Optimal design and synthesis of macroalgae biorefinery processes with potential zero direct greenhouses gas emission: MINLP Model and Global Optimization

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A novel superstructure of seaweed-based biorefinery was developed to find the optimal processing route to produce bioethanol, and protein rich solids. Process intensification was performed to utilize direct greenhouse gas (GHG) from biorefinery. Succinic acid and microalgae production processes use carbon dioxide as a primary precursor, thereby these processes are integrated to reduce GHG. The proposed superstructure contains thirty design alternatives (including different pretreatment steps, fermentation, carbon dioxide mitigation alternatives, and different separation technologies). Based on the superstructure, techno-economic and environmental mixed integer non-linear model (MINLP) was formulated. Global optimization was performed by using Baron solver. The proposed framework was implemented to study optimal process design with high economic benefits and potential zero carbon emission. This target was achieved by formulation two objective function, maximize net present value and minimize GHG. The result indicated NPV of integrated design is 400 times more than base-case (standalone) bioethanol process with more than 90% reduction in GHG.