



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: Integrated Bioprocess Design and Development Strategies for The Production of Optically Pure D-Lactic Acid: A Sustainable Approach for Cassava Based Agri Food Industry Waste

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SHORT ABSTRACT

The stereospecific nature and economic viability of Lactic acid monomer is crucial for the sustainability of Poly (lactic acid). This surges the concepts of “green monomers” from biorefineries especially D lactic acid (DLA). Enantiomeric purity of DLA is crucial factor for its industrial applications and the greatest demand exists for the optically pure isomers. The underutilized Agri-food industries are facing economical threats from its stakeholders especially cassava based industries. Development of an effective techno-economic strategy through greener process integration approaches will boost the economy. DLA production is one of the potential option that could be value added towards the generated cassava fibrous waste (CFW) at different stages.

The objective of this research work is to address the uncherished resource potential of CFW towards enhanced DLA production by imparting process intensification at different stages of integrated bioprocessing strategies, which includes Hydrolysis, Fermentation and Purification.

Electrospun chitosan coated poly lactic acid nanofiber: A novel immobilization matrix for α – amylase and its application in hydrolysis of cassava fibrous waste: The processability of CFW and its enzymatic hydrolysis was improved by a novice process intensification attempt of integrating a polymer matrix with enzyme i.e. using a tailor-made electrospun nanofibers and its application in immobilization of α – amylase enzyme. Chitosan coated nanofiber (CCN) matrix exhibited an optimal performance with enhanced tensile strength (1.262 MPa), reduced elongation (41.2%) and contact angle (128 degrees). Immobilization of α - amylase with CCN matrix at initial substrate concentration of 10 gL⁻¹ yielded a maximum conversion ratio of 0.85 and 0.99 without and with recycling mode, respectively.

Cost-effective waste valorization of CFW into enantiomerically pure DLA, Process intensification involving designed biomass approach (DBA) and Inhibition kinetic modelling(IKM): Kinetic modelling was carried out to gain insight on the dynamics of cassava fibrous waste enzyme hydrolysate (CFWEH) utilization towards DLA production. DBA was attempted to evaluate the potential of organism ability to metabolize CFWEH into high optically pure DLA. The fermentation studies were performed using Lactic acid bacteria (LAB), where *Sporolactobacillus inulinus* and *Lactobacillus delbreuckii* were elucidated as elite LAB for DLA production based on DBA experiments. *S. inulinus* yielded an optical purity of 99.43 % for DLA employing CFWEH as production medium. Kinetic parameters predicted for DLA production by *S. inulinus* were found to be maximum specific growth rate, $\mu_{max} = 0.36 \text{ (h}^{-1}\text{)}$; growth-associated product coefficient ($\alpha = 0.47 \text{ gg}^{-1}$) and specific productivity ($q_{P,max} = 1.12 \text{ gg}^{-1}\text{h}^{-1}$) respectively. *Lactobacillus delbreuckii* based CFWEH fermentation studies predicted parameters show that the inhibitory concentration for substrate was above 99 gL^{-1} , also inhibition due to DLA synthesis occurred as high as 59 gL^{-1} for 120 gL^{-1} substrate loading.

Process engineering strategy for DLA purification: A novel biocatalytic enzyme coupled with solvent engineering and esterification: Development of a novel process intensification strategy for esterification of DLA was aimed from the fermentation broth using a novel Amano lipase. Two different enzymes, namely *Candida antarctica* (Amano CL IM) and *Pseudomonas cepacia* (Amano PS IM) were procured from Amano enzymes, Japan. Amano CL IM outperformed Amano PS IM by yielding a maximum methyl D-Lactate (MDL) conversion efficiency of 22.1% and 67.6% at the end of 18th h and 100th h, respectively. Methanol to DLA ratio of 0.6 was found to be optimal. Esterification studies exhibit promising conversions on aqueous based fermentation broth.

To summarize, this doctoral thesis focusses on these integrated bioprocessing strategies for process enhancement of DLA production from cassava based agro food industry residue.