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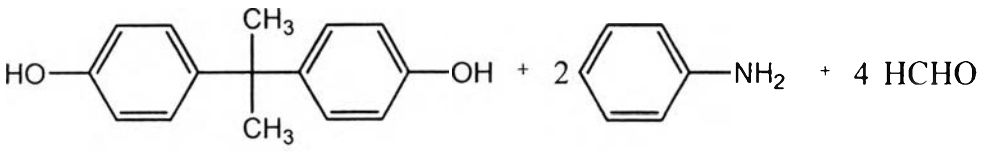
APPENDICES

Appendix A Preparation of Benzoxazine Monomer by Solventless Method

Aniline based benzoxazine monomer

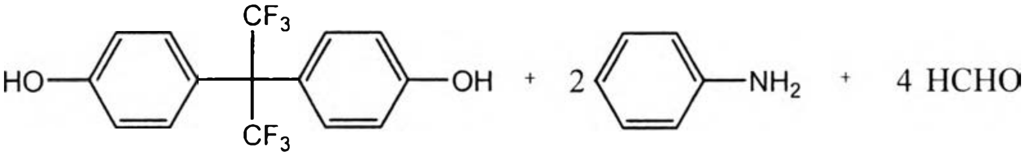


Bisphenol A Aniline Paraformaldehyde

Table A1 Experimental data of precursors for aniline based benzoxazine synthesis

	Precursors			Reaction time
	Bisphenol A	Aniline	Paraformaldehyde	
Mole	0.06	0.24	0.12	30 min
M.W.	228.29	30.03	93.13	
Weight (g)	13.70	7.21	11.18	

Fluorinate based benzoxazine monomer



Hexafluorobisphenol A Aniline Paraformaldehyde

Table A2 Experimental data of precursors for fluorinate based benzoxazine synthesis

	Precursors			Reaction time
	Hexafluoro-bisphenol A	Aniline	Paraformaldehyde	
Mole	0.06	0.24	0.12	30 min
M.W.	336.24	30.03	93.13	
Weight (g)	20.17	7.21	11.18	

Appendix B Preparation of BST by Sol-Gel Process

Precursor materials

1. Barium acetate $Ba(CH_3COO)_2$, d = 2.468 g/cm^3
2. Strontium acetate $Sr(CH_3COO)_2$
3. Titanium tetra-n-butoxide $(CH_3(CH_2)_3O)_4Ti$, d = 0.998 g/cm3
4. Methanol
5. Glacial acetic acid

Table B1 Experimental data of precursors for $Ba_{0.3}Sr_{0.7}TiO_3$

	Precursors		
	Barium acetate $Ba(CH_3COO)_2$	Strontium acetate $Sr(CH_3COO)_2$	Titanium tetra-n-butoxide $(CH_3(CH_2)_3O)_4Ti$
Mole	0.00882	0.02058	0.0294
M.W.	225.42	205.71	340.36
Weight (g)	2.25	4.23	-
Volume (ml)	-	-	10

Appendix C Glass Transition Temperature (T_g) of PBA-a Measured by Dynamic Mechanical Analysis (DMA)

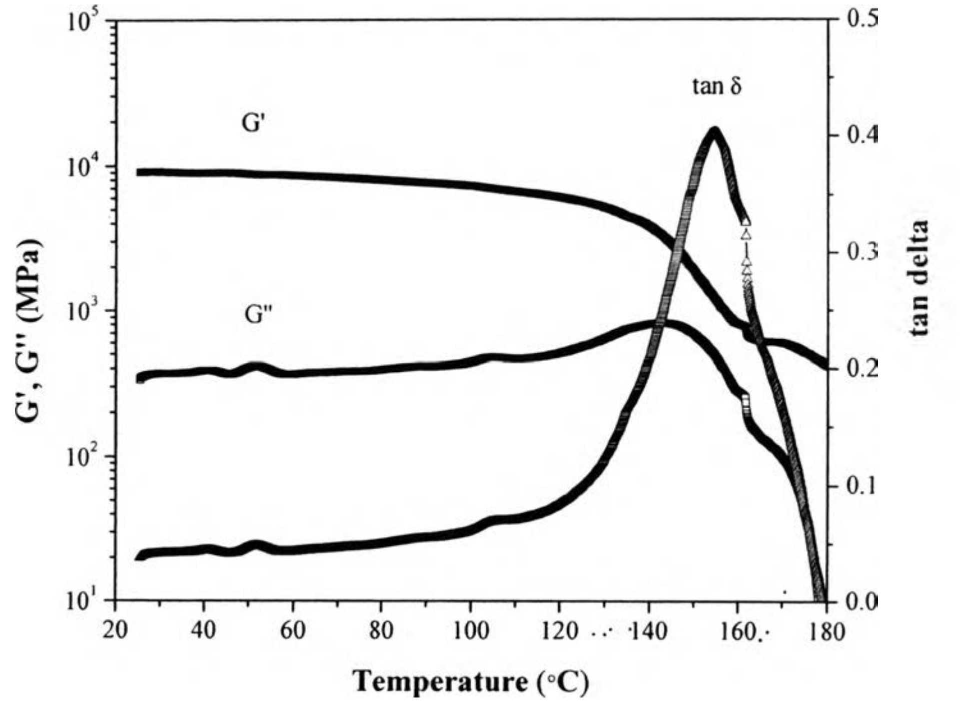


Figure C1 DMA analysis of aniline based polybenzoxazine.

Glass transition temperature (T_g) of aniline based polybenzoxazine and is detected at the maximum of the loss modulus, G'' which is around 144.2°C.

Appendix D Sol-Gel BST Powders Characterization

XRD charaterization

Table D1 The identification of XRD peaks analysis of the sol-gel $Ba_{0.3}Sr_{0.7}TiO_3$ powders calcined at 1000°C

2θ	θ	*hkl*
22.6	11.3	100
32.12	16.06	110
39.62	19.81	111
46.10	23.05	200
51.86	25.93	210
57.30	28.65	211
67.24	33.62	220

SEM micrograph

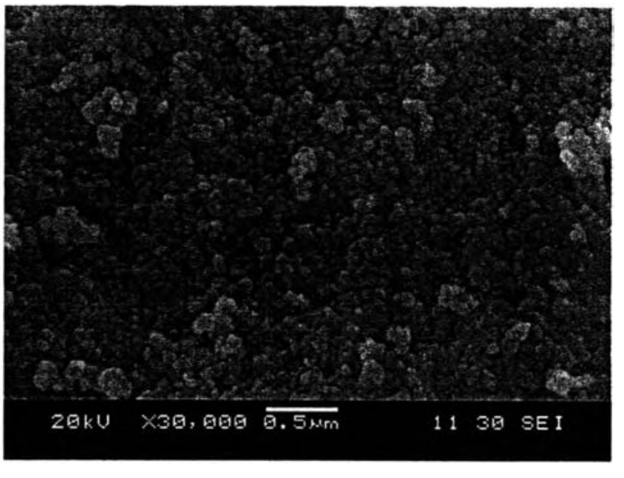


Figure D1 SEM micrographs of sol-gel $Ba_{0.3}Sr_{0.7}TiO_3$ powders calcined at 1000 °C for 80 min.

Appendix E Calculation of BST Volume Fraction in Composites

The volume fraction of BST was calculated by using the following formula:

$$f = \frac{\text{volume of BST powder}}{(\text{volume of BST powder} + \text{volume of BZZ powder})}$$

$$= \frac{(M_i/\rho_i)}{(M_i/\rho_i)+(M_h/\rho_h)}$$

where M_i and ρ_i (5.17 g/cm^3)are the mass and density of BST powder and M_h and ρ_h (1.23 g/cm^3) are those of benzoxazine monomer

Table E1 Volume fraction of BST powder at various BST wt% in the composites

Composites	Volume fraction
30 wt% BST	0.093
50 wt% BST	0.192
80 wt% BST	0.488

Appendix F The Dielectric Constant and Loss tangent at Different Frequencies

Table F1 The dielectric constant of polybenzoxazine and $Ba_{0.3}Sr_{0.7}TiO_3$ ceramic

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
PBA-a	4.95	4.67	4.43	4.22	4.11
PBA-f	4.55	4.14	4.07	3.97	3.97
BST ceramic	326	308	297	297	292

Table F2 The dielectric constant of untreated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	7.14	6.85	6.53	6.20	6.04
50 wt% BST	12.30	9.66	10.38	10.17	9.28
80 wt% BST	39.81	37.93	36.51	35.35	34.99

Table F3 The dielectric constant of silane treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	9.80	9.47	9.17	8.86	8.71
50 wt% BST	12.82	12.67	12.50	11.98	9.65
80 wt% BST	42.39	40.75	41.06	40.39	40.5

Table F4 The dielectric constant of benzoxazine monomer treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	6.02	5.96	5.88	5.81	5.80
50 wt% BST	11.54	11.08	10.25	10.06	8.57
80 wt% BST	39.49	39.04	38.59	38.02	37.97

Table F5 The dielectric constant of phthalocyanine treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	7.05	6.88	6.47	6.13	5.96
50 wt% BST	11.73	11.26	10.49	10.14	8.74
80 wt% BST	39.65	39.14	38.61	37.95	37.86

Table F6 The loss tangent of polybenzoxazine and $Ba_{0.3}Sr_{0.7}TiO_3$ ceramic

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
PBA-a	0.0564	0.0348	0.0289	0.0242	0.0233
PBA-f	0.0091	0.0050	0.0075	0.0074	0.0126
BST ceramic	0.3570	0.0763	0.0224	0.0126	0.0451

Table F7 The loss tangent of untreated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	0.0578	0.0383	0.0363	0.0297	0.0272
50 wt% BST	0.01	0.0484	0.0195	0.0427	0.0978
80 wt% BST	0.118	0.0606	0.0264	0.0346	0.123

Table F8 The loss tangent of silane treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	0.0564	0.0348	0.0289	0.0242	0.0233
50 wt% BST	0.0118	0.0087	0.0181	0.0383	0.0427
80 wt% BST	0.0517	0.0446	0.0277	0.0312	0.0624

Table F9 The loss tangent of benzoxazine monomer treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	0.0035	0.0097	0.0119	0.0127	0.0166
50 wt% BST	0.0095	0.0188	0.0348	0.0219	0.0451
80 wt% BST	0.02	0.0447	0.0209	0.0306	0.0534

Table F10 The loss tangent of phthalocyanine treated BST– polybenzoxazine composites

Materials	Frequency (Hz)				
	10^3	10^4	10^5	10^6	10^7
30 wt% BST	0.0325	0.0087	0.0155	0.0155	0.0155
50 wt% BST	0.0128	0.007	0.0109	0.0304	0.0351
80 wt% BST	0.0632	0.0406	0.0203	0.0189	0.0527

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Proceedings:

1. Krueson, N., Laoratanakul, P., Ishida, H., and Manuspiya, H. (2008, April 23) High Dielectric Composite Material at Multi-Frequency Range. Proceedings of the 14th PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.
2. Krueson, N., Laoratanakul, P., Ishida, H., and Manuspiya, H. High Dielectric Composite Material at Multi-Frequency Range. Advanced Materials Research (accepted).

Presentations:

1. Krueson, N., Ishida, H., and Manuspiya, H. (2008, April 6-10) Dielectric Properties of Surface Treated BST Powder-Polybenzoxazine Composite. Poster presented at the 235th American Chemical Society Conference, New Orleans, USA.
2. Krueson, N., Laoratanakul, P., Ishida, H., and Manuspiya, H. (2008, April 23) High Dielectric Composite Material at Multi-Frequency Range. Poster presented at the 14th PPC Symposium on Petroleum, Petrochems, and Polymers, Bangkok, Thailand.
3. Krueson, N., Laoratanakul, P., Ishida, H., and Manuspiya, H. (2008, April 22-25) High Dielectric Composite Material at Multi-Frequency Range. Poster presented at Smartmat-'08 & IWOFM-2, Chiang Mai, Thailand.