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Safety Considerations of Furanics for Sustainable Applications in Advanced Biorefineries

Authors : Anitha Muralidhara, Victor Engelen, Christophe Len, Pascal Pandard, Guy Marlair

Abstract : Production of bio-based chemicals and materials from lignocellulosic biomass is gaining tremendous importance in advanced bio-refineries while aiming towards progressive replacement of petroleum based chemicals in transportation fuels and commodity polymers. One such attempt has resulted in the production of key furan derivatives (FD) such as furfural, HMF, MMF etc., via acid catalyzed dehydration (ACD) of C6 and C5 sugars, which are further converted into key chemicals or intermediates (such as Furandicarboxylic acid, Furfuryl alcohol etc.,). In subsequent processes, many high potential FD are produced, that can be converted into high added value polymers or high energy density biofuels. During ACD, an unavoidable polyfuranic byproduct is generated which is called humins. The family of FD is very large with varying chemical structures and diverse physicochemical properties. Accordingly, the associated risk profiles may largely vary. Hazardous Material (Haz-mat) classification systems such as GHS (CLP in the EU) and the UN TDG Model Regulations for transport of dangerous goods are one of the preliminary requirements for all chemicals for their appropriate classification, labelling, packaging, safe storage, and transportation. Considering the growing application routes of FD, it becomes important to notice the limited access to safety related information (safety data sheets available only for famous compounds such as HMF, furfural etc.,) in these internationally recognized haz-mat classification systems. However, these classifications do not necessarily provide information about the extent of risk involved when the chemical is used in any specific application. Factors such as thermal stability, speed of combustion, chemical incompatibilities, etc., can equally influence the safety profile of a compound, that are clearly out of the scope of any haz-mat classification system. Irrespective of the bio-based origin, FD has so far received inconsistent remarks concerning their toxicity profiles. With such inconsistencies, there is a fear that, a large family of FD may also follow extreme judgmental scenarios like ionic liquids, by ranking some compounds as extremely thermally stable, non-flammable, etc., Unless clarified, these messages could lead to misleading judgements while ranking the chemical based on its hazard rating. Safety is a key aspect in any sustainable biorefinery operation/facility, which is often underscored or neglected. To fill up these existing data gaps and to address ambiguities and discrepancies, the current study focuses on giving preliminary insights on safety assessment of FD and their potential targeted by-products. With the available information in the literature and obtained experimental results, physicochemical safety, environmental safety as well as (a scenario based) fire safety profiles of key FD, as well as side streams such as humins and levulinic acid, will be considered. With this, the study focuses on defining patterns and trends that gives coherent safety related information for existing and newly synthesized FD in the market for better functionality and sustainable applications.

Keywords : furanics, humins, safety, thermal and fire hazard, toxicity
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