

Supporting Information for

Discovering the potential of algae-derived renewable phloroglucinol epoxy compared to diglycidyl ether of Bisphenol-A in laminating resin systems

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1. Experimental

1.1 Materials

Phloroglucinol Tris Epoxy (PHTE) was obtained from Specific Polymers. 1,2-Epoxy-3-phenoxypropane was purchased from Sigma Aldrich. HEXFORCE 7581 glass fibre satin weave was employed as reinforcing fibre. Epikure 04908 (Hexion) linear amine curing agent was chosen as a hardener. Epikote/Epikure04908 system was used for the manufacturing of a reference resin and composite structure. Marbocote 227, sealant type Cytec LTS90B/G, Wrightlon 8400 nylon film from Airtech and Stich Ply A peel ply from MCTechnics were used for composite manufacturing.

1.2 Preparation of the Mixtures

Based on ¹H-NMR, an estimate of epoxy equivalent weight (EEW) of 112 g/mol of the PHTE and the AEW of 50 for the hardener a mixture ratio of 2:1 was used for the generation of the resin system. The resin was mixed at room temperature. The resin quantities depended in the application while considering the critical mixing mass. Given the viscosity of the mixed resin at room temperature, the use of reactive diluent (1,2-Epoxy-3-phenoxypropane) was investigated and 10 wt.% addition was employed through the study. For benchmark resin system, EPR 04908 100 parts by weight was mixed with EPH 04908 30 parts by weight. To generate a fair comparison, 10 wt.% reactive diluent was added to Epikote/Epikure 04908 system. All resin-composite specimen to collect data includes 10 wt.% reactive diluent in formulation.

1.3 Resin Characterization Techniques

NMR Spectroscopy

¹H-NMR and ¹³C-NMR measurements were collected on a 400MHz Agilent NMR in CDCl₃ solvent with 8 scans. Data was processed using MestReNova.

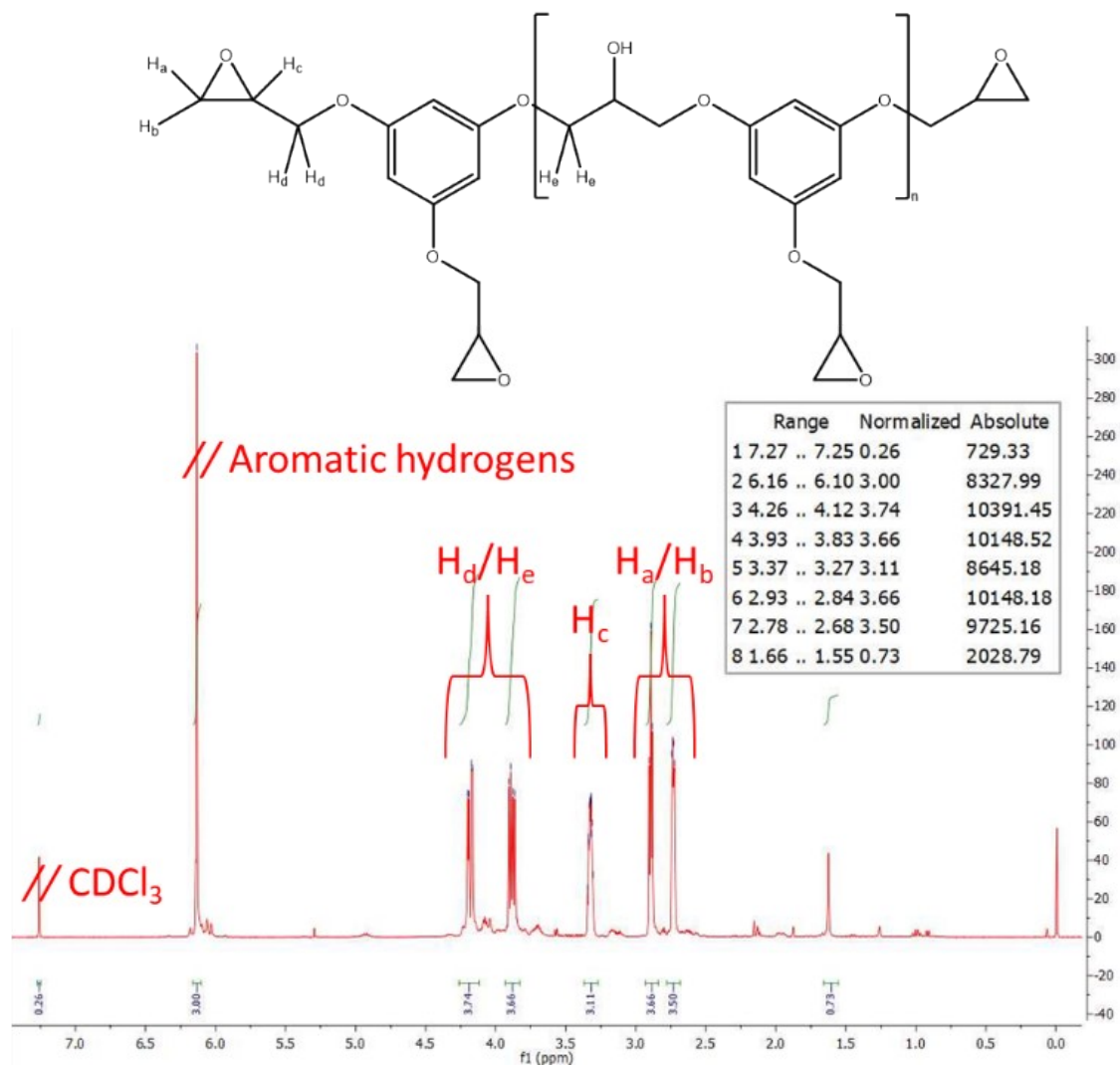


Figure S1. ¹H-NMR spectrum of PHTe monomer.

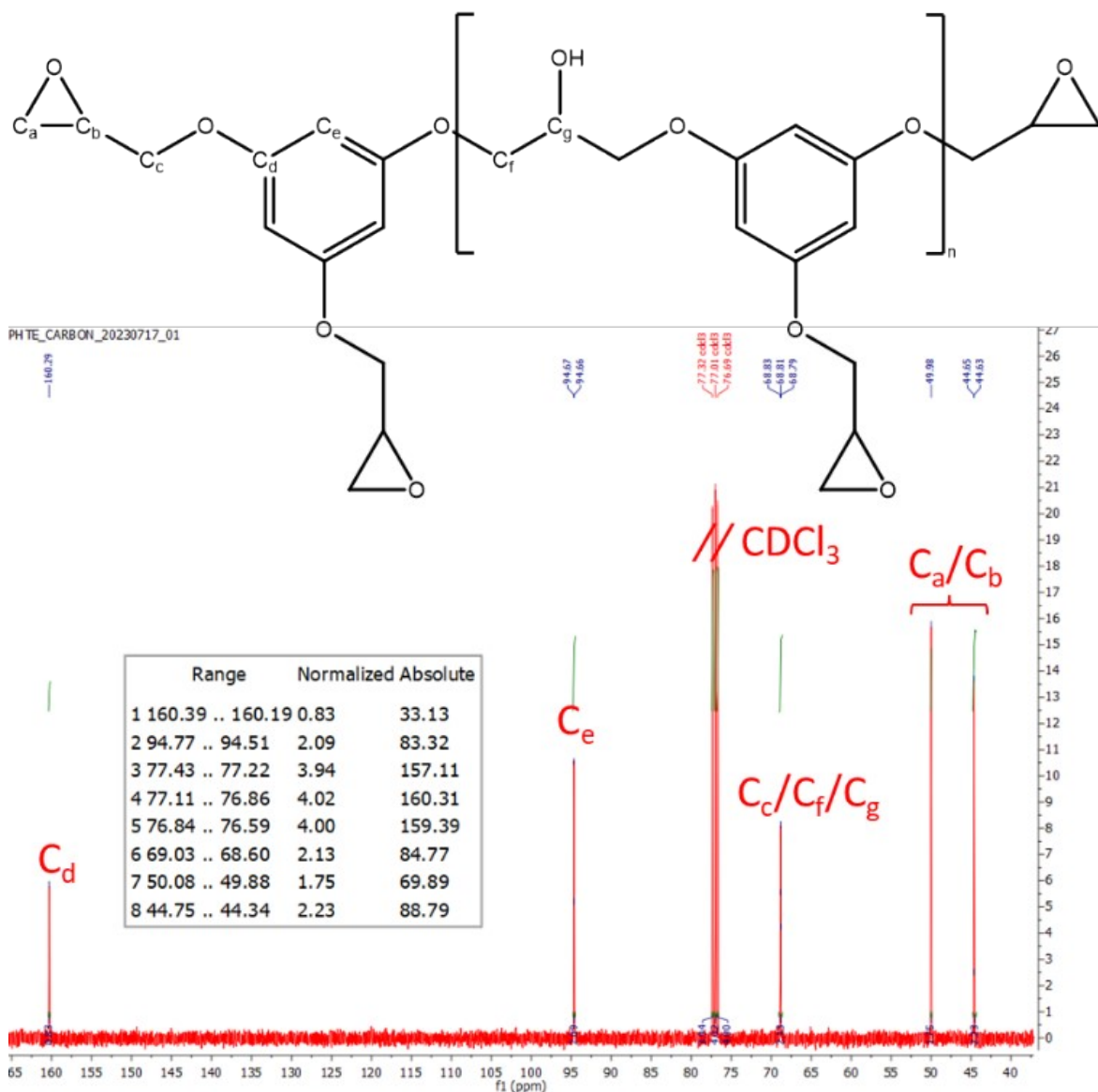


Figure S2. ¹³C-NMR spectrum of PHTe monomer.

FT-IR Spectroscopy

A Spectrum 100 Optica FT-IR Spectrometer with an attenuated-total-reflectance accessory with a diamond crystal was used. The range used for the recorded FTIR spectra was 4000 to 550 cm⁻¹ with a resolution of 1 cm⁻¹ and 16 scans. Liquid samples were placed on the crystal and measurements taken. Solid samples were ground in a pestle and mortar and clamped in place before measurements were taken. Data was processed using Origin software.

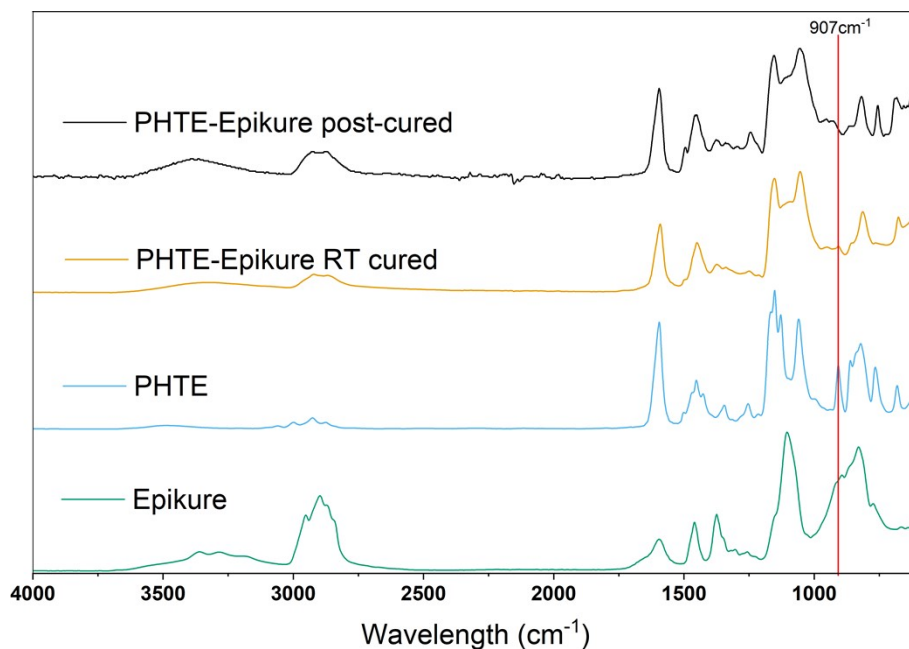


Figure S3. FT-IR spectra of PHTE, Epikure and PHTE-Epikure cured resin systems.

Differential Scanning Calorimetry

DSC was collected on a TA instruments mDSC 250. One master batch of PHTE:Epikure in 2:1 ratio was made mixing 1017.9 mg PHTE with 504.2 mg Epikure and 150 mg reactive diluent stirred for 2 minutes until mixture was homogenous. The master batch was immediately placed at -25°C to quench the curing reaction, where DSC samples were then taken prior to measurement. Tests were performed in a range of $25^{\circ}\text{C} - 200^{\circ}\text{C}$ using various heating rates. The Kissinger model was used to derive the activation energy of the curing reaction. T_g analysis was performed on TRIOS software, E_a analysis was performed on Origin. Results are presented in Figure S4.

Table S1. Details on DSC experiments.

Heating rate (C/min)	2.5	5	7.5	10
Sample mass (mg)	7.2	6.0	8.0	7.6

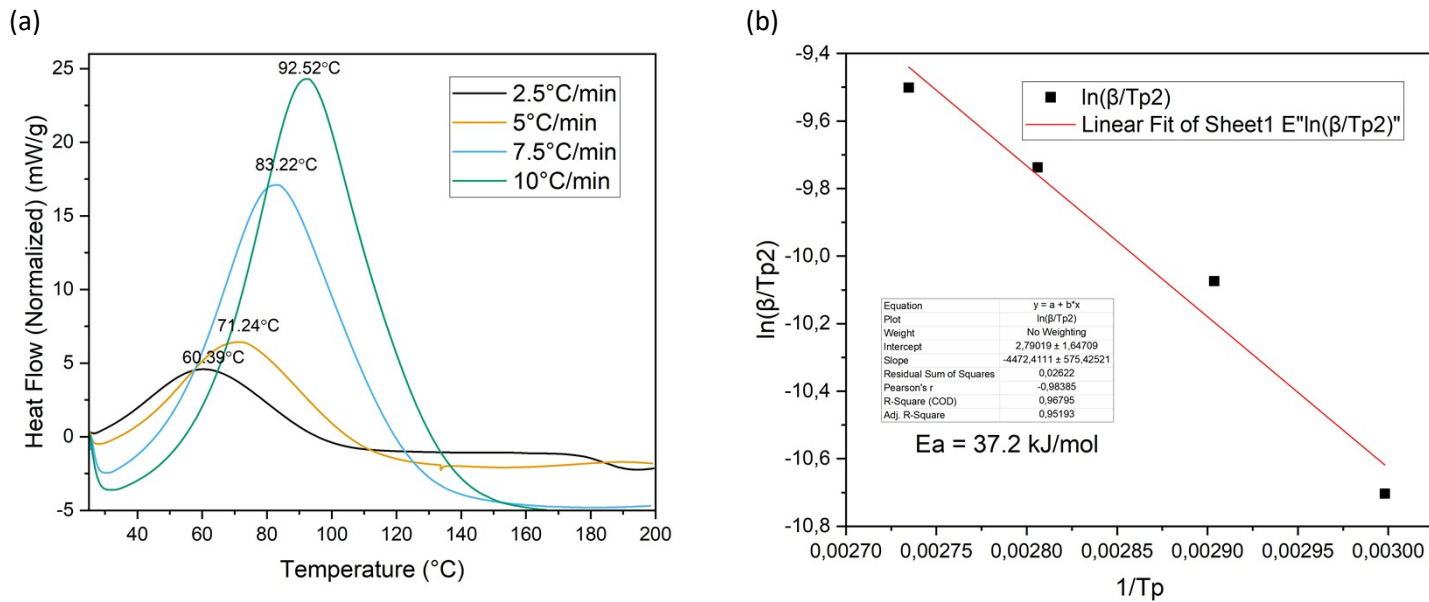


Figure S4. (a) DSC runs for PHTE-Epikure mix in 2:1 ratio at different heating rates and (b) Linear fit using Kissinger model to determine activation energy of the curing reaction.

Rheology

Rheology was performed on a HAAKE MARS III rheometer. All measurements were performed using a resin recipe described above. The viscosity at RT vs time experiment was performed in CS rotational mode with a shear stress (τ) of 1 Pa. The PHTE viscosity vs temperature experiment was performed in CR rotational mode with a rotation of frequency of 1 Hz. The curing behaviour of PHTE-Epikure was performed in CD oscillation mode with a deformation (γ) of 5% and frequency of 1 Hz.

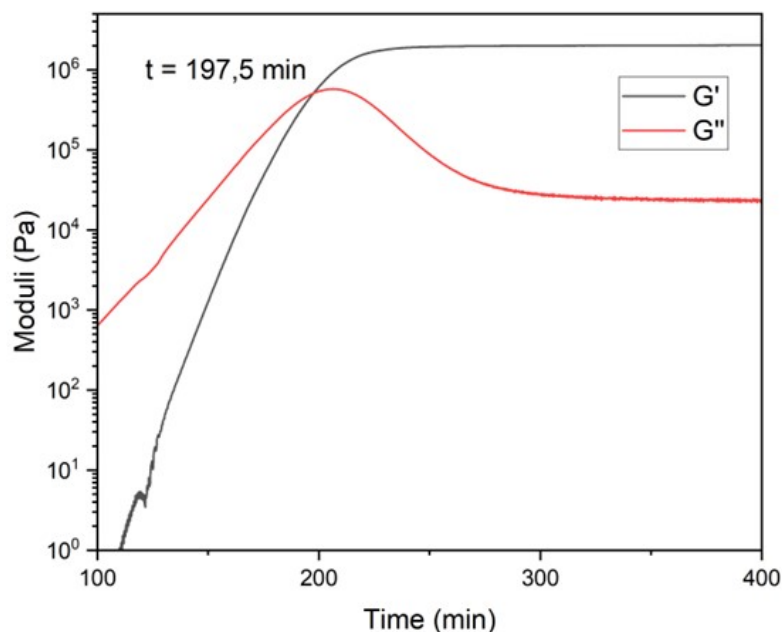


Figure S5. Storage (G') and Loss (G'') moduli of PHTE-Epikure 2:1 mix overtime, showing a gel time of 197.5 minutes.

Thermogravimetric Analysis

The thermal stability of the mixture, resin, and manufactured composite was studied through thermogravimetric analysis (TGA) using Perkin Elmer TGA 4000 Thermogravimetric Analyzer. All measurements were performed in inert atmosphere (N_2 at 20 mL/min). Samples with mass varying from 8 to 25 mg were degraded in a range from 25 to 900 °C with a heating rate of 10 °C/min. Once a temperature of 900 °C is reached, the temperature is held for 10 min. The data obtained by TGA were processed using Python and plotted using Origin software to determine the thermal stability and char yield of the resin. In Figure S6 TGA diagram of the PHTE resin system is provided.

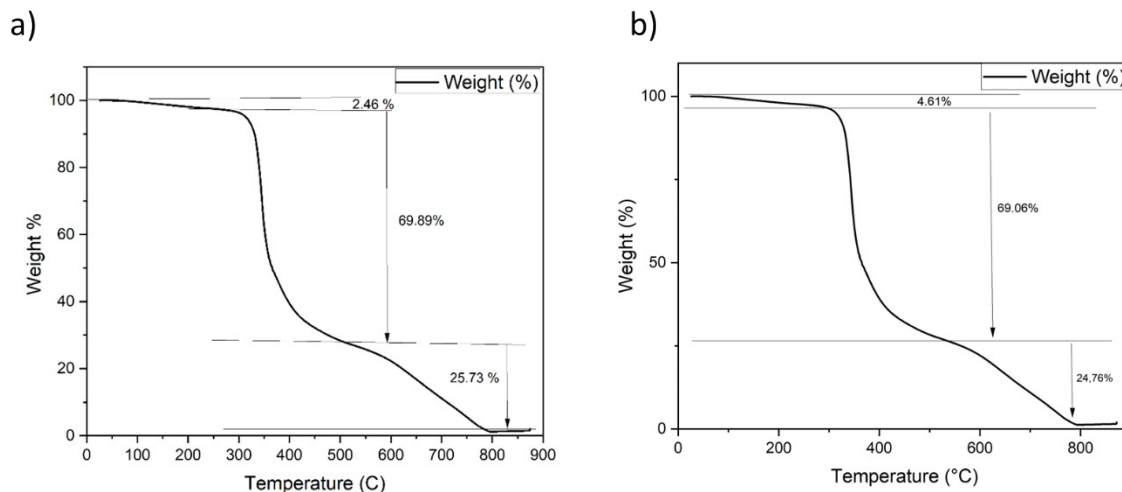


Figure S6. TGA diagram of a) cured PHTE-Epikure and b) cured Epikote-Epikure resins.

Dynamic mechanical analysis

DMA measurements were performed on a TA instruments RSA-G2 DMA using the single cantilever bending geometry. Experiments were conducted on the pure resin and the composite cured at RT for 24 h followed by a post-cure of 1 h at 140° C. Oscillatory experiments over temperature were performed from 25-180° C with a heating rate of 3° C/min, constant displacement of 7.5 μm, and frequency of 1 Hz. The samples used were resin fabricated from 2:1 PHTE:Epikure with 10 wt.% reactive diluent, cut to size using a diamond cutter, sanded to achieve flat edges, and finally post-cured at 140° C for 1h in an oven. Sample dimensions were 46.26 x 9.98 x 3.41mm for the resin sample and 39.09 x 12.14 x 2.30mm for the composite sample.

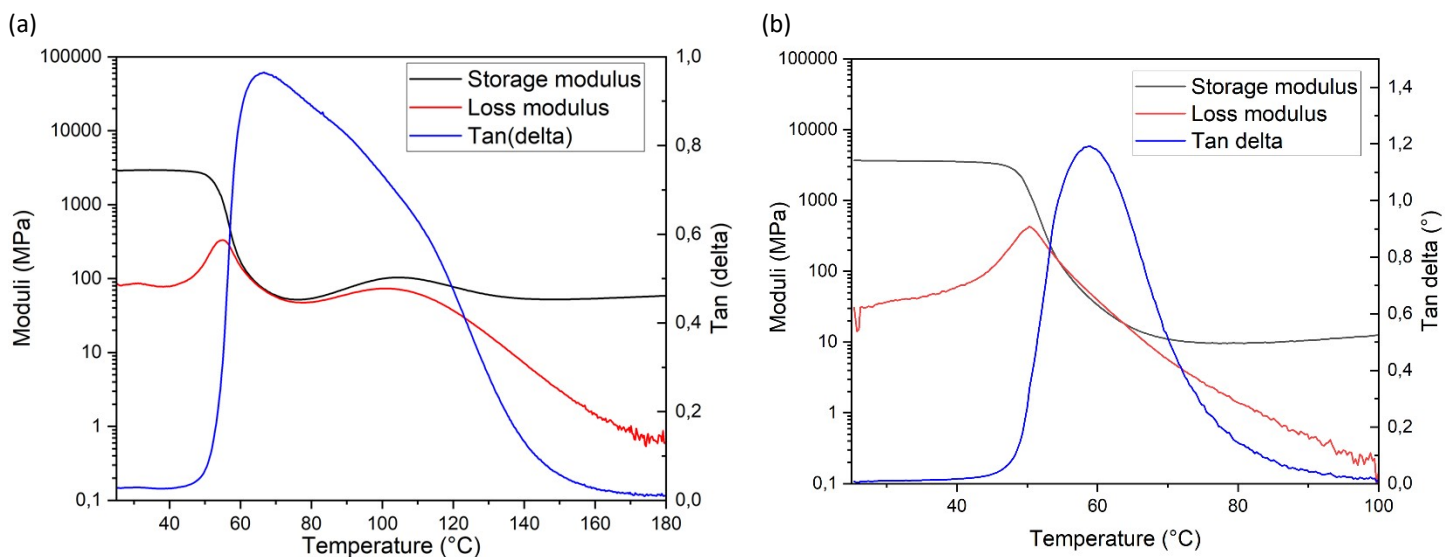


Figure S7. DMA curves of (a) pure resin (PHTE-Epikure with 10 wt.% reactive diluent) cured at RT (b) Epikure-Epikote resin with 10 wt.% reactive diluent) cured at 80°C.

Resin Mechanical Characterization

The mechanical properties of the resin were studied through mechanical testing, both flexural and tensile testing. “*Plastics-Determination of flexural properties*” - **ISO178**¹ and “*Standard Test Method for Tensile Properties of Plastics*”-**ASTM-D638**² were followed for the fabrication of samples and testing process. Five individual samples for each test were generated following the dimensions present in the standards. PHTE and Epikure0498 were mixed at a 2:1 ratio in the presence of 10wt.% of reactive diluent. Mixtures were degassed for 20 minutes to remove any volatiles and ensure that no voids would be present in the specimens, after which, they were poured into silicon moulds with the required shapes, that were manufactured following the dimension guidelines in the standards. The exact dimensions of the specimen can be seen in Table S2 and Table S3 . The samples were cured, and images of resin samples can be seen in Figure S8a-b. Optical inspection of the samples show

(a)

(b)

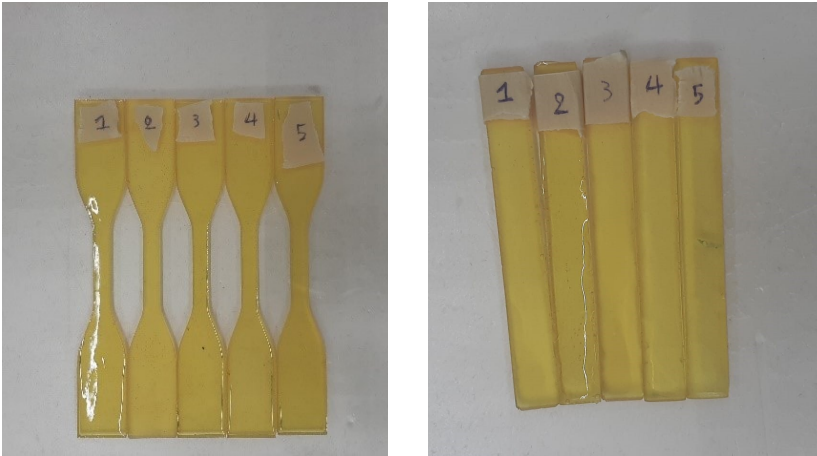


Figure S8. (a) Samples made for tensile testing of the resin (dog-bone shape) and (b) samples made for flexural testing of the resin.

Table S2. Resin flexural test specimen measured dimensions.

Sample	L (mm)	w (mm)	t (mm)	W (g)
FR1	79.8	20.0	4.1	3.7
FR2	79.7	9.90	4.1	3.6
FR3	80.0	10.0	4.2	4.0
FR4	79.9	9.8	3.8	3.4
FR5	79.9	9.8	4.0	3.2

Table S3. Resin tensile test specimen measured dimensions and remarks.

Sample	L (mm)	w1 (mm)	w (mm)	t (mm)	W (g)
TR1	129.2	6.1	18.8	4.0	8.3
TR2	129.6	6.1	18.9	3.9	8.3
TR3	129.3	6.1	18.9	3.9	7.9
TR4	130.2	6.1	18.8	4.0	7.6
TR5	129.2	6.0	18.8	3.9	8.0

For both tests Zwick and Roell 20 kN tensile machine was used. For the tensile testing, a 2 kN head was mounted as the expected load exceeded 1 kN. The speed was set to 1 mm/min and an extensometer was placed in the gage of the dog-bone structure as seen in Figure S9a. In the case of the flexural testing the 1 kN load cell was mounted on the machine and the sample was placed on the three-point-bending fixture a loading edge radius and support radiuses of 5 mm as seen in Figure S9b. A compliance test with a steel specimen was run to determine the machine error. The speed of the head was set to 1 mm/min. To ensure that the extensometer would not be damaged during the fracture of the specimens it was being removed from the sample once 60%

of the expected maximum force was reached. From the five tests the average was taken to determine the flexural and tensile properties of the corresponding sample. In the case of the tensile tests, failure at the grip was observed, due to the clamp force, at two out of the five specimens and namely of specimen 3 and 5. The failed samples were investigated to determine whether or not failure occurred due to the surface quality; remarks during manufacturing showed that the surfaces were both plane and parallel. In the case of sample 3 it was seen that a small piece of the failed specimen 2 was left inside the clamp, which when in contact with sample 3, it could potentially induce high stresses and led to failure of sample 3. The failed specimen can be seen in Figure S9c. The data obtained through those specimens could not be used for the determination of the tensile strength and modulus of the resin. Table S4 and S5 summarizes flexural and tensile test results of resin.

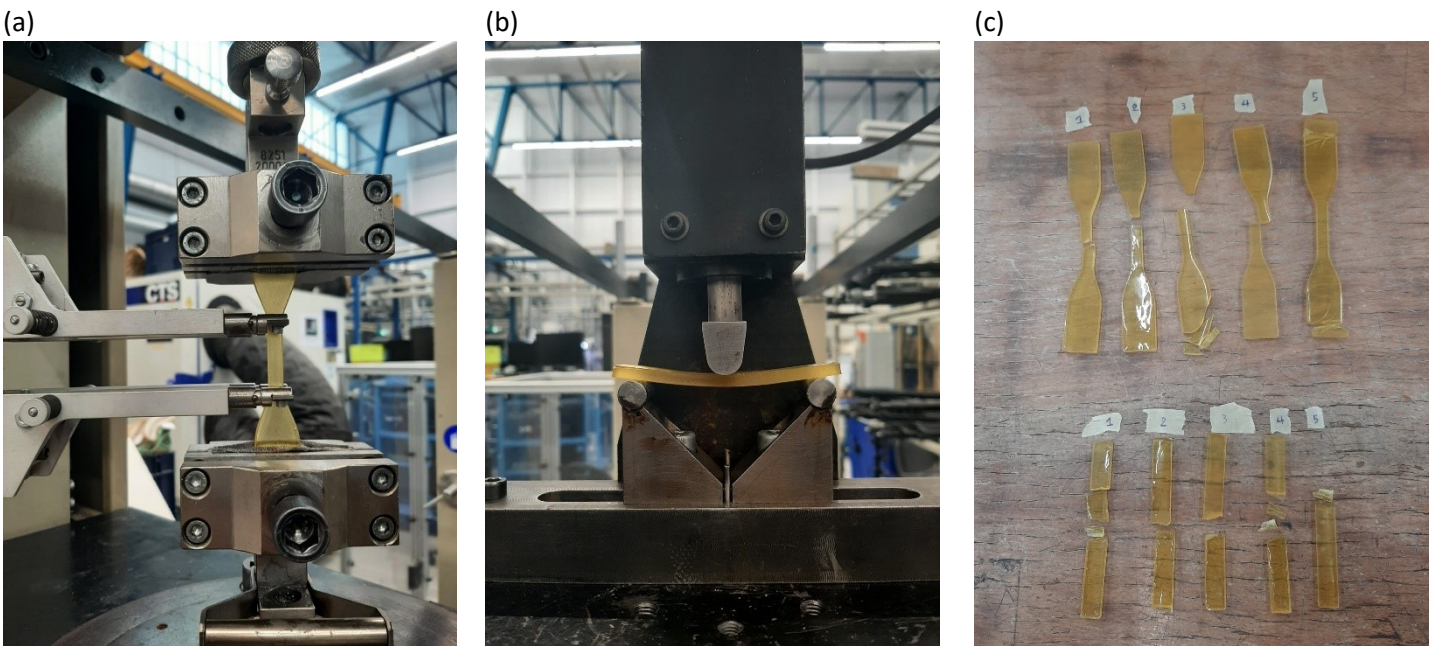


Figure S9. Digital images of mechanical tests and specimens, (a) Tensile testing of resin, (b) Flexural testing of resin, (c) Tensile and flexural specimens after failure.

Table S4. Results of Flexural testing of PHTE resin.

Sample	Maximum Force (N)	Flexural Strength (MPa)	Flexural Modulus (MPa)
FR1	167	94	4011
FR2	127	70	3671
FR3	197	92	4070
FR4	130	85	3559
FR5	101	59	2803
Average (MPa)	144	80	3622
Standard Deviation (MPa)	38	15	507

Table S5. Results of Tensile testing of PHTE resin.

Sample	Maximum Force (N)	Flexural Strength (MPa)	Flexural Modulus (MPa)	Tensile Strain (%)
TR1	1405	59	3910	2.71
TR2	1188	50	3688	2.63
TR4	1408	59	4231	2.01
Average (MPa)	1334	56	3943	2.45
Standard Deviation (MPa)	126	5	273	0.37

Theoretical and Actual Density Determination

The density of both resin and composite were determined following the guidelines presented in “Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement”-**ASTM-D792**.³ Measurements were performed on three samples to obtain the average calculating the density following Archimedes principle:

$$\rho = \frac{A}{A - B}(\rho_o - \rho_L) + \rho_L \quad 1.1$$

Where:

A = Dry mass (mass of sample on air)

B = Wet mass (mass of sample in water)

ρ = Density of sample

ρ_o = Density of auxiliary liquid depending on the temperature of the liquid

ρ_L = Density of air taken as 0.0012 g/cm³

Similarly, the theoretical density, was determined using the masses of fibres and matrix through resin burn-off test following the guidelines described in “Standard Test Methods for Constituent Content of Composite Materials” - **ASTM-D3171**.⁴ The determined densities and the average of all the samples for both the resin as well as composite are summarised in Table S6. A detailed description of the manufacturing of the composite is given in the next section.

Table S6. Density determination or resin and composite taking density of air as 0.0012.

Sample	Auxiliary liquid Temperature (°C)	Auxiliary liquid density (g/cm ³)	Dry weight A (g)	Wet weight B (g)	Density (g/cm ³)
Resin					
R1	22.2	0.9975	0.38	0.06	1.19
R2	20.6	0.9981	0.54	0.09	1.20
R3	20.6	0.9981	0.69	0.11	1.20
Average					1.20
Composites					
C1	22.8	0.9976	1.32	0.58	1.78
C2	20.6	0.9981	1.06	0.46	1.77
C3	20.6	0.9981	1.02	0.44	1.76
Average					1.77

Gel Content Determination (GC %)

ASTM D2765⁵ ‘Standard Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics’ was used for the determination of the gel content of the PHTE resin and composite. Samples of resin and composite were submerged into toluene for 72 h after which they were removed, dried using filter paper-compressed air and weighed. The gel content was calculated using the following equation :

$$GC\% = \frac{W_f}{W_0} * 100$$

Where :

W_f = Mass of dried samples after toluene immersion

W_0 = Initial mass of the sample before immersion

The obtained percentage decrease for each sample can be seen in Table S7. The percentage decrease of the weight corresponds to the gel content of the structure.

Table S7. Gel Content of PHTE resin and composite.

Sample	Mass before Immersion (g)	Mass after immersion (g)	Percentage Decrease (%)
Resin			
Resin	0.3535	0.3515	0.99
Composite			
Composit	0.4241	0.4205	0.97

e			
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Water Absorbance & Water Contact Angle

Water affinity of resin and composite was investigated through swelling and water contact angle (WAC) tests. For the swelling test ‘*Water absorption of plastics*’-ASTM-D570⁶ standard test was used. Both resin and composite samples of varying mass from 0.3 to 0.5 g (W_0) were immersed in vials of distilled water and were left for 24 h, 48 h, 7 days (168 h) and 14 days (336 h) respectively. After that, the samples were removed from water, wiped with filter paper, and dried with compressed air, and weighed (W_D). Water absorption was calculated using:

$$WA\% = \frac{W_D - W_0}{W_0} * 100$$

Where:

W_D = Weight after submerging in distilled water

W_0 = Initial weight of the sample

The obtained percentage increase for each sample can be seen in Table S8. The percentage increase of the weight corresponds to the water absorption of the structure.

Table S8. Water absorbance experiment results on resin and composite samples.

Sample	Duration of test	Dry Mass (g)	Wet Mass (g)	Percentage increase (%)
Resin				
Resin 1	24 h	0.381	0.384	0.76
Resin 2	48 h	0.202	0.204	0.98
Resin 3	7 days	0.308	0.314	1.34
Resin 4	14 days	0.501	0.510	1.87
Composite				
Composite 1	24 h	0.346	0.349	0.98
Composite 2	48 h	0.348	-	-
Composite 3	7 days	0.361	0.376	3.95
Composite 4	14 days	0.481	0.5020	4.34

For water contact angle measurements, Attension Theta Optical Tensiometer by KSV Instruments was used. Five resin and five composite samples with flat surfaces were selected. A water droplet was placed on each surface and a digital image was captured. The captured image

was analysed with Attension Theta software and the left and right contact angle of the droplet with the structure was measured. Out of them the average was taken for each sample.

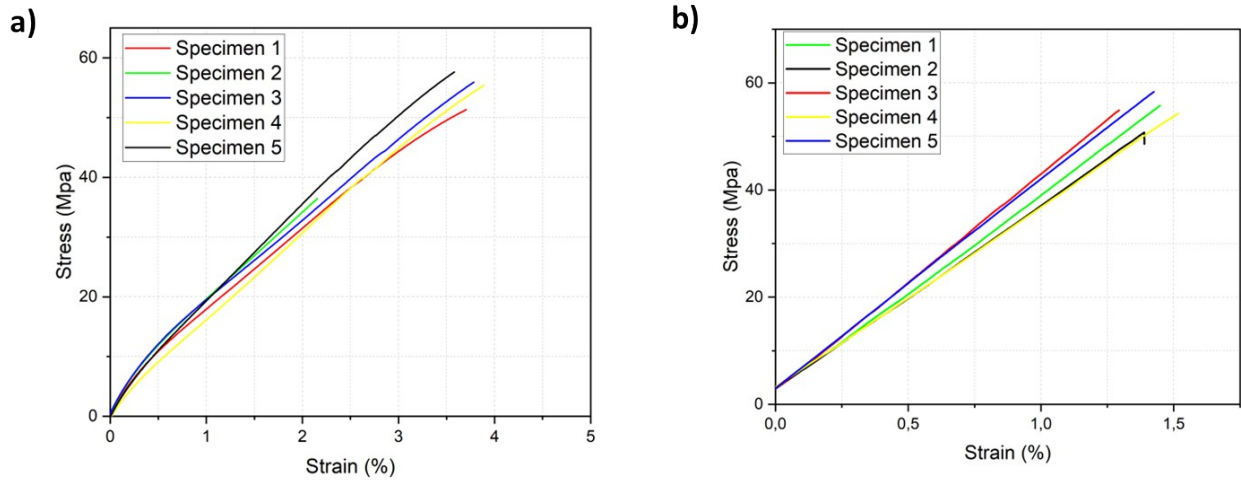
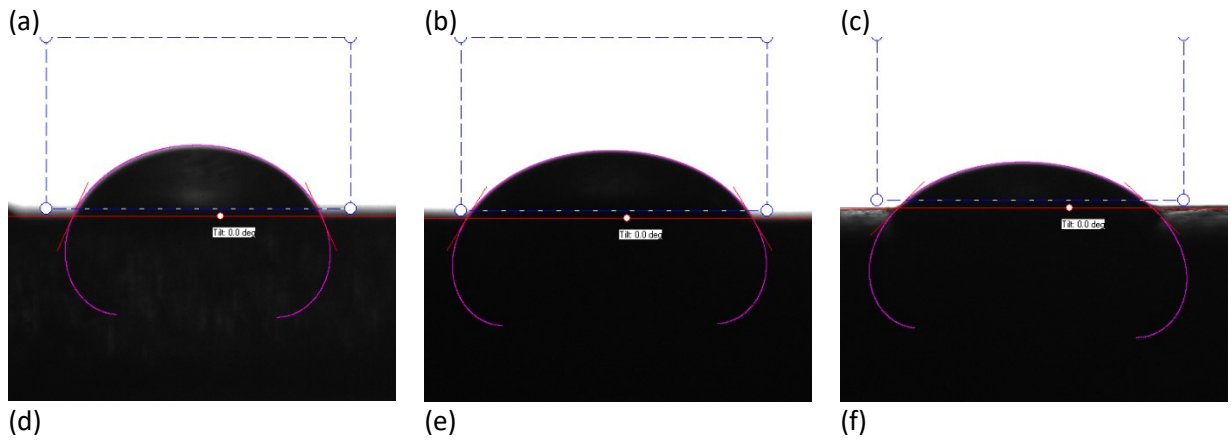


Figure S10. a) Tensile and b) flexural test results of Epikote-Epikure resin system (with diluent).



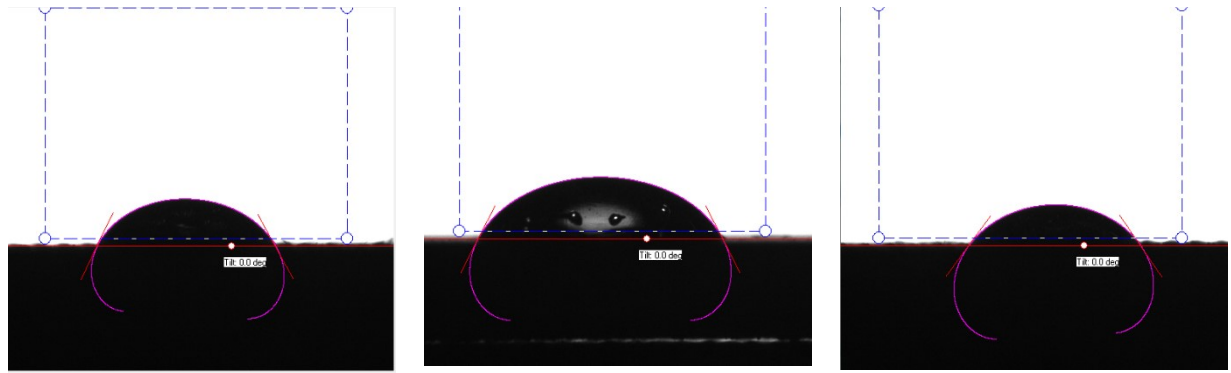


Figure S11. Water contact angle images corresponding to the resin (a) sample 4, (b) sample 3 and (c) sample 5 and composite sample 1 (d), sample 3 (e) and sample 4 (f).

Table S9. Water contact angles measured for both resin and composite.

Sample no	CA (Left)	CA (Right)	CA (Average)
Resin			
<i>Resin 1</i>	57.54	51.94	54.74
<i>Resin 2</i>	53.07	53.90	53.58
<i>Resin 3</i>	57.88	58.55	58.22
<i>Resin 4</i>	65.94	65.06	65.50
<i>Resin 5</i>	45.26	43.00	44.14
Composite			
<i>Composite 1</i>	62.63	62.63	62.63
<i>Composite 2</i>	43.21	43.95	43.58
<i>Composite 3</i>	59.20	55.63	57.41
<i>Composite 4</i>	53.72	55.33	54.52
<i>Composite 5</i>	64.23	60.93	62.58

2.3 Composite Manufacturing and Testing

Wet hand layup was used for the manufacturing of the composite using HEXFORCE 7581 glass fiber satin weave with $[0,90,0,90]_s$ layup. A 300x160 mm laminate was manufactured to get 5 tensile samples of 250 mm length and 25 mm width and samples for optical microscopy, SEM, DMA, swelling and resin ignition tests. Five buckets of 20 g PHTE, 10 g Epikure0498 and 3.3 g 1,2-Epoxy-3-phenoxypropane were prepared to avoid critical mass. The mixtures were degassed for 20 minutes to remove gases. With degassing finished, each layer was saturated with the resin, placed in a vacuum bag and left to cure at room temperature for 24 h after which post-curing took place at 140 C for 4 hrs. Manufacturing steps are provided in Figure S11.

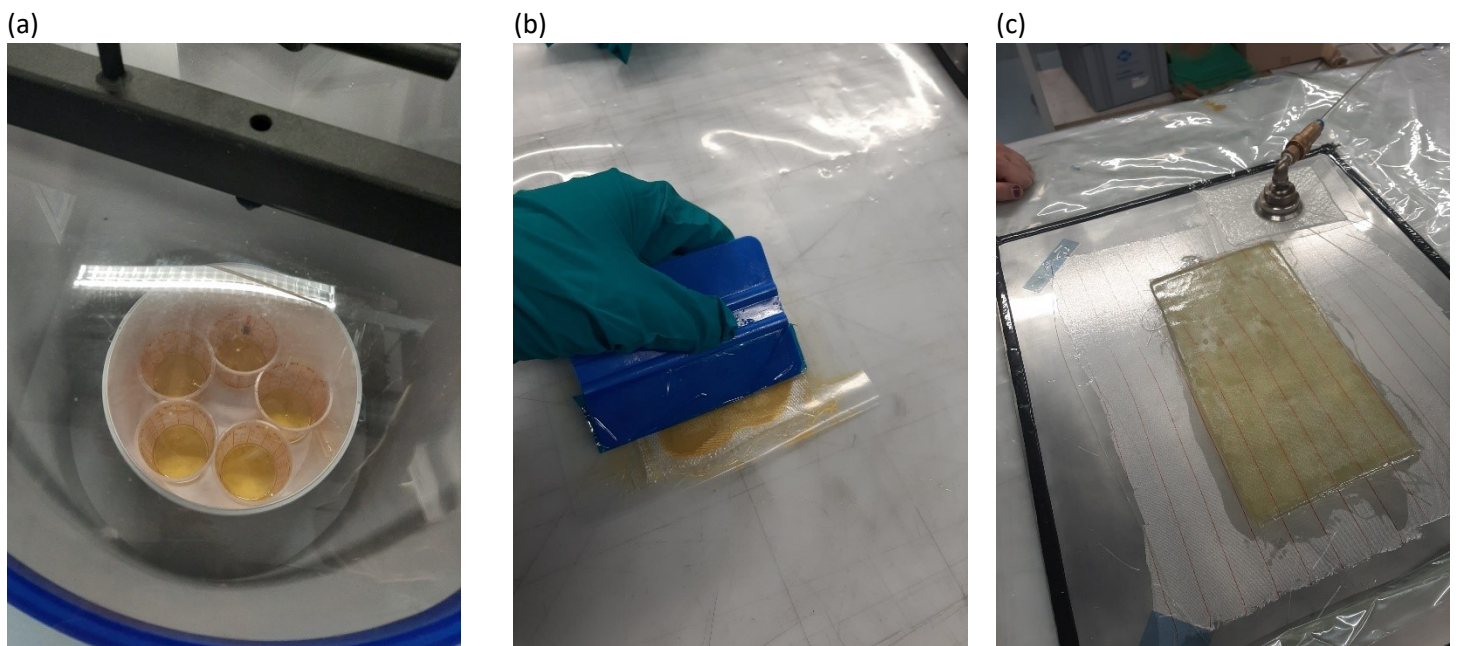


Figure S12. Initial tests of PHTE-based composite manufacturing; (a) degassing of resin in separate buckets to avoid critical mass leading self-initiated exothermic curing, (b) application of resin for saturation of reinforcements and (c) fibres saturated with resin under vacuum bag.

Constituent Content

The fibre, matrix and void content of the manufactured composites was determined following "Standard Test Methods for Constituent Content of Composite Materials" - **ASTM-D3171**⁴, through resin burn-off test through "Standard Test Method for Ignition Loss of Cured Reinforced Resins" - **ASTM-D2584**⁷ and "Standard Test Methods for Void Content of Reinforced Plastics" – **ASTM-D2734**.⁸ The mass of four samples of various weight (>1 g) was measured, after which, the samples were placed in crucibles and in a vacuum furnace at 595° C for 4 hours to fully remove the resin while ensuring that no ignition takes place. The weight of the samples is

measured again, corresponding to the mass of the reinforcement present in the composite. The different contents are then determined following Equation 1.2 to 1.4. The density of the reinforcement was taken as 2.7 g/cm³, of the matrix as 1.2 g/cm³ and of the composite as 1.7 g/cm³ from the measurements described above and shown in Table 1 .

$$V_f = W_{f\text{fraction}} \frac{\rho_c}{\rho_f} \quad (1.2)$$

$$V_m = W_{m\text{fraction}} \frac{\rho_c}{\rho_m} \quad (1.3)$$

$$V_v = 1 - (V_f + V_m) \quad (1.4)$$

The void content of the composite samples was also calculated for each of the samples by using ASTM-D2734 through the theoretical and the actual density of the composite using the following equations:

$$T = \frac{100}{\frac{R}{D} + \frac{r}{d}} \quad (1.5)$$

and

$$V = \frac{100(T_d - M_d)}{T_d} \quad (1.6)$$

Where:

T = theoretical density

R = Resin in composite, weight %

D = Density of resin

r = reinforcement in composite, weight %

d = density of reinforcement

V = void content, volume %

M = measured composite density

The calculated contents were verified through optical microscopy Keyence VK-X1000 3D Laser Scanning Microscope. Four composite samples taken from various locations of the laminate were embedded in Technovit® 4071 epoxy resin at standard mixing ratios and polished using 400, 800, 1200, 2400 and 3200 grit sandpaper for 2 minutes each time using a Tegramin-20 Grinding and polishing machine. Laser microscopy images were taken at 10x and 20x magnification scales and

were later analysed using ImageJ software with *voidContentMeasurement.ijm* macro for void content determination. In Figure S12 images taken at 10x magnification scale and the analysed images for the void determination can be seen.

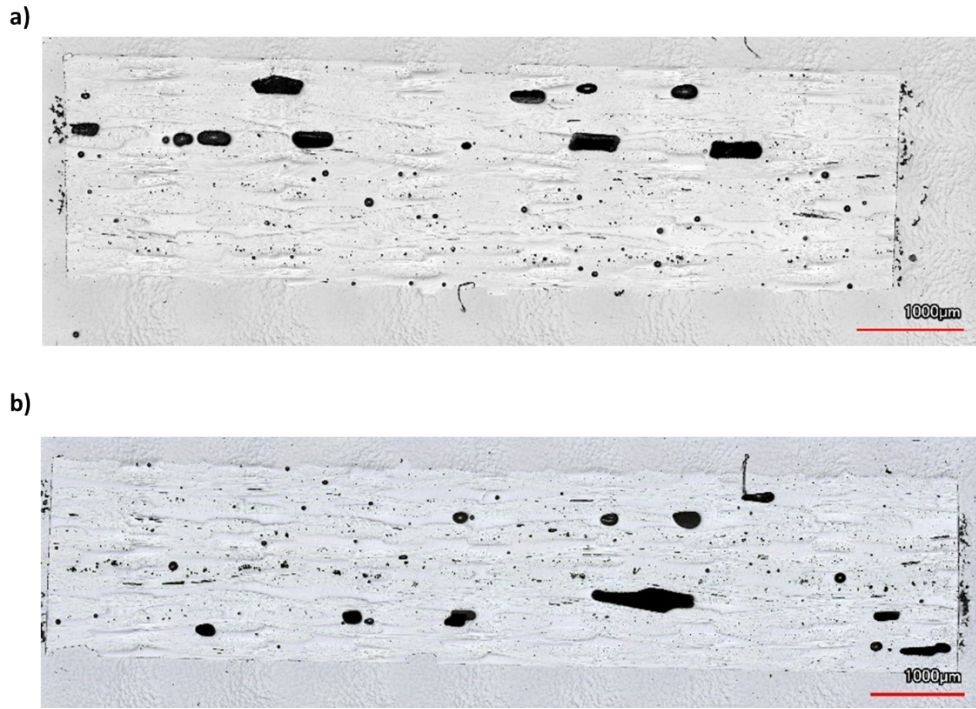


Figure S13. Optical microscopy images of (a) Epikote-Epikure based and (b) PHTE based composites.

The results of all the tests regarding the constituent contents of the laminate are summarised in Table S10.

Table S10. Fiber, Matrix and Void content obtained through Resin Burn-off test and through optical microscopy analysis for the PHTE-Epikote-1,2-Epoxy-3-phenoxypropane glass fibre composite.

							Fiber, Matrix and Void content through Resin Burn-off						
							PHTE-based Laminate				Epikure/Epikote-based Laminate		
Sample	Before Burnoff	After Burnoff					V _f	V _m	V _v (burnoff)	V _v (microscopy)	V _f	V _m	V _v
	Sample Mass (mg)	Dry Mass (mg)	W _m (mg)	W _{ff}	W _{mf}	T _d (g/cm ³)							
1	1518.8	994.4	524.4	0.65	0.34	1.48	0.42	0.50	0.08	0.04	0.45	0.43	0.12
2	1026.8	659.0	367.8	0.64	0.35	1.50	0.41	0.52	0.07	0.04	0.44	0.46	0.10
3	1067.5	691.8	375.7	0.64	0.35	1.49	0.42	0.51	0.07	0.04	0.43	0.47	0.10
4	890.9	588.6	302.3	0.66	0.33	1.48	0.43	0.50	0.07	0.05	0.44	0.46	0.10

Average						1,49	0.42	0.51	0.07	0.04	0.44	0.45	0.11
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Scanning Electron Microscopy

The voids, fibres and fibre-matrix adhesion was investigated using a JSM-7500F Scanning Electron Microscope. The sample was the same sample used for laser microscopy. Images obtained through SEM can be seen in Figure S13. In image (a) a location of an air bubble is seen. In images (b),(c) & (d) voids around bundles of fibers or individual fibres are shown.

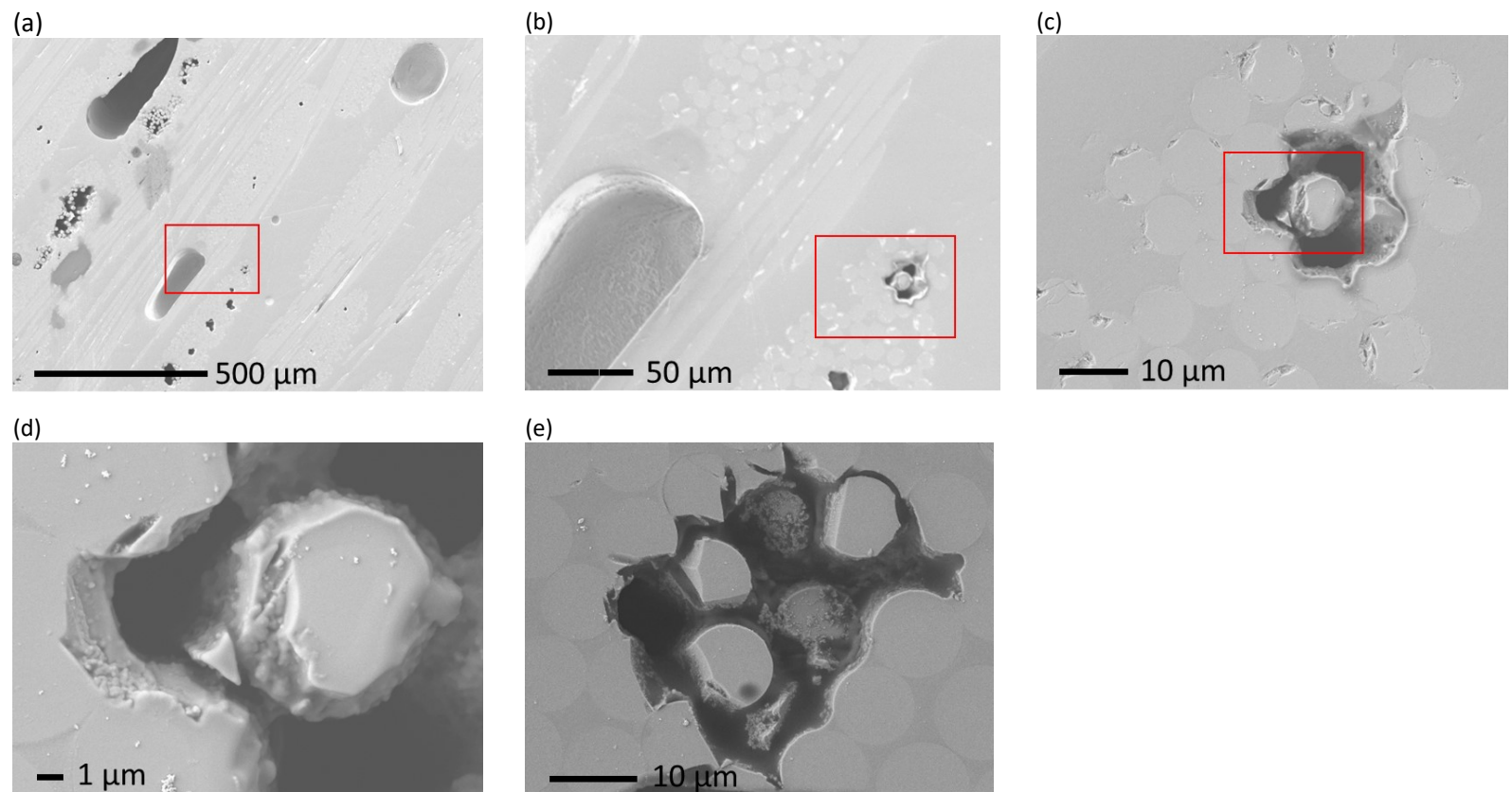


Figure S14. SEM images of PHTe-Epikure glass fibre composite focussing on voids (broken fibres in image e is attributed to defects during sample cutting).

Mechanical testing of composite

The mechanical properties of the composite were studied through tensile testing. The main aim of the tests was to determine whether the manufactured composite would follow the expected failure modes “*Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials*” - **ASTM-D3039-08**⁹ were followed for the creation of the samples and the testing

process. Five tensile specimens were obtained by each of the laminates that were manufactured based on PHTE and Epikure/Epikote04908 using Proth PSG following the dimensions and techniques mentioned in the standard. The exact dimensions of the specimen can be seen in Table S11.

Table S11. PHTE-based and Epikure04908-based tensile test specimens' measured dimensions.

PHTE/Epikure04908			
Sample	Width (mm)	Thickness (mm)	L (mm)
1	24.91	2.05	250.00
2	24.94	2.02	250.00
3	24.90	1.92	250.00
4	24.86	1.83	250.00
5	24.89	1.97	250.00
Epikote/Epikure04908			
Sample	Width (mm)	Thickness (mm)	L (mm)
1	24.89	2.03	250.00
2	24.86	2.10	250.00
3	24.87	2.01	250.00
4	24.83	2.23	250.00
5	24.84	2.06	250.00

Composite Specimens

For both tests of the PHTE and the Epikote based composites Zwick and Roell 250 kN tensile machine was used. The speed of the head was set to 2 mm/min and an extensometer was placed on the structure as seen in Figure S14a and b. Once again, to ensure that the extensometer would not be damaged during the fracture of the specimens it was being removed from the sample once 60% of the expected maximum force was reached. From the five tests of each of the two composites, the average was taken to determine the tensile properties. In the case of the PHTE laminate slipping was observed in the 5th specimen so the results that specimen were not considered for the determination of the properties. In Table S12 the mechanical properties obtained for both the Epikote and the PHTE based composite are summarised.

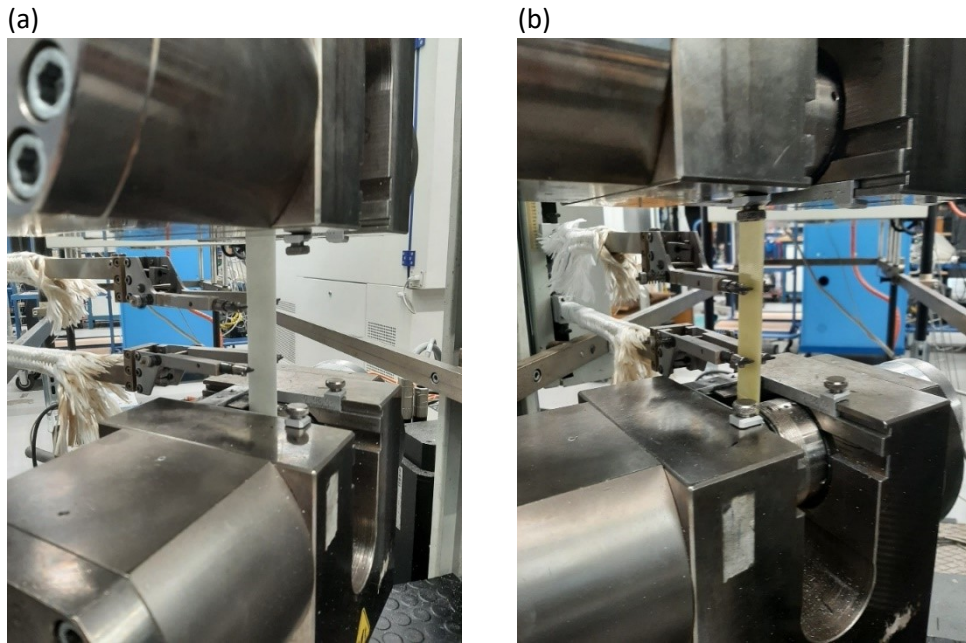


Figure S15. (a) Epikote/Epikure04908 tensile sample, (b) PHTE/Epikure04908 tensile sample.

In order to compare the properties of the obtained laminates, the tensile strength and the tensile modulus had to be normalized based on a common fiber volume fraction of 60 % following the following equation:¹⁰

$$\text{Normalized value} = \text{Test Value} * \frac{F V_{\text{normalizing}}}{F V_{\text{specimen}}}$$

Where :

$F V_{\text{normalizing}}$ = chosen common fiber volume (volume fraction or %)

$F V_{\text{specimen}}$ = chosen common fiber volume (volume fraction or %)

Table S12. Mechanical properties of PHTE and Epikote based laminate obtained through Tensile Testing.

	Strain (-)	Tensile Strength (MPa)	Normalized Tensile Strength for 60% volume content (MPa)	Tensile Modulus (GPa)	Normalized Tensile Modulus for 60% volume content (GPa)	Maximum Force (kN)
PHTE 1	0.01691	269	318	24	34	11.2
PHTE 2	0.01347	223	319	24	34	13.4
PHTE 3	0.02106	338	482	27	39	16.9
PHTE 4	0.02327	339	484	28	40	17.0
PHTE 5	0.02151	231	330	26	37	11.6
Average PHTE (MPa)	0.019244	292	387	26	37	14.6
Standard Deviation PHTE (MPa)	0.00398	57	79	2	2,5	
	Strain (-)	Tensile Strength (MPa)	Normalized Tensile Strength for 60% volume content (MPa)	Tensile Modulus (GPa)	Normalized Tensile Modulus for 60% volume content (GPa)	Maximum Force (kN)
Epikure 1	0.01491	237	323	22	33	11.80
Epikure 2	0.01566	244	333	21	32	12.20
Epikure 3	0.01964	295	402	23	35	14.70
Epikure 4	0.01596	242	330	19	29	12.10
Epikure 5	0.01388	216	295	21	32	10.80
Average Epikure (MPa)	0.01601	247	337	21	32	12.32
Standard Deviation Epikure (MPa)	0.00218	29	35	1.7	2	1.44

Table S13. Properties of Epikote-Epikure04908 resin (without diluent) as reported in supplier database.

Property	Unit	Epikote-Epikure resin
Density	g/cm ³	1.15
Tensile Strength	MPa	74
Tensile Strain	%	9.4

Tensile Modulus	MPa	2900
Flexural Strength	MPa	112
Flexural Modulus	MPa	3100
Water absorption	%	0.18
T_g	°C	89

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