Rheokinetics of ε-caprolactam anionic-ring polymerization applied to the rapid production of thermoplastic composites

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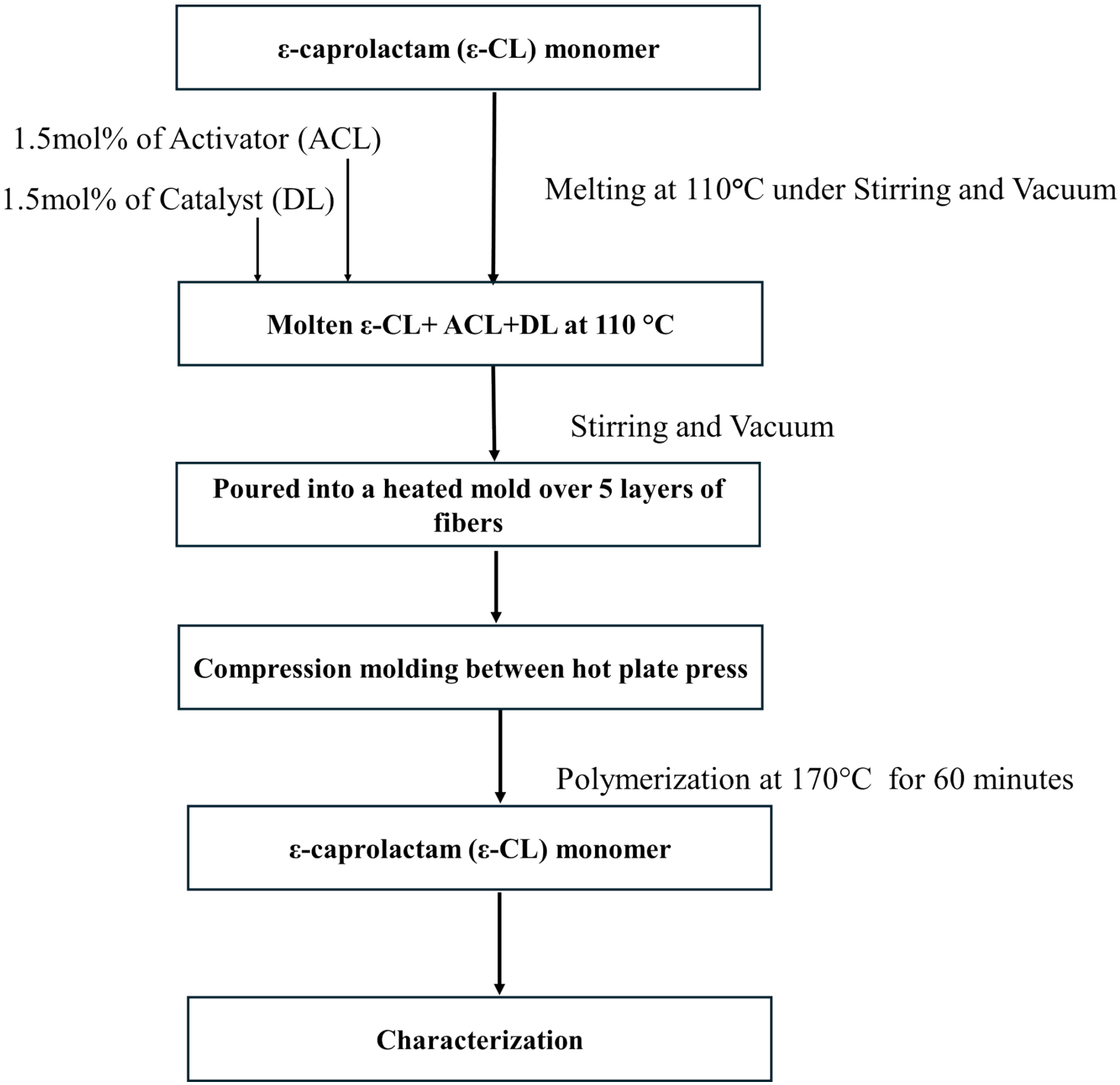

ε-caprolactam (ε-CL) monomer
1.5mol% of Activator (ACL)
1.5mol% of Catalyst (DL)
Melting at 110°C under Stirring and Vacuum
Molten ε-CL+ ACL+DL at 110 °C
Stirring and Vacuum
Poured into a heated mold over 5 layers of fibers
Compression molding between hot plate press
Polymerization at 170°C for 60 minutes
ε-caprolactam (ε-CL) monomer
Characterization

Fig. S1 Flowchart of the fabrication process of the hybrid glass/treated hemp fiber composite samples.

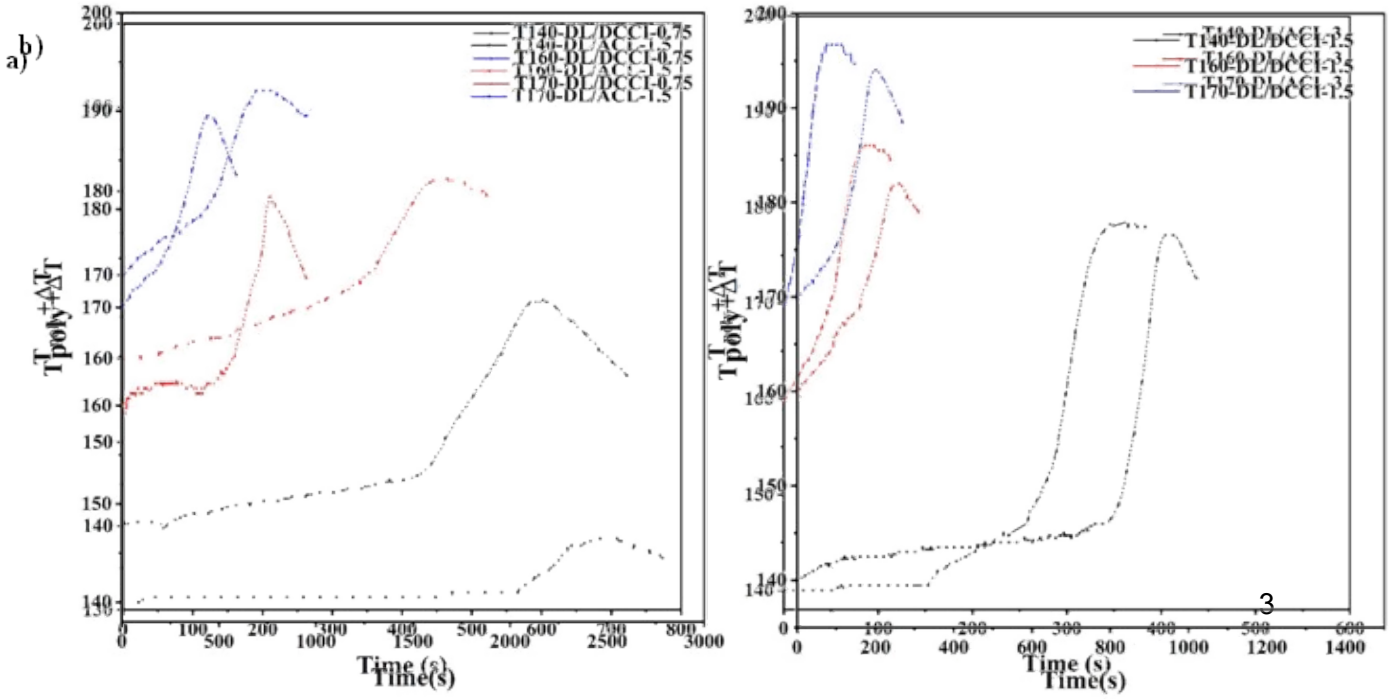
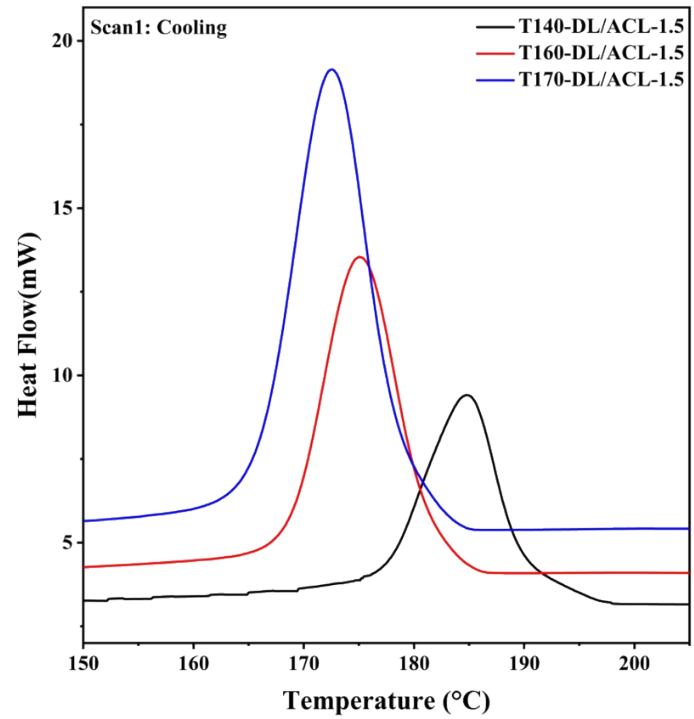
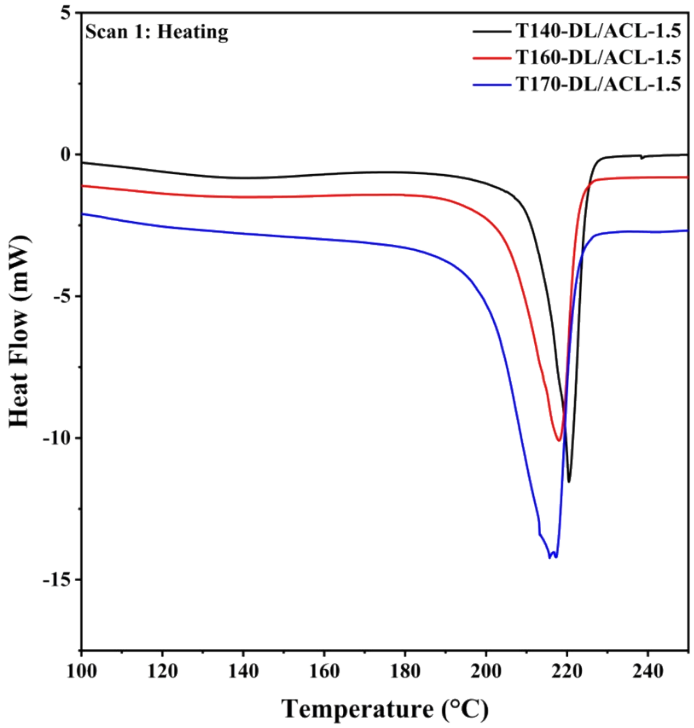
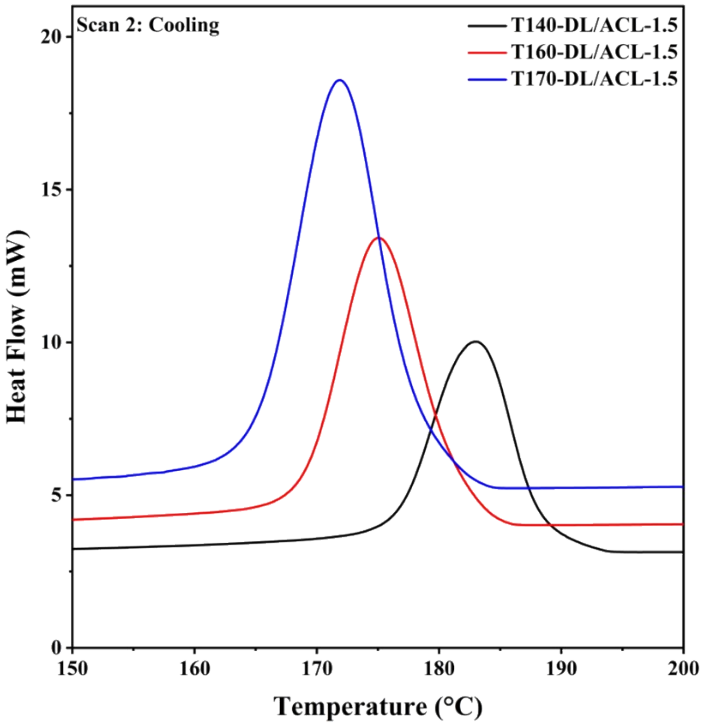


Fig. S2 Temperature change with time dependence (T_{poly}=140°C,160°C and 170°C) for the AROP of ε-caprolactam for two combinations a) DL/ACL and b) DL/DCCI at two concentrations.


Scan1: Cooling
T140-DL/ACL-1.5
T160-DL/ACL-1.5
T170-DL/ACL-1.5
Heat Flow(mW)
Temperature (°C)


Scan 1: Heating
T140-DL/ACL-1.5
T160-DL/ACL-1.5
T170-DL/ACL-1.5
Heat Flow (mW)
Temperature (°C)


Scan 2: Cooling
T140-DL/ACL-1.5
T160-DL/ACL-1.5
T170-DL/ACL-1.5
Heat Flow (mW)
Temperature (°C)

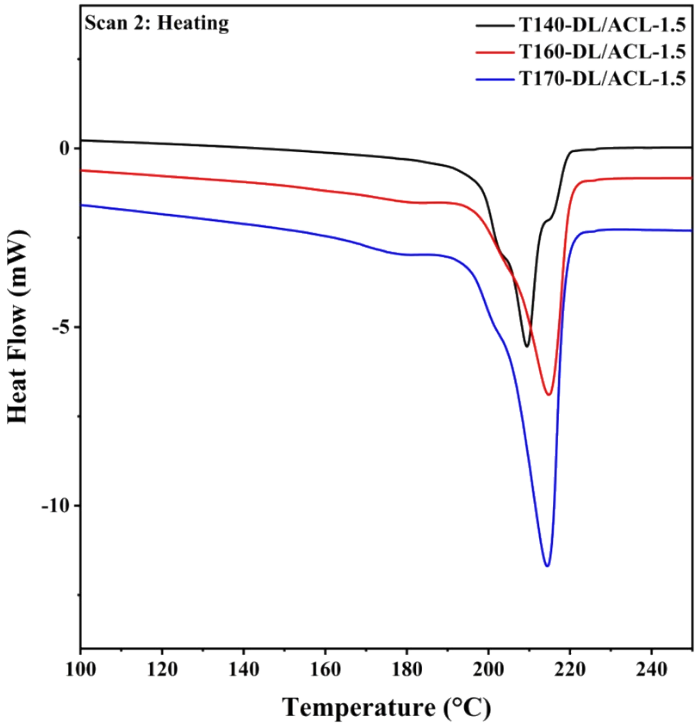
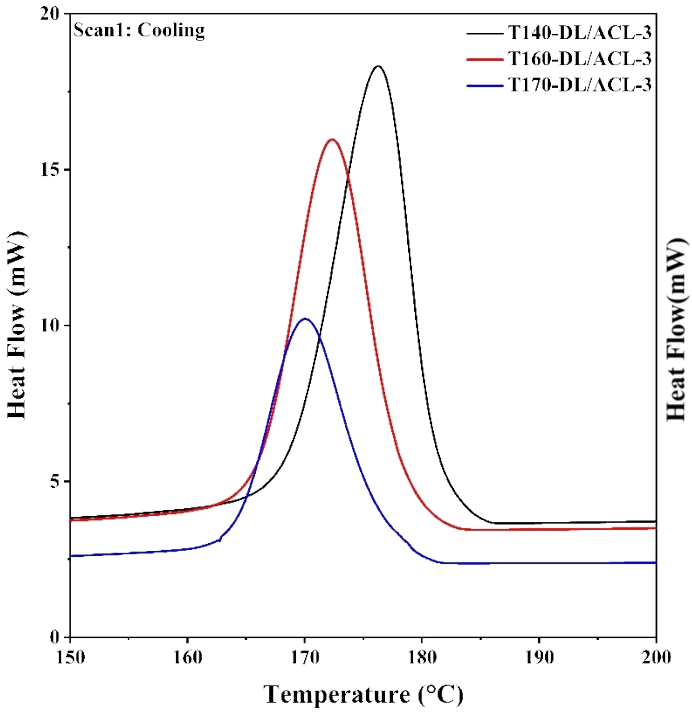
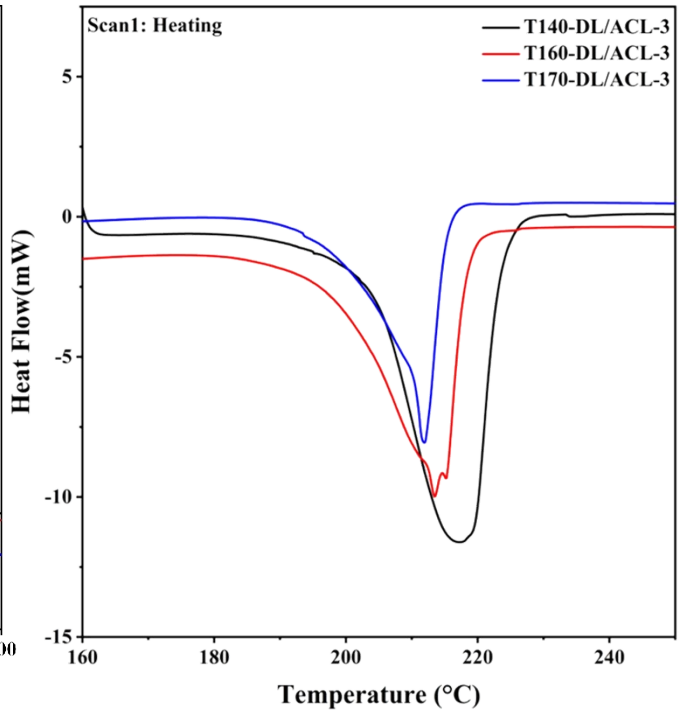
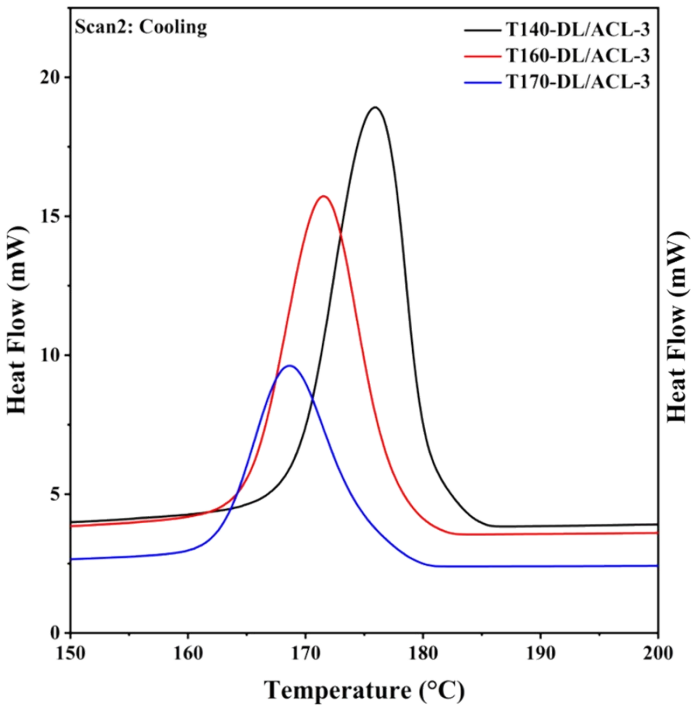

Scan 2: Heating
T140-DL/ACL-1.5
T160-DL/ACL-1.5
T170-DL/ACL-1.5
Heat Flow (mW)
Temperature (°C)

Fig.S3 DSC thermograms during first and second scan of poly-ε-caproamide (PA6) using DL/ACL-1.5 as the catalyst/activator system polymerized at 140°C, 160°C, and 170°C.


Scan1: Cooling
T140-DL/ACL-3
T160-DL/ACL-3
T170-DL/ACL-3
Heat Flow (mW)
Temperature (°C)


Scan1: Heating
T140-DL/ACL-3
T160-DL/ACL-3
T170-DL/ACL-3
Heat Flow(mW)
Temperature (°C)


Scan2: Cooling
T140-DL/ACL-3
T160-DL/ACL-3
T170-DL/ACL-3
Heat Flow (mW)
Temperature (°C)

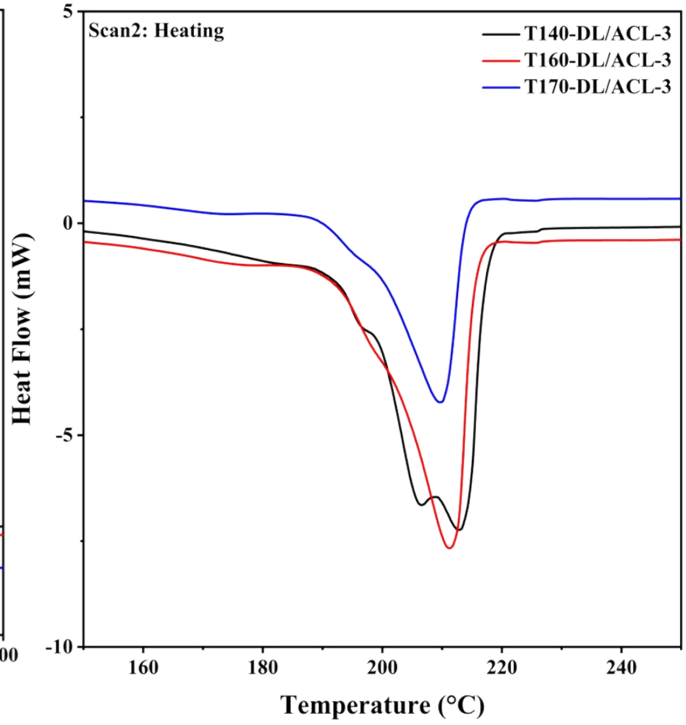
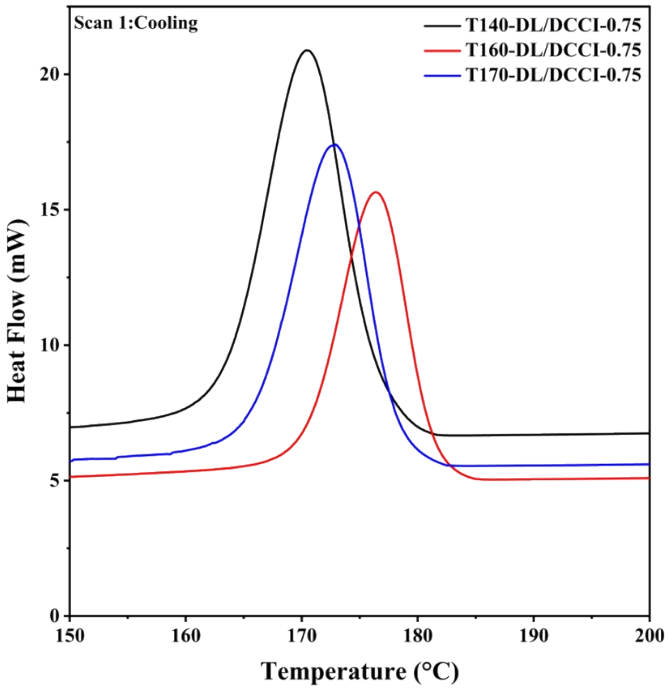
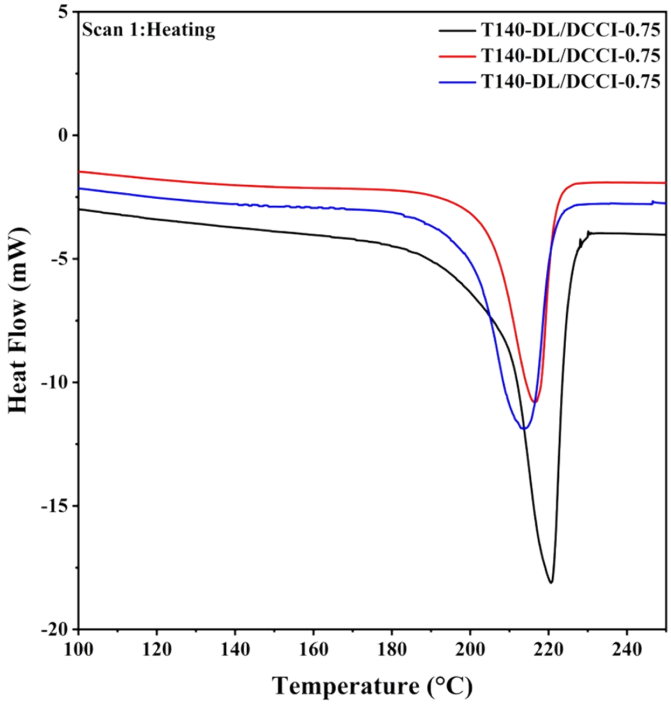
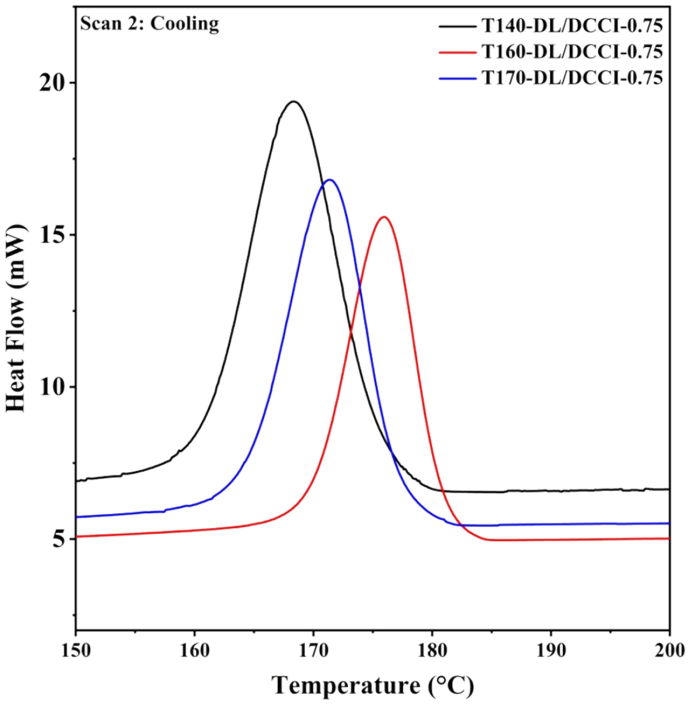

Scan2: Heating
T140-DL/ACL-3
T160-DL/ACL-3
T170-DL/ACL-3
Heat Flow (mW)
Temperature (°C)

Fig.S4 DSC thermograms during first and second scan of poly-ε-caproamide (PA6) using DL/ACL-3 as the catalyst/activator system polymerized at 140°C, 160°C, and 170°C.


Scan 1:Cooling
T140-DL/DCCI-0.75
T160-DL/DCCI-0.75
T170-DL/DCCI-0.75
Heat Flow (mW)
Temperature (°C)


Scan 1:Heating
T140-DL/DCCI-0.75
T140-DL/DCCI-0.75
T140-DL/DCCI-0.75
Heat Flow (mW)
Temperature (°C)


Scan 2: Cooling
T140-DL/DCCI-0.75
T160-DL/DCCI-0.75
T170-DL/DCCI-0.75
Heat Flow (mW)
Temperature (°C)

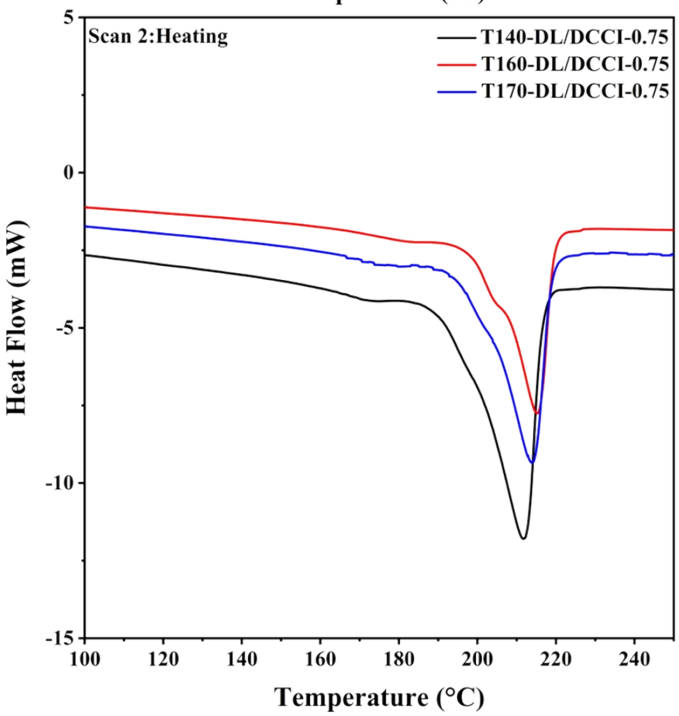
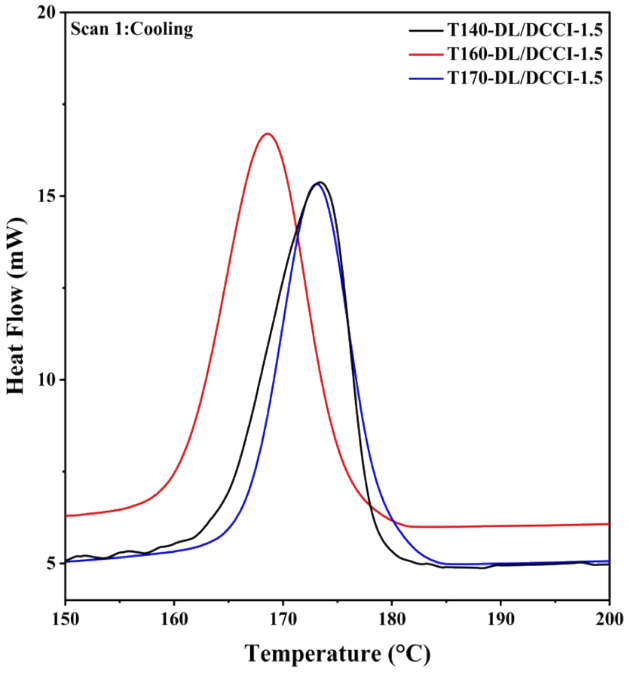
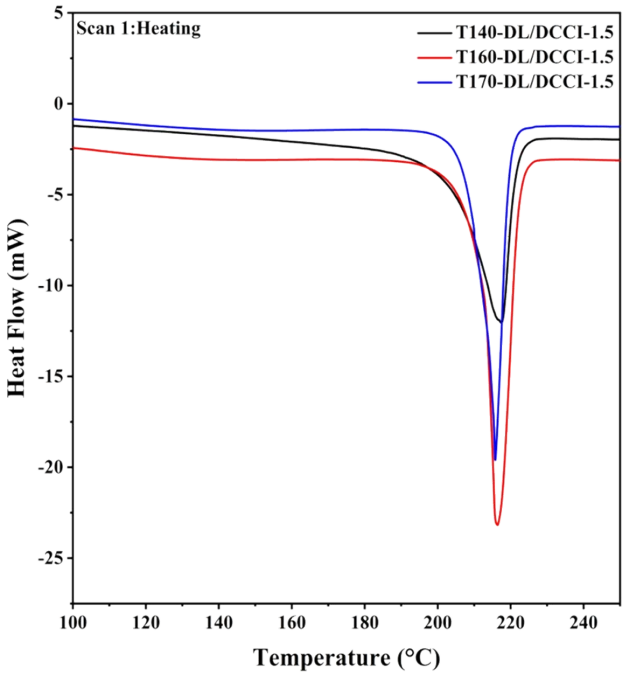
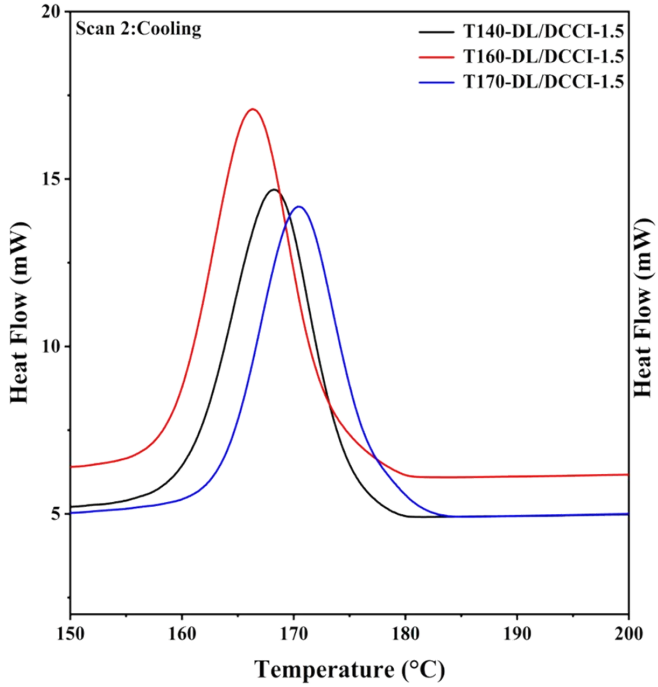

Scan 2:Heating
T140-DL/DCCI-0.75
T160-DL/DCCI-0.75
T170-DL/DCCI-0.75
Heat Flow (mW)
Temperature (°C)

Fig.S5 DSC thermograms during first and second scan of poly-ε-caproamide (PA6) using DL/DCCI-0.75 as the catalyst/activator system polymerized at 140°C, 160°C, and 170°C.


Scan 1:Cooling
T140-DL/DCCI-1.5
T160-DL/DCCI-1.5
T170-DL/DCCI-1.5
Heat Flow (mW)
Temperature (°C)


Scan 1:Heating
T140-DL/DCCI-1.5
T160-DL/DCCI-1.5
T170-DL/DCCI-1.5
Heat Flow (mW)
Temperature (°C)


Scan 2:Cooling
T140-DL/DCCI-1.5
T160-DL/DCCI-1.5
T170-DL/DCCI-1.5
Heat Flow (mW)
Temperature (°C)

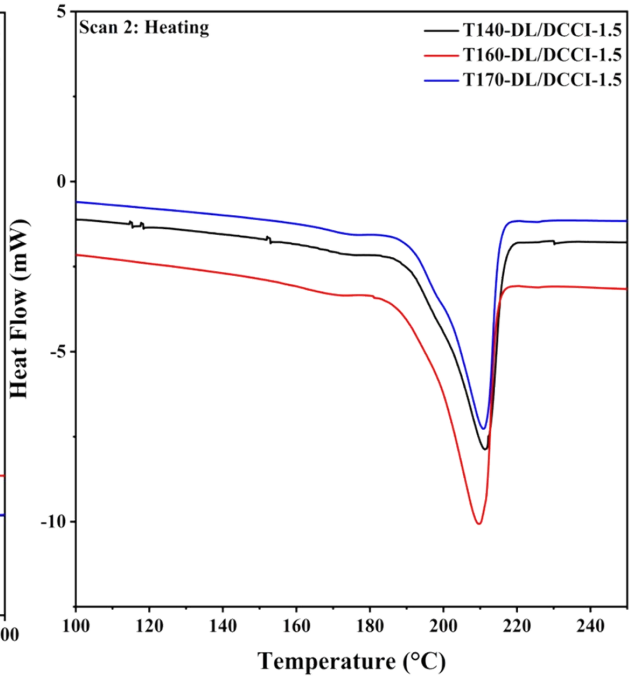

Scan 2: Heating
T140-DL/DCCI-1.5
T160-DL/DCCI-1.5
T170-DL/DCCI-1.5
Heat Flow (mW)
Temperature (°C)

Fig.S6 DSC thermograms during first and second scan of poly-ε-caproamide (PA6) using DL/DCCI-1.5 as the catalyst/activator system polymerized at 140°C, 160°C, and 170°C.

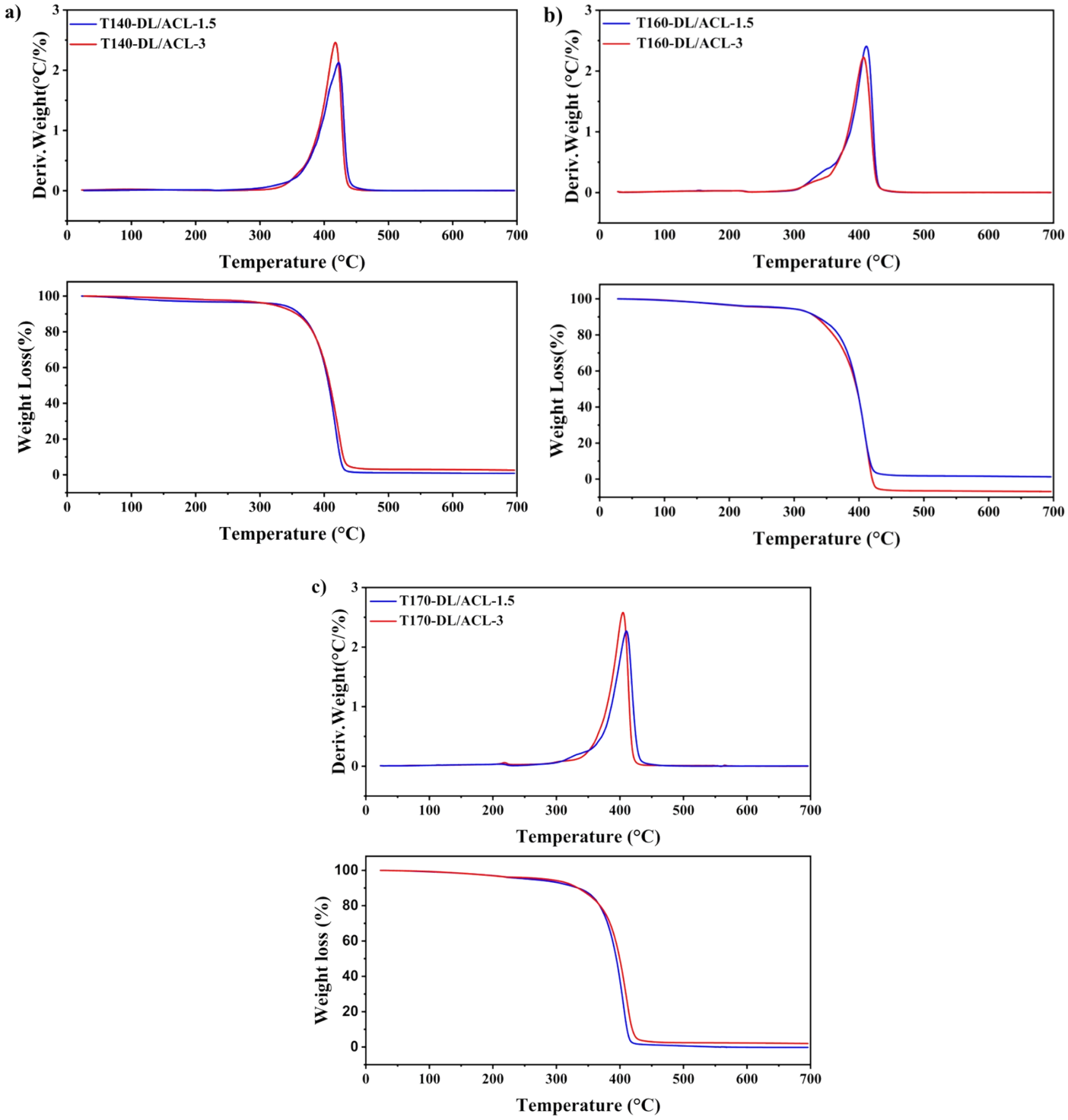

a)
T140-DL/ACL-1.5
T140-DL/ACL-3
Deriv.Weight(°C/%)
Temperature (°C)
Weight Loss(%)
Temperature (°C)
b)
T160-DL/ACL-1.5
T160-DL/ACL-3
Deriv.Weight (°C/%)
Temperature (°C)
Weight Loss(%)
Temperature (°C)
c)
T170-DL/ACL-1.5
T170-DL/ACL-3
Deriv.Weight(°C/%)
Temperature (°C)
Weight loss (%)
Temperature (°C)

Fig.S7 TGA and DTG curves of poly-ε-caproamide (PA6) for formulations DL/ACL-1.5 and DL/ACL-3 polymerized at a) 140°C, b) 160°C, and c) 170°C.

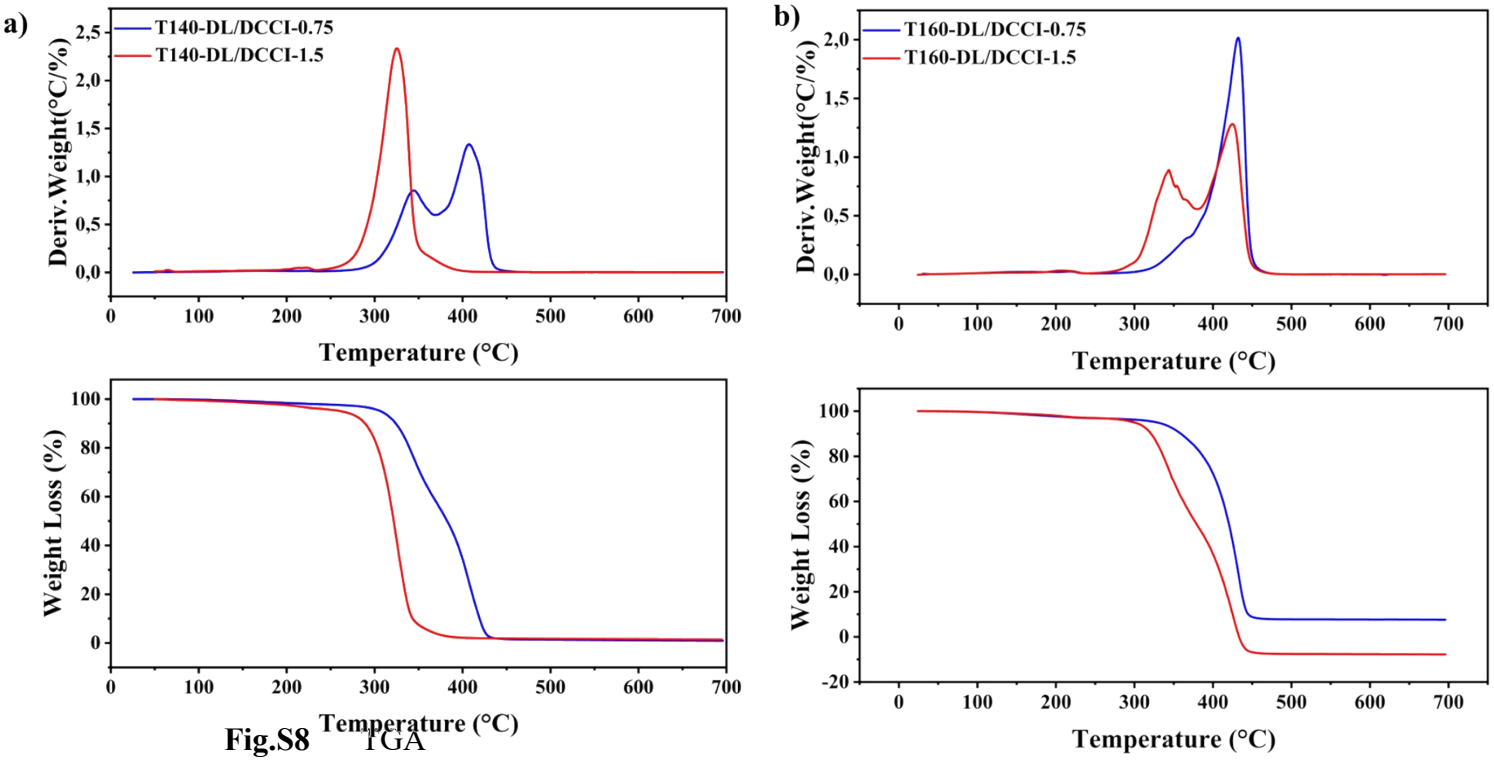
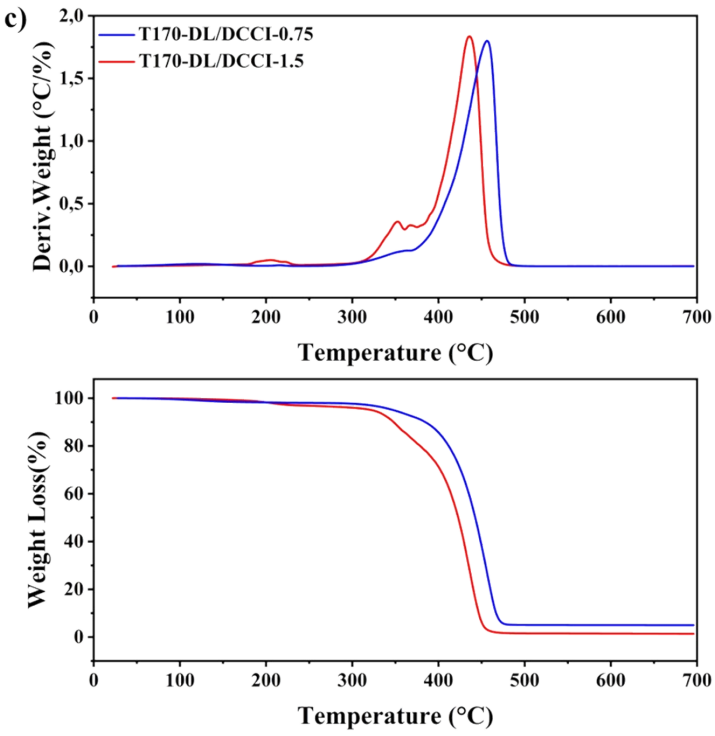


Fig.S8 TGA and DTG curves of the poly-ε-



caproamide (PA6) for formulations DL/DCCI-0.75 and DL/DCCI-1.5 polymerized at a) 140°C, b) 160°C, and c) 170°C.

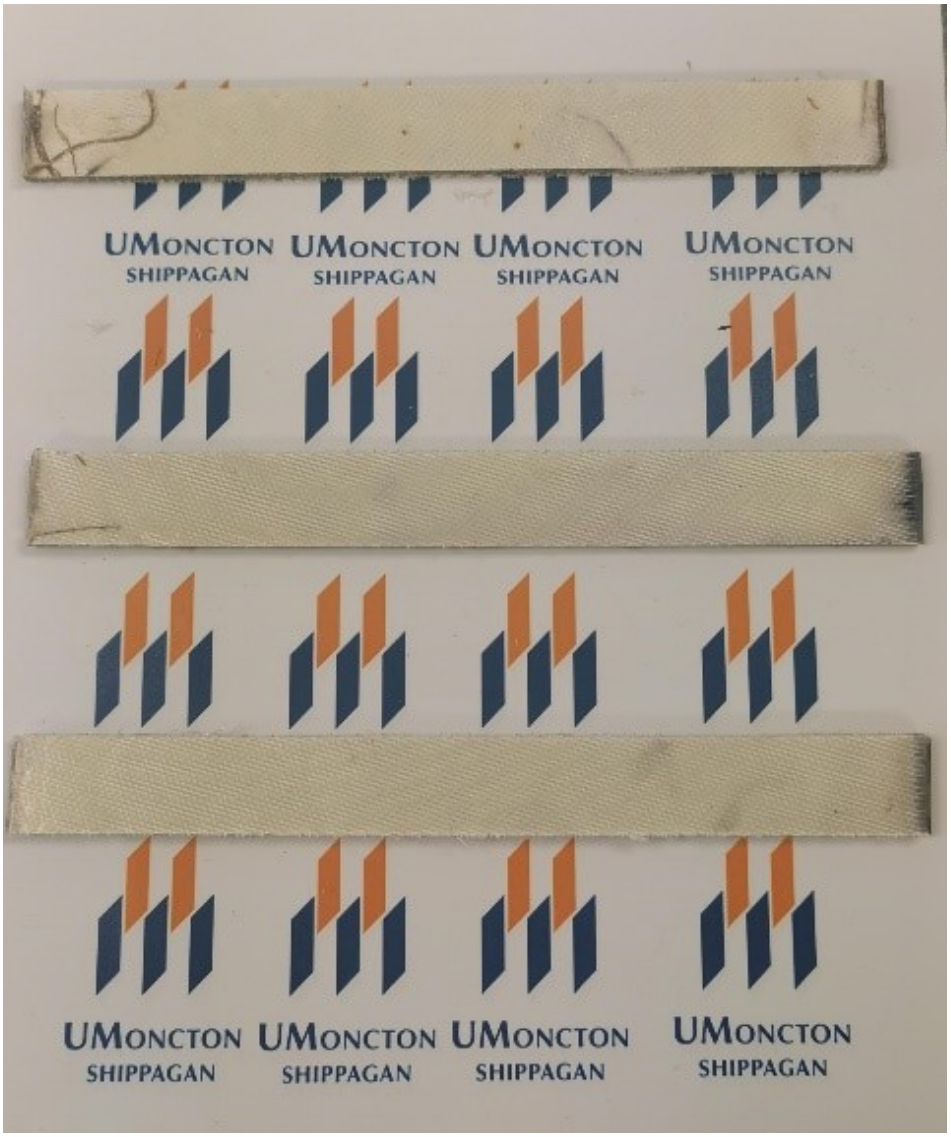


Fig. S9 Manufactured PA-6 hybrid composites reinforced with E-glass and treated hemp fibers, containing 20 wt% glass fiber and 5 wt% treated hemp fiber.