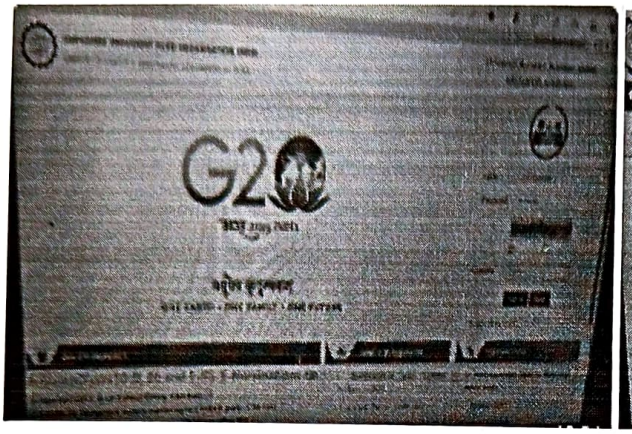
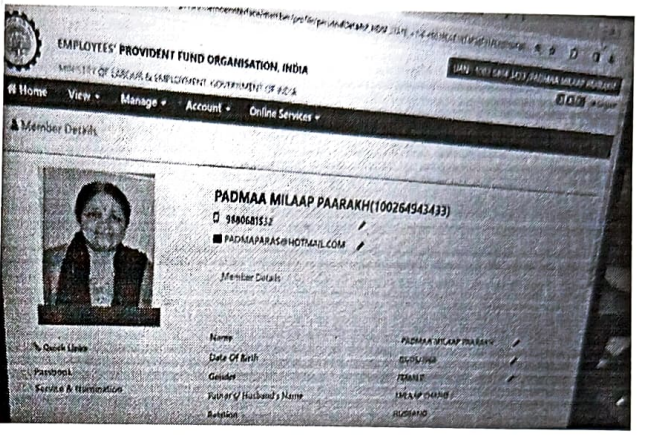
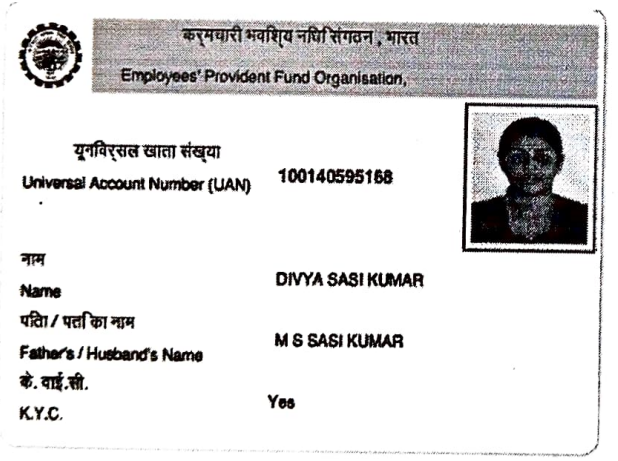
Screenshots of EPF login page







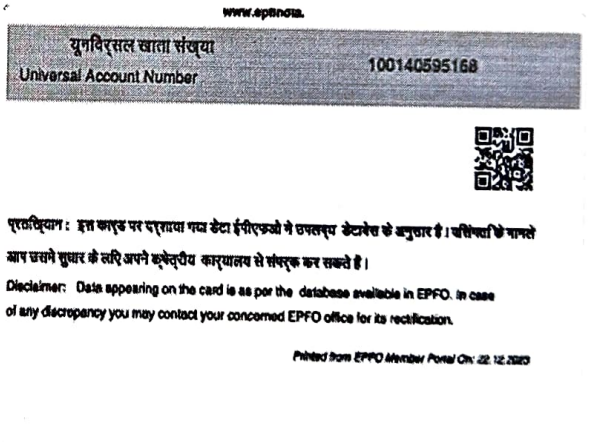
कर्मचारी भविष्य निधि संगठन , भारत
Employees' Provident Fund Organisation,

यूनिवर्सल खाता संख्या
Universal Account Number (UAN) 100140595168

नाम
Name DIVYA SASI KUMAR

पिता / पति का नाम
Father's / Husband's Name M S SASI KUMAR

के. वाई.सी.
K.Y.C. Yes



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Universal Account Number 100140595168

प्रतिक्रिया : इस कार्ड पर दर्शाया गया डेटा ईपीएफओ में उपलब्ध डेटाबेस के अनुसार है। विसंगति के मामले आप उसमें सुधार के लिए अपने क्षेत्रीय कार्यालय से संपर्क कर सकते हैं।

Disclaimer: Data appearing on the card is as per the database available in EPFO. In case of any discrepancy you may contact your concerned EPFO office for its rectification.

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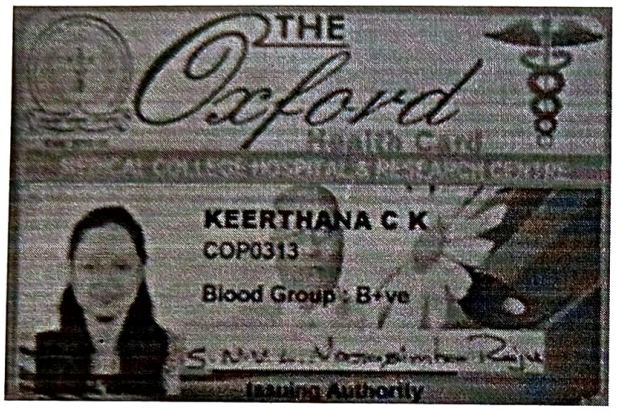
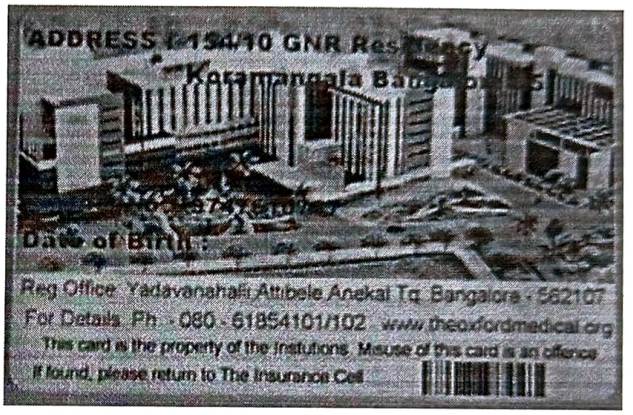
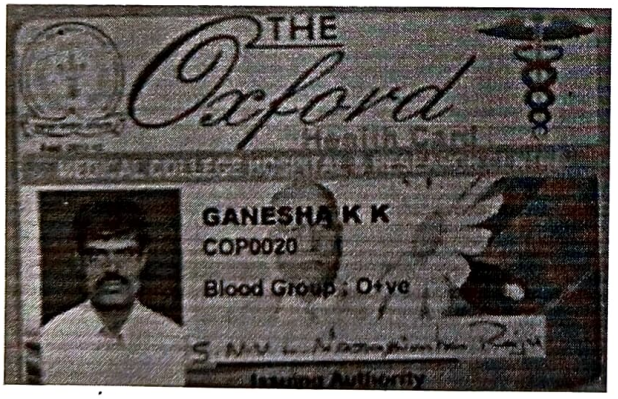
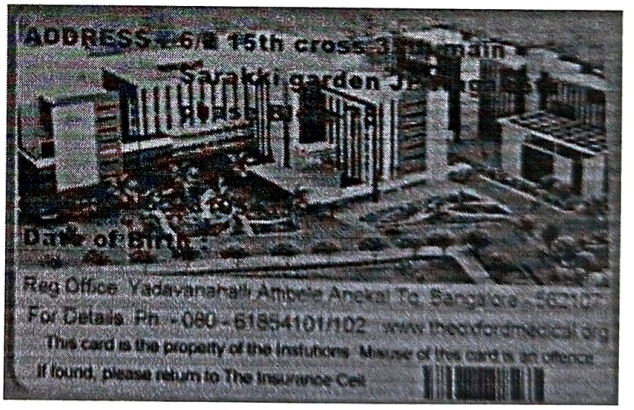
Health Card Details









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The Oxford College of Pharmacy

(Recognised by the Govt. of Karnataka, Affiliated to Rajiv Gandhi University of Health Sciences, Karnataka;
Approved by Pharmacy Council of India, New Delhi)

Ref No: TOCP/MOM/2023-2024/37

Date: 02/02/2024

NOTICE

This is here to inform you that all the HODs and faculty members of the Oxford College of Pharmacy are advised to attend the staff meeting in the Board Room, TOCP, on 03/02/2024 at 12:40 PM

Agenda:

1. Review the agenda of the previous MOM and action taken report.
2. Proposed research activities by the concerned department to be organized
3. Review of a short-term proposal for submitting for RGUHS grant.
4. Discussion on developing a concept bank, including faculty competency to apply for extramural funding.
5. Review of proposals for intramural seed money grant.
6. Discussion on upcoming IPR seminars and RM workshops.
7. Discussion on launching the Oxford College of Pharmacy journal with ISSN and submitting it to UGC for enrollment into UGC care list.
8. Discussion on constituting a scientific advisory committee to evaluate UG, PG, and Pharm.D research proposals.

Member Secretary

P. Padma
Chairperson R&D
PRINCIPAL
The Oxford College Of Pharmacy
No 6/9, 1st Cross, Begur Road, Hongasandra
Bangalore - 560 068

Cc:

1. IQAC
2. Office
3. All department HOD's

No.6/9, 1st Cross, Begur Road, Hongasandra, Bengaluru –560 068
☎: +91- 80 - 61754694; Fax: +91- 80 -61754699; www.theoxford.edu
e-mail: pharmacyprincipal@theoxford.edu; info@theoxford.edu;

MINUTES OF THE MEETING 2023-24

Date: 03.02.2024

Time:01.00PM

Venue: Board Room, TOCP

Meeting No.	37
	2023-2024

Agenda:

1. Review the agenda of the previous MOM and action taken report.
2. Proposed research activities by the concerned department to be organized
3. Review of a short-term proposal for submitting for RGUHS grant.
4. Discussion on developing a concept bank, including faculty competency to apply for extramural funding.
5. Review of proposals for intramural seed money grant.
6. Discussion on upcoming IPR seminars and RM workshops.
7. Discussion on launching the Oxford College of Pharmacy journal with ISSN and submitting it to UGC for enrollment into UGC care list.
8. Discussion on constituting a scientific advisory committee to evaluate UG, PG, and Pharm.D research proposals.

Committee members presented.

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson R&D	P. Padmaa
2	Dr. A.Muthukumar	Member Secretary	A. Muthu
3	Dr. Gururaj. S. Kulkarni	Member	
4	Dr. G. Parthasarathy	Member	
5	Dr. Jyoti Shrivastava	Member	
6	Dr. Noopur Srivastava	Member	Srivastava

The Oxford College of Pharmacy's R&D Committee meeting for the academic year 2023-2024 was held at 1:00 PM and presided over by Dr. Padmaa M. Paarakh. The chairperson welcomed all the members, and the agenda was discussed.

Agenda 1: Review of Agenda of previous MOM and Action taken report

- The member secretary presented the R&D committee's action taken report to the committee members. The committee members suggested to complete all ongoing activities within the defined timelines.

Resolution

The committee members approved the MOM and action taken status of the previous R&D minutes.

Agenda 2: Proposed research activities by concern department to be organized

- The chairperson of R&D has informed all HODs and faculty members to publish one research article per semester and organize ICMR, RGUHS, and APTI-funded conferences, workshops, and FDP programs.

Resolution

It is resolved that faculty members should publish one research article per semester in indexed journals and to undergo planned research workshops.

Agenda 3: Review of short-term proposal for submitting for RGUHS grant.

- During the "R&D Proposal Review" meeting, the chairperson inquired about the status of the RGUHS UG short-term project received in the previous year.
- The chairperson has instructed faculty members to prepare and submit short-term UG proposals to the scrutiny committee before 20th February 2024.
- The committee suggested encouraging student research projects that align with institution guidelines, focusing on innovative ideas to advance pharmacy professional practice in health care.

Resolution

- *It was resolved that all the proposals be reviewed and selected based on merit relevance, practicality, and impact to be submitted to the RGUHS grant.*

Agenda 4: Discussion on developing a concept bank, including faculty competency to apply for extramural funding.

It was discussed that a concept bank for faculty should be developed in line with faculty competency, as the same would facilitate submitting proposals for extramural grants.

Resolution

It is resolved that the members applauded the proposal to develop a concept bank and suggested proceeding immediately.

Agenda 5: Review of proposals for intramural seed money grant.

- The committee members were briefed on the proposal review status of the projects eligible for submission to the institution's grant seed money scheme.

Resolution

It is resolved the projects are to be selected based on a multidisciplinary approach with impact. It is further resolved the selected proposals should have practical applicability, sustainability, and scope for scalability, as the same shell facilitates the nurturing of research acumen among students and faculty.

Agenda 6: Discussion on upcoming IPR seminars and RM workshops.

- The R&D team discussed the upcoming workshops and conferences for the next quarter. Key discussion points included identifying potential themes and speakers and targeting the audience to facilitate research acumen.

Resolution

It was resolved that the workshops shortlist target both early-career researchers and experienced faculty members, aiming to bridge the gap in knowledge around these critical areas.

Agenda 7: Discussion on launching the Oxford College of Pharmacy journal with ISSN and submitting it to UGC for enrollment into UGC care list.

- The discussion revolved around the importance of having a dedicated journal for the college, the benefits of obtaining an ISSN (International Standard Serial Number), and the significance of being listed in the UGC (University Grants Commission) care list discussed in detail.

Resolution

After a thorough discussion, it was resolved to launch the Oxford College of Pharmacy journal with an ISSN. Obtaining UGC indexing is crucial for enhancing the college's academic reputation, providing a platform for faculty and students to publish their research, and contributing to the knowledge in the field of pharmacy.

Agenda 8: Discussion on constituting a scientific advisory committee to evaluate UG, PG, and Pharm.D research proposals.

- During the meeting, the chairperson and members discussed the need to constitute a scientific advisory committee to evaluate undergraduate (UG), postgraduate (PG), and Pharm. D research proposals.
- The discussion highlighted the crucial role of a scientific advisory committee in ensuring the quality and validity of the research proposals submitted by students, underscoring the value of each member's contribution to the research oversight process.

Resolution:

- ***It was resolved to form a scientific advisory committee.***
- ***This scientific advisory committee, comprising experienced faculty members, will evaluate and provide feedback on UG, PG, and Pharm.D research proposals.***

The committee members also decided to schedule a review meeting every quarter of the academic year. Finally, the Member secretary of R&D proposed a vote of thanks and concluded the meeting.

Date: 05.02.2024

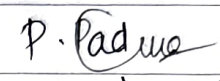
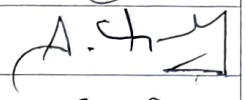
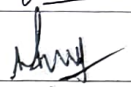
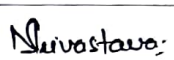
ACTION TAKEN REPORT-2023-24

S. No	Resolution	Action Taken	Status
1	The committee members approved the MOM and action taken status of the previous R&D minutes.	At the previous Research and Development (R&D) meeting, the committee members reviewed and approved the Minutes of Meeting (MOM) as well as the action taken report.	All members expressed satisfaction with the work done.
2	It is resolved that faculty members should publish one research article per semester in indexed journals and to undergo planned research workshops.	The HODs and faculty members have been informed about the research publications. They have been encouraged to contribute to research activities. The member secretary has also provided support and guidance to the faculty members regarding review and research publication guidelines. The faculty members were encouraged to submit research proposals and organize conferences, workshops, and FDP.	The faculty members' active engagement in research activities, in response to the Chairperson's R&D advice, is a testament to their dedication and commitment to enhancing the institution's research culture. The faculty members have taken up the challenge and submitted proposals for research and development activities. With the implementation of the university and institution guidelines and the positive response from the faculty members, the institution is expected to see an increase in research output and participation in conferences and workshops.
3	It was resolved to review all the proposals and select the proposals based on merit relevance,	The action taken was that the team had already compiled the final report,	The status of the agenda was marked as complete, pending submission of the final report to the university.

	practicality, and impact same to be submitted to RGUHS grant.	and the guide was currently reviewing it. The Chairperson of R&D advised junior faculty members to submit short-term project proposals to the scrutiny committee before 20th February 2024.	The scrutiny committee reviews the proposals, selects five projects from all departments, and forwards them to the R&D committee and the head of the institution for application for RGUHS grants.
4	It is resolved that the members applauded the proposal to develop a concept bank and suggested proceeding immediately.	A task force with members from various departments was created to develop the concept notebook, focusing on a multidisciplinary approach.	Workshop and training plans are being prepared for launch next quarter. Collaboration with external experts is progressing, and several contributors are interested in the concept notebook. The project is on schedule, and updates will follow in upcoming meetings.
5	It is resolved that the projects will be selected based on a multidisciplinary approach with impact. It is further resolved that the selected proposals should have practical applicability, sustainability, and scope for scalability, as the same shell facilitates the nurturing of research acumen among students and faculty.	The Scrutiny members were assigned a set of projects to review, with a standardized scoring system to rate each project. After individual assessments, the committee reconvened to discuss and consolidate scores, ensuring a transparent and collective decision-making process.	The scrutiny committee reviewed 9 projects from all departments and forwarded them to the R&D committee and the head of the institution for application for grant seed money.
6	It was resolved that the workshops shortlist target both early-career researchers and experienced faculty members, aiming to bridge the gap in knowledge around these critical areas.	The organizing committee started crafting a strategy to promote the events, targeting social media, industry newsletters, and partnership announcements.	The committee intends to build on previous achievements for the upcoming Intellectual Property Rights (IPR) workshop, which the various departments in TOCP will organize on the 10th and 13th of February 2024, the 16th and 26th of April 2024, and 4th of May 2024. The

			Pharmacy Practice will organize the entrepreneurship workshop on 9th March 2024.
7	After a thorough discussion, it was resolved to launch the Oxford College of Pharmacy journal with an ISSN, and obtaining UGC indexing is crucial for enhancing the college's academic reputation, providing a platform for faculty and students to publish their research, and contributing to the knowledge in the field of pharmacy.	A committee comprising faculty members and administrative staff was formed to oversee the launch of the journal with an ISSN and obtaining UGC indexing. The committee was tasked with setting up the editorial board, establishing the submission and review process, and ensuring that the journal meets the necessary criteria for ISSN and UGC indexing.	As of the last update, the committee has made significant progress in setting up the journal's infrastructure.
8	It was resolved to form a scientific advisory committee. This scientific advisory committee, comprising experienced faculty members, will evaluate and provide feedback on UG, PG, and Pharm.D research proposals.	The chairperson advised the R&D committee to initiate the process of identifying potential faculty members for the scientific advisory committee based on their qualifications and research competency.	The process of constituting a scientific advisory committee is underway. The identified faculty members have been approached, and their interest and willingness to serve on the committee are being confirmed. The agenda's status is progressing positively, and updates will be provided in the upcoming meetings.

Committee members

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson R&D	
2	Dr. A.Muthukumar	Member Secretary	
3	Dr. Gururaj. S. Kulkarni	Member	
4	Dr. G. Parthasarathy	Member	
5	Dr. Jyoti Shrivastava	Member	
6	Dr. Noopur Srivastava	Member	

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The Oxford College of Pharmacy
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Approved by Pharmacy Council of India, New Delhi)

Ref No: TOCP/MOM/2023-2024/38

Date: 20/07/2024

NOTICE

This is here to inform you that all the HODs and faculty members of the Oxford College of Pharmacy are advised to attend the staff meeting in the Board Room, TOCP, on 27/07/2024 at 12:40 PM

Agenda:

1. Review the agenda of the previous MOM and action taken report.
2. Discussion of RGUHS-approved short-term grant status.
3. Review of concept note bank development inline with faculty competency.
4. Discussion on feedback, the impact of completed RM, IPR, and FDP conferences, and discussion on planned events for next quarter.
5. Discussion on reconstituting the committee members

Member Secretary

P. Padma
Chairperson R&D

PRINCIPAL
The Oxford College Of Pharmacy
No 6\9, 1st Cross, Begur Road, Hongasandra
Bangalore - 560 068

Copy to:

1. IQAC
2. Office
3. All Department HODs

MINUTES OF THE MEETING 2023-24

Date: 27.07.2024
Time:01.00PM
Venue: Board Room, TOCP

Meeting No.	**38**
	2023-2024

Agenda:

1. Review the agenda of the previous MOM and action taken report.
2. Discussion of RGUHS-approved short-term grant status.
3. Review of concept note bank development inline with faculty competency.
4. Discussion on feedback, the impact of completed RM, IPR, and FDP conferences, and discussion on planned events for next quarter.
5. Discussion on reconstituting the committee members

Committee members presented.

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson R&D	P. Padma
2	Dr. A.Muthukumar	Member Secretary	
3	Dr. Gururaj. S. Kulkarni	Member	
4	Dr. G. Parthasarathy	Member	
5	Dr. Noopur Srivastava	Member	

The Oxford College of Pharmacy's R&D Committee meeting for the academic year 20232024 was held at 1:00 PM and presided over by Dr. Padmaa M. Paarakh. The chairperson welcomed all the members, and the agenda was discussed.

Agenda 1: Review of Agenda of previous MOM and Action taken report

- The member secretary presented the action taken report of the Research Committee to committee members. The committee members suggested completing all the ongoing activities within the defined timelines.

Resolution

The committee members approved the MOM and the action report of previous R&D minutes.

Agenda 2: Discussion of RGUHS-approved student short-term project status

- The chairperson congratulates the guide and students who have received the short-term grant.
- The chairperson and member secretary have informed that students should complete the projects within a specified timeline.

Resolution

The committee discussed the status of RGUHS-approved student short-term projects and resolved to ensure that all projects adhere to the university's guidelines and requirements.

Agenda 3: Review of concept note bank development inline with faculty competency.

- The R&D Members emphasized the importance of ensuring that the bank development concept is built upon the specific competencies required by faculty.

Resolution

It is resolved that a comprehensive gap analysis of faculty competencies related to their current and future needs be conducted.

Agenda 4: Discussion on feedback, the impact of completed RM, IPR, and FDP conferences, and discussion on planned events for next quarter.

- The chairperson and members reviewed feedback from the RM, IPR, and FDP conferences.
- Plan is develop and propose dates have been given by the department

Resolution

It is resolved that feedback will be compiled for improvements, competency and insight will be addressed, and diverse topics will be prioritized for next quarter's events.

Agenda 5: Discussion on reconstituting the committee members

- The existing members will review potential candidates and evaluate their fit with the committee's goals.

Resolution

It was resolved that Dr. Mahesh would be appointed as a new member.

Date: 19.07.2024

ACTION TAKEN REPORT-2023-24

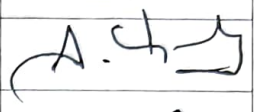
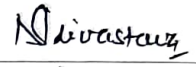
S. No	Resolution	Action Taken	Status
1	The committee members approved the MOM and the action report of previous R&D minutes.	At the previous Research and Development (R&D) meeting, the committee members reviewed and approved the Minutes of Meeting (MOM) and the action taken report.	All members expressed satisfaction with the work done.
2	It was resolved to develop university and institution guidelines for research activities to ensure clarity, practicability, and accessibility.	The committee discussed the status of RGUHS-approved student short-term projects and resolved to ensure that all projects adhere to the university's guidelines and requirements.	The status of the discussion and subsequent actions will be regularly monitored to ensure that all RGUHS-approved projects are progressing according to the university's standards.
3	It is resolved that a comprehensive gap analysis of faculty competencies related to their current and future needs be conducted.	The R&D committee has progressed on the concept note for bank development aligned with faculty competencies.	The committee is optimistic that the revised concept note will more accurately reflect the faculty's needs and competencies. The follow-up meeting will be crucial in finalizing the concept note for bank development before its submission for approval.
4	The chairperson and members reviewed feedback from the RM, IPR, and FDP conferences.	The committee scheduled regular seminars and workshops on RM and IPR to further educate and update the staff on these crucial areas. Additionally, external experts would be invited	The action points are currently being implemented, and the planning for the upcoming seminars on RM and IPR is underway. The committee is working on finalizing the dates and speakers for the next sessions to ensure the continuous professional

		to conduct specialized sessions for a more comprehensive understanding.	development of the staff in these areas.
5	It was resolved that Dr. Mahesh would be appointed as a new member	The chairperson was tasked with formally inviting Dr. Mahesh to join the committee and communicating this decision to the organization's members.	The committee is looking forward to Dr. Mahesh's contributions and expects that his addition will further strengthen the committee's effectiveness.

Committee members

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson R&D	P. Padma
2	Dr. A.Muthukumar	Member Secretary	A. Muthu
3	Dr. Gururaj. S. Kulkarni	Member	
4	Dr. G. Parthasarathy	Member	
5	Dr. Noopur Srivastava	Member	Srivastava

New Committee members

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson R&D	
2	Dr. A.Muthukumar	Member Secretary	
3	Dr. Gururaj. S. Kulkarni	Member	
4	Dr. G. Parthasarathy	Member	
5	Dr. Noopur Srivastava	Member	
6	Dr. A.R.Mahesh	Member	

Scientific Advisory Committee Members

S.No	Name of Members	Designation	Signature
1	Dr. Padmaa. M.Paarakh	Chairperson	
2	Dr. A. Muthukumar	Member Secretary	
3	Dr. G. Parthasarathy	Member	
4	Dr. Gururaj. S. Kulkarni	Member	
5	Dr. Noopur Srivastava	Member	
6	Dr. A.R.Mahesh	Member	
7	Special Invitee	Senior academician/ Researcher	

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Review Article

From Nature To Treatment: A Comprehensive Review Of Natural Polymers In Diabetes Mellitus Therapy

Sonali Milan Nalwade, Vikram T Choudhary*, Gururaj S Kulkarni,Padmaa M Paarakh, Muthukumar A

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ABSTRACT

Diabetes mellitus (DM) is among the most severe and fatal diseases which cannot be transmitted. Insulin is commonly administered in the management of diabetes. Hyperglycemia, or elevated blood sugar, is a complication of diabetes mellitus, a chronic illness that is complicated and results from insufficiencies in the production, functioning, or combination. Many biodegradable and non-biodegradable polymers are currently being studied; however, non-biodegradable polymers have drawbacks such as toxicity, evacuation challenges, and inability to produce persistent insulin release over time. The majority of naturally produced polymers are currently used just like excipients in pharmaceutical compositions since they are often thought to be relatively safe in vivo. Multiple natural polymers, including proteins and polysaccharides, have recently been extensively researched as potential insulin mediums. The study highlights a wide range of naturally occurring polymers, including chitosan, alginate, gelatin, casein, pectin, cyclodextrin, dextran, and starch, demonstrating great potential towards treatment for diabetes-related problems. The natural polymers used to treat diabetes mellitus have been the subject of the present investigation, which has been successful in displaying a wide range of benefits, including enhanced encapsulation performance, blood glucose optimization, more persistent drug delivery, and patient acceptability. Additionally, a number of benefits like affordability, sustainability, safety, and accessibility to everyone support the continual improvement of a potential polymer incorporated insulin delivery system. In this review article an attempt has been made to demonstrate the use of natural polymers in improving the effectiveness of anti-diabetic formulation.

INTRODUCTION

Diabetes mellitus (DM) has been recognized by man for over 2000 years1. Diabetes mellitus has been roughly pretentious to 451 million up until the present time.2 Diabetes mellitus, a chronic

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

lifelong metabolic condition, has reached frightening proportions as a major global health issue.3 According to the most recent International Diabetes Federation figures, The most current data from the International Diabetes Federation indicate that if appropriate attempts are not made to stop the epidemic, almost 5,78,000 individuals would be negatively impacted by twenty-third century. The count of individuals will have increased to an unbelievable seven hundred million by 2045.4 Diabetes mellitus is classified into four categories: Type 1 diabetes T1D, often called dependent upon insulin diabetes, is a chronic condition; Type 2 diabetes, more commonly referred to as non-insulin-dependent diabetic mellitus T2DM, Gestational diabetes & diabetes caused by genetic modification.5 T1D is caused by an insufficient amount of insulin and is associated with an autoimmune response. This illness was originally referred to as insulin-dependent diabetic mellitus IDDM until being reclassified based on etiopathology.6 T2DM is primarily caused by inadequate insulin production from cells in the context of insulin resistance. Insulin resistance occurs when insulin cannot be efficiently used by cells after it is generated by the pancreas.7 Gestational diabetes is described as any degree of glucose intolerance that is initially identified during pregnancy, resulting in hyperglycemia of variable severity.8 Diabetes caused by genetic mutations can induce diabetes mellitus, just as mutations in a single gene can cause monogenic diabetes. The most common kind of monogenic diabetes is neonatal diabetes.9 These are certain severe issues that are been driven on by worsening diabetes mellitus. This Analysis reveals that the sickness raises the likelihood of acquiring additional serious conditions such as impaired kidney function, cardiac arrest, stroke, loss of vision, and amputation of the leg below the knee. As you can see, people with diabetes often have other illnesses that are extremely serious on their own. Therefore, in order to keep diabetes from taking control of one's ability to maintain a stable quality of life, several factors that promote health must be understood.10 Individuals with type 1 diabetes require insulin throughout their lives. Insulin is not a treatment for diabetes, which puts individuals at risk for catastrophic consequences such as heart and kidney damage, as well as blindness.11 The treatments for type 2 diabetes are exogenous production sources of substitute β-cells, such as liver cells, stem cells that are pluripotent, donated mammalian pancreases, and fetus pancreatic tissue, are used as an additional therapy for type 2 diabetes. While the majority of exogenous supplies are heterologous with respect to the recipient, several include naturally occurring, for example stem cells that are derived from fibroblasts in the skin and blood from the umbilical cord.12 There are now several oral therapies for diabetes of the second type that are not insulin-based. SGLT2 inhibiting agents, amylin antagonists, incretin mimetics, biguanides, insulin sensitizers, and insulin secretagogues. Recently, incretin mimetics like DPP-IV inhibitors and GLP-1 antagonists, SGLT2 antagonists/inhibitors, amylin agonists, and alpha glucosidase blockers are the most recent medication classes utilized to treat type 2 diabetes.13 While several novel drug deliveries are also denoted by NDDSs are being studied to treat different illnesses, only a fewer number have been found to treat type 2 diabetes. The two elements of the Particulate structure are the Microparticulate and Nanoparticulate systems, as well as liposomes and niosomes in the vesicles systems and other therapies such as self-nano-emulsifying is also called SNEDDS.14 In additionally the antidiabetic formulation can be developed by encapsulating the active ingredient in ethosomes and phytosomes.

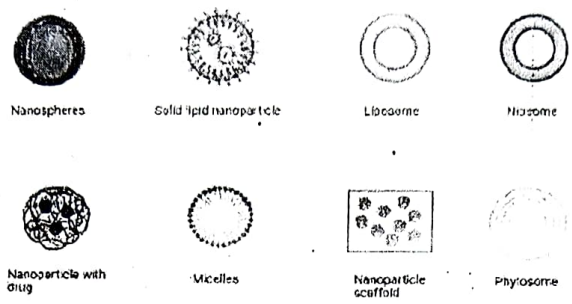

Figure 1: Current insight on anti-diabetic therapy: novel technologies (created with Biorender.com)

The life-style measures that can help in controlling blood-glucose levels: This information is based on several scientific investigations that shows modifying a person's routine can prevent or postpone the beginning of diabetes at a reduced cost, with a 58 percent decrease in threat after three years.15 The studies have shown significant improvement in controlling glycemic by preforming exercises and showed it can improve patients' general health and reduce the hemoglobin A1C significantly 0.66%, regardless of whether or not a significant decrease in body mass index is made.16 Moderate alcohol consumption like ≤2 drinks for men, ≤1 drink for women and intake of sodium to be reduced are other lifestyle measures that should be taken into account in the treatment plan for patients with diabetes, particularly in those who also have comorbid conditions like hypertension, habitual tobacco use, and a lack of immunizations like pneumococcal, hepatitis B, influenza, diphtheria, pertussis, tetanus, and tetanus.17 This review article highlights how the use of natural polymers enhances the anti-diabetic pharmaceuticals' effectiveness for delivery.

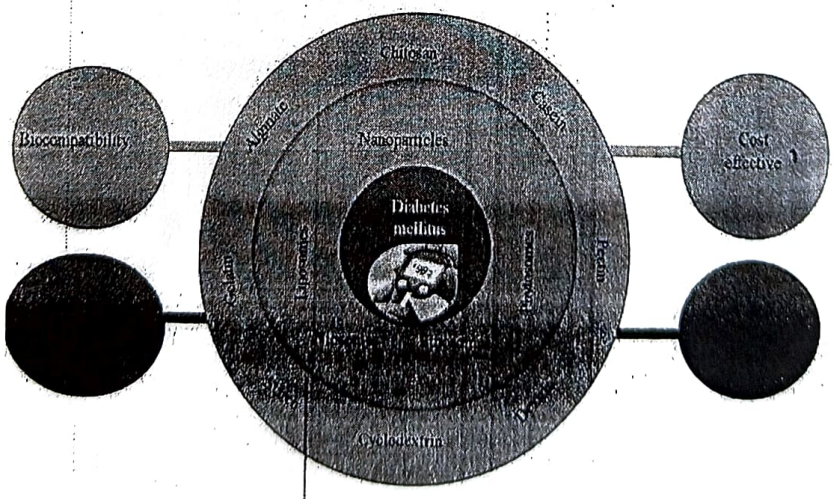

Figure 2: Natural polymers based on different novel deliveries and benefits of natural for the treatment of diabetes mellitus.

POLYMERS:

The importance of polymer science has grown over the past few decades as the potential for structural changes has improved. As polymer components come in numerous diverse forms, it is feasible to alter the physical and chemical features of nanoparticles, including entrapment efficiency, charge and customize them to maintain the stability of insulin, give an effective bioavailability, modulate the release nature, balance systems and modify biological activities.18 A polymeric substance is a large compound composed up of structural components that repeated or reoccur, commonly referred to as a macromolecule. Covalent chemical bonds are typically employed to join these subunits.19 There are two forms of polymers that can be used in employing anti-diabetic drug to improve the effectiveness in delivering the drug. They are natural and synthetic polymer.

Natural polymers:

The majority of natural polymers are now employed as excipients in pharmaceutical formulations as they have been demonstrated to be safe in vivo. Natural materials are preferable than artificial materials in terms of biocompatibility, accessibility, and modification ease. Additionally, as the original natural materials possess reactive groups, other functional groups may potentially be added to, offering the newly developed materials extraordinary functions, or changing their chemical and physical characteristics.20,21 Polymers also offer outstanding characteristics and often serve as nanocarriers for treatments, diagnostics, medication transport, and protection.22 This review article highlights how the use of natural polymers enhances the anti-diabetic pharmaceuticals' effectiveness for delivery.

Classification of natural polymers used for diabetes mellitus

There are 2 kinds of naturally occurring polymers viz: polysaccharide and protein: Polysaccharides Chitosan, Alginate, Dextran, Starch, so the other form is Pectin and Proteins which includes Casein and Gelatin. As polysaccharides are exceptionally durable, secure, environmentally friendly, and have gel-forming attributes, it is possible to modify them chemically and biochemically to make them suitable for consumption during oral protein administration.23 Charged polymers, like alginate as well as chitosan (CS), can electrostatically interact with differently charged components to create polyelectrolyte complexes PECs that produce ion pairing without compromising the fundamental properties of the polymer.24,25 Proteins are known as molecules possessing molecular weights more than 5000 Da, whereas peptides are defined as molecules with molecular weights around 500 and 5000 Da.26 Although being made up of amino acids, they are synthetically distinguished by factors such as molecular weights, spatial conformations, and amino acid units.27

Chitosan:

Chitin, which is sourced from the cuticles of insects, the exoskeletons of crustaceans, and the cell walls of fungus, is alkaline deacetylated to form chitosan, a kind of polycationic polysaccharide.28,29 Chitosan is also well-known carbohydrate polymer, has gained a lot of attention lately due to its biocompatibility, Low toxicity, readily available, and biodegradable.30 Numerous types of chitosan have shown promising effect of improving the poor lipid and glucose metabolism associated with diabetes mellitus. However, chitosan has also produced a number of innovative drug carriers that can be used to transport antidiabetic medications to their intended locations. The present research emphasizes the rising significance of chitosan as polymer-based formulations for the administration of antidiabetic medications to achieve improved control of

hyperglycemia and summarizes the possible actions of chitosan in modulating impaired blood sugar and fatty acid metabolism correlated with diabetes mellitus.31 Chitosan can be produced into powders or beads. It typically appears as white, yellowish flakes. Additionally, the Deacetylation (DD) plays a vital role to the molecular chitosan weight. Specifically, a lower DD corresponds to a larger molecular weight, resulting in increased chemical stability and mechanical strength. Chitosan has an average molecular weight of around 1.2 × 105 g mol-1.32

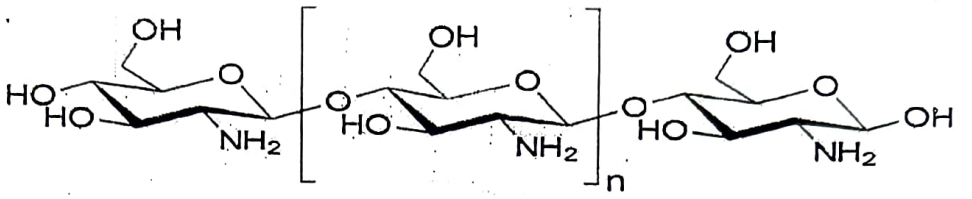

Figure 3: Structure Of Chitosan

Chitosan is cationic in nature as a result of containing amino and hydroxyl groups. Chitosan is capable of being modified chemically and physically by a variety of techniques including as grafting, complexation, crosslinking, and blending. Hydrogen bonds exist in the molecular structure of chitosan, resulting it to be a rigid polymer.33

Researcher **named Florentina Geanina Lupascu et.al 2015** designed xanthine analogues to enhance the chitosan-based scaffold's biological and pharmacokinetic attributes. It was observed that the experiments showed a decrease in the blood glucose level with 59.30% and 4.53% of glycosylated hemoglobin. The formulation containing chitosan formulation (CS-6) displayed lower blood glucose level (114.5 mg/dl) than the one induced by pioglitazone which was was 148.5 mg/dl while taken alongside a regular diabetes medication.34

Jubril Olayinka Akolade et.al 2017 specified the use of chitosan alginate beads polymeric complex with curcumin as therapeutic agent for diabetes mellitus. The studies revealed an improved encapsulation efficiency was (64–76%), loading capacity was (20–26%) and yield was (50–72%). Moreover, curcumin's biological properties, retaining status, and chemotherapeutic functionality were all substantially improved due to its nanoencapsulation in chitosan based polyelectrolyte complex. Further, the complex reduced loss of curcumin by 20% & also extended mean release time by 40 minutes in simulated gastric fluid.35 This case report is on chitosan being an effective polymer for formulating antidiabetic formulation reported by **E. Jaisankar et.al 2020.** They developed chitosan co-polymer membranes fabricated from thiourea, phenyl-hydrazine & formaldehyde via polycondensation method loaded with metformin as an anti-diabetic agent. The metformin loaded tablet formulation were developed. The results showed improved antidiabetic effect by inducing a sustained release of the formulation. Additionally, the developed nanocomposite displayed antimicrobial development properties providing its potential to recover from wounds in diabetic individual.36

Alginate:

Alginate is a renewable polysaccharide comprised of two monomers: mannuronic and guluronic acid. Seaweed develops a lengthy chain of alginic acid and salts. Natural alginate is biocompatible but not biodegradable under physiological conditions. Therefore, it is dissolved in divalent ions like calcium and utilized for wound dressing, scaffolding, and hemostats.37,38,39 Alginate

originates from brown algae called Phaeophyceae comprising Laminaria hyperborea, Laminaria digitata, Laminaria japonica, Ascophyllum nodosum, and Macrocystis pyrifera, employing water-based alkaline solutions, usually NaOH.40 Alginate is a negatively charged polymer. Therefore, it is widely studied and is also been used in biomedical fields because of its relatively safe, harmless gelation with divalent cations like calcium cation, and biological suitability.41 Alginate is a remarkable polymer which offers numerous benefits and has recently been widely used in the development of controlled-release systems that deliver medications.42 The molecular weights of commercial sodium alginates vary between 32,000 to 400,000 g/mol.43 Maximizing the molecular weight of alginate upgrades the physical characteristics of the gels. Highly molecular weighted polymeric alginate solutions can be extremely viscous, making them unfavorable for the processing step.44 Alginate constitutes a straight copolymer consisting of d-mannuronate and l-guluronate residues connected by a 1,4 bond. The Blocks consist of alternate M and G residues, consecutive G residues, and consecutive M residues. Different sources of alginates have various degrees of concentration of M and G.45

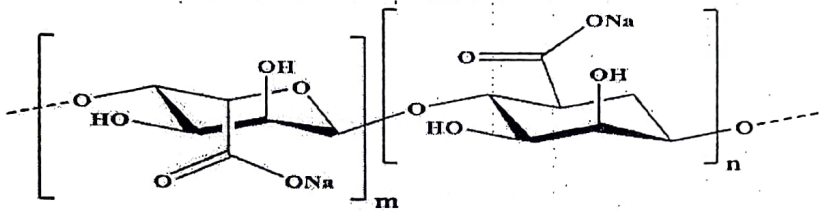

Figure 4: Structure Of Alginate

In relevance to the following the polymer alginate and the antidiabetic agent was been formulated by **S. K. Bajpai et.al 2017** and the formulation included calcium alginate beads containing gliclazide as the antidiabetic agent. This formulation provided an extended release of Ca (II)-ions crosslinked alginate beads and keeping it stable for more than 48h, in the gliclazide the physiological fluid of pH 7.4, while ions crosslinked alginate beads not only enhance the stability of the composite beads but also improved retention time of anti-diabetic drug gliclazide. Additionally, the enhanced stability and prolonged release were confirmed by an in-vivo study on Albino Wistar rats.46

In another research **Mansi Butola et.al 2023** had an objective to demonstrate the synthesis of compressed tablets incorporating sodium & pectin alginate with metformin HCL. The studies revealed the developed tablets showed sustained drug release pattern. It was found that with increase in polymer concentration the drug release was decreased.47

Dilipkumar Pal et.al 2011 developed & optimized alginate methyl-cellulose mucoadhesive microcapsules of gliclazide by central composite design. The developed microcapsules exhibited good mucoadhesive property & showed controlled drug release. In-vivo studies revealed that blood glucose was lowered after administration of optimized gliclazide containing mucoadhesive microcapsules to prolong the systemic absorption and also improved patient compliance.48

Cyclodextrin:

Cyclodextrins (CDs) are oligosaccharide and are widely employed in the pharmaceutical sector which are capable of forming inclusion complexes through interactions with guest molecules.49 Their cylindrical structures, with cavities close to 0.7 nm deep and 0.5-0.8 nm interior diameter, exhibit remarkable features.50

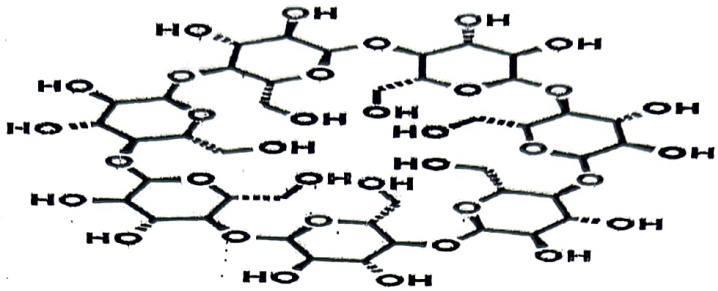

Figure 5: Structure Of Cyclodextrin

Kuljit Kaur et.al 2019 developed an inclusion complex of metformin hydrochloride (MF) and beta-cyclodextrin (β-CD) microwave irradiation method with the aim to improve sustained release, dissolution and oral bio-availability of metformin. Complexation with β-CD was prepared by 4 using ways physical mixture, kneading method, co-precipitation method, microwave method.51

Dextran:

Dextran-based delivery methods have been widely explored over the past decade, with applications in food science, nutraceuticals, pharmaceuticals, and biomedicine.52 Dextran possess a molecular weight of up to 440 MDa. They are categorized into two categories based on chain length: those with a weight of molecule more than 40 kDa are simply termed dextran, whereas those with Oligodextrans are molecules with a weight less than 40 kDa.53,54,55 Dextran is a neutral complex that is branched glucan and is made up of α-1,6 glycosidic connections between glucose monomers, with branches from α-1, 2, α-1, 3, and α-1, 4 links.56

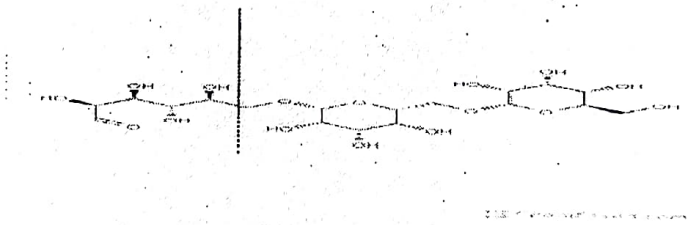

Figure 6: Structure Of Dextran

An attempt was made in this study by Ning-Hui Lu et.al; 2018 to show dextran as effective polymer and developed a formation with dextran as polymer with modified maghemínte of nanoparticles to the human insulin. The aim of this work is to demonstrate the impact of nanoparticles on human insulin's in vitro amyloid fibrillogenesis. Insulin fibril formation was reduced when modified dextran polymer consisting of maghemite nanoparticles that were added to human insulin. The outcome as well as the nanoparticle' size and concentration were strongly connected.57 S. K. Bajpai et.al 2016 designed dextran-based polymer-coated nanoparticles formulation consisting of the dextran hydrogel with the gliclazide as an antidiabetic agent. When compared to the ordinary drug, the drug-loaded hydrogel was found to be reasonably effective in drastically reducing the glucose level at reduced injection repetitions.58

Starch:

The 2nd most prevalent organic bio-polymer, is an inexpensive, adaptable, inexhaustible agricultural commodity with a variety of industrial and therapeutic applications.59 Starch molecule have structure consists of two forms amylose and

amylopectin.60 Amylose is a polymer composed of α (1, 4) glucopyranose and has a mild branching pattern. Between 105 and 107 g/mol are responsible for its molecular mass, and it has a degree of polymerization of 6000. A densely branched polymer with approximately two million polymerization degrees, amylopectin is made up of α (1, 4) glucopyranose molecules connected by α (1, 6) links. The molecular mass of amylopectin ranges between 107 and 109 g/mol.61 Starch is primarily made up of two D-glucose homopolymers [8]: amylase, a linear α D (1, 4')-glucan, and branched amylopectin, which has the corresponding constitution to that of amylose but has more α-1, 6'-linked branches.62

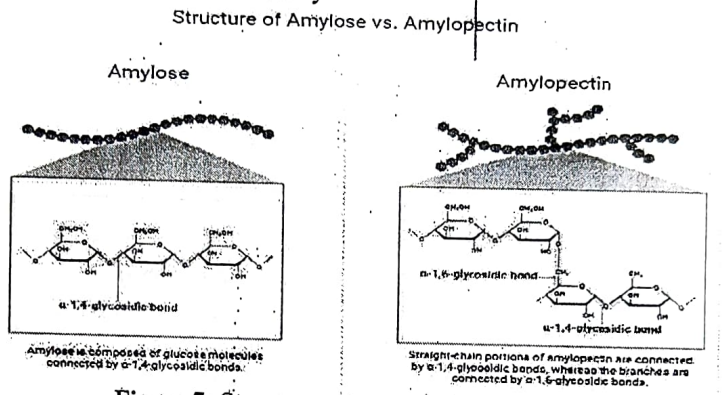

Figure 7: Structure Of Two Forms Starch

Formulation of glipizide as controlled release matrix tablets by employing starch acetate as a polymer to enhance the effectiveness of the anti-diabetic formulation was developed by P. Seenivasan et.al 2013. It was concluded that the use of starch acetate has improved the effect of formulation by providing a controlled release for 24h.63 Dioscorea oppositifolia starch has been tested as a polymer for the formation of floating gastro-retentive beads enabling the carefully controlled administration of metformin hydrochloride in a diabetic medication created by A. Okunlola et.al 2010. The ionotropic gelation approach was used by the team of scientists to create floating micro beads. In contrast to the starch to alginate ratio, releasing of metformin and the starch mixture from floating micro beads in a regulated manner.64 Ying Zhou et.al 2014 prepared a formulation containing the natural polymer indica rice starch with glimepiride as an antidiabetic agent. This research revealed that dual modification revolutionized the structure of indica rice starch, impacting both the diabetic mice's blood glucose levels and the starch's digestibility.65

Pectin:

Pectin is a biocompatible polysaccharide with intrinsic biological activity that may demonstrate different structural features depending on its source or extraction method.66 Pectin can be encountered in all terrestrial plant organs, including meristematic and parenchymal tissues. Pectin originates in plant cells in the cell wall and middle lamella section. However, the quality and quantity of pectin varies depending on the species.67 Pectin is soluble in water, anionic polysaccharide having linear chains of a-(1, 4)-D-galacturonic acid, 1,2 D-rhamnose, and side chains of D-galactose and D-arabinos.68

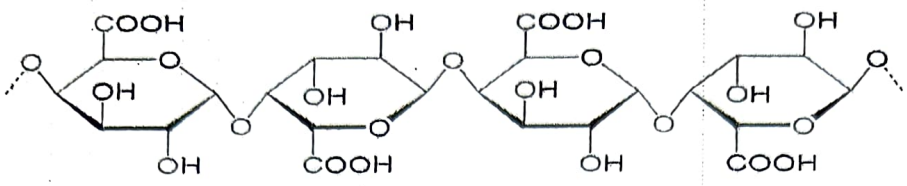

Figure 8: Structure Of Pectin

Researcher Santhosh Kumar Chinnaiyan et.al 2018 developed an antidiabetic formulation consisting of pectin as a polymer in metformin loaded nanoparticles. The method used for preparation of nanoparticles was ionic gelation method. This study depicted slow and sustained release of formulation at pH 6.8 and eventually resulting in increased retention duration in blood circulation.69

Casein:

Milk contains casein, which naturally transfers nutrients from the mother to the baby. It is affordable, safe, and easily absorbed.70 These molecules have molecule weights which range from 19 to 25 kDa with typical isoelectric point pI of 4.6 percent to 4.8 per cent. All the 4 caseins are amphiphilic in nature, with undefined structures.71 Caseins are proteins comprises of amphiphilic proteins that form stable micellar structures in water liquids. Casein micelles are structures made primarily of 4 phosphoproteins bound to one another through hydrophobic forces and calcium phosphate nanoclusters that (CCP) associated through the adjacent chain casein's phosphorylation serine residue.72

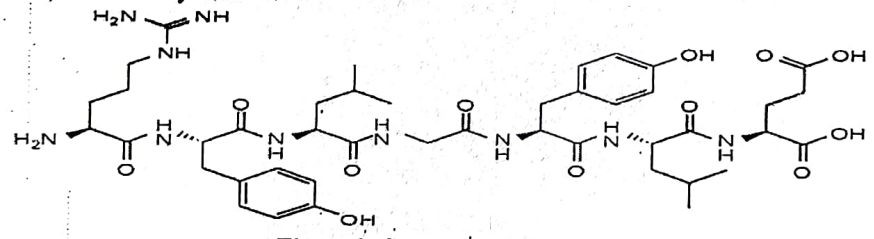

Figure 9: Structure Of Casein

Scientist Janardhan raj et.al 2015 demonstrated the use of casein micelles incorporated with an antidiabetic agent of metformin. The results showed that the use of this formulation lead to the release of metformin loaded casein micelles to provide a controlled release and the micelles also depicted a stronger stability.73

Gelatin:

Gelatin is a naturally occurring protein that is exceptionally biocompatible and biodegradable in physiological circumstance. It is obtained from the hydrolysis of collagen.74 Collagen and gelatin molecules have repeated Gly-X-Y triplets, including proline (Pro) and hydroxyproline (Hypro) amino acids.75 Gelatin is an effective medication delivering medium owing to its ability to carry charged biomolecules. It is true that the gelatin isoelectric point (IEP) can be adjusted to optimize drug loading performance based on the electrostatic characteristics of the target compound by choosing an alkaline or acidic preparation.76

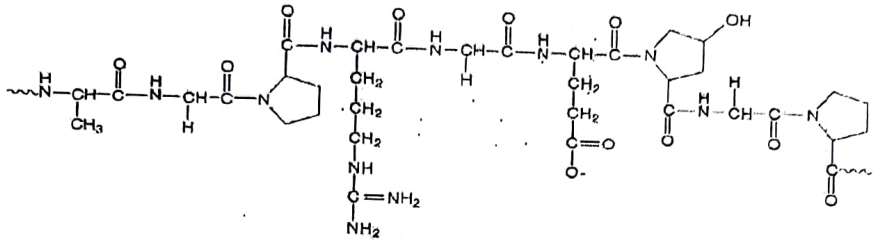

Figure 10: STRUCTURE OF GELATIN

The research study performed by Ying-Zheng Zhao et.al 2021 on modified gelatin which was incorporated with the insulin and thus resulting it to their feasibility as insulin pulmonary administration system. Pharmacodynamic research studies determined that the bioavailability was improved and the duration of hypoglycemic effects was also extended. Sustained release in lung tissue represents a particular benefit that polymeric nanoparticles are capable of providing, which can lower the dosage frequency and increase patient compliance. In additionally it also resulted in providing affordable price, excellent physical characterization, high bioavailability, and quick and consistent hypoglycemic impact.77

Table 1: Polymer And Key Findings In Anti-Diabetic Drugs

API	POLYMER	KEY FINDINGS	REF
Metformin hydrochloride (MET)	Chitosan	The composition demonstrated regulated release of drug, and a greater encapsulation (~90%) additional showed a decrease in blood glucose levels.	78
Polydatin+ Metformin Nanoparticles	Chitosan	Prolonged-release qualities	79
Gliclazide	Sodium Alginate	Gliclazide-loaded alginate beads demonstrated stable blood glucose level and enhanced patient compliance by optimizing, regulating, as well as extending gliclazide's systemic absorption.	80
Metformin hydrochloride (MFH)	Sodium alginate	The MFH and sodium alginate hydrogels formulation complex showed an excessive mechanical strength and in addition it also provides sustained release of the formulation.	81
Glimepiride	Cyclodextrin	Significant increase in the drug's rate of solubility, prolonged its duration of action, and enhancing its therapeutic efficacy.	82
Metformin hydrochloride (MH)	Cyclodextrin	Cyclodextrin matrix tablets filled with metformin hydrochloride provided a sustained release.	83
Insulin	Dextran	Dextran-encapsulated gold NPs (AuNPs@Dextran) binds to the insulin and are used as insulin carrier. AuNPs@ Dextran offer the potential to act as insulin carriers, extending insulin activity and	84

		lowering the need for frequent insulin injections.	
Metformin hydrochloride (MH)	Starch	Mucoadhesive beads showed improved levels of glucose control along with compliance among patients.	85
Metformin hydrochloride (MH)	Pectin	Mucoadhesive beads of (MH), exhibited robust muco-adhesivity with gastrointestinal mucosa and a notable hypoglycemic effect in rats with diabetes provoked by alloxan over a long duration of time after oral administration.	86
Insulin	Casein	Hydrogels containing insulin and casein resulted in improved patient compliance. After tolerating the stomach's acidic environment and reaching the small intestine, the insulin contained within the hydrogel casein begins to be released, allowing the beneficial impacts of hypoglycemia to be effectively shown.	87
Metformin	Gelatin	Metformin incorporated in methacrylated gelatin was released from specially engineered hydrogel microneedles, providing a sustained dosage.	88

FUTURE ASPECTS:

The emphasis has centered on analyzing and presenting multiple polymeric carriers that are capable of a tendency to boost insulin intestinal absorption in a considerably greater range than an oral insulin solution. Although the conclusions reached are considerably below the hypoglycemic impact obtainable by utilizing subcutaneous insulin, beneficial effects have been observed.89

It is possible to combine many biopolymers into one carrier to suit all of the properties which are been covered in this review article. Though the results are not nearly as hypoglycemic compared to those obtained with injection-based insulin, there do appear to be some positive and encouraging results. Even yet, a larger quantity of insulin is needed in the formulation for oral delivery methods than for injectable drugs. This is an important problem since the entrapment efficiency of the carriers counts when considering cost-effectiveness. Development of oral insulin carriers utilizing naturally occurring polymers that function more adequately or at least resemble the features of the injection through the skin thus served as the primary objective of study. In order to maximize protection for users, investigations into the long-run toxicities associated with the carrier molecules is further recommended.90

CONCLUSION:

Globally, the occurrence of diabetes is consistently rising, while over the following fifty years, this upward trajectory is anticipated to persist. Since, insulin therapy was introduced 88 years ago. The vast majority of naturally occurring biopolymers across the habitat are polysaccharides, which can be found in a variety of biosphere constituents such as microbes, plants, and animals, aquatic life, etc. Polymeric nanoparticle offers numerous benefits, including easy preparatory work, specific distribution, minimal dosage, and excellent medicinal effectiveness. It was determined in this assessment that one of the most advanced techniques using nanoparticles made of natural polymeric material for the diabetes mellitus

therapy. Polysaccharide nanoparticles have shown themselves as the highly significant biological nanocarriers of the future. Despite this, the majority of the investigation on polysaccharide-based nanocarriers was limited to preclinical settings, necessitating additional study of these polysaccharide NPs with potential for clinical application. The considerable amount of research demonstrating the exceptional biological and physiochemical properties of polysaccharides makes it seem likely that such compounds will find application as fascinating biomaterials in coming years. This review article investigates on the natural polymers used for diabetes mellitus has succeeded in demonstrating many different advantages like improvement in encapsulation efficacy, optimized blood glucose level, increased drug's rate of solubility, sustained release and compliance among patients. In this review it was also concluded that the usage of polymeric compounds is the advanced method to enhance treatment of diabetes mellitus.

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A Comprehensive Review of Ophthalmic Formulations for Ocular Diseases

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Abstract

Ophthalmic disorders provide considerable problems for healthcare practitioners due to the sensitive nature of the ocular environment and the wide range of conditions seen. Creating suitable pharmacological formulations for eye therapy is critical to good management and treatment results. This comprehensive analysis will examine the numerous ophthalmic preparations used to treat ocular illnesses, including glaucoma, dry eye syndrome, conjunctivitis, cataracts, diabetic retinopathy, and macular degeneration. The study delves into the many types of ophthalmic formulations, such as eye drops, ointments, gels, inserts, and sustained-release systems, emphasizing their modes of action, pharmacokinetics, clinical effectiveness, safety profiles, and obstacles in ocular drug delivery. The focus is on recent advances in formulation technologies, including nanotechnology, microemulsions, and in-situ gel systems, which promise to improve medication bioavailability and patient compliance. The study also examines future possibilities and current trends in ophthalmic drug development, such as personalized medicine methods and innovative drug delivery techniques, which seek to improve treatment results and quality of life for patients with ocular disorders. Overall, this study gives significant insights into the present landscape of ophthalmic preparations and information for doctors, researchers, and pharmaceutical scientists involved in developing and optimizing ocular therapies.

Keywords: ophthalmic formulation; ocular disorder; ocular drug delivery; bioavailability.

INTRODUCTION

The ophthalmic formulation extends the vehicle's contact duration with the ocular surface and delays medication removal. The low bioavailability and therapeutic responsiveness of standard ophthalmic solutions caused by precorneal medication elimination can be resolved using alternative ophthalmic formulations.[1] Precorneal loss characteristics, including tear interactions, unproductive absorption, retinal epithelial membrane impenetrability, and transient resident longevity in the cul-de-sac, all contribute to reduced drug bioavailability in ocular dosage forms. Due to biological and structural limitations, the eyes absorb only a tiny amount of the medications (1% or less). Changing ophthalmic drug administration's intensity, amount, or frequency can adjust its effective dosage: drug delivery and retention period on the eye's surface. Efforts for better ocular medication bioavailability have centered on lengthening drug occupancy time in the sac surrounding the conjunctiva and strengthening medication access through the cornea, the primary means of medication entering the eye.[2]

Local instillation is a critical, harmless approach for treating anterior disorders. Ninety percent of commercial ophthalmic products are administered using the traditional method, such as drops for the eyes. This might be due to the simplicity of management and adherence by patients.[3] Because of these factors, just under five percent of the drug supplied enters the eye. Including permeation enhancers/cyclodextrins or raising solution viscosity did not significantly improve results. Identifying and inhibiting medication efflux pumps has led to enhanced ocular drug absorption. However, continuous usage of these inhibitors may lead to adverse consequences.[4]

Drug administration routes are different based on the target tissue. Both ocular and subconjunctival delivery target the front region of the eye, while intravitreal and systemic therapies target the posterior. Following superficial application, drug permeation occurs in two ways: trans-corneal absorption occurs via lachrymal flow-to-the-front-chamber, as well as transconjunctival and transscleral absorption from the exterior ocular surface to the front uvea-ciliary bodies and eyeball. Hydrophilic medicines have increased trans-corneal permeation compared to hydrophilic medications due to the corneal epithelium's lipidic composition. The transconjunctival route is appropriate for hydrophilic medicines and big molecules. Topical use is used to treat anterior chamber diseases, including infection, allergies, corneal infection, and ulcerated corneas. Specialized versions must match the following requirements: effectiveness, sterility, stability, and ocular tolerance.[5]

Drug distribution to the eyes is essential for treating disorders affecting both the anterior and posterior portions. This review article highlights advances in medication delivery during the last decade. Disorders in the front part of the eye are more accessible to cure than the posterior region. Site-specific delivery of medication devices is necessary for addressing the eye's back parts, including the extracellular cavity, retinal pigment epithelial (RPE), and choroid. Poor drug delivery can contribute to persistent vision loss in disorders of the behind segment, such as proliferating vitreoretinopathy (PVR), sinusitis, a virus called (CMV), age-associated macular degeneration (AMD), and diabetes-related macular edema (DME).[6] Several medication delivery methods have been established to enhance ophthalmic availability and bypass delivery obstacles, including emulsions, aqueous gels, ointments, suspension, nano micelles, dendrimers, nanosuspension, microneedles, in situ thermosensitive gels implants and contact lenses. The paper will offer an overview of traditional and innovative ophthalmic medication delivery methods used to treat eye disorders.[7] Different types of Ophthalmic Formulations as shown in Figure 1.

CONVENTIONAL DELIVERY SYSTEM

Medication is given to the eye's surface for two reasons: treating infections like cataracts. Blepharitis, inflammation of the cornea sicca, or intra-ocular therapy via the cornea's surface for problems such as uveitis or glaucoma. The majority of eye disorders are treated with traditional medicines such as drops for the eyes. Conventional dosage forms make up roughly ninety percent of currently available commercial formulations.[8] Conventional ophthalmic medication administration often results in significant precorneal loss due to tear fluid turnover and washout. Nearly all eyedrops penetrate systemic via the conjunctive tissues and nasolacrimal duct, with less than 5% reaching the eye's and intracranial tissue's lens.[9]

Eye drops:

Eye drops are uncontaminated, aqueous solutions that wash and refresh the eyes. Excipients can affect the pressure of the osmotic fluid, the pH level, and the thickness in formulations. Preservatives may be added to multi-use packaging.[10] Drops for the eyes are available in many forms, including oil and water solutions, fluid emulsions, and suspensions containing active ingredients. Multi-use packaging may contain preservatives. These kinds of solutions are sterile and isotonic conditions. Drops for the eyes should have a pH of around 7.4, similar to tear fluid. When opting to buffer a medicine, consider its stability and tissue tolerance. High pH levels can induce pain, irritation, and decreased medication absorption due to increased tearing. The optimal pH range is 4-8.[11]

Ointment and gels:

Ointments are semi-solid products designed for external application. They are frequently made using mixtures of semi-solid and firm hydrocarbons (paraffin), which have a boiling or softening point near the body's temperature and are harmless to the eye. Ointments can be primary bases, generating a single continuous phase, or complicated bases, using a two-phased system (such as an emulsion). The therapeutic component is combined with the base in solution or as a highly micronized powder. When administered within the eye, ointments are dispersed into tiny droplets and operate as a drug store in the cul-de-sac for extended periods.

Ointments that are highly effective in increasing pharmaceutical bioavailability and prolonging the release of drugs. While secure and effectively accepted by the eye, these balms have a low compliance rate due to blurred vision and periodic discomfort. As a result, they are commonly used as an evening drug.[12]

Aqueous gels:

The gel can be a viscosity enhancer, resulting in a longer precorneal residence duration. It provides advantages such as less systemic exposure. Gel's high viscosity does not significantly enhance absorption, limiting dose frequency to once per day. The excessive viscosity causes blurry vision and matted eyelashes, reducing patient acceptance. Polymers widely used in aqueous gels include carbomer, HPMC, Hydroxy ethyl cellulose, polyacrylamide, PVP, poloxamer, and poly methylvinylethermaleic anhydride. Hydrogels, or insoluble in water polymer compounds with distinct swelling capabilities in aqueous settings, may be employed for the controlled administration of drugs. Medicines are released from these systems by transferring their solvent through the polymeric matrices, resulting in bloating. In this final stage, the substance diffuses into the inflated polymeric material, causing attrition and disintegration. Poly(acrylic acids), a hydrogel, significantly enhances tropicamide's optical absorption in humans compared to thick solutions or wax ointments.[13]

Ocuserts and lacriserts:

Ocular inserts are a solid dosage form that overcomes some drawbacks of standard visual systems, including aqueous solutions, suspensions, and ointments. A controlled-releasing ophthalmic medication delivery system substitutes the traditional pulse entrance method of releasing drugs found in ocular aqueous solutions, suspensions, and ointments. This form of delivery allows for prolonged and continuous medication administration. The eye drops demonstrated a pulse entrance pattern for medication administration in the eye, with transitory overdose, brief intervals of appropriate dosage, and lengthy periods of underdosing. Ocular inserts, like controlled release systems, maintain medication concentration in target tissues while lowering the number of doses. The low use of ocular inserts can be linked to psychological reasons, such as the patient's unwillingness to switch from typical liquid and semi-solid drugs, as well as infrequent therapeutic failures (e.g., unrecognized ejection or membrane ruptures). Various approaches were used to create ocular inserts, including soluble, erodible, non-erodible, and hydrogel options.[14]

Lacriserts:

Merck, Sharp, and Dohme invented this, a sterile cylindrical device used to manage dry eye disease and keratitis sicca 1981. They create a hydrophilic layer by absorbing water from the cornea and conjunctiva, lubricating the cornea.[15]

Emulsion and Suspension

Emulsion:

The mixture of a number of immiscible liquids results in a system having both a dispersed and continuous phase. The susceptibility of cornea and conjunctiva cells to detergents has limited the use of water-in-oil (W/O) or oils-in-water (O/W) macroemulsions for ophthalmic medicine administration.[16] They are the result of an abnormally high. The high concentration of surfactants in the scattered phase may irritate when applied to the eyes, as shown by the stinging sensation caused by even small quantities of alkaline soap. Long-term emulsions with conventional surfactants can cause corneal lesions, even if they are not initially irritating. In addition, the emulsion is more complex to make at clean conditions.[17]

Suspension:

The suspension is one harmless ocular topical fluid medication administration method. A suspension involves a mixture of finely divided solid API in a fluid solution using an appropriate suspension and dispersing substances. In other words, the messenger. The liquid part of the system contains an API-saturated solvent. Suspended particulates persist in the precorneal area for more time than medication solutions. The period of therapeutic activity in solution varies with the size of the particles. Particles of smaller size replace medications introduced into ocular tissues via the precorneal region. Larger particle size allows for longer retention and slower drug dissolution.[18] Examples of API and its dosage forms Table 1.

Table 1 Examples of Ocular Dosage Forms, API, and Therapeutic Use

API	Dosage form	Therapeutic use	Reference
Cyclosporine	Eye drop	Keratoconjunctivitis sicca	33
Acetazolamide	Eye drop	Glaucoma	34
Tacrolimus	Eye drop	Dry Eye	35
Nepafenac	Eye drop	Treat pain and swelling of the eye	36
Pilocarpine	Gel	Glaucoma and Ocular Hypertension	37
Ketoconazole	Gel	Blepharitis	38
Acyclovir	Ointment	To treat an infection of the eye caused by the simplex virus	39
Loteprednol etabonate	Ointment	To treat eye pain, redness, and swelling	39
Ketorolac	Ocular insert	To treat itchy eyes caused by allergies	40
Triamcinolone acetonide	Ocular insert	To treat macular edema associated with uveitis	41
Tenoxicam	Ocular insert	Cataracts	42
Dexamethasone acetate	Emulsion	Swelling and Redness	43
Erythromycin	Emulsion	Conjunctivitis	44
Ketotifen	Emulsion	To relieve the itching of allergic pinkeye	45
Amphotericin B	Suspension	Corneal Ulcers	46
Diclofenac	Suspension	To treat pain or swelling of the eye	47
Olopatadine	Suspension	Allergic Conjunctivitis	48

VESICULAR SYSTEM

Vesicular systems provide controlled ocular administration by preventing drug metabolism by enzymes on the corneal surface. Vesicles are a potential choice for ocular medication administration, providing the ease of a drop while maintaining pharmacological action near the place of operation. Delivering drug molecules into the eye via a topically applied preparation is complex. Drug penetration rates are affected by the drug's solubility and particle dimensions in suspensions and vehicle-specific properties. Vesicle dose forms contain the medication in lipid vesicles, allowing it to pass cell membranes. Vesicles act as drug carriers, affecting both absorption and disposal. Liposomes and niosomes are two standard vesicular drug delivery methods utilized in ophthalmology.[19]

Liposomes:

These are biodegradable and biocompatible cylindrical structures composed of lipid bilayers. They range in size between 10nm to 10μm. The lipid bilayer form with an aqueous center enables the addition of each lipophobic and hydrophobic active molecule. Lipophobic compound drugs can be encapsulated in the liposomes or absorbed in the medium, whereas lipophilic pharmaceuticals are integrated into lipid bilayers. The efficiency of liposomal formulations depends on several aspects, including the active component, liposome size, and charge. Liposomes are commonly used to manage eye ailments because of their high tolerance and capacity to enhance medication permeation when administered topically. This is due to their ability to communicate with ocular cells, such as the cornea's outer layer. These provide several medication delivery possibilities, including prolonged retention of medication on the cornea's surface and continued release after injection.[20]

Niosomes:

Niosomes are non-ionic substance droplets encapsulating active ingredient dual layers that function as innovative medication delivery platforms. Their magnitude is nanometric, and they develop when a surfactant that is not ionized, belonging to the dialkyl polyglycerol ether or alkyl family, is combined with lipids and hydrated in an aquatic solution. Niosomes may be either unilamellar or multilamellar, based on how they are produced. The vesicle comprises a surfactant membrane with lipophobic terminals visible on both sides and hydrophobic chains facing each other. The vesicle entraps hydrophilic drugs, whereas hydrophobic medications are embedded in the bilayer. Niosomal technology is used to treat several ailments.[21] Examples of API and its dosage forms Table 2.

Table 2 Examples of Ocular Dosage Forms, API, and Therapeutic Use

API	Dosage form	Therapeutic use	Reference
Fluconazole	Liposomes	Treats eye infections	49
Hyaluronic acid	Liposomes	Increases tear film stability	50
Ibuprofen	Liposomes	Reduce eye pain	51
Timolol maleate	Liposomes	Glaucoma	52
Acetazolamide	Niosomes	Glaucoma	53
Gatifloxacin	Niosomes	Bacterial Conjunctivitis	54
Lomefloxacin	Niosomes	Bacterial Conjunctivitis	55
Natamycin	Niosomes	Fungal Keratitis	56

NOVEL OCULAR DRUG DELIVERY SYSTEM

In recent decades, various methods have been used to treat eye problems. Nanotechnology-based ophthalmic products are being tested for drug delivery across the anterior and posterior regions. Nanotechnology-based treatments that use suitable sizes of particles can reduce discomfort while maintaining sufficient availability and ocular tissue compliance. Nanocarriers that included tiny particles, minor suspensions, nanoscale micelles, and dendrimers were designed to carry medications directly to the eyes. Some studies have demonstrated promising outcomes for increasing ocular bioavailability.[22]

Implants:

The implants are regulated medication delivery methods created from non-biodegradable and biodegradable polymers. Typically, they are injected through the vitreous through an incision in the optical pars plana. positioned lateral to the pupil and before the retina. Despite the disruptive impact of the implantation approach, implants offer various benefits that exceed the difficulties of the surgery. These benefits include overcoming the blood-retina barrier, allowing medicine administration at therapeutic amounts directly into the intended location, continuous medication administration, and decreasing the adverse effects frequently linked with intravitreal injections and systemic delivery.[23] Implants have advantages in treating chronic ocular illnesses such as CMV retinitis. Previously, polymers that were not biodegradable were utilized, but both installation and withdrawal required surgery. Degradation polymers, such as Polymer Lactate Acid, are safe and effective at delivering drugs into the retinal cavity without causing any damage.[24]

Iontophoresis:

It is a non-invasive treatment that uses minimal electricity to increase ionized medication penetration into tissue. To apply the drug, first use the electrode with the same charge as the medication, followed by an electrode for grounding with a different charge somewhere else on the body to finish the loop. The medicine works as a conductor of electricity in the cells.[25] The donor electrode is filled with the drug for delivery into the eye. An electric field is used to increase medication delivery to the eye. This approach is easy to apply, safe, and produces high medication concentration at the ocular location, addressing low bioavailability issues. It additionally tolerates mild electricity intensity well. Although it causes fewer problems for people, it is not entirely safe for optical tissues. It has been examined as a method of delivering medications to the eyes. This method efficiently distributes therapeutic dosages of ocular drugs, such as proteins, peptides, antibiotics, and corticoids, between the two regions of the eye. Drugs can be administered by transcorneal or transscleral iontophoresis. Transscleral iontophoresis provides several merits over transcorneal distribution, including a larger surface area, better drug delivery to the posterior region, and lower systemic absorption.[26]

Dendrimers:

Dendrimers, a form of precisely specified polymer, are widely used and have several uses. Their branching layered designs with several controlled terminal groups show great potential for biological applications, mainly as drug transporters. Dendrimers can be used as drug delivery vehicles by physical entrapment or chemical conjugation, depending on their size and ratio to the medication. Few in vivo drug delivery studies employ dendrimers since most research focuses on in vitro methods. Verify water solubility and biocompatibility first. PAMAM dendrimers are the most frequently used for biological applications, including medication delivery. Our phosphorus-containing dendrimers are helpful for physical purposes, including transfection, anti-prion, anti-HIV, Alzheimer's disease, imaging, and activation of human monocytes and NK cells.[27]

Nanoparticles:

Initiatives have been made to increase medication bioavailability, release, and absorption rates through formulations and dose forms. Nanodevices and nanostructures regulate human physiological processes at the molecular and cell level. Nanoparticles (NPs) with sizes ranging from 10nm to 1000nm aid in the transit of

significant, water-soluble compounds through the ocular system. Drugs are unable to reach their intended location of action due to minimal difficulties. Drug-loaded nanomaterials offer beneficial biological features such as prolonging the duration of residence of eye drops, lowering toxic effects, and allowing drugs to penetrate deeper parts of the ophthalmic tissue and liquid humor. They also reduce precorneal medication loss due to high tear fluid turnover.[28]

Microneedles:

Microneedles (MNs) are components constructed from polymers or metals and range in size from a few micrometers to 200μm. MNs feature micro-sized projections, making them less intrusive. nature. These MNs provide advantages over traditional delivery systems, including bypassing ocular barriers and targeting medications to precise sites of action. MNs are an efficient approach for percutaneous medication administration. MNs show encouraging results in eye therapy and can also be used for percutaneous administration to the oral mucosa, gastrointestinal tract, and nails. Such micron-sized syringes are easily insertable into the eye and appropriate for many diverse functions. They are less uncomfortable than ordinary hypodermic needles and may be tailored to administer medication for an extended time. As a result, repeated administration would be required.[29]

Microparticles:

Microparticles can travel across the blood-ocular barrier, making them suitable for intraocular delivery. Microparticles have the benefit of delivering the medicine over time, resulting in the same impact as several injections. Microparticles are injected using a typical suspension method. Microparticles are often made from a combination of polymers and active compounds. Depending on the polymer type (erodible, biodegradable, or not biodegradable), microscopic particles may remain or dissolve from the injection site after pharmaceutical administration. Biodegradable microparticles are preferred for disorders affecting the posterior region. Microparticles enable the controlled and long-lasting release of bioactive substances while protecting the leftover drug from breakdown and removal. Microparticles are classed based on their physical structure as microcapsules or microspheres. Microcapsules have a drug core covered by a polymeric shell (reservoir structure). The medication in microspheres is distributed via a network of polymers (matrix structure).[30]

Insitu gelling:

Ophthalmic in-situ gelling uses ecologically friendly polymers that can respond to changes in pH, environment, and ion strength. In-situ developing gels are fluids that rapidly form in the eye's cul-de-sac in reaction to environmental changes. The medication is then slowly released under physiological circumstances. By extending the gel's residence duration in situ, the medication is delivered in a prolonged way, improving bioavailability, minimizing systemic absorption, and reducing frequent dosage, ultimately leading to increased patient compliance. In-situ gelling systems offer several benefits, including easy manufacture, administration, and exact dosage delivery.[31]

Contact lenses:

Researchers are exploring new delivery techniques and technologies to address the limitations of traditional eye drop treatment. A sound medicine administration system should be comfortable and convenient and not interfere with vision or eye function. Therapeutic contact lenses offer prolonged wear and over 50% bioavailability, making them ideal for regulated and sustained ocular medication administration compared to

eye drops. Therapeutic contact lenses distribute medications into the before and post-lens tears films, resulting in a more extended residence period than eye drops (1-3 minutes). High drug residence time can enhance bioavailability by up to 50%, resulting in reduced dosage, frequency, systemic absorption, and related adverse effects. To treat anterior ocular disorders, therapeutic contact lenses have been created utilizing various approaches, including soaking, chemical imprinting, or pharmaceutical-laden nanoparticle entrapment, drug plates, ion-ligand polymeric systems, and supercritical liquids. Contact lenses can effectively transport medications. However, their expansion, retention modulus, ion permeation, accountability, and oxygen penetration limit their use for medicinal purposes.[32] Examples of API and its dosage forms Table 3.

Table 3 Examples of Ocular Dosage Forms, API, and Therapeutic Use

API	Dosage form	Therapeutic use	Reference
Fluocinolone acetonide	Implants	To treat non-infectious uveitis	57
PLGA and dexamethasone	Implants	Management of macular edemas due to retinal vein occlusion	57
Ganciclovir	Implants	Antiretroviral therapy	57
Acyclovir	Iontophoresis	For treating uveitis and other inflammatory eye diseases	58
Dexamethasone	Iontophoresis	To treat inflammation of the eyes caused by allergies	59
Besifloxacin	Iontophoresis	Bacterial conjunctivitis	60
Pilocarpine	Iontophoresis	Treats glaucoma and ocular hypertension	61
Dexamethasone	Nanoparticles	Improve visual acuity while decreasing macular thickness in diabetic macular edema	62
Acetazolamide	Nanoparticles	Glaucoma	63
5-Fluorouracil	Nanoparticles	Reduce fibroblastic proliferation and subsequent scarring	64
Cyclosporine A	Nanoparticles	Dry eye syndrome	65
Triamcinolone acetonide	Microparticles	Edema and Neovascularization	66
Ketorolac	Microparticles	For allergy symptoms	66
Celecoxib	Microparticles	Diabetic Retinopathy	66
Dexamethasone	Microparticles	Retinal vascular diseases	66
Ciprofloxacin	Insitu gel	Treatment of corneal ulcers	67
Bimatoprost	Insitu gel	Open-angle glaucoma	68
Acetazolamide	Contact lens	Glaucoma	69
Timolol	Contact lens	Glaucoma	69
Cyclosporin A	Contact lens	Dry eye	69

Ketotifen fumarate	Contact lens	Allergic conjunctivitis	69

CONCLUSION

Finally, effective management of ocular illnesses requires a thorough awareness of the many pharmacological formulations available for therapy. This detailed analysis delves into the complexities of ophthalmic formulations, which range from essential eye drops to cutting-edge nanotechnology-based delivery methods. These preparations play an important role in treating illnesses such as glaucoma, dry eye syndrome, conjunctivitis, and macular degeneration, giving practitioners a wide range of alternatives for tailoring therapy to particular patient needs. Despite tremendous improvements in ocular medication delivery, problems such as low bioavailability, patient compliance concerns, and the requirement for sustained-release formulations remain. However, recent advances in formulation technologies show promise in overcoming these barriers, with novel techniques such as microemulsions, in-situ gels, and nanoparticle-based carriers providing improved drug delivery efficiency and therapeutic efficacy. In conclusion, this study emphasizes the value of ongoing research and innovation in the field of ophthalmic preparations. By encouraging collaboration among physicians, researchers, and pharmaceutical scientists, we may continue to promote the development of safe, effective, and patient-friendly medicines for ocular disorders, eventually enhancing the quality of life for those suffering from these ailments.

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