Development of Core-Sheath Phase Change Fibres Incorporated with PEG2000 for Thermoregulation Applications

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1. INTRODUCTION

Urban resilience in the face of climate challenges is a concern, impacting well-being due to environmental, economic and social influences. Asphalt pavements aggravate the Urban Heat Island (UHI) by retaining and releasing heat. The development of polymeric coaxial fibres with phase change materials (PCM) for application in asphalt mixtures has emerged as a promising solution to improve thermoregulation and mitigate UHI problems.

This issue is directly related to the United Nations (UN) goals **SDG9**, **SDG11** and **SDG12**, associated with resilient and sustainable cities, and represents a considerable challenge that must be addressed.

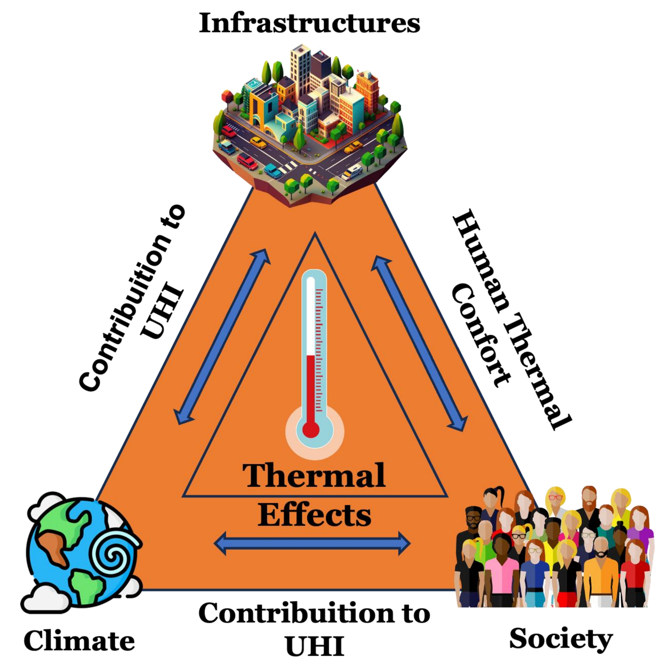

Figure 1: Thermal effects.

2. OBJECTIVES

This research aims to evaluate the ideal composition of coaxial Phase Change Fibres (PCFs) composed of cellulose acetate as the sheath (CA, Mn 30,000 and 50,000) and polyethene glycol (PEG) 2000 as the core, produced by the wet spinning method.

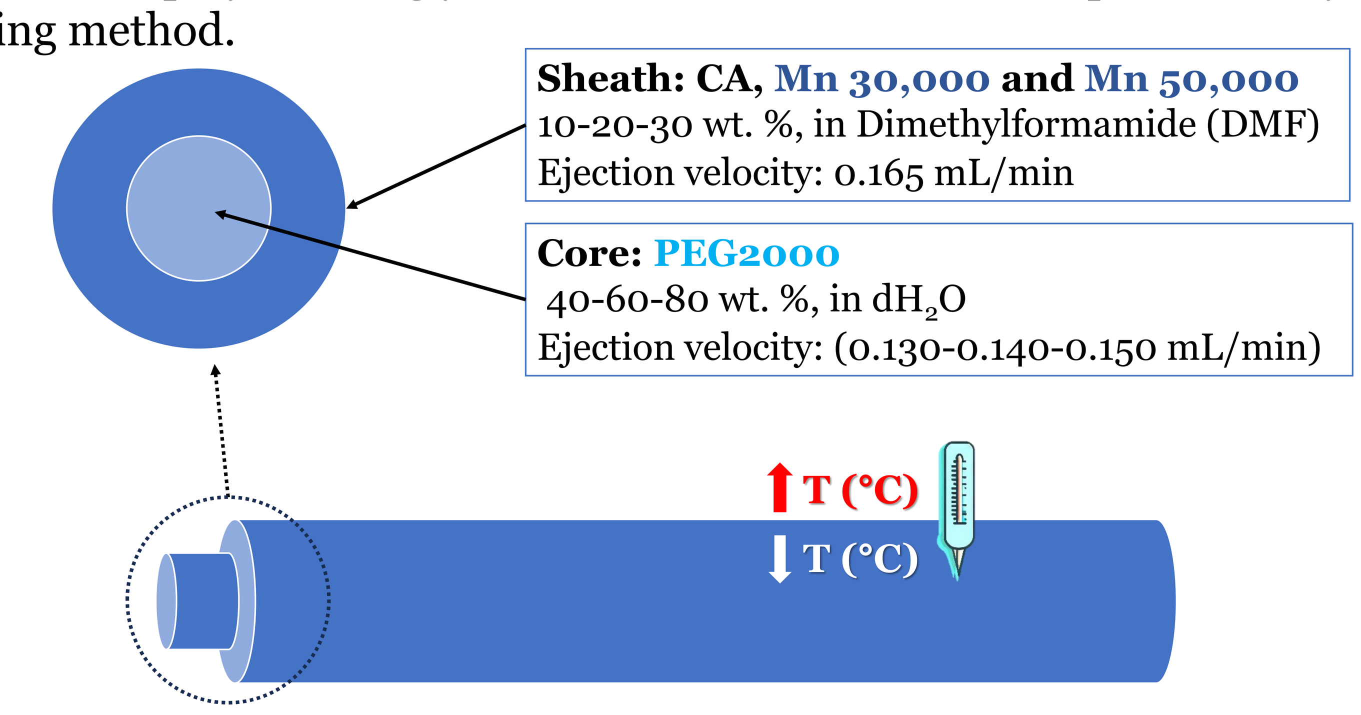

Figure 2: PCF representation.

Nomenclature for fibres

PCF_a_b/x_y	PCF (Type)	a (Mn CA)	b (wt. % CA)	x (wt. % PEG)	y (Ejection Velocity PEG (mL/min))
	Phase Change Fibre	30.000 or 50.000	10, 20 or 30	40,60 or 80	0.130, 0.140 and 0.150

Table 1: Nomenclature for PCFs.

3. METHODOLOGY

Dissolution 1
- CA
- DMF
- 50 °C
- Overnight

Dissolution 2
- PEG2000
- dH_2O
- 50 °C
- Overnight

- The dissolutions were removed from the magnetic stirrer half an hour before starting production to reach room temperature and left to rest to avoid air bubbles;
- Coagulation bath: dH_2O (T = 20 °C);
- Injection port (core): 21 gauge = 0.723 mm;
- Injection port (sheath):11 gauge = 2.304 mm;

Wet spinning process

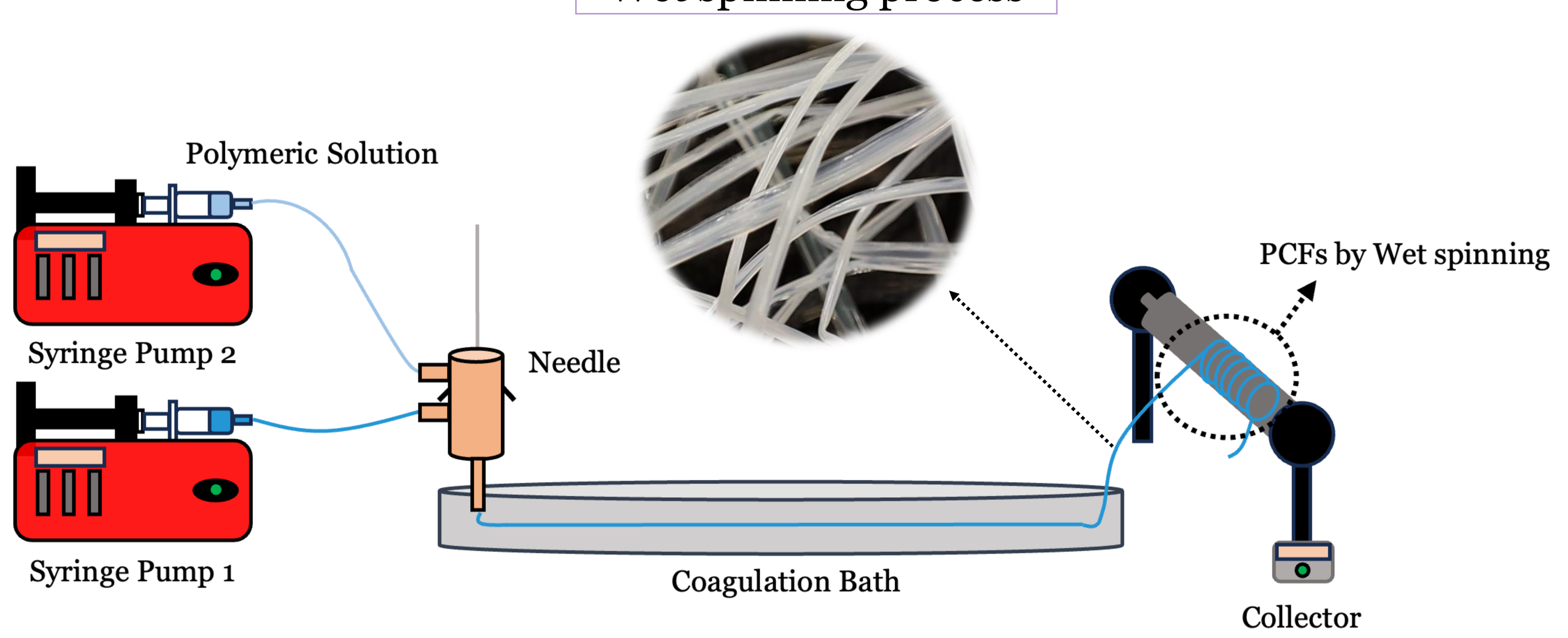

Figure 3: Scheme of production of PCFs.

4. RESULTS AND DISCUSSIONS

4.1 Bright-field Microscopy

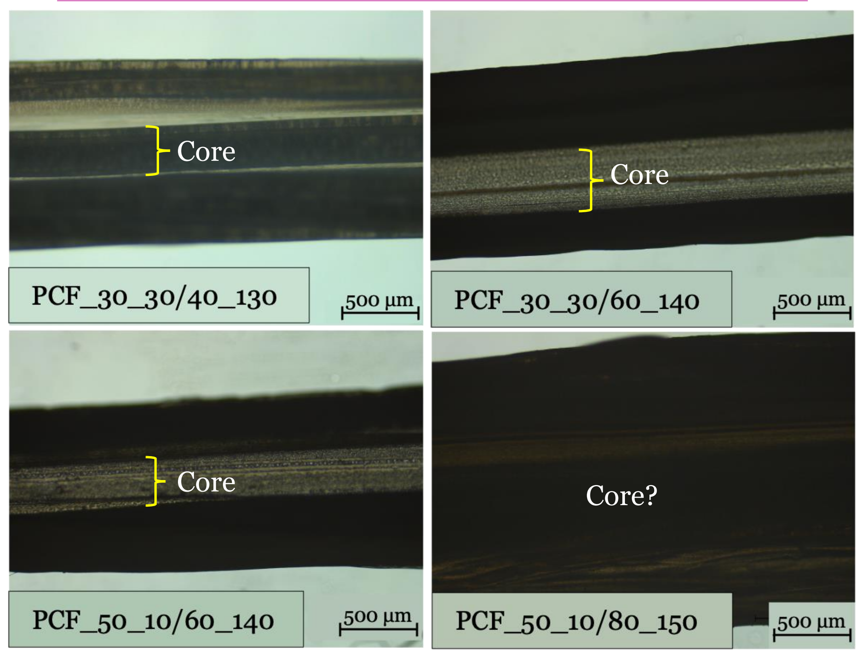

Figure 4: PCFs observed under the microscope (Magnification: 5×).

4.2 Fourier Transform Infrared Spectroscopy (FTIR)

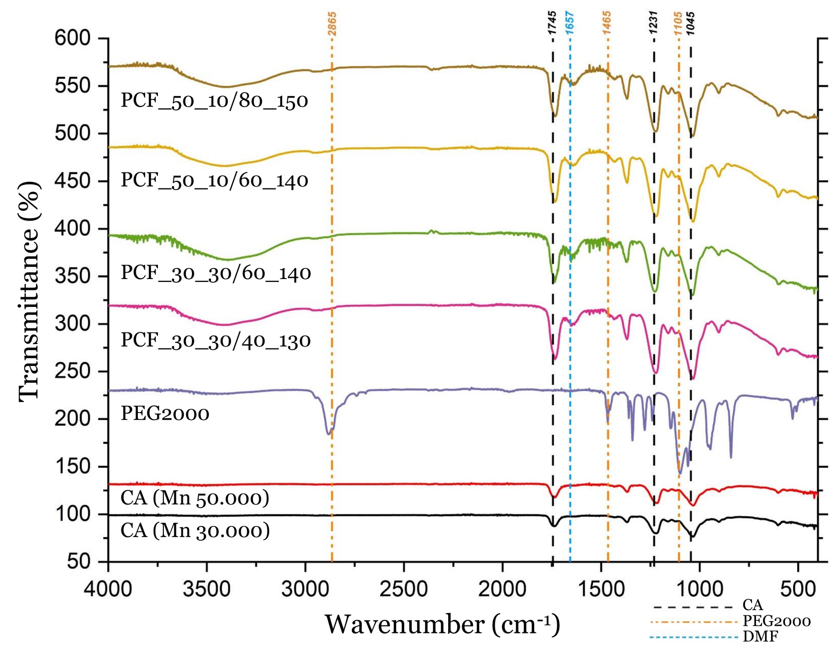

Figure 5: Comparative FTIR between PCFs and virgin materials.

4.3. Thermogravimetric Analysis (TGA)

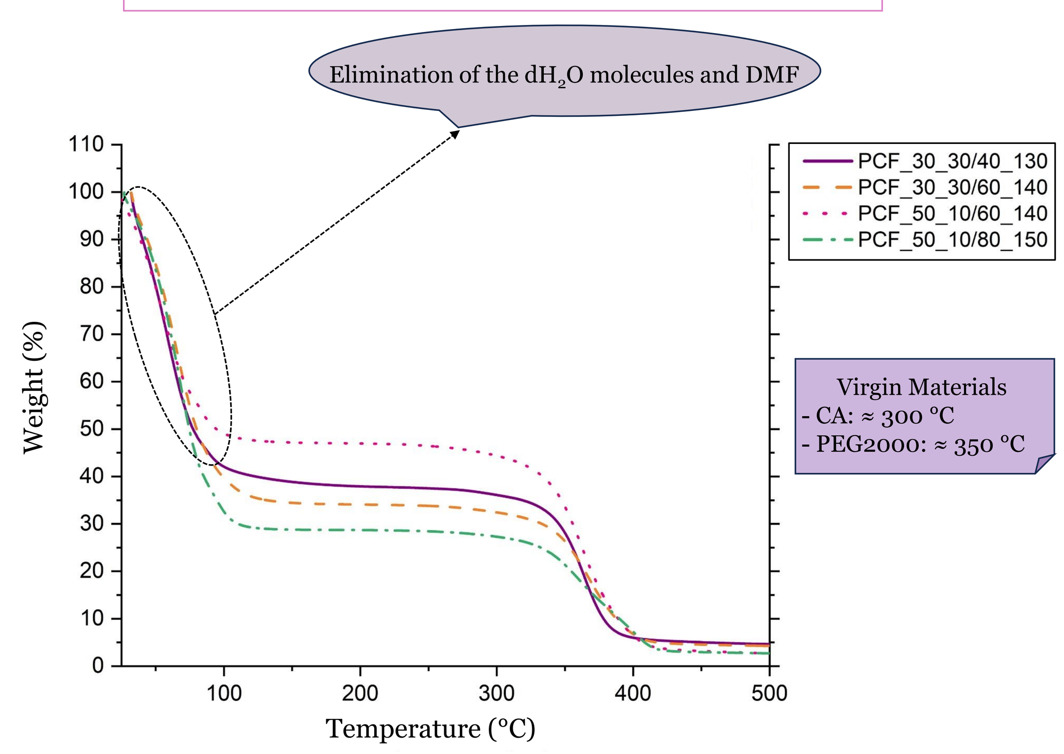

Figure 6: TGA curves of the PCFs.

4.4. Differential Scanning Calorimetry (DSC)

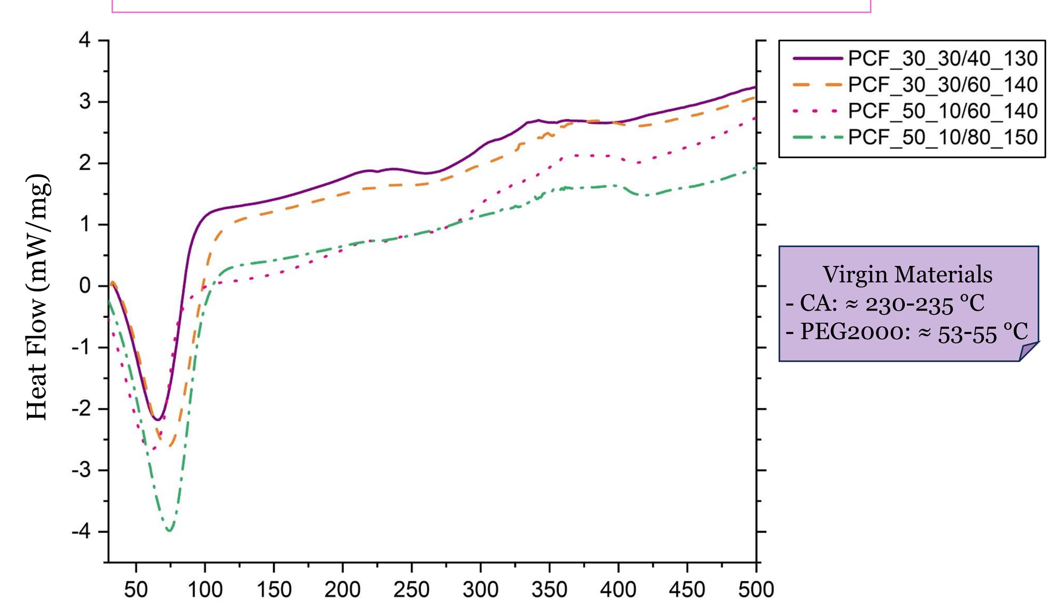

Figure 7: DSC curves of the PCFs.

5. CONCLUSION

The PCFs were successfully produced by wet spinning. The ejection velocity influenced the structure of the PCF, with the best velocity of 0.130 mL/min. By FTIR, the characteristic peaks of PEG and CA were observed. Bright-field Microscopy revealed the coaxial structure, indicating that PEG is in the core and CA is the sheath of the PCF. TGA showed the ability of PCFs to withstand higher temperatures than those used in the production and compaction of the asphalt mixtures (~160 °C). DSC confirmed the phase change of PCF with a change peak close to virgin PEG2000. The phase change temperature of the PCF is therefore compatible with application in infrastructures subjected to moderate temperatures between 50-60 °C.

The next step of this work is to evaluate the thermal behaviour of the asphalt mixtures composed of the produced PCF.

6. ACKNOWLEDGEMENTS

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