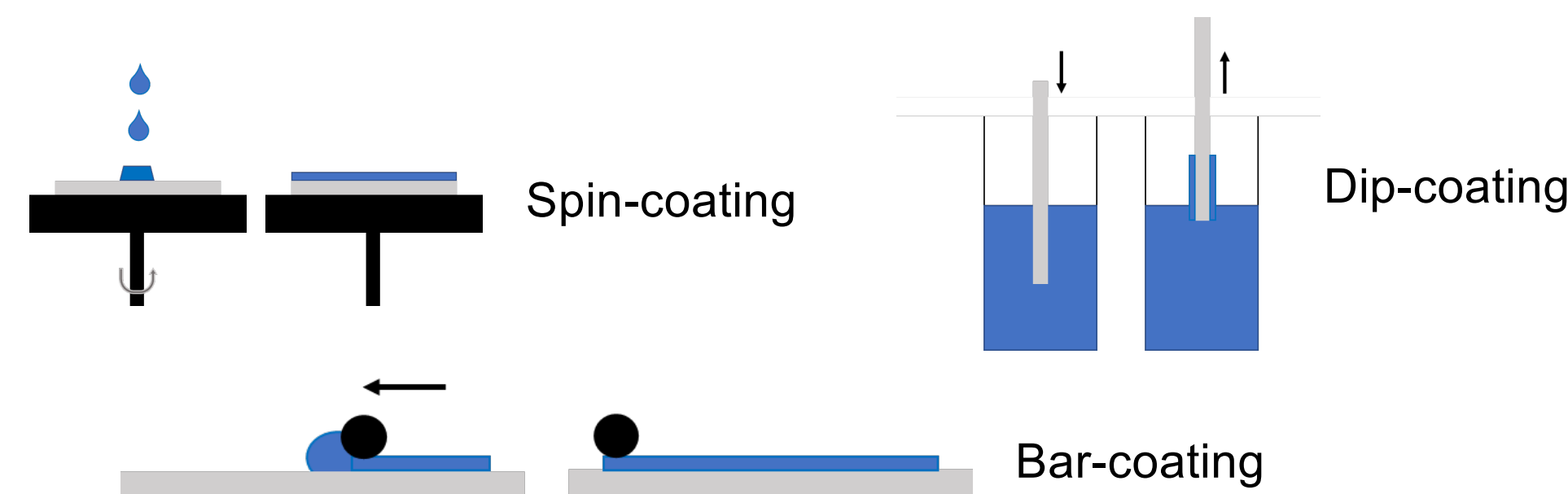


## Introduction

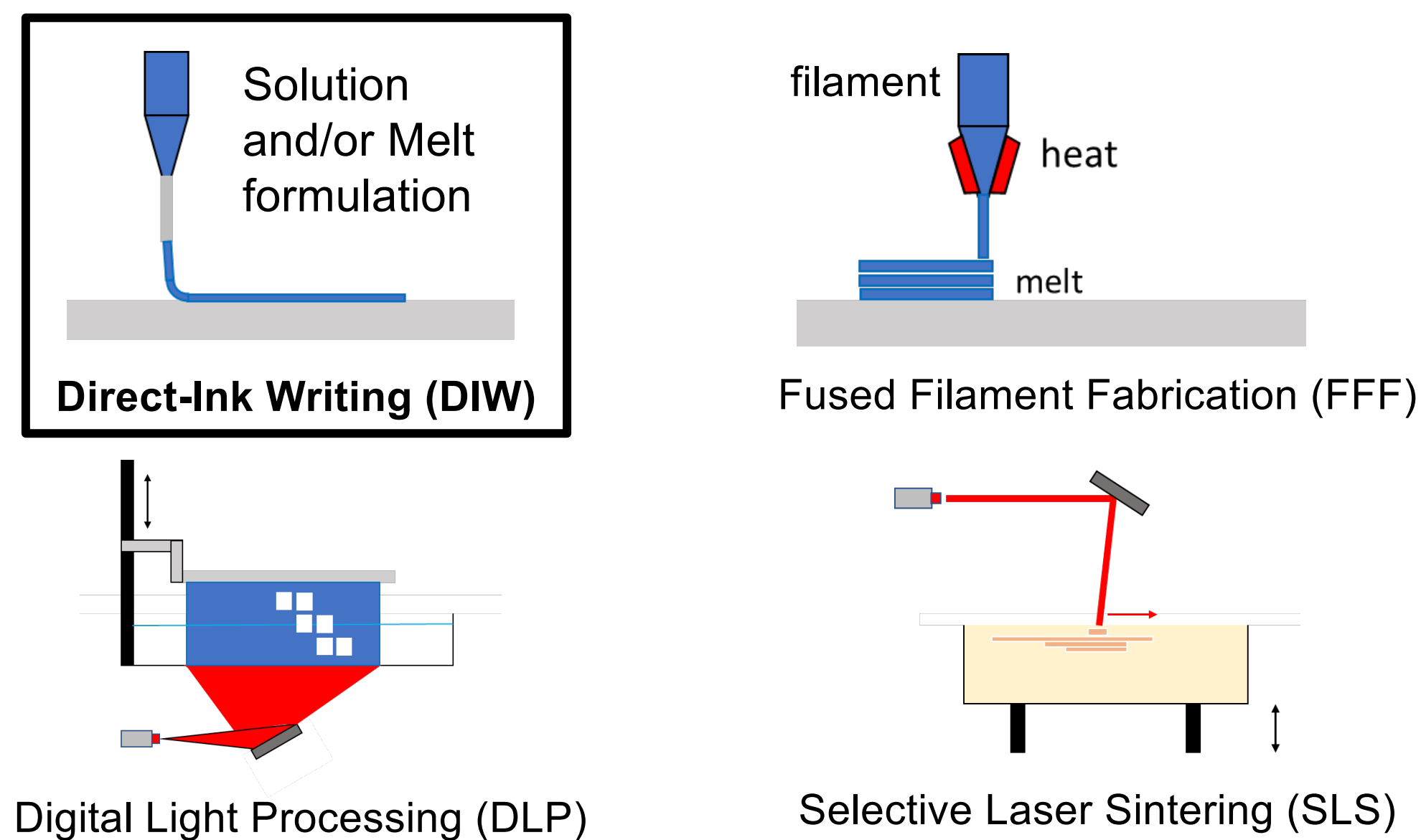
### Organic Semiconductor Polymer

- **Sustainable** aspect vs. inorganic counterparts.
- Capable of electrical conductivity, a **property** highly influenced by their **microstructure**.
- Attractive for opto-electronic and energy conversion applications.
- **Challenging to process** on their own.
- An alternative is to use a polymer matrix to ease their processing.

### Conventional Ways to Prepare 2D Thin Films



### Towards 3D Printing



- Among these 3D printing techniques, **Direct-Ink Writing (DIW)** is environmentally friendly, cost effective, offers access to **complex geometry** and multi-material printing.

## Objective

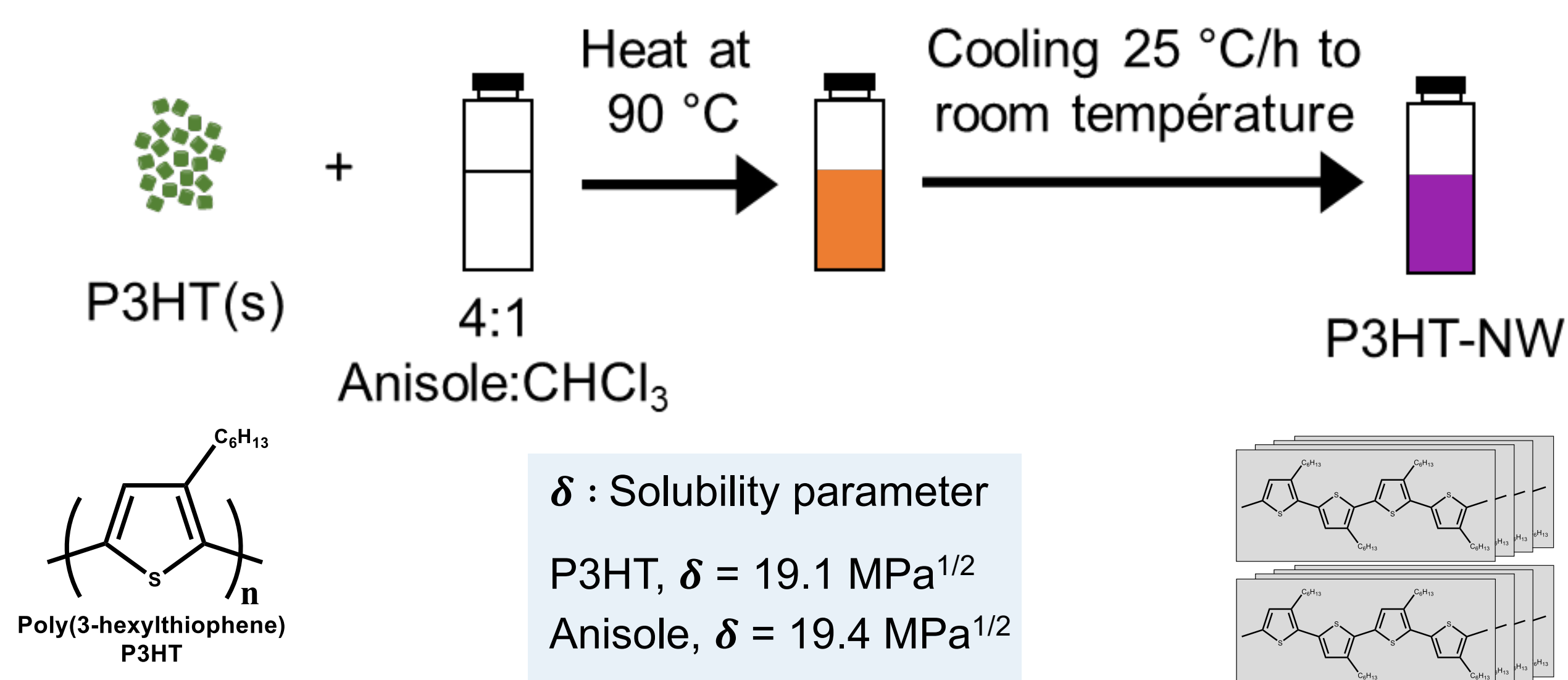
### Goal and Approach

To exploit the shear forces of DIW and the concept of phase separation between polymers **to promote alignment of P3HT nanowires** embedded in a polymer matrix.

## Materials Preparation

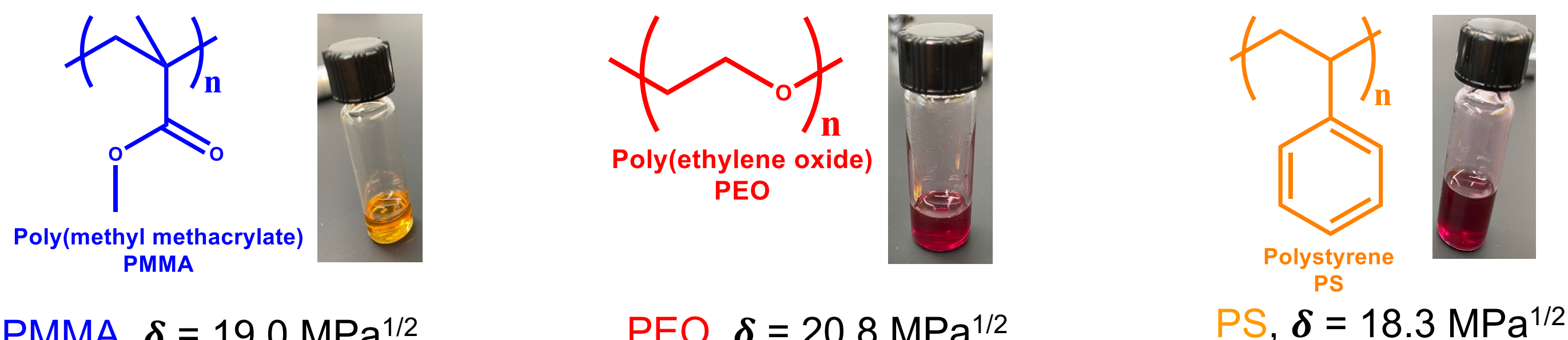
### P3HT-NW Preparation [1]

- P3HT nanowires (NW) result from the aggregation of many single chains of P3HT.
- This aggregation can be induced by using a poor solvent, by chemical doping (e.g. F<sub>4</sub>TCNQ) or UV irradiation.
- P3HT can show electrical conductivity when it is in the form of nanowires. [2]



### P3HT-NW + Polymer Matrix

- P3HT-NW were blended with **PMMA**, **PEO** and **PS** matrices.
- Deaggregation of P3HT-NW after ageing in **PMMA**.
- P3HT-NW aggregation is maintained in the **PEO** and **PS** matrices.



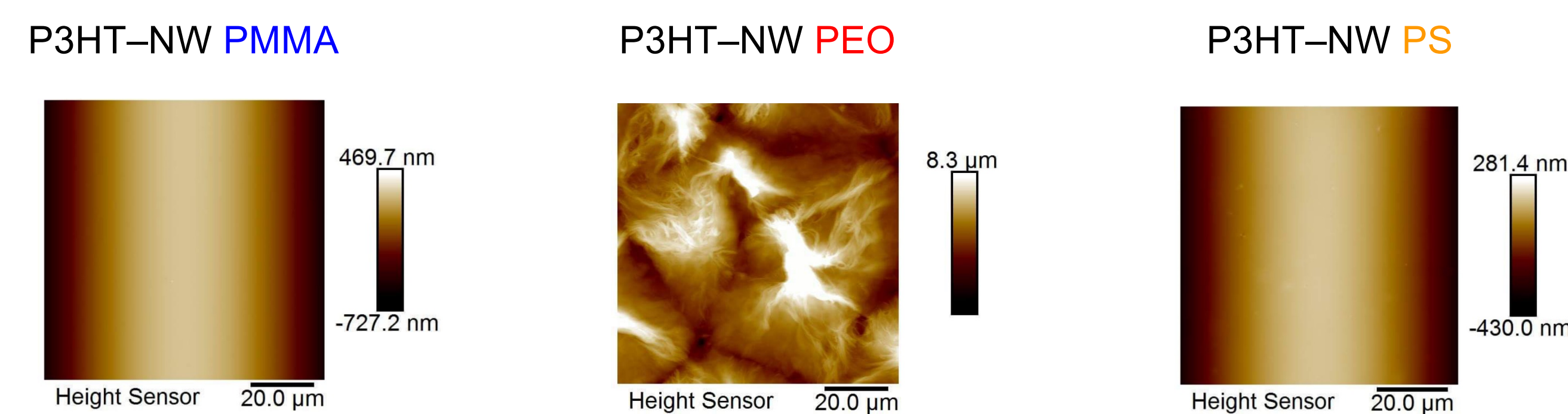
### Predicting Preferential Segregation

| Polymer matrix | $(\delta_{P3HT} - \delta_{anisole})^2 \text{ vs. } (\delta_{P3HT} - \delta_{polymer matrix})^2$ | Preference  |
|----------------|-------------------------------------------------------------------------------------------------|-------------|
| <b>PMMA</b>    | $0.1 > 0.0$                                                                                     | <b>PMMA</b> |
| <b>PEO</b>     | $0.1 < 2.9$                                                                                     | Anisole     |
| <b>PS</b>      | $0.1 < 0.7$                                                                                     | Anisole     |

## Structural Characterization

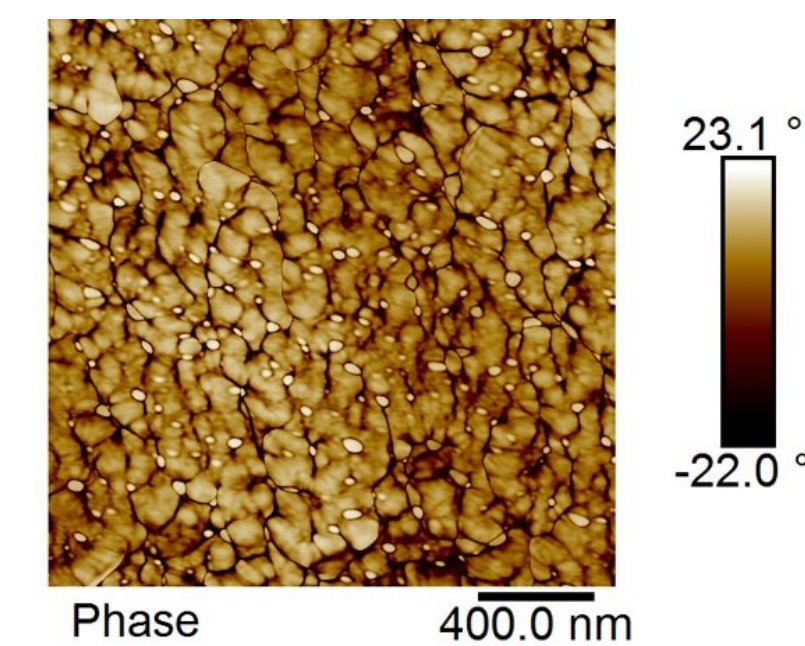
### Atomic Force Microscopy (surface)

- P3HT-NW are not observed on the surface.
- Spherulites and cracks observed for the **PEO** snake due to its crystallization.



### Atomic Force Microscopy (cross-section)

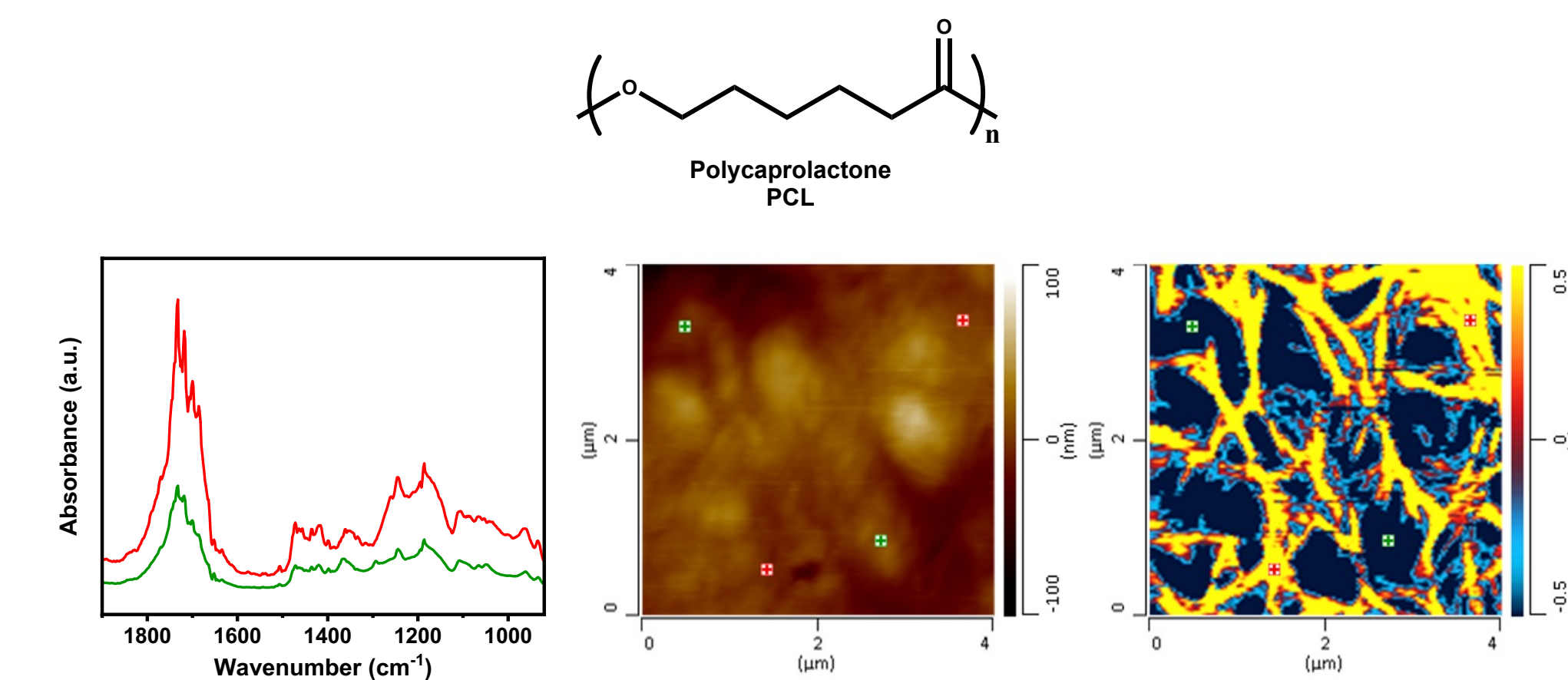
- P3HT-NW **PS** cross-section AFM.
- Sample cross-section image obtained from a sample cut by a microtome.
- P3HT-NW areas are observed in this blend.
- Needs confirmation by AFM-IR.



## Hot Melt Extrusion

### AFM-IR (surface)

- P3HT-NW PCL phase separation.
- Low melting point, low melt viscosity and good toughness after solidification make PCL a good matrix for the hot melt extrusion.
- Hot melt extrusion is also an extrusion based 3D printing technique. No solvent is needed.



## Conclusions

### Early Conclusions

- P3HT-NW aggregation is maintained in **PEO** and **PS** according to  $A_{0-0}/A_{0-1}$  ratio.
- Phase separation observed in P3HT-NW **PS** blend.

### Future Work

- Cross-sections AFM-IR.
- Band fitting of UV-visible spectra (Spano model).
- Charge mobility measurements and percolation threshold.

## References

- [1] Kan T. *et al.*, *ACS Appl. Polym. Mater.* **2019**, 1, 2943–2950.  
[2] Zhi Y. *et al.*, *J. Mater. Chem. C*, **2014**, 2, 6773.

## Acknowledgements

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