

Quality-by-Design Influenced Biorefinery Development

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There are several significant challenges facing pioneer biorefineries associated with feedstock impacting processing efficiency, product quality, sustainability, and process economics. Though decades of research exist for designing and optimization of biorefineries there are still few examples of successful integrated biorefineries at industry scales. A systematic approach, like Quality-by-Design (QbD) that has been successfully applied in the pharmaceutical industry, might help in overcoming the challenges that biorefineries have faced. A QbD approach could be used to better understand and quantify the impacts of feedstock material attributes and process parameters on processing and conversion process quality attributes and development of process models to consistently meet process specification. QbD approaches are based on sound fundamental science and risk analysis that could be potentially applied to the entire industrial bioeconomy. In this work various elements of QbD are demonstrated for large scale demonstration scale processing and conversion systems geared towards bioenergy product generation from terrestrial biomass feedstocks. These QbD elements include systematic risk assessment methodologies to identify critical failures for a biomass preprocessing and conversion system, identification and introduction of in-line machine learning driven decision models to meet process specifications, and quality-driven economic and logistics process models.