CRITICAL REVIEW ON LIFE CYCLE ASSESSMENT OF BIO-BASED PLATFORM MOLECULES: SUSTAINABILITY METRICS OF NOVEL TECHNOLOGIES

Jorge Blanco, Rey Juan Carlos University, Spain
jorge.blanco@urjc.es
Sandra Martín, Rey Juan Carlos University, Spain
María Linares, Rey Juan Carlos University, Spain
José Iglesias, Rey Juan Carlos University, Spain
Jovita Moreno, Rey Juan Carlos University, Spain

Key Words: LCA, Critical revision, Bio-based chemicals, Methodological harmonization, Meta-analysis

Bio-based platform chemicals are a set of compounds identified as key for biorefineries development [1]. Their penetration into the current market would sustain the shifting towards a more sustainable circular bioeconomy. Specifically, their biological origin can reduce both petroleum dependency and waste landfilling. Although this constitutes a promising scenario, incumbent technologies are hampered by intrinsic difficulties mainly related to upstream processing and the complex biomass composition. In this sense, life cycle assessment (LCA) is a fundamental tool to identify hotspots and ensure environmental improvements against conventional petroleum-based processes. Even though the number of LCAs published on biochemicals has rapidly grown, comparison between them is still limited due to the heterogeneous methodological choices applied.

This work aims to identify those divergences and propose harmonized criteria to narrow the gap. For that purpose, a meta-analysis of 65 studies was performed, involving peer-reviewed publications of eight bio-based molecules previously screened as the most relevant to that matter: ethylene, 2,5-furandicarboxylic acid (FDCA), 5-hydroxymethylfurfural (HMF), furfural, and adipic, lactic, levulinic and succinic acids. Among the meta-data analysed are system boundaries, the attributional or consequential approach, data sources, multioutput handling, impact assessment methodologies, indicators, uncertainty management, and data quality.

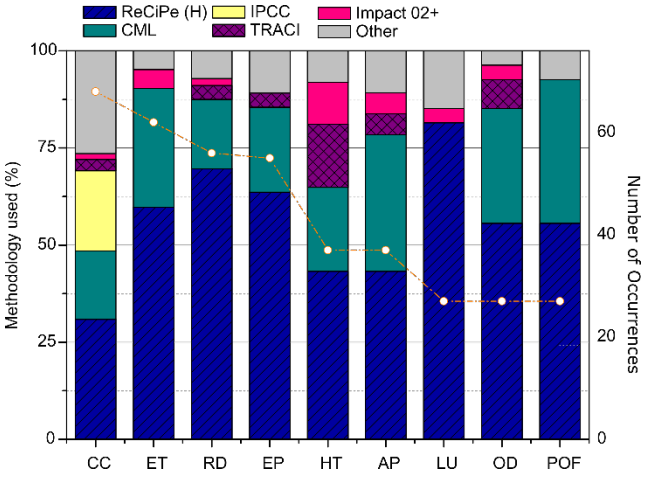

Figure 1 – Occurrences of common impact categories and methodology used for their calculation. CC: Climate Change; ET: Ecotoxicity; RD: Resource Depletion; EP: Eutrophication; HT: Human Toxicity; AP: Acidification; LU: Land Use; OD Ozone Depletion; POF: Photochemical Oxidants Formation

Figure 1 shows the most common impact categories measured via midpoint indicators in decreasing order (orange dotted line). Bars fill colour indicates the calculation method applied in relative terms. Categories from CC to EP were reported in more than half of the analysed cases, while LU to POF are the least investigated. Regarding single indicators, Global Warming Potential (GWP) was quantified in almost 100% of the publications. Finally, the preferred impact assessment methodologies were the hierarchist approach of ReCiPe and the CML. These data were used to determine the comparability between studies, and further process sustainability conclusions are reported for each molecule within this review.

Among other relevant aspects identified, multifunctionality is mainly addressed through non-physical relationships (41%), followed by the recommendation of avoiding impact allocation by subdivision or system expansion (40%). On the other hand, a lack of primary data is detected due to information scarcity on novel technologies. Finally, quantitative data quality assessment and uncertainty analysis are rarely performed.

Acknowledgements: This project has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement No 101023202. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.

[1] J. J. Bozell y G. R. Petersen, «Technology development for the production of biobased products from biorefinery carbohydrates—the US Department of Energy's "Top 10" revisited», *Green Chem.*, vol. 12, nº4, p. 539, 2010, DOI: 10.1039/b922014c. *guidance.* LU: Publications Office, 2010. Accessed: January 19, 2022. [Online]. Available: https://data.europa.eu/doi/10.2788/38479