PhD Thesis Proposal – Thami ZEGHLOUL

Generation of Triboelectric Charge at Solid-Solid Interfaces – Applications to Triboelectric Generators

At solid-solid interfaces, an electric charge can be generated through the triboelectric effect. Although this charging mechanism has been known for centuries, it remains poorly understood due to the complexity of the multi-scale physicochemical phenomena involved. These depend on the surface properties of the materials in contact, the kinematic and dynamic characteristics of their relative movement, ambient conditions, and potential interactions between these factors.

During the initial phase of the LABEX project, an instrumented test bench was developed to study factors affecting charge generation during conformal contact between two polymer plates: material types, surface roughness, normal contact force, relative velocity, relative humidity, etc. As triboelectric charging is a surface phenomenon, recent studies have highlighted the positive effects of exposing polymers to dielectric barrier discharges in atmospheric air.

This thesis has two main objectives: (1) to evaluate the combined tribological and electrostatic effects of non-thermal plasma treatment using dielectric barrier discharges across a wide range of frequencies and voltage levels; (2) to demonstrate the feasibility of using plasma-treated polymers to generate and harness electric charges for electricity production.

Initially, the PhD candidate will use existing facilities at the IUT of Angoulême to treat the surfaces of various polymers through dielectric barrier discharges generated by different electrode configurations powered by alternating voltages of varying intensities and frequencies for different exposure durations. The surface roughness of the treated materials will be measured and correlated with the electrical potentials generated by the triboelectric effect on the polymer plates. This will refine the understanding of the physical mechanisms involved and help establish the optimal operating regime for the plasma reactor.

In the second phase, the PhD candidate will adapt and equip the experimental setup to simulate the operation of a triboelectric generator in lateral sliding mode. Currently, force and displacement sensors continuously measure normal and tangential forces as well as alternating lateral displacement. The tangential force sensor data encompasses frictional forces at the contact interface and friction forces within the guideways. Introducing an additional three-axis sensor at the contact point will provide more precise measurements of interface forces. Electrical voltages and currents generated will be measured under varying contact pressures, sliding amplitudes, and velocities.

From a purely scientific perspective, this research aims to evaluate the physical factors influencing the triboelectric charging of polymers. This should enable the identification of optimal material pairings, DBD configurations, and contact dynamics to maximize electricity production.