SRI VENKATESWARA INTERNSHIP PROGRAM
FOR RESEARCH IN ACADEMICS
(SRI-VIPRA)

SRI-VIPRA

Project Report of 2024: SVP-2409

"Polyacrylates based Nanomaterials as Promising Candidates for Biomedical Applications"

IQAC
Sri Venkateswara College
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SRIVIPRA PROJECT 2024

Title : Polyacrylates based Nanomaterials as Promising Candidates for Biomedical Applications

Name of Mentor: Dr. Laishram Saya Devi **Name of Department: Chemistry** **Designation: Assistant Professor**	**Photo** 

List of students under the SRIVIPRA Project

S.No	Photo	Name of the student	Roll number	Course	Signature
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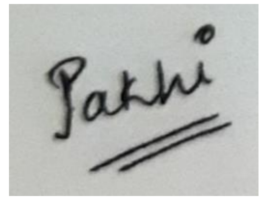
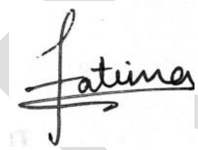
2.		Pakhi Tyagi	1323043	B.Sc. (Hons) Biological Sciences	
3.		Fatima Ansari	1323027	B.Sc. (Hons) Biological Sciences	
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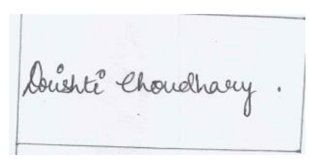
6.		Drishti Choudhary	1222037	B.Sc. (Hons) Biochemistry	

7.		Vikrant	1222013	B.Sc. (Hons) Biochemistry	

Signature of Mentor

Certificate of Originality

This is to certify that the aforementioned students from Sri Venkateswara College have participated in the summer project SVP-2409 titled "**Polyacrylates based Nanomaterials as Promising Candidates for Biomedical Applications**". The participants have carried out the research project work under my guidance and supervision from 1st July, 2024 to 30th September 2024. The work carried out is original and carried out in an online/offline/hybrid mode.

Signature of Mentor

Acknowledgements

I am grateful to the Principal, Sri Venkateswara College, University of Delhi, for his continuous encouragement and support in the field of research. I also would like to thank the SRI VIPRA team for giving me the opportunity and a platform to guide undergraduate students for research in the college as a mentor through the internship programme.

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Objectives:

- The main objective of the research project is to impart students the basic skills of research, to widen their horizon of scientific thought and aptitude along with application of their skill in constructive research.
- To give a hands-on practice of various tools and softwares which are required in doing research subsequently making its way to its publication.
- To inculcate in students the role of natural polysaccharides in present day research and particularly their applications as sensors.

Abstract:

Because of their special qualities, polyacrylate-based nanomaterials have attracted a lot of interest lately and are extremely appropriate for a variety of biomedical applications. These artificial polymers have excellent biocompatibility, easily functionalizable characteristics, and are generated from acrylic acid and its derivatives. Important benefits include the capacity to create hydrogels, absorb water, and be customized for particular applications, allowing them to be used in tissue engineering, medication delivery, and wound healing. Polyacrylate nanocarriers, which have the ability to modify their surface to target particular tissues, can encapsulate and release medications in a regulated manner when used in drug delivery systems. Furthermore, polyacrylate-based scaffolds offer an environment that is conducive to cell growth in tissue regeneration, and because of their hydrogels' capacity to retain water and deliver therapeutic effects, these scaffolds have been effectively used in wound healing. Research is still being done on issues including long-term toxicity, stability, and biodegradability despite its potential. Further developments in polyacrylate nanomaterial design and use could lead to a wider clinical acceptance of these materials in various biological disciplines.

1. Introduction:

By providing cutting-edge technologies for medication delivery, tissue engineering, diagnostics, and regenerative medicine, nanotechnology has completely transformed the biomedical industry. Because of their distinct physicochemical characteristics and adaptability, polyacrylates have become one of the most promising options among the wide spectrum of nanomaterials. Acrylic acid and its derivatives are the source of polyacrylates, which are man-made polymers renowned for their high water absorption capacity, biocompatibility, and ease of functionalization.

Polyacrylate-based nanomaterials have been investigated more and more recently for use in biosensing, tissue engineering, drug delivery, and wound healing. There is a great deal of promise for enhancing therapeutic outcomes from their capacity to form hydrogels, contain therapeutic drugs, and be changed for targeted delivery systems. Moreover, polyacrylates can be engineered to interact with particular biological contexts, which increases their effectiveness in targeted and customized treatment.

Notwithstanding these benefits, there are still issues with maximizing their biodegradability, stability, and lowering any potential long-term toxicity risks for use in clinical settings. The expanding importance of polyacrylate-based nanomaterials in the biomedical field is examined in this introduction, which also highlights the obstacles that must be overcome before these materials can be successfully incorporated into clinical practice.

2. Characterization techniques:

(i) X-Ray Diffraction (XRD) Method: X-ray diffraction technique, that work on the Bragg's Rule, is a very useful characterization tool to study, non-destructively, the crystallographic structure, chemical composition and physical properties of materials and thin films. It can also be used to measure various structural properties of these crystalline phases such as strain, grain size, phase composition, and defect structure. The intensities measured with XRD can provide quantitative, accurate information on the atomic arrangements at interfaces.

(ii) Raman Spectroscopy: Raman spectroscopy represents another non-destructive method for the analysis of the symmetry and structure of a molecule. It offers structural information for both fundamental and practical study. Mainly for carbon-based materials, a careful observation of the G bands and D bands gives information about the nature of hybridisation of the carbon atoms in the graphene sheets. Moreover, information regarding whether the graphene sheets are single layered or multi layered as well the impregnation of the Fe_3O_4 nanoparticles are also predicted Raman spectrum.

(iii) Fourier Transform Infrared (FTIR) spectroscopy: Fourier transform Infrared Spectroscopy is one of the most important tools for surface characterisation of materials. Based on the molecular vibrations of the material, this particular spectroscopic technique results in a molecular fingerprint of these materials in the form of FTIR spectrum. It reveals the chemical composition of the nanoparticle surface as well as the reactive moieties/functional groups on the surface that are responsible for surface reactivity and chemical bonding. For obtaining the final FTIR spectrum, this method focuses on computing interferograms and applying Fourier transforms to them. FTIR is a time-saving approach which can analyse a wide range of samples including liquids, solids, gases and thin films for a variety of compounds in a short time span.

(iv) Scanning Electron Microscopy (SEM): pictures are crucial to many scientific fields because they offer insightful knowledge into the surface morphology, chemical makeup, and structural properties of materials. Visualising and analysing the surface morphology of materials requires the use of SEM images. High-resolution SEM imaging enable close examinations of surface characteristics including topography, texture, and roughness. Understanding surface characteristics and behaviour of materials, such as adhesion, friction, and contact interactions, requires the knowledge of this information. These surface features are visualised in SEM pictures, allowing researchers to assess and evaluate material performance.

(v) Energy-Dispersive X-Ray Analysis (EDAX):

The method of energy-dispersive X-ray analysis (EDAX) is utilized for the SEM assessment of nanoparticles. This method involves activating the nanoparticles using an EDS X-ray spectrophotometer, which is typically fitted together in current SEMs. The isolated individual nanoparticles are placed on a suitable substrate so that their characterization is unaffected. With regard to precise dimensions and elemental characterization, this technique has several drawbacks. EDAX works on the fundamental premise that an electron beam is used to generate X-rays from a specimen. The features and composition of the components present in the sample determine how the X-rays are produced.

(vi) Transmission Electron Microscopy (TEM): images play a crucial role in various scientific disciplines, offering valuable insights into the microscopic structure, composition, and morphology of materials. TEM images provide high-resolution imaging which allows researchers to visualize materials at an extremely fine scale, revealing intricate details at the atomic and nanoscale levels. is vital for understanding the arrangement of atoms, crystal defects, grain boundaries, and other structural features that govern the properties and behavior of materials.

(vii) Vibrating Sample Magnetometry (VSM): is a method used to analyse an adsorbent's or sample's saturation magnetization, hysteresis loop measurement, remanence curves, and other magnetic characteristics. The electronic configuration of the atoms in a sample, their ability to align in the presence of a magnetic field, and the alignment of domains (groups of metal ions) in a sample all affect the sample's magnetic characteristics.

(viii) UV-Visible Spectrophotometry: UV-Visible spectrophotometer is a simple, sensitive, reliable, low-cost technique that allows the determination of very less concentrations of compounds and the use of very small amounts of samples. This technique is based on attenuation of electromagnetic radiation measurement by an absorbing substance. Using Beer-Lambert’s law, it can determine the concentration of the analyte quantitatively. We intend to employ a double beam Cary-100 UV-Visible spectrophotometer in this study.

3. Polyacrylates: salient features responsible for biomedical applications

Polyacrylates are very well suited for biomedical applications due to a number of noteworthy characteristics. Their usefulness in fields including medication administration, tissue engineering, wound healing, and diagnostics is facilitated by these characteristics. Important characteristics consist of:

1. Biocompatibility: Polyacrylates are safe to interact with biological tissues and cells because they are often neither poisonous nor immunogenic. Because of their biocompatibility, the body is protected from experiencing negative immunological responses.

2. High Water Absorption and Swelling Capacity: Polyacrylates can expand and create hydrogels because of their exceptional water absorption capabilities. This characteristic is particularly helpful in drug delivery systems, wound healing, and tissue engineering applications where moisture and hydration retention are essential.

3. Ease of Functionalization: Bioactive molecules, targeting ligands, or stimuli-responsive agents (such as pH- or temperature-sensitive ones) can be added to polyacrylates with ease. This makes it possible to create specialized drug delivery methods or focused treatments for particular illnesses or ailments.

4.Adjustable Mechanical and Physical Properties: Polyacrylates can be made to have varying levels of me chanical strength and elasticity by changing their molecular structure.The ability to adapt is crucial for the development of materials with particular structural and functional characteristics required in various bio medical applications (e.g., stiff scaffolds for tissue engineering versus soft hydrogels for wound healing).

5. Thermal and Chemical Stability: Polyacrylates are necessary for the long-term stability of implants and biomedical devices because they preserve their structural integrity in physiological settings.
6. Cost-Effectiveness and Scalability: Polyacrylates are an accessible material for creating biomedical devices and therapies since they are comparatively cheap to produce and can be produced in big quantities.

Classification of polyacrylate-based polymers and monomers

Sl.no	Polyacrylate type	Monomer
1.	Poly (methyl methacrylate): **PMMA**	methyl methacrylate
2.	Poly (ethyl methacrylate): **PEMA**	ethyl methacrylate
3.	Poly (butyl methacrylate): **PBMA**	butyl methacrylate
4.	Poly (butyl acrylate): **PBA**	butyl acrylate
5.	Poly (ethyl acrylate): **PEA**	ethyl acrylate
6.	Poly (acrylic acid): **PAA**	acrylic acid
7.	Poly (acrylamide): **PAM**	Acrylamide
8.	Poly (dimethylaminoethyl methacrylate): **PDMAEMA**	dimethylaminoethyl methacrylate

4. Biomedical Applications of polyacrylate based materials:

The diverse features of polyacrylate-based materials, generated from the polymerization of acrylic acid or its derivatives, include biocompatibility, hydrophilicity, and tunable mechanical strength, making them suitable for a wide range of biomedical applications. These materials have the potential to be used in a variety of medicinal applications, including in wound healing, medication administration, and tissue engineering. Key biological uses are listed below:

(i) Bandages

Superabsorbent Polymers (SAPs): Superabsorbent wound dressings are typically made from polyacrylates. These dressings have the capacity to retain a moist environment that aids in wound healing while absorbing substantial amounts of exudate. Because polyacrylate hydrogels can retain moisture, absorb fluids, and adapt to the wound bed, they are frequently used as wound dressings. Because polyacrylate hydrogels can retain moisture, absorb fluids, and adapt to the wound bed, they are frequently used as wound dressings. Therapeutic substances like antibiotics can also be included into hydrogels for regulated drug release at the wound site.

(ii) Drug release systems

Polyacrylates can be synthesized into hydrogels, nanoparticles, or microspheres that contain medications, enabling a regulated and prolonged release of those substances. In localized medication delivery scenarios, like cancer therapy, this is particularly helpful because it allows the drug to be given directly at the tumor site, reducing systemic adverse effects. Materials That Respond to Stimuli: Polyacrylates can be engineered to react to pH, temperature, or certain enzymes, among other environmental cues. Using this capability will help develop "smart" drug delivery systems.

(iii) Regulated Release Carriers:

Polyacrylates can be synthesized into hydrogels, nanoparticles, or microspheres that contain medications, enabling a regulated and prolonged release of those substances. In localized medication delivery scenarios, like cancer therapy, this is particularly helpful because it allows the drug to be given directly at the tumor site, reducing systemic adverse effects. Materials That Respond to Stimuli: Polyacrylates can be engineered to react to pH, temperature, or certain enzymes, among other environmental cues. This feature helps develop "smart" drug delivery systems that release medications only in specific circumstances, increasing therapeutic efficacy and minimizing side effects.

(iv) Engineering Tissue:

Scaffolds for Tissue Regeneration: In tissue engineering, hydrogels and other polyacrylate-based polymers are utilized as scaffolds. They offer a three-dimensional matrix that reproduces the extracellular milieu and facilitates cell adhesion, growth, and differentiation. These materials' porous structure facilitates the interchange of nutrients and oxygen, which encourages the development of new tissues. Encapsulation of Living Cells: Living cells can be shielded by polyacrylate hydrogels, which also permit the diffusion of waste materials and nutrients. This is helpful for applications involving cell therapy, where damaged tissues can be repaired by delivering cells to particular areas.

(v) Coatings with antibacterial properties:

Surface Modification: To develop coatings that stop bacterial colonization, polyacrylate polymers can be functionalized with antibacterial chemicals or silver nanoparticles. To lower the danger of infection, these coatings are applied to medical equipment such implants, stents, and catheters.

5. Challenges and Future Directions

In biomedical applications, polyacrylates confront a number of difficulties despite their promising qualities. Even with modified versions, managing their disintegration rate remains challenging, raising worries about long-term buildup and potential chronic toxicity due to their inherent biodegradability. For clinical application, maintaining stable long-term biocompatibility and avoiding inflammatory responses are essential. Technical challenges include obtaining consistent surface functionalization for drug administration and adequate mechanical strength for load-bearing applications. The performance of polyacrylates can also be impacted by their unpredictable response to physiological circumstances. For its successful incorporation into biological sectors, additional challenges include overcoming regulatory barriers and scaling up manufacturing while preserving quality.