

Two Wastes, One Fiber: Upcycling Expanded Polystyrene and Organosolv Lignin into Electrospun Carbon Fibers

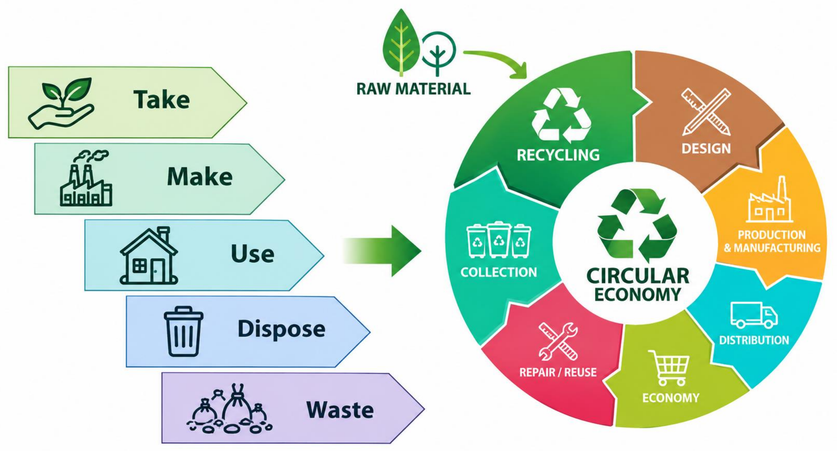
Haleh Naeim[1], Faezeh Mahdavian[1], Roland Jacks Ekila[2], Tatjana Stevanovic[2], Denis Rodrigue[1]

[1] *Department of Chemical Engineering and CERMA, Université Laval, Quebec, QC, G1V 0A6, Canada.*

[2] *Department of Wood Sciences, Faculty of Forestry, Université Laval, Quebec, QC, G1V 0A6, Canada.*

Motivation and Objective

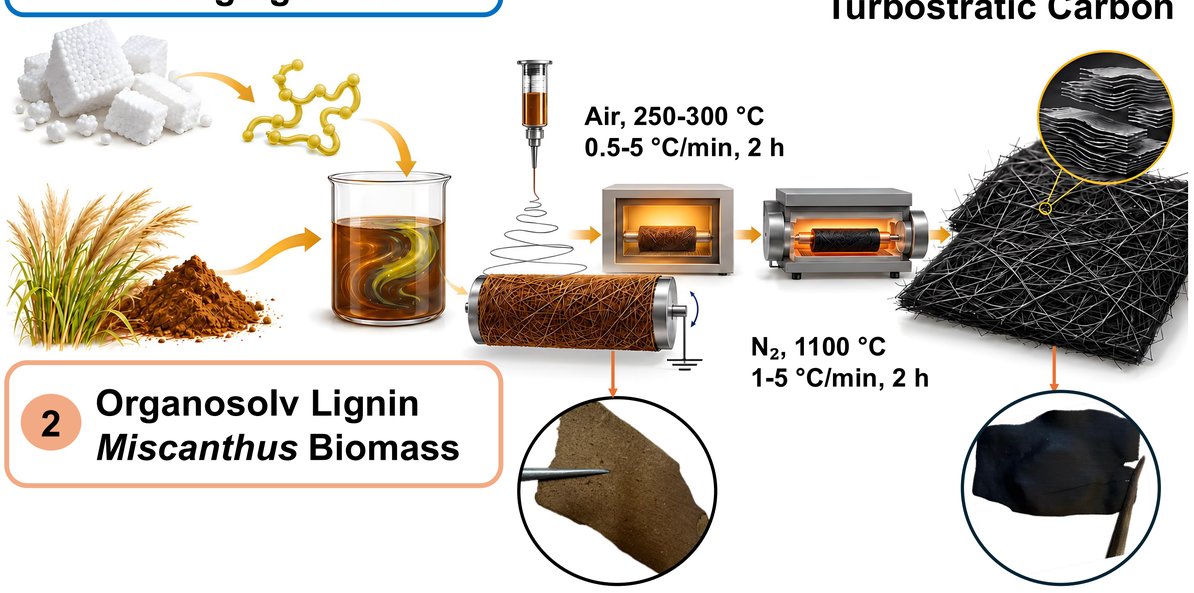
The growing accumulation of plastics and biomass waste has become a major environmental concern. In response, the transition from a linear *take-make-dispose* model towards a circular economy promotes waste valorization, recycling, and resource recovery. **EPS** and **lignin** are two underutilized waste resources. While EPS recycling remains challenging, most industrial lignin is still used for energy production. Their combined valorization offers a promising route to high-value carbon fibres.



Materials and Methods

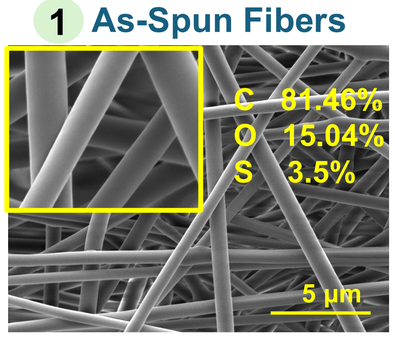
1 Waste EPS Packaging Foam

2 Organosolv Lignin *Miscanthus* Biomass

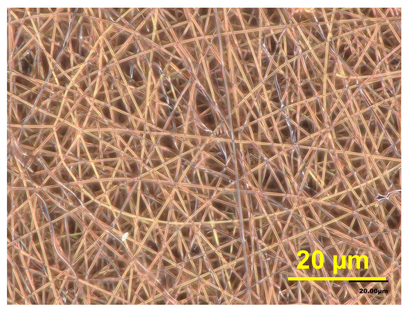


Results and Discussion

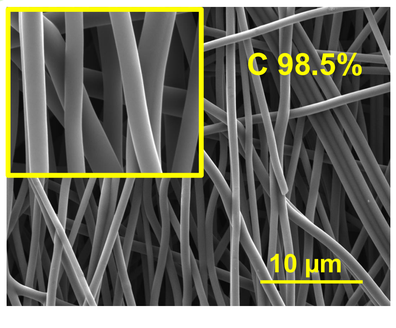
1 As-Spun Fibers

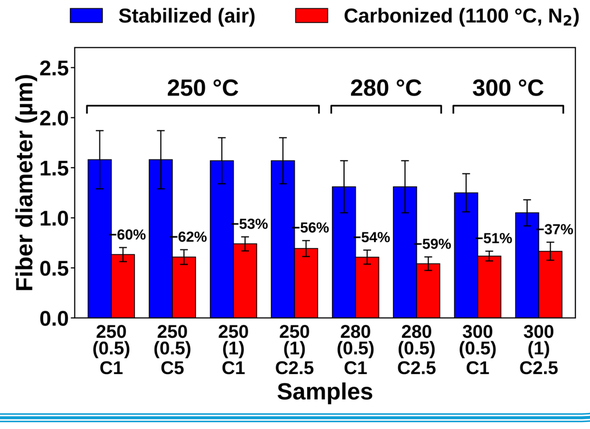


2 Stabilized Fibers (air)



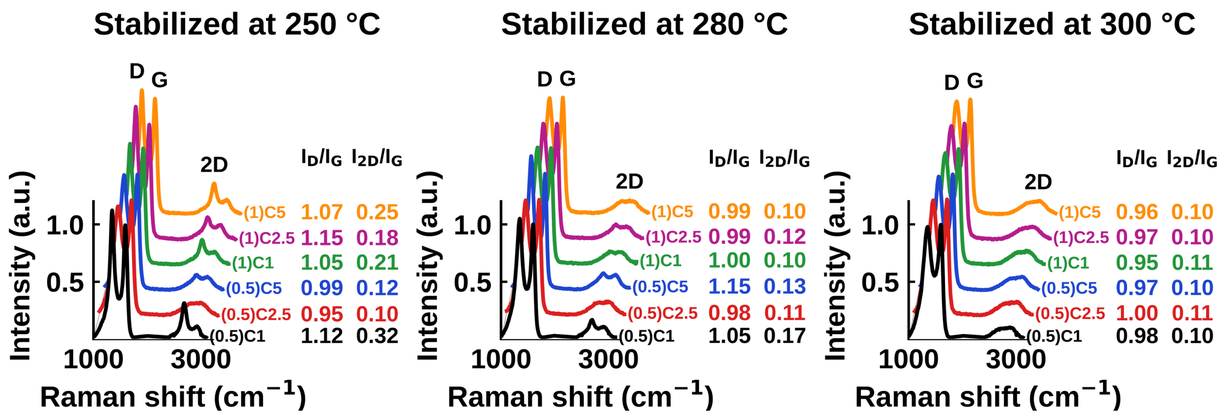
3 Carbonized Fiber (N_2)



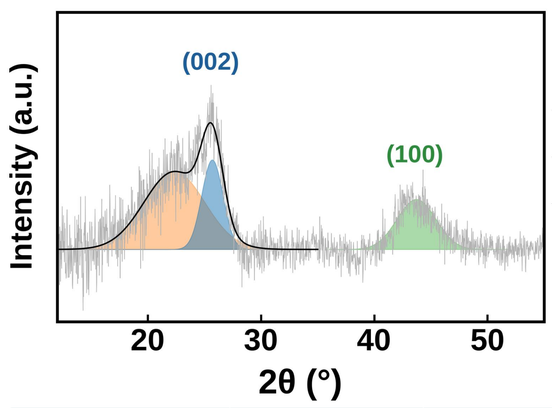


Results and Discussion

4 Raman Spectroscopy



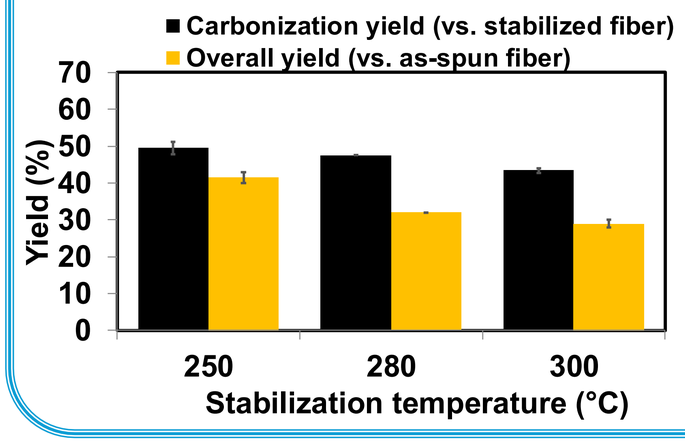
5 X-Ray Diffraction



- ✓ Turbostratic carbon in all fibers
- ✓ d_{002} = 3.43-3.48 Å (graphite: 3.35 Å)
- ✓ 250 °C → 2-5× more stacked layers

Sample	(002) 2θ (°)	d_{002} (Å)	L_c (nm)	(100) 2θ (°)	L_a (nm)
250(0.5)C1	25.69	3.47	3.7	43.71	4.3
250(0.5)C5	25.96	3.43	3.7	43.95	4.2
250(1)C1	25.96	3.43	3.7	44.01	4.0
250(1)C2.5	25.85	3.44	3.6	43.90	3.8
280(0.5)C1	25.61	3.48	4.0	43.90	4.1
280(0.5)C2.5	25.86	3.44	3.7	44.06	3.5
300(0.5)C1	25.86	3.44	3.5	44.11	3.7
300(1)C2.5	25.87	3.44	2.9	44.21	3.4

6 Carbon Yield



- ✓ Over-oxidation doubles mass loss in air (16% → 33%)
- ✓ Yield is set by **stabilization temperature**, not heating rate
- ✓ **Highest overall yield at 250 °C (40-43%)**, falling to 28-32% at 280-300 °C

Conclusion

Two Wastes, One Fiber: EPS (as SPS) + Lignin
Easy Spinning: 32 wt.% solution
Faster Stabilization: 2-4 times faster, No fusion
250 °C Optimal: Highest yield (~43%), Most ordered carbon
Carbon Fibers: 0.54-0.74 µm, 98.5 at% C

Acknowledgments

CRIAQ
DMT Bioproducts
AIRBUS
CERMA centre de recherche sur les matériaux avancés