Converting Biomass to Affordable Biorenewable Cosmetic Ingredients

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Introduction of research

The need to develop affordable renewable technologies for uses in Personal Care and Cosmetics products is becoming increasingly urgent and essential to reducing dependence on fossil fuels, including lowering the carbon footprint and reducing the impact on our fragile environment. The challenge of the work that will be presented is developing biomass derived technology having a favorable environmental profile that meets the growing need for sustainable ingredients. Through a series of studies, it was concluded this work successfully validated a route for using biomass as a feedstock to develop ingredients that address consumer demand for personal care products that are more natural, safer for people, and less impactful on the environment. The levulinic acid derivative technology that has been developed can replace ingredients that have challenges relating to their health, environmental, and safety profile and are also the subject of increasing regulatory pressure.

Sustainability

The study was initiated to investigate using biomass as a feedstock to explore levulinic acid as a platform molecule and synthesize novel structures with unique performance attributes while addressing the trend for more natural ingredients. Process development technology was included to ensure scalability and economic viability. The project aimed to validate the hypothesis that this family of molecules provides a favorable Life Cycle Analysis, using the 12 Principles of Green Chemistry as a roadmap.

Recent years have brought the advent of numerous biobased chemical technologies that have achieved varying degrees of broad-based adoption. To ensure success, it is necessary for a company to meet four fundamental pillars for new chemical technologies: performance, scale, affordability, and environmental impact. These impacts are prioritized and articulated in the ever-increasing range of corporate ESG (Environmental, Social, and Governance) reports which inform stakeholders' progress against milestones. Successful development and acceptance into the Cosmetic and Personal Care markets require technologies that simultaneously provide unique attributes, the ability to manufacture at scale, meeting economic targets, and supporting environmental initiatives.

Derivates of levulinic acid are synthesized from second-generation biomass through an elegant process technology with the conviction that biobased chemicals are essential to reducing the impact of fossil-carbon chemicals on human health and to ensure a sustainable future for our planet. This new technology includes novel ingredients for the Personal Care and Cosmetic industry that are derived from non-food containing biomass, such as corn cobs and bagasse from sugar cane, without using feedstocks containing genetically modified sources. Figure 2 shows the straightforward chemistry that enables commercial scale affordability and Figure 3 describes the synthetic steps for levulinate propanediol ketal.

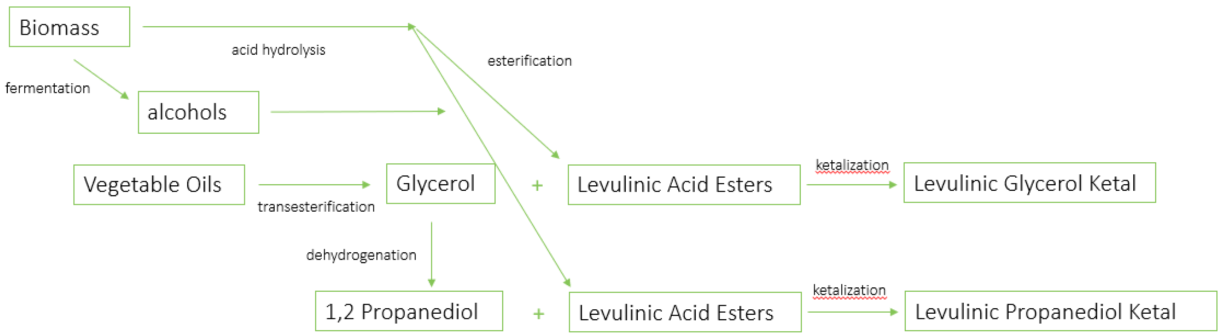
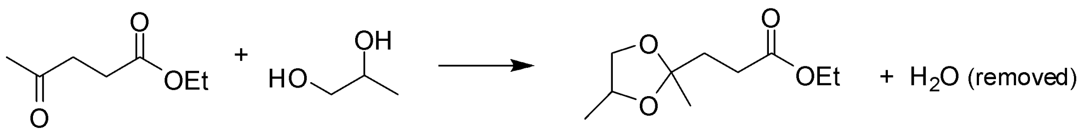


Figure 2. Levulinic acid derivatives process flow diagram



Ethyl levulinate Propylene glycol

Figure 3. Synthesis of levulinate propanediol ketal

Carbon Footprint

Levulinic acid was identified by the US Department of Energy[1] as one of the Top 12 renewable chemicals in part due to its environmental impact and most notably the reduction in carbon footprint levulinic acid derivatives. In a recent Life Cycle Analysis by Maastricht University, using the World ReCiPe H methodology, the levulinate propanediol ketal and levulinate glycerol ketal were reported to have a carbon footprint of 1.7 kg CO_2 eq/kg and 0.295 kg CO_2 eq/kg, respectively. The importance of this becomes clearer when compared to traditional fossil-based carbon ingredients such as 1,2 propanediol which has a carbon footprint of 4.14 kg CO_2 eq/kg. In this example, levulinate propanediol ketal has a 60% lower carbon footprint while levulinate glycerol ketal has a 93% lower carbon footprint.

The results of the levulinate propanediol ketal carbon footprint analysis is shown in the Sankey diagram below.

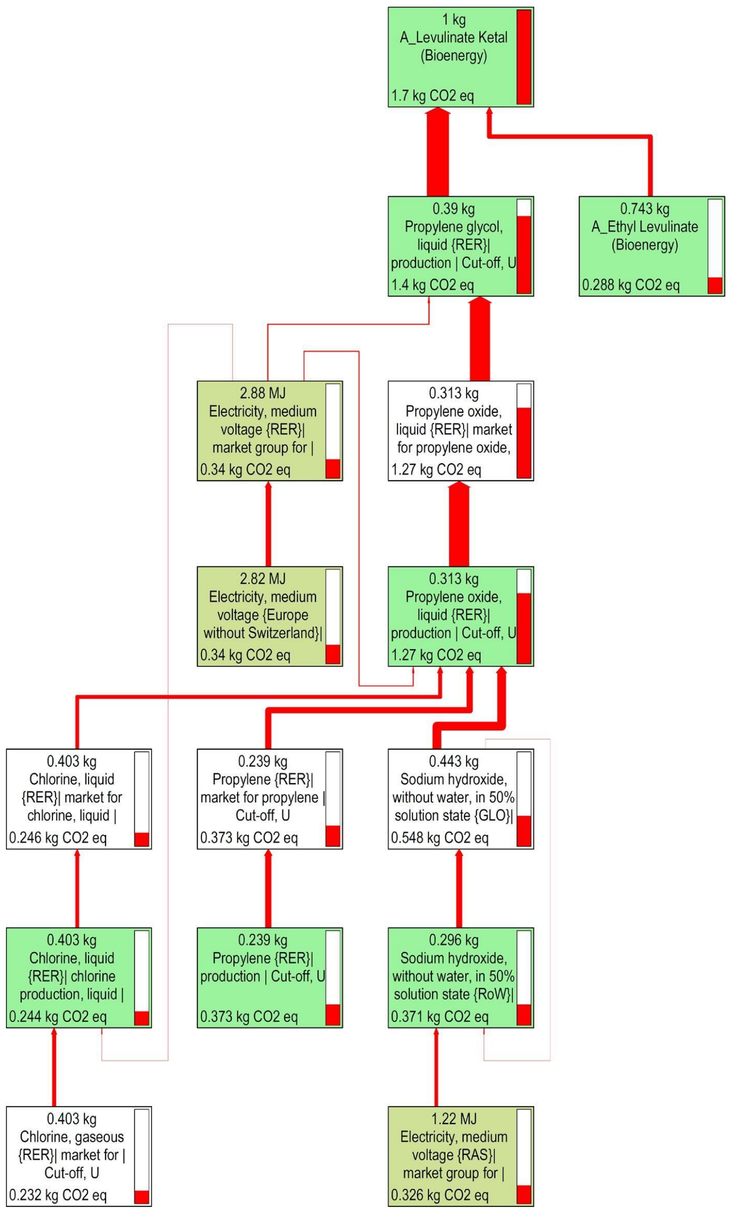


Figure 1. Carbon footprint of levulinate propanediol ketal

As shown in Figure 1, two different types of resources (biomass vs. fossil fuel) made a division between the carbon footprints. On the left part of the diagram, we see the fossil-carbon chemicals while on the right side of the diagram, we see the bio-based chemicals. As expected, the majority of carbon footprint is associated with the fossil-carbon chemical because the intermediate chemicals such as propylene oxide are fully fossil-carbon. Nevertheless, because of the bio-based origin of feedstock, the carbon footprint of ethyl levulinate is very low, thus resulting in a positive contribution in the total carbon footprint of levulinate propanediol ketal.

Conclusion

These levulinic acid derivatives were synthesized from second generation biomass, particularly bagasse from sugar cane and corn cobs, providing a route to adding circularity to agricultural waste and that are produced using a low energy manufacturing scheme. Levulinic propanediol ketal and levulinic glycerol ketal have been confirmed to provide unique performance attributes such as solvency and emolliency in applications such as skin care, nail care, and color cosmetics. The resultant carbon footprint highlight significant improvements over traditional ingredients owing to the biobased raw material feedstocks.

References

1. *Top Value Added Chemicals from Biomass, Volume I: Results of Screening for Potential Candidates from Sugars and Synthesis Gas (2004)*; Pacific Northwest National Laboratory and the National Renewable Energy Laboratory

About the speaker

Steve has been involved in the specialty chemicals industry for over 40 years. His passion is solving problems by identifying opportunities for new biobased chemical technologies. Over his career Steve has had the opportunity to lead both technical and commercial teams focused on innovative technical solutions and more recently centered around biobased chemistry.

Steve received a BS in Chemical Engineering from the Missouri University of Science and Technology, where he is a member of the Academy of Chemical Engineers, and an MS in Engineering Management from Wichita State University.

Steve has been involved in the biobased chemistry industry since 2013 having held commercial leadership roles at both NXTLEVVEL Biochem and Elevance Renewable Sciences. During his career Steve had a nearly 30 year tenure at Dow Corning where he held roles such as technical management, strategic marketing, and commercial leadership. His work spans the personal care, cleaning products, construction materials, coatings, polymers, sealants, and electronics industries.