Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Graphene Titanium dioxide nanocomposite (GTNC): One Pot Green Synthesis and Its Application in Solid Rocket Propellant

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S1: Synthesis of TiO_2 nanoparticles

The TiO_2 nanoaprticles were synthesized by following the reported method). For typical synthesis of myristic acid mediated anatase TiO_2 by sol–gel method. $TiCl_4$ (3 mL) was diluted with deionised water to form $TiOCl_2$ and it was then mixed with myristic acid in such a way to obtain a ratio of 1:0.10 with respect to $TiCl_4$. The suspension thus formed was heated on a water bath for about 30 min at about 100 °C by which a fine white precipitate was formed. The precipitate was dried completely at 100 °C and was calcined at 500 °C for 2 h. After calcinations the TiO_2 nanoparticles were used for preparation of graphene/TiO_2 based nano-composite without any further modifications.

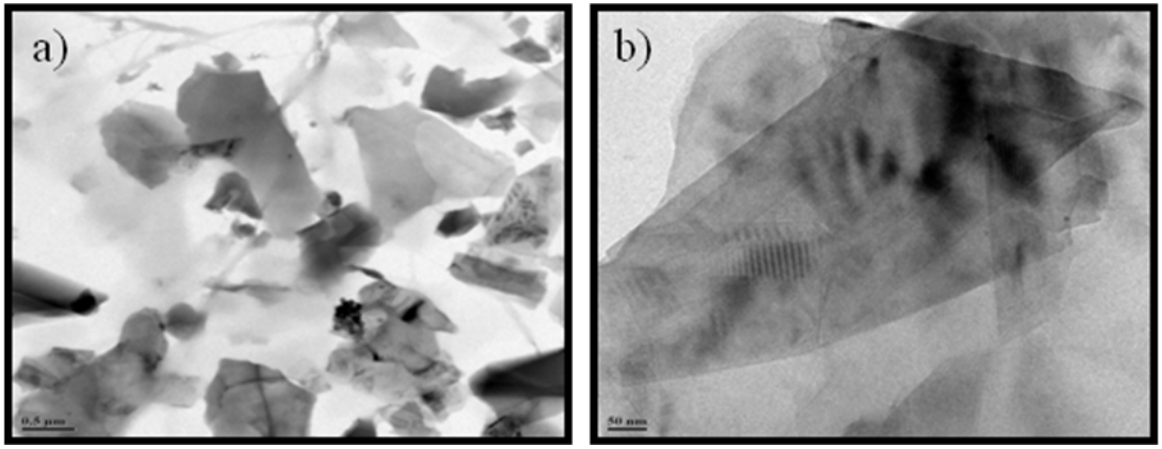
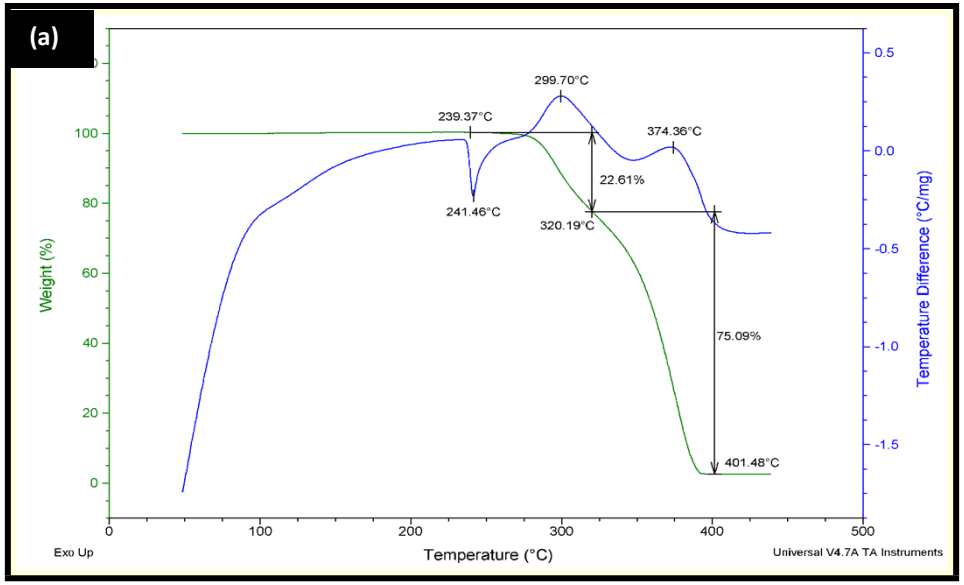
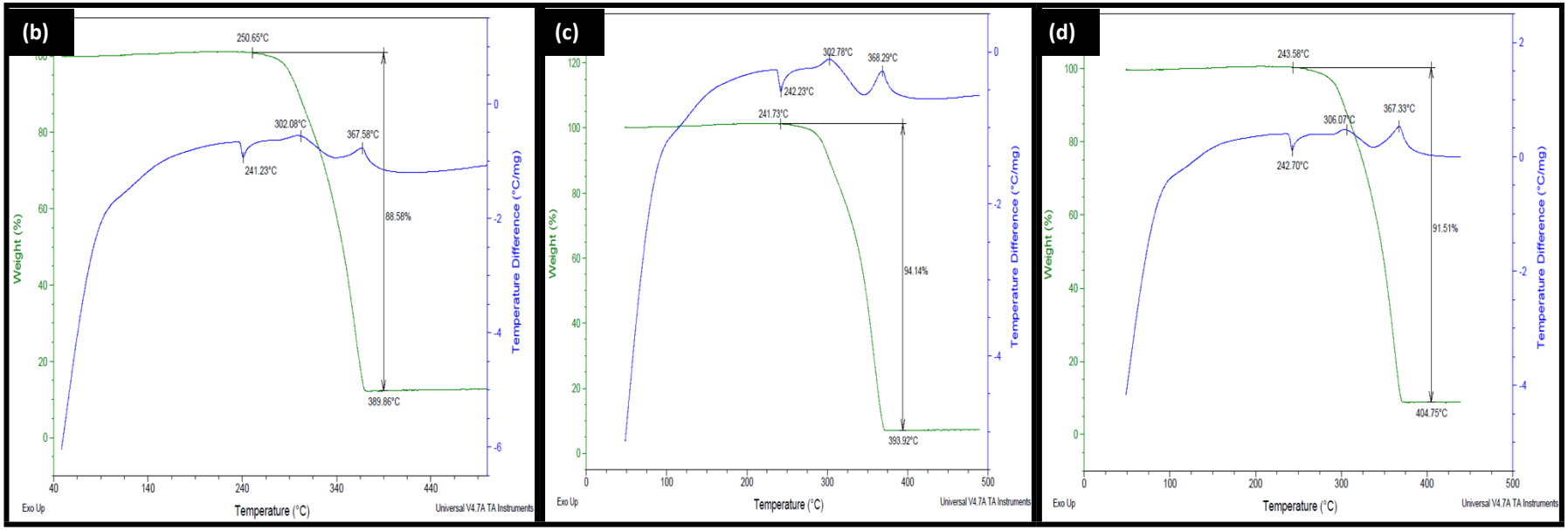
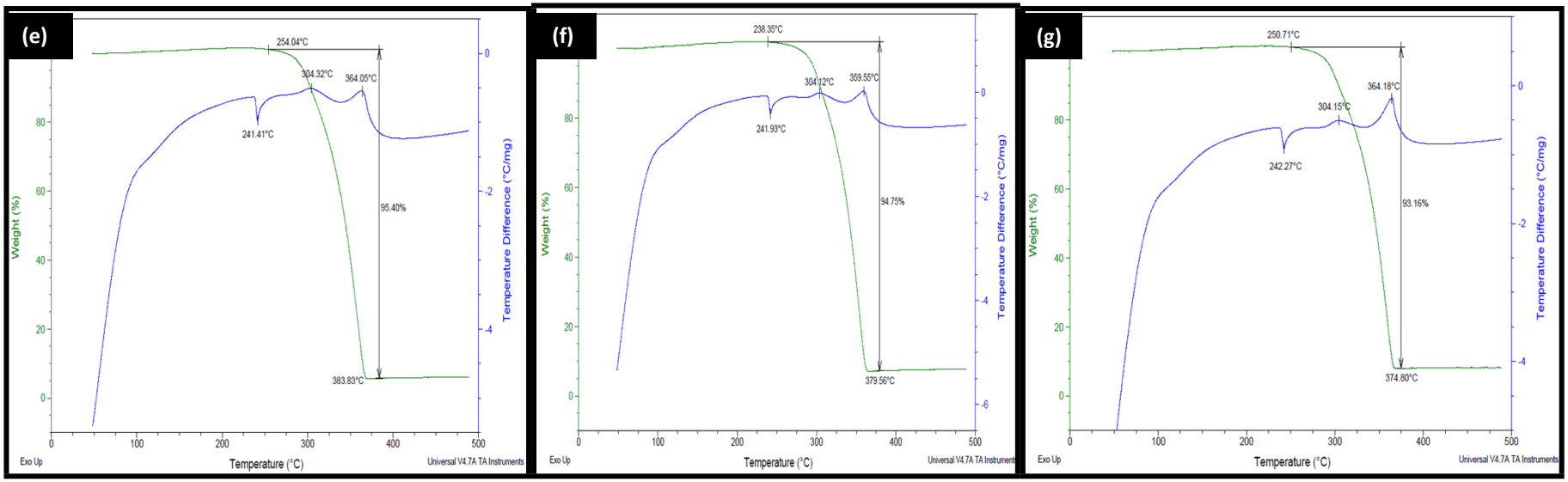


Fig S2: HR-TEM images of Graphene used for preparation of GTNC a) scale bar is 500 nm and b) scale bar is 50 nm.


(a)
299.70°C
239.37°C
374.36°C
22.61%
241.46°C
320.19°C
75.09%
401.48°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments


(b)
250.65°C
302.08°C
241.23°C
367.58°C
88.58%
389.86°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments
(c)
302.78°C
368.29°C
242.23°C
241.73°C
94.14%
393.92°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments
(d)
243.58°C
306.07°C
367.33°C
242.70°C
91.51%
404.75°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments


(e)
254.04°C
304.32°C
364.05°C
241.41°C
95.40%
383.83°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments
(f)
238.36°C
304.12°C
359.55°C
241.93°C
94.75%
379.56°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments
(g)
250.71°C
364.18°C
304.15°C
242.27°C
93.16%
374.80°C
Weight (%)
Temperature Difference (°C/mg)
Temperature (°C)
Exo Up
Universal V4.7A TA Instruments

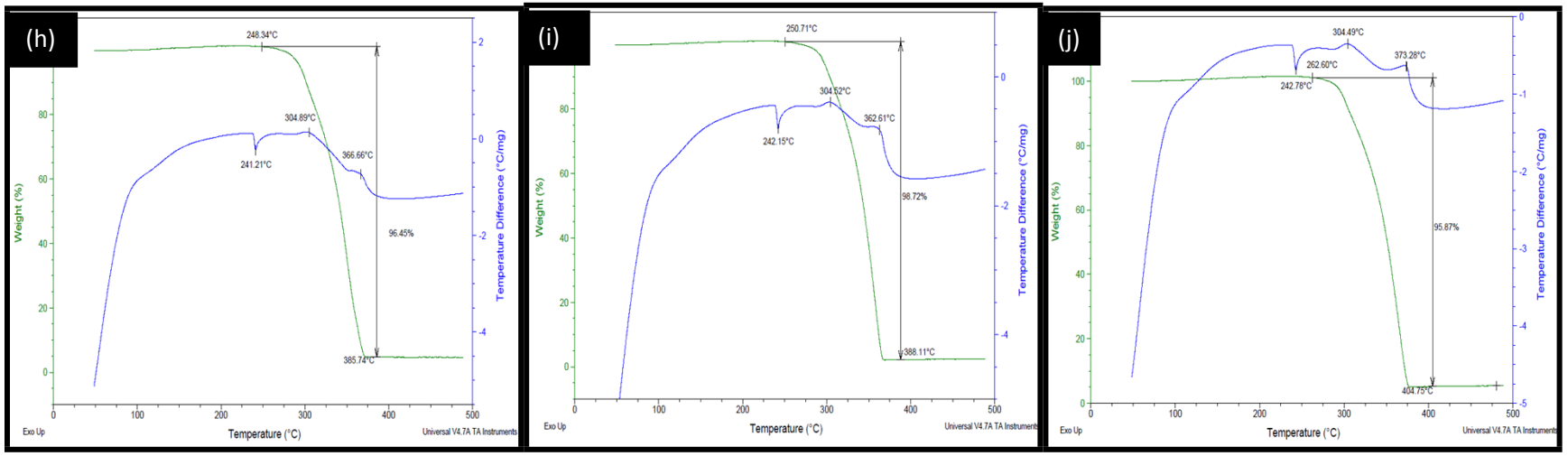


Fig S3: Comparative STA traces of (a) Ammonium perchlorate(AP), (b, c,d) AP with 1-5% of graphene, (e, f, g) AP with 1-5% of GTNC, (h, i, j) AP with 1-5% of titanium dioxide

Table S4. Thermal analysis results with different burn rate enhancers with AP

Sr. No	Composition	DSC @ 10°C/min					DTA @ 20°C/min			TGA@ 20°C/min	
		Peak temperature (°C)			ΔH (J/g)						
		Phase transition	1st Peak	2nd Peak	1st Peak	2nd Peak	initial temp. (Tinitial,°C)	Max. temp. (Tmax,°C)	Final temp (Tmax,°C)	temperature (°C)	weight loss (%)
1.	AP	245.47	296.40	380.43	-583.1	-1849.34	241.46	299.70	374.36	239.37-401.48	75.09
2.	AP+1% Graphene	247.77	--	393.83	--	-3243.5	241.23	302.08	367.58	250.65-389.86	88.58
3.	AP+1%Gr-TiO_2	248.27	302.67	412.87	-542.530	-2053.835	241.41	304.32	364.05	254.04-383.83	95.4

4.	AP+1% nano TiO_2	248.2	296.07	431.1	-519.648	-1509.034	241.21	304.89	366.66	248.34-385.74	96.45
5.	AP+3% Graphene	252.07	--	397.90	--	-2787.682	242.23	302.78	268.29	241.73-393.92	94.14
6.	AP+3%Gr-TiO_2	248.67	313.07	395.70	-154.164	-2827.898	241.93	304.12	359.55	238.35-379.56	94.75
7.	AP+3% nano TiO_2	251.83	314.80	409.63	-802.022	-2680.571	242.15	304.52	362.61	250.71-388.11	98.72
8.	AP+5% Graphene	248.63	--	411.20	--	-1754.746	242.70	306.07	367.33	243.58-404.75	91.51
9.	AP+5%Gr-TiO_2	247.43	--	372.50	--	-3903.340	242.27	304.15	364.18	250.71-374.80	93.16
10.	AP+5% nano TiO_2	248.53	313.03	382.57	-119.211	-2021.137	242.78	304.49	373.28	262.6-404.75	95.87

Table S5 . Physico-chemical properties with different burn rate enhancer in propellant composition

Sr. No	Comp^n	Theoretical performance parameters			Viscosity (Poise)	Density g/cc	Cal-Val (Cal/g)	Sensitivity parameter		
		C*, (m/s)	Flame Temparature (T_f, °C)	Specific Impulse (Isp,s)	Initial at 40°C			Fric^n	Impact	Ignition temp. (°C)
1.	CP-1	1587	1913	264.1	7000-8000	1.76	1892	144	47.0	282.4
2.	CP-2 (nano TiO_2)	1578	1892	262.1	10000-12000	1.776	1884	128	46.0	281.8
3.	CP-3 (Gr-TiO_2)	1577	1895	262.4	4000-5000	1.771	1898	128	46.5	282.0

Table S6. Physico-chemical properties with different burn rate suppressant in propellant composition

Sr. No	Comp^{n}	Ballistic properties				
		Burn rate (mm/s)			n value, 5-10 MPa	a value 5-10MPa
		5 MPa	7 MPa	10 MPa		
1.	CP-1	4.1	5.2	6.8	0.53	1.41
2.	CP-2 (nano TiO2)	5.6	6.8	8.3	0.53	2.96
3.	CP-3(Gr-TiO2)	6.5	7.8	9.0	0.49	4.16