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Activity Report on Memorandum of Understanding (MOU) for Collaboration Research

Purpose: To evaluate the collaborative research efforts facilitated by the MOU and its impact on paper publishing. Scope and objectives outlined in the MOU related to research collaboration and paper publishing.

Collaborative Research Activities:

1. Overview of the collaborative research projects undertaken as per the MOU.
2. Description of the research themes, areas, and interdisciplinary aspects explored.
3. Details of the resources and facilities shared between the two colleges to facilitate research.

Paper Publishing:

1. Analysis of the papers published as a result of collaborative research efforts.
2. Breakdown of publications by journals, conferences, and other platforms.
3. Evaluation of the impact factors and citation counts of the published papers.

The following report outlines the activities and progress made under the Memorandum of Understanding (MOU) for collaboration research between Meenakshi College of Engineering and Sethu Institute of Technology. We distinguish between collaboration at different levels and show that inter-institutional and international collaboration need not necessarily involve inter-individual collaboration. The collaboration created new avenues of research and development for the faculty and students.

Dr. R. Usha Rani, Assistant Professor, Department of Mathematics, Meenakshi College of Engineering collaborated with Dr. Lakshmi Narayanan, Associate Professor, and Dr. Krishna Kumar, Associate Professor, Department of Mathematics, Sethu Institute of Technology published research papers.

1. Mathematical Modelling of Forced Convection in a Porous Medium for General Geometry: Solution of Thermal Energy Equation Via Taylor's Series with Ying Buzu Algorithms, Published on7 May 2022 , Int. J. Electrochem. Sci., 17 (2022) Article Number: 220623, doi: 10.20964/2022.06.26, http://electrochemsci.org/papers/vol17/220623.pdf.

2. Theoretical analysis of the enzyme reaction processes within the multiscale porous biocatalytic electrodes: Akbari–Ganji's and Taylor's series method, available on online 4 March 2024, The International Journal of Electrochemical Science, volume 19, issue 4 https://ouci.dntb.gov.ua/en/works/9ZQkrmLl/.

Emphasis on the significance of collaborative research and paper publishing in advancing academic excellence and innovation was carried through the above research papers. Citations for all sources referenced in the report. This report provides a comprehensive analysis of the collaborative research efforts facilitated by the MOU between two engineering colleges, focusing on its impact on paper publishing and academic collaboration.

COORDINATOR
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Theoretical analysis of the enzyme reaction processes within the multiscale porous biocatalytic electrodes: Akbari–Ganji's and Taylor's series method

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ABSTRACT

We discuss a theoretical model that describes glucose oxidation in a multiscale porous biocatalytic electrode. The model under consideration consists of two nonlinear differential equations that describe diffusion and reaction in the hydrogel film. The Akbari–Ganji's and Taylor series methods have been used in this communication to obtain the analytical expressions for the concentrations of the oxidized mediator, Glucose, and current. Additionally, the optimal electrode thickness of the film is calculated analytically. The impact of parameters on current is also explored. The parameter with the most significant effect on the current is the ratio of the oxidized mediator's diffusion to the enzymatic process occurring within the film. The numerical solution (Matlab) validates our analytical results.

1. Introduction

Porous electrodes have recently attracted significant interest from both theoretical and experimental perspectives. These electrodes are essential for designing miniaturized electro-devices like bio-batteries, enzymatic reactors, biofuel cells and bio-sensors [1–4]. The literature has focused a lot of work on modelling the macroscopic behaviour of a porous electrode [5]. More specifically, the direct electron transfer mode [2] and the mediated electron transfer regime [3,6] have addressed the related diffusion-reaction mechanisms inside the porous media. A macroscopic empirical model has been established [7] for a porous electrode of spherical pores placed on a disc.

A theoretical, quantitative model for transport and reaction in an infinite porous rotating disc electrode was also developed in the convection and diffusion-dominated regimes [8]. Cai et al.'s work [9] addressed the optimal electrode thickness for a planar solid oxide fuel cell based on three-dimensional direct simulations at the pore size.

As far as enzymatic electrodes are concerned, interface models are dominant [10]. Enzymes in these models were either adsorbed at the electrode surface, free-diffusive, fixed inside a non-conductive matrix, or imprisoned behind a thin membrane [10]. A model of a carbon nanotube electrode was developed by Lyons [11], Baronas et al. [12], Barton [13], and Chan et al. [14]. To study the behaviour of the carbon nanotube-based amperometric biosensors over the perforated membrane, Baronas et al. [12] used a macro-homogeneous one-dimensional model.

A theoretical model of porous battery electrodes was developed by Lai et al. [15]. Ke et al. [16] presented a computational model of a flow battery that is similar to a fuel cell and employs a carbon paper electrode. Rasi and Rajendran [17] discussed the theoretical model of multiscale porous biocatalytic electrode. A mathematical model of a multiscale porous carbon-based bioelectrode for ping-pong bi-bi enzyme kinetics was developed by Wen et al. [18,19]. An analytically accurate solution to this problem has not yet been developed. The objective of this study is to use the methodologies of Akbari–Ganji and Taylor's series to develop the analytical equations for the concentration of glucose (substrate), hydrogen peroxide (product), and current in planar and porous electrode models. The objective is to solve the steady-state nonlinear equations to obtain an analytical expression of concentrations and the ideal electrode thickness.

2. Mathematical formulation of the problem

Fig. 1 depicts a schematic diagram for glucose oxidation. The following expression can describe the chemical process occurring within the motorbike porous electrode [18].

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Mathematical Modelling of Forced Convection in a Porous Medium for a General Geometry: Solution of Thermal Energy Equation Via Taylor's Series with Ying Buzu Algorithms

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The effects of thermal dispersion on forced convection inside a porous-saturated pipe were studied. The pipe wall is considered to maintain a constant and balanced heat flux. This model is based on a nonlinear equation containing a nonlinear term related to viscous dissipation, heat source terms and axial conduction. The steady-state thermal energy equation is solved using Taylor's series method coupled with the Ying Buzu algorithm. A numerical solution is also provided that is valid for the wide range of thermal dispersion conductivity. Furthermore, the outcome results based on present investigation are in good agreement with the literature.

Keywords: nonlinear equations, forced convection, porous-saturated duct, Taylor's series method, Ying Buzu algorithm.

1. INTRODUCTION

Convection in solid matrix porous media with an interrelated voids is a well-developed topic for researchers due to its significance to various engineering applications such as geothermal systems, sub-surface fire control, coal and grain storage, and energy recovery in high-temperature furnaces [1–3]. Porous heat exchangers have been identified for prospective applications in solar thermal plants [4], cooling towers [5], electronic cooling [6], diesel engines [7], and thermal storage systems [8]. The effects of thermal dispersion on convection in porous media have been investigated [9]. Also, the effects of thermal dispersion on forced/free convection occur in thermogalvanic cells and electrochemical sensors

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