

Structure–Rheology–Thermal Property Correlation in Graphene Oxide Reinforced Gum Acacia-g-Poly(acrylic acid) Nanocomposite Hydrogels

Material (grade)	IUPAC Name	Suppliers	Molecular Weight
Gum acacia	-	HI-MEDIA Pvt. Ltd.	250 kDa
Acrylic acid (Stabilised) 98%	2-propenoic acid	Loba Chemie Pvt. Ltd.	72.06 g mol ⁻¹
(NH ₄) ₂ S ₂ O ₈ (AR)	Ammonium persulfate	HI-MEDIA Pvt. Ltd.	228.19 g mol ⁻¹
N,N'-methylene bis-acrylamide	N-[(prop-2-enoylamino)methyl]prop-2-enamide	Loba Chemie Pvt. Ltd.	154.17 g mol ⁻¹
Graphene Oxide	-	Sigma-Aldrich	-

Table S1. Material specifications that are utilised

Sample Name	Gum acacia (mg)	TDW (mL)	MBA (mg)	APS (mg)	Acrylic acid (AA) (mL)	Graphene Oxide (GO) (mg)
GAPAA GO-0	500	7	50	50	0.25	0
GAPAA GO-1	500	7	50	50	0.25	1
GAPAA GO-2	500	7	50	50	0.25	2

GAPAA GO-3	500	7	50	50	0.25	3
GAPAA GO-4	500	7	50	50	0.25	4
GAPAA GO-5	500	7	50	50	0.25	5

Table S2. Feed composition for the synthesis of Gum acacia-*grafted*-poly(Acrylic acid)/Graphene oxide nanocomposite hydrogel

Table S3. Summary of Power Law parameters (flow behaviour index n, consistency index k) along with corresponding R² values describing the rheological behaviour of the materials

Sample Name	n	k	R ²
GAPAA GO-0	0.22407 ± 0.08232	97.20753 ± 32.92612	0.8713
GAPAA GO-1	0.14432 ± 0.00747	48.9192 ± 1.52323	0.99901
GAPAA GO-2	0.27026 ± 0.01273	80.5988 ± 4.18711	0.99587
GAPAA GO-3	0.17723 ± 0.01869	99.09318 ± 7.67956	0.99332
GAPAA GO-4	0.21893 ± 0.01348	42.24235 ± 2.34444	0.99607
GAPAA GO-5	0.22896 ± 0.01359	59.08217 ± 3.30028	0.99588

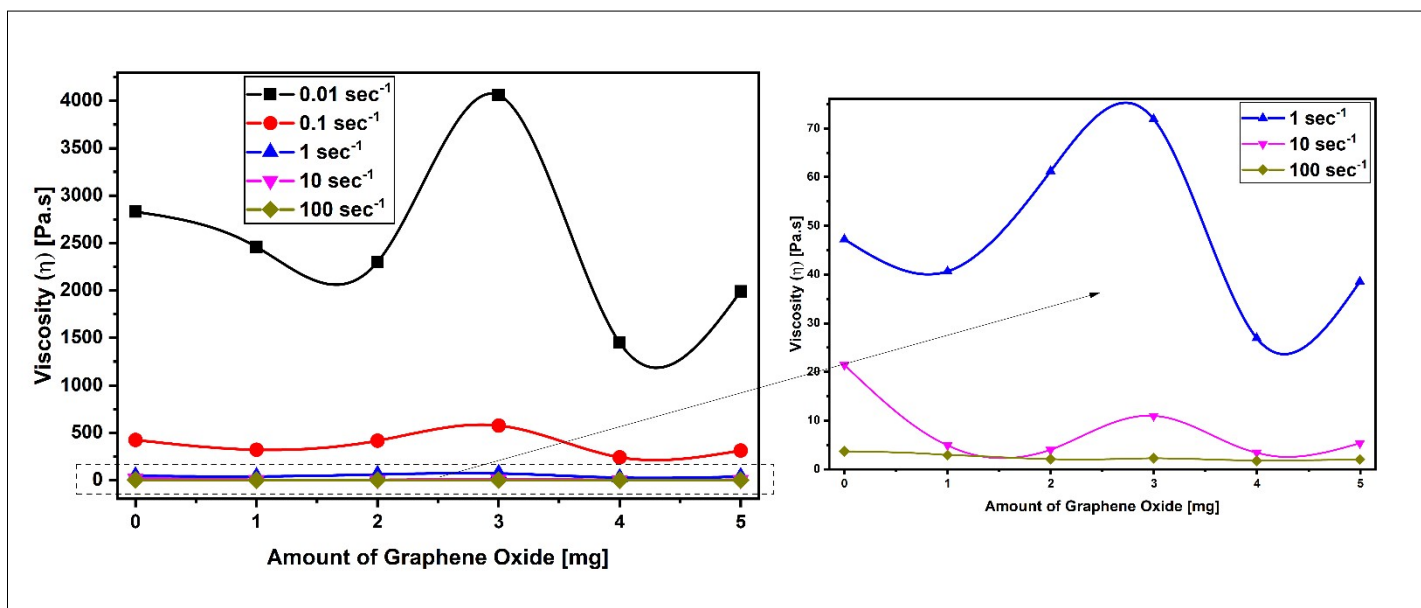


Figure S1 Effect of the amount of GO on viscosity at various shear rates (sec^{-1})

Table S4. Values of viscosity at 0.01, 0.1, 1, 10, and 100 sec^{-1} shear rates for different amounts of the GO nanofillers loaded in Gum acacia-g-poly(Acrylic acid) hydrogel

Graphene Oxide (mg)	Shear rate (sec^{-1})				
	0.01	0.1	1	10	100
	Viscosity (Pa·s)	Viscosity (Pa·s)	Viscosity (Pa·s)	Viscosity (Pa·s)	Viscosity (Pa·s)
0	2830	426	47.2	21.4	3.62
1	2460	322	40.6	4.88	2.84
2	2300	417	61.2	3.94	2.04
3	4060	577	71.9	10.9	2.22
4	1450	243	26.9	3.38	1.67
5	1990	314	38.5	5.3	1.94

Table S5. Herschel - Bulkley Model parameters: Yield stress (τ_0), Consistency coefficient (k), flow index (n), and Goodness-of-fit (R^2) values for the tested samples

Sample Name	τ_0	k	n	R^2
GAPAA GO-0	28.3 ± 10.35727	40.17704 ± 10.37011	0.49298 ± 0.05796	0.91798
GAPAA GO-1	33.99452 ± 3.68495	0.65285 ± 0.39062	1.32362 ± 0.13545	0.9105
GAPAA GO-2	33.9764 ± 4.55632	16.71042 ± 4.4136	0.51687 ± 0.05965	0.91543
GAPAA GO-3	57.87787 ± 3.15904	7.87412 ± 2.35492	0.66105 ± 0.06865	0.91977
GAPAA GO-4	22.10618 ± 2.36885	1.53525 ± 0.68433	1.01721 ± 0.10192	0.91557
GAPAA GO-5	25.69756 ± 2.41926	11.65737 ± 2.05002	0.59715 ± 0.04019	0.96657

Table S6. Summary of viscoelastic parameters: storage modulus, loss modulus, and damping

Sample Name	0.1 rad s ⁻¹			1 rad s ⁻¹			10 rad s ⁻¹			100 rad s ⁻¹		
	G'	G''	tan δ	G'	G''	tan δ	G'	G''	tan δ	G'	G''	tan δ
GAPAA GO-0	59.2	3.22	0.0543	61.2	3.48	0.0569	62.5	4.4	0.0703	0	219	-
GAPAA GO-1	71.3	5.2	0.0729	67.1	5.69	0.0848	69.9	7.24	0.104	0	233	-
GAPAA GO-2	62.1	4.39	0.0707	67.3	5.82	0.0864	71.7	8.91	0.124	0	251	-
GAPAA GO-3	131	8.15	0.062	116	5.6	0.0482	119	7.83	0.0658	0	155	-
GAPAA GO-4	67.7	5.23	0.0772	55	3.31	0.0602	55	4.59	0.0834	0	258	-
GAPAA GO-5	35.9	2.65	0.0736	33.9	2.84	0.0838	32.7	3.75	0.115	0	283	-

factor at 0.1, 1, 10, and 100 (rad s⁻¹) angular frequencies

Table S7. Summary of complex viscosity measured at selected angular frequencies (0.1, 1, 10, and 100 rad s⁻¹)

Sample Name	Complex Viscosity (η^*)			
	0.1 rad s ⁻¹	1 rad s ⁻¹	10 rad s ⁻¹	100 rad s ⁻¹
GAPAA GO-0	593	61.3	6.26	2.19
GAPAA GO-1	715	67.3	7.02	2.33
GAPAA GO-2	622	67.6	7.23	2.51
GAPAA GO-3	1320	116	11.9	1.55
GAPAA GO-4	679	55.1	5.52	2.58
GAPAA GO-5	360	34.1	3.3	2.83

Sample Name	40.7°C				62.7°C				84.7°C			
	G'	G''	tan δ	$ \eta^* $	G'	G''	tan δ	$ \eta^* $	G'	G''	tan δ	$ \eta^* $
GAPAA GO-0	70.4	3.79	0.0538	7.05	231	95.2	0.412	25	2140	1690	0.79	272
GAPAA GO-1	49.2	4.31	0.0877	4.94	219	101	0.462	24.1	1960	1580	0.806	252
GAPAA GO-2	112	7.25	0.0648	11.2	470	247	0.525	53.1	7160	5840	0.815	924
GAPAA GO-3	122	7.7	0.0631	12.2	453	243	0.537	51.4	6990	4820	0.69	849
GAPAA GO-4	83.8	6.05	0.0721	8.4	446	280	0.628	52.7	9710	6370	0.656	1160

Table S8. Storage modulus (G'), Loss modulus (G''), Damping factor (tan δ), and Complex viscosity (η^*) values at the heating temperatures 40.7°C, 62.7°C, and 84.7°C

GAPAA GO-5	83	5.69	0.0685	8.32	786	633	0.806	101	5680	4420	0.779	720
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Table S9. Storage modulus (G'), Loss modulus (G''), Damping factor ($\tan \delta$), and Shear Stress (τ) values at 0.1, 1, 10, and 99.8 % Strain

Sample Name	0.1% Strain				1% Strain				10% Strain				99.8% Strain			
	G'	G''	$\tan \delta$	τ	G'	G''	$\tan \delta$	τ	G'	G''	$\tan \delta$	τ	G'	G''	$\tan \delta$	τ
GAPAA GO-0	66.4	2.42	0.0364	0.0661	67.6	2.73	0.0404	0.675	64.2	4.33	0.0675	6.42	42.9	14	0.326	44.9
GAPAA GO-1	74.4	4.54	0.061	0.0743	76.3	5.1	0.0668	0.763	72.6	6.46	0.089	7.27	41	16.4	0.399	44
GAPAA GO-2	82.8	11.9	0.143	0.0833	82	8.68	0.106	0.823	75.6	9.58	0.127	7.6	48.8	17.1	0.35	51.5
GAPAA GO-3	117	10.9	0.0937	0.117	120	8.17	0.068	1.2	114	10.2	0.0897	11.4	80.1	23.5	0.293	83.1
GAPAA GO-4	52.2	8.19	0.157	0.0526	55.3	4.47	0.0808	0.552	55	4.82	0.0876	5.5	42.9	8.32	0.194	43.5
GAPAA GO-5	29.9	4.75	0.159	0.0303	30.6	3.67	0.12	0.306	29.6	3.93	0.133	2.97	19.8	6.12	0.31	20.6