Supporting Information

Multifunctional Biocomposites based on Polyhydroxyalkanoate and Graphene/Carbon-Nanofiber Hybrids for Electrical and Thermal Applications

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Thermal Diffusivity Setup

The thermal diffusivity measurements were performed using the angstrom method. This technique uses a laser source to generate periodic heat waves into the materials and a high resolution infrared camera as detector (Figure S1).

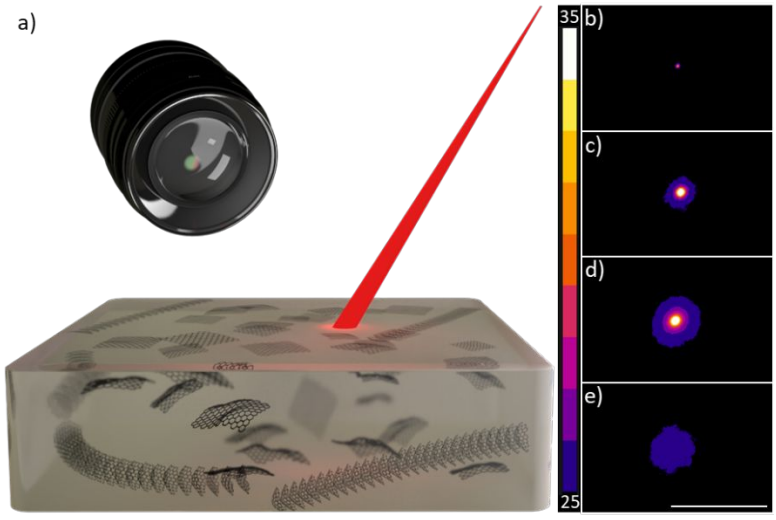

Figure S1: a) schematic representation of the custom-built setup for measuring the thermal diffusivity. The laser is used to produce periodic heat waves that are recorded by the Infrared camera. b-e) four recorded IR photograms highlighting the propagation of the heat wave into the sample, scale bar 1 cm.

Plotting the temperature profile of the pixel of interest (Figure S2a) allows to measure the phase shift of the periodic wave as a function of the distance (Figure S2b). The slope of the phase over the distance is the wavenumber k. The thermal diffusivity is calculated using the following equation:

$$\alpha = \frac{\omega}{2k^2}$$

$$\alpha = \text{Thermal diffusivity}$$

$$\omega = \text{Modulation frequency}$$

$$k = \text{Wavenumber}$$

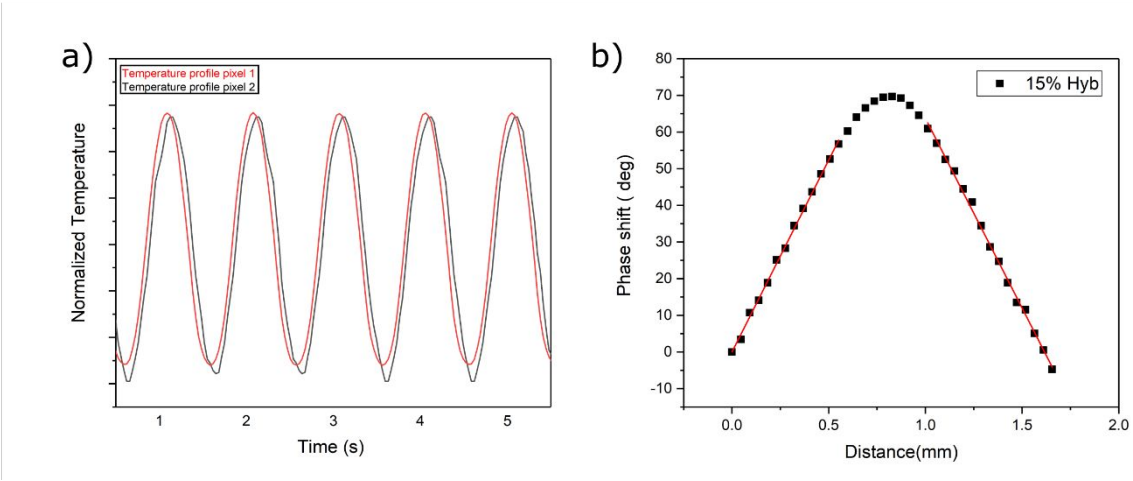

Figure S 2: a) Temperature profile for two individuals pixels, highlighting the phase shift. b) Phase shift as a function of the distance, the slope is the wavenumber.

Morphology of the Biocomposites

The morphologies of the pure PHA sample (Figure S3a) of the 15GNP specimen (Figure S3b) and of the 15CNF nanocomposite (Figure S3c) is shown. Due to the compression moulding, the topographies of all the samples were comparable.

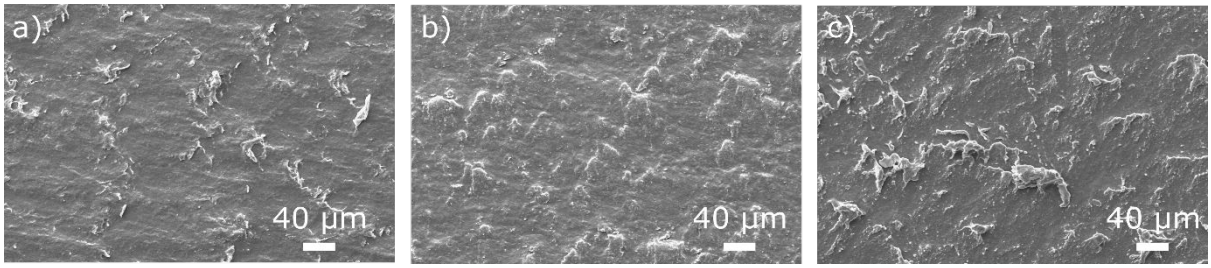

Figure S 3: SEM images of the morphology of the samples. a) pure PHA sample, b) 15GNP sample and c) 15 CNF sample.

Cross-section of the Biocomposites

Low magnification cross section images of the pure PHA sample (Figure S4a) of the 15GNP specimen (Figure S4b) and of the 15CNF nanocomposite (Figure S4c) are shown below. The thickness of all the samples was around 1mm because of the compression moulding process. Figure S4d-S4f shows high magnification SEM of the pure PHA, and of the samples containing 15 wt % of GNP and CNF, respectively. Micron-sized GNP nanoflakes are clearly observable in Figures S4e and S4f. A preferred orientation of the GNPs and of the CNFs in the direction perpendicular to the plate of the press is clearly visible in both the samples.

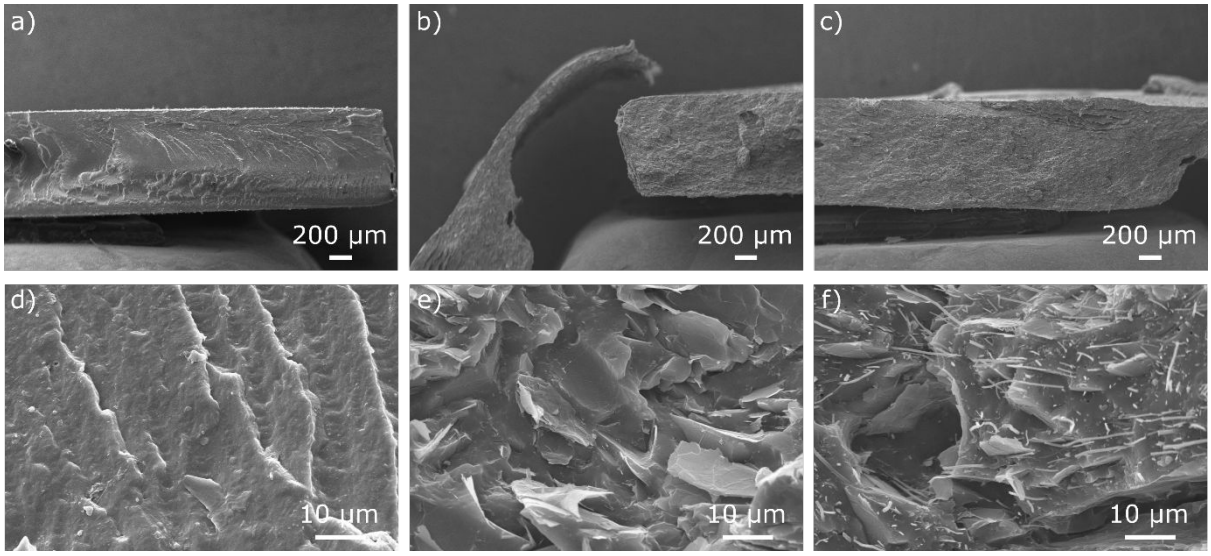

Figure S 4: SEM images of the cross section of the samples: a), d) pure PHA sample; b), e) 15GNP sample; c), f) 15 CNF sample.

EMI Shielding Analysis

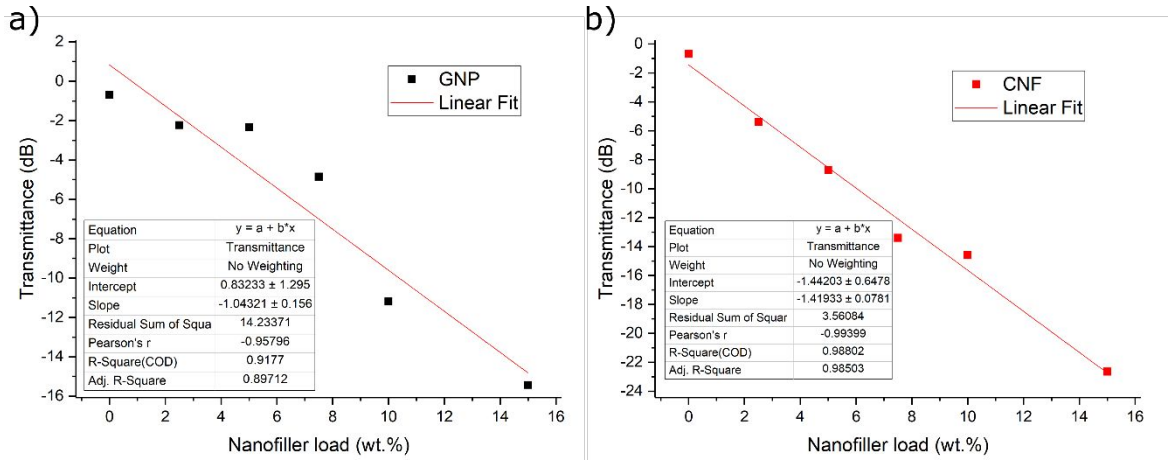

Figure S 5: a) linear fit of the transmittance as a function of GNP concentration. b) linear fit of the transmittance as a function of CNF concentration.