SYNTHESIS, CHARACTERIZATION, AND BIOLOGICAL STUDIES OF HETEROCYCLES AND THEIR CONJUGATED POLYMERIC MATERIALS

Abstract of Thesis

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Submitted By

Sumit Kumar
(M.Sc. Chemistry)
Enrolment Number: 1021/15

Under the Supervision of

Dr. Shailesh Kumar
Assistant Professor

Department of Applied Chemistry
School for Physical Sciences
Babasaheb Bhimrao Ambedkar University
(A Central University)
Vidya Vihar, Raebareli Road,
Lucknow-226025, Uttar Pradesh (India)

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Abstract

Heterocyclic compounds, and heterocycles related conjugated polymeric materials (HRCPM) play a vital role in medical and pharmaceutical fields. Due to some special properties of heterocycles, and their conjugated polymeric materials, they are widely used in the biomedical and pharmaceutical fields. Apart from the above, these materials are also being used in many other fields such as leather Industry, paper Industry, cosmetics industry, rubber industry, food industry, textile industry etc. Taking consideration of the extensive interests of these materials in research and their applications, we have designed our work to synthesize some of these heterocycles, and their related polymeric materials by different methods along with their characterization by various analytical techniques. Apart from this, we also used these synthesized materials for different applications like drug delivery, wastewater treatment, and to determine their biological activities as antibacterial, and anticancer agents. The above work entitled **"SYNTHESIS, CHARACTERIZATION, AND BIOLOGICAL STUDIES OF HETEROCYCLES AND THEIR CONJUGATED POLYMERIC MATERIALS"** consists of five chapters as mentioned below.

Chapter 1: General introduction and literature review of heterocycles and their conjugated polymeric materials

This chapter consists of a detailed review of heterocycles, and heterocycle related conjugated polymeric materials (HRCPM) of our interest. Heterocyclic compounds play a very important role in medical and pharmaceutical fields. Some of these heterocycles are also present in natural polymers which are derivatives of pyran and furan such as pyranose, furanose, arabinose, galactose, mannose, rhamnose, xylose etc. These heterocycles are the building blocks or monomeric units of natural polymers that form the polymer chain. These natural polymers are combined with each other by grafting and cross-linking or other methods to synthesize heterocyclic related conjugated polymeric materials (HRCPM). Due to the biological, physical, and chemical properties of these HRCPM (biodegradability, biocompatibility, bioavailability, short life time, non-toxicity, etc), they are used in biomedical, textile, paper, leather, plastic, waste water treatment, pharmaceutical field, food, cosmetics, etc. Under this chapter, we have reviewed on the functional properties of the above

mentioned as heterocycles and HRCPM, the crosslinking and grafting methods are used to synthesize HRCPM. Apart from this, the types of cross-linking used in the synthesis of these HRCPM with their effects and different types of grafting methods are also described. We have also discussed some applications of these HRCPM like drug delivery, heavy and toxic metal removal, dye removal, antimicrobial activity and food application in this chapter.

Chapter 2: Materials, methods, and instrumental techniques used in the research work

This chapter discusses the materials and methods utilized in the synthesis of heterocycles of our interest, and heterocycle-related conjugated polymeric materials (core-shell nanoparticles and crosslinked copolymers). Furthermore, a variety of characterization techniques using different instruments to identify these heterocyclic compounds and polymeric materials, has also been discussed which includes Fourier Transformation Infrared Spectroscopy (FTIR) used for the functional group determination of heterocycles and polymeric materials, UV-visible spectroscopy uses for the absorbance and concentration determination of the solution, Powder X-ray Diffraction (pXRD) for crystallinity determination of polymeric materials, Transmission Electron Microscopy (TEM) used for the size and morphology, Scanning Electron Microscopy (SEM) use for the surface morphology and element detection, Zeta Potential Analysis (ZPA) used for the stability, particle size and surface charge, Thermogravimetric Analysis (TGA) used for the change of mass, Ultrasonication used to separate the particle, Mass Spectrometry (MS) used for the mass determination of heterocycles and Nuclear Magnetic Resonance spectroscopy (NMR) used for the determination of ^{1}H and ^{13}C in the heterocycles.

Chapter 3: Synthesis and antibacterial applications of rifaximin loaded chitosan-alginate core-shell nanoparticles (Rif@CS/Alg-NPs)

This chapter describes the synthesis of rifaximin loaded chitosan-alginate core-shell nanoparticles and its antibacterial applications. The Fourier Transform Infrared (FT-IR) spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-ray diffraction (XRD), and zeta potential analyser were used to characterize the core-shell nanoparticles (Rif@CS/Alg-NPs). *Escherichia coli (E. coli), Pseudomonas aeruginosa (PA),* and *Bacillus haynesii (BH)* were used as tested

microorganisms for Rif@CS/Alg-NPs' antibacterial properties. The zones of inhibition found for Rif@CS/Alg-NPs against *E. coli*, *P. aeroginosa*, and *Bacillus haynesii* were 24mm, 30mm, and 34mm, respectively. Rif@CS/Alg-NPs were also tested for cytotoxicity against the human lung cancer cell line A549 and were shown to be nontoxic. At different pH levels, the drug release behaviour of Rif@CS/Alg-NPs was examined, and the maximum drug release (80%) was at pH 7.2. The Higuchi (R^2 = 0.9963) kinetic model was followed by the drug release kinetic data, which showed that the drug release from Rif@CS/Alg-NPs was a square root of a time-dependent process and diffusion-controlled. Current research offers a low-cost, environmentally friendly method for the synthesis of Rif@CS/Alg-NPs, which are used in antibacterial applications.

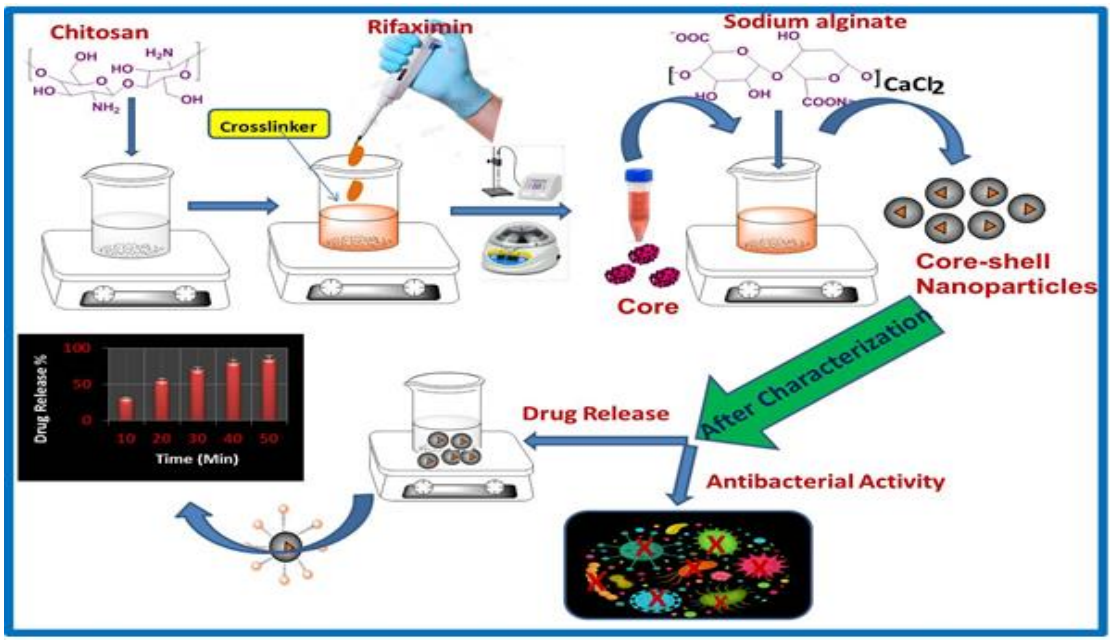

Fig. 1. Graphical Abstract of Chapter 3

Chapter 4: Synthesis, characterization and antibacterial study of chitosan alginate-based crosslinked copolymer and its use for the effective removal of methylene blue from its aqueous solution

This chapter describes the synthesis and characterization of chitosan alginate-based crosslinked copolymers (CACC) and its successful removal of methylene blue (MB) from its synthetic aquatic system (SAS). By using various characterization techniques, the CACC was confirmed both before and after the removal of MB. Thermal gravimetric analysis (TGA) was used to determine the thermal stability of the

materials both before and after MB adsorption. The interaction between the solid and liquid phases of CACC and MB during adsorption and removal was examined using a variety of operational parameters, including MB concentration, CACC dose, pH, contact time, and temperature. The calculated experimental results were compared to the Freundlich and Langmuir isotherm models, and the Langmuir model was best fitted shown to have the highest determination coefficient (R^2 = 0.98999). Consequently, as a material that is affordable, biodegradable, and biocompatible, for the effective removal of MB and its allies from SAS and wastewater, the CACC may be a promising polymeric-based adsorbent. The synthesized material (CACC) was also tested as antibacterial activity against *Escherichia coli (E. Coli), Pseudomonas aeruginosa (PA),* and *Staphylococcus aureus (SA)* with inhibition zones (IZ) 21.0mm, 20.0mm, and 26.0mm, respectively, indicating that CACC has good antimicrobial activities.

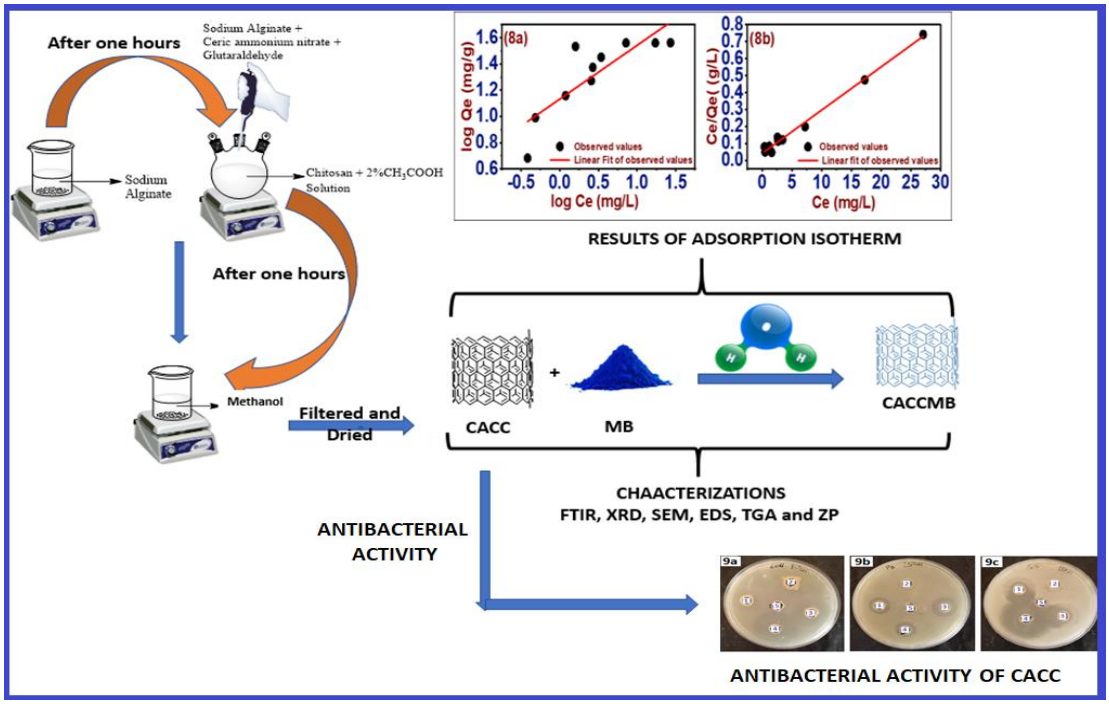

Fig. 2. Graphical Abstract of Chapter 4

Chapter 5: A novel green alternative to the synthesis of 3-phenyl-2-(4-(2-(piperidin-1-yl)ethoxy)phenyl)-2,3-dihydroquinazolin-4(1*H*)-one and its derivatives, its docking studies and anticancer activity evaluation

In this chapter, we have designed and developed a novel series of 3-phenyl-2-(4-(2-(piperidin-1-yl)ethoxy)phenyl)-2,3-dihydroquinazolin-4(1*H*)-one and its derivatives

by a novel green synthetic method. The synthesized compounds **6a-6f** were also evaluated for their breast cancer activity against MDA- MB-231 (breast cancer cell line), with tamoxifen as the standard drug. The IC_{50} value 14.64µM, 10.52µM, 11.8 µM, 10.06µM, and 07.00µM of the synthesized compounds **6a, 6b, 6c, 6d,** and **6f** respectively, were found much better than that of tamoxifen with IC_{50} value 18.77 µM. Apart from this, molecular docking studies of all of the synthesized compounds, along with some designed derivatives **1-15** of the titled compound, **Fig. 2** was performed by the LeadIT software using two PDB-IDs (3FC2 and 3KKR) and a docking study of lapatinib drug (breast cancer) has also been performed for the comparison and to better understand the scope of the compounds as anticancer agents.

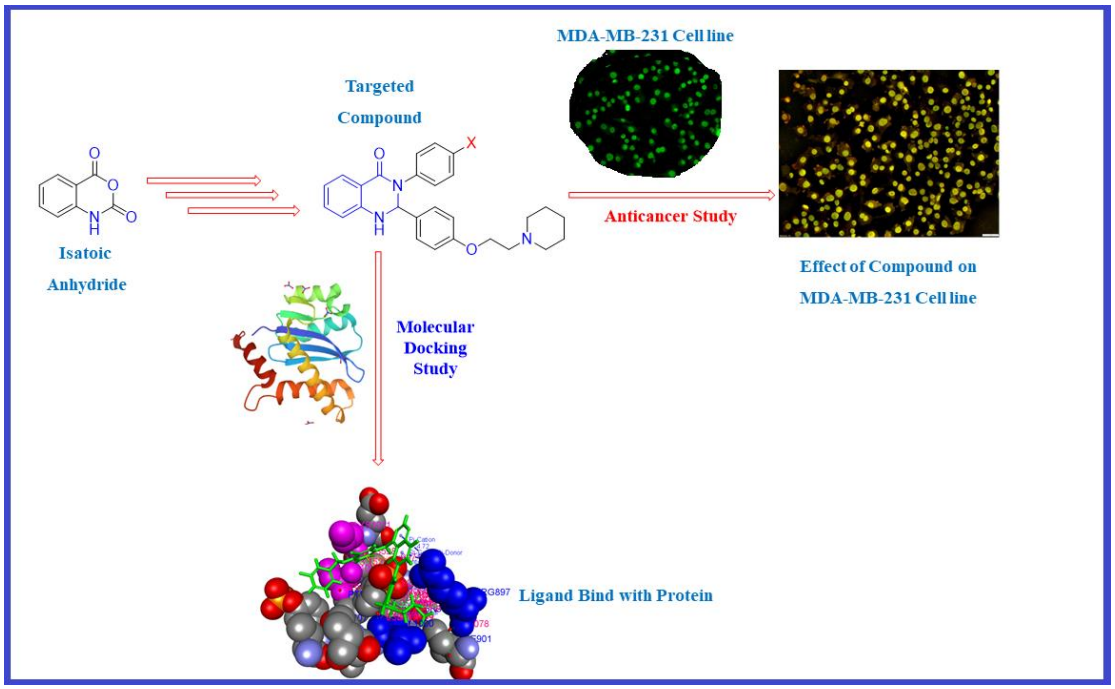

Fig. 3. Graphical Abstract of Chapter 5