Industry Day Theme: ENA

Understanding Polymer Crystallization in Confinement for its Potential Use as Phase Change Materials

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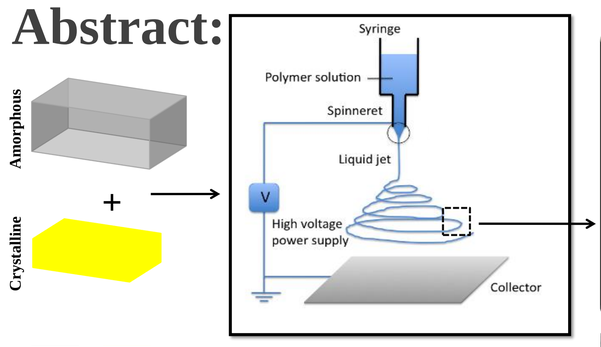
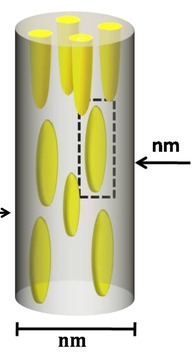
Abstract:





Electrospun Fiber Morphology

$T_g > T_m$

Wt% > Wt%

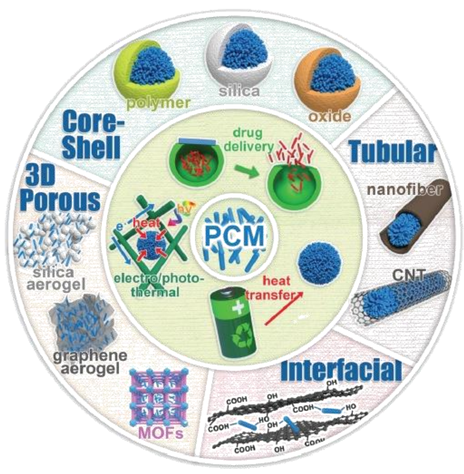
• Crystalline Polymer is scattered in matrix of amorphous polymer

• Crystalline polymer shows fractionated crystallization.

• Fractionated and multiple Phase change signal.

• Potential application as phase change material

Introduction



Highlighting the confinement of PCM's material and potential applications

Source: Energy Environ. Sci., 2018, 11, 1392

• Understanding of the polymer crystallization under nano-confinement is necessary for tailoring of the polymer properties when used in nanotechnology related applications.

• Strategies including porous template (AAO), Interfacial (Thin Film), Core-Shell (self-assembly of block-c--polymer) have been widely presented in recent years to confine polymer.

• Phase Change Materials (PCM) has been extensively characterized as constant temperature latent heat thermal energy storage (TES) materials.

• Nanoconfinement presents several advantages such as small domain size, large surface area, diverse surface functionality, controlled volume expansion, reduced reactivity with external environment, and high heat transfer.

• Electrospinning allow us to infiltrate PCM in fibrous confinement which has diameter in nano scale.

• Such material is light weight, mechanically stable, shape wise stable, flexible.

Materials and Methods

• Poly(ethylene oxide)/PEO & Poly(Ɛ-caprolactone) blend as PCM

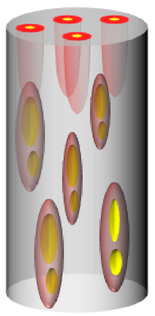
• Poly(styrene)/PS as supportive material

• Method: Single Phase Solution Electrospinning

• PS: 18.6 $MPa^{1/2}$,PCL: 19.7 $MPa^{1/2}$, PEO: 20.2 $MPa^{1/2}$

$T_{gPS} > T_{mPEO} \sim T_{mPCL}$

Immiscible Blend



Schematic of blend morphology in sES fiber

• Compatibility in between PEO & PCL is enhanced due to quick evaporation of solvent during electrospinning

Conclusions

• PEO & PCL shows fractionated crystallization under confinement.

• Phase behaviour of polymer is different under confinement as compare with bulk.

• Polymer gives high latent heat signal as compare with conventional PCM materials.

• Have potential application in PCM field.

Industrial Significance

• The latent heat TES based on phase change materials (PCMs) is one of the effective and efficient technologies being actively pursued owing to high storage density in small temperature region.

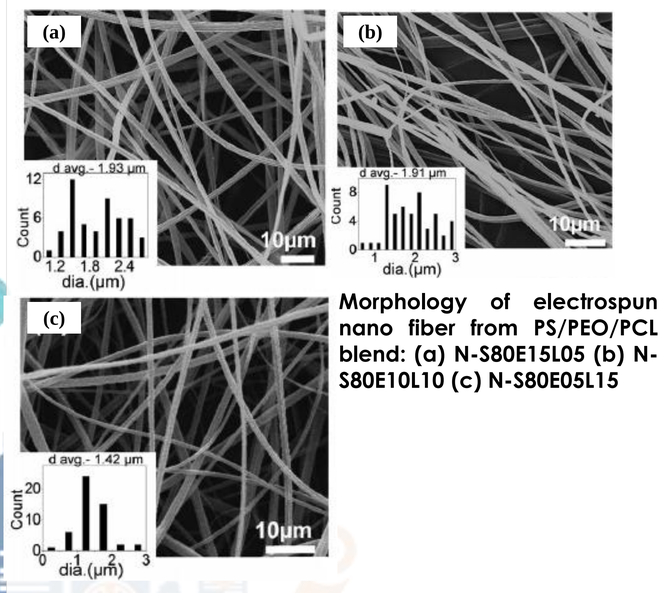
• All characterization results confirm the potentiality of such electrospun fibers as PCM material.

• Potential application in thermal energy storage and heat transfer applications.

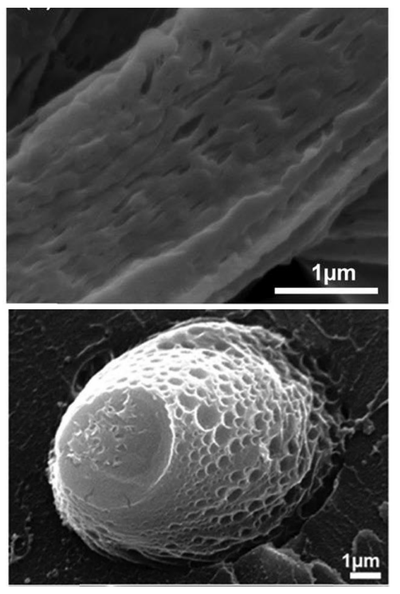
Technology Readiness Level

More study is still going on to explore the potentiality of such electrospun fibers as PCMs

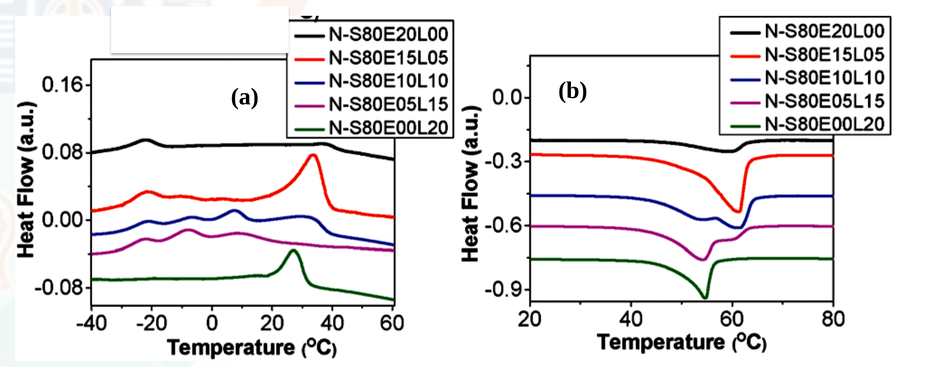
Results



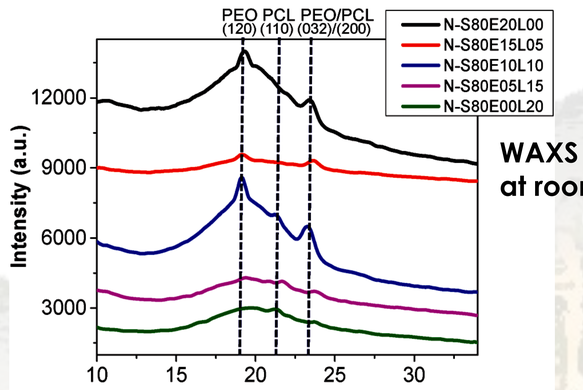
Morphology of electrospun nano fiber from PS/PEO/PCL blend: (a) N-S80E15L05 (b) N-S80E10L10 (c) N-S80E05L15



Domain morphology: studied after selective etching of PEO with de-ionised water



DSC cooling (a) and heating (b) curves of PS/PEO/PCL blends after first heating up to 90 °C, (d) DSC cooling curves of N-S80E10L10 blends after melt annealing at 90 °C for different times;



WAXS profiles of PS/PEO/PCL nanofibers at room temperature

References

• P. Samanta, Thangapandian V. ,Sajan Singh, Rajiv Srivastava, Bhanu Nandan, Chien-Liang Liub and Hsin-Lung Chen, ***Soft Matter, 2016,*** 12, 5110.

• P. Samanta, Rajiv Srivastava, Bhanu Nandan and Hsin-Lung Chen, ***Soft Matter, 2017,*** 13, 156

Acknowledgement

This work was supported by CSIR under grant no. 22(0707)/15/EMR-II

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