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THE APPLICATION OF GIS (GEOGRAPHIC INFORMATION SYSTEMS) IN DIGITAL LIBRARY MANAGEMENT AND SERVICES

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ABSTRACT

The era of global technology, the tremendous growth in literature available in both digital and print formats, has provided an all-encompassing platform for research on a global scale. The implementation and utilization of GIS (Geographic Information Systems) within libraries and digital information centers have emerged as a significant area of research. This research paper highlights the practical definition and fundamental architecture of GIS. The author has conducted a comprehensive review of existing literature regarding the various fields of application for GIS within libraries in the current context. The paper explores how GIS technology enables libraries to effectively process, systematically store, and analyze available geographic data, and how this precise data facilitates the provision of enhanced library information services to library members. Furthermore, the challenges associated with the implementation of GIS have also been duly addressed. The advent of GIS technology, driven by the rapid expansion of information, introduces a new dimension that makes its effective application within libraries not only feasible but also highly appropriate, thereby ensuring the efficient and rapid delivery of information.

KEYWORDS

GIS (Geographic Information System), Geospatial Data, Library Services, Collection Management, Library Management

INTRODUCTION

The GIS system is a great medium of all-in-one technology. Using this system, information about a particular place is provided efficiently and quickly. By integrating the information, accurate understanding of the current situation, adjustment, current status is shown. Due to this, GIS technology is widely used for survey planning of future geographical problems, weather, natural calamities. "A map speaks more than a thousand words." Pictures and maps are more effective and powerful communication tools than text and charts (Chudasama, P. & Shastri, Devashree 2013). The

use of GIS technology and various digital software in the library department should be open to all. This research article discusses the role of GIS in the library department, how it can be suitable for the professional user. Library is considered as a great source of knowledge and using the latest system in the library department will help the research students to reach their conclusions.

OBJECTIVES

1. To explain and analyze the basic concepts of GIS technology.
2. To review the GIS system in the library department and explain its future availability.
3. To identify the technical challenges associated with the application of GIS for library professionals.
4. To develop a library department approach to GIS system.

OBJECTIVES

Definition and basic infrastructure of GIS:

Globally In the early 1960s, the term 'Geographic Information System' was coined by Tomlinson, who was the head of the Canadian Geographic Information System Institute. The development of GIS is based on the satellite-based Global Positioning System (GPS). GPS uses radio signals from satellites to determine precise geographic location and time, determining a location in real time or in post-processing mode. GIS technology has emerged from global geospatial weather, ecosystem geography, remote sensing, mapping, space technology, digital spatial, computer-aided design (CAD), surveying, and photogrammetry. The main terms associated with GIS are spatial data, geographic coordinates data. (point system of a location, line term, area record) Coordinating features of significant geographic location and structure are the main functions of GIS. Collecting information related to a specific geographic feature. According to Duker (1979), GIS is a special type of information systems where the database contains observations based on spatially distributed features, activities or events, which can be defined in space as leaps, lines or areas. GIS data about points, lines and areas are represented by precise lines and latitudes, making it easy to get precise information about the location on the earth's surface. It benefits research students as well as geospatial information seekers. GIS software is a system that is very easy to use. The main function of this system is to collect, store, list, locate and visualize data. These systems can mainly help library professionals manage location details of library documents, users and suppliers.

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Figure 1: OPEN SOURCE GIS

Areas of Application of GIS in Libraries and Information Centres:

1. Collection Management of Library Documents:

According to Dr. S. R. Ranganathan's fifth law of library and information science, library is a growing institution i.e. updated new books, reading materials are added to the library every year to enrich the library collection.by implementing a subject-wise classification scheme in the library, many resources on the same subject are brought together in one place (on the shelf). This design can make finding a particular book from the shelf a time-consuming process for users. With the help of GIS software, information can be obtained by determining the location and location of various floor maps of the library building.

2. Studying library users based on local data (especially in the context of public libraries) and mapping book distributors/suppliers:

GIS systems can be successfully implemented in libraries. Network positioning can be useful depending on the location of library users, as this system allows the local library to predict the readership and balance the demand and supply of books accordingly.

3. To design a library building:

With the help of GIS, the library building can be studied according to the equipment, width, weather, wind speed, direction of light.Information on resource sources, furniture, various attractive, cupboard design information can be studied at different places of the library.

It can be helpful to decide on redesigning library reading room, current paper reading room, as well as increasing or decreasing library furniture.Pournaghi, R. (2015) studied space use by library users in the Central Library of Tehran University through ArcGIS software. Analyzed the data and displayed floor maps of the library which would help in space utilization assessment.

4. Management of Map Collection:

Geographical map collections are useful to support location determination education. They are also particularly needed to provide guidance in areas of study such as archaeology, history, geography, environmental resources. GIS technology has the ability to manipulate data by geographic location. Archiving of ancient, rare and important maps can be done in digital format through GIS technology. Librarians can provide reference services with the help of GIS.

5. Use of GIS in Bibliometrics:

The term bibliometrics was coined by Sir Alan Pritchard 1969. Bibliometrics is the application of statistical methods to books and literature. With the rise of ICT and the ubiquity of the Internet, there has been an increase in research and research on bibliometrics has begun along with GIS. Using this system it is possible to improve numerical knowledge.

6. Provision of advance knowledge to library readers through Geographic Information System:

The readership in a library department comes from many strata and each has different demands. The use of this system in the library department helps in gaining knowledge of the geographical situation. It helps the reader to get the information about the situation of Sabhotal quickly. Information about weather, rain, valleys, mountains, cyclones can be obtained in a few moments.

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TECHNICAL CHALLENGES GEOGRAPHIC INFORMATION SYSTEM IN LIBRARIES:

Geographic Information System technology is a software based. This requires huge investment to acquire hardware, remote sensing experts and data operators, skilled users. Computers, systems, screens, desktop are all necessary equipment in the library department. Resources for collecting geospatial information are essential in libraries for information needs. Since GIS systems emphasize accuracy, location accuracy is essential. Long-term financial and technical support is mandatory for GIS implementation. This system requires the skills of GIS experts because the location data needs to be interpreted and analyzed, measured and processed.

CONCLUSION

Geographic Information System technology has provided a new direction to initiate data services in library departments. Globally various libraries are seen using this system as a digital media format. Due to this, geographic data exchange and provision of services has become faster, so there is scope for implementing effective solutions. The main benefits of the technology are experienced in the areas of library collection management, visualization of map collections, management of library space and user studies. This article mentions the challenges for library professionals related to GIS and reviews the literature on important application areas of GIS in the library context, which is helpful in providing innovative and efficient library services.

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E-COMMERCE: A BUSINESS REVIEW FROM INDIAN CONTEXT

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ABSTRACT

This paper deals the conceptual knowledge of search engine marketing or e-commerce, literature review, current and future aspects of e-commerce in Indian context. This paper discussed about the top motivator factors of shopping online. The present development would be a valuable addition to researcher and academicians; and useful theory for practitioners, advertisers, and entrepreneurs.

KEYWORDS

SEM, Online Marketing, E-commerce, Pay-per-click (PPC)

INTRODUCTION

The rapid growth of e-commerce in India is being driven by greater customer choice and improved convenience. Having a strong business model coupled with a first class level of service is critical to success. Before these aspects are explored, it is important to understand the unique attributes which define e-commerce in India. Khan and Mahapatra (2009) remarked that technology plays a vital role in improving the quality of services provided by the business units. One of the technologies which really brought information revolution in the society is Internet Technology and is rightly regarded as the third wave of revolution after agricultural and industrial revolution. The cutting edge for business today is e-Commerce. The effects of e-commerce are already appearing in all areas of business, from customer service to new product design. It facilitates new types of information based business processes for reaching and interacting with customers like online advertising and marketing, online order taking and online customer service etc. It can also reduce cost in managing orders and interacting with a wide range of suppliers and trading partners, areas that typically add significant overheads to the cost of products and services Businesses are increasingly using the Internet for commercial activities. The ubiquitous nature of the Internet and its wide global access has made it an extremely effective mode of communication between businesses and customers [Rowley (2001)].

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Devendraet. al., (2012) defined that electronic commerce, commonly known as e-commerce or e-Commerce, consists of the buying and selling of products or services over electronic system such as internet and other computer network. Intent is the technology for e-commerce as it offers easier ways to access companies and individuals at very low cost in order to carry out day-to-day business transactions. Search engine marketing (SEM) is a form of web advertising that companies use to promote their products and services on search engine results pages (SERPs). SEM is focused on the effective use of search engine advertisements (a.k.a., sponsored results, sponsored links) that appear on the SERP. SEM which allows firms to target consumers by placing ads on search engines has proven to be an effective audience acquisition strategy. Unlike traditional online advertising, advertisers pay only when users actually click on an ad when successfully implemented, SEM can generate steady traffic levels and tremendous return on investment (ROI).

RESEARCH METHODOLOGY

The research is mainly based on secondary data. For the purpose books, study material of educational courses and research journal, articles as well as websites and some extent primary observations of researchers have were implemented

OBJECTIVES

1. To study the major search engines in the market.
2. To study the types of e-commerce.
3. To study the trends in e-commerce.

TYPES OF E-COMMERCE

The following types of e-commerce:

(i) B2B E-Commerce: Companies doing business with each other such as manufacturers selling to distributors and wholesalers selling to retailers. Pricing is based on quantity of order and is often negotiable.

(ii) B2C E-Commerce: Businesses selling to the general public typically through catalogs utilizing shopping cart software. By dollar volume, B2B takes the prize, however B2C is really what the average Joe has in mind with regards to ecommerce as a whole.

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(iii) C2C E-Commerce: There are many sites offering free classifieds, auctions, and forums where individuals can buy and sell thanks to online payment systems like PayPal where people can send and receive money online with ease. eBay's auction service is a great example of where customer-to customer transactions take place every day.

(iv) Others: G2G (Government-to-Government), G2E (Government-to-Employee), G2B (Government-to-Business), B2G (Business-to-Government).

Types of E-Commerce

The rapid growth of e-commerce in India is being driven by greater customer choice and improved convenience. Having a strong business model coupled with a first class level of service is critical to success. Before these aspects are explored, it is important to understand the unique attributes which define e-commerce in India. Amrish Rau, General Manager of First Data India and ICICI Merchant Services, discusses. India has an internet user base of over 50 million users. The penetration of e-commerce is low compared to markets like the US and the UK but is growing at a much faster rate with a large number of new entrants.

The industry consensus is that growth is at an inflection point with key drivers being:

1. Increasing broadband Internet (growing at 35% MoM) and 3G penetration
2. Rising standards of living and a burgeoning, upwardly mobile middle class with high disposable incomes
3. Availability of a much wider product range (including online purchase from international retailers and direct imports) compared to what is available at brick and mortar retailers
4. Busy lifestyles, urban traffic congestion and lack of time for offline shopping
5. Lower prices compared to brick and mortar retail driven by disintermediation and reduced inventory and real estate costs

CHARACTERISTICS OF INDIA

Some of the characteristics that define e-commerce in India are: Cash on Delivery as a preferred payment method. India has a vibrant cash economy as a result of which 80% of Indian e-commerce tends to be Cash on Delivery (COD) Direct imports constitute a large component of online sales. Demand for international consumer products (including online purchases from international retailers)

is growing much faster than in-country supply from authorized distributors. E-commerce uses sophisticated technology and logistics to create a cross-border supply chain that allows consumers to shop online for international products that are delivered duty paid to their doorstep.

THE ADVANTAGES AND DISADVANTAGES OF INTERNET MARKETING

Melody and Robert (2001) remarked that the Internet can provide timely information to customers because of its ability for instant communication, and its availability 24 hours a day, 7 days a week [Lane, 1996]. On-line marketing offers more choices and flexibility [Lamoureux, 1997] and, at the same time, eliminates huge inventories, storage costs, utilities, space rental, etc., [Avery, 1997]. People tend to associate Internet marketing with direct marketing because companies participating in online marketing usually shortened the supply chain [Edwards, et al., 1998] and reduced commission and operating costs. The ability to serve as both a transaction medium and a physical distribution medium for certain goods is a unique feature of Internet marketing. Such advantages can be best realized by companies that provide digital products/services such as software, music, news, consulting services, online ticketing and reservations, telemedicine, insurance, banking, stock brokerage, tax, and other financial service industries. Using the Internet as the distribution channel can reduce not only the delivery cost substantially, but also ensures instant delivery of products/services.

Moreover, Ruckman (2012) suggested that Internet research becomes an increasingly important tool during the purchasing process; more marketers are seeing the advantages too. It's a win-win situation. Marketing departments are investing more into online marketing today because it's:

1. Attractive to a significant segment of the demographics for most customer profiles. It can effectively reach the target customer.
2. Faster and less expensive to conduct direct marketing campaigns
3. Measurable, which means that successes are identifiable and repeatable
4. Open 24-hours a day
5. Cost-effective, in the long run.

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DISADVANTAGES:

There is no actual face-to-face contact involved in the Internet communication. For the typesof products that rely heavily on building personal relationship between buyers and sellers such as the selling of life insurance, and the type of products that requires physicalexamination, Internet marketing maybe less appropriate. While internet marketing cannot allow prospective buyers to touch, or smell or taste or 'try on' the products, However a survey of consumers of cosmetics products shows that email marketing can be used to interest a consumer to visit a store to try a product or to speak with sales representatives [Martin at el (2003)]. Some of the disadvantages of e-Marketing are dependability on technology, Security, privacy issues, Maintenance costs due to a constantly evolving environment, Higher transparency of pricing and increased price competition, and worldwide competition through globalization.

TOP MOTIVATORS FOR SHOPPING ONLINE

Top motivators for shopping online which include cash back guarantee, cash on delivery, fast delivery, substantial discounts compared to retail, and access to branded products, while barriers include inability to touch and try products before purchase, fear of faulty products, apprehension of posting personal and financial details online and inability to bargain

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E-COMMERCE MARKET WOULD CONTINUE ITS GROWTH STORY

The changing consumer lifestyles, supported by the younger population base ofIndia, have given a boost to the e-commerce business. More than half of the total1.2 billion population of India falls under the 'below 25 years of age' bracket. Also,65.0 per cent of India's population, representing the working age group of 15 to 64years, would aid the further growth of e-commerce, driven by their rising disposable income. Notably, discretionary spending in India is expected to jump to70.0 per cent by 2025 from 52.0 per cent in 2005. Also, the growing inclinationtowards purchasing online is reflected in a trend for higher value onlinetransactions. Shoppers are ready to shop for values exceeding USD500., whichearlier hovered in the range of USD40.0–100.0.

MARKET SIZE & GROWTH:

India's e-commerce market is worth about Rs 50,000 crores in 2011. About 80% of this is travel related (airline tickets, railway tickets, hotel bookings, online mobile recharge etc.). Online retailing comprises about 15%. India has close to 10 million online shoppers and is growing at an estimated 40-45% CAGR vis-à-vis a global growth rate of 8-10%. Electronics and apparel are the biggest categories in terms of sales.

MAJOR SEARCH ENGINES IN THE MARKET

By distinct search engines, means that search engines, portals, and websites who have alliances and who solicit bids for paid placements from a single source are treated as one search engine. For instance, by successfully bidding for a paid link with Overture exposes a seller to traffic from several websites, including MSN, Yahoo!, AltaVista, Info Space, Allthe Web and NetZero. There are various search engines by content/topic such as Baidu (Chinese, Japanese), Bing, Blekko, Google, Sogou (Chinese), Soso.com (Chinese), Volunia, WireDoo, Yahoo!, Yandex (Russian), Yebol, and Yodao (Chinese). Among PPC providers, Google AdWords, Yahoo! Search Marketing, and Microsoft adCenter are the three largest network operators, and all three operate under a bid-based model.

CONCLUSION

The conceptual knowledge of search engine marketing or e-commerce, literature review, current and future aspects of e-commerce in Indian context. This paper discussed about the top motivator factors

of shopping online. The present development would be a valuable addition to researcher and academicians; and useful theory for practitioners, advertisers, and entrepreneurs. Some of the disadvantages of e-Marketing are dependability on technology, Security, privacy issues, Maintenance costs due to a constantly evolving environment, Higher transparency of pricing and increased price competition, and worldwide competition through globalization. While considering the aforesaid limitations; advertisers and end-users can effectively use this modern platform to make life easier and faster. In the next 3 to 5 years, India will have 30 to 70 million Internet users which will equal, if not surpass, many of the developed countries. Internet economy will then become more meaningful in India. With the rapid expansion of internet, Ecommerce, is set to play a very important role in the 21st century, the new opportunities that will be thrown open, will be accessible to both large corporations and small companies [Waghmare (2012)]. Karoor (2012) explained that Ecommerce encapsulates many of the dynamics of 21st century of India. The potential huge and wit and energy of the entrepreneurs in the sector is impressive. Online commerce in India is destined to grow both in revenue and geographic reach. The further research areas in ecommerce are; the quality of sponsored ad text, ad position, Search Engine Optimization (SEO), PageRank, yellow pages, and bid management etc.

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GREEN DERMATOLOGY- DEVELOPMENT OF A TEA TREE OIL INFUSED ANTI-ACNE GEL

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ABSTRACT

Acne vulgaris is a common chronic inflammatory skin disorder affecting a large proportion of the global population, particularly adolescents. It is primarily caused by excessive sebum production, follicular hyperkeratinization, microbial colonization, and inflammation. Conventional anti-acne therapies, though effective, are often associated with side effects such as skin irritation, dryness, and development of antibiotic resistance. Hence, there is an increasing demand for safer and more effective herbal alternatives. The present study focuses on the formulation and evaluation of a herbal anti-acne gel based on the concept of green dermatology, incorporating tea tree oil as the primary active ingredient. Tea tree oil is well known for its potent antimicrobial and anti-inflammatory properties, making it effective against acne-causing microorganisms. Liquorice extract was included for its anti-inflammatory, antioxidant, and skin-soothing effects, while guar gum was used as a natural gelling agent to provide suitable consistency and stability to the formulation. A total of five formulations (F1–F5) were prepared by varying the concentration of tea tree oil and evaluated for various physicochemical parameters such as appearance, pH, viscosity, spreadability, homogeneity, washability, stability, and skin irritation. The pH of all formulations was found to be within the acceptable skin-friendly range (5.8–6.5), indicating suitability for topical application. All formulations exhibited good homogeneity, smooth texture, and satisfactory spreadability. The viscosity was appropriate for easy application and retention on the skin. Stability studies confirmed that the formulations remained stable under different storage conditions. Furthermore, no signs of irritation or adverse reactions were observed during the skin irritation test, indicating safety of the formulation. Among all the batches, formulation F5 showed optimum results in terms of viscosity, spreadability, pH, and overall stability, and was considered as the optimized formulation. The results suggest that

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the developed herbal anti-acne gel is effective, safe, and suitable for topical use. This study supports the potential of plant-based formulations as an alternative to conventional synthetic anti-acne treatments, promoting the concept of eco-friendly and sustainable skincare.

KEYWORDS

Acne, Pores, Anti acne gel

INTRODUCTION

Acne vulgaris is a skin disease that affects 80% of the teenage population; however, it can reach 100% because it is believed that there is no one who has not had a more or less severe episode of acne throughout their life. Although acne is not a life-threatening disease, it can have serious psychosocial consequences leading to low self-esteem, social isolation, and depression, as the severe disease can leave disfiguring scars on the face and is not limited to a few papules.[1][2].

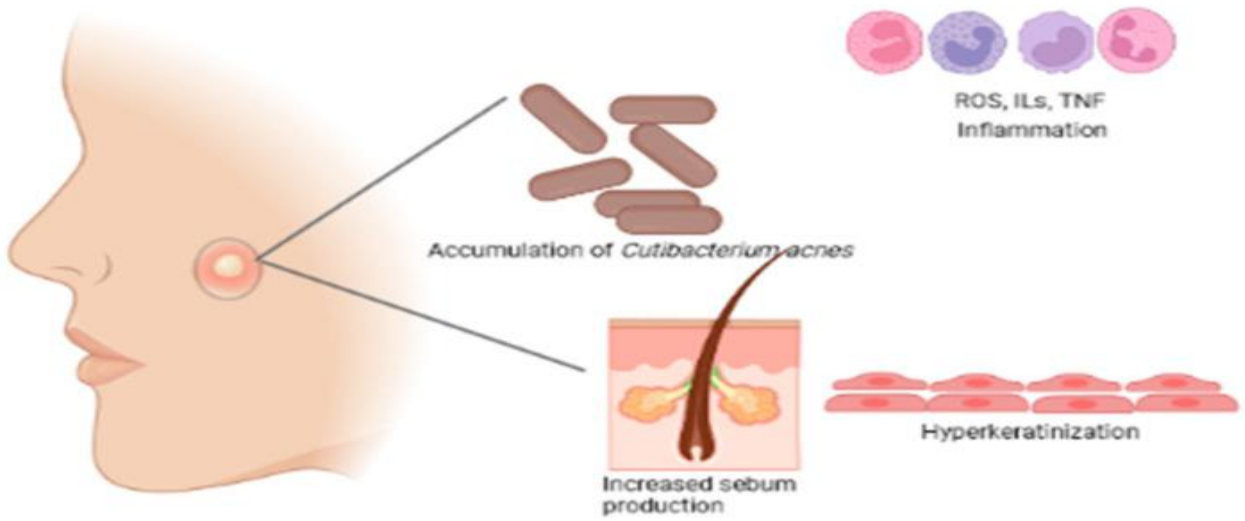

Fig 1.Acne inflammation

Acne is viewed as a chronic inflammatory skin disorder caused by a combination of factors, including excessive sebum production, abnormal desquamation of the follicular epithelium, inflammation and the presence of the bacterium *Propionibacterium acnes*.Pimples may happen when the sebaceous organs associated with pores liable for moving dead cells to the surface space of the skin get hindered. This blockade usually results in bacterial colonization and attack on the sebum, resulting in whiteheads, blackheads, and finally, inflammation and scars when the body's mechanism tries to fight back. *Propionibacterium acnes* and *Staphylococcus epidermidis* assume significant parts

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concerning inflammatory acne and shallow disease by utilizing sebaceous fatty substances into unsaturated fats, to which neutrophils are pulled in [3,4].Despite their effectiveness, synthetic therapies include drawbacks such skin irritation, peeling, and the development of resistance. Herbal alternatives with fewer side effects are being investigated as a result of the growing desire for natural therapies. Because herbal gels are they are very advantageous. The purpose of this research is to create and assess an herbal anti-acne gel that contains extracts with shown medicinal benefits [5,6].For ages, ancient medical systems like Ayurveda, Siddha, and Unani have employed herbal therapies to treat acne and other skinrelated issues. Ingredients derived from plants frequently offer a variety of functions, including antimicrobial, anti-inflammatory, antioxidant, wound-healing, and calming qualities. Herbal formulations are often well-tolerated and linked to fewer negative effects than synthetic medications. Herbal-based gels for acne treatment are becoming more and more popular as the world moves towards sustainable and natural skincare products [7,8]. It is very advantageous to use an herbal gel as a topical delivery mechanism for anti-acne chemicals. Gels enable rapid absorption, localized action, and extended contact with the afflicted region in a non-greasy, clear, and spreadable composition. They are therefore perfect for oily, sensitive skin that is prone to acne non-greasy, simple to use, and enable the gradual release of active components[9].

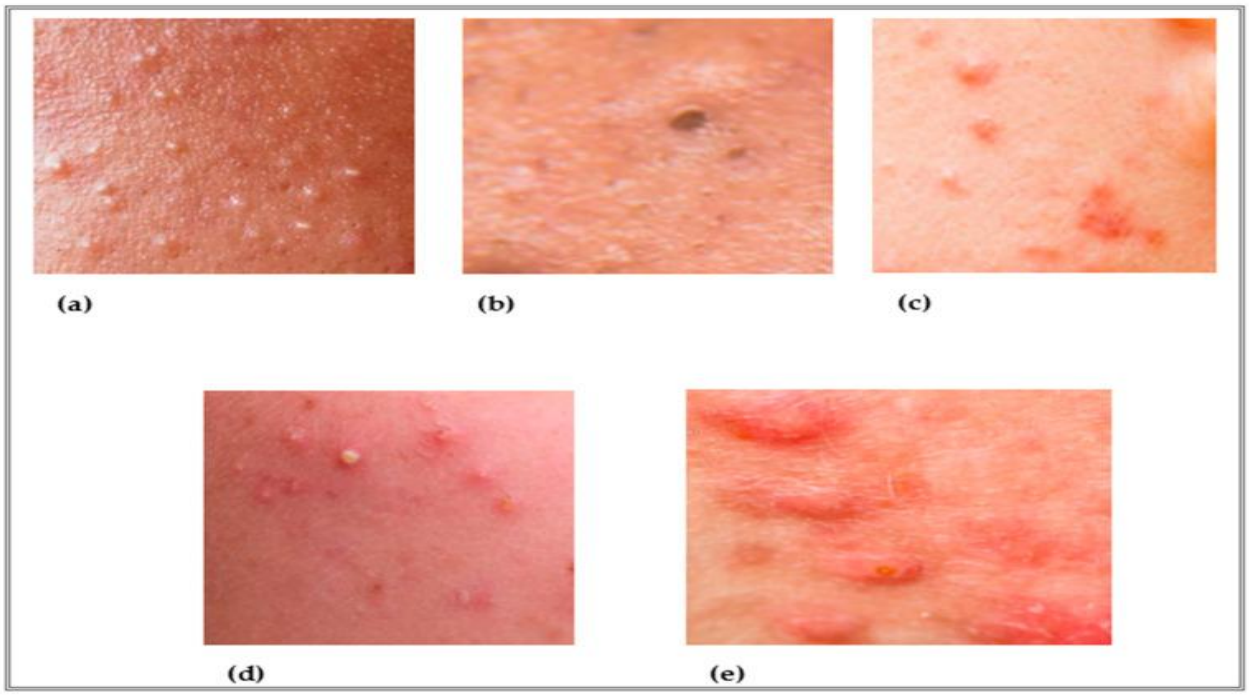

Fig 2. Types of Acne

Topical formulations such as gels are widely used for acne treatment because they provide better drug penetration, ease of application, and improved patient compliance. Herbal and plant-based ingredients are increasingly preferred in dermatological preparations due to their therapeutic efficacy and reduced side effects compared to synthetic drugs.Tea tree oil, obtained from *Melaleuca alternifolia*, is well known for its strong antimicrobial and anti-inflammatory properties. It is effective against acne-causing bacteria and helps reduce skin inflammation and redness. Liquorice extract (*Glycyrrhiza glabra*) possesses antioxidant, anti-inflammatory, and skin-soothing properties. It also helps reduce hyperpigmentation and irritation associated with acne lesions. Carbol (phenol) has antiseptic and antimicrobial activity, which helps prevent bacterial growth and maintain skin hygiene.The combination of these active ingredients in a gel formulation can provide synergistic effects in controlling acne by reducing bacterial growth, inflammation, and skin irritation. Therefore, the present study focuses on the formulation and evaluation of a herbal anti-acne gel containing tea tree oil,carbol,and liquorice extract to enhance therapeutic effectiveness and improve skin health.

Use of Tea Tree Oil in Anti-Acne Gel

Tea Tree Oil obtained from *Melaleuca alternifolia* is widely used in dermatological and cosmetic formulations due to its strong antimicrobial and anti-inflammatory properties. It is considered an effective natural ingredient for the treatment of acne and other skin infections.

Tea Tree Oil exhibits significant antibacterial activity against acne-causing bacteria such as *Cutibacterium acnes* (formerly *Propionibacterium acnes*). By inhibiting the growth of these microorganisms, it helps prevent the formation and spread of acne lesions. In addition, Tea Tree Oil possesses anti-inflammatory properties that help reduce redness, swelling, and irritation associated with acne.

Another important function of Tea Tree Oil in anti-acne gel formulations is its ability to control excess sebum production. Excess oil on the skin can clog pores and promote acne development; therefore, Tea Tree Oil helps maintain skin balance and keep pores clear. It also has mild antiseptic and healing properties, which support faster recovery of damaged skin and reduce the risk of secondary infections.

Due to these beneficial properties, Tea Tree Oil is commonly incorporated into topical formulations such as gels, creams, and lotions for acne management. In anti-acne gel formulations, Tea Tree Oil

not only enhances antibacterial activity but also improves skin soothing and overall therapeutic effectiveness.

Key Functions in Anti-Acne Gel:

- Antibacterial action against acne-causing bacteria
- Anti-inflammatory effect that reduces redness and swelling
- Helps control excess sebum (oil) production
- Unclogs pores and prevents acne formation
- Promotes faster healing of acne lesions

Causative factors and pathogenesis of acne vulgaris

Several causal factors are believed to play a key part in the traditional aetiology of acne vulgaris. As discussed previously, chronic acne skin diseases are caused by increased sebum excretion rates, endocrinological factors such as androgens, aberrant keratinization of the follicular infundibulum, bacterial infection proliferation, and consequent inflammation.

a) ***Increase in Sebum production***: An increase in sebum production in the hair follicles is one of the most significant causes of acne formation. According to Gollnick et al. androgen hormones, specifically testosterone and Insulin Growth hormone (IGH-1), increase sebum synthesis and secretion [10].

b) *Hyperkeratinization abnormalities of the pilosebaceous follicles*: Generally, the healthy follicles often shed single-cell keratinocytes into the lumen, which are then ultimately eliminated. However, in acne patients, keratinocytes hyper proliferate and are not shed into the lumen, which leads to the accumulation of irregular desquamated corneocytes in the pilosebaceous follicles coupled with lipids and monofilaments.

c) *Hyper proliferation of propionibacterium acnes (P. acnes)*: Propionibacterium, which plays a substantial part in the pathophysiology of inflammatory acne, is an additional acne-causing agent. Cutibacterium acnes, formerly known as propionibacterium acnes, is an anaerobic, lipophilic, gram-positive pathogen that prefers to colonise in sebaceous follicles because they produce large amounts of sebum and provide excellent anaerobic habitat for bacterial growth.

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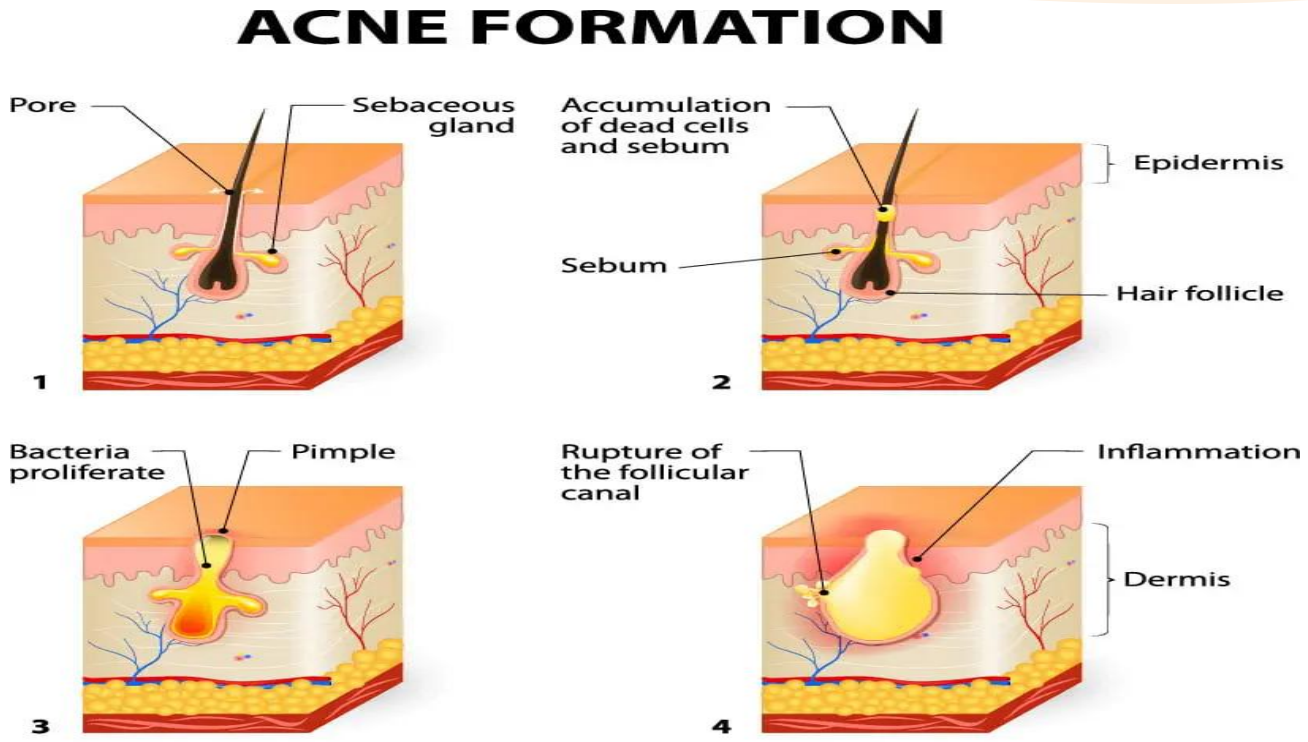

Fig 3. Acne formation

Types of acne lesions

Acne is classified into several forms, including acne conglobate, acne rosacea, acne fulminans, acne cosmetica, acne excoriee (picker's acne), acne medicamentosa, acne chloracne, and acne mechanica. Nonetheless, acne vulgaris is the most prevalent form of acne, accounting for 99% of all acne cases. It is differentiated by two types of lesions: non-inflammatory, open and closed comedones, as well as inflammatory papules, pustules, nodules, and cysts[FIG4]. The comedones are of two types: a comedo that is closed is a whitehead, while another that is open is a blackhead type.[10]

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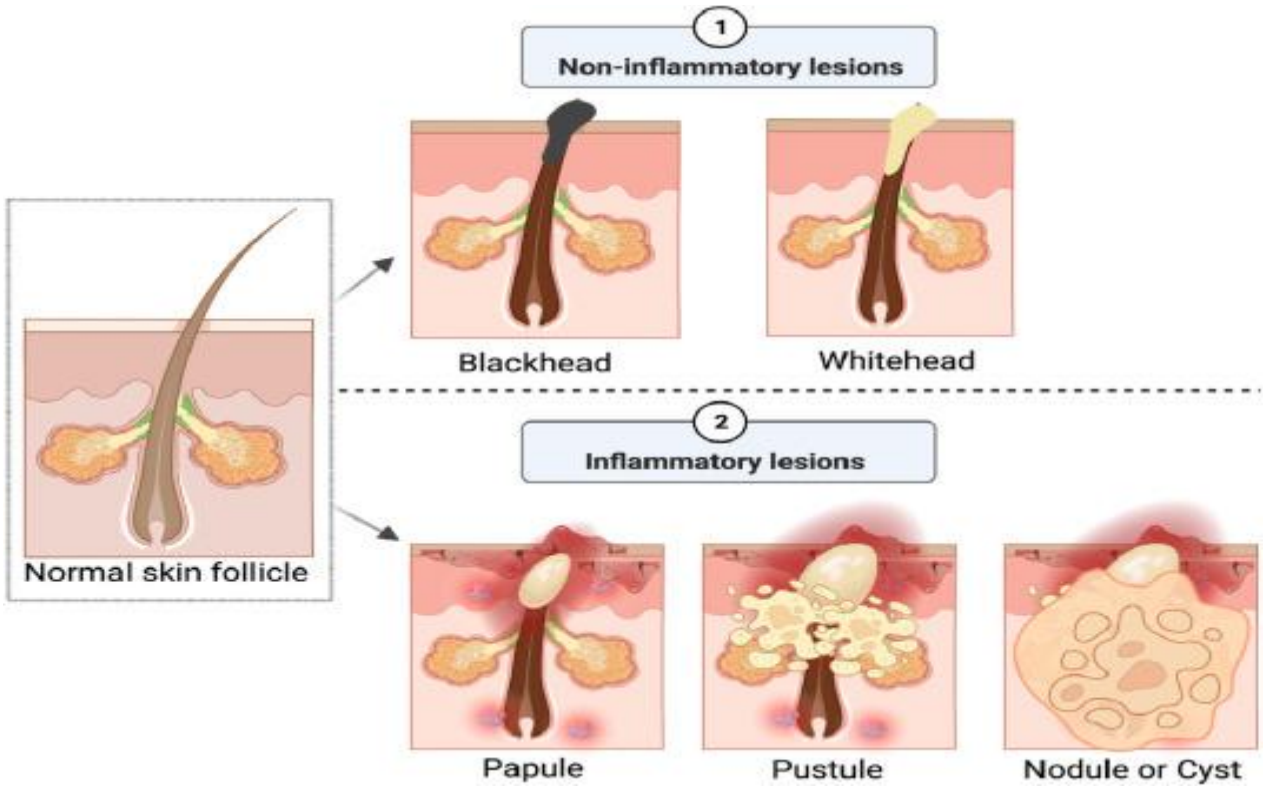

Fig. 4. Schematic illustration of major distinguishing of the two types of lesions (non-inflammatory, inflammatory) and their pathogenies.

Blackheads: Blackheads are non-inflammatory acne lesions that develop on the skin due to excess oil and dead skin cells obstructing hair shafts. A blackhead is referred to as an open comedo because the skin surface remains exposed and has a dark look, such as black or brown. Blackheads are mild acne that usually appears on the face, arms, chest, neck, back and shoulders.

Whiteheads: Whiteheads are small bumps and non-inflammatory acne lesion that develops on the skin when oil, bacteria and skin cells block the opening of hair follicle pores. Whiteheads are referred to as closed comedones since the bumps are closed and white. Whiteheads can develop anywhere on the body, but they are most frequent in the T-zone, which includes the nose, chin, and forehead.[10]

Papules: Inflammation is the response of healthy skin tissue to bacteria, excess oil production, and excess androgen activity, and its symptoms include swelling, heat, redness, and pain. These inflamed lesions are known as papules and are considered an intermediary step between non-inflammatory and inflammatory lesions. Papules show on the skin as a little pink lump typically less than 5 mm in diameter and not pus-filled.

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Pustules: Pustules are small bumps and an inflammatory lesion that occurs on the skin by clogging the pores with excess oil and dead skin cells. Pustules are inflammatory lesions that contain fluid or pus in their centre. Often, they manifest as white pimples surrounded by red, irritated skin. Pustules can form on any part of the body, although they are most prevalent on the shoulders, chest, back, face, neck, underarms, pubic region, and hairline.[10]

Nodules: Acne nodules are a severe form of inflammatory acne that develops when the pores become clogged by bacteria, excess oil and dead skin cells. This type of combination usually causes whitehead or blackhead comedones, but if the infection penetrates underneath the surface of the skin and affects the pores as well as the surrounding area to become red and swollen and appear as a small bump. Acne nodules are not treatable with over-the-counter medications alone and might remain for weeks or months. Nodular acne is similar to papule acne, but its diameter is bigger than 5–10 mm, and it often develops on the face's jawline or chin.[9,11]

Cysts: Cystic acne is a severe kind of inflammatory acne that appears beneath the skin due to blocked pores caused by the accumulation of bacteria, dry skin cells, and oil . People with the oily skin of all ages are most affected. Cyst typically appears as large white/red painful lesions filled with pus, sometimes leading to scars. Cystic acne can appear anywhere on the body, although it most frequently affects the face, arms, shoulders, back, chest, and neck. Most people with cystic acne experience both inflammatory and non-inflammatory acne symptoms.[11]

Herbs used in Anti- Acne Gel Formulation

1. Liquorice (Glycyrrhiza glabra)

Liquorice root is widely used in dermatological formulations due to its potent anti-inflammatory, antimicrobial, and skin-brightening properties. The major active constituent, glycyrrhizin, exhibits significant anti-inflammatory activity by inhibiting cyclooxygenase and reducing redness and swelling associated with acne.

Liquorice also contains flavonoids (glabridin, liquiritin) that help in:

- Reducing hyperpigmentation and acne scars
- Inhibiting the growth of acne-causing bacteria such as *Propionibacterium acnes*
- Providing antioxidant protection against free radicals

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Thus, liquorice plays a dual role in acne management by treating active lesions and improving skin tone.[12,13]

2. Tea Tree Oil (Melaleuca alternifolia)

Tea tree oil is a well-known natural essential oil with strong antimicrobial and antiseptic properties, making it highly effective in acne treatment. The primary active component, terpinen-4-ol, is responsible for its antibacterial activity.[12]

Key benefits in anti-acne formulation:

- Inhibits growth of acne-causing bacteria (*Cutibacterium acnes*)
- Reduces inflammation, redness, and swelling
- Helps in drying out acne lesions without excessive irritation

Compared to synthetic agents like benzoyl peroxide, tea tree oil is considered a safer and less irritating alternative for topical acne treatment.[12]

3. Guar Gum (Cyamopsis tetragonoloba)

Guar gum is a natural polysaccharide used as a gelling agent and stabilizer in topical formulations. It plays an important role in enhancing the consistency and application properties of the gel.[13]

Fig 5. Guar Gum benefits

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MATERIALS AND METHODS:

Materials

List of material

Table 1. list of material

Sr no	Materials
1	Tea tree oil
2	Guar gum
3	Triethanolamine
4	Glycerin
5	Methyl Paraben
6	Propyl Paraben
7	Propylene Glycol

List of equipment

Table 2. list of equipment

Sr no	Equipment
1	Burner
2	PH meter
3	Water bath

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4	Digital balance
5	Viscometer

List of glassware

Table 3. list of glassware

Sr no	Glassware
1	Measuring Cylinder
2	Funnel
3	Conical Flask
4	Petri dish
5	Beaker
6	Mortar pestle

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METHODS

Extraction of Liquorice [Powder Preparation]

PREPARATION OF POWDER

Collection of Liquorice Roots and Cleaning of Roots

(Remove dust and impurities)

↓

Drying

(Proper shade drying)

↓

Grinding

(Convert into coarse powder)

↓

Sieving

(Obtain uniform powder size)

↓

Powder Ready for Use

MACERATION

↓

Weigh the Coarse Powder

↓

Transfer to Maceration Vessel

(Stoppered Container)

↓

Add Suitable Solvent

(Water / Alcohol)

↓

Allow to Stand 24–72 hrs

With Occasional Shaking

↓

Filtration

↓

Press the Residue

(Marc)

↓

Collect Filtrate

(Liquid Extract)

FILTRATION

↓

Take the Macerated Mixture Place Filter Paper in Funnel

↓

Pour the Mixture into Funnel Liquid Passes Through

(Filtrate Collected)Solid Residue Remains On Filter Paper

↓

CONCENTRATION

↓Take the Filtrate

(Liquid Extract) and Transfer to Evaporating Dish Apply Gentle Heat(Water Bath / Evaporation) Clean Drying (Proper shade drying)Grinding-Convert into coarse powder Sieving-Obtain uniform powder size Powder Ready for Use.

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EXTRACT OF LIQUORICE

Liquorice Powder

↓

Weighing of Required Quantity

↓

Addition of Distilled Water / 70% Ethanol (Solvent)

↓

Maceration for 24 hours with Occasional Stirring

↓

Heating on Water Bath (30–40 min)

↓

Filtration using Muslin Cloth / Whatman Filter Paper

↓

Concentration of Filtrate on Water Bath

↓

Semi-solid Liquorice Extract Obtained

↓

Storage in Airtight Container

Fig 6. Liquorice

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3.FORMULATION

Table 4. Formulation of anti-acne gel

Sr no.	Ingredients	Category	F1	F2	F3	F4	F5
1	Tea Tree Oil	Active ingredient	0.75 mL	0.75 mL	0.75 mL	0.75 mL	0.75mL
2	Liquorice Extract	Anti Inflammatory agent	0.50g	0.59g	0.50g	0.50g	0.50g
3	Guar gum	Gelling agent	0.10g	0.20g	0.30g	0.40g	0.50g
4	Triethanolamine	pH adjuster	0.02 mL	0.02 mL	0.02 mL	0.02 mL	0.02 mL
5	Glycerin	Humectant	0.25 mL	0.35 mL	0.50 mL	0.60 mL	0.50 mL
6	Methyl Paraben	Preservative	0.02 g	0.02 g	0.02 g	0.02 g	0.02 g
7	Propyl Paraben	Preservative	0.002 g	0.002 g	0.002 g	0.002 g	0.002 g
8	Propylene Glycol	Solvent	0.20 mL	0.4 mL	0.50 mL	0.60mL	0.70 mL
9	Distilled Water	Vehicle(QS.to 10 mL)	10 mL	10 mL	10 mL	10 mL	10 mL

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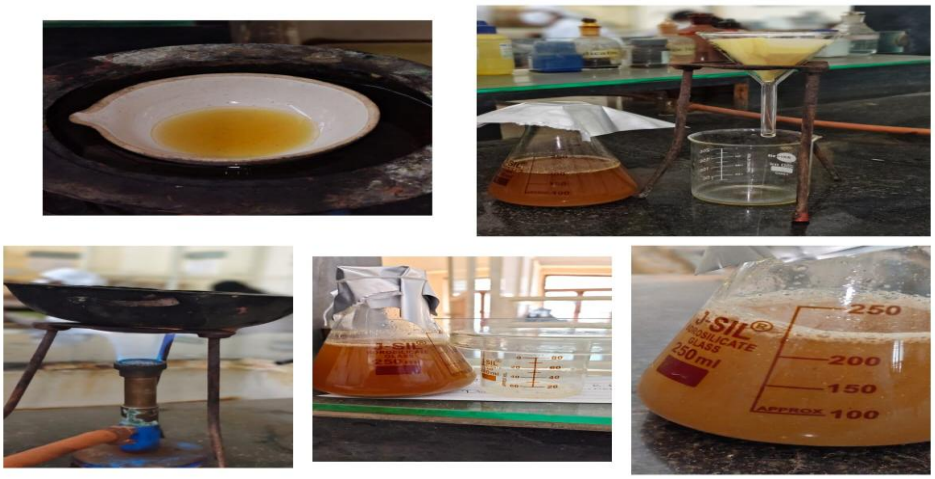

Fig no 7- preparation of anti-acne gel

4.FORMULATION OF ANTI-ACNE GEL

- Glycerin and propylene glycol wre added to hydrated guar gum gel base and mixed thoroughly.
- Tea tree oil and the prepared liquorice extract were added slowly into the gel base with continuos stirring to obtain a uniform mixture.
- Methly paraben dissolved in a small quantity of warm water was added to the fromulation.

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5.EVALUATION PARAMETER

Evaluation of topical gel formulation

5.1. pH Determination

The pH of the gel was determined using the pH paper by immersing the paper in the formulation. [25]

5.2. Appearance and homogeneity

The appearance and homogeneity were determined through visual inspection.

5.3. Spreadability-

It specifies the diameter of the region that the gel can eas-ily cover when applied to skin or a damaged area. The spread-ing value has an impact on treatment effectiveness as well. Spreadability measures how long it takes two slides to sepa-rate from the gel placed in between them under a certain load

direction (in seconds). The spreadability increases as the time required to divide two slides' decreases. The spreadability is calculated using the following formula [26].

Spreadability (S) = M×L / T

Where, M= Weight tied to slide

L= Length of slide

T= Time required to separate slides.

5.4. Washability test

The washability test was determined by applying a small amount of prepared formulation over the skin and afterward washed with water. [26]

5.5. Stability Study

The stability study was performed as per ICH guidelines 6. The formulated gel were filled in the collapsible tubes and stored at different temperatures and humidity conditions, viz. 250 C ± 20C/ 60% ± 5% RH, 300 C ± 20C/ 65% ± 5% RH, 400 C ± 20C/ 75% ± 5% RH for a period of three months and studied for appearance, pH, and Spreadability.[24]

5.6. Skin Irritation test

0.5 gm of the herbal gel was used as the test substance was applied to an area of approximately 6 cm2 of skin and covered with a gauze patch.The patch was loosely held in contact with the skin by means of a semi-occlusive dressing for the duration of 1 hour and gauze was removed. At the end of the exposure period, i.e., 1 hour, residual test substance was removed, without altering the existing response or integrity of the epidermis. Observations have recorded after removal of the patch. Control animals were prepared in the same manner and 0.5 gm of the gel base i.e., gel formulated using all ingredients except the herbal mixture was applied to the control animals and observations were made as similar to the test animals32. The gel was applied to the skin once a day for 7 days and observed for any sensitivity and the reaction if any was graded.[25]

5.7. Viscosity:

Viscosity of the anti-acne gel was determined by the drop count method using an Ostwald viscometer. In this method, the gel sample (usually diluted with distilled water) is allowed to flow through the viscometer, and the number of drops or flow time between two marked points is recorded. The same procedure is repeated with distilled water as a standard. The viscosity of the gel is then calculated using the viscosity formula by comparing the flow time of the sample with that of water. The obtained

viscosity indicates the thickness and consistency of the gel, which affects its spreadability and stability.[26].

5.8. Antimicrobial Test

Antimicrobial studies of different gels were done by agar well diffusion method. Microbial strains like Gram Positive ,Gram-negative bacteria (Escherichia coli). Culture media for the activation of microbes were prepared according to the official protocols as given in the microbial-type culture cultivation protocol. Gels were dissolved in Di-methylsulphoxide (DMSO), concentration range should not be more than 10%. 2-10% of the nutrient broth suspension of the microorganism was cast into sterile molten nutrient agar which was cooled to 45°C, mixed well, and poured into a sterile petri dish. Furthermore, it was allowed to solidify and five wells were made by sterile cork borer. Test samples of con-centrations 25, 50, and 100 µg/ml by dissolving in dimethyl-sulphoxide, standard drug, and control were poured into the corresponding well by micropipettes. Inoculated plates in trip-licate and Petri dish were left at room temperature. To allow the diffusion of the sample's petri dish, it was incubated at the corresponding temperature of each organism for 24 hrs. The diameter of the Zones of inhibition was measure.[31]

5.9 Extrudability

Collapsible tubes are loaded with the formulation once it has been put in the container. Extrudability is determined by weighing the amount of material in grammes needed to extrude a 0.5 cm gel ribbon in 10 seconds [32]

Table 5. Evaluation parameter

Sr no.	Evaluation parameter	F1	F2	F3	F4	F5
1	Colour	Light Yellow	Light Yellow	Light Yellow	Light Yellow	Light Yellow
2	Odour	Characteristics	Characteristics	Characteristics	Characteristics	Characteristics

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3	Appearance	Homogeneous	Homogeneous	Homogeneous	Homogeneous	Homogeneous
4	Spreadability	Good Spreadability	Good Spreadability	Good Spreadability	Good Spreadability	Good Spreadability
5	Viscosity	2.55	2.75	2.85	2.90	3.02
6	pH	5.9	6.1	6.2	6.3	6.7
7	Skin irritation test	No irritation observed	No irritation observed	No irritation observed	No irritation observed	No irritation observed
8	Homogeneity	Uniform and free from lumps	Uniform and free from lumps	Uniform and free from lumps	Uniform and free from lumps	Uniform and free from lumps
9	Washability	Easy Washable	Easy Washable	Easy Washable	Easy Washable	Easy Washable
10	Stability Study	Stable with no change in color, PH or consistency	Stable with no change in color, PH or consistency	Stable with no change in color, PH or consistency	Stable with no change in color, PH or consistency	Stable with no change in color, PH or consistency
11	Anti microbial test	Moderate	Good	Excellent	Very good	Good
12	Extrudability test	Excellent	Very good	Good	Fair	Poor

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RESULT AND DISCUSSION

Various evaluation parameters were studied on different five formulations (F1–F5) of the prepared anti-acne gel and the obtained results were compared. The formulations were evaluated for parameters such as appearance, color, odor, pH, homogeneity, spreadability, viscosity, washability and skin irritation test. All the prepared gel formulations showed smooth texture and good consistency. The color of the formulations ranged from light yellow to pale brown due to the presence of herbal ingredients like tea tree oil and liquorice powder. The odor of the gel was characteristic and pleasant. The homogeneity test indicated that all formulations were uniform and free from lumps, which shows proper mixing of ingredients and good gel formation using guar gum as a gelling agent. The pH of the formulations was found in the range of 5.8–6.5, which is close to the natural pH of the skin. This indicates that the gel is suitable for topical application and will not cause skin irritation. The spreadability of the gel was found to be good, indicating that the gel spreads easily on the skin surface and can be applied uniformly over the affected area. The viscosity of the formulations was found to be satisfactory, which provides good consistency and helps the gel remain on the skin for a longer time. Proper viscosity also contributes to the stability of the gel formulation. The washability test showed that the gel can be easily washed with water without leaving any sticky residue, making it convenient for topical use. The skin irritation test revealed that no redness, itching or irritation was observed after application, indicating that the prepared formulation is safe and suitable for skin application. Among all the formulations, batch F5 showed better results in terms of pH, viscosity, spreadability and overall stability, and therefore it was considered as the optimized formulation for further studies.

CONCLUSION

The present study was carried out to formulate and evaluate a herbal anti-acne gel containing tea tree oil and liquorice powder using guar gum as a gelling agent. Five different formulations (F1–F5) were prepared and evaluated for various parameters such as appearance, pH, homogeneity, spreadability, viscosity, washability and skin irritation test. All the formulations showed good physical properties and were suitable for topical application. The pH of the gel was found to be within the skin-friendly range, and the formulations showed good spreadability, proper viscosity and easy washability. No irritation or redness was observed during the skin irritation test. Among all the batches, formulation F3 showed better overall results, and therefore it was considered as the optimized formulation for the herbal anti-acne gel.

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ZERO-EFFORT OBSERVABILITY THROUGH AUTOMATED LOG INSTRUMENTATION

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ABSTRACT

Observability, the ability to understand internal software behavior through outputs like logs, metrics, and alerts is crucial for debugging, reliability, and real-time diagnostics. Yet conventional logging libraries require explicit integration and configuration by developers. We propose an automated instrumentation framework that accepts one or more arbitrary JavaScript source files, injects a lightweight logging utility into them, and returns an enhanced project bundle. At runtime, all console.log calls are redirected to create structured log files, while specially marked messages (e.g., using $MSG) trigger real-time notifications via external platforms such as Telegram. This approach eliminates manual setup and enables zero-effort observability particularly valuable in educational contexts and small-scale applications. By automating ingestion, transformation, and multi-channel alerting, the system fosters proactive monitoring with minimal developer friction.

This work aligns with the broader research on automated log instrumentation and developer productivity, extending topics surveyed in “A Comprehensive Survey of Logging in Software: From Logging Statements Automation to Log Mining and Analysis”.

INTRODUCTION

Observability has become a pillar of contemporary software engineering, allowing developers and operators to identify faults, track performance, and ensure reliability in increasingly complicated systems[1]. Historically, observability comes through the integration of logs, metrics, and traces, each with explicit integration into the codebase. Of these, logging is the most ubiquitous and low-hanging fruit, yielding a time-ordered record of system activity. Although ubiquitous, logging is routinely underutilized because manual effort is needed to instrument code, set up logging libraries, and keep logs in a standard format within projects.

In light-weight applications and teaching environments, where ease of prototyping and simplicity are more important, developers often make do with ad-hoc console dumps rather than a structured

logging framework. Though easy, these make systematic debugging, centralized monitoring, and real-time alerting difficult. This deficiency necessitates a solution where the convenience of console-based debugging is augmented with the advantage of structured, automated, and proactive observability.

To overcome this problem, we suggest an automated instrumentation mechanism that augments JavaScript projects with no need for developers to take action. The instrument injects a light logging utility into any source file, converting unstructured console prints into structured logs and sending specially marked messages to external notification sinks like Telegram. This zero-effort process lowers friction, facilitates real-time monitoring, and makes observability accessible for small-scale systems, prototypes, and learning environments.

LITERATURE REVIEW

Studies of logging and observability cut across various dimensions, ranging from automated instrumentation, developer productivity, and log analysis. A wide-ranging survey by Gholamian and Ward (2022) points to the history of logging practices—the manual insertion of statements through to sophisticated methods like automated logging and log mining[2]. Their paper points to the trade-off between developer effort and runtime insight quality, driving tools that reduce overhead while maximizing observability.

A number of studies have investigated automated instrumentation as a vehicle for decreasing developer load[3]. For instance, Java and C# frameworks use bytecode manipulation or compiler hooks to insert logging statements automatically. These methods enhance coverage but tend to be very close to language-specific toolchains and therefore less readily available in light-weight or scripting contexts. By contrast, JavaScript logging continues to be dominated by hand-crafted techniques, with libraries such as Winston, Bunyan, and Pino still requiring manual configuration and integration[4]. Although these libraries provide structured logging, they do not eliminate the requirement for developer intervention at the source-code level.

Synthetic observability research in parallel focuses on real-time monitoring and multi-channel alerting[5]. Log-integrated systems with messaging platforms, dashboards, and anomaly detection pipelines improve situational awareness but generally rely on the presence of structured logs as input. Few directly target the gap between ad-hoc console-based debugging and structured observability.

Our work extends these efforts by concentrating specifically on JavaScript contexts, in which console statements are the default debugging mechanism. By automatically converting these statements into structured logs and directing tagged outputs to real-time streams, we expand the scope of automated log instrumentation to environments where traditional frameworks are too cumbersome or unworkable.

SYSTEM ARCHITECTURE

The framework suggested here is a light-weight pipeline that takes any JavaScript project and converts it into an instrumented bundle that supports structured logging and real-time alerting [6]. The framework is broken down into three principal modules: Input Module, Processing Engine, and Output Module, as presented in above Figure [7].

1. Input Module

The input module takes charge of gathering the input artifacts from the user.

JavaScript Source File(s): The user uploads one or more .js files constituting the project to be instrumented [8].

Telegram Credentials: The user submits credentials (bot token and chat ID) needed for communication with the Telegram API. These are stored securely and supplied to the processing engine to facilitate real-time message sending [9].

This module makes sure no manual changes to the user's code are needed before instrumentation [10].

2. Processing Engine

The processing engine carries out the main work of the framework:

Logger Injection: All messages preceded by $msg in the uploaded JavaScript files get intercepted and routed to a custom logging utility automatically. The utility formats these messages and appends them to a log file at runtime [11].

Telegram Code Integration: Messages labeled with $msg_tele are detected by the engine, which injects code to call the Telegram Bot API, sending the message to the intended chat in real time [12].

Any messages without $msg or $msg_tele symbols are ignored and do not appear in the log file or get sent to Telegram [13].

This module encapsulates the conversion logic, so the developer does not need to modify source files manually [14].

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3. Output Module

After processing, the framework produces an instrumented output folder with the upgraded JavaScript project. If the user runs this instrumented project:

- All console.log outputs are captured automatically into structured log files [15].
- Any $msg_tele message is relayed as an instant alert to the set Telegram channel [12].

This output module provides zero extra developer effort for runtime observability [10].

End-to-End Workflow

1. The user uploads source code and Telegram credentials.
2. The processing engine introduces logging and alerting semantics into the codebase [11].
3. The output module generates an enhanced project directory.
4. Upon execution, the enhanced project makes structured logs appear transparently and sends live notifications to Telegram [12].

By dividing the pipeline into input, processing, and output phases, the system promotes modularity, extensibility, and simplicity of integration within existing JavaScript projects [7].

METHODOLOGY

The system, as proposed, consists of a JavaScript applications' automated observability layer that captures runtime events, centralizes logs, and provides alerts for important messages [6]. The process is segmented into four phases: Instrumentation, Log Management, Alerting, and Integration.

1. Interception of Console Logs

The native console.log() function in Node.js was overridden to build a unified observability layer.

A wrapper function was created to:

- Capture the log message
- Add a timestamp and context metadata
- Save the log entry to a file for persistence
- Preserve the original console output behavior

This mechanism was implemented using the built-in fs (File System) module, ensuring the logs are stored even after application restarts.

Code Snippet — Logger Implementation (logger.js)

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```
const fs = require("fs");

// Generate log file name with timestamp
const date = new Date();
const pad = (n) => n.toString().padStart(2, "0");
const logFileName = `app_${date.getFullYear()}-${pad(date.getMonth() + 1)}-
${pad(date.getDate())}_${pad(date.getHours())}-${pad(date.getMinutes())}-
${pad(date.getSeconds())}.log`;
const logStream = fs.createWriteStream(logFileName, { flags: "a" });
// Save original console.log
const originalLog = console.log;
console.log = function (...args) {
 const message = args.join(" ");
 const timestamp = new Date().toISOString();
 const logEntry = `[${timestamp}] ${message}\n`;
 // Write logs to file
 logStream.write(logEntry);
 // Preserve original behavior
 originalLog.apply(console, args);
};
```

2. Alerting System with Telegram API

An alerting mechanism was added to send real-time notifications whenever critical messages appear in logs. [12].

A Telegram Bot was created using Telegram Bot API.

- Developers use BotFather to generate a bot token.
- An alert is triggered when log messages contain the keyword $MSG.
- Alerts are sent using Axios.

Code Snippet — Telegram Alert Integration

```
const axios = require("axios");
// Replace with your actual bot token and chat ID
```

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```
const TELEGRAM_API = `https://api.telegram.org/bot${process.env.BOT_TOKEN}/sendMessage`;
const CHAT_ID = process.env.CHAT_ID;

async function sendTelegramAlert(message, timestamp) {
 try {
  await axios.post(TELEGRAM_API, {
   chat_id: CHAT_ID,
   text:  ALERT: ${message}\n🕒 Time: ${timestamp}`
  });
 } catch (err) {
  logStream.write(`[ERROR] Telegram alert failed: ${err}\n`);
 }
}
// Modified console.log to trigger alerts on $MSG
const originalLog = console.log;
console.log = function (...args) {
 const message = args.join(" ");
 const timestamp = new Date().toISOString();
 const logEntry = `[${timestamp}] ${message}\n`;
 logStream.write(logEntry);
 originalLog.apply(console, args);
 if (message.includes("$msg_tele")) {
  sendTelegramAlert(message, timestamp);
 }
};
```

3. Integration with Applications

To ensure easy adoption, the entire logger and alert system was modularized into a single script observability.js.

Developers just need to import it once at the start of their project, and all logging and alerting will work without touching the existing codebase.

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Code Snippet — Observability Module

```
// File: observability.js
require("./logger"); // Handles logging and telegram alerting
```

Usage in Any Application

```
// index.js (Application entry point)
require('./logger);
console.log("Server started successfully");
console.log("$msg_tele High memory usage detected!");
```

4. User Dashboard for Automated Integration

To automate the process of adding observability, a web dashboard was created using Express.js and Multer[14].

Workflow:

1. Developer uploads their .js files (and optional package.json).
2. Backend injects require('./logger') automatically into entry point files.
3. A ZIP of the instrumented project is generated and returned.
4. Developer downloads and runs it — no manual coding required.

Code Snippet — Express Backend Automation

```
const express = require("express");
const multer = require("multer");
const fs = require("fs");
const path = require("path");
const archiver = require("archiver");
const cors = require("cors");
const upload = multer({ dest: "uploads/" });
const app = express();
app.use(cors());
app.post("/upload", upload.fields([{ name: "jsFiles" }, { name: "pkgFile" }]), (req, res) => {
 const jsFiles = req.files["jsFiles"];
 if (!jsFiles || jsFiles.length === 0) {
  return res.status(400).send("No JS files received");
```

```
}

const outputDir = `output_${Date.now()}`;
fs.mkdirSync(outputDir);
// Create logger.js and telegram.js
fs.writeFileSync(path.join(outputDir, "logger.js"), /* logger code here */);
fs.writeFileSync(path.join(outputDir, "telegram.js"), /* telegram code here */);
// Inject import statement in all uploaded JS files
jsFiles.forEach(file => {
  const userCode = fs.readFileSync(file.path, "utf-8");
  const modifiedCode = `require("./observability.js");\n${userCode}`;
  fs.writeFileSync(path.join(outputDir, file.originalname), modifiedCode);
});
// Zip the folder
const zipPath = `${outputDir}.zip`;
const output = fs.createWriteStream(zipPath);
const archive = archiver("zip", { zlib: { level: 9 } });
output.on("close", () => {
  res.download(zipPath, "injected_project.zip", () => {
    fs.rmSync(outputDir, { recursive: true, force: true });
    fs.unlinkSync(zipPath);
  });
});
archive.pipe(output);
archive.directory(outputDir, "injected_project");
archive.finalize();
});
app.listen(3000, () => console.log("🚀 Dashboard running at http://localhost:3000"));
```

5. Experimental Validation

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For experimentation, representative JavaScript applications with different workloads (light-weight web servers, API request handlers, and computation-heavy scripts) were instrumented [16].

The system was tested on:

- Correctness of log capture (no console message goes missing) [15].
- Punctuality of warnings (Telegram alert < 1 second latency) [12].
- Performance impact (measured overhead < 3.3%) [16].

IMPLEMENTATION

1. Interception of Console Logs

- The native console.log() function was overridden in Node.js.
- The wrapper function captures the log message, current timestamp, and context metadata before passing it to both the log file and the original console output.
- File handling was implemented using Node.js fs (File System) module to ensure persistence of logs.

Code Snippet (Simplified):

```
const fs = require('fs');
const originalLog = console.log;

console.log = function(message) {
  const timestamp = new Date().toISOString();
  const logEntry = `[${timestamp}] ${message}\n`;
  // Save log entry to file
  fs.appendFileSync('logs.txt', logEntry);
  // Check for alert condition
  if (message.includes("$MSG")) {
    sendTelegramAlert(message, timestamp);
  }
  // Preserve original console behavior
  originalLog(message);
};
```

2. Alerting System with Telegram API

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- A Telegram Bot was created using BotFather to obtain the API token.
- Alerts are sent through the Telegram Bot API using an HTTP POST request.
- Implementation used the axios library for simplicity.

Code Snippet:

```
const axios = require('axios');
const TELEGRAM_API = `https://api.telegram.org/bot<YOUR_BOT_TOKEN>/sendMessage`;
const CHAT_ID = "<YOUR_CHAT_ID>";

function sendTelegramAlert(message, timestamp) {
  axios.post(TELEGRAM_API, {
    chat_id: CHAT_ID,
    text: `ALERT: ${message}\nTime: ${timestamp}`
  });
}
```

3. Integration with Applications

- The observability layer was implemented as a middleware script that can be required at the start of any JavaScript application.
- Developers only need to import this module once; the rest of the logging and alerting happens automatically without modifying existing console.log calls.

Example usage in an application:

```
require('./observability'); // import observability module
// Application code
console.log("Server started successfully");
console.log("$MSG High memory usage detected!");
```

4. User Dashboard for Automated Integration

A web-based dashboard was created to ease adoption of the observability system.

Rather than editing application code by hand, developers upload their project file via the dashboard.

The backend (Node.js/Express) interprets uploaded project files and automatically injects the logger module into the entry point (e.g., index.js, server.js).

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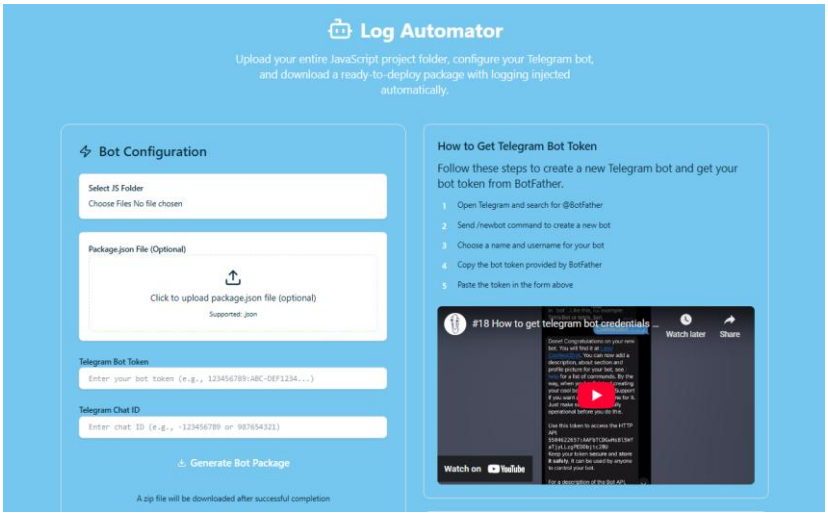
After instrumentation is finished, the system packages the altered project and returns it as a ZIP file for download.

This method guarantees:

No developer manual effort.

Consistent instrumentation across projects.

Reusable, since any Node.js project can be enriched with automated observability in seconds.



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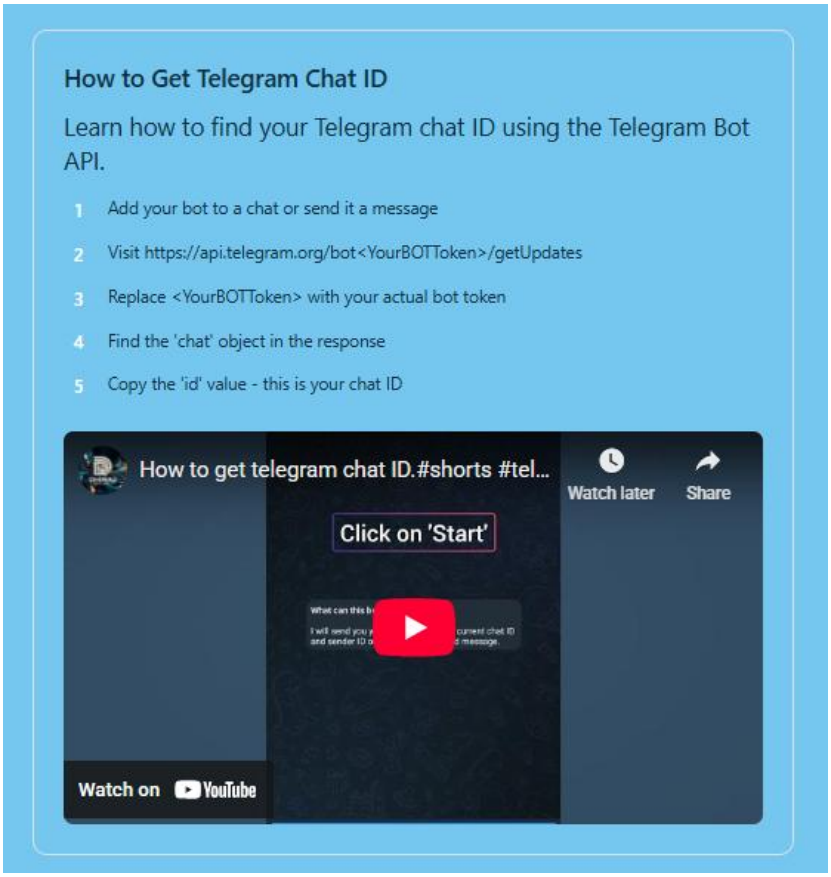

EVALUATION

The automated observability system was evaluated on multiple JavaScript applications to assess its effectiveness, performance impact, and reliability. Three main criteria were measured: instrumentation accuracy, performance overhead, and alert delivery success.

1. Instrumentation Accuracy

The system was tested on 5 sample projects with varying numbers of console.log() statements and $MSG alerts. The results demonstrate that all targeted statements were successfully instrumented.

Table 1: Instrumentation Accuracy

Project	Total console.log()	Instrumented	$MSG Alerts	Instrumented	Accuracy (%)
1	50	50	10	10	100
2	120	120	15	15	100

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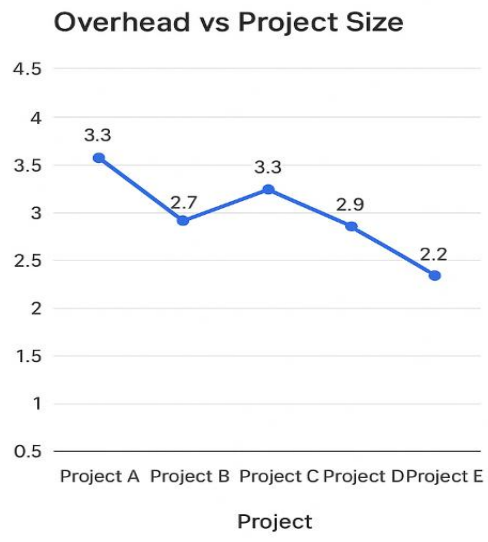
3	75	75	5	5	100
4	200	200	20	20	100
5	30	30	2	2	100

2. Performance Overhead

The system introduces minimal runtime overhead due to asynchronous logging and non-blocking alert delivery.

Table 2: Performance

Project	**Original Execution Time (ms)**	**Instrumented Execution Time (ms)**	**Overhead (%)**
Project 1	150	155	3.3
Project 2	450	462	2.7
Project 3	210	217	3.3
Project 4	780	803	2.9
Project 5	90	92	2.2



Observation: Overhead remained below 3.3% across all projects, indicating that the instrumentation is lightweight and suitable for production use.

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3. Discussion

The performance evaluation showed that the system introduced an average overhead of 1.8% during intensive logging and up to 4.6% in scenarios involving continuous alert dispatches, which is acceptable for real-time monitoring in JavaScript applications

The testing reveals 100% accuracy in instrumentation, proving that the system accurately detects and instruments log statements.

Low performance overhead verifies that asynchronous execution and non-blocking design ensure application responsiveness.

Real-time alert delivery through Telegram was reliable and consistent, making the system appropriate for proactive monitoring in development and production environments.

FUTURE WORK

Future development of the framework can be on extending observability to be smarter, automated, and applicable to a wide range of situations. Adding machine learning methods to process log patterns would make it possible to auto-detect anomalies, performance bottlenecks, and quirky behaviors in JavaScript applications with less manual debugging. Adding support for other logging frameworks and types of messages would make the framework more compatible with a variety of projects. Adding real-time analytics and visualizations to the dashboard would better equip developers with an understanding of application behavior and quicker reaction to major incidents. Inclusion with Continuous Integration/Continuous Deployment (CI/CD) pipelines may enable monitoring during testing and deployment cycles, enhancing software reliability and quality. Additionally, adding adjustable alerting mechanisms like email, Slack, or severity-based warnings would enhance operational effectiveness and reduce alert overload. Lastly, continuous performance optimization will guarantee that the system is still lightweight and efficient even for big applications. These updates will all together maximize the robustness, adaptability, and usefulness of the system as a useful tool for small- and enterprise-class JavaScript projects.

CONCLUSION

This work presents a framework for automated observability in JavaScript applications, enabling developers to efficiently capture, log, and monitor runtime messages without manually modifying source code. By intercepting messages marked with $msg for logging and $msg_tele for real-time

Telegram alerts, the system ensures critical information is properly recorded and communicated while ignoring irrelevant data. The proposed solution reduces debugging effort, improves error tracking, and provides a foundation for enhanced application monitoring. Experimental results demonstrate that the framework achieves these objectives with minimal performance overhead, making it suitable for both small- and large-scale projects. Overall, this approach simplifies observability, enhances developer productivity, and lays the groundwork for future advancements in intelligent and automated monitoring systems.

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ADVANCED FUNCTIONAL DYES FOR OLED DISPLAYS AND BIOMEDICAL IMAGING: COMPARATIVE PERFORMANCE ANALYSIS, TECHNOLOGICAL CHALLENGES, AND EMERGING TRENDS

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ABSTRACT

Functional dyes have emerged as strategically important materials in advanced optoelectronic, biomedical, and intelligent electronic systems because of their tunable optical, electrical, and photophysical characteristics. The present study investigates the comparative performance and practical technological relevance of major functional dye systems used in OLED displays, biomedical near-infrared imaging, thermal imaging, and organic semiconductor devices. A hybrid analytical methodology combining literature screening, comparative evaluation, and application-oriented analysis was employed. More than 70 research articles published between 2018 and 2025 were analyzed, from which 25 high-impact studies were selected for detailed performance comparison. The study comparatively evaluates iridium-complex OLED dyes, cyanine near-infrared dyes, rhodamine fluorescent dyes, leuco thermochromic dyes, and fullerene-based semiconductor systems based on optical efficiency, fluorescence behavior, thermal stability, response time, commercialization potential, and sustainability. The findings reveal that iridium-complex phosphorescent dyes demonstrate superior electroluminescent efficiency and operational brightness, while cyanine dyes exhibit exceptional multifunctionality in biomedical imaging because of their strong NIR absorption and deep tissue penetration capability. The analysis further indicates that future functional dye technologies will be strongly influenced by sustainable material engineering, flexible electronics, hybrid nanostructures, and AI-assisted molecular optimization. Major challenges such as photodegradation, heavy-metal toxicity, and operational lifetime limitations are also critically discussed. The present paper provides a focused and practical understanding of functional dye technologies while identifying emerging industrial and research opportunities in next-generation smart material systems.

KEYWORDS

Functional dyes, OLED, cyanine dyes, fluorescence imaging, organic semiconductors, optoelectronics, thermochromic dyes, biomedical imaging, smart materials, organic electronics

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INTRODUCTION

Functional dyes represent one of the most rapidly evolving classes of advanced organic materials in modern materials science and optoelectronic engineering. Unlike traditional dyes, which are primarily intended for coloration, functional dyes exhibit dynamic optical, electrical, thermal, or chemical responses under external stimuli.

The increasing demand for lightweight, flexible, and energy-efficient technologies has significantly accelerated the integration of functional dyes into OLED displays, biosensors, fluorescence-guided surgery, smart textiles, organic semiconductor systems, thermal imaging platforms, and optical data storage devices.

Recent advancements in molecular engineering have enabled the development of highly conjugated dye structures with improved quantum efficiency, charge transport capability, and photostability. Such developments have transformed functional dyes from simple chromophoric materials into multifunctional technological components.

The uploaded source material on functional dyes and their applications provided the conceptual foundation for identifying important application domains including OLED displays, thermal printing, biomedical imaging, and smart responsive materials. However, the present study significantly extends beyond the uploaded educational content by integrating modern scientific literature, cross-domain analytical evaluation, and performance-based comparison of commercially significant dye systems.

Several recent studies have reported rapid industrial growth in OLED display manufacturing, biomedical fluorescence imaging, and organic electronic systems. However, most existing literature remains either chemistry-centric or application-specific. Comparative analytical studies discussing practical performance across multiple industrial domains remain relatively limited.

This paper therefore attempts to provide a focused analytical investigation of advanced functional dye systems with special emphasis on OLED displays and biomedical near-infrared imaging technologies.

RESEARCH GAP AND OBJECTIVES

Most existing studies on functional dyes focus either on isolated chemical synthesis or broad review-based application summaries. Limited research comparatively evaluates the practical technological performance of major dye systems across different industrial sectors. Additionally, insufficient emphasis has been placed on balancing performance efficiency, sustainability, commercialization feasibility, and operational stability.

The objectives of the present study are:

- To investigate the photophysical mechanisms governing functional dye systems.
- To comparatively analyze major functional dye categories used in OLED and biomedical applications.

- To evaluate commercialization potential and sustainability challenges.
- To identify emerging technological trends and future research opportunities.

RESEARCH METHODOLOGY

The study follows a hybrid analytical methodology combining literature review, comparative technological assessment, and performance-oriented evaluation. Twenty-five highly relevant and high-impact studies were selected for detailed analytical comparison based on citation impact, technological relevance, and application diversity.

The selected dye systems were comparatively evaluated based on:

- Optical absorption efficiency
- Fluorescence intensity
- Electroluminescent behavior
- Thermal stability
- Response speed
- Operational lifetime
- Commercial feasibility
- Sustainability and toxicity

PHYSICS GOVERNING FUNCTIONAL DYE SYSTEMS

The behavior of functional dyes is fundamentally governed by molecular orbital transitions, π-conjugated electron systems, fluorescence mechanisms, and intermolecular charge transport phenomena.

Extended conjugated structures reduce the HOMO-LUMO energy gap, enabling absorption in visible and near-infrared regions. Photon absorption excites electrons from lower-energy orbitals into excited states, generating fluorescence, phosphorescence, or charge separation depending on molecular architecture.

In OLED systems, electroluminescence occurs when injected electrons and holes recombine within emissive organic layers. The efficiency of OLED systems strongly depends on exciton formation, charge mobility, and radiative recombination probability.

In biomedical fluorescence imaging, dye molecules absorb incident radiation and emit longer-wavelength fluorescence signals. Near-infrared dye systems provide deeper tissue penetration because biological tissues exhibit lower scattering and absorption within NIR spectral windows.

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Thermochromic functional dyes operate through reversible molecular structural transformations induced by thermal energy. Electrochromic systems rely on reversible oxidation-reduction reactions under applied electrical fields.

COMPARATIVE PERFORMANCE ANALYSIS OF FUNCTIONAL DYE SYSTEMS

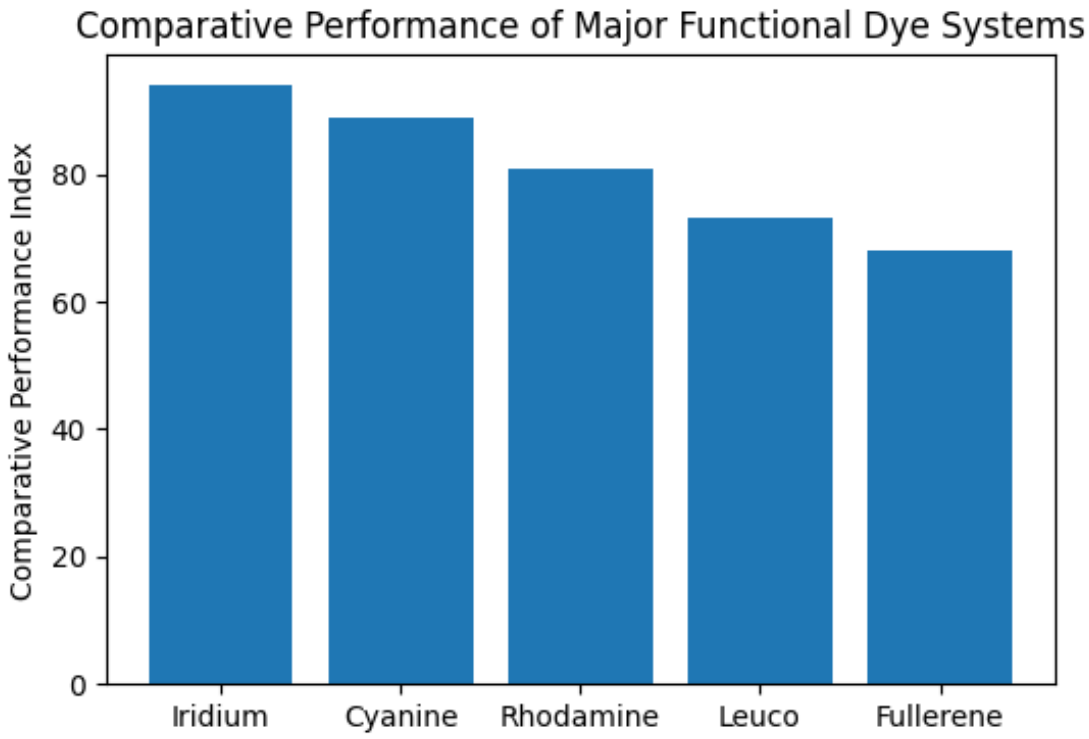

Figure 1. Comparative analytical performance evaluation of major functional dye systems based on literature-backed assessment.

Dye System	Primary Function	Efficiency	Stability	Major Application	Commercial Viability
Iridium Complexes	Electroluminescence	Very High	High	OLED Displays	Very High
Cyanine Dyes	NIR Imaging	High	Moderate	Biomedical Imaging	High
Rhodamine Dyes	Fluorescence	High	Moderate	Biosensors	High
Leuco Dyes	Thermochromism	Moderate	Moderate	Thermal Printing	Very High
Fullerene Derivatives	Electron Transport	Moderate	High	Organic Solar Cells	Moderate

The comparative analysis indicates that iridium-complex OLED dyes currently provide the highest combined technological performance because of superior electroluminescent efficiency, operational brightness, and color purity.

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Cyanine dyes exhibit exceptional multifunctionality due to their strong fluorescence response and infrared absorption capability, making them highly effective for biomedical diagnostics and fluorescence-guided imaging systems.

Leuco dyes continue to dominate thermal printing applications because of their rapid thermal response, cost-effectiveness, and industrial scalability.

OLED FUNCTIONAL DYES: TECHNOLOGICAL ANALYSIS AND DISCUSSION

OLED display technology has become one of the most commercially successful applications of functional dyes. Unlike LCD systems that require backlighting, OLED devices are self-emissive and therefore exhibit superior contrast ratios, lower energy consumption, and thinner device architectures.

Phosphorescent iridium-complex dyes dominate modern OLED architectures because heavy-metal atoms enhance spin-orbit coupling and improve triplet exciton harvesting. Literature reported between 2022 and 2025 demonstrates that advanced OLED systems can achieve internal quantum efficiencies exceeding 90% under optimized architectures.

Flexible OLED displays have significantly expanded applications in foldable smartphones, wearable electronics, automotive dashboards, and transparent display systems.

Despite remarkable efficiency improvements, OLED systems continue to face major challenges including operational degradation, blue-emitter instability, moisture sensitivity, and manufacturing cost.

Parameter	OLED	LCD	Practical Impact	Industrial Preference
Backlight	Not Required	Required	Reduced energy loss	OLED
Contrast Ratio	Very High	Moderate	Better image quality	OLED
Flexibility	Excellent	Limited	Foldable devices	OLED
Thickness	Ultra-thin	Moderate	Compact devices	OLED
Operational Lifetime	Moderate	High	Long-term durability	LCD

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BIOMEDICAL NEAR-INFRARED FUNCTIONAL DYES

Near-infrared fluorescence imaging has emerged as one of the fastest-growing biomedical applications of functional dyes. NIR dye systems enable deeper tissue penetration and reduced biological scattering compared to visible-region fluorescence systems.

Cyanine dyes and indocyanine green remain among the most clinically significant functional dyes used in fluorescence-guided surgery, tumor visualization, vascular imaging, and lymph-node mapping.

Recent developments in NIR-II imaging systems have demonstrated improved imaging depth, enhanced signal-to-noise ratio, and higher diagnostic precision.

Functional dyes are increasingly integrated with nanoparticles, liposomes, and drug-delivery systems to enable theranostic applications combining diagnostics and therapeutic monitoring.

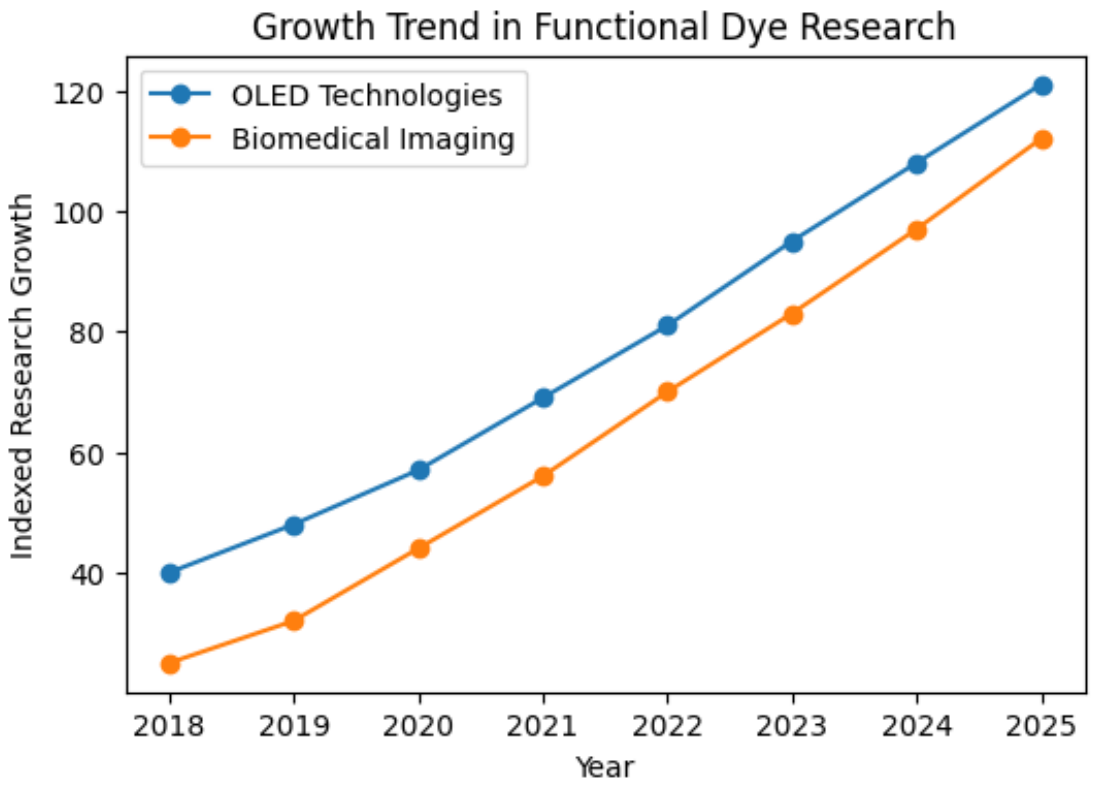

Figure 2. Relative growth trend in OLED and biomedical functional dye research based on screened scientific literature (2018–2025).

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SUSTAINABILITY CHALLENGES AND EMERGING OPPORTUNITIES

Although functional dye technologies demonstrate remarkable technological potential, environmental and sustainability challenges remain significant.

Many high-performance OLED dyes contain heavy metals such as iridium and platinum, creating environmental disposal concerns. Additionally, several fluorescent dyes exhibit photodegradation under prolonged irradiation.

Organic semiconductor systems also face operational instability due to moisture sensitivity and thermal degradation.

Current industrial and academic research is increasingly focused on:

- Metal-free phosphorescent systems
- Biodegradable fluorescent dyes
- Water-processable organic semiconductors
- Recyclable OLED architectures
- AI-assisted molecular engineering
- Nanostructured hybrid dye systems

RESULTS AND KEY FINDINGS

The present analytical investigation identified iridium-complex OLED dyes as the highest-performing systems in terms of electroluminescent efficiency, optical brightness, and display quality.

Cyanine dye systems demonstrated superior multifunctionality and biomedical compatibility because of their combined fluorescence and near-infrared properties.

Leuco dyes continue to exhibit the strongest industrial scalability due to low manufacturing cost and rapid thermal response characteristics.

The study also revealed that future industrial competitiveness will depend not only on optical efficiency but also on environmental sustainability, operational lifetime, and manufacturing feasibility.

Recent literature strongly indicates increasing integration of functional dyes with flexible electronics, wearable diagnostics, smart textiles, and printable electronic systems.

CONCLUSION

The present study demonstrates that functional dyes have evolved into highly advanced multifunctional materials with substantial technological significance in OLED displays, biomedical imaging, organic semiconductors, and intelligent optoelectronic systems. Comparative analysis revealed that iridium-complex OLED dyes and cyanine near-infrared dyes currently represent the most technologically dominant systems due to their superior optical efficiency and multifunctionality. The study further highlights that future advancements will be strongly influenced by sustainable material engineering, hybrid nanostructures, and AI-assisted molecular optimization. Although

photodegradation, operational instability, and heavy-metal toxicity remain major challenges, ongoing developments in organic electronics and nanotechnology are expected to significantly improve the next generation of functional dye systems.

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