

## **Supporting Information**

### **PLA matrix composites reinforced with diatomaceous earth**

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## Experimental section

### *True density*

The true density has been measured using a micromeritics AccuPyc II 1340 Gas Pycnometer (accreditation No. AB 1503: from 0.7 cm<sup>3</sup> to 7 cm<sup>3</sup>) using a Boyle's law as below (1):

$$V_S = V_C - \frac{V_E}{P_1 P_2 - 1} \quad (1)$$

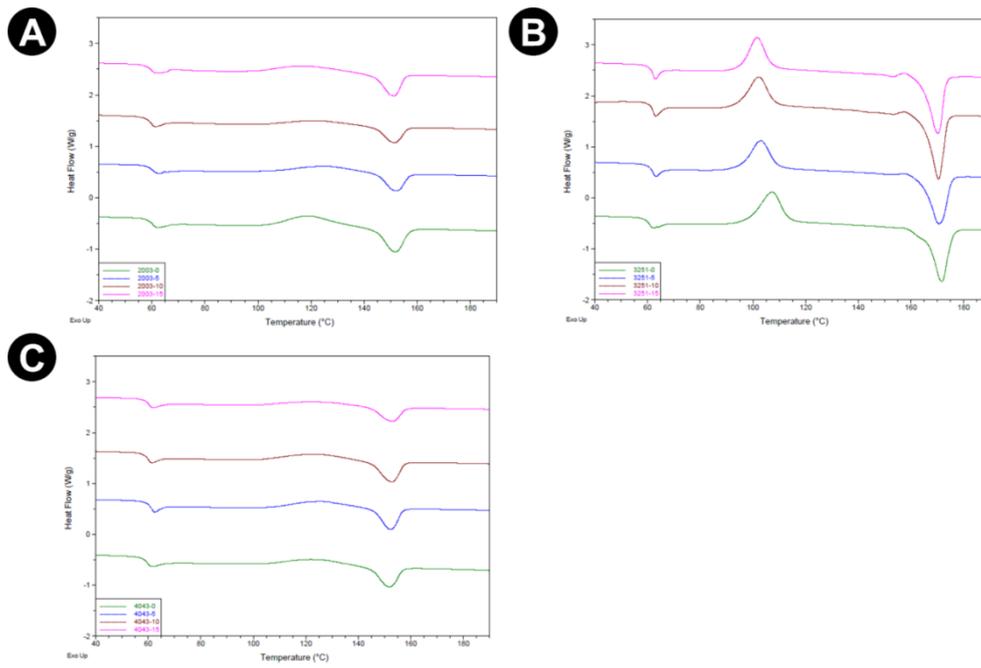
where  $V_S$  is the volume of the sample,  $V_C$  is the volume of the sample's cell, and  $V_E$  is the volume of the expansion cell. After that, the true density of the sample was calculated by using the formula (2):

$$\rho_t = \frac{m}{V_S} \quad (2)$$

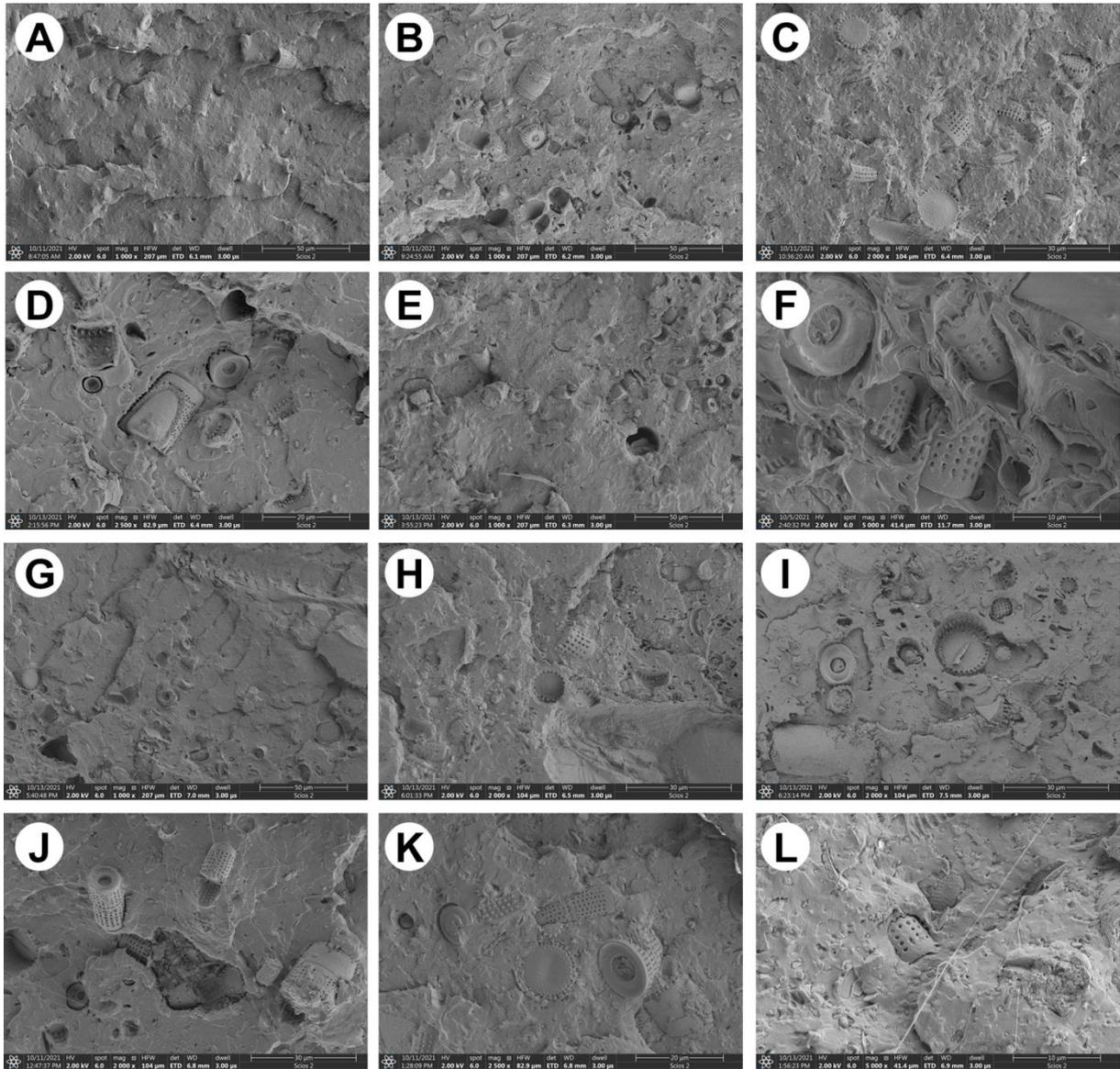
where  $\rho_t$  is the true density and  $m$  is the mass of the sample. As for the true density, it measures just the volume of the solid materials and excludes the volume of all open pores. The experiments have been conducted in the atmosphere of the inert gas - helium (purity  $\geq 99.999\%$ ). The analysis was carried out with the usage of the FoamPyc V1.06 software.

The obtained results are presented in Table S1. The measurement uncertainty was determined in accordance with the document EA-4/02 M:2013. The given uncertain values represent the expanded uncertainties with a coverage probability of approx. 95% and a coverage factor  $k = 2$ . The expanded uncertainty was determined in accordance with the procedure P5.12 and with the document EA-4/16.

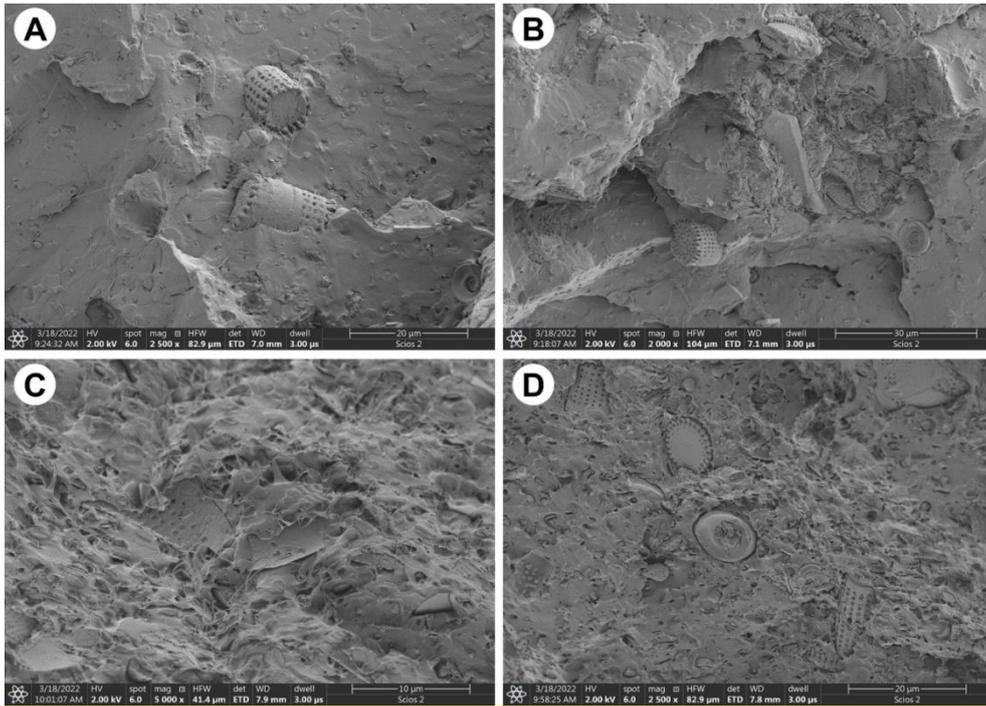
## Figures



**Figure S1.** DSC scans of the 1<sup>st</sup> heating of manufactured composites PLA-DE with (A) Ingeo™ Biopolymer 2003D, (B) Ingeo™ Biopolymer 3251D and (C) Ingeo™ Biopolymer 4043D PLA as a matrix



**Figure S2.** SEM images of breakthroughs of composites with (A-C) PLA2003D, (D-F) PLA3001D, (G-I) PLA3251D, (J-L) PLA4043D matrix and (A,D,G,J) 5wt% DE, (B,E,H,K) 10wt% DE and (C,F,I,L) 15wt% DE reinforcement



**Figure S3.** SEM images of breakthroughs of composites (A-B) PLA4043D-5wt% and (C-D) PLA4043D-15wt% after tensile tests in elastic range.

## Tables

**Table S1.** The results of the true density

Sample	$\rho_s$ [g·cm <sup>-3</sup> ]	SD( $\rho_s$ ) [g·cm <sup>-3</sup> ]	U <sub>c</sub> ( $\rho_s$ ) [g·cm <sup>-3</sup> ]	$V_s \pm SD_v$ [cm <sup>3</sup> ]	T + SD <sub>temp</sub> [°C]
diatomaceous earth	2.227	0.005	0.012	(0.2188±0.0005)*	29.3±0.1

Parameters:

- $\rho_s$  [g·cm<sup>-3</sup>] – true density
- SD( $\rho_s$ ) [g·cm<sup>-3</sup>] – standard deviation of density
- T [°C] – average temperature in the measuring chamber
- SD<sub>temp</sub> [°C] – standard deviation of temperature in the measuring chamber
- U<sub>c</sub>( $\rho_s$ ) [g·cm<sup>-3</sup>] – total expanded uncertainty of density
- $V_s$  [cm<sup>3</sup>] – true volume of the sample
- SD<sub>v</sub> [cm<sup>3</sup>] – standard deviation of the true volume of the sample

\*result outside the scope of accreditation No.AB 1503

**Table S2.** The theoretical and experimental composition as well as density of PLA and PLA–DE composites

Sample	Theoretical composition		Composition determined by TGA		Determined $\rho$ [g·cm <sup>-3</sup> ] Archimedes method	Theoretical $\rho_{th}$ [g·cm <sup>-3</sup> ]	$\Delta\rho$ $\rho_{th} - \rho$ [g·cm <sup>-3</sup> ]	$\Delta\rho$ /[DE]
	PLA (wt%)	DE (wt%)	PLA (wt%)	DE (wt%)				
2003-0	100	0	100	0.00	1.235±0.004			
2003-5	95	5	95.46	4.54	1.207±0.019	1.285	0.078	0.017
2003-10	90	10	90.23	9.77	1.226±0.016	1.334	0.108	0.011
2003-15	85	15	85.63	14.37	1.303±0.003	1.384	0.081	0.006
3001-0	100	0	100	0.00	1.247±0.005			
3001-5	95	5	96.17	3.83	1.258±0.009	1.296	0.038	0.010
3001-10	90	10	90.78	9.22	1.278±0.010	1.345	0.067	0.007
3001-15	85	15	85.70	14.3	1.323±0.009	1.394	0.071	0.005
3251-0	100	0	100	0.00	1.236±0.005			
3251-5	95	5	95.79	4.21	1.255±0.008	1.286	0.031	0.007
3251-10	90	10	90.67	9.33	1.275±0.017	1.335	0.060	0.006
3251-15	85	15	85.69	14.31	1.294±0.016	1.385	0.091	0.006
4043-0	100	0	100	0.00	1.234±0.004			
4043-5	95	5	95.72	4.28	1.258±0.007	1.284	0.036	0.008
4043-10	90	10	90.41	9.59	1.287±0.002	1.333	0.046	0.005
4043-15	85	15	87.07	12.93	1.318±0.005	1.383	0.065	0.005

**Table S3.** Tensile results and degree of the crystallinity for the PLAs and the PLA/DE composites

<b>Sample</b>	<b>E [GPa]</b>	<b>R<sub>m</sub> [MPa]</b>	<b>ε<sub>f</sub> [%]</b>	<b>X<sub>c</sub> [%]</b>
2003-0	3.34±0.28	64.17±2.54	5.59±2.53	2.28
2003-5	3.67±0.26	51.14±2.60	5.00±1.38	4.97
2003-10	3.54±0.42	48.16±2.77	2.73±1.33	7.30
2003-15	3.18±0.84	35.53±7.19	1.25±0.18	8.41
3001-0	4.02±0.38	66.51±1.98	1.98±0.34	8.69
3001-5	3.89±0.45	60.55±4.60	1.96±0.68	9.10
3001-10	4.41±0.39	54.54±1.43	1.37±0.11	9.45
3001-15	4.34±0.62	51.65±2.88	1.37±0.17	10.84
3251-0	3.18±0.35	65.02±2.90	5.41±2.78	8.75
3251-5	4.16±0.47	59.46±3.51	2.67±1.97	10.88
3251-10	4.20±0.77	56.26±4.40	1.95±0.51	14.28
3251-15	4.39±0.44	48.73±1.94	1.11±0.16	13.16
4043-0	3.22±0.53	61.42±2.38	6.12±4.53	5.09
4043-5	3.73±0.40	52.82±2.96	3.97±1.90	5.30
4043-10	3.95±0.34	51.83±2.96	1.76±0.55	6.21
4043-15	4.46±0.39	50.00±3.65	1.27±0.14	8.01