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KEY RESULT

50PP (50% PHA + 50% PBS) is the lead candidate for 3D-printed eyewear frames: both phases confirmed by Raman, cohesive two-phase morphology, and a melt-flow window shared with its constituents.

Discarded fossil-based frames

Bio-based polymers + natural fillers

FTIR · Raman · SEM · MFI screening

50PP blend selected

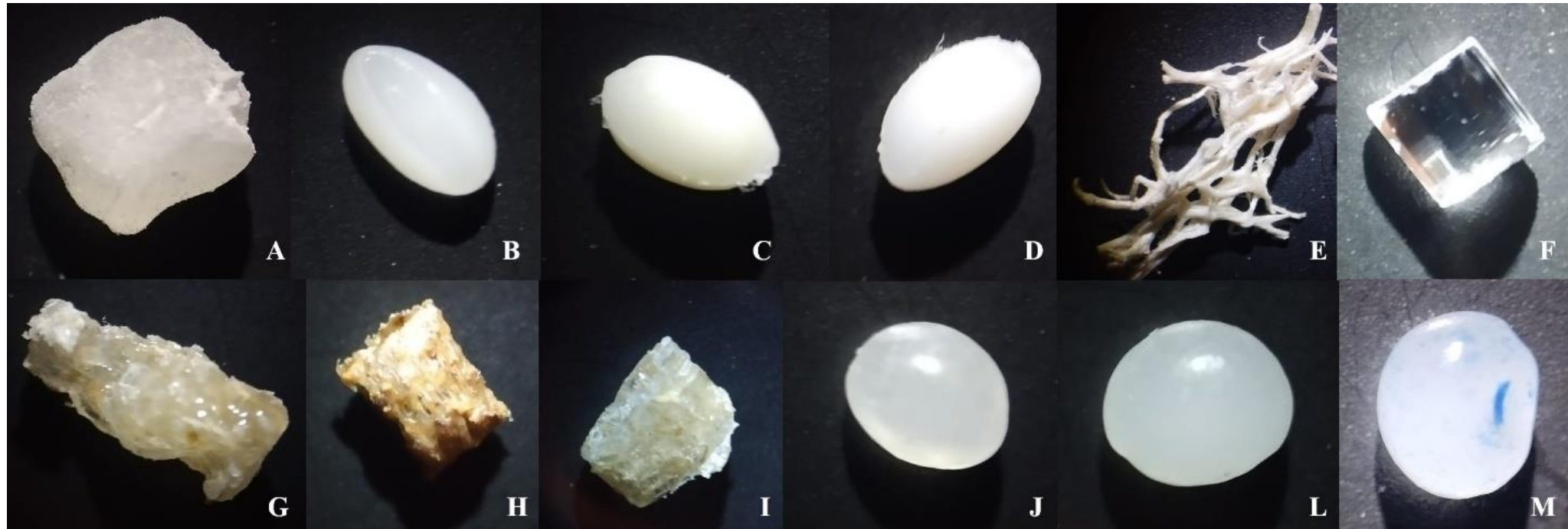
Printed personalised frame

1 Motivation

- Discarded eyewear frames accumulate in landfills and waterways, where fossil-based plastics contribute to micro- and macro-pollution.
- On-Demand develops sustainable, personalised frames produced by additive manufacturing from bio-based materials.
- Selecting suitable biopolymers requires reliable composition control, adequate processing and thermal-safety performance.

2 Materials screened

Polymer matrices	PLA 51 (L) · PHA (A) / PHAx · PBS (B) · Cellulose acetate (F)
Biofillers	Luffa (E) · Cork · Wood
Modifiers	ATBC plasticiser · COACE BP-1 (C) and BP-2 (D)
Selected blends	PLA-Luffa (G: untreated; I: NaOH-treated) · PPCA (H) · 20/80PP · 50PP (50% PHA + 50% PBS) · PPM



3 Methods

ATR-FTIR

Nicolet iS5 · iD7 diamond ATR · DTGS detector
4000–400 cm⁻¹ · 2 cm⁻¹ resolution · 32 scans

Raman

Horiba LabRam HR Evolution · 532 nm · 50× objective
100–4000 cm⁻¹ · 2 cm⁻¹ · 20 accumulations × 10 s; ≈7.5 mW at sample

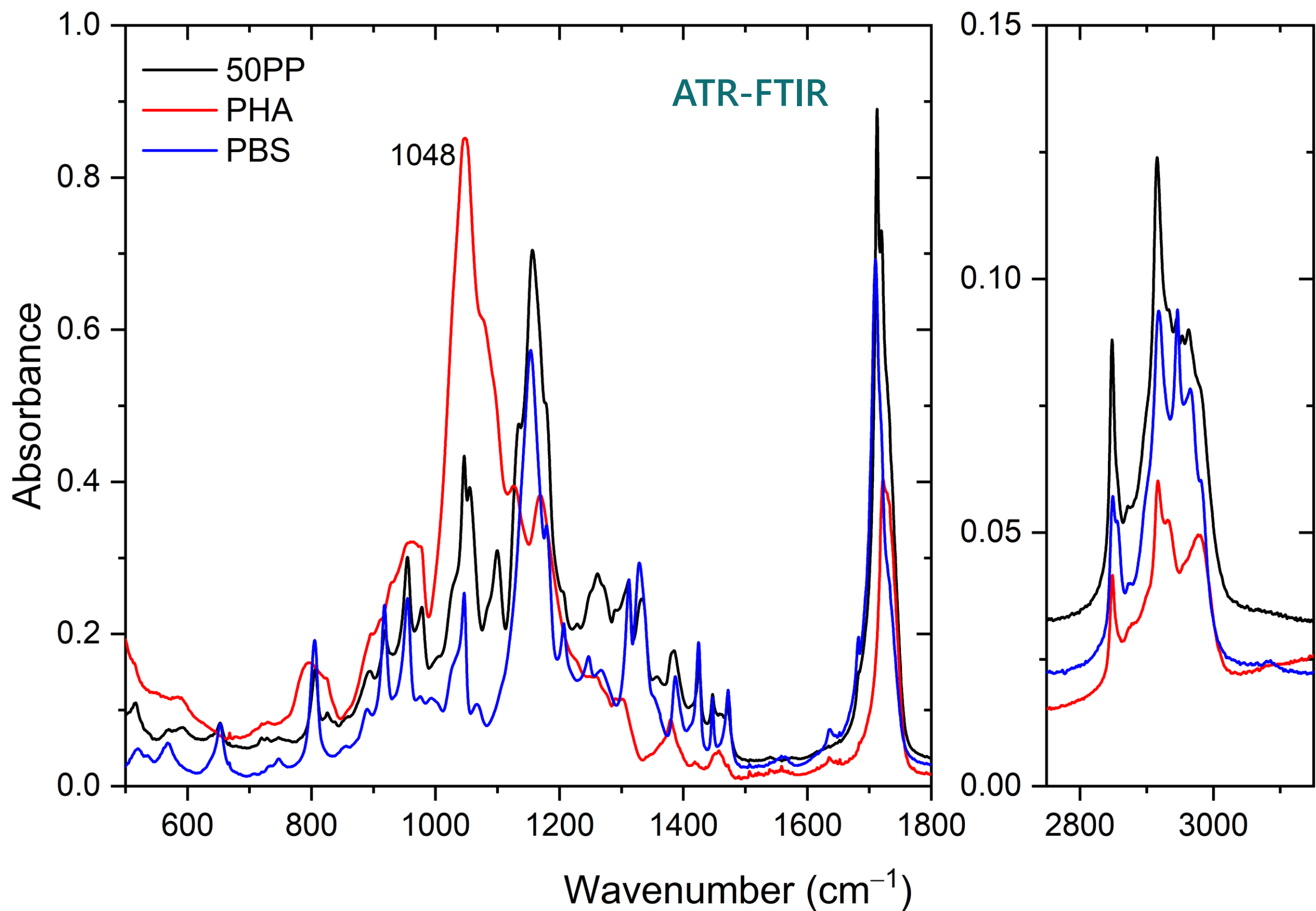
SEM

TESCAN VEGA 3 SBH · 5 kV · secondary electrons
Samples coated with 10 nm Au/Pd

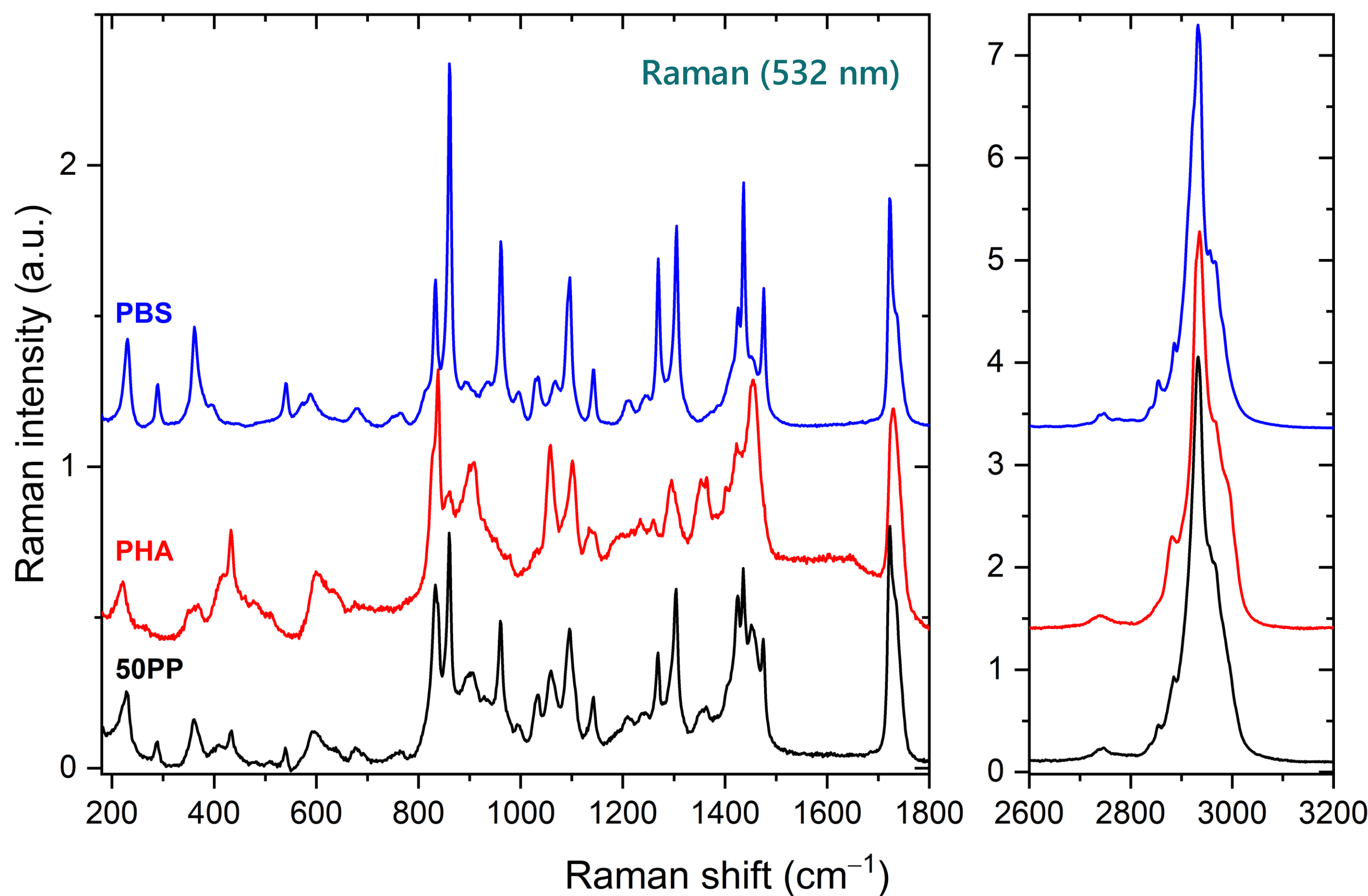
MFI (melt flow index)

190 °C · 2.16 kg load
Single-point measure of melt viscosity → processability ranking

4 ATR-FTIR + Raman of the 50PP blend

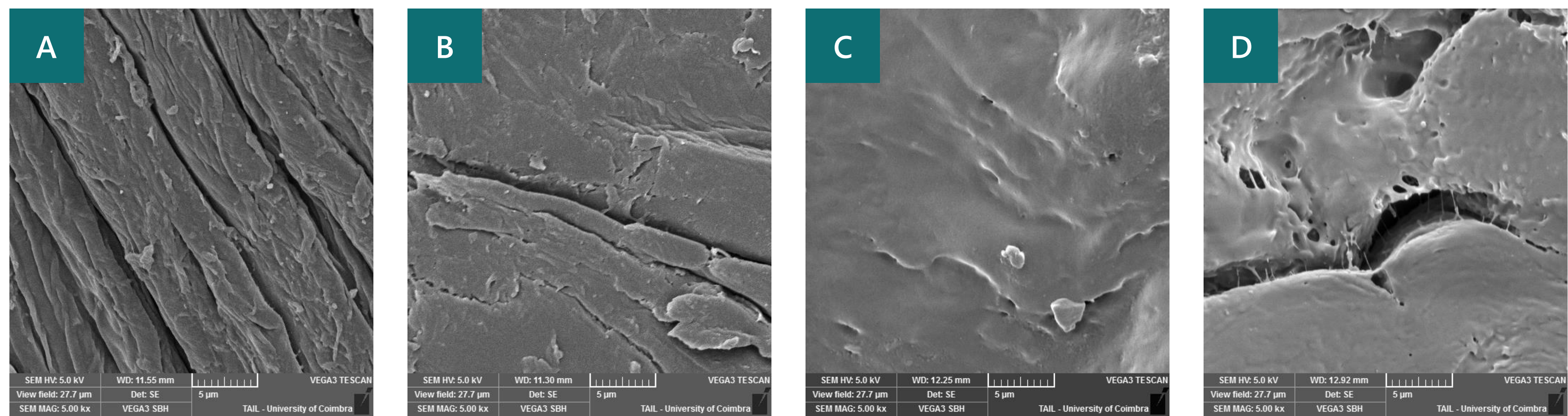


- PBS dominates the blend spectrum despite the 50:50 mass ratio.
- PBS markers: C=O ester stretch ≈ 1714 cm⁻¹; C–O–C ester stretches ≈ 1144 and 1264 cm⁻¹; CH₂ modes ≈ 1330 and 2945 cm⁻¹.
- PHA contributes the ≈ 1048 cm⁻¹ band, partly overlapped by PBS at 1044 cm⁻¹.



- Raman shows the 50PP profile as a superposition of both components, so PHA and PBS are both identified.
- PBS bands appear slightly more intense, consistent with the stronger Raman response of the PBS ester/methylene modes.
- Contrast with ATR-FTIR, where polar PBS ester modes dominate and PHA is confirmed only through isolated bands.

5 SEM: morphology reveals distinct interfacial behaviour



NaOH-treated luffa (I)
Rough, defined fibrils — consistent with improved fibre–matrix adhesion

Untreated luffa (G)
Less-defined fibrils — weaker matrix integration

blend (50% PHA + 50% PBS)
Cohesive, wavy morphology; good interfacial cohesion, ductile-looking fracture surface

PLA/PHAx + 5% wood
Three-phase morphology; cracks at the wood interface indicate limited adhesion

6 Thermal: hot-bar ignition tests

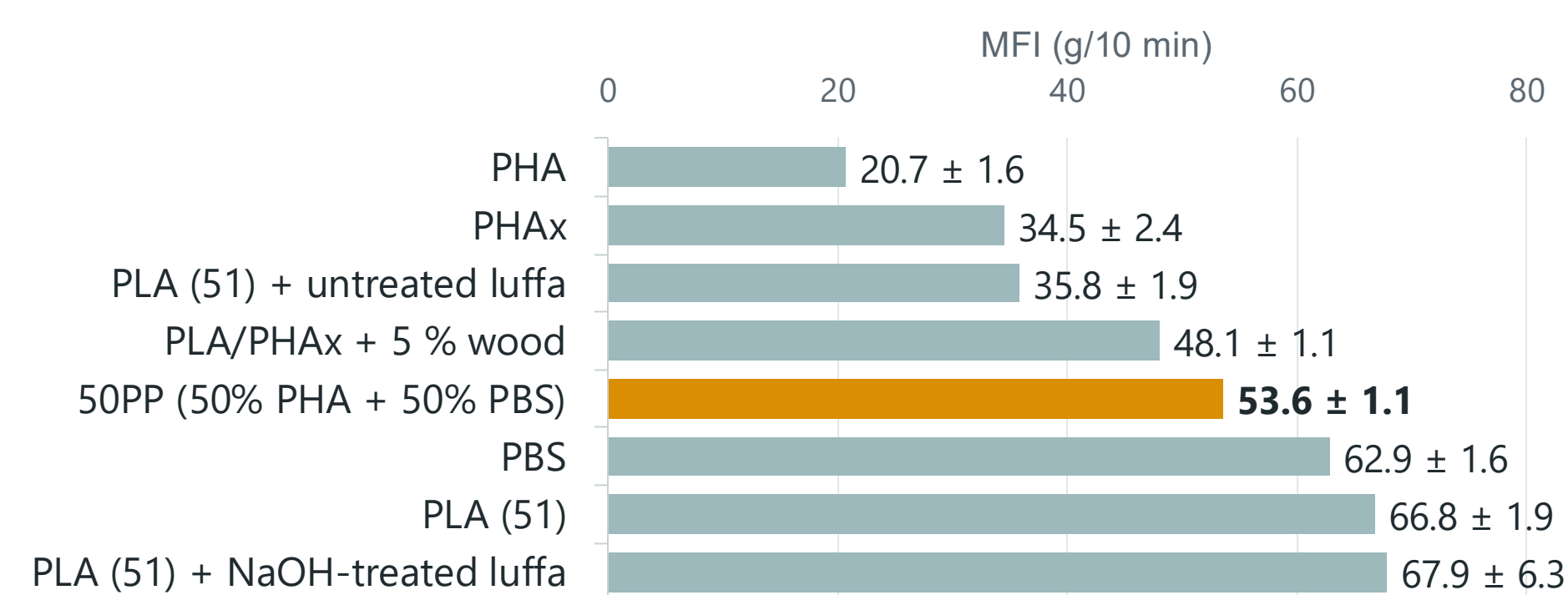
A heated metal bar is brought into contact with the printed material; heating/cooling temperatures and times are recorded for two consecutive cycles (two runs per material).

Material	Run	1st heating T (°C)	1st cooling T (°C)	1st cooling time (s)	Max T, 2nd heating (°C)	2nd cooling time (s)	Bar-contact T (°C)
PLA/PHAx + 5% wood	1	801.0	634.9	2	1037.2	3	644.7
	2	938.4	635.9	3	1004.6	4	616.3
50PP	1	904.4	653.8	3	935.7	2	640.4
	2	909.0	651.7	3	1017.5	5	611.9

Two ignition resistance tests were carried out on each material, in accordance with the ISO 12870 standard. No ignition was observed in the materials, demonstrating good flame resistance and highlighting their potential for use in the manufacture of spectacle frames.

7 Rheological testing: melt flow index (MFI)

MFI (g/10 min) gives a single-point measure of melt viscosity and ranks the processability of polymers, blends and composites.



- NaOH-treated luffa restores flow to the neat-PLA level; untreated fibre halves it, consistent with poorly wetted fibre aggregates obstructing the melt.
- PLA/PHAx + 5% wood keeps a consistent melt flow despite its limited interfacial adhesion.
- The 50PP blend sits at an intermediate MFI, consistent with good phase compatibility.

8 Conclusions

- ATR-FTIR + Raman together validated the composition of the selected formulations. Raman resolved overlapping spectral signatures and confirmed the 50PP (50% PHA + 50% PBS) identity.
- ATR-FTIR is PBS-dominated; the ≈1048 cm⁻¹ region contains overlapping PHA/PBS contributions.
- SEM: NaOH treatment of luffa strengthens fibre–matrix adhesion, while three-phase PLA/PHAx + wood bonds poorly.

50PP (50% PHA + 50% PBS): two-phase but cohesive morphology, both components confirmed by Raman, and processable in the same MFI window as its constituents — **lead candidate for printed eyewear frames.**