ICTF 2026
20th International Conference on Thin Films
8-12 June 2026
Biarritz, France
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PLASMA SURFACE ENGINEERING OF MATERIALS DERIVED FROM WOODY BIOMASS: RECENT FINDINGS AND PERSPECTIVES

L. Stafford
Chaire de recherche du Canada en Science et Applications des Plasmas Froids Hautements Réactifs
Département de physique, Université de Montréal – Montréal, Québec (Canada)

Materials derived from woody biomass play an important role in both the global economy and many regional economies. They include traditional products such as lumber, paper, and wood panels, as well as emerging bio-based materials and nanomaterials. Forest-based industries contribute significantly to economic growth, trade, and employment, particularly in forest-rich countries such as Canada, Finland, Sweden, Brazil, and the United States. However, the broader adoption of forest-based materials in many strategic applications is challenged by issues related to durability and performance, including susceptibility to fire, moisture, water, ultraviolet degradation, and biological attacks from fungi, insects, and microorganisms, which necessitate the development of effective and sustainable protection strategies.

This presentation will summarize our recent work on advanced surface engineering of materials and nanomaterials derived from woody biomass using non-thermal plasmas at atmospheric pressure. The advantages of such plasmas are numerous and address major industrial concerns, including atmospheric-pressure operation, low neutral gas temperatures compatible with heat-sensitive substrates, high processing throughput, environmental friendliness through reduced chemical consumption, and remarkable flexibility for a wide range of surface functionalization and thin film coating applications. The surfaces were processed with plane-to-plane Dielectric Barrier Discharges (DBDs) at atmospheric pressure over a wide range of experimental conditions, and plasma-processed materials were characterized in terms of wettability, adhesion, and resistance to various physical and chemical attacks.

Through a France-Québec collaboration, it was first demonstrated that wood samples treated in HMDSO-containing DBDs became highly hydrophobic with an excellent dimensional stability following natural ageing The possibilities were further extended to wood-based foams for decontamination of oily wastewater (Plasma Sources Science and Technology 2021, and Plasma Processes and Polymers 2021) and wood-based films for dry and wet packaging (Plasma Processes and Polymers 2020, Progress in Organic Coatings 2020, Cellulose 2023, Coatings 2023). Inspired by these results, a new application for Li-ion batteries was explored. In this field, the use of water-soluble binders extracted from woody biomass in electrodes is typically impossible due to their inherent hydrophilicity that leads to a dissolution of the electrode and thus to a loss of mechanical cohesion and electronic percolation. It was shown that electrodes modified by DBD can provide a stable reversible redox capacity for more than 85 days in aqueous electrolyte (ACS Sustainable Chemistry and Engineering 2020 and 2023). Very recently, the possibility of producing (multi)functional, nanocomposite coatings using complex aerosols as the precursor for thin-film deposition was also examined.

Thanks/Acknowledgement
This work realized in Canada was funded by National Science and Engineering Research Council (NSERC) through both the Discovery and Alliance programs, the Fonds de Recherche du Québec (FRQ), PRIMA-Québec, the Canadian Foundation for Innovation (CFI), Plasmionique inc., FPInnovations, and SAFRAN.