AMET
ACADEMY OF MARITIME EDUCATION AND TRAINING
Deemed to be University Under Section 3 of UGC Act 1956

DEPARTMENT OF MATHEMATICS

RAMANUJAN GAIT

Even Semester Magazine

2021 - 2022

ACADEMY OF MARITIME EDUCATION AND TRAINING

Deemed to be University Under Section 3 of UGC Act 1956

DEPARTMENT OF MATHEMATICS

RAMANUJAN GAIT

2021 –2022 Semester Magazine

AMET Deemed to be University,

Chennai – 603112

Editorial

Dear Readers,

I am pleased to know that this issue of AMET university Maths department magazine "RAMANUJAN GAIT" is being published. The mathematics department is an abode of excellence like other departments in the AMET University. Students are made familiar with the latest theoretical developments in their respective engineering disciplines. Because the nature of mathematics makes it appear abstract, particular attention is paid to placing all classroom discussions in the perspective of practical issues. I am sure that our students and faculty members would continue to prove mettle and make us proud by their achievements.

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FOREWORD

Dr. P. Balaganesan, Associate Professor & Head, Department of Mathematics

It is a great pleasure to learn that the AMET University Department of Mathematics magazine "RAMANUJAN GAIT" has been published.

This publication gives a venue for aspiring writers to express themselves. The mathematics department at AMET University is dedicated to offering all of the resources necessary to create young marine engineers through high-quality engineering and technology education and support. Since its foundation in 2001, the Department of Mathematics at AMET in Chennai has been heavily involved in Engineering Sciences teaching and research.

I am convinced that students and faculty will continue to utilize opportunities and bring honour to yourselves and your institutions.

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WITH BEST WISHES TO ALL

PREAMBLE

AMET is India's first Deemed to be University in Maritime Education which is ranked as 3rd among Maritime Universities of the World in the PIMET (Performance Indicators in Maritime Education and Training) Ranking of International Association of Maritime Universities (IAMU). Established during 1993, AMET's uncompromising strides of excellence in the field of maritime education and training laced with its capacity to feed the global shipping industry with an unrivalled maritime human resource secured it to have many national and international recognitions, accreditations and rankings such as NAAC, NIRF, ARIIA, DGS-CIP, PIMET etc.

AMET serves as an ocean of knowledge for over 4000 students pursuing Programmes ranging from diploma to Doctoral programs through 9 schools and 23 intensive research and training centres for marine and marine related activities. Equipped with an excellent infrastructure for research and development, co-curricular and extracurricular activities AMET secured its compliance certificate forISO 9001:2015 QMS standards from the prestigious and globally renowned

DET NORSKE VERITAS, Norway.

For over two decades AMET is remaining as the favourite destination for campus interviews by many shipping giants such as AP MOLLER MAERSK, GOODWOOD, NYK, SONANGOL, VSHIPS, WALLEMS, SHELL, CHEVRON, STENA and so goes a list of over 100 companies.

Besides positions on board, AMET Business school graduates have secured lucrative jobs in commercial shipping sectors such as chartering and ship broking. Never the less, Naval architecture, petroleum engineering, harbour engineering, marine electrical and electronics engineering graduates have successfully walked away from AMET with jobs offering sumptuous packages along with an opportunity to grow and glow in their career swiftly. Needless to say, about the entrepreneurship development activities nurtured into AMET'ians has been found rewarding by students who are chiefexecutive officers of their own organization.

QUALITY POLICY

AMET is committed to provide the highest quality in education and be the most preferredinstitution for pursuing marine and marine-related courses.

This will be achieved by a consistent focus on:

- Providing a conductive, vibrant, progressive and enriching learning atmosphere.
- Teaching excellence and research output.
- Global outlook and engaging with the world through learning, teaching and research.
- Providing competitive advantage in gaining employment for further academic opportunities.
- Maintaining excellent links with commerce and industry in both national and international.
- Complying with all applicable requirements and continually improving the effectiveness ofthe Quality Management System.

VISION AND MISSION OF THE UNIVERSITY

VISION

To sustain identity as a World Class Leader in Maritime Education and empower learners with wholesome knowledge through progressive innovation in training, research and development which will render students a unique learning experience and a transformation impact on the Global Society.

MISSION

AMET will strive continuously to

- Impart value-based higher education and technical knowledge with uncompromising strides of outstanding quality.
- Emerge as a Centre of Excellence inculcating skill development in recent technologies by industrial trends.
- Create World-class research capabilities on par with the finest in the world and broaden student's horizons beyond classroom education.
- Nurture talent and entrepreneurship to enable all-round personality development among students.
- Empower students across socio-economic strata
- Make a positive difference to society through technical education.

DEPARTMENT OF MATHEMATICS

Vision

To transform the Department into a Centre of excellence to contribute significantly to Marine based realms through Mathematics

Mission

- To provide adaptive learning ambiance in Mathematics and its related fields to enhance problem
  solving, leadership and teamwork skills of students.
- To enable the students to tap the potentials of Mathematics in the Marine related domains by adopting innovative Teaching – Learning techniques.
- To nurture knowledge through cutting-edge research and innovations to enrich the society in meaningful and sustainable ways.
- To inculcate among students the value of commitment, quality, and ethical behavior.

- The Department of Mathematics in AMET University is a thriving community of dedicated teachers, diligent researchers and devoted students sharing the enthusiasm for Mathematics. The Department of Mathematics serves as an ideal training ground for learning a broad range of analytical and problem-solving skills. Excellence and commitment are two eyes of the department as it constantly strives to be the centre for excellence in acquiring knowledge and skill required for engineers and technologists. Five faculty members are doctorate holders.
- **Programmes Offered**
- Mathematics is a fundamental analytical tool in all engineering subjects.
  The department laysa strong foundation in Mathematics and its applications to Marine engineering students of
  B.E courses. The syllabus is designed to cater to all engineering departments' needs, both atundergraduate and postgraduate levels. Also, the department offers PhD in Mathematics.

- **Research thrust areas**
- The specific areas of research in which the department is actively engaged are Mathematical modelling, Computational chemistry, Graph Theory, Theory of Nonlinear equations, Mathematical Biology, Numerical Analysis & Differential equations.
- **Noteworthy Achievements**

Dr.P.Balaganesan is a HOD & AAssociate Professor at the Department of Mathematics, AMET University, has 25 years of expertise in Graph theory and Non linear differential equation. He has over 33 papers in international and national journals to his credit.

More than 05 students under his guidance. Many faculty members served as resource persons and chaired sessions in National and International conferences conducted in India and abroad. Also, some faculty members are acting as reviewers in reputed international journals.

Extension Activity 2022

Category: Enhancing Knowledge development

Title: Business Mathematics for school Children

About the Programme:

Business Mathematics consists of Mathematical concepts related to business. It comprises mainly profit, loss and interest. Maths is the base of any business. Business Mathematics financial formulas, measurements which helps to calculate profit and loss, the interest rates, tax calculations, salary calculations, which helps to finish the business tasks effectively and efficiently.

Business Mathematics is highly related to the Statistics concepts which give solutions to business problems. In business, we deal with the exchange of money or products, which have a monetary value. Each business leads to some profit and some loss. To identify these factors, we have to study the primary topics of Maths such as formulas to find a profit, loss, their percentages, discount, etc. Even Though, the requirement of this subject does not contain pure Maths, it needs Mathematical thinking and math formulas. Here, we have discussed what is Business Mathematics, terminologies, and important formulas with problems and solutions.

Mainly in the topic of statistics, the concepts of probability is explained with simple examples. They were very eager to learn this and tried to practice to more problems. This really helped the students to know the basics of probability and how they are connected with real time situations and how to implement in their daily life. The students are benefited much and this event make them to improve their mental calculations.

The AMET cadets were involved to assist in this activity and to persuade their interest towards such social activities. The cadets were done some activities using properties to the school students related to the topics they have learned.

Beneficiary Institution: Government Higher Secondary School,Uthandi.

Coordinators:

1. Dr. I. Paulraj Jayasimman
2. Ms.T.Dhivya

No of faculty Involved: 1

No. of Cadets involved: 10

No of Beneficiaries Involved: 34

Uses of Programme from the Beneficiaries:

It was very informative, interesting and useful, and we have got to know about Concepts and methods of Statistical topics from business maths. Look forward for more.

Figure: 1 Snapshot of class

Figure: 2 Snapshot of students interaction with cadets

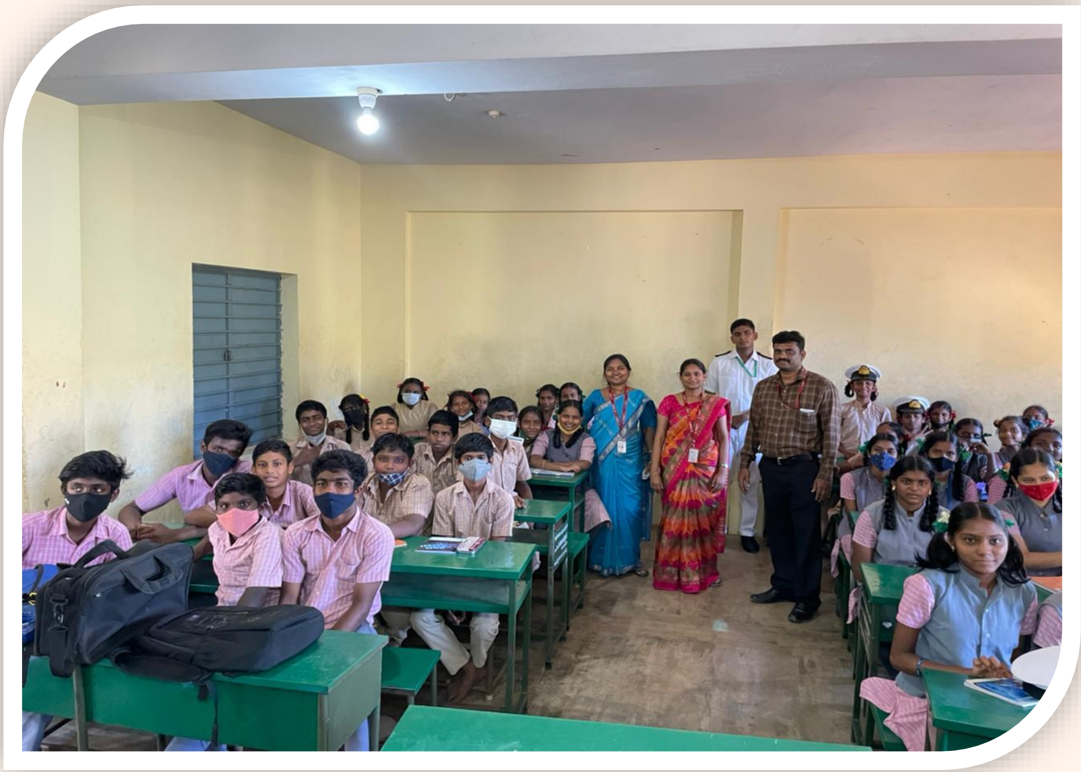

Figure :3 View of Presentation Class room

PUBLICATIONS

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Amperometric biosensors and coupled enzyme nonlinear reactions processes: A complete theoretical and numerical approach

S. Vinolyn Sylvia [a], R. Joy Salomi [a], L. Rajendran [a,*], M.E.G. Lyons [b]

[a] Department of Mathematics, Academy of Maritime Education and Training (AMET) Deemed to be University, India
[b] School of Chemistry & AMBER National Centre, Trinity College Dublin, University of Dublin, Ireland

ARTICLE INFO

Keywords:
Mathematical modelling
Nonlinear reaction-diffusion equations
Enzymatic trigger reactions
Amperometric biosensor
Homotopy perturbation method

ABSTRACT

The transient response of amperometric enzyme-based biosensors working in trigger mode is discussed. Nonlinear time-dependent partial differential equations for Michaelis-Menten reaction kinetics are solved analytically using a new approach of homotopy perturbation technique. The simple and closed-form analytical expression for concentration profiles are provided. Subsequently, the biosensor's current, sensitivity, resistance, and amplification are derived from the concentration profiles. The current response is predicted under steady-state conditions when $T \rightarrow \infty$, proving the validity of the mathematical analyses. The limiting situations of catalytic sites (unsaturation and saturation) are considered. The compatibility of analytical results with simulation and limiting case results can be observed from the graphs and tables presented. The existence of the moving boundary between the two categories of catalytic sites is also discussed.

1. Introduction

Chemical amplification greatly enhances the sensitivity of biosensors. The amplification in the biosensor response was attained by cyclic substrate/product conversion [1–3]. In the CCE scheme, biosensors used a trigger enzymatic reaction, followed by the product's cyclic enzymatic and electrochemical conversion. In contrast, biosensors utilized an enzymatic trigger reaction in the CEC scheme, followed by an electrochemical and enzymatic product cyclic conversion [4]. Transient responses of biosensors acting in a trigger mode for the CEC mechanism were performed [5]. Schulmeister and co-workers examined the response of dual enzyme biosensors [6,7]. Krasuski et al [8]. developed a mathematical model to assess the accurate velocity of aircraft using GNSS sensors. An optimal nano/micro-electromechanical system can be designed by using apt pull-in instability, which in turn ensures effective operation of electrostatically actuated sensors. He et al [9]. determined the pull-in voltage of a nano/micro-electromechanical system using Chinese algorithm and He's frequency formulation. Kulys and Tetianec obtained significant biosensor sensitivity by utilizing peroxidase to trigger initiator conversion, and cyclic conversion of the mediator thus generated [10]. Baronas studied the effects of internal and external diffusion limitations on the response and sensitivity of amperometric biosensors using a two-compartment model based on reaction-diffusion equations with a nonlinear term related to Michaelis-Menten kinetics [11].

Baronas et al [4]. developed the numerical model of the biosensors acting in a trigger mode for CCE and CEC scheme. More recently, Joy Salomi et al [5]. derived the transient current, sensitivity and resistance of biosensors acting in a trigger mode for the CEC scheme. Zhang et al [12]. reported the theoretical model for immobilized enzyme biosensing systems based on diffusion limited inhibitor transport. Recently Goyal et al [13]. developed mathematical model to understand the transport and kinetics of an analyte in the electro-polymerized layer used as the recognition element of a non-enzymatic biosensor. Zouaoui et al [14]. developed a mathematical model to simulate the response of the conductometric biosensor for the detection of urea.

However, to the best of our knowledge, there is no rigorous analytical expression corresponding to concentration and current for this coupled enzyme reaction which involves electrochemical and enzymatic amplification. The benefit of extracting an approximate analytic solution is to understand the mechanism and know absolutely how the model will behave under any circumstances. Moreover, it is the solution for myriad of particular cases, whereas the numerical solution must be acquired anew for each such case separately. Hence this paper presents the approximate analytical expression for substrate and products concentration for transient conditions using the homotopy perturbation method along with the analytical expressions for current, sensitivity,

* Corresponding author.
E-mail address: dr.rajendranlr@gmail.com (L. Rajendran).

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Reaction-diffusion in a packed-bed reactors: Enzymatic isomerization with Michaelis-Menten Kinetics

P. Jeyabarathi [a,b], L. Rajendran [b,*], M.E.G. Lyons [c]

[a] Department of Mathematics, Government Arts College, Ariyalur, Affiliated to Bharathidasan University, Thiruchirappalli, India
[b] Department of Mathematics, AMET (Deemed to be University) Chennai, Tamilnadu, India
[c] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland

ARTICLE INFO

Keywords:
Enzymatic reactions
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Non-linear differential equation
Hyperbolic function method
Packed-bed reactors

ABSTRACT

A theoretical model for the enzyme-catalyzed isomerization reaction in a packed-bed reactors made up of microporous particles is discussed. The system is described in terms of finite-range Fickian diffusion and non linear Michaelis-Menten reaction kinetics to produce a non linear reaction/diffusion equation which is solved both numerically by MATLAB and analytically by hyperbolic function methods (HFM). Approximate analytical expressions of the substrate concentration within the microparticle, the related flux and the effectiveness factor for a wide range of values of pore-level Thiele modulus and kinetic parameters are reported using these simple, and robust methods. A satisfactory agreement is obtained between the estimated analytical solution and the numerical simulation.

1. Introduction

The enzymatic reaction is a common mechanism for converting various substrates, e.g. glucose to fructose. This procedure, which uses immobilized enzymatic catalysis, is carried out in a packed-bed reactor, which comprises microporous particles with a range of pore sizes characterized by a pore size distribution. Glucose isomerase was discovered by Marshall and Kooi [1] and succeeded in producing it in commercially viable amounts using enzymatic reactions. [16]

Converting glucose to fructose through an enzymatic isomerization process using IGI is considered one of the most successful processes of its kind. In addition to batch reactors, it is also carried out in continuous stirred-tank reactors and fixed-bed and fluidized-bed reactors. In the latter two cases, the enzymes are trapped in the pores of the microporous particles, which give the reactions a vast surface area. As constructing a packing of microporous particles is straightforward, packed-bed reactors are widely used. Hence, the problem of modelling converting glucose to fructose by an enzymatic process in packed-bed reactors has received considerable attention.

The effect of a porous medium on mass transport and reaction kinetics is described by percolation theory [2-9]. Many have used this approach to model catalyst deactivation at a single microporous particle [9-15]. Dadvar et al. [16] developed a pore network model of deactivating microporous biocatalyst particles in a packed-bed reactor. They reported the preliminary simulation results of this phenomenon using 2D networks in two recent papers [17,18].

Pourani et al. [19] solved the coupled, steady-state non-linear reaction–diffusion equation in the pore network model analytically. As a result, approximate analytical expressions for the packed-bed reactor's concentration and flux are obtained. Ananthasamy and Rajendran [20] derived analytical expressions for the concentration and flux in a packed bed reactor under steady-state conditions using the new homotopy approach. Selvi and Hariharan [21] are derived steady-state concentrations in immobilized glucose isomerase of the packed-bed reactor using a wavelet-based analytical algorithm.

To our knowledge, no general analytical results for the steady-state substrate concentration and current for all values of the parameter Φ, and β have been provided. This communication aims to derive an analytical expression for the steady-state substrate concentration, the current and the effectiveness factor using the hyperbolic function methods.

2. Mathematical formulation of the problem

The reaction scheme for converting glucose to fructose by the enzymatic reaction is described as follows [16]:

$$G + E \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} X \underset{k_{-2}}{\overset{k_2}{\rightleftharpoons}} F + E \quad (1)$$

* Corresponding author.
E-mail address: raj_sms@rediffmail.com (L. Rajendran).

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Transport and kinetics in an electroenzymatic process incurred in PPO-based rotating disk bioelectrodes

R. Saravanakumar [a], P. Pirabaharan [a], L. Rajendran [b,*]

[a] Department of Mathematics, Anna University, University College of Engineering, Dindigul, Tamil Nadu, India
[b] Department of Mathematics, AMET (Deemed to be university), Kanathur, Chennai, India

ARTICLE INFO

Keywords:
Rotating disc electrode
Mathematical modeling
Nonlinear equations
Hyperbolic function method

ABSTRACT

The motivation for this work was to develop a theoretical analysis corresponding to the transport and kinetics of substrate and product in PPO-based rotating disk bioelectrodes. This model is based on a nonlinear reaction–diffusion system containing the nonlinear term related to the CEC' mechanism. The hyperbolic function approach was used to solve the nonlinear coupled system of reaction–diffusion equations. The approximate analytical expressions concentrations of phenol, catechol and o-quinone and current response for all possible diffusion and kinetic parameters values are reported. The bioelectrode's sensitivity and amplification factor towards phenol substrate were also presented in terms of rotation rate and enzyme layer thickness. The numerical solution of this problem is also reported using Scilab/Matlab program. Also, a satisfactory agreement is noted between the analytical and numerical results upon comparison.

1. Introduction

Enzyme electrodes, including various amplification schemes, have been developed for a variety of applications, including electrochemical immunoassays [1,2], water pollutant detection[3-5], and monitoring of biological metabolites [6]. The sensitivity and amplification factor of enzyme electrodes are frequently increased by embedding a substrate-recycling scheme, and several strategies, such as chemical, enzymatic, or electrochemical recycling, have been developed. Due to the numerous applications of such biosensors with amplified responses, there is growing interest in studying the rate-limiting steps of these types of devices to improve their metrological characteristics. Table 1, Table 2.

As evidenced by the critical work already reported in the literature [7–10], theoretical and kinetic analysis is a powerful approach to simplifying biosensor operation. Labbe and colleagues [11–13] developed a theoretical analysis of substrate and product transport and kinetics in an immobilized enzyme layer involving catechol-polyphenol oxidase (PPO) as a prototype electroenzymatic model system. Indira and Rajendran [14] developed approximate analytical expressions regarding substrate, product concentration, and current response for all possible diffusion and kinetic parameters values in the PPO system. But the analytical expressions are not in compact form. Coche et al. [15] provided a complete theoretical analysis of this phenol sensor, including the effects of mass transport, permeation through the enzyme layer, and enzyme reaction mechanisms for the limiting case (a low phenol substrate concentration).

No analytical expression is available for the steady-state concentration of phenol, catecholando-quinone, current, sensitivity and amplification factor for all values of parameters at the rotating disk electrode for the reciprocal competitive inhibition process [15]. This communication aims to derive the steady-state concentrationprofiles, current, sensitivity and amplification factor at electrodes analytically for all parameter values using the hyperbolic function method in simple, monomial and compact form. This method is primarily intended to solve various nonlinear differential equations that are easier than other methods and accept minimal errors compared to numerical approaches.

2. Mathematical formulation

The complete mathematical formulation of this problem is described in Coche-Guerenteet al. [15]. The electroenzymatic process occurring in CEC' mechanism is written as follows:

Step C: [illegible] (1)

Step E: [illegible] (2)

* Corresponding author.
E-mail address: [illegible] (L. Rajendran).

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Theoretical Analysis of Transient Responses of Amperometric Biosensor Based on the Phenol–Polyphenol Oxidase Model

R. Joy Salomi[1], S. Vinolyn Sylvia[1], Marwan Abukhaled[2], Michael E.G. Lyons[3], L. Rajendran[1,]*

[1] Department of Mathematics, Academy of Maritime Education and Training (AMET), India
[2] Department of Mathematics and Statistics, American University of Sharjah, Sharjah, UAE
[3] School of Chemistry & AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
*E-mail: raj_sms@rediffmail.com

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ELSEVIER

Cyclic voltammetric response of homogeneous catalysis of electrochemical reactions: Part 1. A theoretical and numerical approach for EE'C scheme

R. Joy Salomi, L. Rajendran *

Department of Mathematics, Academy of Maritime Education and Training (AMET), Deemed to be University, Chennai, India

A R T I C L E I N F O

Keywords:
Mathematical modelling
Cyclic voltammetry
Electrochemical reactions
Homogeneous catalysis
Rajendran-Joy method

A B S T R A C T

This paper reports the mathematical modelling of homogeneous redox catalysis of electrochemical reactions for the EE'C scheme. This model is described by the system of nonlinear differential equations for which the nonlinear term is related to homogeneous reaction. The concentration of species and current–voltage curves at a planar electrode has been calculated by solving the nonlinear equations using a simple and new innovative approach which is named as Rajendran-Joy method(RJM). In particular, the limiting current and plateau current is highly sensitive to the solution flow rate and the concentrations of the mediator and substrate employed. The effect of two dimensionless parameters that group the experimental intrinsic and operational parameters on current is discussed. Our analytical results for cyclic voltammetry current are compared with simulation results, and satisfactory agreement is noted. The characteristic of concentration and the current–potential response for the extreme values of parameters are also provided.

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Cyclic voltammetric response of homogeneous catalysis of electrochemical reactions: Part 2. A theoretical and numerical approach for EC scheme

S. Vinolyn Sylvia, L Rajendran *

Department of Mathematics, Academy of Maritime Education and Training(AMET), Deemed to be University, India

A R T I C L E I N F O

Keywords:
Mathematical modelling
Cyclic voltammetry
Homogeneous redox catalysis
Nonlinear equations
Homotopy perturbation method

A B S T R A C T

The theory of homogeneous redox catalysis in cyclic voltammetry for a low scan rate is discussed in this paper for the EC reaction scheme, which is the fundamental mechanism in which a chemical reaction accompanies the initial electron-transfer process. The analytical expression corresponding to the concentration of species for steady and non-steady-state conditions has been obtained using a new approach to the homotopy perturbation method. Moreover, the closed approximate analytical expression of concentration and current–potential, plateau current, and half-wave potential is derived for three limiting situations. The effect of the kinetic parameters on current–potential using sensitivity analysis is also discussed. The shape and characteristics of the voltammograms are presented.

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Transport and Kinetics in Biofiltration Membranes: New Analytical Expressions for Concentration Profiles of Hydrophilic and Hydrophobic VOCs Using Taylor's Series and Akbari- Ganji methods.

Singaravel Anandhar Salai Sivasundari[1], *Ramu Usha Rani*[2], *Michael E.G. Lyons*[3], *Lakshmanan Rajendran*[1,*]

[1] Department of Mathematics, AMET (Deemed to be University), Kanathur, Chennai, India.
[2] Department of Mathematics, Meenakshi College of Engineering, KK Nagar, Chennai, India.
[3] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 02 PN40, Ireland, India.
[*]E-mail: raj_sms@rediffmail.com

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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

K. Lakshmi Narayanan[1], *R. Shanthi*[2], *Ramu Usha Rani*[3], *Michael E.G. Lyons*[4], *Lakshmanan Rajendran*[2,*]

[1] Department of Mathematics, Sethu Institute of Technolgy, Kariapatti, Viruthunagar, India.
[2] Department of Mathematics, AMET (Deemed to be University), Kanathur, Chennai, India.
[3] Department of Mathematics, Meenakshi College of Engineering, KK Nagar, Chennai, India.
[4] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland.
[*]E-mail: raj_sms@rediffmail.com

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Mathematical Modeling of pH-Based Potentiometric Biosensor Using Akbari-Ganji Method

R. Shanthi[1], M. Chitra Devi[2], Marwan Abukhaled[3], Michael E.G. Lyons[4], L. Rajendran[1,]*

[1] Department of Mathematics, AMET (Deemed to be University), Kanathur, Chennai, India
[2] Department of Mathematics, Anna University, University College of Engineering, Dindigul, India.
[3] Department of Mathematics and Statistics, American University of Sharjah, Sharjah, UAE
[4] School of Chemistry & AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
[*]E-mail: raj_sms@rediffmail.com

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Mathematical Modelling of Unsteady Flow of Gas in a Semi-Infinite Porous Medium

M. Lilly Clarance Mary[1], R. Saravanakumar[4], D. Lakshmanaraj[2,], L. Rajendran[3,*], .M.E.G. Lyons[5]*

[1] Department of Mathematics, Fatima College (Autonomous), Madurai, India.
[2] Department of Mathematics, Sethu Institute of Technology, Kariapatti, India
[3] Department of Mathematics, AMET (Deemed to be University), Kanathur, Chennai, India
[4] Department of Mathematics, Vidhyaa Giri College of Arts and Science, Puduvayal, Karaikudi, India
[5]School of Chemistry & AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland.
[*]E-mail: lakshmanaraj@sethu.ac.in, raj_sms@rediffmail.com

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The Steady-State Concentration of the Species in a Reagentless Enzyme-Containing Polymer Modified Electrode Using Akbari-Ganji's method

S. Padma[1], P. Jeyabarathi[2], L. Rajendran[1,], M. E. G. Lyons[3]*

[1] Department of Mathematics, AMET, Deemed to be University, Chennai, India.
[2] Department of Mathematics, Government Arts College, Ariyalur, Affiliated to Bharathidasan University,Thiruchirappalli, India
[3] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
[*]E-mail: raj_sms@rediffmail.com

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Mathematical modeling of substrate consumption in a biofilm: Solutions arrived using Akbari-Ganji method

R. Vanaja[1], P. Jeyabarathi[2], L. Rajendran[1,], M.E.G. Lyons[3]*

[1] Department of Mathematics, AMET, Deemed to be University, Chennai, India.
[2] Department of Mathematics, Government Arts College, Ariyalur, Affiliated to Bharathidasan University, Thiruchirappalli, India
[3] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
[*]E-mail: raj_sms@rediffmail.com

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The Analytical Expression of Steady-State Concentration of Mixture of Toluene and N- Propanol in the Biofilm: Akbari-Ganji's Method

R. Vanaja[1], P. Jeyabarathi[2], L. Rajendran[1,], M.E.G. Lyons[3]*

[1] Department of Mathematics, AMET (Deemed to be university) chennai, Tamilnadu, India.
[2] Department of Mathematics, Government Arts College, Ariyalur, Affiliated to Bharathidasan University, Thiruchirappalli, India
[3] School of Chemistry and AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
[*] E-mail: raj_sms@rediffmail.com

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Theoretical analysis of reaction-diffusion process in biocatalyst modified electrodes: Solutions derived via Akbari-Ganji method and Taylor's series with Ancient Chinese algorithms

R. Umadevi[1], M. Chitra Devi[2], K. Venugopal[1], L. Rajendran[3], Michael E.G. Lyons[4,]*

[1] PG &Research Department of Mathematics, Government Arts College, Kulithalai Affiliated to Bharathidasan University, Tiruchirappali, India
[2] Department of Mathematics, Anna University, University College of Engineering, Dindigul, India.
[3] Department of Mathematics, AMET(Deemed to be university) chennai, Tamilnadu, India
[4] School of Chemistry & AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland
[*] E-mail: melyons@tcd.ie (Mike Lyons)

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Analytical Expression of Concentrations and Current in Enzyme-Based Two-Compartment Model of Amperometric Biosensors for Steady-State Condition

S. Thamizh Suganya[1], L Rajendran[1,], MEG Lyons[2,*]*

[1] Department of Mathematics, AMET Deemed to be University, Kanathur, Chennai-603112.
[2] School of Chemistry & AMBER National Centre, University of Dublin, Trinity College Dublin, Dublin 2, Ireland.
[*]E-mail: raj_sms@rediffmail.com (L.Rajendran); melyons@tcd.ie (MEG Lyons)

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Semi-analytical expressions for the concentrations and effectiveness factor for the three general catalyst shapes

P. Jeyabarathi[1,3] · L. Rajendran[1] · Marwan Abukhaled[2] · M. Kannan[3]

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Cyclic voltammetric response of homogeneous catalysis of electrochemical reactions: Part 1. A theoretical and numerical approach for EE'C scheme

R. Joy Salomi, L. Rajendran *

Department of Mathematics, Academy of Maritime Education and Training (AMET), Deemed to be University, Chennai, India

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ABSTRACT

This paper reports the mathematical modelling of homogeneous redox catalysis of electrochemical reactions for the EE'C scheme. This model is described by the system of nonlinear differential equations for which the nonlinear term is related to homogeneous reaction. The concentration of species and current–voltage curves at a planar electrode has been calculated by solving the nonlinear equations using a simple and new innovative approach which is named as Rajendran-Joy method(RJM). In particular, the limiting current and plateau current is highly sensitive to the solution flow rate and the concentrations of the mediator and substrate employed. The effect of two dimensionless parameters that group the experimental intrinsic and operational parameters on current is discussed. Our analytical results for cyclic voltammetry current are compared with simulation results, and satisfactory agreement is noted. The characteristic of concentration and the current–potential response for the extreme values of parameters are also provided.

Dr. P. Balaganesan, Head,

Department of Mathematics,

AMET Deemed to be University,

#135, East Coast Road, Kanathur-603112,

Chennai, India

Tel.: +91 44 2744 4625 / 627 / 628

Email: **hodmaths@ametuniv.ac.in**

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