**Fabrication of BN/CuO@MWCNTs composites for enhancing heat transfer and photothermal conversion of phase change materials**

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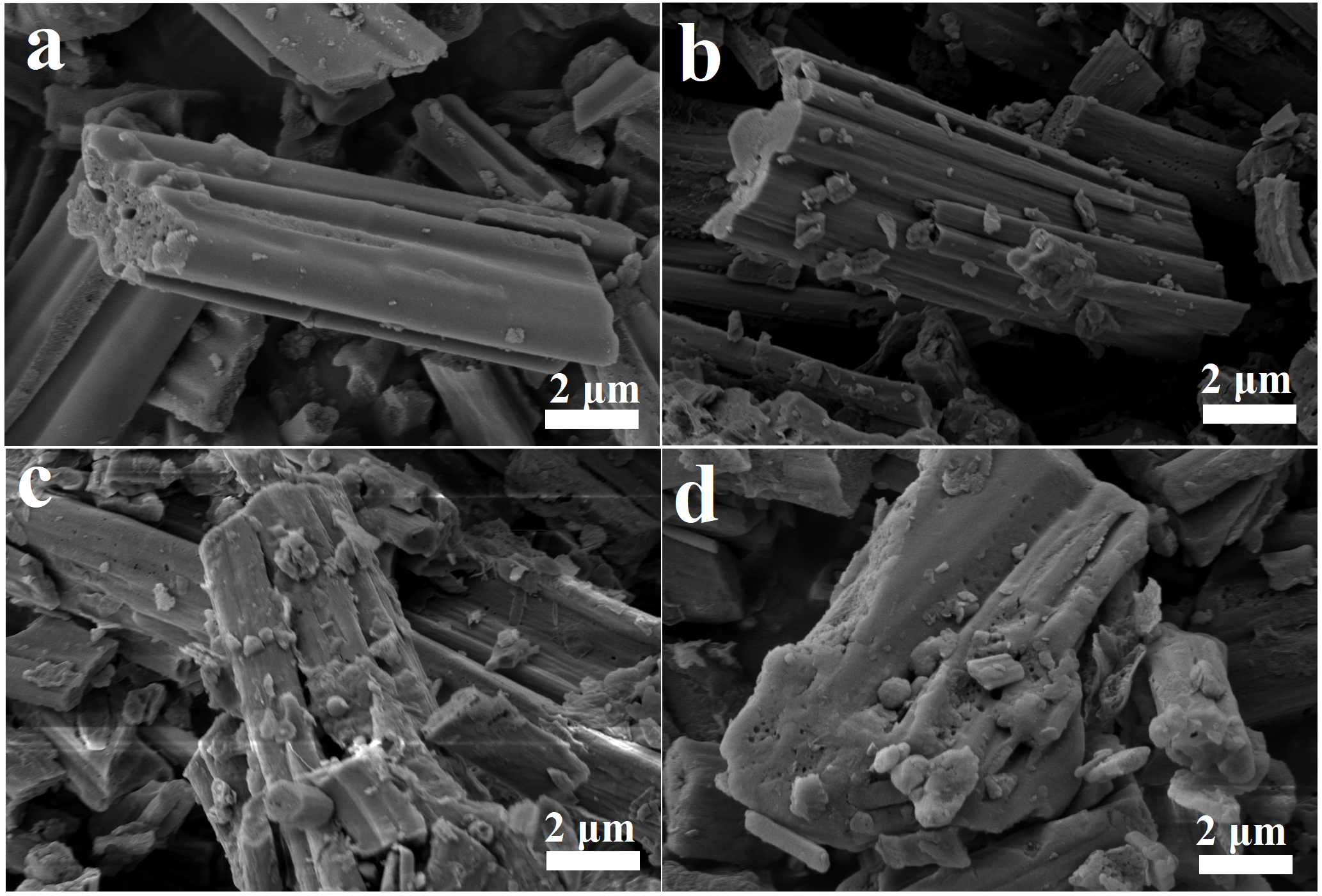
**Table S1.** The amount of raw material used for the preparation of BN@CuO hybrids.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Material Type** | **Boric acid**  **(H3BO3)** | **Melamine**  **(C3N6H6)** | **CuSO4** | **aRB/Cu** |
| BN/CuO | 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.010 mol  (1.60g) | 10.0 |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.015 mol  (2.40 g) | 6.7 |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.020 mol  (3.20 g) | 5.0 |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.025mol  (4.00 g) | 4.0 |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.030 mol  (4.80g) | 3.3 |

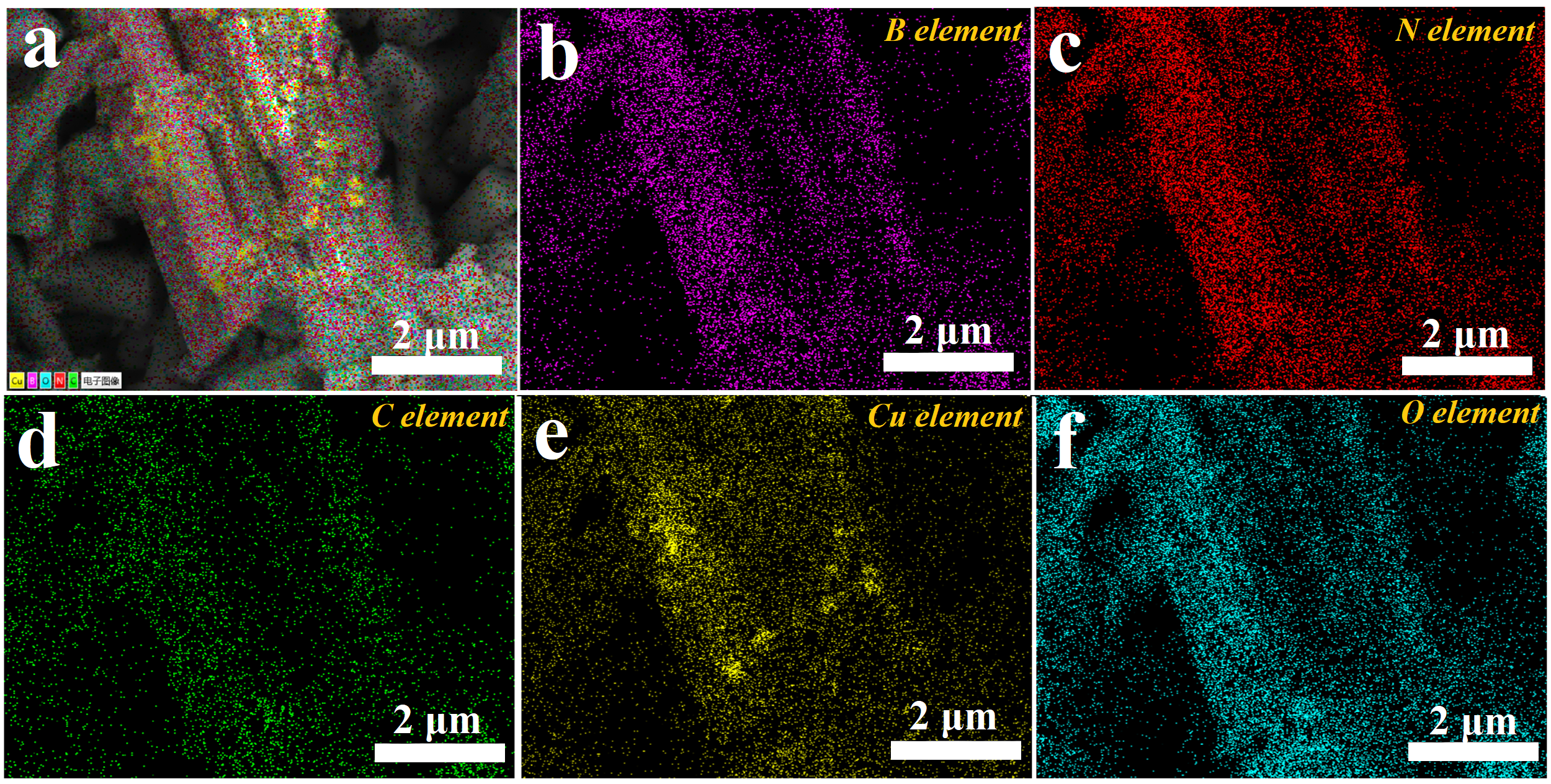
aRB/Cu: Molar ratio of H3BO3 to CuSO4.

**Table S2.** The amount of raw material used for the preparation of BN/CuO*@*MWCNTs composite.

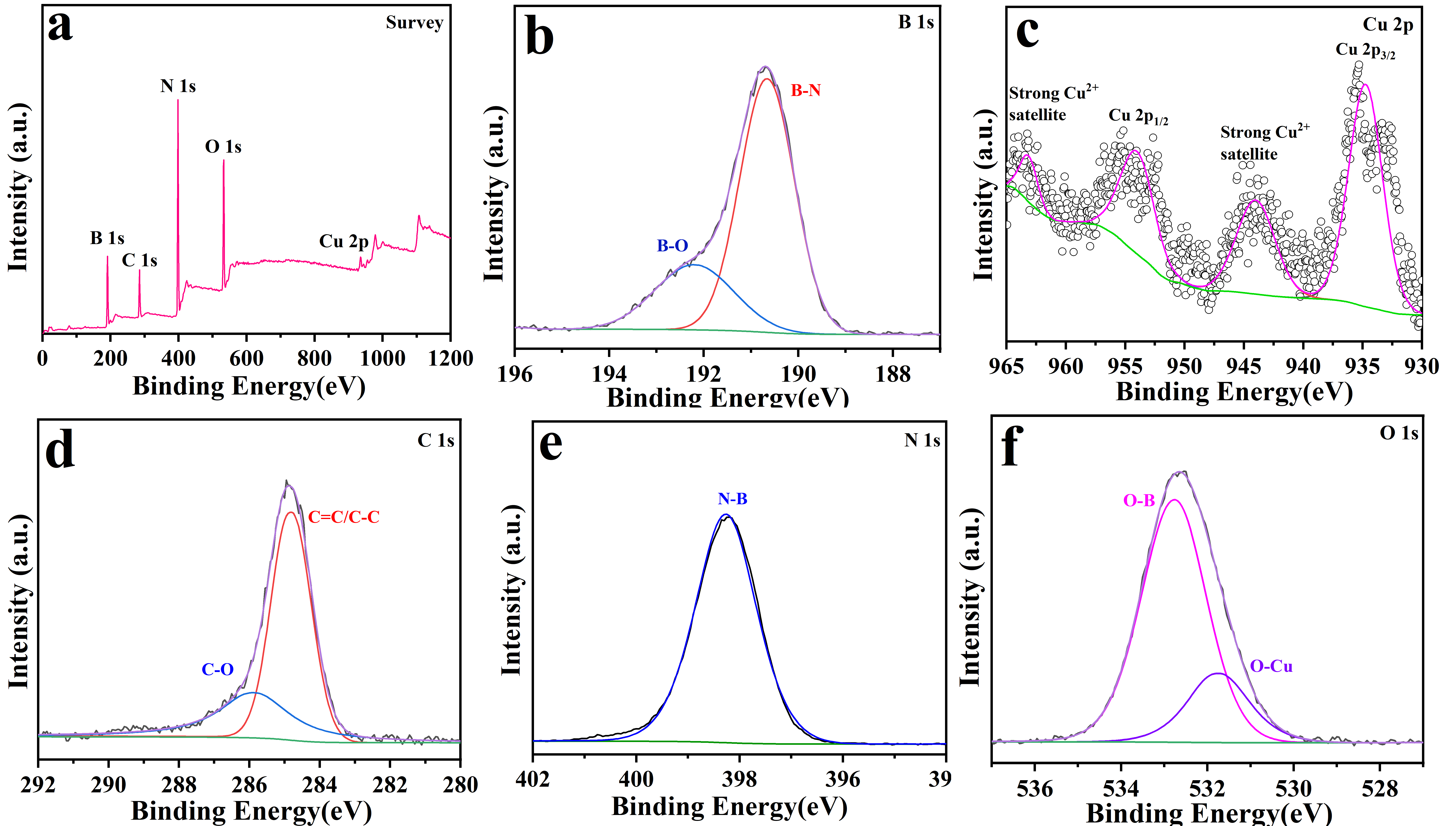
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Material Type** | **Boric acid**  **(H3BO3)** | **Melamine**  **(C3N6H6)** | **CuSO4** | **MWCNTs** | **PVP** |  |
| BN/CuO*@*MWCNTs | 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.005 mol  (0.80g) | 0.01mol  (0.12 g) | 1 g |  |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.01 mol  (1.60 g) | 0.05 mol  (0.6 g) | 1 g |  |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.02 mol  (3.20 g) | 0.1 mol  (1.2 g) | 1 g |  |
| 0.1 mol  (6.1830 g) | 0.05 mol  (6.3060 g) | 0.03 mol  (4.79 g) | 0.15 mol  (1.8 g) | 1 g |  |



**Fig. S1.** SEM images of the BN/CuO hybrids prepared at different RB/Cu: (a) 10.0, (b) 6.7, (c) 4.0, (d) 3.3.



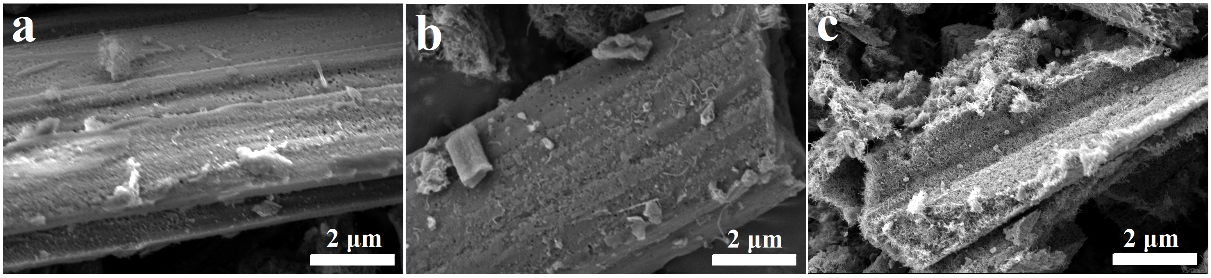
**Fig. S2.** Elemental mapping images of BN/CuO hybrid: (b) B, (c) N, (d) C, (e) Cu and (f) O elements.



**Fig. S3.** XPS analysis of hybrid. (a) Survey spectrum, (B) high-resolution spectrum of (b) B 1s, (c) Cu 2p and (d) C 1s (e) N 1s (f) O 1s.



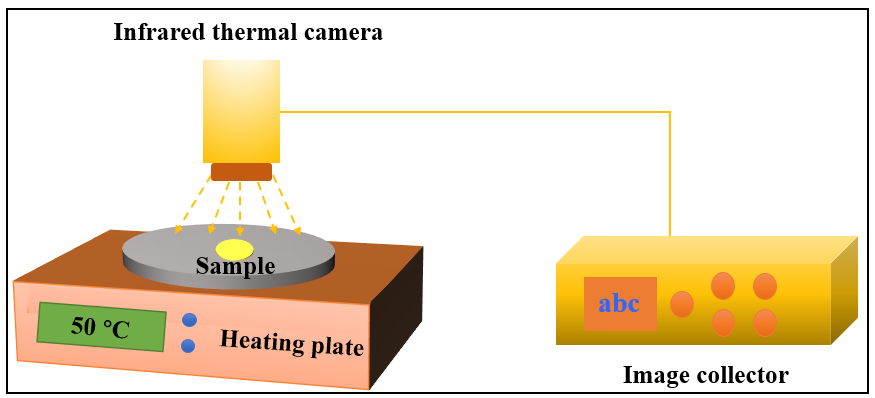
**Fig. S4.** XRD pattern of CuO



**Fig. S4.** SEM images of the BN/CuO/MWCNTs composites prepared at RB/Cu=3.6 and different amount of MWCNTs: (a) 0.01mol, (b) 0.50 mol and (c) 0.15 mol.



**Fig. S5.** XRD pattern of CuO



**Fig. S6.** Devices for testing the heat transfer performance



**Fig. S7.** Nitrogen adsorption/desorption isotherms of BN, BN/CuO hybrid and BN/CuO@MWCNTs composite

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**Fig. S8.** UV–vis–NIR spectra absorption spectra

**Table S3.** Thermophysical properties of PEG and PEG-based composite PCMs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sample | *ΔΗm* (J/g) | *Tm* (°C) | *ΔΗc* (J/g) | *Tc* (°C) |
| PEG | 172.3 | 58.6 | 169.4 | 38.4 |
| PEG/BN | 153.1 | 58.1 | 151.8 | 40.0 |
| PEG/BN/CuO | 153.4 | 57.5 | 152.3 | 41.7 |
| PEG/BN/CuO@MWCNTs | 154.5 | 56.4 | 153.2 | 43.8 |

**Table S4.** Solar-thermal conversion efficiencies data of the PEG/BN/CuO and PEG/BN/CuO@MWCNTs composites.

|  |  |  |
| --- | --- | --- |
|  | PEG/BN/CuO | PEG/BN/CuO@MWCNTs |
| m (g) | 0.10 | 0.10 |
| *P* (mW/cm2) | 100 | 100 |
| *s* (cm2) | 1.16 | 1.16 |
| *Δt* (s) | 174.54 | 144.40 |
| Input energy a (J) | 20.25 | 16.75 |
| Thermal energy storage b (J) | 15.34 | 15.45 |
| (%) | 75.8 | 92.2 |

a Input energy= *P*×*s*×*Δt*

b Thermal energy storage = *m*×*ΔHm*

**Table S5.** The comparison of heat transfer and photothermal conversion between this work and some previously reported PEG-based PCMs.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Composite PCMs | Filler | TC (W/m·K) | η (%) | Ref. |
| PEG/GNPs | 4 | 3.11 | 86 | 2018[1] |
| PEG/Ti3C2Tx | 20 w% | 0.293 | 94.5% | 2019[2] |
| RHTC/PEG | 7 | 0.51 | 90.1 | 2021[3] |
| Ti3C2Tx@PVA/PEG | 7.68 | 0.428 | 96.5 | 2021[4] |
| B-GAPCM | --- | 1.07 | 89.3 | 2021[5] |
| CF/(HO-BNNS@CuO)/PEG | 10 wt% | 1.12 | 91.8 | 2022[6] |
| PAAAM/RHTC/PEG |  | 0.76 | 93.3 | 2022[7] |
| PI/PR Aerogel/PEG | 16 | 0.3469 | 82.5 | 2022[8] |
| FCPCMs | 40 | 1.733 | 95 | 2022[9] |
| PU/GO/PEG | 11 | 0.972 | 95.3 | 2022[10] |
| MXene@PVP/PEG | 10 | 0.533 | 96.2 | 2023[11] |
| PVDF/RB/PEG | 9.1 | 1.01 | 92.1 | 2024[12] |
| PEG@PFCC | --- | 1.61 | 91.5 | 2024[13] |
| BCNSs/PEG | 14.3 | 0.635 | 80.2 | 2024[14] |
| PEG/CPAC | 3.9 | 0.61 | 94.6 | 2024[15] |
| CuO@PEG | 20 | 0.52 | 91.6 | 2024[16] |
| MPC@PEG |  | 0.96 | 90.8 | 2024[17] |
| PEG/BN/CuO@MWCNTs | 10 | 2.35 | 92.2 | This work |

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