PhD Project Abstract – Marco Mazzali

Synthesis, Characterization and Application of new raw materials for bio-based polyester resins

Over the past few years, shortages of oil resources and environmental pollution have become increasingly serious. Increased environmental awareness has led to a significant interest in replacing nonrenewable petroleum-based materials with renewable counterparts. The transfer from a petroleum-based to a bio-based industry provides a sustainable and economically viable solution [1]. A slow shift to bio-based production has been observed in many fields, but one of the most promising areas is chemically manufactured products for wide consumption, i.e., polymers. Bio-based polymers offer important contributions by reducing the dependance on fossil fuels and through related positive environmental impacts such as reduced carbon dioxide emissions.

Unsaturated polyester resins (UPRs), as the most used type of resin for reinforcing fiber matrices, possess outstanding characteristics such as good mechanical processing, heat and chemical resistance, and excellent electrical conducitivity, therefore, they are widely used in transportation, construction, coatings, electronics, and other areas and are considered as indispensable polymer materials [2]. However, current commercially available UPRs are mainly synthesized from petrochemical products, containing two main components, namely UPs and reactive diluents. UP is a linear polymer possessing ester bonds and carbon-carbon double bonds, and which is synthesized by the polycondensation of dibasic organic acids (including at least one unsaturated dibasic organic acid) with diols. These diacids and diols are mostly extracted and produced from fossil resources. The most conventionally used reactive diluent for UPs is styrene, which is a low viscosity and highly reactive solvent that can be miscible with UPs to reduce the viscosity of resin and provide excellent fiber impregnation; on the other hand, the carbon-carbon double bond of styrene participate in the free radical polymerization of UPs, thus increasing the cross-link density of the system and improving the material properties. Besides its unsustainable sources, styrene is a suspected carcinogen, thus, the environmental and healt issues triggered by its high volatility cannot be ignored.

Therefore, chemical building block derived form renewable resources have gained more and more importance and started to be an alternative to chemicals from petrochemical feedstock [3]. The aim of this project is to identify or synthesize new bio-based raw materials for the synthesis of UPRs from renewable sources. The unsaturated polyester pre-polymer, as well as the cross-linked unsaturated polyester resin will the be characterize with the aim of understanding their most suitable application sector in the global market. The characterization will include the evaluation of the chemical properties (IR, NMR, GPC), the mechanical and thermo-mechanical properties (TMA, DMA) and finally the thermal stability (DSC, TGA) of the resin.

The project will be carried out in collaboration with Carlo Riccò & F.lli S.p.A., a local company specialized in the industrial production of unsaturated polyester resins that exhibited great interest in co-funding this scolarship and hosting me for training inside the company.

[1] B. Z. Fidanovski, P. M. Spasojevic, V. V. Panic, S. I. Seslija, J. P. Spasojevic, e I. G. Popovic, «Synthesis and characterization of fully bio-based unsaturated polyester resins», *J. Mater. Sci.*, vol. 53, fasc. 6, pp. 4635–4644, mar. 2018, doi: 10.1007/s10853-017-1822-y.

[2] Q. Li, S. Ma, X. Xu, e J. Zhu, «Bio-based Unsaturated Polyesters», in *Unsaturated Polyester Resins*, Elsevier, 2019, pp. 515–555. doi: 10.1016/B978-0-12-816129-6.00020-X.
[3] T. Robert e S. Friebel, «Itaconic acid – a versatile building block for renewable polyesters with enhanced functionality», *Green Chem.*, vol. 18, fasc. 10, pp. 2922–2934, 2016, doi: 10.1039/C6GC00605A.