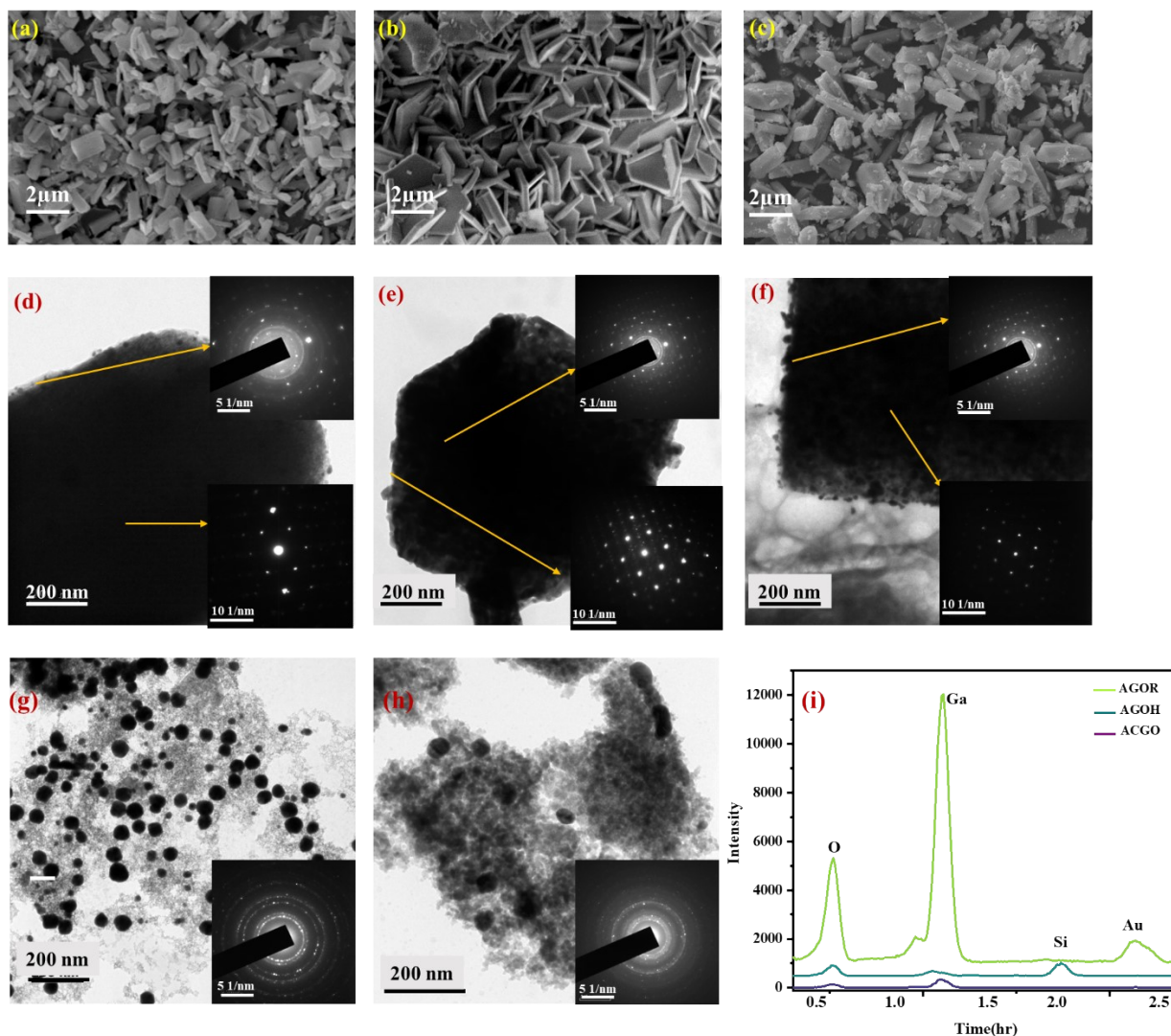


## Chemically engineered plasmonic Au-Gallium oxide nanocomposites for harsh environment applications: an inquiry into thermal and chemical robustness

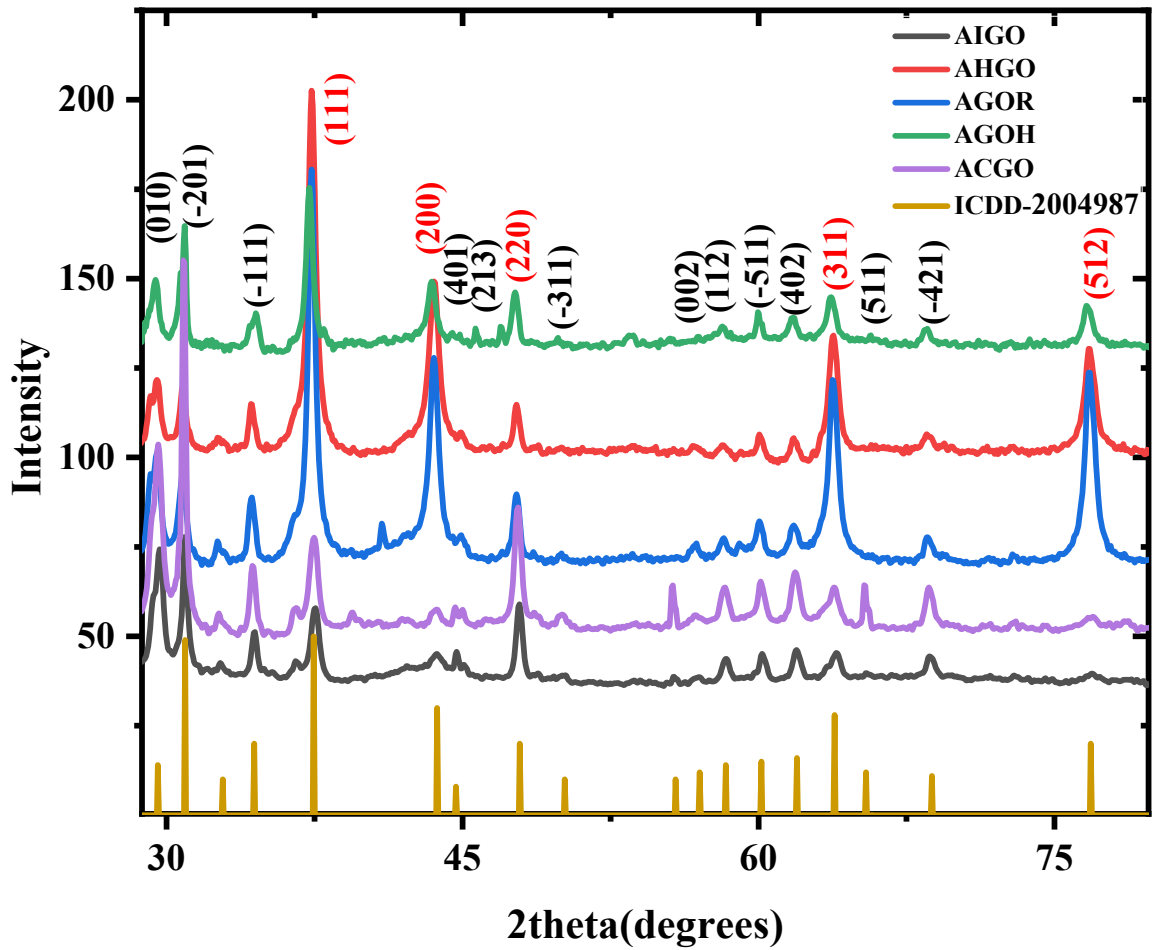
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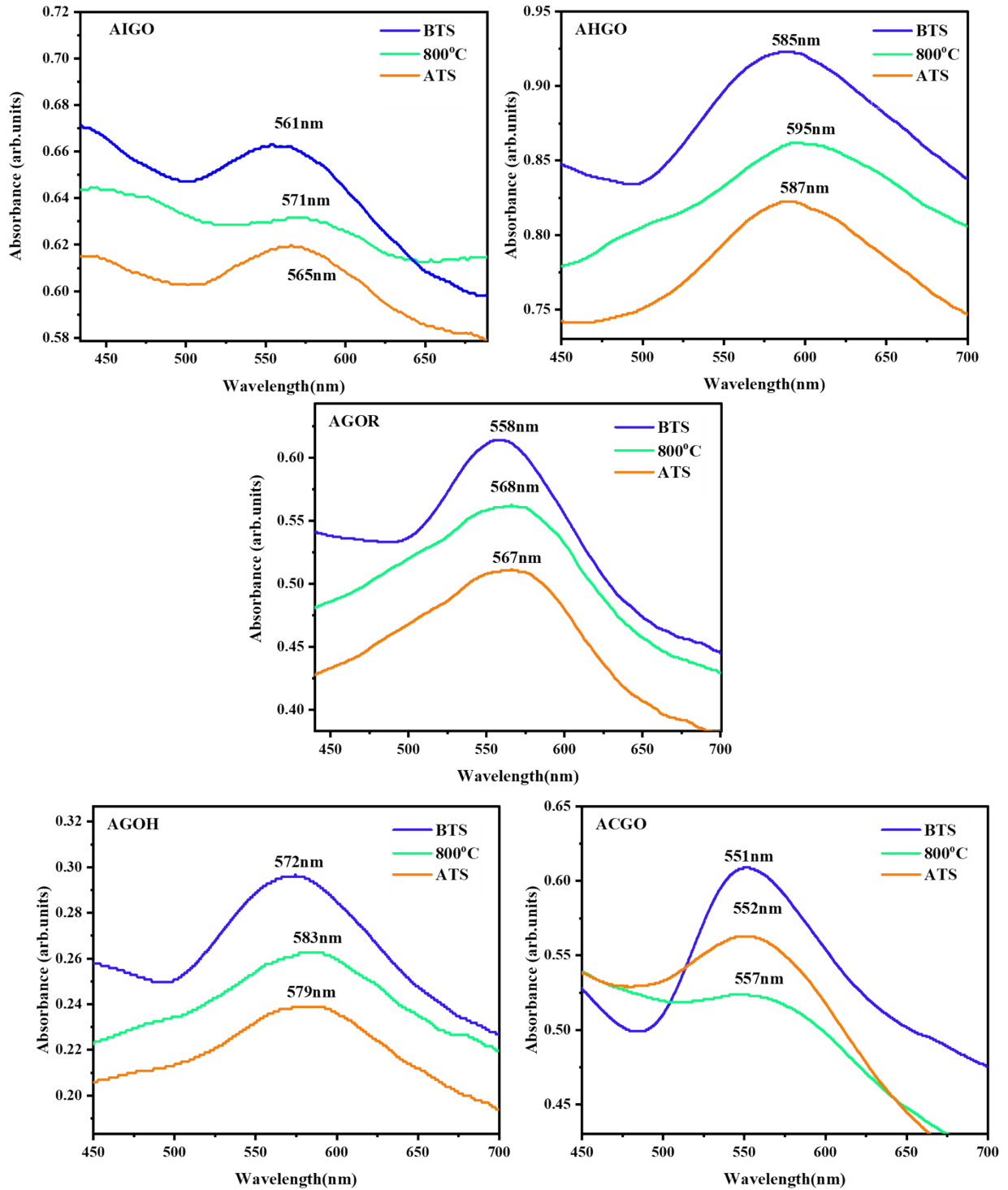


S1. (a), (b), (c) are SEM images of AGOR, AGOH and ACGO respectively, (d)- (h) are TEM images of AGOR, AGOH, ACGO, AIGO and AHGO respectively and (i) shows EDS spectra of all sample for confirmation of constituent elements.



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2. XRD patterns of AGO composites prepared through hydrothermal and microwave methods matched with ICDD 2004987 and 64701 for Ga<sub>2</sub>O<sub>3</sub> and Au respectively. Red labels in denote lattice planes of AuNPs whereas the black labels denote those of Ga<sub>2</sub>O<sub>3</sub>. The plane (213) has been observed only for the hexagonal phase of the AGOH composites.



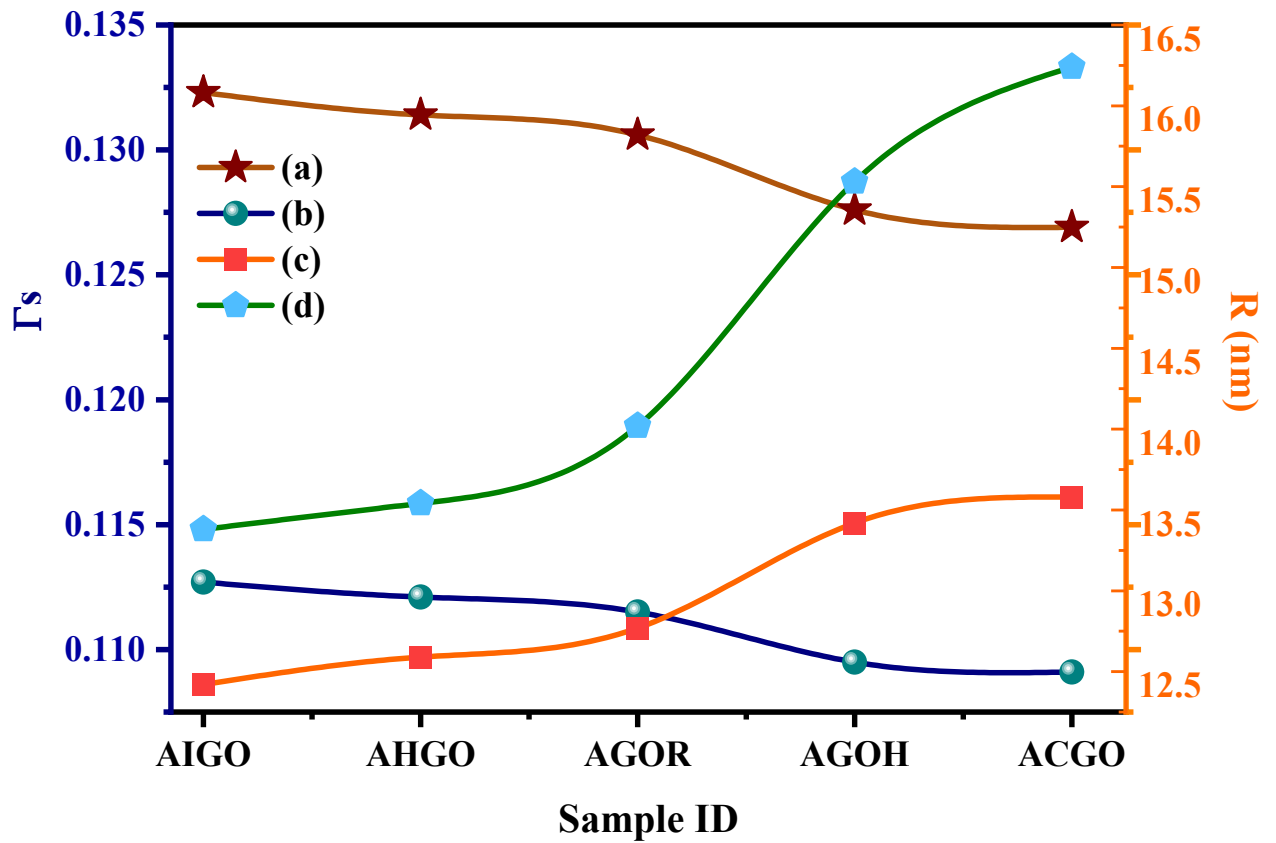
S3. Optical absorbance of composites before and after TS denoted as BTS and ATS respectively. A red-shift has been observed for all the samples at 800°C as well as ATS, indicating particle ripening/agglomeration.

Composite	RT before TS tests			800°C			%R
	$\lambda_p$ (nm)	$\Delta\lambda$	R (nm)	$\lambda_p$ (nm)	$\Delta\lambda$	R (nm)	
AIGO	556	60	12.42	569	40	13.38	7.72
AHGO	588	70	12.59	594	62	13.54	7.54
AGOR	558	75	12.77	562	61	14.02	9.78
AGOH	572	85	13.42	582	80	15.53	15.72
ACGO	551	84	13.58	557	34	16.24	19.58

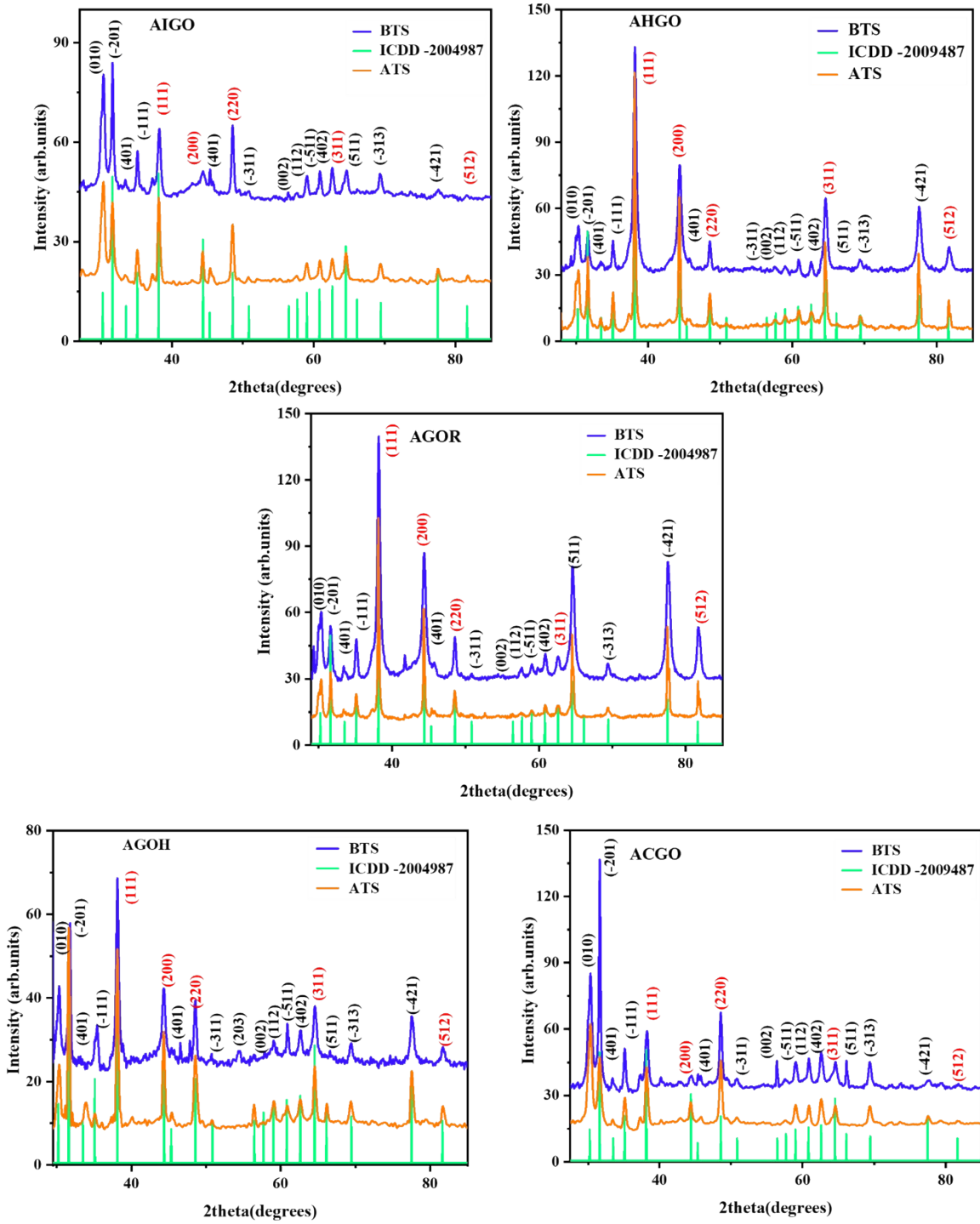
S4. Theoretical calculations of the radii of AuNPs in the respective composites obtained using FWHM and peak position ( $\lambda_p$ ) at RT and 800°C.

Sample	Volume (V) (nm <sup>3</sup> )		Radius (nm)		$\Gamma_s$	
	RT	800°C	RT	800°C	RT	800°C
AIGO	8021.08	35061450.23	12.42	18.09	0.1323	0.1127
AHGO	8354.98	36520967.86	12.59	18.34	0.1314	0.1121
AGOR	8718.48	38109897.44	12.77	18.60	0.1306	0.1115
AGOH	10118.72	44230580.14	13.42	19.55	0.1276	0.1095
ACGO	10484.98	45831534.48	13.58	19.78	0.1269	0.1091

S5. Calculations of volumetric and radial expansions, associated changes to free electron densities, and plasmon damping constants at room temperature and at 800°C for the AGO composites



S6. (a) and (b) are the plasmonic damping constant of composites at room temperature and at 800°C respectively. (c) and (d) represent the theoretically calculated radii of the composites at room temperature and at 800°C respectively.



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7. XRD patterns of AGO before (BTS) and after (ATS) TS matched with references 2004987 and 64701 for Ga<sub>2</sub>O<sub>3</sub> and Au respectively. Red labels denote the lattice planes of AuNPs and black labels denote the lattice planes of Ga<sub>2</sub>O<sub>3</sub>.

Sample	Cell parameters	Distortion	Cell Volume	Avg. Crystallite
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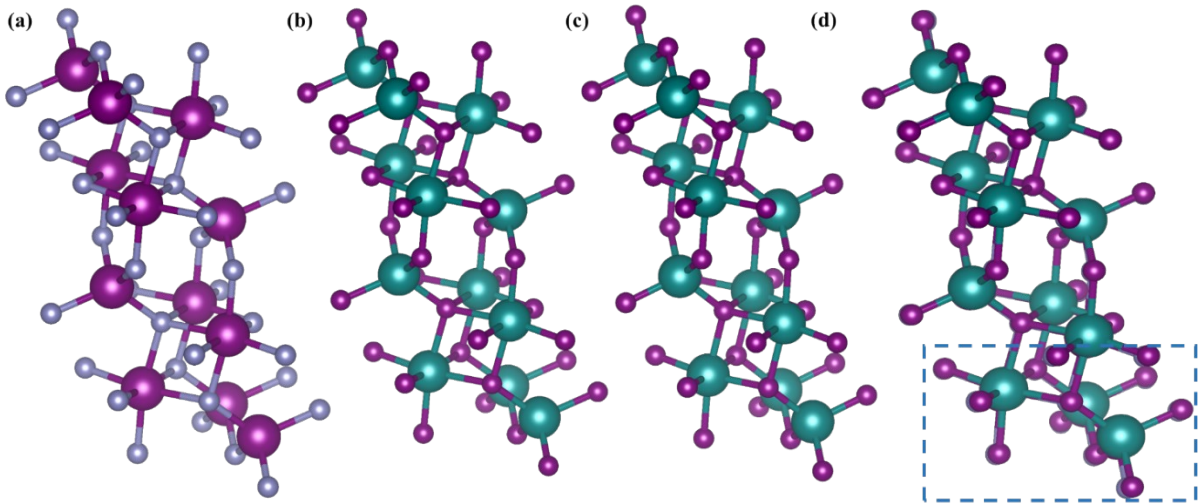
			across (c)		(nm <sup>3</sup> )		size (nm)	
	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>
AIGO	a=11.79 c=5.43	a=11.82 c=5.39	6.37	7.06	180.16	179.46	18.2	18.5
AHGO	a=11.82 c=5.39	a=11.82 c=5.39	7.06	7.07	179.30	179.32	18.12	18.76
AGOR	a=11.78 c=5.43	a=11.82 c=5.39	6.38	7.08	180.01	179.30	19.35	20.54
AGOH	a=11.97 c=5.17	a=12.00 c=5.13	10.86	11.55	183.2	183.5	20.81	22.43
AGOH (Hexagonal)	a=2.8 c=9.4	a=2.81 c=8.7	4.25	3.33	67.41	67.53	23.9	24.1
ACGO	a=11.72 c=5.45	a=11.82 c=5.39	6.43	7.07	178.03	179.32	27.01	31.13

S8. Unit cell parameters of Ga<sub>2</sub>O<sub>3</sub> alone before and after TS studies for all composites are presented. Calculations of the monoclinic phase for all composites and hexagonal as well as monoclinic phases of the AGOH composite have been included.

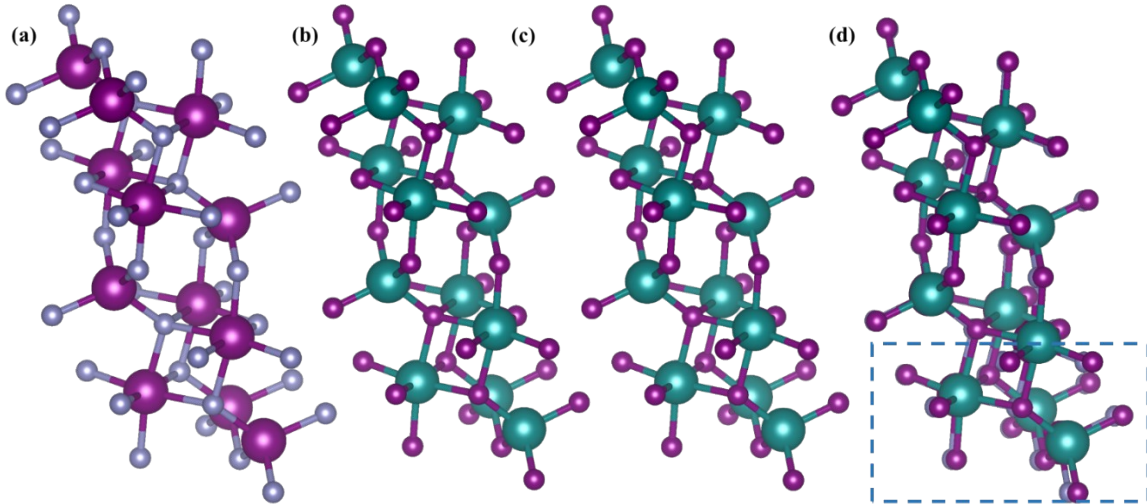
Sample	Cell parameters		Distortion		Cell Volume (nm <sup>3</sup> )		Avg. Crystallite size (nm)	
	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>	<i>BTS</i>	<i>ATS</i>
AIGO	4.07906	4.07906	-	-	67.8704	67.8702	12.33	12.85
AHGO	4.07906	4.07906	-	-	67.8704	67.8701	12.34	12.87
AGOR	4.07906	4.07905	-	0.0002	67.8704	67.8699	12.34	12.87
AGOH	4.07905	4.07904	0.0002	0.00024	67.8701	67.8696	12.35	12.88
ACGO	4.07906	4.07905	-	0.0002	67.8702	67.8698	12.34	12.87

S9. Unit cell parameters of AuNPs before and after TS studies for all composites.

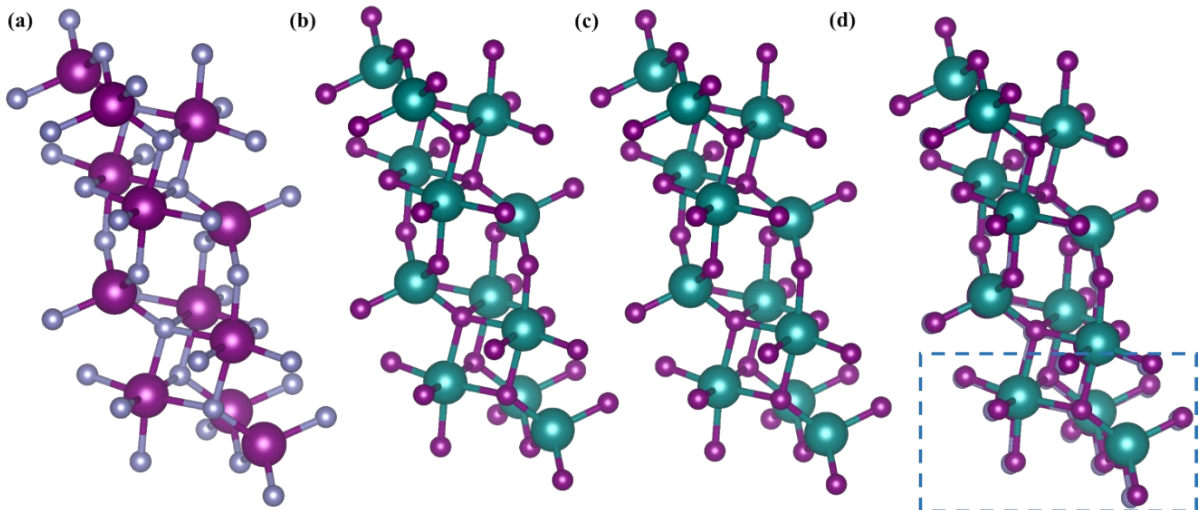
**AIGO – monoclinic**



**AHGO – monoclinic**

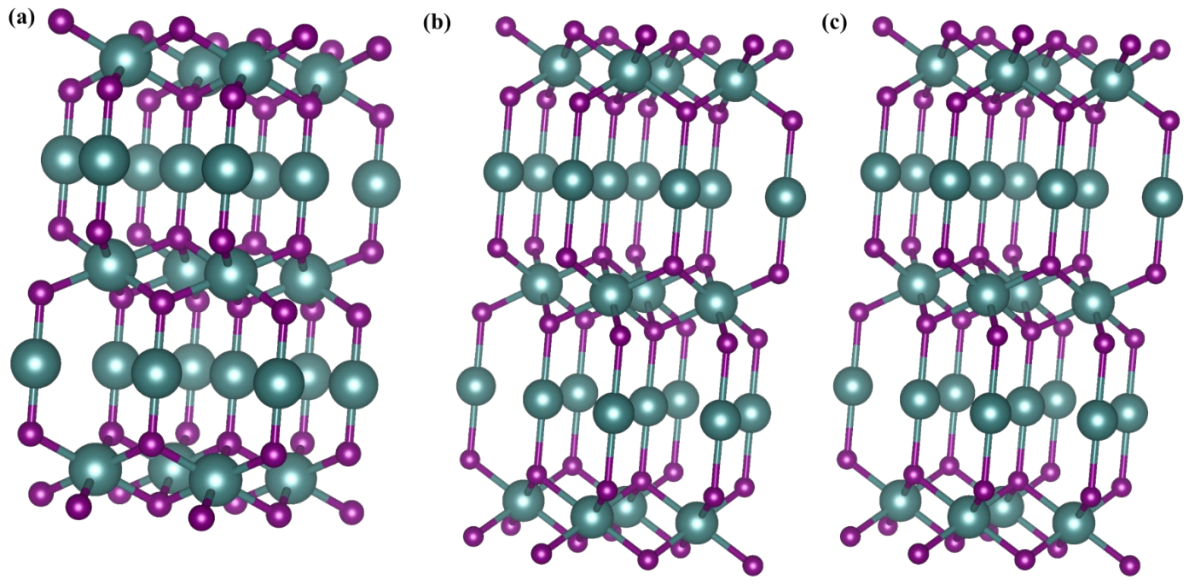


**AGOR – monoclinic**

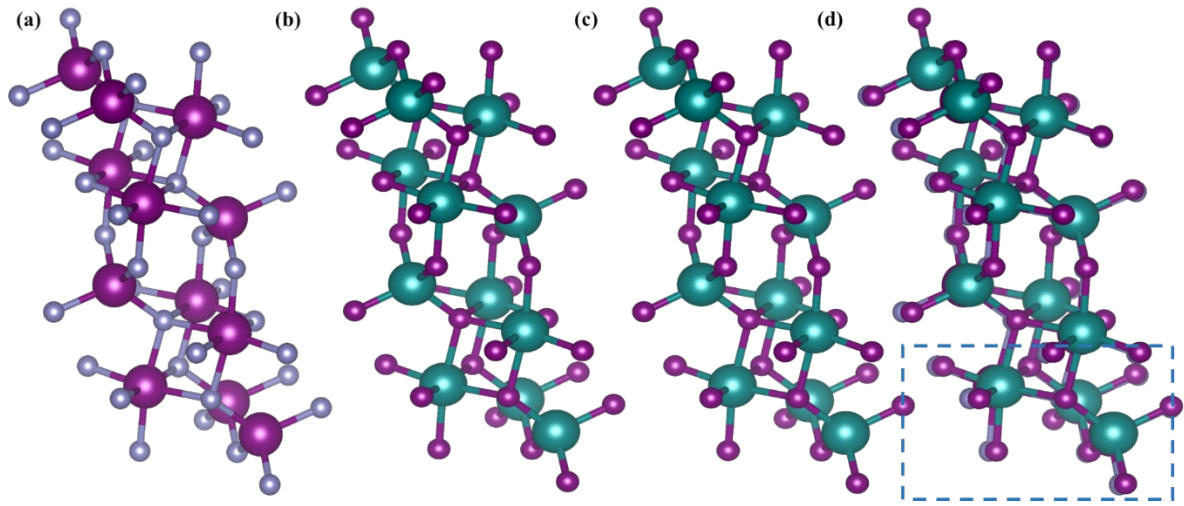




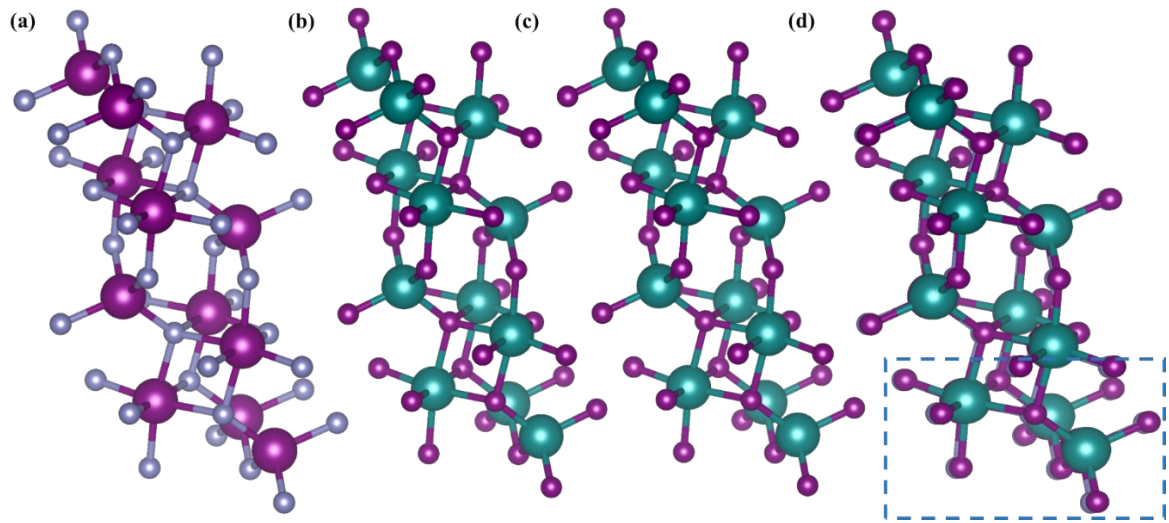
**AGOH – hexagonal**



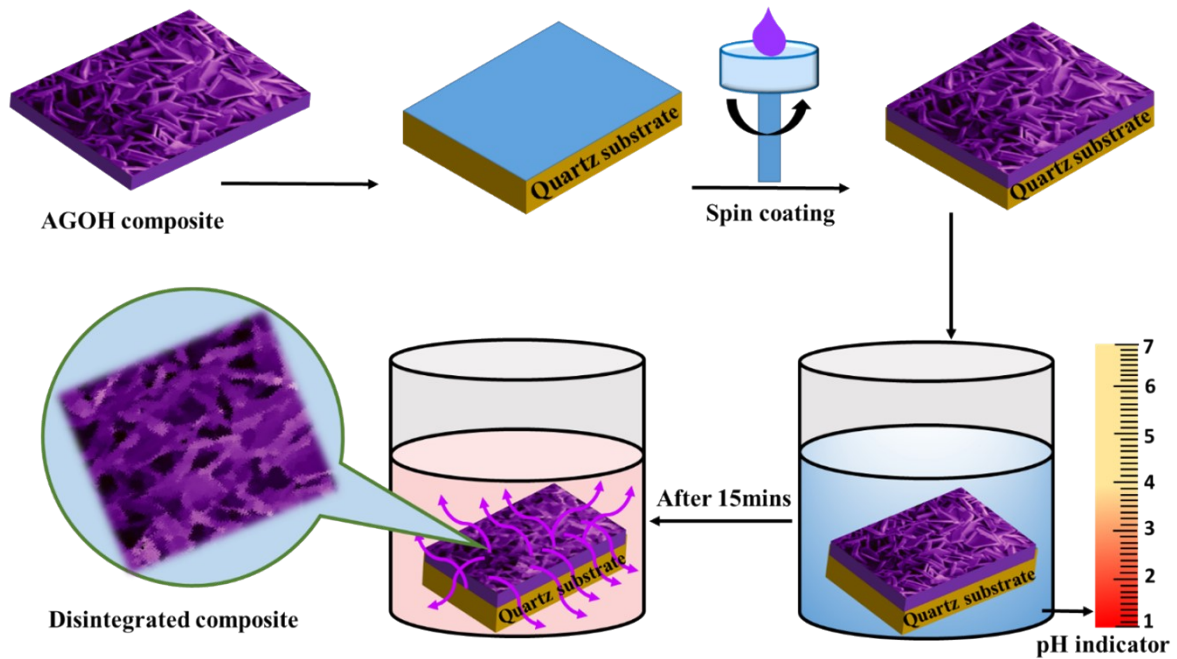
**AGOH – monoclinic**



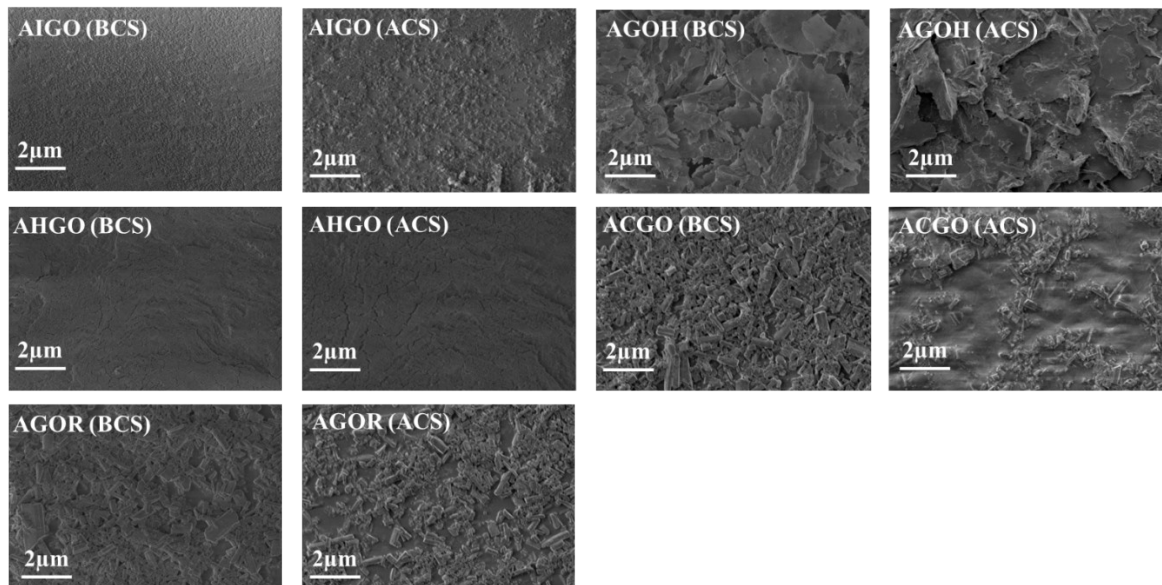
**ACGO – monoclinic**



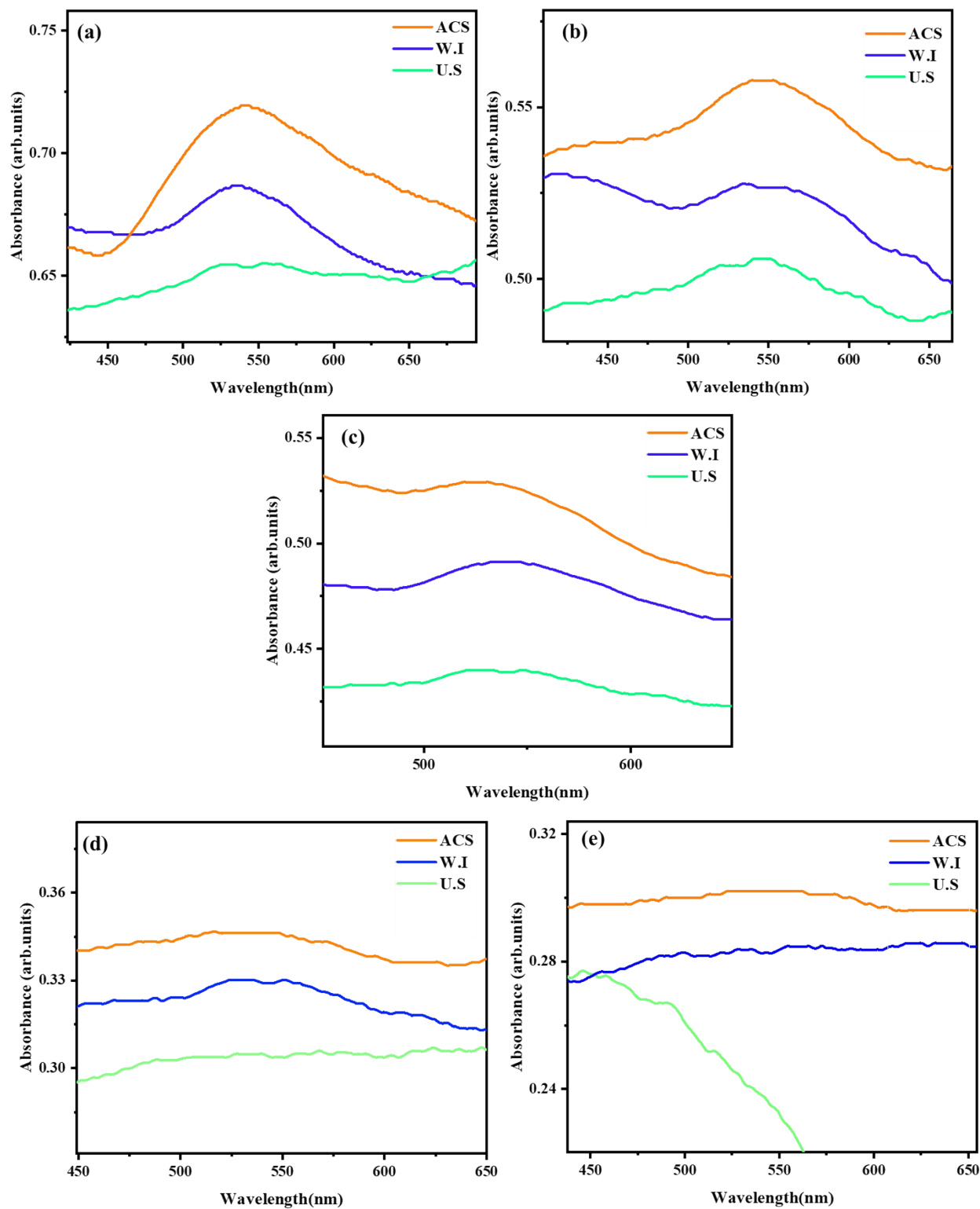
S10. The primitive  $Ga_2O_3$  lattices of the composites before and after TS tests. In each case (a) is the stoichiometric lattice (b) the lattice BTS (c) the lattice ATS. Image to the far right in each case represents superimposed lattices from before and after TS studies for better visualization of their distortion.



S11. Schematic representation of the chemical stability testing process



S12. SEM images of AGO composites. Before and after etching images have been imaged at precisely the same regions and without the typical charge dissipating sputtered sputtering of Au (with a consequence of inability to image at higher magnifications) to study the changes in the surface morphology.



S13. Optical absorbances of (a) AIGO (b) AHGO (c) AGOR (d) AGOH and (e) ACGO composites post water immersion and ultrasonication. ACS, W.I, and U.S denote spectra acquired after chemical stability tests, after water immersion and after ultra-sonication respectively.