Linee di Ricerca

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Over the course of my research activities, I gained experience in various aspects of ionic liquid and deep eutectic solvent chemistry. I specialised in their preparation, physico-chemical characterisation and use in several fields. The main research areas are:

a. **Optimisation of the Synthesis of Ionic Liquids, Focusing on Sustainability;**

b. **Studiy of the Effect of the Chemical Structure on the Physico-Chemical Properties of Ionic Liquids;**

c. **Use of Ionic Liquids and Deep Eutectic Solvents (DES) in the Treatment, Functionalization and Processing Of Biomasses, and in the Extraction of Bioactive Substances from Food Waste;**

d. **Use of Ionic Liquids and DES in Electro-Enantiodiscrimination;**

e. **Use of Bio-Based Ionic Liquids as Anti-Corrosion Additives.**

During my research, I gained in-depth knowledge of organic synthesis techniques with a focus on the chemistry involved in the production of ionic liquids. I became familiar with the use of pressure and microwave reactors, and with the semi-scale-up of optimised reactions. In particular, I gained expertise in ammonium, imidazolium and phosphonium salt synthesis via the Menschutkin reaction. This expertise allowed me to synthesise a wide variety of ionic liquids with different structures. This enabled me to study the effect of small structural changes on the physico-chemical properties of ionic liquids. To shed light on this aspect, of the highest importance were the skills I acquired in studying rheology, thermal stability (TGA) and thermal behaviour (DSC) of ionic liquids.

A comprehensive understanding of the ionic liquid structure-property relationship and trends facilitates the conceptualisation and design of novel ionic liquids whose properties are tailored on the needs of a specific application. One of the main interests has been the development of new ionic liquids based on chemicals derived from renewable sources. Derivatives of cellulose, lipids and lignin, such as levulinic acid, fatty acids and cinnamic acid, were used in the production process. Lignin derivatives have proven to be highly effective in the production of ionic liquids for use as additives in metal corrosion inhibitors. Furthermore, by exploiting the unique properties of ionic liquids as solvents, I gained extensive knowledge of processing, dissolution and transformation of the primary naturally occurring biopolymers: cellulose, hemicellulose and lignin. In the same context, I also developed and used a new class of 'green' solvents: Deep Eutectic Solvents (DESs). DESs exhibit characteristics similar to those of ionic liquids, although they generally have lower thermal stability and higher vapour pressure. At the same time, they are usually cheaper and less toxic. Nevertheless, the most significant feature that DESs and ionic liquids share is the tunability. The use of DESs has expanded my expertise in biomass processing, facilitating the development of a Kraft cellulose purification process and of several environmentally sustainable approaches for extracting polyphenols from food waste.

In this frame, complementary potential of DESs and ionic liquids have also been combined to developing biorefinery processes for the valorisation of food waste, in agreement with the zero waste-circular economy concept.

A further research area in which I was involved was the development and use of new DESs and ionic liquids for electro-enantiodiscrimination. Indeed, due to their elevated electrical conductivity, chiral DES and ionic liquids have been utilised as media in the electroanalysis of chiral molecules.
The multidisciplinary nature of my various research activities allowed to establish numerous long-lasting national and international collaborations. Concerning national collaborations, the groups of Prof. Patrizia Mussini of the University of Milan, Prof. Andrea Mele of the Politecnico di Milano and Prof. Stefano Vecchio Ciprioti of the University of Rome Sapienza were involved in several joint projects. Among the numerous international collaborations, worth of mentioning are those with the groups of Prof. Konstantinos Moutzouris of the University of West Attica, Prof. Justina Łuczak of the Gdansk University of Technology, Prof. Gary J. Blanchard of Michigan State University, Prof. Maria Forsyth of Deakin University and Prof. David Mecerreyes of the University of the Basque Country UPV/EHU.

In addition to scientific collaborations, I have received numerous grants from companies for projects related to the energy transition. In this regard, I have been the scientific leader and co-principal investigator of six research projects, with a total funding amount of over 400k euros.