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Bio-based chemicals – green, but also sustainable?

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For almost two decades, the chemical industry has put great effort into developing bio-chemicals, among others to fight global warming caused by greenhouse gas emissions, one of the biggest threats that are faced by our society today. To facilitate a growing and versatile bio-based chemical production, the US Department of Energy proposed in 2004 a list of 12 building block chemicals which can either be converged through biological or chemical conversions. Moving toward more bio-based chemicals, the chemical industry does not only claim to reduce climate change impacts, but also that they are increasing overall sustainability in chemical production. Whether such claims are justifiable is unclear. When sustainability of bio-based polymer production is assessed, various environmental trade-offs occur that need to be considered.[1] It is not enough to claim that a bio-chemical is sustainable by exclusively looking at reduced global warming impacts related to avoiding oil refining and related greenhouse gas emissions. However, there is big variation of which impacts are assessed and which life cycle stages are included between existing published studies focusing on assessing environmental sustainability of bio-based polymers.[2]

As an example, when comparing studies focusing on succinic acid, as a final product or building block chemical, bio-based succinic acid (SA) shows a better environmental sustainability performance than fossil-based SA when only “global warming” and “resources depletion” are considered as environmental impacts.[3] When other potentially relevant impacts are included into the assessment, trade-offs become apparent and bio-based SA may show worse environmental sustainability performance for example related to potentially toxic impacts on ecosystems from using pesticides during growing of the organic biomass (feedstock of bio-chemicals), and/or emissions of dust and particulate matter and occupying and using arable land.[4,5]

As the new era in biorefineries is rising, 2nd generation bio-chemicals are based on using waste streams instead of field crops as feedstock. However, it is currently unclear how these systems perform in terms of environmental sustainability related to for example additional energy and materials used during the waste treatment. This requires a full analysis of all relevant environmental impacts to fully support sustainability claims and consistency in environmental assessment studies to be able to identify and address potential hot-spots for reducing environmental impacts in bio-chemical production.

[1] (Weiss et al. 2012)
[2] (Hottle, Bilec, and Landis 2013)
[3] (Cok et al. 2014)
[4] (Smidt et al. 2015)
[5] (Breedveld et al. 2014)