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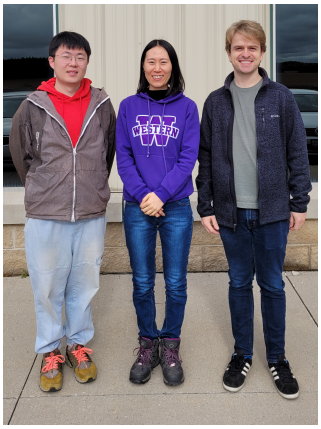

The Industrial Bioproducts Laboratory

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The Industrial Bioproducts Lab (IBL) at Western University, led by Prof. Dr. Charles Xu, aims at the conversion of lignin and forestry/agricultural biomass/residues into biofuels and industrial bioproducts (bio-based platform chemicals and functionalized polymeric materials). In a project carried out by Dr. Hongwei Li, funded by Agriculture and Agri-Food Canada (AAFC), wet greenhouse wastes and agricultural residues have been converted into bio-polyurethane (BPU) foams that can be applied as a hydroponic growing media for seed germination and soilless planting (Figure 1).

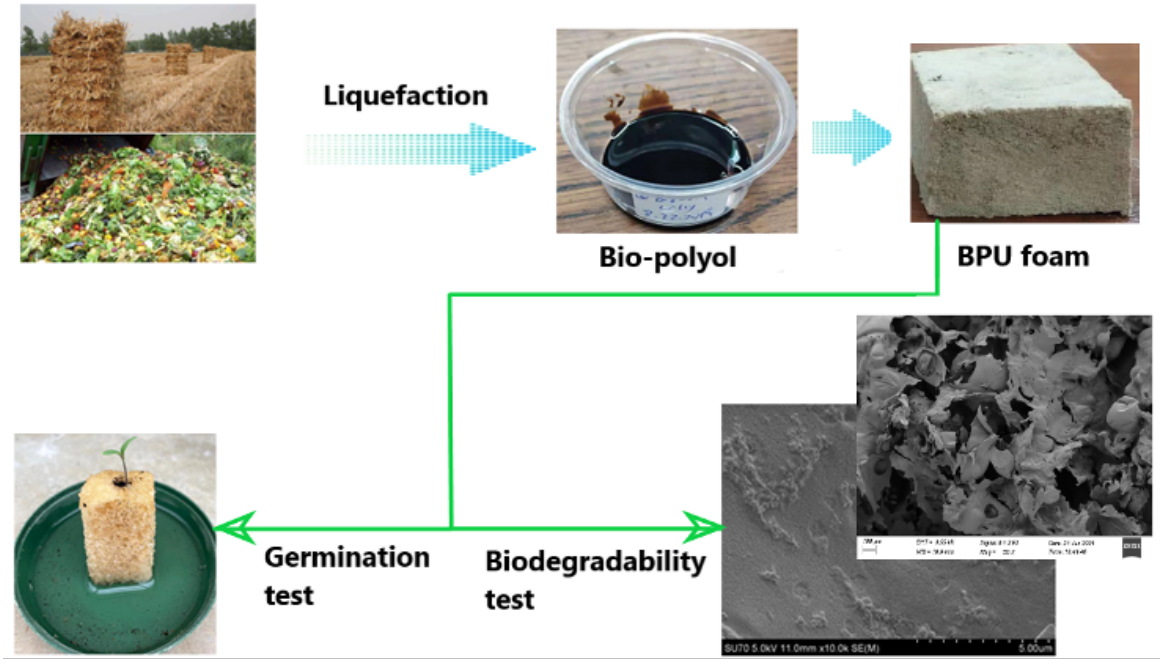


Figure 1. Conversion of Wet Greenhouse Wastes and Agricultural Residues into Bio-based Hydroponic Foams.

The BPU foams achieved a water absorption capacity as high as 1000~2000%. Besides, the BPU foams demonstrated better biodegradability than the petroleum-based PU foams. In another project conducted by Mingyuan Zhang, funded by MITACS, the challenge of catalyst development for the upgrading of pyrolysis bio-oil was addressed. Pyrolysis bio-oil as a renewable feedstock derived from agro-forestry residues, can be a potential feedstock to substitute petroleum for fuels and chemicals production. However, its poor qualities including high oxygen content, low heating value, high viscosity, strong acidity and poor stability have been a long-standing barrier for its applications. Hydrodeoxygenation (HDO) is one of the most promising ways to upgrade pyrolysis oils by reducing their oxygen contents. In this study, supercritical ethanol and formic acid were employed as both an effective solvent and in-situ hydrogen donor, and CoMoP catalysts supported on different carbon-based materials as inexpensive catalysts. As illustrated in Figure 2, Co, Mo, P elements show good dispersibility in different carbon-base supports.

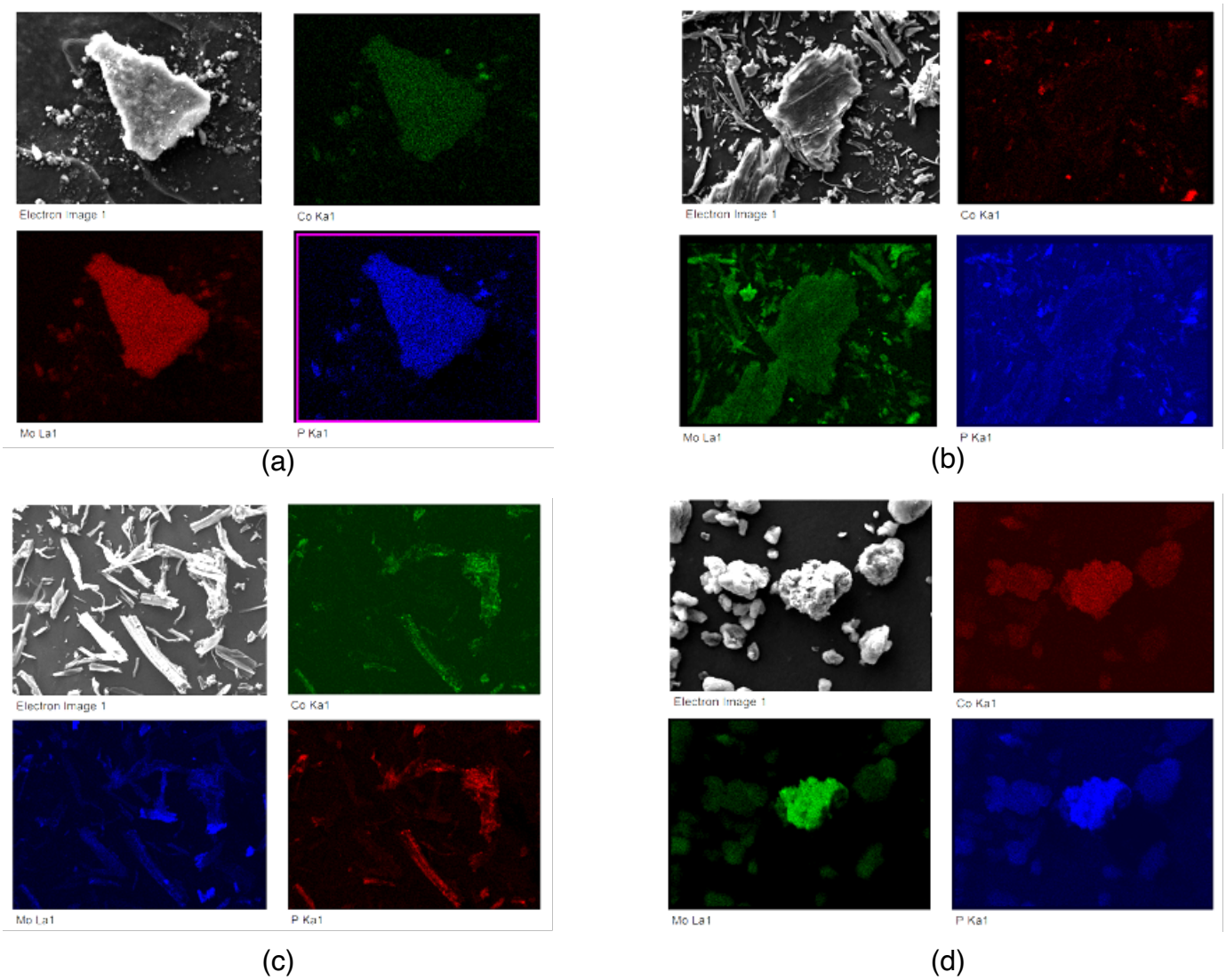
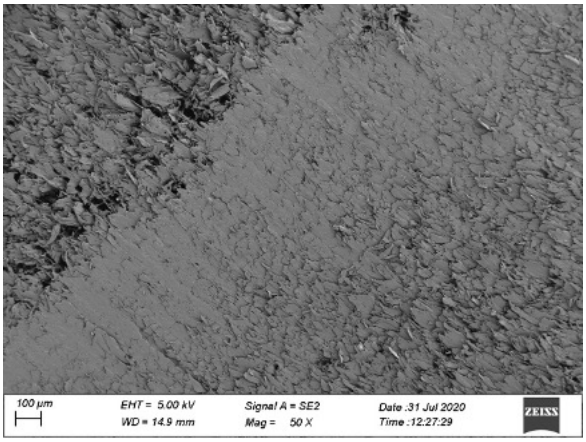
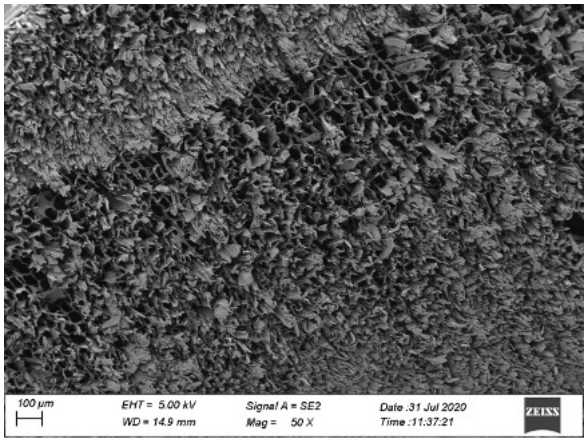


Figure 2. SEM-EDS mapping of CoMoP catalysts supported on (a) commercial activated carbon (AC), (b) cornstalk carbon (CC), (c) sawdust carbon (SC), (d) multi-walled carbon nanotubes (MWCNTs)

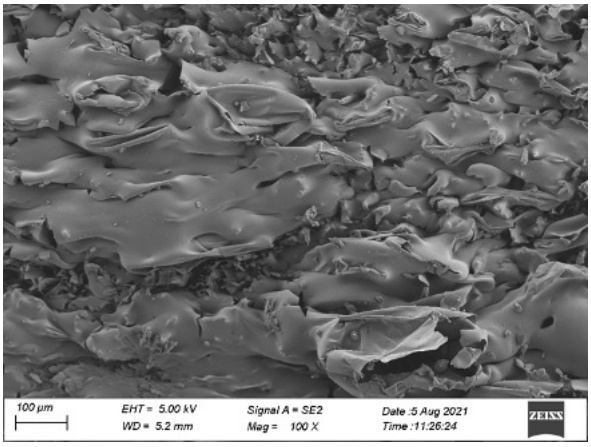
In another interesting project carried out by Ramon Beims, funded by Natural Science and Engineering Research Council of Canada (NSERC), AAFC, and CAPES scholarship, novel high-performance lightweight structural materials, stronger than most of metals and more corrosion-resistant, are being developed via re-engineering natural wood (lignin extraction to produce de-lignified wood, conversion of the extracted lignin to lignin-based epoxy resins, followed by composting the de-lignified wood with the lignin-based epoxy resins (Figure 3c and 3d).



(a)



(b)



(c)

(d)

Figure 3. SEM images of (a): natural pinewood; (b): delignified wood; (c): wood-based composite – impregnated with lignin-based epoxy resin; and (d): image of the wood composite specimen prepared for mechanical testing.

Electrospun Poly(amino acid ester) Phosphazenes (PαAPz) for Tissue Engineering

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Tissue engineering has emerged as a promising technology for the repair of failed or injured tissues and organs.[1] Designing fibrous biodegradable scaffolds that mimic the natural extracellular matrix (ECM) is one of the goals of tissue engineering. Among the various methods for forming tissue engineering scaffolds, electrospinning (ES) is of particular interest in this study. ES provides a porous structure similar to ECM with controllable fiber diameter and possibly aligned nanofibers, which can affect cell orientation.[2] In this study, we synthesized poly(amino acid ester) phosphazenes (PαAPz), including ethyl esters of alanine (PαAPz-A), methionine (PαAPz-M), and phenylalanine (PαAPz-F), to produce ES fiber mat.

At Western's Nanofabrication facility, we mainly use 1530 SEM to obtain morphological information such as fiber diameter and fiber alignment. In our research, we studied how the applied ES parameters such as solution composition, concentration, applied voltage are influenced on these three PαAPz fiber morphologies and produced beads-free fibers. For example, in Fig. 1, we used two different concentrations of PαAPz-F solution for electrospinning. After taking the SEM images, we used ImageJ to measure fiber diameters. From the analysis of these images, we determined the fiber diameters produced from 7.5% polymer solution were in the range of 50-150nm, while the diameters from 10% polymer solution were in the range of 150-350nm.

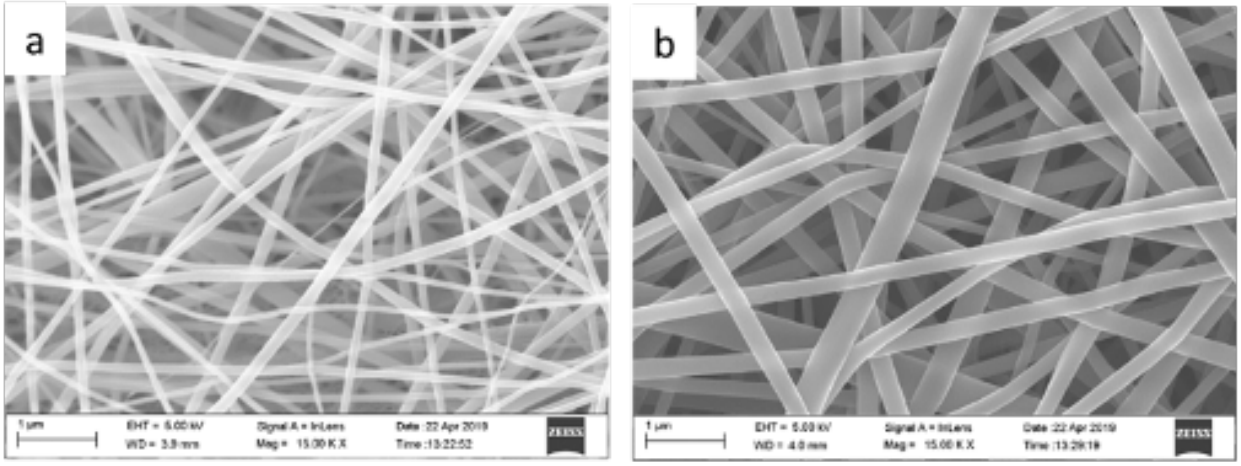

Figure 1. SEM of electrospun PαAPz-F fibers from **(a)** 7.5 and **(b)** 10% (wt/v) THF solutions at an applied voltage of 12 kV, the working distance of 12 cm, and flow rate of 0.2ml/h.

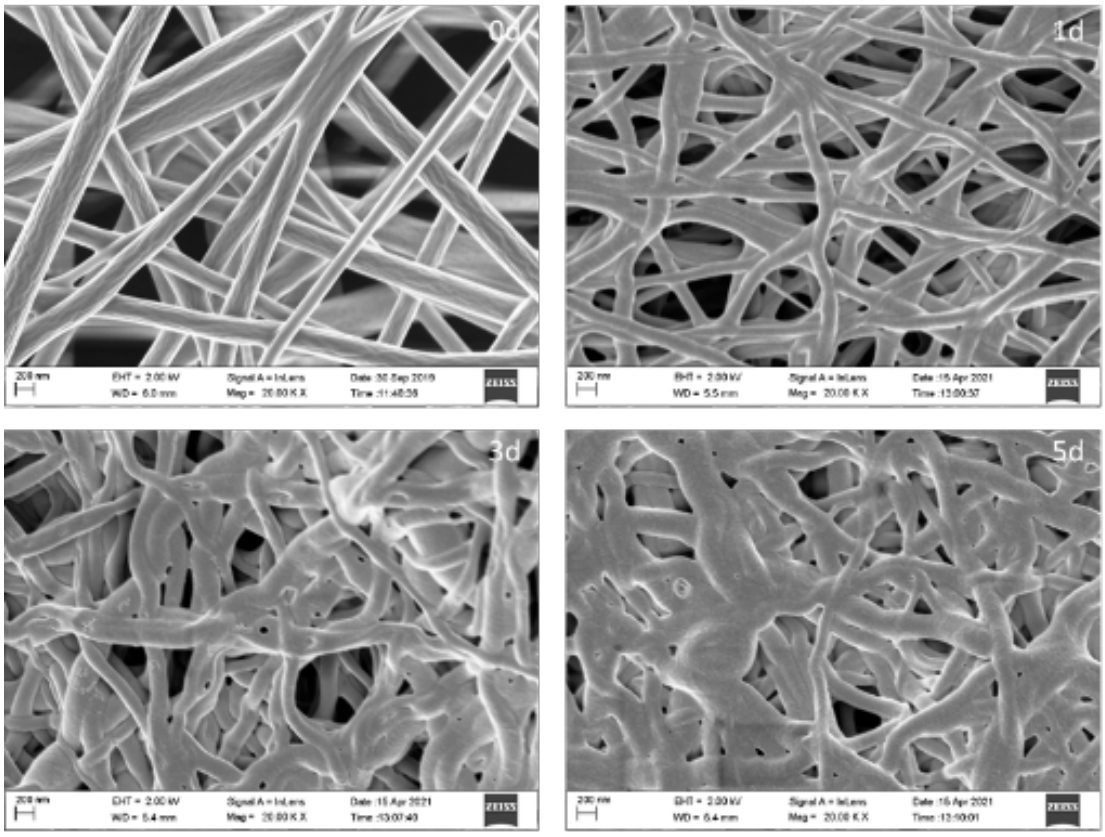

Figure 2. SEM of PαAPz-F fibers mat after degradation for day 0, day 1, day 3, and day 5.

Another aspect where SEM is a useful tool in our research is for degradation study. Since the fiber mat used for degradation has a higher thickness and light cannot pass through the fiber mat, we cannot get this information with an optical microscope. At the same time, the details of the changes in the degradation process are also at the sub-micron level.

Figure 2 shows how the morphology of fiber mats changed during the degradation process in PBS after day 0, day 1, day 3, and day 5. These morphological changes provide insight into the degradation behavior (e.g., surface erosion vs. bulk erosion) that may provide data for developing degradation mechanisms and degradation kinetics.

References:

1. Eltom, A.; Zhong, G.; Muhammad, A., Scaffold techniques and designs in tissue engineering functions and purposes: a review. *Adv Mater Sci Eng.* **2019,** Article ID 3429527.

2. Kishan, A. P.; Cosgriff−Hernandez, E. M., Recent advancements in electrospinning design for tissue engineering applications: A review. *JBMR A.* **2017,** 105, (10), 2892-2905.