	99.60	3.80	0.00	0.00
1156	0.97	99.49	3.19	0.00	0.00
972.0	3.79	98.52	2.690	0.00	0.00
818.0	4.23	94.73	2.260	0.00	0.00
687.0	8.86	90.50	1.900	0.00	0.00
578.0	31.81	81.64	1.600	0.00	0.00
486.0	41.20	49.83	1.340	0.00	0.00
409.0	8.63	8.63	1.130	0.00	0.00
344.0	0.00	0.00	0.950	0.00	0.00
289.0	0.00	0.00			
243.0	0.00	0.00			
204.4	0.00	0.00			
171.9	0.00	0.00			
144.5	0.00	0.00			
121.5	0.00	0.00			
102.2	0.00	0.00			
85.90	0.00	0.00			
72.30	0.00	0.00			
60.80	0.00	0.00			
51.10	0.00	0.00			
43.00	0.00	0.00			
36.10	0.00	0.00			
30.40	0.00	0.00			
25.55	0.00	0.00			
21.48	0.00	0.00			

Peaks

Dia(nm)	Vol%	Width
486.0	100.0	169.30

-

SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	212
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.179
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00228
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7930
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	69.935%	Cell Temp(C):	30.28
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	423	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Tb2S3 GO

10.6.1

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04/01/2022 15:48
DB Rec: 443

Zetatrac
U2771ZS

Summary

Data	Value
MV(nm):	809.0
MN(nm):	25.41
MA(nm):	88.40
CS:	67.91
SD:	4.93
PDI:	1.207
Mz:	377.0
σi:	850.9
Ski:	571.5
Kg:	3,506

Size %

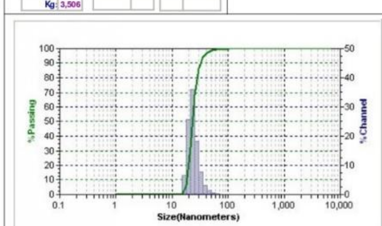
Size(nm)	%Tile

%Tile

%Tile	Size(nm)

Peak Summary

Dia(nm)	Vol%	Width
23.36	100.0	9.86



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Warnings: NONE

SOP Name: **BSA(*)**

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	206
Progression:	Standard	Runs:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.212
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00264
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7550
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	54.301%	Cell Temp(C):	32.62
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	443	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	6.47	6.47
5500	0.00	100.00	15.19	0.00	0.00
4620	0.00	100.00	12.77	0.00	0.00
3890	0.00	100.00	10.74	0.00	0.00
3270	0.00	100.00	9.03	0.00	0.00
2750	0.00	100.00	7.60	0.00	0.00
2312	0.00	100.00	6.39	0.00	0.00
1944	0.00	100.00	5.37	0.00	0.00
1635	0.00	100.00	4.52	0.00	0.00
1375	0.00	100.00	3.80	0.00	0.00
1156	0.00	100.00	3.19	0.00	0.00
972.0	0.00	100.00	2.690	0.00	0.00
818.0	0.00	100.00	2.260	0.00	0.00
687.0	0.00	100.00	1.900	0.00	0.00
578.0	0.00	100.00	1.600	0.00	0.00
486.0	0.01	100.00	1.340	0.00	0.00
409.0	0.01	99.99	1.130	0.00	0.00
344.0	0.01	99.98	0.950	0.00	0.00
289.0	0.02	99.97			
243.0	0.03	99.95			
204.4	0.04	99.92			
171.9	0.05	99.88			
144.5	0.05	99.83			
121.5	0.04	99.78			
102.2	0.05	99.74			
85.90	0.11	99.69			
72.30	0.25	99.58			
60.80	0.58	99.33			
51.10	1.36	98.75			
43.00	3.24	97.39			
36.10	7.74	94.15			
30.40	18.42	86.41			
25.55	35.93	67.99			
21.48	25.59	32.06			

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Zetatrac

Ho2S3

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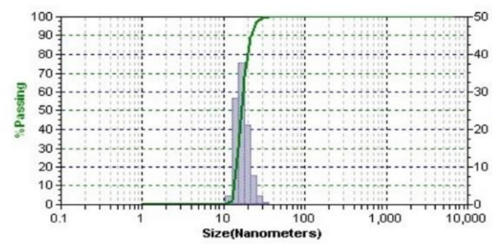
Data Acquired: 04/01/2022 - 14:24

Calculated: 04/01/2022 - 14:24



Summary

Data	Value
MV(nm):	1,152
MN(nm):	17.37
MA(nm):	28.45
CS:	210.9
SD:	3.09
PDI:	5.35
Mz:	1,252
σι:	1,719
Ski:	996.7
Kg:	955.6

Percentiles

%Tile	Size(nm)

Size Percent

Size(nm)	%Tile

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	37.64	68.12
5500	0.00	100.00	15.19	28.20	30.48
4620	0.00	100.00	12.77	2.28	2.28
3890	0.00	100.00	10.74	0.00	0.00
3270	0.00	100.00	9.03	0.00	0.00
2750	0.00	100.00	7.60	0.00	0.00
2312	0.00	100.00	6.39	0.00	0.00
1944	0.00	100.00	5.37	0.00	0.00
1635	0.00	100.00	4.52	0.00	0.00
1375	0.00	100.00	3.80	0.00	0.00
1156	0.00	100.00	3.19	0.00	0.00
972.0	0.00	100.00	2.690	0.00	0.00
818.0	0.00	100.00	2.260	0.00	0.00
687.0	0.00	100.00	1.900	0.00	0.00
578.0	0.00	100.00	1.600	0.00	0.00
486.0	0.00	100.00	1.340	0.00	0.00
409.0	0.00	100.00	1.130	0.00	0.00
344.0	0.00	100.00	0.950	0.00	0.00
289.0	0.00	100.00			
243.0	0.00	100.00			
204.4	0.00	100.00			
171.9	0.00	100.00			
144.5	0.00	100.00			
121.5	0.00	100.00			
102.2	0.00	100.00			
85.90	0.00	100.00			
72.30	0.00	100.00			
60.80	0.00	100.00			
51.10	0.02	100.00			
43.00	0.14	99.98			
36.10	0.58	99.84			
30.40	2.29	99.26			
25.55	7.80	96.97			
21.48	21.05	89.17			

Peaks

Dia(nm)	Vol%	Width
16.57	100.0	6.18

-

SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	204
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.0648
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.061
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7830
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	100.244%	Cell Temp(C):	30.84
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	427	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Ho2S3 GO

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10.6.1

04/01/2022 16:07

DB Rec: 447

Zetatrac

U2771ZS

Summary

Data	Value
MV(nm):	1,855
MN(nm):	205.5
MA(nm):	452.0
CS:	13.29
SD:	89.70
PDI:	1.369
Mz:	1,862
σι:	1,963
Ski:	900.5
Kg:	578.0

Size %

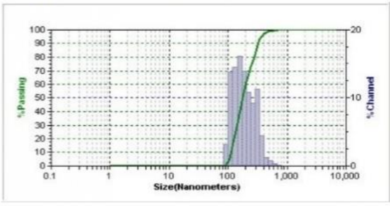
Size(nm)	%Tile

%Tile

%Tile	Size(nm)

Peak Summary

Dia(nm)	Vol%	Width
325.0	20.9	98.00
157.7	79.1	104.30



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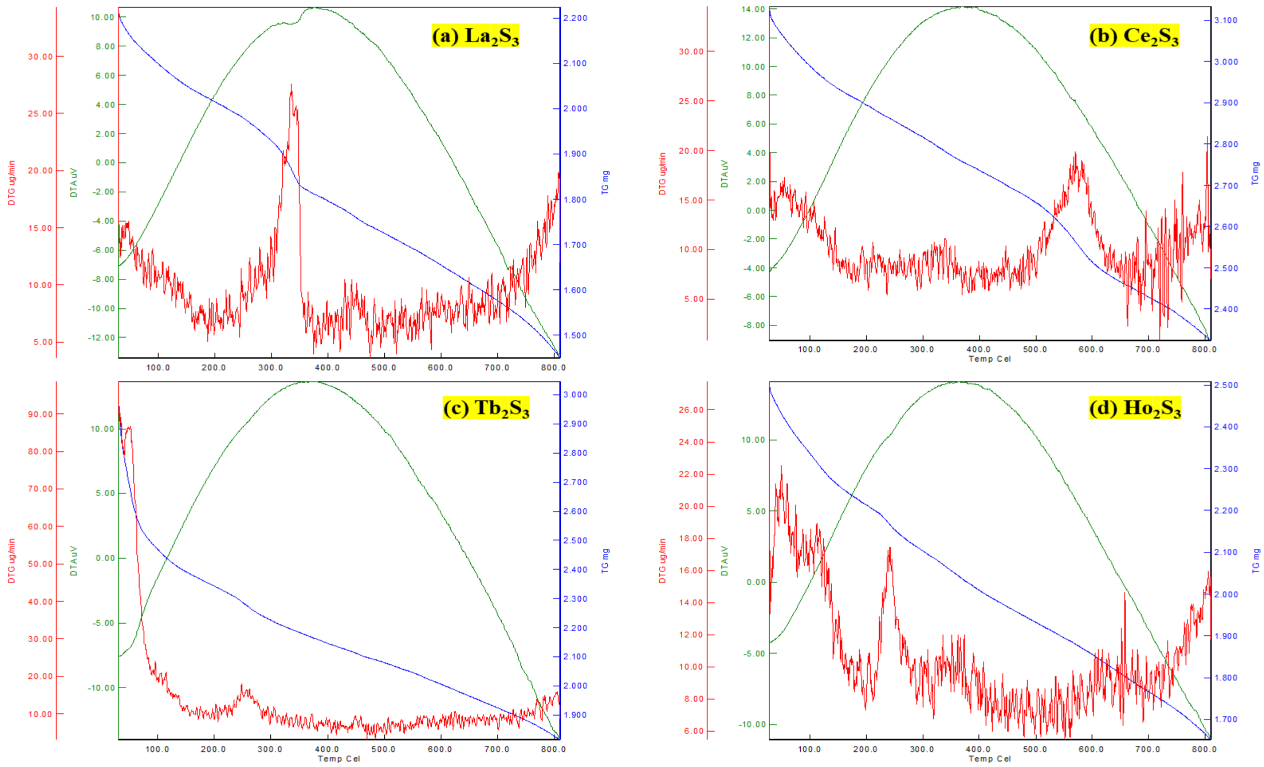
Warnings: NONE

SOP Name: BSA(*)

Distribution:	Number	Run Time:	60 Sec	Fluid:	CURRENT CARRIER	Reflected Pwr(mv):	209
Progression:	Standard	Run#:	Avg of 3	Fluid Ref Index:	1.333	Loading Index:	0.0913
Up Edge(nm):	6540	Particle:	CURRENT PARTICLE	Above Residual:	0	Conc. Index:	0.00144
Low Edge(nm):	0.8	Transparency:	Transparent	Below Residual:	0	Viscosity(cp):	0.7510
Residuals:	Disabled	Part. Ref. Index:	1.59	RMS Residual:	88.657%	Cell Temp(C):	32.88
#Channels:	52	Particle Shape:	Irregular				
Analysis:	UPA	Density:	1.05 g/cc	Multi Run Delay:	0 Min.	Nanotrac Type:	Nano. Zeta
Filter:Resolution:	Std:Norm	DB Record:	447	Recalc Status:	Original	Serial Number:	U2771ZS
Sensitivity:	Standard	Database:	C:\Program Files\Microtrac FLEX 10.6.1\Databases\VMT HOLLOW ZEIN.MDB				

Size(nm)	%Chan	% Pass	Size(nm)	%Chan	% Pass
6540	0.00	100.00	18.06	0.00	0.00
5500	0.00	100.00	15.19	0.00	0.00
4620	0.00	100.00	12.77	0.00	0.00
3890	0.00	100.00	10.74	0.00	0.00
3270	0.00	100.00	9.03	0.00	0.00
2750	0.00	100.00	7.60	0.00	0.00
2312	0.00	100.00	6.39	0.00	0.00
1944	0.00	100.00	5.37	0.00	0.00
1635	0.00	100.00	4.52	0.00	0.00
1375	0.00	100.00	3.80	0.00	0.00
1156	0.01	100.00	3.19	0.00	0.00
972.0	0.05	99.99	2.690	0.00	0.00
818.0	0.14	99.94	2.260	0.00	0.00
687.0	0.35	99.80	1.900	0.00	0.00
578.0	0.82	99.45	1.600	0.00	0.00
486.0	1.30	98.63	1.340	0.00	0.00
409.0	4.43	97.33	1.130	0.00	0.00
344.0	11.28	92.90	0.950	0.00	0.00
289.0	9.30	81.62			
243.0	10.81	72.32			
204.4	13.97	61.51			
171.9	16.09	47.54			
144.5	14.49	31.45			
121.5	13.81	16.96			
102.2	3.15	3.15			
85.90	0.00	0.00			
72.30	0.00	0.00			
60.80	0.00	0.00			
51.10	0.00	0.00			
43.00	0.00	0.00			
36.10	0.00	0.00			
30.40	0.00	0.00			
25.55	0.00	0.00			
21.48	0.00	0.00			

Figs. (SI-3.4). The detailed analysis of DLS GO, LSNR, and LGT.



Figs. (SI-3.5). Differential thermal analysis of LSNR.

2. Tables

Primary parameters for PCPs

Table (SI-1.1). The pendant drop, number (PDN) values of LSNR and LGT.

Temp.(K)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	La_2S_3: GO	Ce_2S_3: GO	Tb_2S_3: GO	Ho_2S_3: GO
283.15	145	150	145	146	145	149	147	142
288.15	132	136	134	134	135	137	136	134
298.15	127	126	126	125	126	126	126	126
310.15	158	145	142	139	134	137	134	132
315.15	183	163	157	153	143	150	144	140

Table (SI-1.2). The viscous flow time (VFT) values of LSNR and LGT.

Temp.(K)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	La_2S_3: GO	Ce_2S_3: GO	Tb_2S_3: GO	Ho_2S_3: GO
283.15	370	328	318	311	326	317	314	339
288.15	306	285	280	278	284	280	283	283
298.15	222	223	224	227	224	224	232	210
310.15	195	192	192	191	194	190	192	191
315.15	207	193	190	184	195	187	182	205

Unit: (Sec)

Table (SI-1.3). The sound velocity of LSNR and LGT.

Temp.(K)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	La_2S_3: GO	Ce_2S_3: GO	Tb_2S_3: GO	Ho_2S_3: GO
283.15	1448.75	1449.48	1449.80	1449.41	1449.46	1449.03	1449.17	1448.69
288.15	1466.56	1466.93	1467.12	1467.03	1466.88	1466.68	1466.82	1466.65
298.15	1496.80	1496.77	1496.79	1497.00	1496.95	1496.94	1496.97	1497.08
310.15	1523.65	1523.83	1523.74	1523.69	1524.65	1524.3	1524.15	1523.87
315.15	1531.79	1532.31	1532.12	1531.87	1533.49	1532.86	1532.54	1531.98

Unit: (m/s)

The thermodynamic parameters calculated by Mansingh survismeter for LSNR

Table (SI-1.4). ΔG, ΔH and ΔS for E_a =1.097J/mol of La_2S_3.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	1.0152	-5.42042	-35.505	0.10625
288.15	1.0475	-5.51725	-111.251	0.36694
298.15	0.8746	-5.70872	332.078	-1.13294
310.15	0.7095	-5.93849	885.146	-2.87308
315.15	0.6379	-6.03422	1178.233	-3.75779

η, viscosity $(mPa.S)$ ΔH, change in enthalpy (kJ/mol) ΔG, change in Gibbs free energy (kJ/mol) ΔS, change in entropy (kJ/mol).

Table (SI-1.5). ΔG, ΔH and ΔS for E_a =0.9765J/mol of Ce_2S_3.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.9035	-0.04408	-5.42054	238.9877
288.15	0.9736	-0.01161	-5.51725	64.04413
298.15	0.8787	-0.05615	-5.70872	320.5623
310.15	0.6986	-0.15578	-5.93849	925.1163
315.15	0.5930	-0.22694	-6.03422	1369.415

Table (SI-1.6). ΔG, ΔH and ΔS for E_a =0.9267J/mol of Tb_2S_3.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.8705	-0.060218	-5.420587	326.471557
288.15	0.9565	-0.019307	-5.517249	106.521421
298.15	0.8827	-0.054193	-5.708720	309.374898
310.15	0.6986	-0.155791	-5.938486	925.165645
315.15	0.5833	-0.234097	-6.034222	1412.594320

Table (SI-1.7). ΔG, ΔH and ΔS for E_a =0.9420J/mol of Ho_2S_3.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.8514	-0.069867	-5.42057	378.785678
288.15	0.9497	-0.022408	-5.51725	123.6283794
298.15	0.8945	-0.048400	-5.70872	276.3013315
310.15	0.6950	-0.158038	-5.93849	938.5061109
315.15	0.5650	-0.247989	-6.03422	1496.421535

Table (SI-1.8). ΔG, ΔH and ΔS for E_a = 0.9324J/mol of $La_2S_3: GO$.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.8946	-5.42058	262.364489	-0.945736
288.15	0.9704	-5.51725	71.907460	-0.268696
298.15	0.8825	-5.70872	309.767751	-1.058113
310.15	0.7058	-5.93849	898.556297	-2.916314
315.15	0.5990	-6.03422	1343.221806	-4.281314

η, viscosity $(mPa.S)$ ΔH, change in enthalpy (kJ/mol) ΔG, change in Gibbs free energy (kJ/mol) ΔS, change in entropy (kJ/mol).

Table (SI-1.9). ΔG, ΔH and ΔS for E_a = 0.9554J/mol of $Ce_2S_3: GO$.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.8680	-5.42056	333.4165	-1.19667
288.15	0.9565	-5.51725	106.4711	-0.38865
298.15	0.8827	-5.70872	309.4768	-1.05714
310.15	0.6913	-5.93849	952.1691	-3.08917
315.15	0.5748	-6.03422	1451.069	-4.62352

Table (SI-2.0). ΔG, ΔH and ΔS for E_a = 0.9879J/mol of $Tb_2S_3: GO$.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.8596	-5.420525	356.276174	-1.277403
288.15	0.9668	-5.517249	81.018933	-0.300316
298.15	0.9142	-5.708720	222.426400	-0.765169
310.15	0.6986	-5.938486	925.160453	-3.002092
315.15	0.5586	-6.034222	1526.173068	-4.861835

Table (SI-2.1). ΔG, ΔH and ΔS for E_a =0.9190 J/mol of $Ho_2S_3: GO$.

Temp.(K)	$\eta, (mPa.S)$	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
283.15	0.9281	-5.42059	175.6666907	-0.63955
288.15	0.9668	-5.51725	80.98536272	-0.3002
298.15	0.8275	-5.70872	469.4750327	-1.59377
310.15	0.6950	-5.93849	938.5528358	-3.04527
315.15	0.6301	-6.03422	1210.493555	-3.86015

The thermodynamic parameters calculated PCR of dyes with LSNR.

Table (SI-2.2). ΔG, ΔH and ΔS for $E_a = 2.2612$ J/mol of La2S3 for MB under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
24.3465046	0.204663	-463.905	-95.41	-15.1356
23.8145897	0.195069	-453.72	-88.95	-15.3172
23.2066869	0.183839	-442.081	-81.69	-15.5297
18.9513678	0.095866	-360.603	-34.79	-17.1923
15.668693	0.013259	-297.749	-3.978	-18.749

Table (SI-2.3). ΔG, ΔH and ΔS for $E_a = 1.8151$ J/mol of Ce2S3 for MB under SL.

Ct (ppm)	log (Absorbance)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
25.19757	0.219584526	-480.646	-105.941	-14.8707
24.72644	0.211387553	-471.626	-100.079	-15.0263
24.16413	0.201397124	-460.859	-93.1812	-15.2158
24.11854	0.200576927	-459.986	-92.6267	-15.2314
23.38906	0.18723862	-446.019	-83.8517	-15.4845

Table (SI-2.4). ΔG, ΔH and ΔS for $E_a = 2.2612$ J/mol of Tb2S3 for MB under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
23.03951	0.180699	-438.88	-79.7138	-15.5891
22.46201	0.169674	-427.822	-72.9741	-15.7977
21.94529	0.159567	-417.928	-67.0485	-15.9888
18.86018	0.093772	-358.857	-33.8627	-17.2318
16.56535	0.037426	-314.918	-11.8709	-18.294

Table (SI-2.5). ΔG, ΔH and ΔS for $E_a = 2.7322$ J/mol of Ho2S3 for MB under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
18.99696	0.09691	-361.005	-35.2498	-17.1478
18.22188	0.078819	-346.165	-27.4998	-17.488
17.29483	0.056142	-328.414	-18.5913	-17.9142
14.54407	-0.01909	-275.745	5.315595	-19.3248
13.90578	-0.03858	-263.524	10.27186	-19.6893

Table (SI-2.6). ΔG, ΔH and ΔS for $E_a = 2.2325$ J/mol of La2S3 for BBR under SL.

log (Abs)	Ct (ppm)	1/Ct	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
-0.26841	21.13725	0.04731	-402.486	108.6309	-24.1808
-0.27572	20.78431	0.048113	-395.728	109.7272	-24.3191
-0.27984	20.58824	0.048571	-391.973	110.3148	-24.3969
-0.30539	19.41176	0.051515	-369.447	113.5091	-24.8796
-0.32698	18.47059	0.05414	-351.426	115.6391	-25.287

Table (SI-2.7). ΔG, ΔH and ΔS for $E_a = 1.9683$ J/mol of Ce2S3 for BBR under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
24.11765	-0.21112	-459.816	97.4941	-23.108
23.84314	-0.2161	-454.56	98.65405	-23.2022
22.78431	-0.23582	-434.286	102.8792	-23.5761
22.39216	-0.24336	-426.778	104.3412	-23.719
20.82353	-0.27491	-396.743	109.6079	-24.3163

Table (SI-2.8). ΔG, ΔH and ΔS for $E_a = 2.3742$J/mol of Tb2S3 for BBR under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
19.4902	-0.30364	-370.807	113.3142	-24.8392
19.09804	-0.31247	-363.299	114.2622	-25.0058
18.39216	-0.32883	-349.783	115.7989	-25.3142
18.19608	-0.33348	-346.029	116.1861	-25.4019
17.64706	-0.34679	-335.517	117.1763	-25.6526

Table (SI-2.9). ΔG, ΔH and ΔS for $E_a = 2.3991$ J/mol of Ho2S3 for BBR under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
19.4902	-0.30364	-370.782	113.3142	-24.838
19.17647	-0.31069	-364.776	114.0779	-24.9709
18.7451	-0.32057	-356.516	115.0582	-25.1572
18.19608	-0.33348	-346.004	116.1861	-25.4005
17.37255	-0.3536	-330.236	117.6184	-25.7794

Table (SI-3.0). ΔG, ΔH and ΔS for $E_a = 2.2574$ J/mol of La2S3 for BBG under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
20.99526	-0.3536	-399.742	142.1454	-25.81
19.43128	-0.38722	-369.796	144.0651	-26.4451
19.38389	-0.38828	-368.889	144.1073	-26.4651
19.19431	-0.39254	-365.259	144.2667	-26.5456
18.10427	-0.41794	-344.388	144.8756	-27.0247

Table (SI-3.1). ΔG, ΔH and ΔS for $E_a = 1.9740$ J/mol of Ce2S3 for BBG under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
24.59716	-0.28483	-468.991	134.1463	-24.5206
23.36493	-0.30715	-445.398	137.4116	-24.9438
22.93839	-0.31515	-437.231	138.4174	-25.0954
22.8436	-0.31695	-435.416	138.632	-25.1295
20.56872	-0.36251	-391.858	142.7682	-25.9922

Table (SI-3.2). ΔG, ΔH and ΔS for $E_a = 2.3244$ J/mol of Tb2S3 for BBG under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
20.18957	-0.37059	-384.248	143.2601	-26.1278
19.38389	-0.38828	-368.822	144.1073	-26.4616
19.2891	-0.39041	-367.007	144.1889	-26.5018
19.19431	-0.39254	-365.192	144.2667	-26.5422
17.96209	-0.42136	-341.598	144.9155	-27.0856

Table (SI-3.3). ΔG, ΔH and ΔS for $E_a = 2.3072$ J/mol of Ho2S3 for BBG under SL.

Ct (ppm)	Log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
20.52133	-0.36351	-390.618	142.8329	-25.9949
19.95261	-0.37572	-379.728	143.5375	-26.2254
19.00474	-0.39686	-361.579	144.4104	-26.6244
18.38863	-0.41117	-349.782	144.7681	-26.8944
17.77251	-0.42597	-337.986	144.9541	-27.1734

Table (SI-3.4). ΔG, ΔH and ΔS for $E_a = 4.2200$ J/mol of La2S3 for MO under SL.

Ct (ppm)	Log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
10.825	-0.06248	-203.048	12.95053	-19.9537
10.7875	-0.06399	-202.33	13.21696	-19.9812
10.675	-0.06854	-200.176	14.00972	-20.0642
10.6375	-0.07007	-199.458	14.27179	-20.0921
10.125	-0.09151	-189.645	17.74153	-20.4826

Table (SI-3.5). ΔG, ΔH and ΔS for $E_a = 4.0477$ J/mol of Ce2S3 for MO under SL.

Ct (ppm)	Log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
11.25	-0.04576	-211.358	9.856408	-19.6635
10.9875	-0.05601	-206.332	11.78358	-19.8512
10.9125	-0.05899	-204.895	12.32467	-19.9056
10.675	-0.06854	-200.348	14.00972	-20.0804
10.5625	-0.07314	-198.194	14.79262	-20.1644

Table (SI-3.6). ΔG, ΔH and ΔS for $E_a = 4.8691$ J/mol of Tb2S3 for MO under SL.

Ct (ppm)	log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
9.625	-0.11351	-179.422	20.91877	-20.8146
9.4	-0.12378	-175.114	22.2787	-20.9992
8.875	-0.14874	-165.062	25.2758	-21.4465
8.6875	-0.15802	-161.472	26.28437	-21.6122
8.5	-0.16749	-157.882	27.25929	-21.7813

Table (SI-3.7). ΔG, ΔH and ΔS for $E_a = 4.6336$ J/mol of Ho2S3 for MO under SL.

Ct (ppm)	Log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
10.625	-0.07058	-198.805	14.3589	-20.0625
10.5625	-0.07314	-197.608	14.79262	-20.1089
10.4125	-0.07935	-194.736	15.82098	-20.2216
10.125	-0.09151	-189.231	17.74153	-20.4418
8.625	-0.16115	-160.51	26.61312	-21.6955

Table (SI-3.8). The ΔG, ΔH and ΔS for $E_a = 8.7541$ J/mol of $LSNR{:}\,GO$ for BBR under SL.

C_t (ppm)	Log(abs)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
0.8235	-1.67778	-7.0141	26.4556	-40.6419
2.5098	-1.19382	-39.3015	57.3697	-38.5174
1.8039	-1.33724	-25.7858	46.1883	-39.8987
0.5490	-1.85387	-1.7581	19.4882	-38.6985

Table (SI-3.9). The ΔG, ΔH and ΔS for E_a =1.4896 J/mol of $LSNR:GO$ for BBG under SL.

C_t (ppm)	Log(abs)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
0.0474	-3.0000	0.5822	2.722342	-45.1580
2.0379	-1.3665	-37.5306	53.32239	-44.5814
0.0474	-3.0000	0.5822	2.722342	-45.1580
1.7536	-1.4318	-32.0860	48.07342	-45.7125

Ct, degradation of concentration at time 't' ΔH, change in enthalpy (kJ/mol) ΔG, change in Gibbs free energy (kJ/mol) ΔS, change in entropy (kJ/mol).

Table (SI-4.0). The ΔG, ΔH and ΔS for E_a =10.0446 J/mol of $LSNR:GO$ for MO under SL.

C_t (ppm)	Log(abs)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
1.1000	-1.0555	-11.0173	22.23115	-30.2258
1.3375	-0.9706	-15.5647	24.8568	-30.2217
1.3375	-0.9706	-15.5647	24.8568	-30.2217
1.2875	-0.9872	-14.6073	24.33548	-30.2469

Table (SI-4.1). The ΔG, ΔH and ΔS for E_a =10.5692 J/mol of $LSNR:GO$ for MB under SL.

C_t (ppm)	Log(abs)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
0.8663	-1.2441	-6.01723	20.63559	-30.7676
1.9605	-0.8894	-26.9685	33.38643	-30.7857
1.2766	-1.0757	-13.874	26.29401	-31.4649
1.0790	-1.1487	-10.0911	23.73334	-31.3471

The thermodynamic parameters calculated by SCR for dyes with LGT

Table (SI-4.2). ΔG, ΔH and ΔS for $E_a = 0.538\ J$ of La_2S_3:GO with BBG dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.368	-5.17072	2478.453	-8.33012
10	301.15	0.359	-5.22816	2565.397	-8.53603
20	305.15	0.367	-5.30475	2543.548	-8.35278
30	308.15	0.368	-5.36219	2561.581	-8.33017
60	313.15	0.263	-5.45793	3477.903	-11.1236

UI, ultra-irradiation time (min) Abs, absorbance (a.u.) ΔH, change in enthalpy (kJ) ΔG, change in Gibbs free energy (kJ) ΔS, change in entropy (kJ)

Table (SI-4.3). ΔG, ΔH and ΔS for $E_a = 0.312\ J$ of Ce_2S_3:GO with BBG dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.432	-5.39672	2080.921	-6.99755
10	301.15	0.410	-5.45416	2232.751	-7.43219
20	305.15	0.381	-5.53075	2448.551	-8.04221
30	308.15	0.384	-5.58819	2452.526	-7.97700
60	313.15	0.370	-5.68393	2589.031	-8.28585

Table (SI-4.4). ΔG, ΔH and ΔS for $E_a = 0.478\ J$ of Tb_2S_3:GO with BBG dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.431	-5.23072	2086.667	-7.01626
10	301.15	0.348	-5.28816	2643.328	-8.79501
20	305.15	0.373	-5.36475	2502.398	-8.21813
30	308.15	0.362	-5.42219	2603.704	-8.46707
60	313.15	0.317	-5.51793	2991.613	-9.57091

Table (SI-4.5). ΔG, ΔH and ΔS for $E_a = 1.292\ J$ of Ho_2S_3:GO with BBG dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.491	-4.41672	1763.529	-5.92972
10	301.15	0.470	-4.47416	1890.737	-6.29325
20	305.15	0.412	-4.55075	2250.059	-7.38853
30	308.15	0.297	-4.60819	3110.838	-10.1102
60	313.15	0.284	-4.70393	3277.864	-10.4824

Table (SI-4.6). ΔG, ΔH and ΔS for $E_a = 3.1879\ J$ of La_2S_3:GO with BBR dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.307	-5.70553	2927.784	-9.83897
10	301.15	0.213	-5.76616	3872.672	-12.8788
20	305.15	0.165	-5.84275	4572.046	-15.0021
30	308.15	0.094	-5.90019	6058.743	-19.6808
60	313.15	0.068	-5.99593	7000.192	-22.3733

Table (SI-4.7). ΔG, ΔH and ΔS for $E_a = 0.4537\ J$ of Ce_2S_3:GO with BBR dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.587	-5.70827	3487.080	-11.71487
10	301.15	0.577	-5.76616	4853.018	-16.13410
20	305.15	0.534	-5.84275	6110.100	-20.04241
30	308.15	0.492	-5.90019	6286.664	-20.42046
60	313.15	0.484	-5.99593	7698.751	-24.60401

Table (SI-4.8). ΔG, ΔH and ΔS for $E_a = 3.0061\ J$ of Tb_2S_3:GO with BBR dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.245	-5.70571	3487.080	-11.71486
10	301.15	0.144	-5.76616	4853.018	-16.13410
20	305.15	0.09	-5.84275	6110.100	-20.04241
30	308.15	0.086	-5.90019	6286.664	-20.42046
60	313.15	0.052	-5.99593	7698.751	-24.60401

Table (SI-4.9). ΔG, ΔH and ΔS for $E_a = 1.1698\ J$ of Ho_2S_3:GO with BBR dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.165	-5.70755	4467.165	-15.0021
10	301.15	0.152	-5.76616	4717.622	-15.6845
20	305.15	0.137	-5.84275	5043.926	-16.5485
30	308.15	0.137	-5.90019	5093.514	-16.5485
60	313.15	0.086	-5.99593	6388.670	-20.4205

Table (SI-5.0). ΔG, ΔH and ΔS for $E_a = 0.3886\ J$ of La_2S_3:GO with MB dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.862	-5.70833	356.549	-1.21502
10	301.15	0.797	-5.76616	550.270	-1.84638
20	305.15	0.759	-5.84275	677.629	-2.23979
30	308.15	0.759	-5.90019	684.291	-2.23979
60	313.15	0.699	-5.99593	903.067	-2.90296

Table (SI-5.1). ΔG, ΔH and ΔS for $E_a = 0.6835\ J$ of Ce_2S_3:GO with MB dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.599	-5.70804	1270.608	-4.28079
10	301.15	0.576	-5.76616	1381.443	-4.60637
20	305.15	0.518	-5.84275	1669.100	-5.48892
30	308.15	0.474	-5.90019	1912.970	-6.22707
60	313.15	0.438	-5.99593	2149.695	-6.88389

Table (SI-5.2). ΔG, ΔH and ΔS for $E_a = 0.2297\ J$ of Tb2S3:GO with MB dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	1.06	-5.70849	-144.464	0.465389
10	301.15	1.009	-5.76616	-22.4371	0.055358
20	305.15	0.989	-5.84275	28.06687	-0.11112
30	308.15	0.965	-5.90019	91.29182	-0.3154
60	313.15	0.944	-5.99593	150.0661	-0.49836

Table (SI-5.3). ΔG, ΔH and ΔS for $E_a = 0.2738\ J$ of Ho_2S_3:GO with MB dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	0.959	-5.70845	103.792	-0.36727
10	301.15	0.95	-5.76616	128.449	-0.44568
20	305.15	0.943	-5.84275	148.922	-0.50718
30	308.15	0.861	-5.90019	383.494	-1.26365
60	313.15	0.854	-5.99593	410.974	-1.33153

Table (SI-5.4). ΔG, ΔH and ΔS for $E_a = 0.3331\ J$ of La_2S_3:GO with MO dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	1.277	-5.70839	-606.214	2.014106
10	301.15	1.207	-5.76616	-471.137	1.545314
20	305.15	1.207	-5.84275	-477.395	1.545314
30	308.15	1.186	-5.90019	-437.114	1.399363
60	313.15	1.054	-5.99593	-136.951	0.418185

Table (SI-5.6). ΔG, ΔH and ΔS for $E_a = 0.1340\ J$ of Ce_2S_3:GO with MO dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	1.281	-47.46217	-613.968	1.90007
10	301.15	1.272	-47.93987	-602.490	1.84144
20	305.15	1.270	-48.57663	-606.499	1.828355
30	308.15	1.220	-49.05419	-509.540	1.494355
60	313.15	1.207	-49.85014	-489.911	1.405271

Table (SI-5.7). ΔG, ΔH and ΔS for $E_a = 0.4882\ J$ of Tb_2S_3:GO with MO dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	1.307	-5.70823	-663.785	2.20720
10	301.15	1.213	-5.76616	-483.555	1.58655
20	305.15	1.154	-5.84275	-363.453	1.17192
30	308.15	1.093	-5.90019	-227.866	0.72032
60	313.15	1.027	-5.99593	-69.3755	0.20239

Table (SI-5.8). ΔG, ΔH and ΔS for $E_a = 0.8003\ J$ of Ho_2S_3:GO with MO dye under SCR.

UI, Time (min)	Temp.(K)	Abs (a.u.)	ΔH (kJ/mol)	ΔG (kJ/mol)	ΔS (J/mol)
5	298.15	1.205	-5.70792	-1229.505	4.10464
10	301.15	1.177	-5.76616	-408.109	1.33602
20	305.15	1.138	-5.84275	-328.025	1.05582
30	308.15	1.109	-5.90019	-265.105	0.84116
60	313.15	1.045	-5.99593	-114.620	0.34688

Table (SI-5.9). Friccohesity velocity of fluid dynamics of LSNR and LGT.

Temp.(K)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	$La_2S_3: GO$	$Ce_2S_3: GO$	$Tb_2S_3: GO$	$Ho_2S_3: GO$
283.15	65.144	71.068	75.830	73.483	73.970	74.027	75.936	64.692
288.15	67.067	70.042	72.357	72.877	70.809	70.772	70.537	71.590
298.15	84.052	87.780	81.165	80.733	81.165	81.165	78.366	86.576
310.15	82.424	91.217	93.148	95.657	97.692	101.257	100.202	100.724
315.15	81.801	98.820	104.217	110.429	111.486	110.830	118.620	203.994
283.15	65.144	71.068	75.830	73.483	73.970	74.027	75.936	64.692

Table (SI-6.0). Friccohesity velocity of fluid dynamics of LSNR and LGT with BSA.

Temp.(K)	La_2S_3 BSA	Ce_2S_3 BSA	Tb_2S_3 BSA	Ho_2S_3 BSA	$La_2S_3: GO$ BSA	$Ce_2S_3: GO$ BSA	$Tb_2S_3: GO$ BSA	$Ho_2S_3: GO$ BSA
283.15	77.190	81.65	83.299	86.322	85.179	84.200	81.625	81.964
288.15	70.270	71.34	72.128	73.716	73.192	73.192	70.839	71.039
298.15	75.754	74.98	74.316	74.774	74.862	76.093	74.774	74.107
310.15	97.396	100.21	99.514	98.952	108.268	108.128	108.743	106.975
315.15	120.683	127.31	128.792	126.538	133.625	130.178	130.315	128.782
283.15	77.190	81.65	83.299	86.322	85.179	84.200	81.625	81.964

Table (SI-6.1). Densities (g/cm³) of $LSNR$ and LGT.

Conc. (%)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	$La_2S_3: GO$	$Ce_2S_3: GO$	$Tb_2S_3: GO$	$Ho_2S_3: GO$
0.002	0.997049	0.997097	0.99712	0.997199	0.997191	0.997174	0.997163	0.997148
0.006	0.997152	0.997146	0.997145	0.997225	0.997206	0.997172	0.997197	0.997179
0.010	0.997196	0.997194	0.997232	0.997268	0.997226	0.997191	0.997211	0.997195

Table (SI-6.2). Densities (g/cm³) of $LSNR$ and LGT with BSA.

Conc. (%)	La_2S_3 BSA	Ce_2S_3 BSA	Tb_2S_3 BSA	Ho_2S_3 BSA	$La_2S_3: GO$ BSA	$Ce_2S_3: GO$ BSA	$Tb_2S_3: GO$ BSA	$Ho_2S_3: GO$ BSA
0.002	0.997217	0.997222	0.997211	0.997233	0.99718	0.997207	0.997192	0.997216
0.006	0.997267	0.997271	0.997229	0.997238	0.997244	0.997258	0.997263	0.997272
0.010	0.996887	0.997257	0.99721	0.99721	0.997188	0.997243	0.997146	0.997123

Table (SI-6.3). Viscosities (mPa.S) of $LSNRs$ and LGT.

Conc. (%)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	$La_2S_3: GO$	$Ce_2S_3: GO$	$Tb_2S_3: GO$	$Ho_2S_3: GO$
0.002	0.8865	0.8747	0.8826	0.8905	0.88659	0.8708	0.9023	0.8077
0.006	0.8826	0.8826	0.8826	0.9024	0.88266	0.8787	0.9063	0.8196
0.010	0.8748	0.8787	0.8827	0.8945	0.88268	0.8827	0.9142	0.8275

Table (SI-6.4). Viscosities (mPa.S) of $LSNR$ and LGT with BSA.

Conc. (%)	La_2S_3 BSA	Ce_2S_3 BSA	Tb_2S_3 BSA	Ho_2S_3 BSA	$La_2S_3: GO$ BSA	$Ce_2S_3: GO$ BSA	$Tb_2S_3: GO$ BSA	$Ho_2S_3: GO$ BSA
0.002	0.8748	0.8669	0.8866	0.8748	0.8629	0.8630	0.8590	0.8590
0.006	0.8670	0.8748	0.8906	0.8866	0.8827	0.8748	0.8748	0.8709
0.010	0.8824	0.8786	0.8865	0.8747	0.8866	0.8786	0.8746	0.8825

Table (SI-6.5). Surface tension (mN/m) of $LSNR$ and LGT.

Conc. (%)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	$La_2S_3: GO$	$Ce_2S_3: GO$	$Tb_2S_3: GO$	$Ho_2S_3: GO$
0.002	72.200	72.204	71.632	71.074	72.2106	71.6363	72.209	71.634
0.006	72.208	71.634	71.634	71.640	72.2117	71.6362	72.211	71.637
0.010	71.074	71.638	71.640	72.216	71.6401	71.6375	71.639	71.638

Table (SI-6.6). Surface tension (mN/m) of $LSNR$ and LGT with BSA.

Conc. (%)	La_2S_3 BSA	Ce_2S_3 BSA	Tb_2S_3 BSA	Ho_2S_3 BSA	$La_2S_3: GO$ BSA	$Ce_2S_3: GO$ BSA	$Tb_2S_3: GO$ BSA	$Ho_2S_3: GO$ BSA
0.002	0.8748	0.8669	0.8866	0.8748	0.8629	0.8630	0.8590	0.8590
0.006	0.8670	0.8748	0.8906	0.8866	0.8827	0.8748	0.8748	0.8709
0.010	0.8824	0.8786	0.8865	0.8747	0.8866	0.8786	0.8746	0.8825

Table (SI-6.7). Friccohesity (cm/S) of $LSNR$ and LGT.

Conc. (%)	La_2S_3 (10^{-4})	Ce_2S_3 (10^{-4})	Tb_2S_3 (10^{-4})	Ho_2S_3 (10^{-4})	$La_2S_3: GO$ (10^{-4})	$Ce_2S_3: GO$ (10^{-4})	$Tb_2S_3: GO$ (10^{-4})	$Ho_2S_3: GO$ (10^{-4})
0.002	123	121	123	125	123	122	125	113
0.006	122	123	123	126	122	123	125	114
0.010	123	123	123	124	123	123	128	115

Table (SI-6.8). Friccohesity (cm/S) of $LSNR$ and LGT with BSA.

Conc. (%)	BSA (10^{-4})	La_2S_3 (10^{-4})	Ce_2S_3 (10^{-4})	Tb_2S_3 (10^{-4})	Ho_2S_3 (10^{-4})	$La_2S_3: GO$ (10^{-4})	$Ce_2S_3: GO$ (10^{-4})	$Tb_2S_3: GO$ (10^{-4})	$Ho_2S_3: GO$ (10^{-4})
0.002	130	130	128	131	130	130	129	128	128
0.006	129	128	130	132	132	131	130	129	120
0.010	132	132	133	135	134	134	131	134	135

Table (SI-6.9). Isentropic compressibility of $LSNR$ and LGT.

Conc. (%)	La_2S_3 (10^{-7})	Ce_2S_3 (10^{-7})	Tb_2S_3 (10^{-7})	Ho_2S_3 (10^{-7})	$La_2S_3: GO$ (10^{-7})	$Ce_2S_3: GO$ (10^{-7})	$Tb_2S_3: GO$ (10^{-7})	$Ho_2S_3: GO$ (10^{-7})
0.002	4.4753	4.4757	4.4767	4.4769	4.4750	4.4754	4.4767	4.4752
0.006	4.4752	4.4756	4.4772	4.4750	4.4757	4.4669	4.4772	4.4750
0.010	4.4760	4.4762	4.4749	4.4745	4.4749	4.4752	4.4749	4.4747

Table (SI-7.0). Isentropic compressibility of $LSNR$ and LGT with BSA.

Conc. (%)	BSA (10^{-7})	La_2S_3 (10^{-7})	Ce_2S_3 (10^{-7})	Tb_2S_3 (10^{-7})	Ho_2S_3 (10^{-7})	$La_2S_3: GO$ (10^{-7})	$Ce_2S_3: GO$ (10^{-7})	$Tb_2S_3: GO$ (10^{-7})	$Ho_2S_3: GO$ (10^{-7})
0.002	4.4751	4.4747	4.4750	4.4749	4.4753	4.4748	4.4745	4.4745	4.4752
0.006	4.4748	4.4749	4.4740	4.4732	4.4732	4.4739	4.4743	4.4752	4.4746
0.010	4.4731	4.4639	4.4726	4.4731	4.4729	4.4711	4.4707	4.4699	4.4695

The thermodynamic parameters calculated by PCR for dyes with GO.

Table (SI-7.1). ΔG, ΔH and ΔS for $E_a = 3.8524$ J/mol of GO for MB under SL.

log (Abs)	Ct	ΔH	ΔG	ΔS
-0.10237	12.00607903	-226.03	23.53369924	-20.78641984
-0.1107	11.7781155	-221.665	24.96437563	-20.93961683
-0.11805	11.58054711	-217.882	26.17464124	-21.07470561
-0.1261	11.36778116	-213.808	27.44664378	-21.22267842
-0.14267	10.94224924	-205.66	29.89066814	-21.52675039

Table (SI-7.2). ΔG, ΔH and ΔS for $E_a = 1.9396$ J/mol of GO for BBR under SL.

log (Abs)	C_t (ppm)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
-0.18977	25.33333	-483.121	92.04879	-22.7041
-0.20551	24.43137	-465.851	96.13663	-23.0027
-0.23582	22.78431	-434.315	102.8792	-23.5774
-0.27572	20.78431	-396.021	109.7272	-24.3332
-0.27737	20.70588	-394.519	109.9641	-24.3642

Table (SI-7.3). ΔG, ΔH and ΔS for $E_a = 2.2478$ J/mol of GO for BBG under SL.

log (Abs)	C_t (ppm)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
-0.35262	21.04265	-400.659	142.0718	-25.7919
-0.35754	20.80569	-396.122	142.4312	-25.8849
-0.36151	20.61611	-392.492	142.7026	-25.96
-0.36452	20.47393	-389.77	142.8967	-26.0168
-0.40894	18.48341	-351.657	144.7241	-26.8555

Table (SI-7.4). ΔG, ΔH and ΔS for $E_a = 3.5977$ J/mol of GO for MO under SL.

Ct (ppm)	Log (Abs)	ΔH(kJ/mol)	ΔG(kJ/mol)	ΔS(kJ/mol)
12.8375	0.011570444	-242.2037354	-2.84403	-18.6454
12.725	0.007747778	-240.049682	-1.88773	-18.7161
12.6125	0.003891166	-237.8956285	-0.93969	-18.7874
12.3375	-0.005682847	-232.6301644	1.342447	-18.9643
11.7375	-0.027334408	-221.1418792	6.143123	-19.364

Table (SI-7.5). Isentropic compressibility of $LSNR$ and LGT.

Temp.(K)	La_2S_3 (10^{-7})	Ce_2S_3 (10^{-7})	Tb_2S_3 (10^{-7})	Ho_2S_3 (10^{-7})	$La_2S_3{:}\,GO$ (10^{-7})	$Ce_2S_3{:}\,GO$ (10^{-7})	$Tb_2S_3{:}\,GO$ (10^{-7})	$Ho_2S_3{:}\,GO$ (10^{-7})
283.15	4.7678	4.7596	4.7580	4.7604	4.7605	4.7621	4.7622	4.7648
288.15	4.6546	4.6503	4.6492	4.6497	4.6510	4.6519	4.6512	4.6522
298.15	4.4760	4.4762	4.4759	4.4745	4.4750	4.4752	4.4749	4.4743
310.15	4.3356	4.3346	4.3352	4.3353	4.3301	4.3320	4.3329	4.3343
315.15	4.2973	4.2931	4.2976	4.2986	4.2878	4.2882	4.2966	4.2935

Table (SI-7.6). Isentropic compressibility of $LSNR$ and LGT with BSA.

Temp.(K)	BSA (10^{-7})	La_2S_3 BSA(10^{-7})	Ce_2S_3 BSA(10^{-7})	Tb_2S_3 BSA(10^{-7})	Ho_2S_3 BSA(10^{-7})	$La_2S_3{:}\,GO$ BSA(10^{-7})	$Ce_2S_3{:}\,GO$ BSA(10^{-7})	$Tb_2S_3{:}\,GO$ BSA(10^{-7})	$Ho_2S_3{:}\,GO$ BSA(10^{-7})
283.15	4.7628	4.7437	4.7618	4.7578	4.7589	4.7602	4.7616	4.7574	4.7566
288.15	4.6376	4.6376	4.6506	4.6497	4.6499	4.6479	4.6487	4.6463	4.6461
298.15	4.4639	4.4639	4.4726	4.4731	4.4730	4.4712	4.4707	4.4700	4.4695
310.15	4.3155	4.3155	4.3277	4.3231	4.3243	4.3298	4.3317	4.3295	4.3257
315.15	4.2844	4.2680	4.2864	4.2750	4.2790	4.2896	4.2923	4.2904	4.2889

Table (SI-7.7). MB @SCR and Φ LGT under SCR.

$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$	
@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)
34.50	13.80	54.48	40	19.45	46.00	27.13	51.15
39.44	20.30	56.23	42	23.33	48.60	27.81	51.60
42.33	24.10	60.64	48	24.85	49.62	28.34	51.96
42.33	24.10	63.98	53	26.67	50.84	34.57	56.14
46.88	30.10	66.72	56	28.27	51.91	35.11	56.50

Table (SI-7.8). BBR @SCR and Φ under SCR.

$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$	
@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)
39.80	71.99	42.45	46.44	51.96	77.65	67.65	84.95
58.24	80.57	43.43	47.35	71.76	86.86	70.20	86.13
67.65	84.95	47.65	51.28	82.35	91.79	73.14	87.50
81.57	91.42	51.76	55.11	83.14	92.15	73.14	87.50
86.67	93.80	52.55	55.84	89.80	95.26	83.14	92.15

Table (SI-7.9). BBG $@SCR$ and Φ under SCR.

$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$		$La_2S_3: GO$	
@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)
56.40	54.00	48.82	46.00	48.93	46.13	41.82	38.63
57.46	55.13	51.42	48.75	58.77	56.50	44.31	41.25
56.52	54.13	54.86	52.38	55.81	53.38	51.18	48.50
56.40	54.00	54.50	52.00	57.11	54.75	64.81	62.88
68.84	67.13	56.16	53.75	62.44	60.38	66.35	64.50

Table (SI-8.0). MO @SCR and Φ under SCR.

$La_2S_3: GO$		$Ce_2S_3: GO$		$Tb_2S_3: GO$		$Ho_2S_3: GO$	
@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)	@SCR (%)	Φ (%)
20.19	22.23	19.94	21.99	18.31	20.40	24.69	26.61
24.56	26.49	20.50	22.53	24.19	26.13	26.44	28.32
24.56	26.49	20.63	22.66	27.88	29.72	28.88	30.69
25.88	27.77	23.75	25.70	31.69	33.43	30.69	32.46
34.13	35.81	24.56	26.49	35.81	37.45	34.69	36.36

Table (SI-8.1). Densities (g/cm3) of $LSNR$ and LGT.

Temp.(K)	La_2S_3	Ce_2S_3	Tb_2S_3	Ho_2S_3	$La_2S_3: GO$	$Ce_2S_3: GO$	$Tb_2S_3: GO$	$Ho_2S_3: GO$
283.15	0.999292	1.00000	0.999900	0.999940	0.999848	1.000100	0.999900	1.00000
288.15	0.998894	0.999305	0.999277	0.999306	0.999219	0.999298	0.999263	0.999277
298.15	0.997196	0.997194	0.997232	0.997268	0.997226	0.997191	0.997211	0.997195
310.15	0.993533	0.993517	0.993498	0.993547	0.993475	0.993499	0.993500	0.993529
315.15	0.991740	0.992064	0.99126	0.99136	0.991752	0.992484	0.99094	0.992384

Table (SI-8.2). Densities (g/cm3) of $LSNR$ and LGT with BSA.

Temp. (K)	BSA	La_2S_3 BSA	Ce_2S_3 BSA	Tb_2S_3 BSA	Ho_2S_3 BSA	$La_2S_3: GO$ BSA	$Ce_2S_3: GO$ BSA	$Tb_2S_3: GO$ BSA	$Ho_2S_3: GO$ BSA
283.15	0.999981	0.999500	0.999949	0.999928	0.999939	0.999200	0.99988	0.999802	0.999621
288.15	0.999328	0.998931	0.999301	0.999267	0.999275	0.999238	0.999295	0.999213	0.999197
298.15	0.997283	0.996887	0.997257	0.99721	0.997210	0.997188	0.997243	0.997146	0.997123
310.15	0.993432	0.992953	0.993461	0.993302	0.993357	0.991799	0.993089	0.993045	0.992637
315.15	0.991885	0.990156	0.991597	0.991992	0.991683	0.988960	0.991528	0.991066	0.989349

Table (SI-8.3). PCR data for reduction of methylene blue through $LSNR: GO$ under SL.

System	ΔAbs	ΔC (ppm)	m, (Kg, 10^{-5})	E_{used} (J/Kg) (10^{12})	n_a & n_e (10^{45})	Abs. Rate (%)	Φ (%)
$La_2S_3: GO$	1.843	28.01	2.801	2.5173	3.80	96	97
$Ce_2S_3: GO$	1.771	26.91	2.691	2.4190	3.65	90	93
$Tb_2S_3: GO$	1.816	27.60	2.760	2.4805	3.74	94	96
$Ho_2S_3: GO$	1.829	27.80	2.780	2.4982	3.77	95	96

ΔAbs, change in absorbance ΔC, change in concentration (ppm) m, mass of sample (Kg) $E_{used,}$ energy used during PCR (J/Kg) n_a & n_e , number of photons absorbed and emitted during PCR Ads. rate, rate of adsorption (%) Φ, Quantum yield (%).

Table (SI-8.4). PCR data for reduction of methylene orange through $LSNR: GO$ under SL.

System	ΔAbs	ΔC (ppm)	m, (Kg, 10^{-5})	E_{used} (J/Kg) (10^{12})	n_a & n_e (10^{45})	Abs. Rate (%)	Φ (%)
$La_2S_3: GO$	1.530	19.13	1.913	1.7189	2.59	95	95
$Ce_2S_3: GO$	1.511	18.89	1.889	1.6975	2.56	93	93
$Tb_2S_3: GO$	1.511	18.89	1.889	1.6975	2.56	93	93
$Ho_2S_3: GO$	1.515	18.94	1.894	1.7020	2.57	94	94

Table (SI-8.5). PCR data for reduction of brilliant blue-R through $LSNR: GO$ under SL.

System	ΔAbs	ΔC (ppm)	m, (Kg, 10^{-5})	E_{used} (J/Kg) (10^{12})	n_a & n_e (10^{45})	Abs. Rate (%)	Φ (%)
$La_2S_3: GO$	1.106	43.37	4.337	3.898	5.88	96	98
$Ce_2S_3: GO$	1.063	41.69	4.169	3.747	5.65	87	94
$Tb_2S_3: GO$	1.081	42.39	4.239	3.810	5.75	91	96
$Ho_2S_3: GO$	1.113	43.65	4.365	3.923	5.92	97	99

Table (SI-8.6). PCR data for reduction of brilliant blue-G through $LSNR: GO$ under SL.

System	ΔAbs	ΔC (ppm)	m, (Kg, 10^{-5})	E_{used} (J/Kg) (10^{12})	n_a & n_e (10^{45})	Abs. Rate (%)	Φ (%)
$La_2S_3: GO$	0.781	37.01	3.7014	3.3267	5.0206	100	100
$Ce_2S_3: GO$	0.738	34.98	3.4976	3.1435	4.7442	90	94
$Tb_2S_3: GO$	0.781	37.01	3.7014	3.3267	5.0206	100	100
$Ho_2S_3: GO$	0.744	35.26	3.5261	3.1691	4.7827	91	95

Table (SI-8.7). C, H, N, and S analysis of GO, and LGT.

EuroEA Elemental Analyser

AutoRun name : KK211122-KK21112022 (18)
Date of print : 21 Nov 2022
Time of print : 12:47:29

Balance Operator :
Operator :
Configuration : EVR
EVR
CHNS
Calibration Type :

Linear

Results Summary for Element %

#	Type	Name	N %	C %	H %	S %	O %	Weight (mg)
1	Std	Sulphanilamide	15.982	41.533	4.715	18.8	-	0.5900
2	Std	Sulphanilamide	16.402	42.179	4.677	18.499	-	0.7250
3	Std	Sulphanilamide	16.399	41.792	4.646	18.576	-	0.9170
4	Std	Sulphanilamide	16.327	41.905	4.698	18.602	-	1.1260
5	Std	Sulphanilamide	16.180	41.800	4.685	18.654	-	1.3760
6	Smp	GO	-	60.558	3.306	-	-	1.0752
7	Smp	La2S3-GO	-	18.782	2.669	2.134	-	1.0756
8	Smp	Ce2S3-GO	-	20.915	1.799	2.642	-	1.0995
9	Smp	Tb2S3-GO	-	19.264	2.480	1.764	-	1.0299
10	Smp	Ho2S3-GO	-	25.024	2.475	1.964	-	1.0295

21 Nov 2022 12:47:29 AutoRun: KK211122-KK21112022 (18)
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