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The Korteweg-de Vries–Caudrey–Dodd–Gibbon dynamical model: Its conservation laws, solitons, and complexiton

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ABSTRACT

The main purpose of the present paper is to conduct a detailed and thorough study on the Korteweg-de Vries–Caudrey–Dodd–Gibbon (KdV-CDG) dynamical model. More precisely, after considering the integrable KdV-CDG dynamical model describing certain properties of ocean dynamics, its conservation laws, solitons, and complexiton are respectively derived using the Ibragimov, Kudryashov, and Hirota methods. Several numerical simulations in two and three-dimensional postures are formally given to analyze the effect of nonlinear parameters. It is shown that nonlinear parameters play a key role in the dynamical properties of soliton and complexiton solutions.

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1. Introduction

The search for solitons of nonlinear partial differential equations (NLPDEs) plays a fundamental role in a wide variety of nonlinear sciences, as such a class of solutions is capable of giving helpful information regarding the phenomena under investigation. Researchers have devoted much effort to constructing new methods for obtaining solitons of NLPDEs. Some of the methods that have been able to attract the attention of many researchers are the modified Jacobi method [1–4], the exponential method [5–8], and the Kudryashov methods [9–15]. Nowadays, Kudryashov methods, as pioneer approaches, are frequently used to extract solitons of many NLPDEs. Very newly, Hosseini et al. [16] applied successfully Kudryashov methods to derive solitons of a fifth-order nonlinear water wave equation that are classified as W-shaped and bright solitons.

Today, many researchers deal with Lie groups and conservation laws of NLPDEs [17–22] which play a significant role in the solution process of differential equations. As it turns out, researchers face problems in applying Noether's theorem as Euler–Lagrange equations are not available for all differential equations. To overcome this shortcoming, Ibragimov [23] proposed a new conservation theorem that is based on the formal Lagrangian equation, and conservation laws are related to Lie symmetries. Here are some recent papers on the conservation laws of NLPDEs. Arnous et al. [24] obtained conservation laws of the Chen–Lee–Liu equation using the new conservation theorem. Akbulut et al. [25] employed the new conservation theorem to acquire conservation laws of the (3 + 1)-dimensional Wazwaz–KdV equations.

The main purpose of the present paper is to conduct a detailed and thorough study on the following KdV-CDG model [26–31]

$$u_t + c_1\left(u_{xx} + \frac{1}{5}u^2\right)_x + c_2\left(\frac{1}{15}u^3 + uu_{xx} + u_{xxx}\right)_x = 0, \qquad (1)$$

describing certain properties of ocean dynamics, and obtain its conservation laws, solitons, and complexiton. Eq. (1) as a nonlinear evolutionary equation includes the KdV and CDG equations which have useful applications in nonlinear sciences. Wazwaz [26] utilized Hirota's bilinear method to construct multiple solitons of the KdV-CDG model. Biswas et al. [27] extracted soliton and other solutions of the KdV-CDG model through several effective meth-

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ORIGINAL PAPER

A Detailed Study on a Tumor Model with Delayed Growth of Pro-Tumor Macrophages

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Abstract

This paper investigates a tumor-macrophages interaction model with a discrete-time delay in the growth of pro-tumor M2 macrophages. The steady-state analysis of the governing model is performed around the tumor dominant steady-state and the interior steady-state. It is found that the tumor dominant steady-state is locally asymptotically stable under certain conditions, and the stability of the interior steady-state is affected by the discrete-time delay; as a result, the unstable system experiences a Hopf bifurcation and gets stabilized. Furthermore, the transversality conditions for the existence of Hopf bifurcations are derived. Several graphical representations in two and three-dimensional postures are given to examine the validity of the results provided in the current study.

Keywords Tumor-macrophages interaction · Discrete-time delay · Steady-state analysis · Hopf bifurcation · Numerical resolution

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Original articles

Modelling and analysis of delayed tumour–immune system with hunting T-cells

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Abstract

This study proposes a modified prey–predator-like model consisting of tumour cells, hunting T-cells, and resting T-cells to illustrate tumour–immune interaction by incorporating discrete-time-delay with conversion or growth of hunting cells. For analysis, the proposed system has been transformed into a normalized system, and its non-negativity solution has been verified. The linear stability of the system has been analysed at each equilibrium. The discrete-time delay affects the system's stability, and the system undergoes a Hopf bifurcation. Moreover, the length of time delay for which a periodic solution can be preserved has been derived. Finally, numerical computations have been presented that correlate with analytical results and are also relevant from a biological perspective.
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Keywords: Tumour–immune interaction; Hunting T-cells; Time-delay; Hopf-bifurcation

1. Introduction

Nowadays, researchers are employing mathematical models to investigate how cancer grows under the influence of the immune system [3,7,9–11,14–16,20,29,31,40,43,44], and different treatment strategies [1,2,12,28,41,42,45]. Nevertheless, there has been an increasing interest in the role of the immune system in stopping tumour growth [30]. Cells such as macrophages, natural killer cells, and T-cells help the immune response fight against tumours. Kuznetsov et al. [27] proposed a mathematical model to show how the cytotoxic T-lymphocytes respond when an immunogenic tumour develops. They used a realistic set of parameter values for local and global bifurcations to

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[1] All authors jointly worked on the results and they read and approved the final manuscript.

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A study on cancer-obesity-treatment model with quadratic optimal control approach for better outcomes

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ABSTRACT

In this study, we propose a cancer-obesity-treatment model under the control parameters: IL-2 therapy, ACI therapy, and nutritional diet. We analyze the proposed model and examine the existence and stability of the equilibrium points for the cases: with and without treatment cases. Further, to reduce the number of cancer cells and minimize the toxicity effect of the drug dose on other healthy cells, we consider an optimal control problem over a finite time interval under the treatment control parameters. To understand the treatment effect, we present simulation results for our proposed model considering different treatment strategies: no treatment; only IL-2 therapy; a combination of IL-2 therapy and ACI therapy; and a combination of IL-2 therapy, ACI therapy, and nutritional diet. Our results demonstrate that we could achieve an optimal treatment schedule for cancer management by controlling all three treatment parameters.

1. Introduction

A tumor originates from any part of the body via abnormal growth of a single cell. It has a spreading tendency. Depending upon its spreading tendency, a tumor can be classified as benign (having no spreading tendency and not cancerous), premalignant (having the potential to become cancerous), and malignant (having rapid and uncontrolled spreading tendency and cancerous) [1,2]. Worldwide, millions of people die from cancer every year, and trends indicate that millions more will die from this disease. Therefore, scientific research (both clinical and theoretical) on cancer is crucial for the research community. The theoretical study of cancer through mathematical modeling is a valuable approach to shaping our understanding of tumor-immune dynamics. Significant research work [3–5] has been done to understand the tumor-immune dynamics.

Researching a suitable cancer treatment method is a broad research area in medical science. Chemotherapy [6], radiotherapy [7], and virotherapy [8] are widely used in the cancer eradication process. Immunotherapy is gaining more interest in cancer treatment as it has fewer side effects than other methods. The two types of immunotherapy are: one is passive (such as ACI and CAR-T cell therapy), where the external input of the immune system is used to attack tumor cells directly, and the other is active, where the external input enhances the immune system (such as IL-2 therapy, vaccine therapy) [9–11]. Moreover, scientific studies have reported that vitamin intervention and nutritional diet are also responsible for suppressing cancer formation [12,13]. Researchers claim that with the combination of various therapeutic approaches, cancer can be eradicated from the body optimally [14]. Mathematical modeling is making a significant contribution to the treatment of cancer. The reviewed work of Malinzi et al. [15] discussed some mathematical models related to different cancer treatment methods. de Pillis et al. [16] presented a mathematical

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A STUDY ON A GENE THERAPY MODEL FOR THE COMBINED TREATMENT OF CANCER

Dehingia K., Sarmah H. K., Das A., Park C., Hosseini K.

Abstract This paper addresses a gene therapy model under different cancer treatment combinations, considering effector cell and cancer cell populations. A gene therapy model has been modified by introducing radiotherapy and mAb drug treatment, respectively. The qualitative behaviour of the model under gene therapy, radio-genic therapy, and mAb-gene therapy is examined at each of the equilibrium points of the model. Analytical findings have been verified numerically. In addition, the system's dynamics have been investigated for different values of the treatment parameters. Our results reveal that the optimum level of immunotherapy can eradicate cancer cells from the body for the gene therapy model. Besides these findings, we have also found that combining radiotherapy, immunotherapy, and gene therapy could be a better cancer treatment strategy. For mAb-gene therapy, two scenarios have been presented in which the applied treatment can suppress cancer growth to zero.

Key words: mathematical modelling, cancer treatment, gene therapy, immunotherapy, radiotherapy, monoclonal antibody therapy (mAb), stability.

AMS Mathematics Subject Classification: 37M05, 37M10, 37N25, 92B05.

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1 Introduction

Cancer is caused by malignant tumours, which are uncontrollable growths of abnormal cells. In the initial stage, a tumour is not so dangerous; it becomes so when it invades other tissues and gains the ability to spread rapidly within the body. In the early 1990s, researchers developed mathematical models to explore the complex phenomenon of tumour-immune dynamics [1, 2, 4, 3]. Also, a few works [5, 6, 7, 8, 9] were carried out to observe the effect of different treatment procedures on tumour-immune dynamics. During this time, surgery, radiotherapy, chemotherapy, and immunotherapy were the primary treatment methods for cancer management. However, effective treatment depends on many factors, such as the tumour's response to the treatment, the stage and location of the tumour, the patient's immune response to the applied treatment, etc. So, combining two or more treatments has gained more interest in searching for effective cancer treatment. The current study separately represents a gene therapy model under radiotherapy and mAb therapy.

The prime aspect of surgery for cancer treatment is to remove the tumour physically through an operating procedure. In radiation treatment, an ionizing agent kills

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On the dynamics of soliton waves in a generalized nonlinear Schrödinger equation

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ABSTRACT

The main objective of the present paper is to investigate the dynamics of soliton waves in a generalized nonlinear Schrödinger (GNLS) equation. To achieve such a goal, the real and imaginary portions of the GNLS equation are first extracted using a complex wave transformation. Solitons and Jacobi elliptic structures of the governing model, describing the propagation of femtosecond pulses in nonlinear optical fibers, are then constructed through applying the modified Jacobi elliptic expansion method (MJEEM). In the end, by employing a series of 2 and 3D-dimensional numerical representations, it is exposed that the width of bright and dark solitons respectively decreases and increases, while the amplitude of both waves decreases with the increase of nonlinear parameters.

1. Introduction

As it is clear to all, solitons play a crucial role in diverse areas of scientific disciplines such as plasma physics, quantum electronics, and nonlinear optics, as they are valuable tools to understand the dynamics of nonlinear phenomena modeled by nonlinear partial differential (NLPD) equations. The nonlinear Schrödinger equation

$$iu_t + \frac{1}{2}u_{xx} + |u|^2 u = 0,$$

is an example of NLPD equations that is used to describe picosecond duration pulses in optical fibers [1]. As pulse duration diminishes, the results of the NLS equation are not reliable, and so the NLS equation must be generalized [1]. To this end, based on a multiple-scale perturbation calculation, Kodama [2] proposed a generalized nonlinear Schrödinger equation as follows

$$iu_t + u_{xx} + |u|^2 u + i\alpha\left(u_{xxx} + \beta_1|u|^2 u_x + \beta_2 u^2 u_x^*\right) = 0, \tag{1}$$

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An optimally controlled chemotherapy treatment for cancer eradication

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ABSTRACT

In the present study, we developed a modified immune-tumor-normal cell model, considering Lotka-Volterra-type competitions between the cell populations and the chemotherapy drugs. The local stability of the model has been examined at each equilibrium point. Also, the global stability of the model at tumor-free equilibrium has been looked at, and a range of drug administration rates has been found for which the tumor-free state is asymptotically stable globally. Also, the growth of tumor cells was kept to a minimum by setting up an optimal control policy for how drugs are given. We found that the optimal control strategy helped eliminate tumor cells with fewer adverse side effects because it kept the number of normal and immune cells high. The optimal control strategy also reduces the time needed for the treatment strategy. Finally, numerical simulations are performed to verify some of our theoretical results.

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1. Introduction

A tumor is created by the abnormal proliferation of cells, which may be classified broadly into two types: benign and malignant. Benign tumors are non-cancerous in nature and remain localized in the region where they originate. A tumor becomes cancerous when it is malignant in nature. Cancer is a disease in which some of the body's cells grow uncontrollably and spread to other parts. Cancer cells can spread to other body parts through the blood and lymphatic systems. During the last several decades, cancer has been the leading cause of death among human beings [1].

The rapid proliferation of cells and tumors is not yet precise. The growth of tumor cells is a highly complex process that involves genes, the environment, radiation, viruses, the use of tobacco and alcohol, and many other things. In many cases, mainly when vital organs are attacked, or the disease is detected after a prolonged duration, cancer becomes an incurable disease which generally becomes fatal [2]. Treatment methods in response to the tumor depend upon many factors, including the severity of the tumor, location of the tumor, patient's immune response, etc.

Chemotherapy is a treatment method that uses powerful chemical drugs to kill rapidly growing malignant cells. Chemical drugs are absorbed into the bloodstream and transported to different body parts. So, chemotherapy is usually recommended for people with cancer that has already spread to other parts of the body or for people with tumors that can't be removed by surgery because of where they are. In addition, chemotherapy is used when a patient gets sick again after surgery or for radiation therapy for the first time. Chemotherapy has more potential to kill cancer cells directly and can control cancer growth or eliminate pain symptoms [3]. At the same time, chemotherapy has the drawback of killing all cells, including normal and immune cells, apart from the cancerous cells for which the therapy is intended. As a result, the patient's immune response drops alarmingly when chemotherapy drugs are used in a higher amount, making the patient susceptible to other opportunistic diseases. So, an optimally controlled chemotherapy treatment is needed for a better treatment strategy. Control theory is concerned with verifying whether the evolution of system is controllable, i.e. whether the evolution can be influenced or controlled by some external agent, called 'control'. Optimal control theory deals with finding a 'control' for the system over a period of time such that the performance criterion is optimized. Mathematically, chemotherapy dose applied for treatment of cancer can be formulated as an optimal control problem. In literature, applications of optimal control theory to mathematical models of cancer biology and role of chemotherapy began to appear in the 1980s and this continued with regularity in the subsequent years to present day [4].

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Dynamical Behavior of a Fractional Order Model for Within-Host SARS-CoV-2

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Abstract: The prime objective of the current study is to propose a novel mathematical framework under the fractional-order derivative, which describes the complex within-host behavior of SARS-CoV-2 by taking into account the effects of memory and carrier. To do this, we formulate a mathematical model of SARS-CoV-2 under the Caputo fractional-order derivative. We derived the conditions for the existence of equilibria of the model and computed the basic reproduction number $\mathcal{R}_0$. We used mathematical analysis to establish the proposed model's local and global stability results. Some numerical resolutions of our theoretical results are presented. The main result of this study is that as the fractional derivative order increases, the approach of the solution to the equilibrium points becomes faster. It is also observed that the value of $\mathcal{R}_0$ increases as the value of β and π_θ increases.

Keywords: SARS-CoV-2; fractional order; local stability; global stability; basic reproduction number

MSC: 37M05; 37M10; 37N25; 92B05

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1. Introduction

In December 2019, coronavirus disease 2019 (COVID-19), which began in Wuhan, China, was classified as a global pandemic. Since then, it has rapidly spread throughout the world, becoming the most pressing public health crisis and affecting millions of people [1]. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is responsible for this disease. SARS-CoV-2 is a single-stranded RNA virus with a positive-sense single-stranded RNA (+ssRNA) genome. SARS-CoV-2 is one of the viruses that belongs to the Coronaviridae family and the Nidovirales order [2]. In addition, SARS-CoV-2 belongs to the Beta coronavirus family, which includes two additional extremely deadly viruses, SARS-CoV and MERS-CoV [3]. COVID-19's infection dynamics are complicated by several factors, including uncertainty about the source of the infection, a long period of incubation during which an infected individual may not develop symptoms or be aware of their infection, and the inefficiency and lack of availability of drugs or vaccines. All of these factors contribute to the rapid spread of COVID-19, complicating disease control [4].

Mathematical modeling of diseases is a new research area in mathematical biology. Researchers have used mathematical modeling to observe the dynamics of disease spread in populations and the within-host dynamics in the body to control and manage disease

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A new generalized KdV equation: Its lump-type, complexiton and soliton solutions

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A new generalized KdV equation, describing the motions of long waves in shallow water under the gravity field, is considered in this paper. By adopting a series of well-organized methods, the Bäcklund transformation, the bilinear form and diverse wave structures of the governing model are formally extracted. The exact solutions listed in this paper are categorized as lump-type, complexiton, and soliton solutions. To exhibit the physical

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Influence of Various Silyl Protecting Groups on Stereoselective 2-Deoxyrhamnosylation

Ananya Mukherji, Mahendra K. V. Rotta, Bikash K. Sarmah, and Pavan K. Kancharla*

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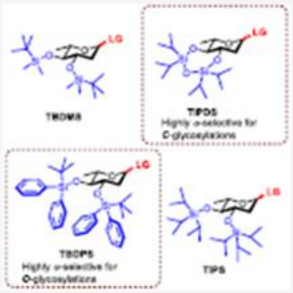
ABSTRACT: The influence of various silyl protecting groups on 2-deoxyrhamnosylation using 2-deoxyrhamnosyl acetates, thioglycosides, and (*p*-methoxyphenyl)vinylbenzoate (PMPVB) donors has been presented. *C*-Glycosylation reactions reveal that *tert*-butyldimethylsilyl (TBDMS), triisopropylsilyl (TIPS), and *tert*-butyldiphenylsilyl (TBDPS) silyl protected rhamnosyl oxocarbenium ions have no facial selectivity except for the conformationally ($^4H_3$) locked tetraisopropyldisiloxane (TIPDS) protected rhamnose donor, which provides complete α-selectivity. However, TBDPS protected rhamnosyl donors are found to be superior protecting groups for α-stereoselective *O*-glycosylation reactions with various acceptors. The observed results are found consistent across donors and donor activation conditions. Most importantly, the study was conducted at room temperature unlike the other energy-intensive low-temperature studies and was bound to have more practical utility. The outcomes have been explained using kinetic and thermodynamic analyses.



INTRODUCTION

2-Deoxy and 2,6-dideoxyhexoses are an important class of glycosides due to their presence in a wide range of natural products ranging from antibiotics to anticancer agents and in biologically active glycoconjugates.[1−3] These glycosides are more challenging to synthesize stereoselectively than their fully oxygenated analogues. The absence of any stereodirecting group adjacent to the anomeric center makes it difficult to form the glycosidic linkage in a stereoselective fashion and results in a mixture of anomers.[4−6] There are limited studies done on glycosylation of silyl protected 2,6-dideoxysugars.[7] Owing to the presence of 2-deoxyrhamnosides in natural products like mithramycin and landomycin families,[8] research efforts in achieving their stereoselective synthesis have increased in recent years. The fact that protecting groups play a significant role in carbohydrate reactivity[9] makes it more interesting for us to study the influence of the underexplored acid-labile silyl protecting groups on glycosylation with L-rhamnose-based sugar donors. Silyl protecting groups that are usually sterically hindered restrict access to several possible conformations and generally provide improved anomeric selectivity.[10] However, a comparative study on the stereoselective glycosylation of various silyl protected donors particularly for the synthesis of 2,6-dideoxy glycosides has not been reported and is highly desirable.

The tuning effect of various silyl protecting groups has been studied earlier on C2-benzoyl protected arabinofuranosyl donors by Yang and co-workers.[11] The group found the intriguing torsional strain imposed by the 3,5-*O*-di-*tert*-butylsilyl protecting group that presumably destabilizes the formation of the arabinofuranosyl oxocarbenium ion and hence decreases the reactivity of the corresponding thioglycoside donors. 2,6-Dideoxysugars are inherently more reactive than the corresponding 2,6-di-oxy counterparts. Furanosyl oxocarbenium ions are generally perceived to be relatively more stable or long-lived than the pyranosyl oxocarbenium ions and hence generally lead to less selective coupling reactions. Similar to furanoses, and unlike the fully oxygenated pyranoses, part of the high reactivity of 2,6-dideoxy donors could be attributed to the increased stability of the oxocarbenium ions. The absence of two electron-withdrawing oxygen atoms in the ring could decrease the destabilizing effect, which means the mechanism of glycosylation reactions of 2,6-dideoxysugars may proceed via dissociative mechanisms (S_N1). It is widely accepted that the mechanism of glycosylation is very complex and is controlled by several factors and is generally perceived to be somewhere in between the two extreme ends of the S_N1 and S_N2 continuum, depending on the protecting groups, solvent, temperature, and reactivity of the acceptor as well.[12] On the other hand, increasingly found pieces of evidence suggest the *O*-glycosylation reactions follow more associative mechanisms than dissociative ones.[13] However, most of the studies to understand the mechanistic aspects were carried out on the 2-oxysugars, and the corresponding 2-deoxy or 2,6-dideoxysugars were underexplored. The mechanism involved in the case of

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SPECIAL ARTICLE

Polity, Policy, and the Economy of Salt in Manipur circa 1826–1947

PARANAN KONWAR

While the traditional production of spherical flat salt chunks through the evaporation of saline water from salt wells dates back to the ancient history of Manipur, notions of salt monopolies and salt as a revenue source evolved during the colonial period in Manipur. The British became involved in local politics and took control of the fiscal policy of the state. Under them, the quantum of salt produced reduced, and salt production itself became more expensive. This paper studies how British business practices, and, later on, an uninterested state government, caused the self-reliant salt economy to become a dependent one.

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The traditional production of circular, flat salt chunks dates back to the ancient history of Manipur. Saline water from salt wells was evaporated to manufacture spherical salt slabs. Some salt was kept for domestic consumption, and the remainder, surplus amount was sold in local markets.

In Manipur, salt was scarce but a necessity. It had a high barter rate and so was a highly valued commodity. It is still used for medicinal purposes and for social and religious occasions. In addition to agricultural land and royal cloths, a salt cake was one of the three honourable gifts or rewards that the king of Manipur offered a person for their distinguished performance. Traditionally, menstruating women and royal family members were barred from visiting salt wells as it was considered unlucky. So, kings always sent their subordinate officials and nobles to the salt wells (Haokip 2019: 248, 250).

Information about salt wells in the precolonial period can primarily be found in the *Cheitharon Kumpapa*,[1] a court chronicle of the kings of Manipur. It mentions a guru who dug salt wells, superstitious beliefs about salt wells, gifts of salt cakes or lands with salt wells presented by the king, the location of salt wells, etc. In the colonial period, details on manufacturing methods, production, revenue, and state policies on salt can be found in British reports and diaries that became available after the Yandabo Treaty of 1826. In these records, the valley salt wells were documented than those located in the hills, for reasons that will be explained further in this paper.

The Political History of the Salt Economy

The economy of a nation state revolves around its internal and external political affairs. The concept of salt monopolies, and of salt as a prime source of revenue for the state treasury, evolved during colonial times. Political unrest, internal quarrels in the royal family, and foreign hostility provided the British with the opportunity to take over and control Manipur's salt economy. Therefore, it is necessary to understand the political background of the salt economy during the colonial period. The history of Manipur can be traced back to around 33 CE with the ascension of Nongda Lairen Pakhangba, the founder and first ruler of Manipur. The indirect rule of the British in Manipur started partially with the first Anglo–Burmese War (1824–26) and worsened in 1835 with the first appointment of the political agent. It reached its height after the Palace Revolution of 1890, which broke out as a result of the dissension, mistrust, and rivalry among the princes. Manipur was completely subordinated under the British as per the

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The Female Voice and Mode[illegible]mancipation in Anita *Desai's Clear [illegible] of Day*

★ Dr. Anita Konwar

Abstract:

Society at large determines specific roles to girls and boys that leads to gender differentiation. On the basis of this differentiation society set certain behavioural norms for girls and boys, men and women. A society determines appropriate gender roles on the basis of its beliefs and customs related to the differences between the sexes. The gender difference theorists hold the view that the differences between men and women should not be a cause of discrimination. In order to acknowledge women's work, their distinctive contributions at home as well as in the workplace must be appreciated. Though Anita Desai herself ignores her link with the western feminist trend of writing, her novels are studied from feminist point of view as they deal with the problems faced by women in different fields and the possible modes of women empowerment through education and economic independence. The present paper is an attempt to discuss the female voice and modes of emancipation in Clear Light of Day, one of the major novels of Anita Desai. The methodology applied in the paper is analytical method. For the present study, both primary and secondary sources have been used along with various library resources and internet materials.

Keywords: Gender, Emancipation, Discrimination, Feminist, Education

Introduction:

Society at large determines specific roles to girls and boys that leads to gender differentiation. On the basis of this differentiation society set certain behavioural norms for girls and boys, men and women. Gender influences the perceptions of human beings and plays an important role in distribution of power and resources in society. The interactions between individuals and environment lead to gender roles and individuals receive hints about appropriate behavior suitable for both men and women. A society determines appropriate gender roles on the basis of its beliefs and customs related to the differences between the sexes. The gender difference theorists hold the view that the differences between men and women should not be a cause of discrimination. In order to acknowledge women's work, their distinctive contributions at home as well as in the workplace must be appreciated. Though Anita Desai herself ignores her link with the western feminist trend of writing, her novels are studied from feminist point of view as they deal with the problems faced by women in different fields and the possible modes of women empowerment through education and economic independence. The traditional patriarchal set-up at domestic as well as social level crushes the very selfhood of woman. The emancipation of women is not possible until they are aware of their own potentialities. Proper education and economic independence can pave the way for a new horizon where women can lead a meaningful life. The female protagonist in *Clear Light of Day* empowers herself through education and economic independence, she is aware of her individual selfhood and rights against the traditional patriarchal social system.

Objective and Methodology:

The present paper is an attempt to discuss the female voice and modes of emancipation in *Clear Light of Day*, one of the major novels of Anita Desai. The methodology applied in the paper is analytical method. For the present study, both primary and secondary sources have been used along with various library resources and internet materials.

Discussion:

The women characters of Anita Desai's novels dare to go against the current flow of life and question the so-called conventions of society that entrap them. They represent the voice of thousands of women who lose their voice in the shackles of femininity. Simone de Beauvoir puts forward her arguments in the book, *The Second Sex*:

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Entomological Research (2021) •• ••

RESEARCH PAPER

Lipoxygenase - trypsin inhibitor activity axis induction in the host plants of muga silkworm, *Antheraea assamensis* Helfer by feeding

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Abstract

The muga silkworm, *Antheraea assamensis* Helfer bears great economic importance, producing golden yellow muga silk which is in global demand for both the textile and biomedical industries. The insect's larval stages are maintained in the field by farmers on its primary host plant *Persea bombycina* Kost in Assam located in the North-East part (25.57 ° N, 93.25 ° E) of India. If continuous feeding by *A. assamensis* is inducing any direct defense in *P. bombycina*, the aspect is not yet questioned. We used the activity of lipoxygenases (LOX) and trypsin inhibitors as markers for determining defense responses in *P. bombycina* and *Litsea monopetala* Roxb, the two primary host plants of the silkworm due to insect feeding. The induction of anti-herbivore trypsin inhibitor by insect feeding was examined by studying their effect on the midgut trypsin activity of *A. assamensis* larvae. This is the first report showing that the LOX- trypsin inhibitor axis is differentially activated in the two host plants and greater induction of the defense response is exhibited in *P. bombycina*, the most commercially used host plant in muga silkworm rearing.

Key words: Feeding induced defense, LOX-trypsin inhibitor, muga silkworms

Introduction

Antheraea assamensis Helfer has great economic importance, producing golden yellow muga silk which is in global demand for both the textile and biomedical industries. The insect is cultured in a semi-domesticated way. The larval stages are maintained on host plants in outdoor fields. *A. assamensis* is endemic to the north-east part (25.57 ° N, 93.25 ° E) of India and is raised largely on its primary host plant, *Persea bombycina* Kost. The insect uses its gustatory sensilla for host plant preference (Bora *et al.* 2015, 2016). Upon herbivory, the plants may activate their defense response pathways. Literature reveals that a specialist herbivore generally wins the evolutionary arms race (Jongsma & Bolter 1997; Mello & Silva-Filho 2002) and can substantially damage plants. *A. assamensis* is oligophagous as it prefers plants in the Lauraceae family and occupies a position between a generalist (polyphagous) and a specialist (monophagous). Neither the host plant nor *A. assamensis* is reported to be even involved in any arms race. But if the race has been on, the host plants might have been producing defensive factors antagonistic to *A. assamensis*. The very question of the possibility of defense induction in the popular host plant is raised in the present work from a popular belief among the muga farmers of the state of Assam (26.20 ° N, 92.94 ° E) located in North East India. The authors noted, during personal interactions with the local silk growers of Assam, that they invariably reported about unsuccessful rearing and greater loss of cocoon production if they used the same host plants consecutively for several generations. The muga silk worm growers carry the seeds produced in one area of Assam to another area for producing the next generation of the silkworms and never go for continuous production of several generations in the same area. It is well

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Optimal control of combined antiretroviral therapies in an HIV infection model with cure rate and fusion effect

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This paper mainly targets to deduce an optimal treatment strategy for combined antiretroviral drugs, which can maximize healthy $CD4^+$ T cells level with minimum side effects and cost. For this purpose, we consider a within-host treatment model for the HIV infection with two controls incorporating full logistic proliferation of healthy $CD4^+$ T cells, cure rate and fusion effect. These two controls represent the effects of reverse transcriptase inhibitors (RTIs) and protease inhibitors (PIs), respectively. The model analysis begins with proving different basic properties like non-negativity, boundedness of the model solutions and calculation of the basic reproduction number of the model under consideration. Then, stability results are obtained for HIV infection-free equilibrium point and also, a critical efficacy for the combined therapies is calculated. After that, the optimal control problem is proposed and solved numerically using a forward–backward iterative method. Finally, we obtain an optimal treatment strategy that can maximize healthy $CD4^+$ T cells count and control the viral load, and HIV-infected

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Original articles

Combination of virotherapy and chemotherapy with optimal control for combating cancer

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Abstract

The purpose of this paper is to study the behaviors shown by a modified mathematical model representing interactions between immune cells, un-infected tumor cells, infected tumor cells, and normal cells when subjected initially to chemotherapy and virotherapy alone and subsequently a combination of both. Stability analysis is carried out for all steady states in each treatment model. Conditions are derived under which recurrence of tumors can be prevented when the amount of applied drugs are reduced. Analysis of the model shows that the tumor can be eliminated with a lower dose of chemotherapy if it is combined with virotherapy. The existence of an optimal control set, and optimality of the model are discussed. The optimal control problem relative to the model is designed in a way to reduce the number of tumor cells and the amount of chemotherapeutic drugs and at the same time to increase the positive effect of virotherapy to improve the immune system, thereby causing a reduction in patient's recovery time.
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Keywords: Immune response; Chemotherapy; Virus therapy; Chemo-virotherapy; Stability analysis; Optimal control

1. Introduction

Cancer is one of the most feared and persistent killer diseases. Cancer can develop in almost any organ or tissue of the body. In the case of cancer patients, abnormal cells grow uncontrollably, exceeding their normal limits, and these abnormal cells invade adjoining parts of the body and thus spread to other organs [22]. According to the 2018 report of WHO [6], 18.1 million people worldwide had cancer, 9.6 million died. By 2040, those figures will be almost doubled [6]. Cancer treatment is, therefore, still a significant field of research. Surgery, chemotherapy, and radiation therapy are traditional methods adopted for cancer treatment. Nevertheless, the major drawback of these therapies is that they involve a high level of toxicity. To overcome this drawback, nowadays, immunotherapy, virotherapy, etc., are used along with chemotherapy. Immunotherapy, which uses genetically engineered cytokines, is used to boost up the immune system. The fundamental goal of virotherapy treatment is selective damage of cancerous cells with virus infection while leaving normal cells undamaged. Virotherapy can replicate viruses within

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Advances in Continuous and Discrete Models

RESEARCH Open Access

Analysis of a delay-induced mathematical model of cancer

Anusmita Das[1], Kaushik Dehingia[1], Hemanta Kumar Sarmah[1], Kamyar Hosseini[2*], Khadijeh Sadri[2*] and Soheil Salahshour[3]

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Abstract

In this paper, the dynamical behavior of a mathematical model of cancer including tumor cells, immune cells, and normal cells is investigated when a delay term is induced. Though the model was originally proposed by De Pillis et al. (Math. Comput. Model. 37:1221–1244, 2003), to make the model more realistic, we have added a delay term into the model, and it has incorporated novelty in our present work. The stability of existing equilibrium points in the delay-induced system is studied in detail. Global stability conditions of the tumor-free equilibrium point have been found. It is shown that due to this delay effect, the coexisting equilibrium point may lose its stability through a Hopf bifurcation. The implicit function theorem is applied to characterize a complex function in a neighborhood of delay terms. Additionally, the presence of Hopf bifurcation is demonstrated when the transversality conditions are satisfied. The length of delay for which the solutions preserve the stability of the limit cycle is estimated. Finally, through a series of numerical simulations, the theoretical results are formally examined.

Keywords: Mathematical model of cancer; Stability analysis; Global stability analysis; Hopf bifurcation; Implicit function theorem

1 Introduction

Cancer is one of the most difficult diseases to treat and is considered one of the leading causes of death. Fighting cancer is important for public health. For this and other economic reasons, extensive research is going on to understand the mechanism involved in the growth of cancer and to predict the impact of this growth on the system [2].

Mathematical modelling is very important in epidemiology because it can provide insight into the key mechanisms that contribute to the spread of disease and suggest control strategies [3]. It is possible to describe a specific disease with mathematical models of differential equations by considering the most important factors which are assumed to be responsible for it and then derive useful information by solving the equations of the model with suitable techniques. Researchers are using mathematical modelling for different diseases like Covid, mumps, rabies, etc., to name a few. Interested readers are referred to the recent works [4–7].

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NONLINEAR PHYSICS AND MECHANICS

MSC 2010: 34K99, 35C08

A Study of Different Wave Structures of the $(2+1)$-dimensional Chiral Schrödinger Equation

K. Hosseini, M. Mirzazadeh, K. Dehingia, A. Das, S. Salahshour

In the present paper, the authors are interested in studying a famous nonlinear PDE referred to as the $(2+1)$-dimensional chiral Schrödinger (2D-CS) equation with applications in mathematical physics. In this respect, the real and imaginary portions of the 2D-CS equation are firstly derived through a traveling wave transformation. Different wave structures of the 2D-CS equation, classified as bright and dark solitons, are then retrieved using the modified Kudryashov (MK) method and the symbolic computation package. In the end, the dynamics of soliton solutions is investigated formally by representing a series of 3D-plots.

Keywords: $(2+1)$-dimensional chiral Schrödinger equation, traveling wave transformation, modified Kudryashov method, different wave structures

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Catalytic stereoselective synthesis of 2-deoxy α-glycosides using glycosyl *ortho*-[1-(*p*-MeOPhenyl)Vinyl]Benzoate (PMPVB) donors†

Suvendu Halder, Rupa Bai Addanki, Bikash K. Sarmah and Pavan K. Kancharla *

2-Deoxy glycosyl *ortho*-[1-(*p*-MeOPhenyl)Vinyl]Benzoates (PMPVB) have been presented as stable, reactive glycosyl donors for the synthesis of 2-deoxy α-glycosides. The donors react under Brønsted acid conditions to provide the 2-deoxy-α-glycosides with very high stereocontrol. The observed high stereoselectivities were discussed with respect to the relative free energy differences between the anomeric reactive intermediates.

The 2-deoxysugars form a part of many bioactive natural products[1] and have been found to play important roles in many biological activities.[2] Consequently, the synthesis of this class of compounds has received significant attention from organic chemists in recent times.[3–5] Unusual challenges associated with the stereoselective synthesis of both 2-deoxy α- and β-glycosides include (a) the general 2-deoxy donors like the glycosyl acetimidates are very reactive, unstable and are difficult to handle, (b) lack of any functionality at C-2 that can be manipulated to control the anomeric stereochemistry makes the stereoselective construction of 2-deoxysugars, a challenging task, and (c) the formation of Ferrier byproducts. A number of direct methods are available for the synthesis of 2-deoxyglycosides based on glycosyl halides,[6–8] phosphites,[9,10] acetimidates,[11] hemiacetals,[12–14] and thioglycosides (Fig. 1).[15] However, a majority of them rely on extremely low temperatures due to the high reactivity and instability of the 2-deoxy donors or on the protecting groups to control the stereoselectivities. Other indirect methods use a stereodirecting auxiliary at C-2 that needs extra steps for the installation and removal of the same.[16,17] Recently, there has been an upsurge in the development of glycal activation methods for the α-selective synthesis of 2-deoxyglycosides; however, a majority of them are not compatible with less reactive acetyl/benzoyl substrates,[18–21] or use metal catalysts[22–26] that are prone to provide the undesired Ferrier byproducts.[27,28] Notwithstanding the numerous efforts, a general catalytic user-friendly method for the stereoselective construction of the 2-deoxyglycosidic bond remains a challenge. We present here 2-deoxy *ortho*-[1-(*p*-MeOPhenyl)Vinyl]Benzoates (PMPVB) donors as stable and reactive glycosyl donors for a protecting group independent stereoselective synthesis of α-2-deoxyglycosides under simple Brønsted acid catalysis. These alkene donors by virtue of their rigidity and 1,1-diphenyl substitutions[29,30] along with a *p*-methoxy group can easily react with not only strong electrophilic reagents like NIS but also can be activated under simple Brønsted acidic conditions. The ability of these donors to react with Brønsted acid makes them the first Fraser-Reid type alkene donors[31,32] that can be catalytically activated. Along with stability and reactivity, PMPVB donors allow the construction of the 2-deoxy *O*-glycosidic linkage in a highly stereoselective fashion. Here, we discuss the synthesis, reactivity, and mechanistic aspects of the glycosylation reactions. 2-Deoxy PMPVB donors are readily prepared by DCC coupling of the corresponding acid with 2-deoxy hemiacetals in excellent yields. 2-Deoxyglucose and 2-deoxygalactose donors with various protecting groups have been made, as shown in Scheme 1. All the donors with various protecting groups have been obtained as a mixture of isomers

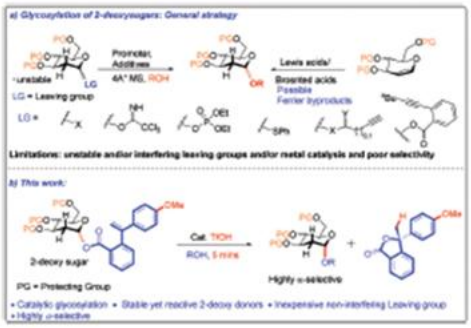

Fig. 1 a) Previous work. b) This work.

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Mir Jumla's Invasion of Assam (1662–63), War Experience of a Dutch Sailor Heiden and Translator Glanius

Paranan Konwar[1]

Abstract

Frans Jansz van der Heiden (1638–81), a Dutch East India Company sailor, accompanied the expedition of Mir Jumla to Assam (1662–63) during the reign of sixth Mughal emperor Aurangzeb (1658–1707) and Sūa-taam-laa (1648–63), king of the Ahom kingdom in Assam. Heiden was the eyewitness of the war, history, topography and culture of then Assam. Many historians mentioned that it was W. Glanius who came along with Mir Jumla. But by evidence, W. Glanius was the English translator of the travel account authored by Heiden who was actually a conscripted sailor and accompanied Mir Jumla's expedition to Assam. Heiden visited Northeast India, such as, Bengal, Assam and the adjacent areas. It was a sensational narrative of his journey, filled with hallucination, shipwreck, experience in a desert island, hunger, cannibalism, bad luck, warfare of the Mughal army and Ahom, culture, customs, society, religion, knowledge of a new land and people. In his travelogue, we found much information on gold, elephants, the nature of Assamese people, beliefs in cows, the capital (Gargaon) of the Ahom kingdom, a tribe as a man-eater, plundering of grave (*maidam*), tradition of burial system of Ahom kings and nobles and so on.

Keywords

Heiden, Glanius, Mir Jumla, Assam

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