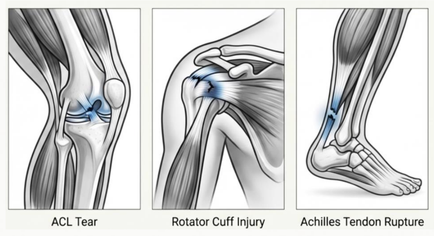
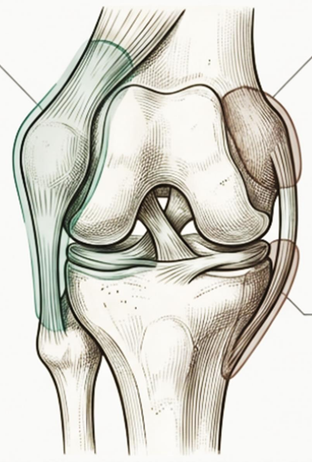
NEXT-GENERATION LIGNIN-BASED TUBULAR SCAFFOLDS FOR SOFT TISSUE ENGINEERING

Muhammad Muddasar, Maurice N. Collins
School of Engineering, Bernal Institute, University of Limerick, Ireland

"Soft tissue injuries represent a vast and costly challenge for world healthcare system."

33 Million
Musculoskeletal injuries recorded annually in the United States.
DOI: 10.1016/j.jhsa.2007.09.007





45%
The proportion of those injuries affecting soft tissues like tendons, ligaments, and joint capsules.

>$390 Billion
The combined annual expenditure on these injuries in the U.S.
DOI: 10.1001/jamanetworkopen.2022.50674

"Scaffolds-based tissue engineering offers a promising strategy for tendon repair by guiding regeneration and restoring aligned structure."

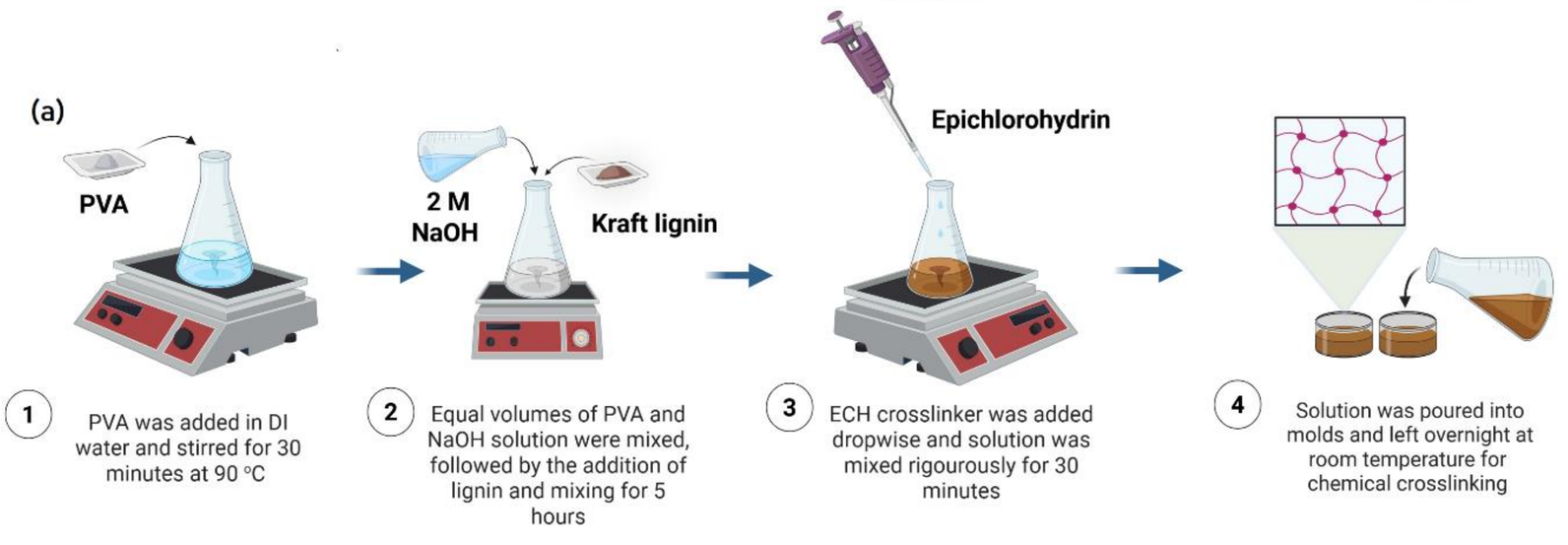


Lignin: A Versatile Biopolymer

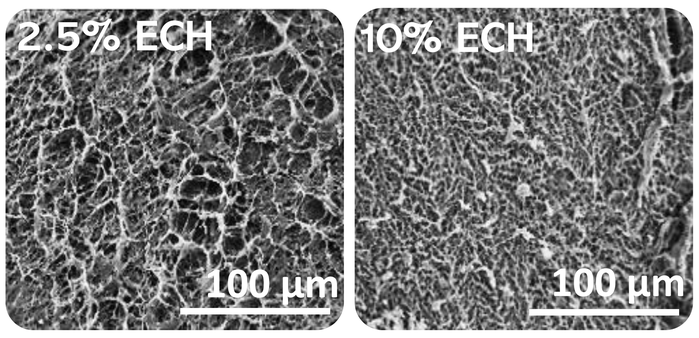
- Second most abundant biopolymer.
- Aromatic backbone.
- Rich in functional groups.

Experimental Approach

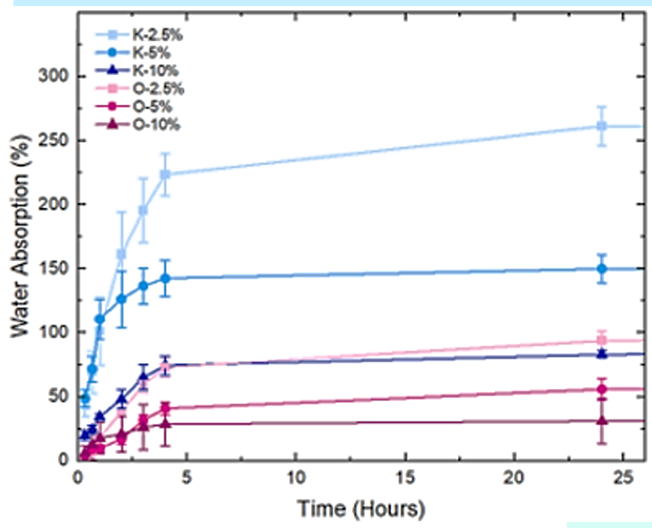
- Hydrogels formed using Kraft (KL) and Organosolv (OL) lignin and crosslinked with Epichlorohydrin (ECH) at concentrations from 2.5% to 10%.



Morphology



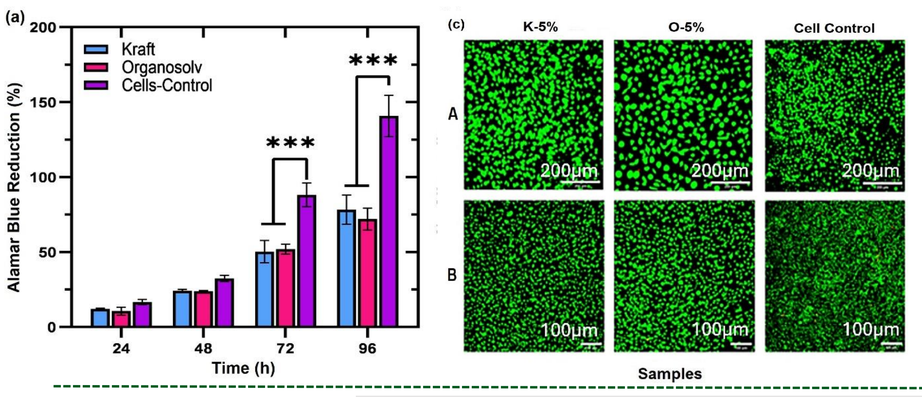
Swelling Behaviour



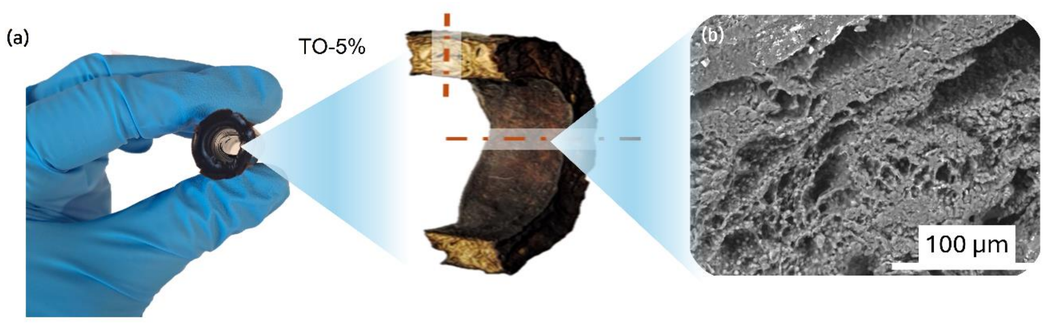
Mechanical properties

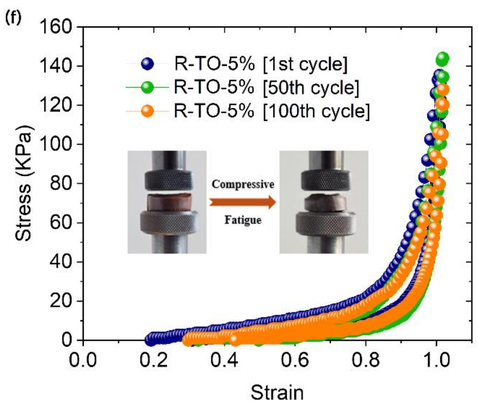
- Hydrogels show nonlinear elastic behaviour up to 40% strain; OL hydrogels show steeper slopes.
- All hydrogels stretched over 130% strain without failure. OL elongation (133–176%) exceeds KL (135–158%).
- O-5% achieved the highest combination of strength (UTS 83.14 kPa) and flexilbitly (~176% elongation).

Biocompatibility



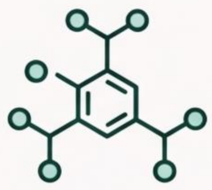
Tubular Scaffolds





Summary & Future

Optimized Material



- Organosolv Lignin at **5% ECH** provides the optimal balance of properties.
- UTS: **83.14 kPa**
- Young's Modulus: **39 kPa**

Engineered Form

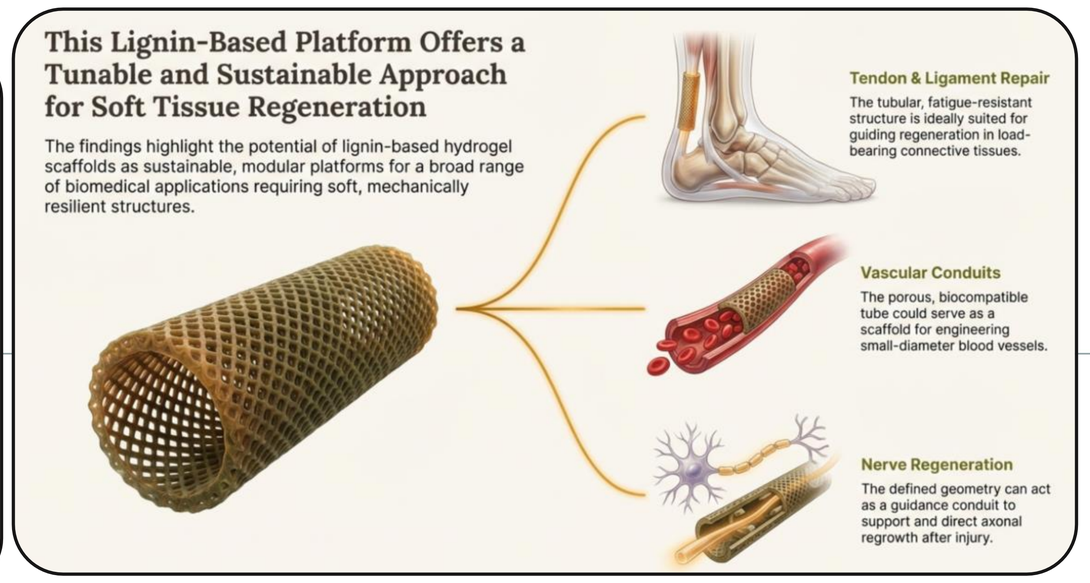


- Successfully fabricated into a **reinforced tubular scaffold**.
- **~10x increase** in compressive modulus.
- Excellent fatigue resistance over **100+ cycles**.

Proven Potential



- Highly **cytocompatible** with fibroblast cultures.
- Maintains cell viability **above 85%** after 96 hours.



https://doi.org/10.1002/cssc.202501520