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Humins: From Industrial By-Product to High Value Polymers

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Abstract : During the last decades renewable and low-cost resources have attracted increasingly interest. Carbohydrates can be derived by lignocellulosic biomasses, which is an attractive option since they represent the most abundant carbon source available in nature. Carbohydrates can be converted in a plethora of industrially relevant compounds, such as 5-hydroxymethylfurfural (HMF) and levulinic acid (LA), within acid catalyzed dehydration of sugars with mineral acids. Unfortunately, these acid catalyzed conversions suffer of the unavoidable formation of highly viscous heterogeneous poly-disperse carbon based materials known as humins. This black colored low value by-product is made by a complex mixture of macromolecules built by covalent random condensations of the several compounds present during the acid catalyzed conversion. Humins molecular structure is still under investigation but seems based on furanic rings network linked by aliphatic chains and decorated by several reactive moieties (ketones, aldehydes, hydroxyls, …). Despite decades of research, currently there is no way to avoid humins formation. The key parameter for enhance the economic viability of carbohydrate conversion processes is, therefore, increasing the economic value of the humins by-product. Herein are presented new humins based polymeric materials that can be prepared starting from the raw by-product by thermal treatment, without any step of purification or pretreatment. Humins foams can be produced with the control of reaction key parameters, obtaining polymeric porous materials with designed porosity, density, thermal and electrical conductivity, chemical and electrical stability, carbon amount and mechanical properties. Physico chemical properties can be enhanced by modifications on the starting raw material or adding different species during the polymerization. A comparisons on the properties of different compositions will be presented, along with tested applications. The authors gratefully acknowledge the European Community for financial support through Marie-Curie H2020-MSCA-ITN-2015 "HUGS" Project.

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