ABSTRACT – ADELE KARST THESIS

Electrically conductive polymer materials are among functional polymer materials with high added value for multiple emerging applications, particularly in the field of flexible electronics (sensors, organic transistors, organic optoelectronic components, organic light-emitting diodes, flexible supercapacitors, flexible batteries, piezoelectric and triboelectric nanogenerators, etc.). Some achievements have also evolved towards higher scales of maturity with many interesting industrial applications such as electromagnetic shielding. Currently, this dynamic is extending to the plastics industry via emerging technologies of additive manufacturing and MID (Molded Interconnect Devices). However, many obstacles concerning actual conductive polymers must be removed, particularly in terms of material cost, resulting electrical performance, processability in the melt state or even adhesion to various supports. Electrically conductive polymer materials are based on two main families. The first, which is by far the most widespread at present, consists of dispersing various conductive fillers (mainly carbon black and/or carbon nanotubes or metal particles) by extrusion in a polymer matrix. Many commercial solutions based on this method are available today, however the maximum conductivities remain relatively modest (of the order of 0.1 S/cm). The second family is that of stimulatingly conductive polymers via electronic delocalization along their carbon chain (family of polyanilines, polypyrrols or even polythiophenes). Recently, one of these inspired conductive polymers, poly(3,4-ethylenedioxythiophene) PEDOT, made it possible to achieve levels of electrical conductivity close to metals (of the order of 5000 S/cm). However, PEDOT is an infusible polymer and therefore cannot be easily processed by conventional techniques in the plastics industry (injection molding, extrusion or even 3D printing). To overcome this drawback, the strategy implemented during this thesis is to use PEDOT as an organic conductive filler by dispersing it in a thermoplastic matrix by melt extrusion to obtain conductive thermoplastic composites.

For this, an oxidative polymerization of EDOT was carried out to obtain PEDOT in the form of a fine conductive powder, which was then redispersed in a thermoplastic matrix by extrusion. Two optimizations were then carried out in parallel: that of the conductive charge (conductivity, morphology, etc.) and that of its dispersion within the thermoplastic matrix. The charge optimization phase was partly characterized by carrying out a supported oxidative polymerization of PEDOT on the surface of the sepiolites (which is a clay which is in the form of sticks) to obtain particles of conductive PEDOT with high form factor, preferred for obtaining the lowest possible percolation threshold. Numerous characterizations were also implemented (SEM, TEM, rheology, tomography, XRD, XPS, etc.) in order to best understand the link between structure and properties of the material.

Finally, the final material obtained is a PEO (Polyethylene Oxide) / PEDOT thermoplastic composite presenting electrical conductivities of around 10^1 $S.cm^{-1}$, approximately 2 decades higher than commercially available conductive composite materials.