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Biocatalyst Based Process for Fatty Acid Esters Synthesis

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Abstract: ***The present research proposal discusses the biocatalyst based synthesis process for various fatty acid esters, especially isopropyl myristate. The research proposal includes origin of proposal, objectives, methodology, significance of proposal and future prospects. The origin of proposal evaluates the needs of green technologies for synthesis of esters and provides important opinion for implementation of biocatalytic process. The objectives part includes different milestones which should be achieved while developing biocatalytic process for given fatty acid ester synthesis. The methodology provides the research work flow need to be carried to meet the stated objectives. The significance of proposal open-up the final outcome from the present proposal and future prospects discusses the scope for further improvement in biocatalyst based process for fatty acid esters synthesis.***

Keywords: Biocatalyst, Fatty acid ester, Isopropyl myristate (IPM), Research proposal.

1. Origin of proposal

The natural based fatty acid esters are specialty chemicals used in a broad range of different fields, such as the cosmetic industry, the food industry, chemical industries, the coating industry, lubricants, etc [1, 2]. The fatty acid esters include methyl esters, ethyl esters, propyl esters, butyl esters, partial glycerides, wax esters (esters of fatty acids with long-chain fatty alcohols), and ester oils (esters of fatty acids with poly alcohols) [1, 2, 3]. Among the commonly used fatty acid esters is isopropyl myristate which is the main focus of the present proposal.

The isopropyl ester of tetradecanoic acid, Isopropyl myristate (IPM), is used in cosmetics industries as a substitute for natural oils because it's high skin absorptivity and spreading properties. In topical pharmaceutical creams and transdermal pharmaceutical preparations, IPM is used as a co-solvent with skin penetration enhancement properties for active pharmaceutical ingredient [4].

Traditionally, fatty acid esters syntheses such as isopropyl myristate synthesis are catalyzed by hazardous chemicals. But this chemical approach has several disadvantages including poor reaction selectivity and undesirable side reactions. In addition, these processes are highly energy intensive and affect the environment adversely. In this regards, the use of biocatalysts is considered to be one of the major routes for synthesis of fatty acid esters. The most promising biocatalysts are certainly lipases because of their unique structural characteristic, versatility and selectivity.

Lipase-catalyzed esterification of fatty acid has been reported in literature, with a wide range of esterification yields ranging from 3 to 100%, depending on the nature of the lipase, reaction medium, the alcohol and/or acid chain length and the structure of alcohol. On other hand, the use of an immobilized *Candida antarctica* B lipase as catalyst for esterification of myristic acid and isopropyl alcohol has been attempted by few researchers [5, 6]. However, low rate of reaction and yield need to be address for an efficient lipase based synthesis reaction.

So, there is an urge need for biocatalyst based process for efficient synthesis of fatty acid esters with aiming reduction of energy load and making environment more pollution free. To fulfill all the requirements needed for a proficient synthesis of isopropyl myristate, reaction optimization studies would be conducted in batch and continuous bioreactor systems. Relevant aspects, such as bioreactor configuration, operating conditions, and mass transfer effects would be assessed with the final aim of setting up a feasible process for the industrial fatty acid esters production.

2. Objectives

- Screening of various biocatalysts for efficient fatty acid esters synthesis.
- Development of stable and robust lipases either by pre-expression or post expression modifications.
- Determining the lipase's specificity of various chain lengths of fatty acid and alcohol.
- Reaction engineering for lipase stability and rapid rate of esterification reaction.
- Design of reactor for obtaining high yield and purity of product.
- Inventing novel product separation process based on physico-chemical properties.
- Integration of product recovery step with reaction for industrial acceptance.

3. Methodology

1) Lipases from microbial origin such as *Thermomyces lanuginosa*, *Candida antartica*, *Yarrowia lipolytica*, etc. will be over expressed and mutated using site directed mutagenesis for thermal/organic solvent tolerance.
2) Lipases showing improved thermal/organic tolerance will be immobilized on matrices based on polystyrene divinyl

benzene/ polymethacrylate/ polyacrylamide/ agarose etc. under different conditions for high synthetic activity.

3) Reaction optimization will be done with solvent, substrate to enzyme ratio, temperature, water activity etc.
4) Reactor designing will be done with due deliberation of rate determining parameters like water removal.
5) Separation methods for product recovery and/or for water removal will be used for achieving high conversion of substrates to products.

4. Significance of the Proposal

- The proposed work will result in stable and economically viable lipase enzyme prepared using novel immobilization strategies for fatty acid synthesis reactions.
- This would likely to replace the high energy intensive process for making fatty acid ester using chemical route.
- Models explaining various parameters influencing synthetic activity of immobilized enzyme will be developed.
- Suitably designed reactor systems optimized for fatty acid ester synthesis would be generated.
- Unit operations integrating reactions with downstream separation will increase the reaction productivity and thus improve the economic feasibility of process.

5. Future Prospects

Established scaled-up process would be a novel one-of-its-kind operation for fatty acid ester technology that combines use of enzymatic reaction with indigenous separation technology for fatty acid ester production. The products so formed would be of superior quality as they are not exposed to any harsh conditions of temperature and pressure and would also not contain polymers of fatty acids that are usually formed as side-products of the chemical reaction. This would attract the industrial partners who are implementing use of green technology in their existing processes.

The present proposal aims in future for technology validation at pilot scale using various fatty acids and alcohol to produce different fatty acid esters. The pilot scale operation of the project would be established the over process economy and provide basis for larger commercial scale plants.

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