CHAPTER III
SCOPE, OBJECTIVE AND WORKPLAN OF THE PRESENT INVESTIGATION

Calcium hydroxyapatite, \([\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]\), commonly referred to as HAP, is one of the calcium phosphate based bioceramic material which makes up the majority of the inorganic components of human bones and teeth. Synthetic HAP is known to be one of the most important implantable materials due to its biocompatibility, bioactivity and osteoconductivity coming from the analogy to the mineral components of natural bones and is used as a substitute material for human hard tissues [194-197]. The first report on the clinical use of a calcium phosphate for successful repair of a bony defect was made in 1920 [198]. It was not until the late 1970s and 1980s that serious efforts were made to popularize calcium phosphates and HAP in particular [199-201]. HAP has been utilized as a reinforcement in biomedical polymers, as a coating on metallic implants and as a scaffold material for bone growth [6,85,202,203]. HAP has found success in hard tissues surgery as it is bioactive i.e., able to bond surrounding natural tissue whilst being relatively insoluble. [204,205]. The properties like osteoconductivity and osteoinductivity enhances the bone regeneration and make it an important material in bone tissue engineering and drug delivery applications [206-211]. HAP also finds applications in other fields of industrial and technological interest as catalyst in chromatography, as a potential candidate in fuel cell, protein separation, catalyst, gas sensor areas, water purification, fertilizer production, drug carrier [212-215], as bone fillers [216], acidic catalyst for different chemical reaction [217], a promising material as reinforcing filler for composites, insulating agents, chromate-medium for simple and
rapid fractionation of proteins and nucleic acids [218–221], lighting materials, liquid chromatographic column, powder carriers, chemical sensors retardant of cancer cells and ion conductors [155,178,222,223]. Nano HAP is used as a drug delivery agent for anti-tumour and antibodies in the treatment of osteomyetitis, a bone infection that is often treated by excision of necrotic tissue and irrigation of the wound [224]. Nanorod morphology of HAP has gain a lot of attention in recent years. In column chromatography application rod shaped HAP shows enhanced protein adsorption because of their charging surface efficiency [225,226]. Even HAP present in human tooth and bone exhibits the form of nanopolycrystalline hexagonal nanorods [227].

These applications require HAP powders to have several corresponding properties to suit in such as mechanical strength, adsorption capability and so on. Those corresponding properties usually depend on the particle size, particle size distribution, morphology and surface area, etc. [228]. Because of this significant research effort has been devoted to develop the preparation and morphology control method of HAP powder. HAP powders with various morphologies had been synthesized by means of solid-state reaction [74,229,230], sol-gel method [231,232], hydrothermal method [114,233], micro-emulsion [234,235] or emulsion technique and the wet chemical precipitation method. However, the common template assisted method, especially under normal atmospheric pressure was proved to be the most convenient way to prepare HAP powders. Many have reported the synthesis of HAP using template obtained from commercial source [155,236]. But no work has been done using the extract obtained from various parts of plants as green chelating agent and template.
The aim of the present work is to synthesize hydroxyapatite using various chelating agents as template obtained from the plant materials such as root, stem, fruits and from vegetable. Thus, our work reports on the synthesis of hydroxyapatite using malic acid as green chelating agent, the synthesis of hydroxyapatite using oxalic acid as green chelating agent, the synthesis of hydroxyapatite using sucrose as green chelating agent and the synthesis of hydroxyapatite nanorods using tartaric acid as green template. Further, the antimicrobial activity of the as-synthesized hydroxyapatite powders has also been studied. Finally, the as-synthesized HAP powders were characterized by various analytical techniques.

3.1 OBJECTIVES OF THE RESEARCH WORK

At the outset of a good review on the synthesis of hydroxyapatite, the following objectives were drawn with the scheduled work plan as follows:

- to synthesize hydroxyapatite by using malic acid as the green template.
- to investigate the spectral characterization of the extracted malic acid from the natural fruit apple, to confirm their bonding nature and also the purity of the extracted malic acid with the aid of various analytical techniques like FT-IR, $^1$H-NMR and $^{13}$C-NMR.
- the as-synthesized HAP powders using malic acid as template have been characterized using FT-IR, $^{13}$C-NMR, XRD, SEM and EDAX analysis.
- to synthesize hydroxyapatite by using oxalic acid as the green template.
- the spectral characterization of the oxalic acid extracted from the vegetable tomato, to confirm their bonding nature and also the purity of the extracted oxalic acid with the aid of various analytical techniques like FT-IR, $^1$H-NMR and $^{13}$C-NMR.
the as-synthesized HAP powders using oxalic acid as template have been characterized using FT-IR, $^{13}$C-NMR, XRD, SEM and EDAX analysis.

to synthesize hydroxyapatite using simple, cost effective and eco-friendly green chelating agent sucrose as template.

the spectral characterization of the extracted sucrose from different plant materials, to confirm their bonding nature and also the purity of the extracted sucrose with the aid of various analytical techniques like FT-IR, $^1$H-NMR and $^{13}$C-NMR. Further, the hydrolyzed products of the extracted sucrose were analyzed by LC-MS.

the as-synthesized HAP powders using sucrose as template have been characterized by using FT-IR, $^{13}$C-NMR, XRD, SEM and EDAX analysis.

to synthesize a novel hydroxyapatite nanorods using tartaric acid as green template.

the spectral characterization of the extracted tartaric acid from different plant materials, to confirm their bonding nature and also the purity of the extracted tartaric acid with the aid of various analytical techniques like FT-IR, $^1$H-NMR and $^{13}$C-NMR.

the as-synthesized HAP powders using tartaric acid as template have been characterized using FT-IR, $^{13}$C-NMR, XRD, SEM and EDAX analysis.

to analyze the weight loss of the as-synthesized HAP powders obtained by using all the green templates by the thermal analysis methods.

to study the antimicrobial activities of the as-synthesized HAP powders obtained by using all the green chelating agents.
Thus, with all these objectives, I have synthesized hydroxyapatites with four different chelating agents such as malic acid, oxalic acid, sucrose and tartaric acid as green template which were very cheap, eco-friendly and environmentally beginnin materials. The work plan for the above was given below in a comprehensive style.

3.2 WORK PLAN

The present work has been processed through different steps which are listed as flow chat below:

Fig. 3.1 Work plan of the synthesis and spectroscopic characterization of hydroxyapatite using the green chelating agent as template.