

Solid-solid latent thermal energy storage in nanotube-reinforced pentaerythritol and pentaglycerine composites

*Original*

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# **Solid-Solid Latent Thermal Energy Storage in Nanotube-Reinforced Pentaerythritol and Pentaglycerine Composites**

## **- Supplementary Information –**

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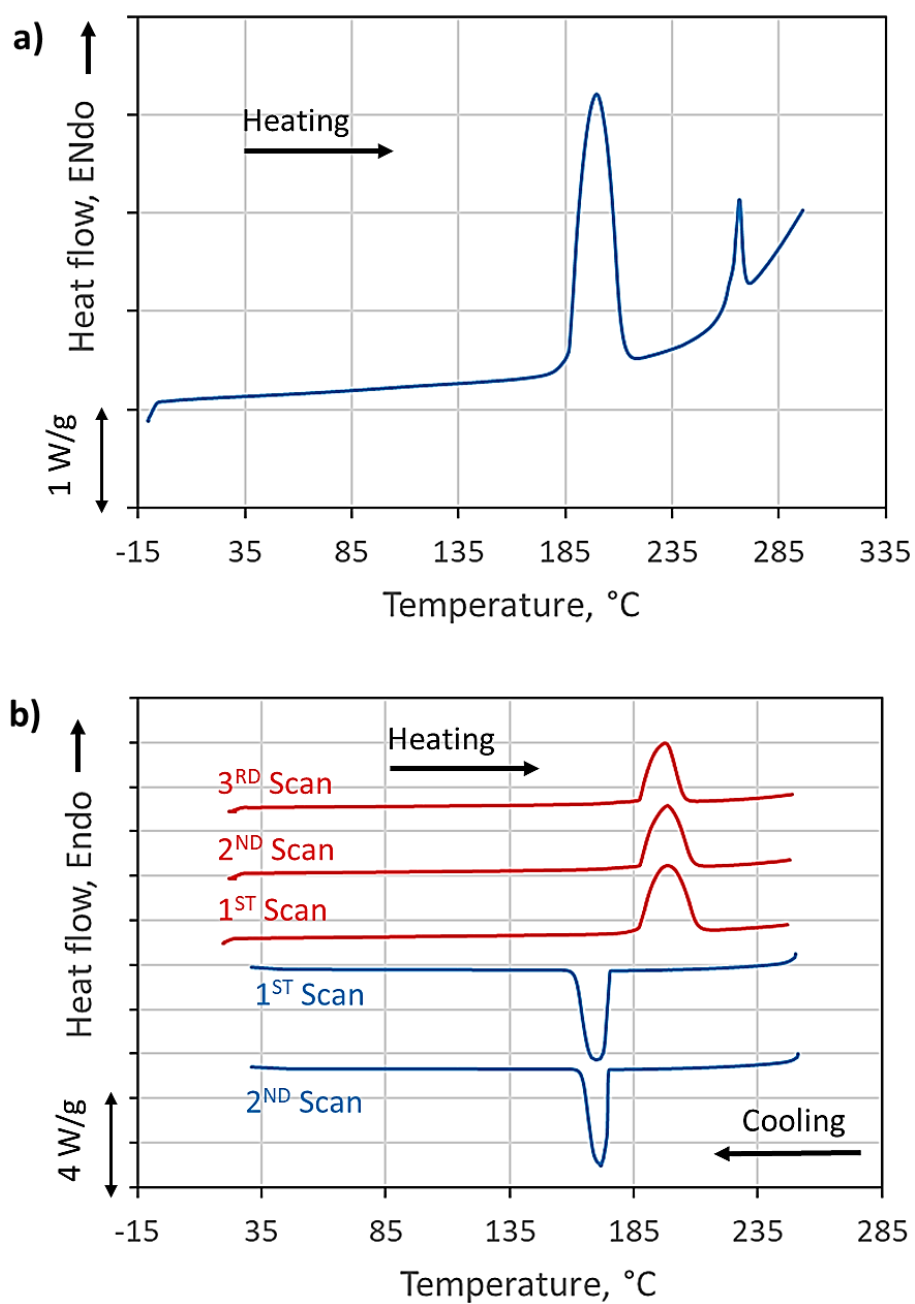
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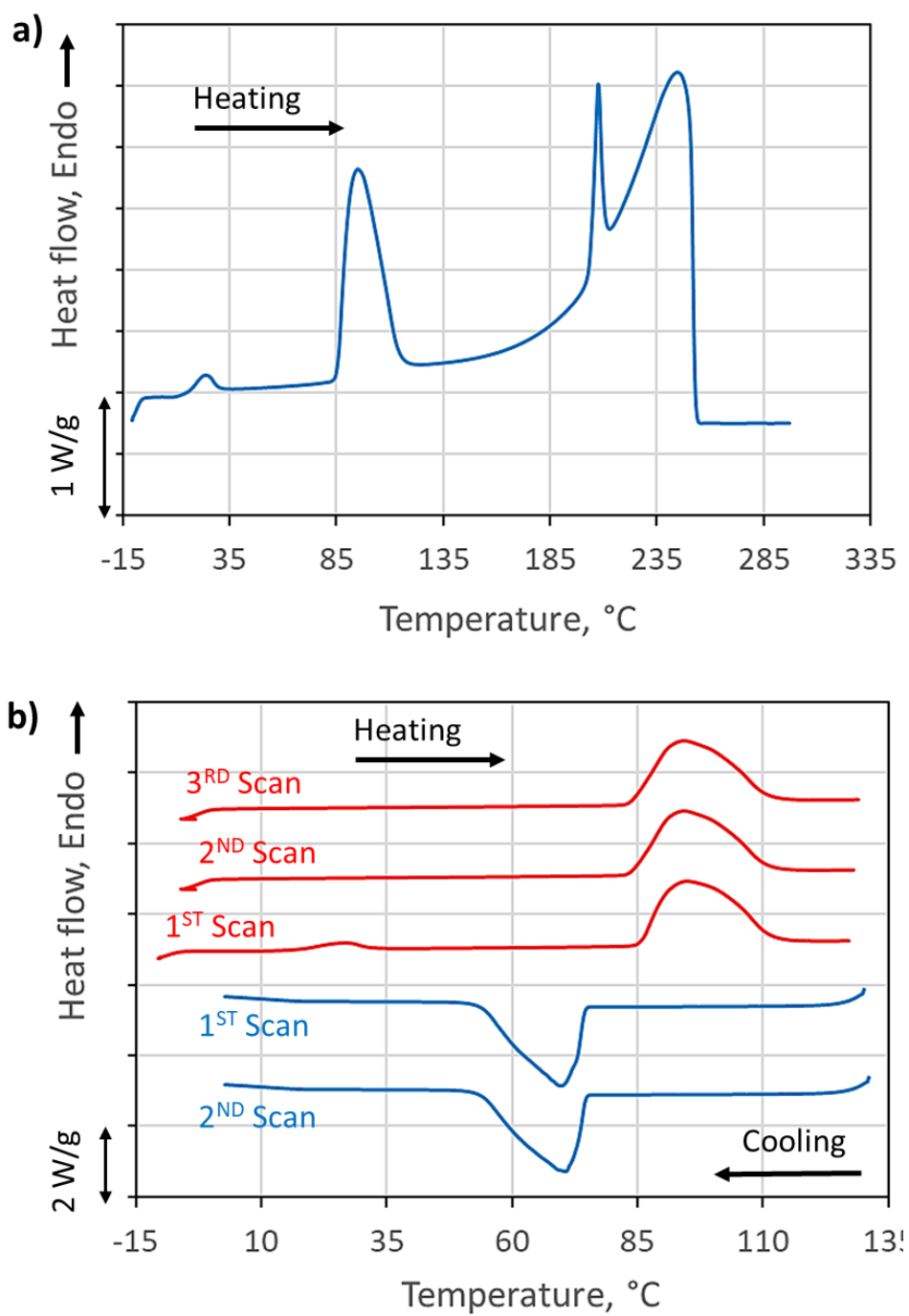
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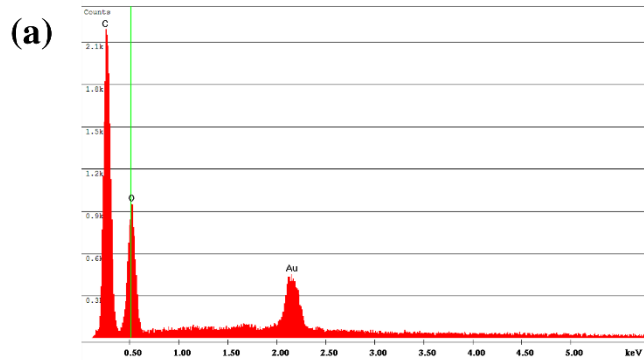
## Supplementary Note 1: Graphical results



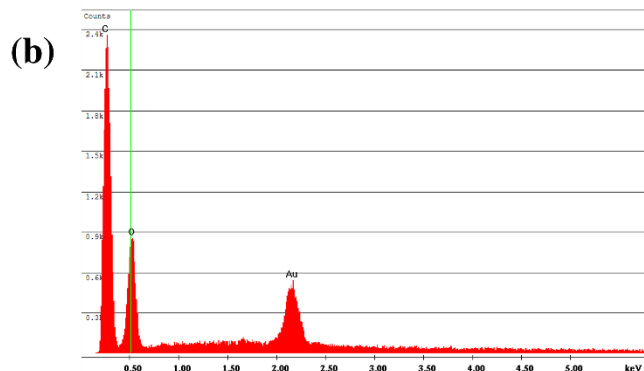
**Figure S1.** (a) Long DSC curve (Solid-Solid and Solid-Liquid phase transition) and (b) multiscans DSC curves (only solid-solid phase transition) of pure PE powder.



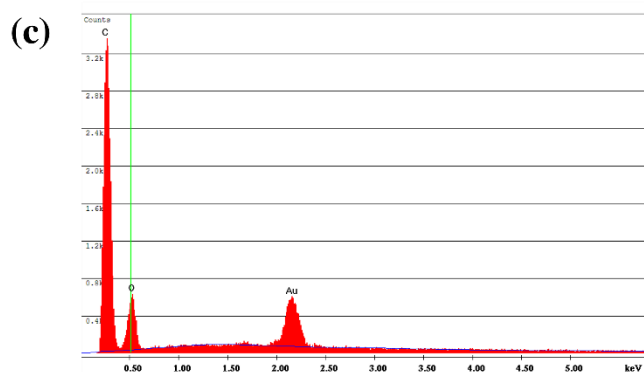
**Figure S2.** (a) Long DSC curve (Solid-Solid and Solid-Liquid phase transition) and (b) multiscans DSC curves (only solid-solid phase transition) of pure PG powder.



| Element | Weight % | Atomic % |
|---------|----------|----------|
| C       | 60.42    | 72.62    |
| O       | 29.53    | 26.65    |
| Au      | 10.05    | 0.74     |
| Total   | 100      | 100      |



| Element | Weight % | Atomic % |
|---------|----------|----------|
| C       | 62.16    | 74.94    |
| O       | 26.79    | 24.24    |
| Au      | 11.05    | 0.81     |
| Total   | 100      | 100      |



| Element | Weight % | Atomic % |
|---------|----------|----------|
| C K     | 71.34    | 83.70    |
| O K     | 17.61    | 15.51    |
| AuM     | 11.05    | 0.79     |
| Total   | 100      | 100      |

**Figure S3.** EDS elemental mapping of (a) PG, (b) PG/MWCNTs-5% and (c) PG/MWCNTs-10%.

## Supplementary Note 2: Tabulated results

|                      | PG powder                            |                                       | PG tablet                            |                                       |
|----------------------|--------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|
|                      | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ |
| Heating <sub>1</sub> | 97.0±0.8                             | 182±6                                 | 97.9                                 | 186.3                                 |
| Heating <sub>2</sub> | 96.0±0.6                             | 182±5                                 | 98.0                                 | 180.3                                 |
| Cooling <sub>1</sub> | 70.1±0.7                             | 168±4                                 | 64.1                                 | 175.6                                 |

**Table S1.** Thermal properties of pure PG powder and tablet.

|                      | PE powder                            |                                       | PE tablet                            |                                       |
|----------------------|--------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|
|                      | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ |
| Heating <sub>1</sub> | 199.5±1.0                            | 266±5                                 | 209.0                                | 249.42                                |
| Heating <sub>2</sub> | 200.0±0.5                            | 222±5                                 | 207.2                                | 212.18                                |
| Cooling <sub>1</sub> | 169.3±1.1                            | 242±3                                 | 161.6                                | 228.8                                 |

**Table S2.** Thermal properties of pure PE powder and tablet.

| System |   | Heating                              |                                       | Cooling                              |                                       |
|--------|---|--------------------------------------|---------------------------------------|--------------------------------------|---------------------------------------|
|        |   | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ | $T_{\text{trans}}(^{\circ}\text{C})$ | $\Delta H_{\text{trans}}(\text{J/g})$ |
| Closed | 1 | 199.53                               | 324.25                                | 169.07                               | 302.93                                |
|        | 2 | 198.30                               | 308.29                                | 167.97                               | 289.05                                |
|        | 3 | 199.56                               | 297.17                                | -                                    | -                                     |
| Open   | 1 | 199.5±1.0                            | 266±5                                 | 169.3±1.1                            | 242±3                                 |
|        | 2 | 200.0±0.5                            | 222±5                                 | 170.6±1.2                            | 202±6                                 |
|        | 3 | 197.9±0.7                            | 187±4                                 | -                                    | -                                     |

**Table S3.** Comparison of thermal properties of pure PE powder in open and closed system.

| <b>Hydrostatic balance</b><br> | S. No    | Density (g/cm <sup>3</sup> ) |       |
|-----------------------------------------------------------------------------------------------------------------|----------|------------------------------|-------|
|                                                                                                                 |          | PE                           | PG    |
|                                                                                                                 | Sample-1 | 1.17                         | 1.08  |
|                                                                                                                 | Sample-2 | 1.18                         | 1.07  |
|                                                                                                                 | Sample-3 | 1.17                         | 1.07  |
|                                                                                                                 | Sample-4 | 1.15                         | 1.09  |
|                                                                                                                 | Sample-5 | 1.14                         | 1.07  |
|                                                                                                                 | Average  | 1.16                         | 1.08  |
|                                                                                                                 | Stdev    | 0.01                         | 0.008 |

**Table S4.** Density measurement of PE and PG tablet using Archimedes principle.

| Materials     |   | HEATING                 |                           | COOLING                 |                           |
|---------------|---|-------------------------|---------------------------|-------------------------|---------------------------|
|               |   | T <sub>trans</sub> (°C) | ΔH <sub>trans</sub> (J/g) | T <sub>trans</sub> (°C) | ΔH <sub>trans</sub> (J/g) |
| PG            | 1 | 97.98                   | 186.3                     | 64.12                   | -175.6                    |
|               | 2 | 98.0                    | 180.3                     | -                       | -                         |
| PG/MWCNTs-1%  | 1 | 99.6                    | 179.5                     | 67.0                    | -168.0                    |
|               | 2 | 98.9                    | 174.2                     | -                       | -                         |
| PG/MWCNTs-5%  | 1 | 100.78                  | 167.7                     | 66.5                    | -157.5                    |
|               | 2 | 99.9                    | 164.9                     | -                       | -                         |
| PG/MWCNTs-10% | 1 | 100.0                   | 160.4                     | 68.4                    | -150.7                    |
|               | 2 | 99.0                    | 144.3                     | -                       | -                         |

**Table S5.** Latent heat and phase transition temperature of PG/MWCNTs composite PCM tablets.

| MWCNTs (wt. %) | λ (W/mK) Experimental | λ (W/mK) Two step H-J model | λ (W/mK) Modified ME-I model | φ (-) Porosity |
|----------------|-----------------------|-----------------------------|------------------------------|----------------|
| 0              | 0.3642±0.002          | 0.3642                      | 0.3642                       | 0.044262       |
| 1              | 0.2694±0.009          | 0.2736                      | 0.2705                       | 0.215237       |
| 5              | 0.2394±0.006          | 0.2506                      | 0.2675                       | 0.246588       |
| 10             | 0.2734±0.003          | 0.2281                      | 0.2692                       | 0.273352       |

**Table S6.** Measured and predicted thermal conductivities, along with porosity values of the PG/MWCNTs composite tablets as a function of the MWCNTs content.