# Morphological and Thermal Properties of Polystyrene Composite Reinforced with Biochar from Elephant Grass (Pennisetum purpureum) 

## Supplementary material

## Heat capacity calculations

$\Delta \mathrm{H}=\mathrm{mC}_{\mathrm{P}} \Delta \mathrm{T}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t$
Where,
$\mathrm{C}_{\mathrm{P}}$ is the specific heat capacity
$\Delta \mathrm{H}$ is the heat capacity
m is the mass
$\Delta \mathrm{T}$ is the temperature change
t is the time taken

## Specific Heat Capacity of polystyrene (PS) resin

$\mathrm{m}=9 \mathrm{mg}=9 \times 10^{-6} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(3.62-0.1) \mathrm{mW}=3.5 \mathrm{~mW}=3.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta \mathrm{~T}} \times \mathrm{t}=\frac{3.5 \times 10^{-3}}{9 \times 10^{-6} \times 373} \times 600=625.56 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $10 \%$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 600=757.66 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$
$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 600=657.03 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $\mathbf{3 0 \%}$ composition composite
$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 600=601.92 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite

$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 600=670.24 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity at varying times;

## At 2mins;

Specific Heat Capacity for $\mathbf{1 0 \%}$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=2 \mathrm{mins}=120 \mathrm{secs}$
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 120=151.53 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{2 0 \%}$ composition composite

$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=2 \mathrm{mins}=120 \operatorname{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 120=131.41 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $30 \%$ composition composite
$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=2 \mathrm{mins}=120 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 120=12.38 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite
$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=2 \mathrm{mins}=120$ secs
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 120=134.05 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## At 4mins;

Specific Heat Capacity for $10 \%$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=4 \mathrm{mins}=240$ secs
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 240=303.07 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $20 \%$ composition composite

$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=4 \mathrm{mins}=240 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 240=262.81 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{3 0 \%}$ composition composite

$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=4 \mathrm{mins}=240 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 240=240.77 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite

$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=4 \mathrm{mins}=240 \mathrm{secs}$
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 240=268.10 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## At 6mins;

Specific Heat Capacity for $10 \%$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=6 \mathrm{mins}=360$ secs
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 360=454.60 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{2 0 \%}$ composition composite

$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=6 \mathrm{mins}=360 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 360=394.22 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $\mathbf{3 0 \%}$ composition composite
$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=6 \mathrm{mins}=360 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 360=361.15 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$
Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite
$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=6 \mathrm{mins}=360 \mathrm{secs}$
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 360=402.14 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## At 8mins;

Specific Heat Capacity for $\mathbf{1 0 \%}$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=8 \mathrm{mins}=480$ secs
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 480=606.137 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{2 0 \%}$ composition composite

$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=8 \mathrm{mins}=480 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 480=525.62 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{3 0 \%}$ composition composite

$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=8 \mathrm{mins}=480 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$\mathrm{C}_{\mathrm{P}}=\frac{\Delta \mathrm{H}}{\mathrm{m} \Delta \mathrm{T}} \times \mathrm{t}=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 480=481.54 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite
$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=8 \mathrm{mins}=480 \mathrm{secs}$
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 480=536.19 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## At 10mins;

Specific Heat Capacity for $\mathbf{1 0 \%}$ composition composite
$\mathrm{m}=13.8 \mathrm{mg}=1.38 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(6.5-0) \mathrm{mW}=6.5 \mathrm{~mW}=6.5 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{6.5 \times 10^{-3}}{1.38 \times 10^{-5} \times 373} \times 600=757.66 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$
Specific Heat Capacity for $20 \%$ composition composite
$\mathrm{m}=14.2 \mathrm{mg}=1.42 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600$ secs
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.42 \times 10^{-5} \times 373} \times 600=657.03 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

## Specific Heat Capacity for $\mathbf{3 0 \%}$ composition composite

$\mathrm{m}=15.5 \mathrm{mg}=1.55 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(5.8-0) \mathrm{mW}=5.8 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.8 \times 10^{-3}}{1.55 \times 10^{-5} \times 373} \times 600=601.92 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

Specific Heat Capacity for $\mathbf{4 0 \%}$ composition composite
$\mathrm{m}=13.2 \mathrm{mg}=1.32 \times 10^{-5} \mathrm{~kg}$
$\Delta \mathrm{T}=100^{\circ} \mathrm{C}=373 \mathrm{~K}$
Time $(\mathrm{t})=10 \mathrm{mins}=600 \mathrm{secs}$
$\Delta \mathrm{H}=(5.5-0) \mathrm{mW}=5.5 \mathrm{~mW}=5.8 \times 10^{-3} \mathrm{~J} / \mathrm{s}$
$C_{P}=\frac{\Delta H}{m \Delta T} \times t=\frac{5.5 \times 10^{-3}}{1.32 \times 10^{-5} \times 373} \times 600=670.24 \mathrm{~J} / \mathrm{kg} . \mathrm{K}$

